DEER WINTERING HABITAT MODELS

FOR

TWO REGIONS OF NOVA SCOTIA

by

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ABSTRACT

A project jointly supported by the Nova Scotia Department of Natural Resources and Acadia University was initiated in 1993 to study the winter habitat of white-tailed deer (*Odocoileus virginianus*). Two geographically separate areas representing the extremes of the Nova Scotia climate were selected, one in Queens county and the other in Inverness county. The first part of the study involved an analysis of forage aspects of the deer wintering area in order to document the potential available winter forage per hectare for the given study areas, and to suggest the applicability of these data for other regions of Nova Scotia. The Queens study area had an average of 10656 stems per hectare available for browse, whereas the Cape Breton study area had 22789 stems per hectare. The mean mass of the browsed portion of the available stem was represented by browsed biomass and was measured for each area. Browsed biomass identified a significant difference between study areas and among species, but not among cover types. Current annual increment of unbrowsed shoots showed significant differences among species and cover types, but not between study areas.

Habitat model construction and testing were the focus of the second part of the study. This involved the capturing of deer using various methods, followed by the attachment of a radio-collar. Radio-locations, recorded during three winter seasons, were transferred to a geographical information system to perform various queries in preparation for further statistical analysis. Kendall-tau testing, coupled with t-testing and Mann-Whitney testing aided in the elimination process of insignificant habitat variables. A total of 29 variables were considered at a local scale, whereas 22 were considered at a landscape scale in developing the models. A step-wise logistic regression, using the habitat components as the independent variables and the presence or absence of deer as the dependent variable, was performed to generate coefficients indicating the degree of influence of each of the variables on the habitat model. Finally, the model was applied to a geographical information system to produce a data layer representing a weighted composite probability map for habitat evaluation. Such a probability map has the potential for practical application in the development of resource management systems that aim to meet the demands of Nova Scotia's silvicultural needs while maintaining critical deer winter habitat.

Keywords: white-tailed deer, winter habitat, logistic regression, habitat model, geographical information system, browse

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CHAPTER I

PROBLEM AND STUDY OBJECTIVES

The last decade of this century is one of unprecedented rates of social, economic and ecological change throughout the world (Hanley 1994). It is only a dream to think that the efforts of ecologists, wildlife biologists, and resource management professionals will ever lead to a full understanding of all biological systems in the face of such persistant change. Since we are engulfed by forces beyond our control, it is clear that we must keep our heads up in an effort to look toward the future (McCullough 1994).

To this end, Shumacher (1978) pointed out that comprehension of many problems can only be found in a widened field of interest and cooperation. "Landscape Management" and "Ecosystem Approaches" are both buzz words popularized in this decade, which are examples of Shumacher's "widened field of interest". Simply using an ecosystem approach to increase the scope and scale of wildlife research and/or forest management in isolation of one another, is neither keeping our heads up, nor looking towards the future. Wildlife research and forest management must work in synchrony to provide a scientific basis for integrated resource management (Turner *et al.* 1995).

Integrated resource management has recently become a much more realistic and manageable goal due to advancements in and widespread availability of geographic information systems (GIS), spatial resource inventories, radio-telemetry equipment and high-power desktop computers permitting sophisticated spatial analyses and modeling. These new technologies have helped to better integrate research and management, by formalizing the bridge between scientific theory, knowledge, and study, and management planning, implementation and monitoring. Finally, with the increasing development of GIS, the visualization of biological models has been greatly improved, and the ability to predict the influence of an extensive number of landscape variables has been aided tremendously.

The use of both habitat and population models is a common part of many wildlife and fish management plans and planning processes. A model is any representation or simplification of some part of the real world. A habitat model is a model incorporating only habitat features or variables, while a population model is often more complex, incorporating habitat values as well as including the concept of carrying capacity. Habitat is an area offering a combination of resources, such as food, cover, and water, and environmental conditions that promote occupancy by individuals of a given species (Morrison 1992). Carrying capacity is a function of all factors that interact to limit populations, including habitat, predators, inter- and intra-specific competition, disease, mortality, natality, and weather (Schamberger and O'Neil in Verner *et al.* 1986). It should be noted that different habitat and population models assume different definitions of habitat and carrying capacity, some narrow and some broad.

Habitat Suitability Index (HSI) models are examples of first generation habitat models which use a narrow definition of habitat. This family of theoretical models provided the first widely used tools integrating the concepts of scientific rigor into the realm of large-scale land planning. Some authors (Hobbs and Hanley 1990; Van Horne 1983) have questioned the applicability of these models given the assumption that density is a misleading indicator of habitat quality. Perhaps this confusion arises as a result of the conceptual differences between true habitat models and population models, as detailed in the previous paragraph. Other factors that tend to further confound habitat modeling are seasonal climate differences, scale, and pattern. Like habitat and carrying capacity, clarification of these terms is necessary in order to understand the limitations of any model.

Many provincial and state wildlife agencies throughout northeastern North America base their white-tailed deer (*Odocoileus virginianus*) management programs on models such as those previously mentioned (A.H. Boer, Head of Wildlife Branch, NB DNR, pers. comm.). Nova Scotia is no exception, as is evident in the Department of Natural Resources' interest in developing a model representing critical deer winter habitat. Common to all of these deer management programs is a descriptive theoretical model of deer winter habitat. Like HSI models, all of these descriptive models use a narrow definition of habitat and do not address carrying capacity. Seven winter variables that are most often used include: conifer crown closure, conifer basal area, cover type, site productivity, slope and aspect, age, and woody browse (food). With the advantage of a GIS, it is possible to develop more encompassing models to overcome the inadequacies of past modeling, and to include many more variables than the seven indicated above. The study described here addresses this possibility, allowing for the development of a comprehensive model representing the preferred deer winter habitat.

In the search for critical deer winter habitat, it is essential that modeling not be done on the basis of summer habitat features. Since Nova Scotia is close to the northern limit of white-tailed deer, they experience a negative energy balance in the winter season (Drolet 1976). This negative balance is due to harsh climatic conditions and a poor-quality or inaccessible food base. Good winter range reduces the rate of energy loss by providing shallow snow, adequate food, good security cover, and a favorable thermal environment (Armleder *et al.* 1994; Parker *et al.* 1984; Telfer 1978). Areas where deer traditionally concentrate during the winter are called deer yards or deer wintering areas (DWA). These areas are critical in the life history of northern white-tailed deer, and must be studied independently in order to develop an accurate model of the winter habitat.

Increased public awareness and concern regarding the management of the world's forests and wildlife, as well as heightened demand for forest products, has precipitated the need for a set of forestry wildlife guidelines. In 1989, the Nova Scotia Forest Wildlife Guidelines and Standards were released with an aim to protect wildlife habitats while still allowing for efficient, sustainable forest harvesting (Anon. 1989). Included in the guidelines are recommendations to contractors regarding harvesting in and around sensitive areas, which would include DWA and riparian zones. There is little dispute over the validity of the theoretical winter habitat model which was used as a basis for the guidelines. However, there are still several concerns regarding management within known DWA, as well as indications of needing an objective means for identification of these critical DWA within the landscape. To date, wildlife and forest managers have been lacking such information, and have had to rely solely on local knowledge and experience. This void in large scale management tools has necessitated the development of the quantitative model designed in this study. Many factors confound the solution to these concerns, such as highly variable winter conditions between regions, and from year to year within the same region. Additionally, the present scenario of relatively low deer densities probably does not reflect current habitat quality or arrangement.

Provincial population estimates reveal that during the early 1990's, Nova Scotia's deer herd was probably at its lowest level in the last 50 years (T. Nette, pers. comm.). It has been suggested that the reduction in deer numbers is the result of several factors working in concert; namely, reduction in habitat quality, loss of critical habitat, recent range expansion of the eastern coyote, and a series of harsh winters. Adequate identification of deer wintering areas using the common descriptive model confirmed by aerial census or site visits has been hindered by low deer numbers. The ever-present demand for conifer wood volume, public demands for sustainable resource management, in concert with sustained wood production; and ecologists', wildlife biologists' and resource management professionals' essential focus on the future, have necessitated the investigation of further methods to identify accurately both present and potential critical deer wintering habitat.

The Nova Scotia Deer Wintering Area Project (NSDWA Project), initiated in 1993, had the mandate to increase the knowledge base of white-tailed deer ecology in Nova Scotia in order to provide a better scientific basis for management. The approach was to compare white-tailed deer movements and survivorship relative to: eastern coyote (*Canis latrans*) predation, winter forest habitat, and forest harvest operations in two geographic regions of Nova Scotia. As one of three inter-related studies constituting the NSDWA Project, this study investigates deer habitat relationships. Specifically, this study attempts to identify known deer yards on the basis of vegetative, topographic, hydrologic, and spatial characteristics, and to distinguish them from seemingly suitable areas, as identified by the theoretical DWA model, which have little or no history of winter deer use.

STUDY AREAS

Two distinctly different regions of Nova Scotia, which are geographically separate, were selected for the study. These two areas represent the climatic extremes that Nova Scotia offers. Each of these regions represents one study area, of which the exact size has been determined according to the minimum area required to encompass the home ranges of all the radio-collared deer.

The first study region is located in central southwestern Nova Scotia (44° 20' N, 65° 15' W) in the Atlantic Interior Natural History Theme region (Simmons *et al.* 1984). Topographically, this area is characterized by flat undulating terrain, underlain by resistant quartzite and granite, and blanketed with quartzite, and granite till and erratics. Drainage is typically impeded and the landscape is dominated by lakes and ponds. Elevation ranges between 100 meters on the northern shores of Lake Rossignol to 175 meters north of Kejimkujik National Park.

The main influences on vegetation are the inland climate, mixed drainage, sandy acidic soil and extensive logging and natural disturbance. The whole area, including the national park, was opportunistically cut-over in the late 1800's and early 1900's. The area straddles Loucks' Red Spruce-Hemlock-Pine Zone and Sugar Maple-Hemlock-Pine Zone (Loucks 1960). The existing vegetation is characterized by Spruce, Fir, Hemlock, and heath cover types growing on the flat land between drumlins and eskers, with Hardwood and Pine cover types occupying the well drained knolls and ridges. Agricultural fields tend to be concentrated near the few main roads atop drumlins, and are therefore not scattered throughout the landscape.

The climate of this region is characterized by warm summers typified by 1700 annual degree days greater than 5°C and cool winters averaging -5°C January air temperature, with moderate snow fall (Dzikowski *et al.* 1984). The median duration of snow cover is 120-130 days, while the period during which the ground is actually snow covered is 59 days (Gates 1975).

The second study region is located in Inverness county on Cape Breton Island (45° 45' N, 61° 15' W). The area straddles two Natural History Theme regions, the Avalon uplands and Carboniferous lowlands (Simmons *et al.* 1984). River Denys Mountain and Skye Mountain represent the Avalon upland section of the study area, while the River Denys Basin represents the Carboniferous lowlands section.

Topography, geology and elevation vary greatly within this study area. The northern section of the study area is comprised of metamorphosed volcanic and sedimentary rock reaching a height of 260 meters, sloping sharply at its southern fringe. The mid and upper slopes are mainly undisturbed tolerant hardwood forest of Yellow Birch, Sugar Maple and Beech, while the upland surface is covered with naturally occurring and second growth coniferous stands. Repeated disturbance of the lowland forest has resulted in softwood and intolerant cover types predominating, regularly interspersed with agricultural fields and recent clear cuts. The lowland area slopes gently to the South with an average elevation of 100 m.

The climate in this region is generally more moist, but has approximately the same annual degree days greater than 5°C (1600 days) as the southwestern study area (Dzikowski *et al.* 1984). Average winter temperatures are also very similar, although there is a smaller minimum temperature range in the Cape Breton area as compared to the southwestern area, due to Cape Breton's proximity to the ocean. Large variations in snow fall and duration of snow cover within this study area make it impossible to characterize properly the area as a whole. The higher elevations, lower slopes and abutting lowland fringe in the northern section of the study area receive between 250 and 300 centimeters of snow fall annually, while the lowland areas receive between 200 and 250 centimeters of snow fall annually (Gates 1975). Similarly, median duration of snow cover varies from 140 days on higher elevations, with an average of 85% of this period having the ground snow covered, to 130 days on lower elevations, with an average of 65% of this period having the ground snow covered (Gates 1975).

DESCRIPTION OF THESIS LAYOUT

The thesis has been organized into three main sections, of which this is the first. The second chapter studies the forage aspects of the DWA, which identifies preferred food sources, and any bias demonstrated towards these foods within certain cover types. The third section presents the process involved in and the results obtained from three winter seasons of tracking radio-collared deer. The processing of data with the aid of a GIS, and ultimately the development of models to represent the preferred winter habitats at a landscape and local level, are then detailed. Finally, the thesis concludes with a discussion of the practical applications of these results in the field of integrated resource management.

CHAPTER II

INTRODUCTION

Carrying capacity, however defined, is a concept central to most wildlife management programs and investigations. The current carrying capacity paradigm is generally expressed in terms of a particular density of animals (Hobbs and Hanley 1990. Thomas and Taylor 1990, Caughley 1979). However, carrying capacity is a function of the composition and density of vegetation, abundance of preferred forage. and use versus availability of preferred forage. Few studies have documented the importance of these factors in influencing carrying capacity. Caughley (1979) points out that the concept of carrying capacity would be most appropriately defined as an equilibrium between animals and vegetation, indexed by "the densities of both plants and animals." Using Caughley's definition, several states and provinces, including Quebec, Ontario, and Maine (Voigt 1992, Lavigne 1990, Moen *et al.* 1986, Potvin and Hout 1983), have designed and/or made use of carrying capacity models in their deer management programs. These models involve the interaction of some, or all of the following key components: total biomass of forage (Voigt 1992, Hobbs and Hanley 1990); proportion of forage available in relation to environmental conditions. namely snow depth and air temperature (Williamson and Hirth 1985, Potvin and Hout 1983, Drolet 1976); energetic requirements and costs for white-tailed deer (Gray and Servello 1995, Schmitz 1990, Hanley and McKendrick 1985); and nutritive value of foods (Masters *et al.* 1993, Potvin and Hout 1983, Mautz *et al.* 1976). With the exception of total forage biomass, all of the above components are readily obtainable for northeastern white-tailed deer and their habitat.

This paper documents the total forage biomass, or potential available food, per hectare in two geographic regions of Nova Scotia. To avoid confusion in terms, "potential available food" is defined as the total amount of woody forage per hectare in an area that is within the physical reach and capability of a deer, expressed as dry weight in kilograms per hectare. It should be noted that this term does not account for any environmental restrictions such as snow depth or air temperature. The information presented here is not intended to be used directly as an index of potential white-tailed deer carrying capacity, but rather as one key component, necessary for any estimate of carrying capacity on a regional basis.

In forested areas, understory plant production is principally influenced by the type and age of the overstory, cover type, and age class. Additional factors influencing the growth of these understory plants are: soil nutrient levels, available light, and stand history. As this study primarily deals with deer winter habitat, only woody species have been included in the following analysis.

Thus, it is the objective of this chapter to document the potential available winter forage per hectare for the given study areas, and to suggest the applicability of these data to other regions of Nova Scotia.

METHODS

Field Methods

Total browsable stems per hectare were determined by tallying the number of browsed and unbrowsed twigs present in 20 m^2 (20 m x 1 m) sample plots. In order to qualify in the tally, each unbrowsed twig had to be greater than 2 cm in length. Points of browse, regardless of remaining length, were each counted as one twig. Also, only those twigs on the 20 m^2 plot in a space between 0.3 and 2.0 meters from the ground were tallied. Four of these plots were randomly located along every 1 kilometer of multipurpose sample line (Pellet group inventory lines, MacDonald (1996)). These lines, 20 per study area, were sampled once in fall and once in spring during both the 1994/95 and 1995/96 study seasons.

The diameter at the point of browse was measured for 100 randomly selected browsed stems of the most preferred woody species. In Queens, the preferred species included red maple (*Acer rubrum*), witch hazel (*Hamamelis virginiana*), wild raisin (*Viburnum cassinoides*), and red oak (*Quercus rubra*); whereas in Cape Breton, red maple, wild raisin, and aspen (*Populus tremuloides* and *Populus grandidentata*) were sampled. Measurements for each species were taken in three broad cover types (softwood, hardwood, mixed wood), and two broad development stages (regenerating and mature).

In order to determine the dry weight of browse per hectare for each species in each study area, the mean diameter of browse for each species was used to collect samples of respective diameters, which were subsequently dried and weighed.

Throughout the sampling process, a modified set of secateurs was used to ensure accurate and consistent measuring of mean diameter for each species. The blade modifications included the attaching of a template with slotted openings of widths representing the calculated mean browse diameter for each species. Using these secateurs, 100 samples were clipped at mean browse diameter of each preferred species, in each cover type, for both study areas, thereby simulating deer browsing. The samples were dried on cookie sheets in a conventional oven at 150 ^{0}F for 48 hours. Each stem was subsequently weighed on a balance, and grams of dry weight of browse per hectare for each species in each cover type were determined.

A similar process was followed to determine dry weight of current annual increment of each species. For each species, in each cover type, and in both study areas, 100 randomly selected stems were clipped at the proximal end of the current year's growth, identified by bud scale scars. The same drying process was used as that previously described, and mass of stems was determined. In an attempt to eliminate the drying process in future experimentation, the wet and dry mass of each species was found and used to calculate a wet mass to dry mass ratio.

Statistical Methods

The statistical analysis was completed with three main emphases for comparison, namely the total number of stems per hectare, the mean diameter of browse, and mean mass of browsed portion per stem, as well as current annual increment (CAI) per stem. In all cases, qualitative data analysis was followed with specific parametric or nonparametric analysis.

The total number of stems per hectare found in Queens were compared to Cape Breton using a Wilcoxon paired-sample test to determine whether or not there was a significant difference. Significant differences in the number of stems per hectare among species, and then among cover types were identified using the Kruskal-Wallis test. In those cases where the Kruskal-Wallis test identified a difference, a nonparametric Tukey-type multiple comparison (Zar 1984) was conducted in order to isolate specifically which cover types had produced the difference in total number of stems.

Quantitative analysis, using a two-sample t-test with unequal variances, was performed on both the mass of browsed twigs, as well as the mass of CAI, to compare means between Queens and Cape Breton. Where significant differences were found between means, further analysis was conducted, including an ANOVA test to determine if there were any differences in stem mass among cover types, and then among species. Subsequently, the differences were identified more specifically using a Tukey test.

Degrees of freedom, sums of squares, and any other intermediate steps in the analyses were calculated using standard statistical procedures. S-Plus Version 3.3 for Windows was used to assist in the statistical analysis where possible. Table values are associated with a 95% confidence interval as found in Zar (1984).

RESULTS

General

Two winter field-seasons allowed for 204 plots to be sampled in Queens, and 180 plots in Cape Breton (Appendix I and II). This resulted in 4321 stems tallied in Queens. and 8204 in Cape Breton. Diameter at the point of browse was measured for 1920 stems. Twenty-five hundred stems were clipped and weighed for mean mass of CAI, and 1760 stems were clipped and weighed to determine mean mass of browsed stems for both years combined.

Available Browse

Total available browse is represented by the number of stems per hectare located between 0.3 and 2.0 meters from the ground surface, regardless of snow depth, or deer density. To report accurately whether total available browse per hectare is best described on a per region, per cover type and/or per species basis, a variety of statistical analyses were performed. It was first necessary to determine whether or not the two areas, which represent different regions of the province could be considered together. The Queens study area had an average of 10655 ± 4522 stems per hectare, whereas the Cape Breton study area averaged 22788 ± 7929 stems per hectare (Table 2.1). There was a significant difference ($Z=6.997$; $p<0.05$; Wilcoxon paired-sample) in the number of stems per hectare between the two study areas (Appendix 3, Table 1); therefore, all subsequent tests that consider the number of stems per hectare, treat Queens and Cape Breton separately.

A Kruskal-Wallis test was performed to determine if there was a significant difference in number of stems among species. The data representing the total number of stems per hectare for each species are summarized in Table 2.1. There was no significant difference (H=9.604; p>0.05; df=5 and H=17.782; p>0.05; df=6; Kruskal-Wallis) in the total number of stems per hectare among species for each study area (Appendix 3, Table 2).

The numbers of stems per hectare for each cover type (Table 2.1) was significantly different among cover types within both the Queens and Cape Breton study areas (H=21.681; p<0.05; df=3 and H=14.795; p<0.05; df=3, respectively; Kruskal-Wallis) (Appendix 3, Table 3). These differences were more specifically identified using a nonparametric Tukey-type multiple comparison.

Table 2.1 Summary table of total number of browsable stems per hectare (standard error in brackets), by species and by cover type.

Study Area	Total stems/ha	Stems/ha by species: Red maple	Aspen	Witch hazel	Red oak	Wild raisin	Yellow birch	Hobblebush	Beech	Stems/ha by Cover Type: Cutover (1)	Mixedwood (3)	Hardwood (2)	Softwood (4)
QUEENS Mean (SE)	10590.69 (2290.90)	3603.96 (937.99)	0 (0)	3725.25 (1189.18)	821.78 (416.21)	1779.70 (1060.00)	91.58 (54.49)	0 (0)	633.66 (277.29)	61437.5 (39737.80)	6296.61 (1425.00)	16500.00 (6164.13)	8303.42 (2294.30)
Sample size (n)	202	202	202	202	202	202	202	202	202	8	59	31	117
CAPE BRETON Mean (SE)	22788.89 (4057.16)	15755.56 (1529.00)	1144.44 (301.77)	211.11 (167.00)	0	2030.56 (636.75)	3055.56 (1209.66)	47.22 (47.22)	344.44 (218.72)	45264.71 (17649.21)	31472.00 (8539.00)	16610.67 (5456.24)	8941.67 (1639.85)
Sample size (n)	180	180	180	180	180	180	180	180	180	17	73	30	60

Table 2.2 *Summary table of mean mass per stem in grams of browsed stem portions (standard error in brackets), by species and by cover type.*

Study Area	Total Mean Mass (g) Per browsed twig	Mean Mass (g) / browsed stem by Species: Red maple	Aspen	Witch hazel	Red oak	Mean Mass (g) / browsed stem by Cover Type: Cutter (1)	Mixedwood (3)	Hardwood (2)	Softwood (4)
QUEENS Mean (SE)	0.052 (0.0012)	0.051 (0.0016)	-	0.030 (0.0009)	0.093 (0.0021)	0.064 (0.003)	0.043 (0.002)	0.053 (0.002)	0.049 (0.002)
Sample size (n)	1198	599	-	599	400	301	300	297	300
CAPE BRETON Mean (SE)	0.1906 (0.013)	0.426 (0.02)	0.11 (0.008)	-	0	0.14 (0.005)	0.29 (0.017)	-	0.14 (0.005)
Sample size (n)	565	140	225		180	202	242	-	121

The results from the Tukey tests differed somewhat between the Queens and Cape Breton study areas (Appendix 3, Tables 4 and 5, respectively). In the Queens study area there were significant differences between the regenerating cover type and all other mature cover types (hardwood, mixedwood, and softwood), while there were no differences identified among the mature cover types themselves. This is represented by the underlined mean values in Table 2.1. The same multiple comparison was performed on data from the Cape Breton study area, comparing all mature cover types to the regenerating cover type. The only significant difference identified was between the regenerating cover type and the softwood cover type. As well, comparisons among the three mature cover types identified a significant difference in number of stems per hectare between mixedwood and softwood.

Browsed Biomass

Browsed biomass is represented by the mean mass of the browsed portion of an available stem. The mean mass of browse for each of the areas, for all species and for all cover types is shown in Table 2.2. There was a significant difference in the mean mass of browsed stems ($t=26.755$; $p<0.05$; $df=574$; two-sample t-test with unequal variances) between the two study areas (Appendix 3, Table 6); therefore, all subsequent tests that consider the mean mass of browsed stems treat Queens and Cape Breton separately. There was no significant difference in mean mass of browsed stems among cover types for either Cape Breton or Queens ($F=1.645$; $p>0.05$; $df=563$ and $F=0.599$; $p>0.05$; $df=1196$, respectively; ANOVA) (Appendix 3, Table 7 and 8, respectively). There were significant differences in mean mass of browsed stems among species for both study areas ($F=12.114$; $p<0.05$; $df=563$ and $F=506.328$; $p<0.05$; $df=1196$, Cape Breton and Queens respectively; ANOVA) (Appendix 3, Tables 9 and 10).

The mean mass of red maple and aspen browse differed significantly within the Cape Breton study area. However, in Queens the mean mass of browsed red oak stems was significantly different from the mean mass of both red maple and witch hazel, while the mean mass of browse was the same for both red maple and witch hazel (Appendix 3, Table 11).

Current Annual Increment Biomass

The mean mass of CAI for each of the areas, for all species, and for all cover types is shown in Table 2.3. There was no significant difference in the mean mass of the CAI between Queens and Cape Breton study areas ($t=0.564$; $p>0.05$; $df=362$; two-sample t-test) (Appendix 3, Table 12). Since no difference was found between mean mass of annual biomass, testing Queens versus Cape Breton, all subsequent tests were performed on pooled Queens and Cape Breton data. Mean mass of CAI differed among cover types, as well as among species, ($F=21.531$; $p>0.05$; $df=365$ and $F=9.715$; $p>0.05$; $df=365$, cover type and species respectively; ANOVA) Table 13 and 14, respectively in Appendix 3.

A significant difference in mean mass of CAI was evident between the regenerating cover type and all other mature cover types (hardwood, mixedwood and softwood) (Appendix 3, Table 15). No significant difference among the mature cover types themselves was observed (Table 2.3).

Table 2.3 Summary table of mean mass per stem in grams of current annual increment, CAI, (standard error in brackets), by species and by cover type.

	Total Mean Mass (g)	Mean Mass(g) / Current Annual Increment (CAI) by Species					Mean Mass (g) / CAI by Cover Type			
Study Area	Per CAI	Red maple	Wild Raisin	Witch hazel	Aspen	Red oak	Cutover (1)	Mixedwood (3)	Hardwood (2)	Softwood (4)
QUEENS Mean (SE)	0.48 (0.03)	0.31 (0.038)	0.23 (0.028)	0.32 (0.023)		1.27 (0.257)	1.17 (0.224)	0.19 (0.014)	0.41 (0.054)	0.23 (0.018)
Sample size (n)	1128	318	202	211	-	397	199	402	419	309
CAPE BRETON Mean (SE)	0.51 (0.03)	0.6 (0.045)	0.24 (0.028)	-	0.69 (0.032)	-	0.44 (0.044)	0.55 (0.049)		0.54 (0.069)
Sample size (n)	804	320	168	-	316	-	244	321	-	239

Table 2.4 Summary table of statistically significant mean values for number of stems per hectare and mass per stem of browsed twig and current annual increment in grams (standard error in brackets), accounting for cover type and species effects.

		Stems/ha by cover type				Total Mean Mass (g)	Mean Mass (g) / CAI by Cover Type		Mean Mass(g) / Current Annual Increment (CAI) by Species				
Study Area	Total stems/ha	Cutover (1)	Mixedwood (3)	Hardwood (2)	Softwood (4)	Per browsed twig	Cutover	MW, HW and SW Combined	Red maple	Wild Raisin	Witch hazel	Aspen	Red oak
QUEENS Mean (SE)	10590.69 (2290.90)	61437.50 (19757.80)		8515.31 (1675.49)*		0.052 (0.0012)	1.17 (0.22) **	0.37 (0.02) **	0.31 (0.038)	0.23 (0.028)	0.32 (0.023)	-	1.27 (0.257)
Sample size (n)	202	8		196*		1198	441 **	1590 **	318	202	211		397
CAPE BRETON Mean (SE)	22788.89 (4057.16)	45264.71 (17649.31)	11472.00 (6559.00)	16616.67 (5456.24)	8941.67 (1659.85)	0.1506 (0.013)	1.17 (0.22) **	0.37 (0.02) **	0.6 (0.045)	0.24 (0.028)	-	0.69 (0.032)	
Sample size (n)	180	17	71	30	60	565	441 **	1590 **	320	168	-	316	

* Mixedwood, Hardwood, and Softwood combined (mature)

** Cape Breton and Queens Combined

The results from a Tukey test for identification of specific differences in mean mass of CAI among species (Appendix 3, Table 16) showed a significant difference between mean mass of red oak CAI and all other species' (red maple, wild raisin, witch hazel and aspen) mean mass of CAI. Also evident in these Tukey test results, was the significant difference between aspen and wild raisin.

Per Hectare Summaries

The preceding results lend guidance for the summary outlined in Table 2.4. The mean number of available stems per hectare for Queens is 10591 ± 2291 and for Cape Breton is 22789 ± 4057 (Table 2.4). The mean number of stems for mature and regenerating cover types in Queens is 8515 ± 1675 and 61438 ± 39758, respectively (Table 2.4). In Cape Breton, the mean number of stems for the four different cover types is as follows: 45265 ± 17649 (regenerating cover), 31473 ± 8539 (mixedwood), 16617 ± 5456 (hardwood), and 8942 ± 1660 (softwood) (Table 2.4).

The mean mass of CAI for all mature cover type data combined is 0.37 ± 0.02 grams, and 1.17 ± 0.22 grams for regenerating cover types, both study areas combined regardless of species (Table 2.4). Regardless of cover type, mean mass of CAI for the individual species in each study area is: A) Queens: red maple 0.31 ± 0.04 grams, wild raisin 0.23 ± 0.03 grams, and red oak 1.27 ± 0.26 grams, and B) Cape Breton: red maple 0.6 ± 0.04 grams, wild raisin 0.24 ± 0.03 and aspen 0.69 ± 0.03 (Table 2.4). Biomass of the average browsed portion of a stem, all cover types combined, is greater in Cape Breton (0.39 ± 0.01 grams) than in Queens (0.05 ± 0.001 grams).

Given the summaries described above, one can confidently (α=0.05) calculate "Available Browse Biomass" in kilograms per hectare for a variety of different stand situations given the general equation (2.1):

Available Biomass(kg/ha) = Number of stems / hectare * Mean mass of current annual increment (kg)/stem

"Browsed Biomass" can be calculated using Equation (2.2):

Browsed Biomass (kg/ha) = Number of stems / hectare * Mean mass of browse (kg)/ stem

Depending on which aspect of biomass is of interest, equations one and two can be used to calculate the respective biomass in kilograms per hectare for a variety of stand conditions.

DISCUSSION

Available Browse

The forest in Queens is classified under the "Atlantic Uplands" forest region, which is distinctly different from the forest of the River Denys area - a part of the "Cape Breton-Antigonish" forest region (Rowe 1972). Since these forest types differ by climatic regions, forest associations, forest history, geology and soils (Loucks 1962, Simmons *et al.* 1984), it is not surprising that the number of available stems per hectare differ between these two areas. The total stems per hectare (Table 2.1) for both Queens and Cape Breton strongly agree with the number of stems reported by Drolet (1976) for seven sites in the central region of Nova Scotia.

Sampling design is most likely the cause of the failure to detect a significant difference in number of stems among species within each area, since only those species which were observed to be the most preferred (MacDonald 1996) during the first year's survey were tallied in all subsequent tallies. This design essentially removes those species that occurred at low frequency, thereby favoring the more plentiful, ubiquitous species such as red maple, wild raisin, and aspen. Furthermore, pooling of data regardless of crown closure or cover type could also have masked potential differences among species within a forest stand, which would likely result from association of certain understory species with the overstory species (eg. aspen root suckers with mature aspen).

As expected, differences were evident among cover types when all species were pooled in both study areas. Relationships between overstory cover type, crown closure and understory vegetation are well known. Species occurrence, abundance, and diversity have all been described in numerous forest silvicultural papers and texts (Odum 1989; Smith 1986; Kimmins 1987). Removal of the overstory (cutover stand types) results in increased sunlight reaching the forest floor, as well as a surge of available nutrients. This allows for prolific growth of intolerant deciduous stems, thus explaining the significant differences in number of stems per hectare between cutover stand types and all other cover types.

The differences in number of stems per hectare among cover types in Cape Breton were only evident when the regenerating cover type was compared with the softwood cover type, and when the softwood cover type was compared with the mixedwood cover type. A comparison among the regenerating, mixedwood and hardwood cover types in Cape Breton indicated that there was no difference in number of stems per hectare. These observations could be a result of Cape Breton's forest history, specifically the 1980's spruce budworm (*Choristoneura fumiferana*) infestation which reduced the typical fir-dominated mixedwoods to intolerant hardwood-dominated mixedwoods with minor components of black spruce (*Picea mariana*) and balsam fir (*Abies balsamea*) (Bridgland 1996). Since essentially no homogeneous fir stands remain, only homogeneous white spruce (*Picea glauca*) stands growing on old field sites represent the existing pure softwood stands.

The remaining degraded mixedwood stands, as mentioned above, are of an uneven age structure, and have an open crown closure. Such a stand structure provides ample growing space and resources for the understory species, thereby creating a similar situation to the cutover areas. The same phenomenon has also resulted in most hardwood-dominated mixedwood sites being reduced to the current hardwood sites, with little softwood present. Since the hardwood stand's original softwood content was lower than that of the mixedwood stand, the effect on the hardwood crown closure was not as severe as in the mixedwood stand. Even though the resulting crown closure was not as open as that of the mixedwood stand, understory growth still reflected that of the regenerating and mixedwood stands.

The difference in number of stems per hectare was evident between cutover and softwood stands in Cape Breton because white spruce stands growing on old field sites typically have a very poorly developed understory component (Smith 1986). A difference between number of stems in softwood and mixedwood cover types could also result from the large difference between crown closures as explained above. Following this same reasoning, it is understandable that there was a difference between softwood and mixedwood and not softwood and hardwood, since the crown closures would be more similar in these two cover types.

The more traditional mixedwood, hardwood and softwood stands, all with closed tolerant overstories, are the dominating mature cover types in the Queens study area. This explains why the only significant difference observed among cover types was in number of available stems per hectare between all mature cover types and the regenerating cover type.

Browsed Biomass

The mean mass of browsed stems differed significantly between Queens and Cape Breton. Given the difference in over-wintering deer density between Cape Breton (4-6 deer/km^2) and Queens (1-2 deer/km^2) (MacDonald 1996), the result is to be expected. The observed difference would likely be further compounded by the greater average snow depth and longer duration of snow cover typical of Cape Breton (Gates 1975). These environmental factors would reduce forage accessibility vertically, as well as horizontally. The reduced horizontal accessibility translates into increased browsing pressure on those stems close to main travel trails, as is evident in Cape Breton. In addition, the significant difference in the mean mass of browsed stems identified among species within both study areas indicates a typical preference and or avoidance of particular browse species, as alluded to by MacDonald (1996) and documented by numerous other authors (Gray and Servello 1995; Masters *et al.* 1993; Robinson and Bolen 1989; Shafer 1963).

Current Annual Increment Biomass

No significant difference was identified in the mean mass of CAI per stem between Queens and Cape Breton, comparing data of all species and cover types combined for each study area. This effect is a direct result of the sampling design, which insured that all woody species must be of a similar stature (height between 0.3 m and 2.0 m), and possess like morphological characteristics.

Differences in mean mass of current annual increment per stem were evident among cover types, specifically between all mature cover types pooled and the regenerating cover type. This finding can be explained by the life history of the deciduous shrubs and most importantly, the trees which are the preferred forage species tallied in this investigation. All the cover types classed as regenerating were the product of various overstory harvests, the most common of these being clear cut. Red maple, aspen, and red oak all use "suckering" as a regenerating strategy, which gives these species the ability to produce stump-sprouts and stool-shoots (Smith 1986). Furthermore, aspen also produces root suckers (Wilson 1984), a regeneration strategy that produces a more prolific, thicker stem in less time than one produced on a seed regenerated plant of the same species.

In all cover types, the red oak stems in the 0.3 m to 2.0 m strata were predominantly stump sprouts from adventitious buds near the root collar of overmature red oak trees. It is likely that this is the reason for the difference in mean mass of CAI between red oak and all other species. Two facts explain the difference in mean mass of CAI between wild raisin and trembling aspen. Firstly, almost all aspen stems in the tallied strata were from root shoots, while the raisin stems were from seed. Secondly, these two species differ morphologically and silvically (Wilson 1984; Harlow *et al.* 1979). Aspen typically aspires to reach the classification of a tree, while wild raisin will only ever become an understory shrub; therefore, allocation of nutrients and resources within each plant is inherently different.

MANAGEMENT IMPLICATIONS

Although the expression of over-wintering carrying capacity would benefit greatly if some measure of vegetation were incorporated into its definition, it should never be the sole index, but rather only one of the key ones. As one of these key indices, vegetation should be differentiated regionally, as well as locally. The number of total available stems per hectare should be reported specifically to region. The mass of CAI should be calculated by species, or more realistically species group, and reported specifically by development class (mature cover types versus regenerating cover types).

Mean mass of CAI and total number of stems per hectare have been presented in such a way that they can be incorporated into a variety of carrying capacity models for use at a variety of scales. One can use previously published data to calculate either the net or gross energy and protein content per gram of woody species determined by this study's results (Schmitz 1990; Hanley and McKendrick 1985; Potvin and Huot 1983; Mautz *et al.* 1976). Once the available biomass is converted into energy (kcal) it can also be reported per hectare using the density of stems per hectare, per region or cover type. As well, using published energetic requirements per deer per day (Schmitz 1990; Potvin and Huot 1983; Mautz *et al.* 1976), the number of deer that an area of known species composition and stand structure is capable of supporting can be predicted.

Data and observations collected during this study also point out the potential pitfalls of indiscriminate use of such a basic model as described above. Greater deer density increases utilization per stem, as well as the intensity of browsing in a given area. This increase in utilization per stem was not uniform but differed according to species. Available browse biomass as calculated using these findings must be regarded as the maximum for general use during winters of average or less than average snow accumulation and deer density. Biomass, and subsequently gross energy estimates, must be reduced in relation to deer density and prolonged snow depths greater than 30 cm. The above follows the reasoning that available browse biomass, as calculated here, is not necessarily accessible because the energetic cost of acquiring the browse may be higher than its nutritive value during severe winters and or during times of elevated deer density.

Potvin and Huot (1983) attempted to quantify the impact snow depth has on available browse by modeling the distance deer would browse away from trails, given different snow depths and subsequently energy expenditure. A similar approach was attempted during this study but the lack of snow made it impossible. In years or areas of little snow accumulation the measures of available browse given here may be used confidently.

Additional pitfalls not directly addressed in this study include the potential overestimation of available biomass for clearcut stands, as the reduction of browsed biomass in relation to distance from forest edge was not captured by my sampling design. Some indication of the magnitude of this overestimation can be found in papers by Williamson and Hirth (1985) and Drolet (1976).

CHAPTER III

INTRODUCTION

Effective management of wildlife populations is largely dependent upon a good understanding of animal habitat selection, and the capability to predict accurately its habitat needs (Clark *et al.* 1993). The observation of the animal in its natural habitat as a means of identifying areas of use, followed by the initiation of a detailed survey of biological habitat components constitute the first steps involved in the management of the animal's habitat needs. The second part of this process studies the relationships of the above data and their associated physical attributes, both spatially and non-spatially. This type of analysis has been greatly enhanced by the advancement of technology and the development of geographic information systems (GIS), thereby making habitat assessment and habitat modeling increasingly more accurate and encompassing (Chang *et al.* 1992). This study was designed to identify specifically the habitat features that constitute winter habitat for the white-tailed deer (*Odocoileus virginianus*) using such comprehensive methods.

Nova Scotia is close to the northern limit of the white-tailed deer, where climatic conditions play a large role in the behaviour and habitat selection (Parker *et al.* 1993; Tierson *et al.* 1985). During winter, harsh weather conditions as well as a poor-quality, or unavailable food base, cause deer to experience a negative energy balance (Morgan *et al.* 1993; Drolet 1978). Good winter range reduces the rate of energy loss by providing shallow snow, adequate food, good security cover, and a favorable thermal environment (Armleder *et al.* 1994; Parker *et al.* 1984; Telfer 1978).

Areas that provide good winter range, and where deer traditionally concentrate during winter, are called deer yards or deer wintering areas (DWA). Deer yards are typically mature softwood stands consisting of spruce (*Picea* sp.), balsam fir (*Abies balsamea*) and eastern hemlock (*Tsuga canadensis*). The softwoods effectively create a protective environment with reduced snow depth and wind velocity, which consequently increases the local air temperatures and relative humidity, while moderating the daily temperature fluctuations (Morgan *et al.* 1993; Weber *et al.* 1983). Such advantages in the microclimate reduce the severity of the winter conditions making these areas critical for the survival of deer in northern ranges (Weber *et al.* 1983). Thus, it is of utmost importance that the approach used to develop an accurate model representing critical deer winter habitat acknowledge that these softwood areas are critical in the life history of the deer, and that the deer's habitat selection varies seasonally. Specifically, it is essential that features typifying winter habitat areas be studied independent of the summer habitat features. As such, only the winter deer habitat relations were analyzed in this study.

Wildlife habitat models attempt to simulate the environment of a species in order to "explain the spatial and temporal variations in terms of biotic and abiotic components" (Morgan *et al.* 1993). Many habitat evaluation models currently in use, base their evaluation on animal densities, and therefore assume that densities are directly correlated to habitat quality. Several researchers argue whether or not this is in fact the case, suggesting that density can be a misleading indicator of quality habitat (Morgan *et al.* 1993; Hobbs *et al.* 1990; Van Horne 1983). A more suitable approach is to assess habitat quality based on individual absence and presence.

Reasons for density being a poor indicator of habitat quality are well documented in the literature. Van Horne (1983) suggests that many studies are completed in the warmer months when a substantial number of animals may be distributed differently than they are during winter. This is especially significant for the white-tailed deer in many areas of Nova Scotia, where they often exhibit seasonal movements to more favourable winter habitat. Thus, the summer distribution of deer would not be representative of good winter habitat. Furthermore, there may be variations in density from year to year, within the same season, reflecting the changes in food sources, predator populations, and/or abiotic environmental factors; therefore making the densities more representative of recent conditions rather than long-term habitat quality (Hobbs *et al.* 1993; Van Horne 1983). Also, social interactions evident within a population could impact animal density (Van Horne 1983).

Continual advances in technology have made it increasingly easy for foresters, wildlife biologists, and resource managers to incorporate an essentially unlimited number of factors representative of the animal's environment into the creation of habitat models. More specifically, GIS have enabled researchers to incorporate measures such as juxtaposition, "a measure of the adjacency of the habitat requirements to the site being analyzed for a particular species", as well as interspersion which measures "the intermixing of units of different cover types" (Armleder *et al.* 1994; Chang *et al.* 1993; Morgan *et al.* 1993; Stenback *et al.* 1989). Such capabilities allow the consideration of proximity to food, cover, water, and roads in the development of a deer habitat model (Stenback *et al.* 1989). With the use of a GIS it is possible to experiment with various data queries and overlays. Furthermore, the GIS provides numerous quantitative measures for spatial features such as area, perimeter, edge length, and edge/area ratio of the polygons (Chang *et al.* 1993).

The spatial capabilities of GIS have been further enhanced using statistical methods. Due to the analytical capabilities of GIS, complex multivariate calculations are now possible at landscape and local scales (Clark *et al.* 1993). Logistic regression is a statistical method that has been used in many studies as a part of this multivariate approach to habitat modeling (Mladenhoff *et al.* 1995). Logistic regression uses a linear combination of independent variables to explain the associated variance of the dependent variable (West *et al.* 1994; Osborne *et al.* 1992). The dependent variable has only two states, which in this study are the presence or absence of deer, represented by a 1 and 0, respectively.

There are several advantages to using logistic regression: it allows the inclusion of categorical data (Thomasma *et al.* 1991), as well it requires fewer assumptions than linear regression, including no assumption of multivariate normality (Thomasma *et al.* 1991). The latter is of particular importance to this study. Finally, logistic regression relates the species occurrence to the habitat components in a logistic rather than a linear manner, therefore providing better biological representation (Osborne *et al.* 1992).

The results generated by logistic regression are in the form of coefficients for each of the independent variables included in the model statement. The coefficients are incorporated into a mathematical model that can then be applied to the GIS (Narumalani *et al.* 1994). Once the model is validated, probability of presence of deer can be estimated by the model and identified by the GIS to produce a data layer representing a weighted composite probability map for habitat evaluation (West *et al.* 1994).

Thus, it is the purpose of this thesis to create an accurate and comprehensive model representing winter habitat for white-tailed deer in Nova Scotia. Using locations of radio-collared deer collected during three winter seasons, and overlaying these on a detailed set of habitat data layers, it is possible to perform step-wise logistic regression to generate DWA models at both a landscape and local scale for two geographic regions of Nova Scotia. Arc/Info's GRID extension is used as the GIS interface to apply the models to the study areas and subsequently identify areas of varying probabilities of deer presence. Finally, it is hoped that, upon verification, the results of this study may be incorporated into management planning as a method of predicting suitable deer winter habitat, so that a system can be developed that meets the province's silvicultural demands while maintaining critical deer winter habitat.

METHODS

Capture Methods

Several methods were used to capture deer for radio-collaring including: Stevenson box trap, CAP-CHUR dart rifle and pistol, rocket net, and helicopter net gun. Subsequent to capture, deer were temporarily immobilized in order to apply the collar and collect descriptive data.

The Stevenson box traps were constructed according to the guidelines detailed by the Bureau of Game, New York State Conservation Department and SUNY College of Forestry (Project number W-105-R-8, 1969), with a few modifications. Modifications consisted of a reduction in trap length, and the inclusion of a wire screen at one end of the trap. The screen provided deer with an unobstructed view through the trap, while limiting their entrance to one end, and thereby preventing escape after triggering the trap. Traps were situated in areas of frequent deer sightings in order to increase the likelihood of capture. To encourage deer to enter the traps, apples, vegetables, and grain were used as bait and trailed from the entry to the screened end of the trap. Upon full entry, the deer touched the trip wire thereby causing the doors to fall at either end of the box (MacDonald 1996). The traps were checked daily, early in the morning and evening, and rebaited where necessary.

Capturing deer using the dart gun method relied on the actual sighting of deer while equipped with the dart rifle or pistol, and associated equipment; therefore, this technique usually required stalking of deer, or waiting in a tree stand. Dart and rifle configuration were adjusted accordingly for each use to accommodate animal size and distance of shot.

Rocket nets proved to be effective in capturing deer in winters with little snow cover, when deer were grazing fields. Bait was laid out close to the nets to encourage aggregation of deer within capturing distance of the net. Nets of two sizes were used, which required use of two and three rockets accordingly. A Hughes 500 helicopter was used in open areas also, to locate and follow deer which were subsequently shot with a net gun.

When capture required deer to be immobilized, all standard humane procedures were followed. The deer were fitted with a mortality sensitive 0.4 kg radio-collar, and released in a familiar environment.

Deer Locational Data

The radio-collared deer were monitored using portable TR2 Telonics receivers that were attached to a vehicle or helicopter mounted, or hand-held antenna. The locations were taken using a random design by dividing the day into six four-hour periods and taking the locations during a new time period each day. The time periods were as follows: 1) 1:00 hrs - 5:00 hrs 2) 5:00 hrs - 9:00 hrs 3) 9:00 hrs - 13:00 hrs 4) 13:00 hrs - 17:00 hrs 5) 17:00 hrs - 21:00 and 6) 21:00 hrs - 1:00 hrs. Aside from rotating through the time periods, it was also important that the order of locating deer was varied to ensure that the locations were representative of the deer's daily 24 hour routine throughout all levels of activity.

Each location consisted of two or more bearings taken from the same number of known stations which were all identified by their UTM coordinate values. All the telemetry data collected in the field were amalgamated into a computer database (Microsoft Access). The data were sorted by animal and by study area, and a filter was applied to isolate all data that were taken between January 1 and March 31, 1994, November 1, 1994 and March 31, 1995, and November 1, 1995 and March 31, 1996, thus representing the winter months. These data were transferred into the software program. LOCATE II (Nams 1990), to perform triangulations resulting in an output of UTM coordinates corresponding to the deer location in the centre of a 95 % error polygon. The program used a maximum likelihood estimator which weights all bearings equally. and allowed for specification of an error angle. A $\pm 4^{0}$ error angle was associated with each bearing, which was determined by placing collars at known locations and comparing those to experimental locations (H. Broders, pers. comm.).

Only those locations with error polygons of 3 hectares or less were saved for further analysis - this area represented one-half the mean stand size of 6 hectares. The filtering resulted in 998 locations for Queens using 18 deer, and 617 locations for Cape Breton using 33 deer. Furthermore, only locations that had a minimum of two hours between successive locations, for any one animal, were used. It was this final set of locations that was ultimately used for analysis.

True random sampling using radio locations is seldom achieved (Alldredge and Ratti 1992). During the collection and processing of all locations, attempts were made to ensure that all locations were as independent as possible. Conscious efforts were made to reduce the number of serially correlated locations. Nonetheless, all locations regardless of individual were pooled to give overall sample size. This pooling may have artificially inflated the degrees of freedom, thereby causing the statistical tests to be over-sensitive (Aebischer *et al.* 1993).

Vegetative Sampling

Telemetry locations, browse data and snow tracking data collected during the winters of 1993-94 and 1994-95 were used to construct a map of over-wintering "deer concentration sites" (DC). Seemingly suitable stands of comparable cover type, height and age, which exhibited little or no use by deer in the two winters, were also selected from within the study areas and mapped to represent "no deer concentration sites" (NDC). One DC site and one NDC site, each approximately 100 hectares, were selected from each study area for intensive vegetative sampling, completed during the summer of 1995. The data sheets used to record the field data are shown in Appendix IV.

The overstory was inventoried using random horizontal point sampling technique (Husch *et al.* 1992). The overstory characteristics measured included: 1) total number of stems, 2) total number of softwood stems, 3) number of species represented by tally, 4) median DBH by species (accounting for 19 variables), 5) range in DBH by species (accounting for 19 variables), 6) number of trees per species (accounting for 19 variables), 7) number of trees containing lichen, 8) nearest conifer range, 9) mean value of nearest conifer distances, 10) stand age, 11) stand height, 12) height by species (accounting for 7 variables), and 13) crown closure.

The understory sampling used a 20 m^2 plot centered on the overstory point. A total of 20 measurements were taken and were referred to as stand level habitat variables. These measurements included: 1) presence of deer pellets, 2) presence of deer browse, 3) presence of deer trail, 4) presence of hare pellets, 5) presence of hare browse, 6) presence of hare trail, 7) presence of squirrel sign, 8) soil type, 9) soil depth, 10) total number of species of moss, 11) cover class of most abundant moss species, 12) distribution of moss, 13) total number of shrub species in three levels of understory (> 1.3 m, 0.5 - 1.3 m and <0.5 m, therefore accounting for 3 variables), 14) cover class of most abundant shrub species in three levels of understory (> 1.3 m, 0.5 - 1.3 m and <0.5 m, therefore accounting for 3 variables), 15) distribution of all shrub species in three levels of understory (> 1.3 m, 0.5 - 1.3 m and <0.5 m, therefore accounting for 3 variables), and 16) browse of four shrub species in three levels of understory (accounting for 12 variables).

<u>Geographic Information Systems Coverages and Preparation</u>

The use of the Arc/Info Geographic Information System (GIS) allowed for the located deer, generated in LOCATE II, to be analyzed in order to create models representing their use patterns relative to road and river line layers, forest polygon layers, and digital elevation models. The data layer compilation required that all the data be transformed from a number of different sources, of varying scales, accuracy, years, and datum, into a standard format. Following this process, the data were queried in order to generate the statistical information necessary for further analysis. The completion of these tasks required considerable understanding and familiarity with the conceptual basis and operation of Arc/Info Version 7. Participation in the creation of the customized graphic user interface, DEERWIN, as developed by Brodzik (1995), provided great exposure and assisted in learning the program.

Deer locations from all sources were transposed to MTM coordinates, and then overlayed on the various data layers that were developed. The following spatial measurements were then performed on each of the location points to generate the statistical information necessary for further analysis: 1) distance from location to nearest cut block, 2) distance from location to nearest edge, 3) distance from location to the nearest stream, 4) distance from location to nearest road, and 5) distance from location to nearest field. A detailed flowchart representing the steps necessary to perform this task, as well as all other steps involved, is shown in Appendix V.

Analytical Methods

Knowledge of deer winter habitat preferences and the Nova Scotia forest inventory system helped to reduce many irrelevant habitat variables that could potentially be used in model development. The remaining potentially relevant variables were further reduced using Kendall's-tau test, which identified any correlation between each of the independent variables. Those variables that had an absolute Kendall-tau value greater than 0.33 were identified as showing high correlation and therefore were removed from subsequent testing.

The list of independent variables was analyzed univariately using t-tests and Mann-Whitney tests. T-tests were used to identify differences in the means of the parametric independent variables between the DC and NDC areas for each study area.

Furthermore, the nonparametric Mann-Whitney test was performed to compare rank differences of the independent variables between the DC and NDC areas for both study areas. In the case of the last two tests, any difference that was not significant would indicate that those particular variables would not differ between the DC and NDC areas, and therefore would not be responsible for any preferences shown by the deer. Despite the outcomes of the t-test and Mann-Whitney test, all variables were included in the initial logistic regression analysis to identify any interactions between or among variables that may not have been detected in the univariate testing. The results of the t-test and Mann-Whitney test did, however, provide comprehensible indications of deer habitat preferences/requirements. In addition, these data aided in the decision of variable inclusion when aiming for the most biologically sound model.

Modeling

A combined GIS and statistical approach was used to model winter habitat suitability for white-tailed deer in both study areas. The specific tasks were to: 1) develop a statistical model that correlates deer presence determined by radio telemetry to habitat variables at that location and 2) apply the model to evaluate the suitability of winter deer habitat of the entire study area using GIS.

Two groups of data were analyzed in the modeling procedure: 1) deer locations as the dependent variable and 2) the habitat components as explanatory, independent variables. Deer locations determined by telemetry were treated as the "presence" data set of dependent variables, while the "absence" data set was generated from random locations in areas known to be void of deer during the winter months. The habitat variables were extracted using various GIS procedures.

Logistic regression was considered the appropriate method to model the relationship between the two groups of variables due to the dichotomous nature of the dependent variable. Additionally, logistic regression was chosen over linear regression since it made fewer assumptions and allowed for categorical data, which was relevant for several variables, including cover classes, distributions, and tree species.

The independent variables and their corresponding data were transposed from the GIS into a usable format for S-Plus Version 3.3. This statistical software was used as a tool to aid in the inclusion and/or removal of variables in a series of models. Decisions on whether or not to include a given variable were based on the magnitude and statistical significance (P[r] Chi-Squared) of the change in the explained variance, R^2 (Residual deviance divided by Null deviance). The model only used data that were significant at $P[r] \leq 0.01$ (Menard 1995). All possible combinations of single variables, as well as many variable transformations and multi-variable interactions were considered in order to develop the most statistically sound model. The resulting models were then tested to insure that most general model assumptions were reasonably satisfied (Jonsen and Kehler 1996). This was done graphically using the following "Model Diagnostics" techniques: Cook's distance and leverage plots. Models with variables accounting for leverage values greater than 0.8 and/or Cook's distance values greater than 0.6 were eliminated.

Once all models were developed at the landscape and local levels for each study area, the associated equations were used to identify probabilities of deer presence in all parts of each study area. A coefficient corresponding to each of the variables used in the logistic regression served as a weight in the mathematical calculation performed within individual cells in the Arc/Info database. The outcome of these calculations was a map representing the probability of the presence of deer, first at a landscape scale and then at a local scale.

Model accuracy was assessed by comparing the predicted probability of deer presence as generated by each given model to actual deer telemetry locations not used in the model. Model precision was tested by removing a subset of locations from the model building exercise, and then assessing the proportion of those locations that were predicted correctly by the model constructed without these data. Overall model performance was compared among regression models by determining the percent difference in total area predicting deer presence and the proportion of total telemetry locations correctly predicted within that area.

Delineation of Study Area

The boundaries of each study area were identified based on the critical assumption that the study animals each had access to all habitat types within each study area. Using the telemetry data collected from February 1994 - March 1995, composite home ranges were defined accordingly, to represent each study area. Within each study area, an area of deer winter use (DC) was delineated using winter telemetry locations. Comparable areas of little or no deer use (NDC), within the study area boundaries, were delineated based on similar general area as that of the DC area, and the absence of deer, determined by aerial surveys, ground observations, and lack of telemetry locations.

RESULTS

Variable Autocorrelation

The use of the non-parametric Kendall-tau test for correlation resulted in the elimination of 10 local scale variables from vegetation sampling. Specifically, these variables were: total softwood stems, total hardwood stems, and distribution, cover and number of species in the understory for each of three understory layers. Prior to the Kendall-tau testing, 24 potential landscape variables standard in the Nova Scotia forestry GIS database were also eliminated since they were extrapolated directly from only three photo-interpreted variables. From the total of 45 potential local scale variables 29 were considered in all subsequent testing and modeling, while only 22 of a potential 48 landscape scale variables were retained. A list of all the variables included for both levels can be found in Appendix VI.

Univariate Analyses

Univariate analyses showed several variables, at both the local and landscape scales, to be significantly different between DC and NDC areas for both the Queens and Cape Breton study areas (Table 3.1). In order to identify any significant differences, a t-test was performed on the parametric variables, whereas a Mann-Whitney test was used for the non-parametric variables.

Differences in mean distances from deer and random points to various edges in DC and NDC areas were tested for each study area. A significant difference was identified between DC and NDC areas, for both study areas, in distance to cut edge (t=-

7.506; p<0.05; df=462(CB); t= -14.002; p<0.05; df=948(Q); t-test), to agriculture edge (t=-10.136; p<0.05; df=462 (CB); t= -9.593; p<0.05; df=948(Q); t-test), and to roads (t=-8.562; p<0.05; df=462(CB); t= -25.162; p<0.05; df=948(Q); t-test) at the landscape scale (Table 3.1).

The mean distance to softwood/mixedwood (SW/MW) edges and softwood/hardwood (SW/HW) edges differed significantly in both study areas. The distance to SW/MW edge was significantly greater in the NDC areas than in the DC areas (t=4.570; p<0.05; df=462 (CB); t=-9.593; p<0.05; df=948(Q); t-test), where the mean distances were 268 m versus 183 m, and 365 m versus 243 m for NDC versus DC areas in Cape Breton and Queens, respectively. As is evident in Table 3.1, the distance to SW/HW edge was significantly greater in the DC area than in the NDC area (t=4.570; p<0.05; df=462 (CB); t=7.264; p<0.05; df=948 (Q); t-test), where the mean distances were 343 m versus 252 m, and 235 m versus 153 m for DC versus NDC areas in Cape Breton and Queens, respectively.

Average tree height was significantly different in DC and NDC areas for both study areas. The trees in the DC areas were consistently of greater average height than those in NDC areas (t=-2.641; p<0.05; df=462 (CB); t=-4.560; p<0.05; df=948 (Q); t-test) (Table3.1). In addition, diversity of cover types within a 296 m radius (representing average daily winter home range size (Drolet 1978)) of random locations in the NDC areas and actual deer locations in DC areas, showed there to be significantly greater diversity at the landscape level within DC areas (Z=1.864; p<0.10; df=1 (CB); Z=8.985; p<0.05; df=1 (Q); Mann-Whitney test).

Using the Mann-Whitney test, further consistencies were shown at the landscape scale between study areas in regards to elevation (Z=-11.415; p<0.05; df=1 (CB); Z=-6.608; p<0.05; df=1 (Q); Mann-Whitney test), slope (Z=3.908; p<0.05; df=1 (CB); Z=3.001; p<0.05; df=1 (Q); Mann-Whitney test), maturity (Z=-4.152; p<0.05; df=1 (CB); Z=-3.541; p<0.05; df=1 (Q); Mann-Whitney test), and second story crown closure (Z=-7.138; p<0.05; df=1 (CB); Z=-3.094; p<0.05; df=1 (Q); Mann-Whitney test). The significant difference indicated in slope between DC and NDC was also evident at a local scale for both study areas (Z=1.105; p<0.05; df=1 (CB); Z=0.2161; p<0.05; df=1 (Q); Mann-Whitney test). Soil type, which was changed from a categorical variable to an integer on the basis of increasing soil particle size (sand content), showed DC areas to have predominantly clay, and clay loam soils while NDC areas were consistently typified by loams and sandy loams. Soil type was also unique as it was the only variable measured at the local scale that showed consistency between and within study areas.

Table 3.1. Relationship of landscape variables (means with 95% confidence intervals in brackets) for deer concentration areas (DC) and no deer concentration areas (NDC) for study areas in Cape Breton and Queens.

	CAPE BRETON		QUEENS	
Variable	**Deer Concentration Area (DC)**	**Non-deer Concentration Area (NDC)**	**Deer Concentration Area (DC)**	**Non-deer Concentration Area (NDC)**
Cut (m)	366.0 (238.7)^a	555.2 (139.6)^a	572.6 (389.0)^a	913.8 (293.4)^a
Agriculture (m)	392.9 (251.1)^a	603.2 (169.5)^a	243.4 (146.8)^a	365.3 (97.0)^a
Roads (m)	226.0 (248.2)^a	427.8 (155.5)^a	133.0 (287.1)^a	399.4 (245.6)^a
SW/MW (m)	183.5 (48.1)^a	268.8 (101.4)^a	243.4 (146.8)^a	365.3 (97.0)^a
SW/HW (m)	343.0 (51.6)^a	252.6 (129.4)^a	235.0 (59.4)^a	153.62 (103.4)^a
Ave Height (m)	7.9 (2.8)^a	9.5 (0.4)^a	12.2 (2.2)^a	13.8 (0.9)^a
Diversity (m)	6.6 (0.2)^b	6.0 (1.0)^b	5.8 (0.8)^b	4.8 (1.2)^b
Elevation (m)	2.9 (2.4)^b	5.0 (1.8)^b	13.5 (1.2)^b	14.4 (0.7)^b
Slope	4.5 (0.2)^b	4.0 (0.7)^b	4.2 (0.1)^b	3.9 (0.4)^b
Maturity	2.9 (1.7)^b	4.1 (0.7)^b	4.6 (0.8)^b	5.1 (0.3)^b
2nd story crwn clos	0.8 (5.8)^b	5.7 (3.8)^b	1.8 (2.5)^b	3.5 (0.8)^b

Superscripts indicate differences in statistical testing: a) t-test b) Mann-Whitney test

The other variables, at both the local and landscape level, that differed significantly between DC areas and NDC areas, but only within their respective study areas were: stand size (hectares), tree species associations (spscd), site class (site), overstory crown closure from GIS (crncl) and from vegetative sampling (crown), average diameter at breast height for all species combined (avedbhall), presence of squirrels (squirrels), hare trails (rabbittrai), mean distance to a hydrological feature (water), depth of the forest floor litter layer (lfh), stand area to perimeter ratio (ratio), the proportion of overstory canopy comprised of coniferous species (sccc) (Sabine 1994), and aspect. A statistical summary for each of these can be found in Appendix VII.

Logistic Regression

The logistic regression modeling procedure led to the production of four significant models. Two models for each of the two study areas included: 1) a local scale model and 2) a landscape scale model. In Cape Breton, the landscape scale model consists of five variables based on the function:

$$\text{logit}(p) = 1.729 - 1.605\,ELEV - 0.556\,SSC - 0.710\,ST4 + 4.691\,ST5 + 6.834\,PCCC \quad (3.1)$$

where p is the probability of occurrence of a deer, $ELEV$ is the elevation in meters, SSC is the second story crown closure in percent, $ST4$ and $ST5$ are site classes 4 and 5, respectively, and $PCCC$ is the proximity to the nearest stand with high (50-100%) stand coniferous canopy cover (Sabine 1994).

The second model for the Cape Breton study area is at the local scale and contains three related variables based on the function:

$$\text{logit}(p) = 1.386 - 10.589\,ASP1 - 5.294\,ASP2 - 0.0418\,ASP4 \qquad (3.2)$$

where p is the probability of occurrence of a deer. *ASP 1, 2* and *4* represent north, northeast and southeast aspects, respectively.

The Queens study area landscape model consists of thirteen variables based on the function:

$$\begin{aligned}\text{logit}(p) = {} & 11.179 - 0.192\,SqCUT + 0.005\,SWHW + 0.441\,DIV + 0.003\,WATER - 0.162\,ELEV \\ & - 0.643\,SLOPE1 + 1.21\,ASP3 + 0.993\,SLOPE5 - 0.636\,SqAGRI + 0.015\,SWMW \\ & - 1.549\,SP2 - 2.18\,SP3 - 0.154\,\text{Sq}NCCC \qquad (3.3)\end{aligned}$$

where p equals the probability of occurrence of a deer, *SqCUT* is the square root of the distance to the nearest clear cut or partial cut, *SWHW* is the distance in meters to the nearest softwood / hardwood edge, *DIV* is the diversity of cover types within a 296 m radius (representing average daily winter deer home range size (Drolet 1978)), *WATER* is the distance in meters to the nearest significant hydrological feature, *ELEV* is the elevation in meters, *SLOPE3* and *SLOPE5* are areas of 2-5% and 10-20% slopes, respectively, *ASP2* is an area of northeast aspect, *SqAGRI* is the square root of the distance to the nearest agricultural field, *SWMW* is the distance in meters to the nearest softwood / mixedwood edge, *SP2* and *SP3* are areas of hardwood and mixedwood cover types, respectively, and *NCCC* is the "neighborhood" coniferous canopy cover (Sabine 1994).

The local model for Queens is based on only one variable and the constant, expressed in the function:

$$\text{logit}(p) = -55.697 + 11.027DIV \qquad (3.4)$$

where p and *DIV* are the same as previously described. Goodness-of-fit indices and S-Plus model statements for all of the above models can be found in Appendix VIII.

Probability values for the occurrence of the dependent variable (deer presence) were calculated using equation (3.5) applied to each of equations (3.1 - 3.4), where e is the natural exponent.

$$\text{Probability} = 1/(1 + e^{\text{logit}(p)}) \qquad (3.5)$$

These probability values were calculated for all 50 by 50 meter grid cells contained within each study area. The outcome was a map layer indicating probability of deer occurrence in each of the study areas (Figure 3.1 and 3.2).

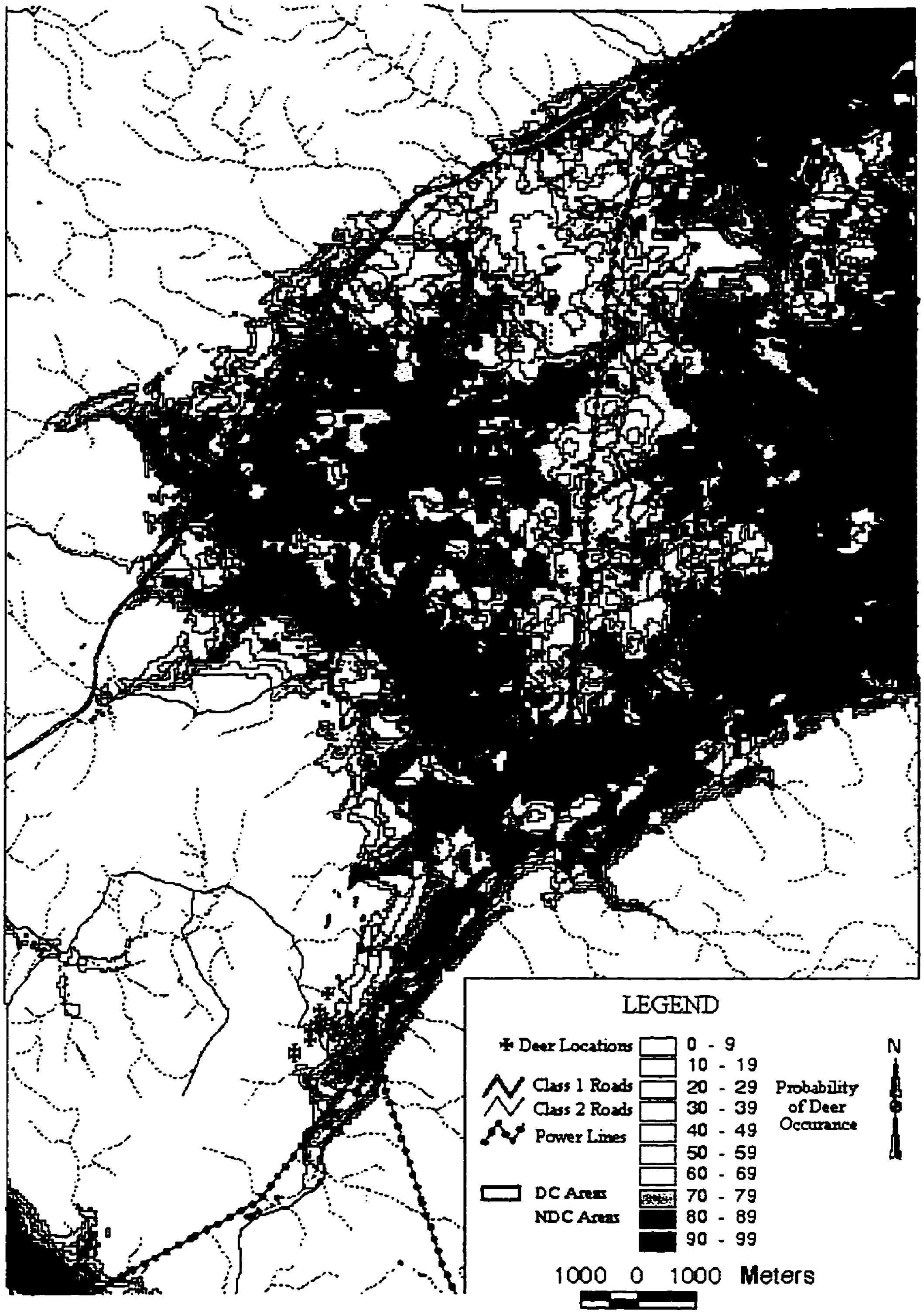

Figure 3.1. Map showing the probability of deer occurrence as predicted by the Cape Breton landscape model.

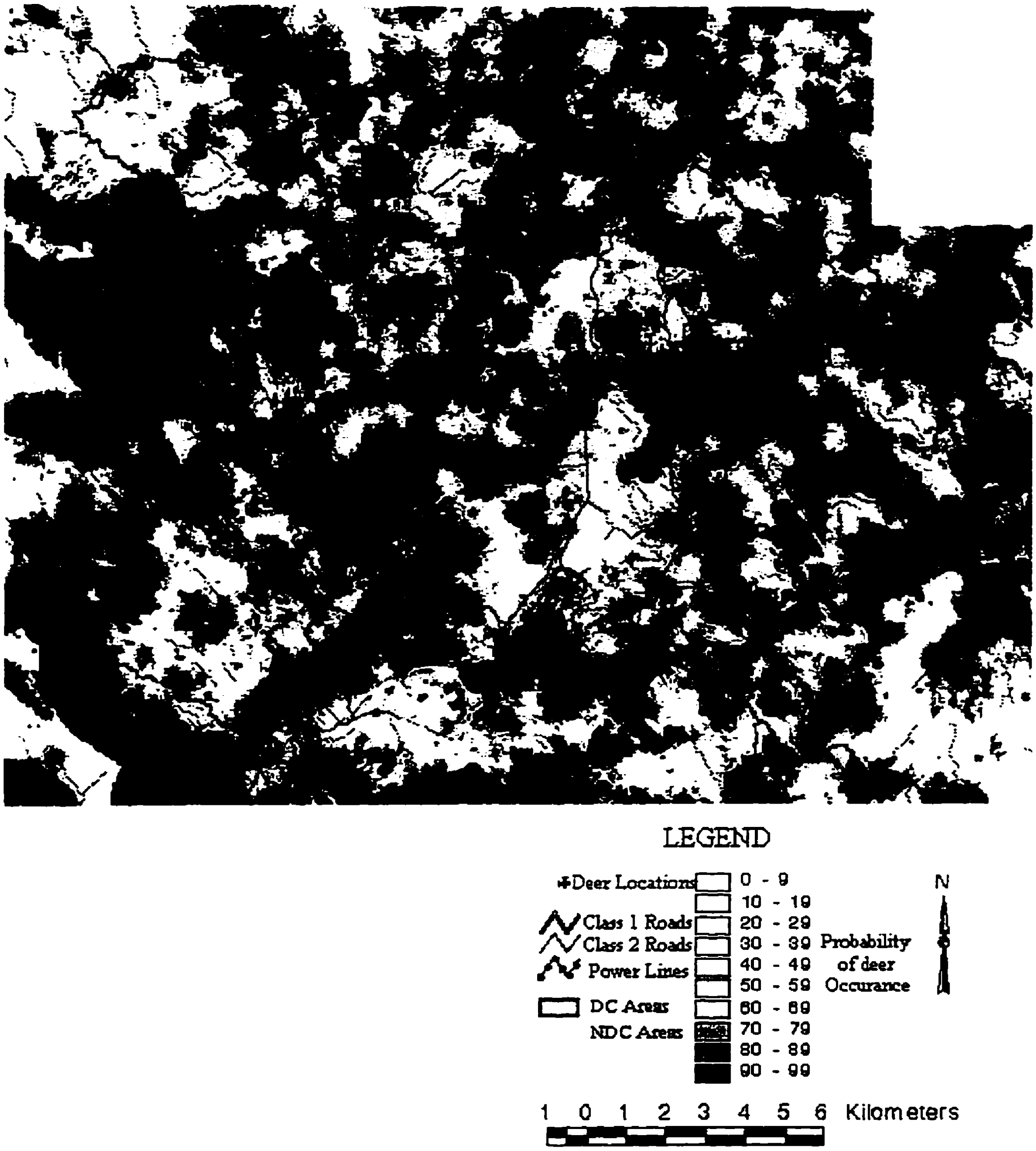

Figure 3.2. Map showing the probability of deer occurrence as predicted by the Queens landscape scale model.

Probability cut-off levels were set at p>0.4, as this level produced the least misclassification of the dependent variable (deer presence = locations) used in the modeling exercise. Three deer in Cape Breton (107 locations) and three deer in Queens (148 locations) were reserved from the model construction process to allow independent validation of the model. Regardless of which area each model had been originally constructed for, all models were tested for precision, accuracy and overall performance on both study areas. Model accuracy was calculated by dividing the total number of locations correctly predicted by the total number of deer locations, and then multiplying by 100 to report it as a percentage. Accuracy is presented in Table 3.2 for both those dependent variables that were used and those that were not used for the model construction.

Table 3.2 Model precision, accuracy and overall performance of each model in both study areas.

AREA TESTED	CAPE BRETON				QUEENS			
MODEL TESTED	Land CB	Land Q	Local CB	Local Q	Land Q	Land CB	Local Q	Local CB
Correct # of locations used	420						860	
Correct # of locations not used	86	527	489	532	996	986	128	998
Total locations used	437						866	
Total locations not used	107	544	544	544	1012	1012	148	1012
Total area (ha)	34411	34411	34411	34411	66168	66168	66168	66168
Area with deer present (ha)	8939	17900	18481	31177	29401	43560	47716	45536
Precision (%)	26	52	54	91	44	66	72	69
Accuracy - locations not used (%)	80	97	90	98	98	97	86	99
Accuracy - locations used (%)	96	97	90	98	98	97	86	99
Performance - locations not used (%)	54	45	36	7	54	32	14	30
Performance - locations used (%)	70	45	36	7	54	32	14	30

Precision of the models was assessed by dividing the area classified as having a high probability of deer presence ($p \geq 0.4$) by the total area in that study area and then multiplying by 100 to determine the percent value. The smaller the precision value the more precise the model. Overall model performance is a combined assessment of accuracy and precision, determined as the percent difference in accuracy and precision for locations used and locations not used in the model construction (Table 3.2). Given this calculation of model precision, the greater the value the better the overall model performance. Accuracy, precision, and performance were not used in model determination, rather were presented as relative measures to allow for standardized model comparison.

DISCUSSION

Habitat Characteristics

Numerous researchers have analyzed, documented, and commented on white-tailed deer habitat preferences (Pauley *et al.* 1993, Tierson *et al.* 1985, Parker *et al.* 1984, Drolet 1978). The authors who have analyzed deer winter habitat preference, in particular, and commented on its requirement/benefit, have all reported very similar results. Some of the common conclusions are that deer in the northern part of their range begin to experience a negative energy balance during the winter due to the lack of easily accessible forage, cold air temperatures, and belabored movement through deep snow. This negative energy balance necessitates that deer seek out areas which contain the optimum habitat, or mix of habitats, that reduce the factors responsible for this energy deficit (yarding behavior). This optimum mix of favourable habitat features typically occurs at low elevations, on south facing slopes, comprised of conifer-dominated stands (Pauley *et al.* 1993; Beier and McCullough 1989; Mooty *et al.* 1987). Clearly lacking in all of these studies is the spatial arrangement and location of these areas. To this end, this study does not focus on the reconfirmation of preference or avoidance patterns for a particular segment of habitat, but rather it uses past literature, area specific telemetry information, and multi-source habitat information, to develop comprehensive habitat models that identify preferred DWA.

Using a combination of variables at the landscape level, the first of the models to be developed was for the Cape Breton study area. The first three variables in this model were all inversely related to deer presence, namely elevation, presence and density of multi-layered stands, and presence of low to medium site quality areas. The remaining two variables, proximity to stands with closed coniferous canopy, and medium site quality, both had a positive influence on deer presence. Logistic regression facilitated the statistical formulation of these significant variables into a function which is not only statistically stable but also makes biological sense. Furthermore, the order of independent variables in the logistic equation corresponds to their level of significance in predicting the dependent variable.

The significant variables identified can be well justified. Areas of relatively high elevation such as the Cobequid Hills, Cape Breton Highlands, and Avalon Uplands (Simmons *et al.* 1984) typically receive and accumulate more snow relative to their surrounding areas (Gates 1975). In addition higher elevations are usually colder, more windy and experience longer winters. All of these factors combine to impact negatively upon a deer's energy balance, as more energy is required to maintain body temperature and to move about (Lavigne 1991, Weber *et al.* 1983, Telfer 1967).

The second variable indicated that the presence and density of multi-layered stands had a negative influence on the probability of deer presence. A "second story" in a forest stand is defined as a distinct second layer either above or below the main forest stand (Anon. 1994). Presence of this second stand story is typical in areas of Nova Scotia, such as Cape Breton, which were affected by moderate to heavy spruce budworm defoliation in the early 1980's (Bridgland 1996). Essentially these stands are open canopy stands with copious amounts of balsam fir (*Abies balsamea*) regeneration, typically 2-4 meters in height, inter-twined with fallen dead wood. These stand types provide very little thermal benefit and available forage, while also constraining deer movement. Consequently, these stand types are avoided by deer during the winter, thus verifying the negative interaction seen in the model.

The positive relationship between good site classes, and the negative relationship with poorer site classes, and deer presence are biologically understandable (Kirchhoff and Schoen 1987). By definition, high site classes are characterized by larger, more fully developed overstory trees, increased diversity and quantity of understory vegetation, and greater growth rate (Kimmins 1987). The large difference seen from site class 4 to site class 5 in this model does however seem questionable. Some explanation may be attributed to the fact that site class 5 was the most common site class in the lower elevation areas of Cape Breton, while site class 4 was the second most prevalent. This essentially reduces site to a binary condition of low productivity (site class 4) versus high productivity (site class 5). In this situation, avoidance of one class results in preference for the other (Hobbs and Hanley 1990); therefore, the difference between site class 4 and site class 5, even though they are only two of 12 possible province-wide site classes, makes more sense.

PCCC is a relative measure of the juxtaposition of a stand to another stand providing good coniferous cover (Sabine 1994). The strong positive effect PCCC has on probability of deer presence as predicted by the model supports previous findings that document the importance of high coniferous crown closure. Interestingly, PCCC was included over all other variables representing some aspect of coniferous canopy closure (i.e. stand coniferous crown closure, total stand crown closure, and coniferous stand types). This finding is important since it suggests that it is not purely the abundance of mature coniferous stands with closed coniferous canopies that determines preferable

DWA, but rather the proximity to or interspersion with these stand types (Lavigne 1991). This observation is more easily understood when the univariate "t" and Mann-Whitney test results are examined (Appendix VII). Although, according to the Mann-Whitney test, there is a slight significant difference in crown closure between DC and NDC areas ($Z=1.991; p=0.05; df=1$; Mann-Whitney test), there was no significant difference between individual stand coniferous crown closure (SCCC) values in DC and NDC areas ($Z=1.443; p=0.15; df=1$; Mann-Whitney test).

Thus, it is evident that at the landscape level in northeastern Nova Scotia, the probability of deer occurrence during the winter, or the deer's selection of suitable yarding areas, is most strongly correlated with low elevation, high site quality, absence of a second stand story, and proximity to and interspersion with stands of high coniferous canopy.

The local scale model for the Cape Breton study area contained three related variables all representing aspect. The function indicated that the northerly aspects, represented by ASP 1 (North) and ASP 2 (Northeast), had a large negative correlation with the probability of the occurrence of deer. The negative correlation was greater for ASP1 than it was for ASP 2, suggesting a greater avoidance the more northerly the aspect. These relationships verify the expectations of the deer's tendency to avoid northerly aspects - a theory that is well supported by the literature (Pauley *et al.* 1993, Beier and McCullough 1989, Drolet 1976). The third variable involved in the model was the southeast aspect, ASP 4, which showed a very small negative correlation. This observation is consistent with the correlations identified above.

The fact that none of the remaining southerly or westerly aspects were incorporated into the model is likely a function of the statistical test. A significant difference was identified in the combined aspects of the DC area when compared to the combined aspects of the NDC area using the Mann-Whitney test. However, in order for the logistic regression to be performed, the aspect had to be separated into eight individual aspect variables, each representing one of the standard compass orientations. The data were then organized accordingly into these eight separate categories for the DC area and the NDC area. When the statistical analysis was performed, the comparisons between the DC and NDC area were now between specific aspects. Consequently, it was possible that there was no significant difference between the two concentration areas for certain aspects, thereby eliminating them from the model.

Similar to the landscape level model for Cape Breton, the Queens model is dominated by habitat arrangement or spatial variables. Unlike the situation in Cape Breton, deer in Queens seem to select areas that are most diverse in cover type, and are not as influenced by the proximity to stands with high percentage of coniferous crown closure. Other factors in the Queens model which have positive influences on probability of winter deer presence were, as expected: distance to significant hydrological features, distance to SWHW and SWMW edge, easterly exposure, and areas with 10 to 20 percent slope. The least significant variable in the Queens landscape model, NCCC, had a negative impact on deer preference indicating slight avoidance of large homogeneous coniferous stands with closed canopies. Perhaps the most surprising result was the negative influence of increasing distance to recent clear cut or partial cut edges. This may seem questionable when compared with traditional theory on selection of a DWA.

but given the relatively snow-free winters experienced in southern Nova Scotia. this makes biological sense. This result can be explained by the different mechanisms used to accommodate the deer's priorities as dictated by the climate. The northerly climate of Cape Breton, with greater snow depths and colder temperatures, makes energy conservation a leading priority for deer of that area. In order to accommodate this need, deer tend to search for food in proximity to suitable coniferous cover (Pauley *et al.* 1993). Although deer in the Queens area still aim to conserve energy, they do not typically have the snow depth or the extreme temperatures to contend with, and therefore are able to meet their needs differently. As indicated by the order of importance in the model function, proximity to cut edges and increased diversity dictate deer distribution more than proximity to or abundance of closed canopy coniferous stands. Deer search for a diversity of cover types where all of their habitat needs can be accommodated without much movement being required (Mooty *et al.* 1987). Research conducted by Verme and Ullrey (1972) led to the conclusion that given a choice, deer prefer a variety of vegetative materials. Other research has also shown a diverse diet to be of great benefit to deer because it allows them to maintain a better weight throughout the winter (Mooty *et al.* 1987), provides vegetative selection so that they can choose the most nutritious forage (Swift 1948), seems to contribute to the dilution of compounds that interfere with digestion (Bryant and Kuropat 1980), and has been shown to improve the survival of fawns (Lavigne 1991). The same reasoning applies to the local scale model of the Queens area, where diversity of cover types (DIV) was the sole influencing variable of any significance.

Like most wildlife models, the four equations generated herein by logistic regression provide a simplification of the many complex relationships that affect deer natality and mortality (Morgan *et al.* 1993). However, when applied to the pertinent data layers in a GIS they provide a visual representation of the real world. This enables researchers and managers, not trained in the technical aspects of GIS, to appreciate more readily the spatial arrangement of actual geographic areas or regions that are preferred.

In these models, "preference" for an area has been represented as a probability map layer. The models proved to be very precise, with 26% of the total landscape area in Cape Breton and 44% of the total landscape area in Queens identified as areas of high probability of deer occurrence. Due to the demonstrated high precision and accuracy, as seen in these overall model performances (Table 3.2), it can be concluded that the models developed in this study are much better than past wildlife models, such as those developed by Timossi *et al.* 1994, Chang *et al.* 1992, Stenback *et al.* 1989 and Weber 1983.

CONCLUSIONS

The models resulting from this study have great potential in the identification and management of DWA. Application of these models could enable the Nova Scotia resource managers to: 1) identify actual as well as potential DWA at the landscape level, and 2) identify probability of deer occurrence within the areas previously delineated at the landscape level. In addition, the statistical analysis used in the development of these models would allow for comment to be made on: 1) the optimum spatial arrangement of habitat features, 2) the relative importance of individual habitat variables, and 3) which areas would benefit most from silvicultural treatment for habitat improvement. There are certain aspects of the models that should be interpreted, and likewise applied, with caution. In all cases, it should be kept in mind that the intent of the models is not to replace field verification, but rather to focus the areas of investigation.

The landscape models effectively identify the portions of landscape representing actual and potential DWA within their respective regions. Within these reduced areas, levels of browse and hectares of suitable closed canopy can be better monitored, and thus provide a more reasonable basis for calculation of carrying capacity by area, region, or landscape. Without this focused area of interest, resource managers run the risk of over-estimating carrying capacity of winter habitat.

Landscape models successfully fulfilled the objectives set-out for this scale of investigation, yet the local models were weak in some areas. In particular, they lack the ability to indicate the importance of critical habitat for severe winters. The mild winters experienced during this study no doubt resulted in the lack of evidence highlighting the importance of closed canopy coniferous stands. The food and cover requirements of deer vary considerably with winter severity. Specifically, during mild winters with little snow cover deer dependence on closed canopy coniferous stands is minimized, while the need for a diversity of interspersed stand types and conditions within their daily home range is maximized. Conversely, severe winters force deer to become more dependent on closed canopy coniferous stands, which tend to ameliorate the harsh conditions. Thus, it is important that resource managers carefully monitor deer numbers and winter conditions in order to ensure that healthy population levels are sustained over the long term.

The use of area-specific models acknowledges a deer's differential habitat requirements as dictated by regional climatic conditions. Specifically, winter severity should be used to determine appropriate amounts of coniferous stands to be managed within the identified areas. For example, in southern regions, like Queens, a lower percentage would be required, whereas in northern regions, like Cape Breton, a larger percentage would be required to accommodate the typically more severe winters.

Models from each study region were applied to the other study region, and assessed for accuracy and precision just as they were within their own region of construction. Although in all cases the models do provide some benefit in the opposite study area, overall model performance is not as good as that of that areas' own models. Therefore, it can be concluded that one provincially universal model would affect model accuracy marginally but compromise model precision greatly. To this end, regionally specific models would be best to identify actual and potential deer wintering habitat.

CHAPTER IV

PRACTICAL STUDY APPLICATION

Although presented as two distinct sections, forage aspects and habitat modeling are directly linked to the greater understanding of white tailed-deer winter ecology in Nova Scotia. When appended together, the results from both sections provide a clear starting point for the development of sound, regionally specific carrying capacity estimates.

An example demonstrating the practical applications is outlined as follows:

1) The Cape Breton landscape model identified that approximately 26% of the whole study area had a high probability of winter deer-use. Within this reduced area, the number of hectares contained in each cover type was: 3272 hectares in softwood types, 1298 hectares in mixedwood types, 2232 hectares in hardwood types and 322 hectares in regenerating types.

2) The total number of stems present in each of the areas identified by the landscape model were calculated using the values for mean number of stems per hectare in each cover type (Table 2.4). The calculated total number of stems per area were 29,255,000 stems in softwood types, 21,567,000 in mixedwood types, 70,245,000 in hardwood types and 14,575,000 in regenerating types.

3) Available biomass (kg) was calculated using equation 2.1 and the mean mass of current annual increment by cover type from table 2.4. The calculated values were: 10,824 kg in softwood types, 7,979 kg in mixedwood types, 25,990 kg in hardwood types and 17,053 kg in regenerating types.

4) Further calculations determined that a maximum of 11 white-tailed deer per square kilometer could be supported in the 7124 hectares of Cape Breton's predicted winter habitat. This calculation assumes that a deer of average body mass consumes 0.842 kg of woody forage per day (Mautz *et al.* 1976) and the typical yarding period in Cape Breton is 90 days.

The mathematical procedure performed was as follows:

$$\text{Generalized maximum carrying capacity} = {}^{*}61846 \text{ kg} \div 0.842 \text{ kg/day/deer} \div 7124 \text{ ha} \div 90 \text{ days}$$
$$= 0.11 \text{ deer/ha}$$
$$= 11 \text{ deer/km}^2 \qquad (4.1)$$

*Total mass of current annual increment {all cover types combined} = 61846 kg

The result from the previous example is not the best possible estimate of carrying capacity, but rather it provides a starting point. Further development should incorporate additional factors including: 1) additional forage aspects (lichens, herbs), 2) environmental conditions (winter severity), 3) predation pressures (coyotes, hunting), and 4) population parameters (age structure). The example does however, clearly outline the applicability of this study's results. This true integration of research and management arms all Nova Scotians with reliable, regionally specific information to better manage our forests for white tailed deer.

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APPENDIX I

Overstory	Crown	Unbrowsed								Browsed											Total									
SW,HW,MW,CC	Closure	Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Year	Season	Location	Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Totals	Total/ha
CC	0	146	0	0	0	0	34	0	0	0	0	0	0	0	0	0	0	93	wi	cb	146	0	0	0	0	34	0	0	180	90000
CC	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	15	0	0	0	0	0	0	0	15	7500
CC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	0	0	0	0	0	0	0	0	0	0
CC	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	95	wi	cb	4	0	0	0	0	0	0	0	4	2000
CC	0	143	0	0	0	0	178	0	0	32	0	0	0	0	3	0	0	95	wi	cb	175	0	0	0	0	181	0	0	356	178000
CC	0	40	16	0	0	0	0	0	0	29	7	0	0	0	0	0	0	95	wi	cb	69	23	0	0	0	0	0	0	92	46000
CC	0	4	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	95	sp	cb	21	0	0	0	0	0	0	0	21	10500
CC	0	145	0	0	0	0	339	0	0	40	0	0	0	0	7	0	0	95	sp	cb	185	0	0	0	0	346	0	0	531	265500
CC	0	15	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	95	sp	cb	20	0	0	0	0	0	0	0	20	10000
CC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	0	0	0	0	0	0	0	0	0
CC	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	1	0	0	0	0	0	0	0	1	500
CC	0	83	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	96	sp	cb	100	0	0	0	0	0	0	0	100	50000
CC	0	7	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	96	sp	cb	19	0	0	0	0	0	0	0	19	9500
CC	0	81	0	0	0	0	17	0	0	23	0	0	0	0	2	0	0	96	sp	cb	104	0	0	0	0	19	0	0	123	61500
CC	0	4	12	0	0	0	0	0	0	13	3	0	0	0	0	0	0	96	sp	cb	17	15	0	0	0	0	0	0	32	16000
CC	0	5	0	0	0	0	7	0	0	3	0	0	0	0	2	0	0	96	sp	cb	8	0	0	0	0	9	0	0	17	8500
CC	0	24	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	96	sp	cb	28	0	0	0	0	0	0	0	28	14000
HW	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	95	wi	cb	0	3	0	0	0	0	0	0	3	1500
HW	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	cb	0	8	0	0	0	0	0	0	8	4000
HW	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	95	wi	cb	0	0	0	0	0	18	0	0	18	9000
HW	0	19	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	95	wi	cb	44	0	0	0	0	0	0	0	44	22000
HW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	cb	0	0	0	0	0	0	0	0	0	0
HW	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	cb	5	0	0	0	0	0	0	0	5	2500
HW	0	7	4	0	0	0	0	0	0	3	5	0	0	0	0	0	0	95	wi	cb	10	9	0	0	0	0	0	0	19	9500
HW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	cb	0	0	0	0	0	0	0	0	0	0
HW	0	3	3	0	0	0	0	0	0	8	3	0	0	0	0	0	0	95	wi	cb	11	6	0	0	0	0	0	0	17	8500
HW	0	17	0	0	0	0	0	0	4	11	0	0	0	0	0	0	7	95	wi	cb	28	0	0	0	0	0	0	11	39	19500
HW	0	7	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	95	sp	cb	10	0	0	0	0	0	0	0	10	5000
HW	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	6	0	0	0	0	0	0	6	3000
HW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	0	0	0	0	0	0	0	0	0	0
HW	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	0	3	0	0	0	0	0	0	3	1500
HW	0	50	19	0	0	0	0	0	0	82	2	0	0	0	0	0	0	96	sp	cb	132	21	0	0	0	0	0	0	153	76500
HW	0	4	12	0	0	0	2	0	0	7	1	0	0	0	0	0	0	96	sp	cb	11	13	0	0	0	2	0	0	26	13000
HW	0	47	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	96	sp	cb	50	0	0	0	0	0	0	0	50	25000
HW	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	7	0	0	0	0	0	0	0	7	3500
HW	0	1	7	0	0	0	0	0	0	3	5	0	0	0	0	0	0	96	sp	cb	4	12	0	0	0	0	0	0	16	8000
HW	0	10	0	0	0	0	0	0	0	30	4	0	0	0	0	0	0	96	sp	cb	40	4	0	0	0	0	0	0	44	22000
HW	0	89	0	0	0	0	188	0	0	0	0	0	0	0	0	0	0	96	sp	cb	89	0	0	0	0	188	0	0	277	138500
HW	0	63	0	0	0	0	0	0	78	9	0	0	0	0	0	0	0	96	sp	cb	72	0	0	0	0	0	0	78	150	75000
HW	30	37	0	0	0	0	12	0	0	1	0	0	0	0	4	0	0	94	sp	cb	38	0	0	0	0	16	0	0	54	27000
HW	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	0	0	0	0	0	0	0	0	0	0
HW	35	12	0	0	0	0	3	0	0	13	0	0	0	1	2	0	0	94	sp	cb	25	0	0	0	1	5	0	0	31	15500
HW	40	0	0	0	0	0	4	0	0	0	0	0	0	0	6	0	0	94	sp	cb	0	0	0	0	0	10	0	0	10	5000
HW	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	0	0	0	0	0	0	0	0	0	0
HW	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	0	0	0	0	0	0	0	0	0	0
HW	70	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	94	sp	cb	0	2	0	0	0	0	0	0	2	1000
MW	0	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	cb	39	0	0	0	0	0	0	0	39	19500
MW	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	cb	6	0	0	0	0	0	0	0	6	3000
MW	0	1	0	0	0	0	25	0	0	0	0	0	0	0	2	0	0	95	wi	cb	1	0	0	0	0	27	0	0	28	14000
MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	wi	cb	0	0	0	0	0	0	0	0	0	0
MW	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	95	wi	cb	4	0	0	0	0	0	0	0	4	2000
MW	0	5	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	95	wi	cb	24	0	0	0	0	0	0	0	24	12000
MW	0	3	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	95	wi	cb	11	0	0	0	0	0	0	0	11	5500
MW	0	0	0	0	0	1	0	0	0	0	0	0	0	6	0	0	0	95	wi	cb	0	0	0	0	7	0	0	0	7	3500
MW	0	0	3	0	0	52	0	0	0	0	0	0	0	0	0	0	0	95	wi	cb	0	3	0	0	52	0	0	0	55	27500

Overstory SW,HW,MW,CC	Crown Closure	Unbrowsed Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Browsed Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Year	Season	Location	Total Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Totals	Total/ha
MW	0	58	0	0	0	110	0	0	0	2	0	7	0	4	0	0	0	95	wi	cb	60	0	7	0	114	0	0	0	181	90500
MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	0	0	0	0	0	0	0	0	0
MW	0	16	0	0	0	0	0	0	0	28	0	0	0	0	0	0	0	95	sp	cb	46	0	0	0	0	0	0	0	46	23000
MW	0	8	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	95	sp	cb	13	0	0	0	0	0	0	0	13	6500
MW	0	2	0	0	0	0	29	0	0	0	0	0	0	0	2	0	0	95	sp	cb	2	0	0	0	0	31	0	0	33	16500
MW	0	19	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	95	sp	cb	21	0	0	0	0	1	0	0	22	11000
MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	0	0	0	0	0	0	0	0	0
MW	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	95	sp	cb	0	3	0	0	0	0	0	0	3	1500
MW	0	9	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	95	sp	cb	13	0	0	0	0	0	0	0	13	6500
MW	0	5	0	0	0	0	0	0	0	5	1	0	0	0	0	0	0	95	sp	cb	10	1	0	0	0	0	0	0	11	5500
MW	0	0	11	0	0	0	9	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	11	0	0	0	9	0	0	20	10000
MW	0	42	0	6	0	74	0	0	0	5	2	4	0	2	0	0	0	95	sp	cb	47	2	10	0	76	0	0	0	135	67500
MW	0	3	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	95	sp	cb	3	4	0	0	0	0	0	0	7	3500
MW	45	0	0	0	0	0	13	0	0	0	0	0	0	0	12	0	0	96	sp	cb	0	0	0	0	0	25	0	0	25	12500
MW	60	60	0	0	0	0	7	0	0	0	0	0	0	0	1	0	0	96	sp	cb	60	0	0	0	0	8	0	0	68	34000
HW	65	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	96	sp	cb	5	0	0	0	0	0	0	0	5	2500
MW	0	13	0	0	0	0	0	0	0	25	0	0	0	0	5	0	0	96	sp	cb	38	0	0	0	0	5	0	0	43	21500
MW	0	0	3	0	0	6	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	0	3	0	0	6	0	0	0	9	4500
MW	0	31	0	0	0	75	0	0	0	23	0	0	0	39	0	0	0	96	sp	cb	54	0	0	0	114	0	0	0	168	84000
MW	0	47	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	96	sp	cb	77	0	0	0	0	0	0	0	77	38500
MW	0	1055	0	0	0	0	10	0	0	5	0	0	0	0	7	0	0	96	sp	cb	1060	0	0	0	0	17	0	0	1077	538500
MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	0	0	0	0	0	0	0	0	0	0
MW	0	83	1	0	0	0	0	0	0	100	3	0	0	0	0	0	0	96	sp	cb	183	4	0	0	0	0	0	0	187	93500
MW	0	178	18	0	0	0	3	0	0	300	41	0	0	0	9	0	0	96	sp	cb	478	59	0	0	0	12	0	0	549	274500
MW	0	95	0	0	0	0	26	0	0	10	0	0	0	0	0	0	0	96	sp	cb	105	0	0	0	0	26	0	0	131	65500
MW	0	16	0	0	0	40	0	0	0	6	0	0	0	21	0	0	0	96	sp	cb	22	0	0	0	61	0	0	0	83	41500
MW	0	6	0	0	0	48	0	0	0	8	0	0	0	21	0	0	0	96	sp	cb	18	0	0	0	69	0	0	0	85	42500
MW	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	2	0	0	0	0	0	0	0	2	1000
MW	0	23	0	0	0	0	6	0	0	12	0	0	0	0	4	0	0	96	sp	cb	35	0	0	0	0	10	0	0	45	22500
MW	0	11	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	96	sp	cb	16	0	0	0	0	0	0	0	16	8000
MW	0	27	0	0	0	0	0	0	0	241	0	0	0	0	0	0	0	96	sp	cb	268	0	0	0	0	0	0	0	268	134000
MW	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	0	2	0	0	0	0	0	0	2	1000
MW	0	2	8	0	0	0	0	0	0	18	8	0	0	0	0	0	0	96	sp	cb	20	16	0	0	0	0	0	0	36	18000
MW	0	9	0	0	0	0	5	0	0	18	0	0	0	0	0	0	0	96	sp	cb	27	0	0	0	0	5	0	0	32	16000
MW	0	106	7	0	0	0	0	0	0	57	0	0	0	0	0	0	0	96	sp	cb	163	7	0	0	0	0	0	0	170	85000
MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	0	0	0	0	0	0	0	0	0	0
MW	0	2	13	0	0	0	0	0	0	14	0	0	0	0	0	0	0	96	sp	cb	16	13	0	0	0	0	0	0	29	14500
MW	0	9	0	0	0	0	0	0	0	34	0	0	0	0	0	0	0	96	sp	cb	43	0	0	0	0	0	0	0	43	21500
MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	0	0	0	0	0	0	0	0	0	0
MW	0	185	0	0	0	0	0	0	0	65	0	0	0	0	0	0	0	96	sp	cb	250	0	0	0	0	0	0	0	250	125000
MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	0	96	sp	cb	0	0	0	0	0	23	0	0	23	11500
MW	10	11	14	0	0	0	0	0	0	12	0	0	0	0	0	0	0	94	sp	cb	23	14	0	0	0	0	0	0	37	18500
MW	10	26	9	0	0	0	0	0	0	5	0	0	0	0	0	0	0	93	wi	cb	31	9	0	0	0	0	0	0	40	20000
MW	20	12	0	0	0	0	7	0	0	3	0	0	0	0	4	0	0	94	sp	cb	15	0	0	0	0	11	0	0	26	13000
MW	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	0	0	0	0	0	0	0	0	0	0
MW	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	0	0	0	0	0	0	0	0	0	0
MW	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	0	0	0	0	0	0	0	0	0	0
MW	20	6	0	0	0	0	1	0	0	6	0	0	0	0	1	0	0	93	wi	cb	12	0	0	0	0	2	0	0	14	7000
MW	30	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	5	0	0	0	0	0	0	0	5	2500
MW	30	14	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	93	wi	cb	15	0	0	0	0	3	0	0	18	9000
MW	30	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	24	0	0	0	0	0	0	0	24	12000
MW	30	31	0	0	0	0	3	0	0	1	0	0	0	0	6	0	0	93	wi	cb	32	0	0	0	0	9	0	0	41	20500
MW	30	19	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	93	wi	cb	19	0	0	0	0	1	0	0	20	10000
MW	30	5	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	5	49	0	0	0	0	0	0	54	27000
MW	35	1	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	93	wi	cb	1	0	0	0	0	17	0	0	18	9000

Overstory	Crown	Unbrowsed								Browsed											Total									
SW,HW,MW,CC	Closure	Rm	Te	WH	Oak	Raisin	Birch	Hobble	Beech	Rm	Te	WH	Oak	Raisin	Birch	Hobble	Beech	Year	Season	Location	Rm	Te	WH	Oak	Raisin	Birch	Hobble	Beech	Totals	Total/ha
MW	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	0	0	0	0	0	0	0	0	0	0
MW	40	4	60	0	0	0	0	0	0	3	0	0	0	0	0	0	0	94	sp	cb	7	60	0	0	0	0	0	0	67	33500
MW	40	5	6	0	0	0	0	0	0	1	0	0	0	0	0	0	0	93	wi	cb	6	6	0	0	0	0	0	0	12	6000
MW	40	6	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	6	19	0	0	0	0	0	0	25	12500
MW	50	29	14	0	0	0	0	0	0	3	1	0	0	0	0	0	0	94	sp	cb	32	15	0	0	0	0	0	0	47	23500
MW	50	41	4	0	0	0	2	0	0	3	2	0	0	0	1	0	0	94	sp	cb	44	6	0	0	0	3	0	0	53	26500
MW	50	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	0	1	0	0	0	0	0	0	1	500
MW	60	0	7	0	0	0	0	0	0	0	1	0	0	0	0	0	0	93	wi	cb	0	8	0	0	0	0	0	0	8	4000
MW	60	0	9	0	0	0	0	0	0	-0	-0	0	0	0	0	0	0	93	wi	cb	0	9	0	0	0	0	0	0	9	4500
MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	0	0	0	0	0	0	0	0	0	0
SW	0	22	0	0	0	0	0	13	0	16	0	0	0	0	0	4	0	95	wi	cb	38	0	0	0	0	0	17	0	55	27500
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	cb	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	95	wi	cb	0	0	0	0	4	0	0	0	4	2000
SW	0	7	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	95	wi	cb	19	0	0	0	0	0	0	0	19	9500
SW	0	2	1	0	0	0	0	0	0	13	1	0	0	0	0	0	0	95	wi	cb	15	2	0	0	0	0	0	0	17	8500
SW	0	10	2	0	0	0	0	0	0	12	2	0	0	0	0	0	0	95	wi	cb	22	4	0	0	0	0	0	0	26	13000
SW	0	36	0	0	0	0	0	0	0	61	4	0	0	0	0	0	0	95	wi	cb	97	4	0	0	0	0	0	0	101	50500
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	cb	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	cb	0	0	0	0	0	0	0	0	0	0
SW	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	cb	3	0	0	0	0	0	0	0	3	1500
SW	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	15	95	wi	cb	0	0	0	0	0	0	0	35	35	17500
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	cb	0	0	0	0	0	0	0	0	0	0
SW	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	cb	0	4	0	0	0	0	0	0	4	2000
SW	0	2	0	0	0	64	0	0	0	0	0	0	0	0	0	0	0	95	wi	cb	2	0	0	0	64	0	0	0	66	33000
SW	0	12	0	0	0	56	0	0	0	6	0	0	0	0	0	0	0	95	wi	cb	18	0	0	0	56	0	0	0	74	37000
SW	0	0	10	0	0	0	20	0	0	0	0	0	0	0	0	0	0	95	wi	cb	0	10	0	0	0	20	0	0	30	15000
SW	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	95	wi	cb	0	0	0	0	0	3	0	0	3	1500
SW	0	2	0	55	0	0	0	0	0	0	0	4	0	0	0	0	0	95	sp	cb	2	0	59	0	0	0	0	0	61	30500
SW	0	16	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	16	0	0	0	5	0	0	0	21	10500
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	0	1	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	95	sp	cb	6	0	0	0	0	0	0	0	6	3000
SW	0	13	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	95	sp	cb	20	0	0	0	0	0	0	0	20	10000
SW	0	3	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	95	sp	cb	10	0	0	0	0	0	0	0	10	5000
SW	0	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	51	0	0	0	0	0	0	0	51	25500
SW	0	0	0	0	0	63	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	0	0	0	63	0	0	0	63	31500
SW	0	5	0	0	0	20	0	0	0	0	0	0	0	9	0	0	0	95	sp	cb	5	0	0	0	29	0	0	0	34	17000
SW	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	0	0	0	0	3	0	0	3	1500
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	0	5	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	95	sp	cb	19	0	0	0	0	0	0	0	19	9500
SW	0	2	4	0	0	0	0	0	0	16	2	0	0	0	0	0	0	95	sp	cb	18	6	0	0	0	0	0	0	24	12000
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	0	18	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	96	sp	cb	19	0	0	0	0	0	0	0	19	9500
SW	0	9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	96	sp	cb	10	0	0	0	0	0	0	0	10	5000
SW	0	65	0	0	0	0	0	0	0	42	0	0	0	0	0	0	0	96	sp	cb	107	0	0	0	0	0	0	0	107	53500
SW	0	4	0	0	0	0	0	0	0	4	0	0	0	0	1	0	0	96	sp	cb	8	0	0	0	0	1	0	0	9	4500

Overstory	Crown	Unbrowsed								Browsed											Total									
SW,HW,MW,CC	Closure	Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Year	Season	Location	Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Totals	Total/ha
SW	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	96	sp	cb	4	0	0	0	0	0	0	0	4	2000
SW	0	10	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	10	4	0	0	0	0	0	0	14	7000
SW	0	0	0	0	0	10	0	0	0	1	1	0	0	0	0	0	0	96	sp	cb	1	1	0	0	10	0	0	0	12	6000
SW	0	1	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	96	sp	cb	6	0	0	0	0	0	0	0	6	3000
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	0	17	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	96	sp	cb	26	0	0	0	0	0	0	0	26	13000
SW	0	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	48	0	0	0	0	0	0	0	48	24000
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	0	12	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	96	sp	cb	14	0	0	0	0	0	0	0	14	7000
SW	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	0	0	0	0	0	0	0	0	0	0
SW	40	47	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	94	sp	cb	52	0	0	0	0	0	0	0	52	26000
SW	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	94	sp	cb	0	0	0	0	0	0	0	0	0	0
SW	60	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	cb	3	0	0	0	0	0	0	0	3	1500
SW	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	94	sp	cb	0	0	0	0	0	0	0	0	0	0

APPENDIX II

Overstory SW,HW,MW,CC	Crown Closure	Unbrowsed Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Browsed Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Year	Season	Location	Totals Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Totals	Total/ha
CC	5	239	0	0	0	353	0	0	0	26	0	0	0	56	0	0	0	94	sp	qu	265	0	0	0	409	0	0	0	674	337000
CC		0	0	0	0	0	0	0	40	0	0	0	0	0	0	0	3	95	wi	qu	0	0	0	0	0	0	0	43	43	21500
CC		0	0	0	0	0	5	0	0	0	0	0	0	0	5	0	0	95	wi	qu	0	0	0	0	0	10	0	0	10	5000
CC		0	0	0	0	0	0	0	66	0	0	0	0	0	0	0	5	95	sp	qu	0	0	0	0	0	0	0	71	71	35500
CC		0	0	0	0	0	5	0	0	0	0	0	0	0	12	0	0	95	sp	qu	0	0	0	0	0	17	0	0	17	8500
CC		39	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	96	sp	qu	52	0	0	0	0	0	0	0	52	26000
CC		2	0	2	0	0	10	0	0	0	0	0	0	0	0	0	0	96	sp	qu	2	0	2	0	0	10	0	0	14	7000
CC		34	0	0	0	0	0	0	68	0	0	0	0	0	0	0	0	96	sp	qu	34	0	0	0	0	0	0	68	102	51000
HW	40	10	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	94	sp	qu	16	0	0	0	0	0	0	0	16	8000
HW	20	0	0	19	1	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	qu	0	0	19	1	0	0	0	0	20	10000
HW	60	17	0	0	9	0	0	0	0	0	0	0	3	0	0	0	0	93	wi	qu	17	0	0	12	0	0	0	0	29	14500
HW		7	0	61	0	0	0	0	0	0	0	14	0	0	0	0	0	95	wi	qu	7	0	75	0	0	0	0	0	82	41000
HW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
HW		230	0	49	0	57	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	230	0	49	0	57	0	0	0	336	168000
HW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
HW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
HW		12	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	12	0	0	2	0	0	0	0	14	7000
HW		3	0	24	0	0	0	0	0	0	0	3	0	0	0	0	0	95	sp	qu	3	0	27	0	0	0	0	0	30	15000
HW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
HW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
HW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
HW		0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	96	sp	qu	7	0	0	0	0	0	0	0	7	3500
HW		9	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	96	sp	qu	18	0	0	0	0	0	0	0	18	9000
HW		0	0	70	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	70	0	0	0	0	0	70	35000
HW		0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	96	sp	qu	9	0	0	0	0	0	0	0	9	4500
HW		1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	96	sp	qu	3	0	0	0	0	0	0	0	3	1500
HW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
HW		2	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	96	sp	qu	2	0	0	0	0	0	0	16	18	9000
MW	60	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	94	sp	qu	3	0	0	0	0	0	0	0	3	1500
MW	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	94	sp	qu	0	0	0	0	0	0	0	0	0	0
MW	10	17	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	94	sp	qu	30	0	0	0	0	0	0	0	30	15000
MW	50	34	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	94	sp	qu	55	0	0	0	0	0	0	0	55	27500
MW	40	25	0	0	78	0	0	0	0	0	0	0	9	0	0	0	0	93	wi	qu	25	0	0	87	0	0	0	0	112	56000
MW	75	48	0	0	15	0	0	0	0	6	0	2	0	0	0	0	0	93	wi	qu	54	0	2	15	0	0	0	0	71	35500
MW	95		0	45	0	0	0	0	0	0	0	0	0	0	0	0	0	93	wi	qu	0	0	45	0	0	0	0	0	45	22500
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
MW		5	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	95	wi	qu	11	0	0	0	0	0	0	0	11	5500
MW		4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	4	0	0	0	0	0	0	0	4	2000
MW		0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	2	0	0	0	0	0	2	1000
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
MW		40	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	95	wi	qu	43	0	0	0	0	0	0	0	43	21500
MW		15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	15	0	0	0	0	0	0	0	15	7500
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
MW		4	0	0	0	1	0	0	3	0	0	0	3	0	0	0	11	95	wi	qu	4	0	0	3	1	0	0	14	22	11000
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
MW		7	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	95	sp	qu	10	0	0	0	0	0	0	0	10	5000
MW		5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	5	0	0	0	0	0	0	0	5	2500

Overstory	Crown	Unbrowsed								Browsed											Totals									
SW,HW,MW,CC	Closure	Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Year	Season	Location	Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Totals	Total/ha
MW		0	0	0	0	7	0	0	0	0	0	0	0	1	0	0	0	95	sp	qu	0	0	0	0	8	0	0	0	8	4000
MW		4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	95	sp	qu	8	0	0	0	0	0	0	0	8	4000
MW		0	0	2	0	0	0	0	0	0	0	10	0	0	0	0	0	95	sp	qu	0	0	12	0	0	0	0	0	12	6000
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	19	0	0	0	0	0	0	0	3	0	0	0	0	0	95	sp	qu	0	0	22	0	0	0	0	0	22	11000
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	8	0	0	0	0	0	0	0	8	4000
MW		3	0	0	0	0	0	0	11	1	0	0	3	1	0	0	14	95	sp	qu	4	0	0	3	1	0	0	25	33	16500
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	2	0	0	0	0	0	0	0	2	1000
MW		0	0	0	0	41	0	0	0	1	0	0	0	0	0	0	0	96	sp	qu	1	0	0	0	41	0	0	0	42	21000
MW		0	0	34	0	0	0	0	0	0	0	25	0	0	0	0	0	96	sp	qu	0	0	59	0	0	0	0	0	59	29500
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	36	0	0	0	0	0	0	0	2	0	0	0	0	0	96	sp	qu	0	0	38	0	0	0	0	0	38	19000
MW		15	0	0	0	0	0	0	0	26	0	0	0	0	0	0	0	96	sp	qu	41	0	0	0	0	0	0	0	41	20500
MW		0	0	10	0	0	0	0	0	0	0	18	0	0	0	0	0	96	sp	qu	0	0	28	0	0	0	0	0	28	14000
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
MW		0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	14	14	7000
SW	30	20	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	94	sp	qu	32	0	0	0	0	0	0	0	32	16000
SW	65	22	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	94	sp	qu	25	0	0	0	0	0	0	0	25	12500
SW	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	94	sp	qu	0	0	0	0	0	0	0	0	0	0
SW	10	13	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	94	sp	qu	21	0	0	0	0	0	0	0	21	10500
SW	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	94	sp	qu	0	0	0	0	0	0	0	0	0	0
SW	60	5	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	94	sp	qu	10	0	0	0	0	0	0	0	10	5000
SW	6	4	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	94	sp	qu	9	0	0	0	0	0	0	0	9	4500
SW	25	8	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	94	sp	qu	20	0	0	0	0	0	0	0	20	10000
SW	90	0	0	16	0	0	0	0	0	0	0	1	0	0	0	0	0	93	wi	qu	0	0	17	0	0	0	0	0	17	8500
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		5	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	5	0	4	0	0	0	0	0	9	4500
SW		0	0	0	0	99	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	99	0	0	0	99	49500
SW		0	0	0	0	0	0	0	-8	-0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		9	0	91	0	0	0	0	0	0	0	35	0	0	0	0	0	95	wi	qu	9	0	126	0	0	0	0	0	135	67500
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0

Overstory	Crown	Unbrowsed								Browsed								Year	Season	Location	Totals								Totals	Total/ha
SW,HW,MW,CC	Closure	Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech				Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech		
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	398	0	0	0	0	0	0	0	3	0	0	0	0	0	95	wi	qu	0	0	399	0	0	0	0	0	399	199500
SW		0	0	8	3	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	8	3	0	0	0	0	11	5500
SW		0	0	98	134	11	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	98	134	11	0	0	0	243	121500
SW		0	0	98	0	4	0	0	0	0	0	0	0	4	0	0	0	95	wi	qu	0	0	98	0	8	0	0	0	106	53000
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	2	0	0	0	0	0	0	0	6	0	0	0	95	wi	qu	0	0	0	0	8	0	0	0	8	4000
SW		2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	2	0	0	0	0	0	0	0	2	1000
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	wi	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	20	0	0	0	0	0	0	0	20	10000
SW		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	1	0	0	0	0	0	0	0	1	500
SW		0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	3	0	0	0	3	1500
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		8	0	4	0	0	0	0	0	1	0	0	0	0	0	0	0	95	sp	qu	9	0	4	0	0	0	0	0	13	6500
SW		10	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	95	sp	qu	21	0	0	0	0	0	0	0	21	10500
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		3	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	95	sp	qu	16	0	0	0	0	0	0	0	16	8000
SW		4	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	95	sp	qu	11	0	0	0	0	0	0	0	11	5500
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	95	sp	qu	4	0	0	0	0	0	0	0	4	2000
SW		33	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	95	sp	qu	36	0	0	0	0	0	0	0	36	18000
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	45	16	0	0	0	0	0	0	0	6	0	0	0	95	sp	qu	0	0	0	45	22	0	0	0	67	33500
SW		0	0	15	0	46	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	15	0	46	0	0	0	61	30500
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	8	0	0	0	0	0	0	0	5	0	0	0	95	sp	qu	0	0	0	0	13	0	0	0	13	6500
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0

Overstory	Crown	Unbrowsed								Browsed											Totals									
SW,HW,MW,CC	Closure	Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Year	Season	Location	Rm	Ta	WH	Oak	Raisin	Birch	Hobble	Beech	Totals	Total/ha
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		12	0	11	0	0	0	0	0	7	0	0	0	0	0	0	0	96	sp	qu	19	0	11	0	0	0	0	0	30	15000
SW		22	0	48	0	0	0	0	0	0	0	7	0	0	0	0	0	96	sp	qu	22	0	55	0	0	0	0	0	77	38500
SW		0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	96	sp	qu	1	0	0	0	0	0	0	0	1	500
SW		0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	96	sp	qu	2	0	0	0	0	0	0	0	2	1000
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		71	0	35	22	0	0	0	0	1	0	0	5	0	0	0	0	96	sp	qu	72	0	35	27	0	0	0	0	134	67000
SW		0	0	82	0	0	0	0	0	6	0	43	0	0	0	0	0	96	sp	qu	6	0	125	0	0	0	0	0	131	65500
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		7	0	41	0	0	0	0	0	1	0	19	0	0	0	0	0	96	sp	qu	8	0	60	0	0	0	0	0	68	34000
SW		3	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	96	sp	qu	9	0	0	0	0	0	0	0	9	4500
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		26	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	96	sp	qu	34	0	0	0	0	0	0	0	34	17000
SW		23	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	96	sp	qu	27	0	0	0	0	0	0	0	27	13500
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	96	sp	qu	4	0	0	0	0	0	0	0	4	2000
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	9	0	0	0	0	0	0	0	9	4500
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	5	5	2500
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0
SW		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	sp	qu	0	0	0	0	0	0	0	0	0	0

APPENDIX III

Table 1. Wilcoxon paired-sample test to determine whether the total number of stems is the same in Queens as in Cape Breton.

Z (calculated)	$t_{0.05(2),\infty}$	p-value
6.997	1.96	0

Reject Ho = total number of stems is the same in Queens as in Cape Breton.

Table 2. Kruskal-Wallis test to determine whether there is a difference in number of stems among species.

Area	H (calculated)	H 0.05,5 & 6 (x^2)	df	p	Conclusion
Queens	9.604	11.07	5	0.0873	Accept Ho
Cape Breton	17.782	12.592	6	0.0068	Accept Ho

Ho = total number of stems is the same among species.

Table 3. Kruskal-Wallis test to determine whether there is a difference in number of stems among cover types.

Area	H (calculated)	H 0.05,3 (x^2)	df	p	Conclusion
Queens	21.681	7.815	3	0.0001	Reject Ho
Cape Breton	14.795	7.815	3	0.002	Reject Ho

Ho = total number of stems is the same among cover types

Table 4. Nonparametric Tukey-type multiple comparisons to identify the differences in the total number of stems among cover types in the Queens county study area.

Comparison	Difference in Means	SE	Q (Diff/SE)	Q 0.05,4	Conclusion
1 vs 2	50.538	24.696	2.046	2.639	Reject Ho
1 vs 3	72.395	22.242	3.255	2.639	Reject Ho
1 vs 4	82.630	21.573	3.830	2.639	Reject Ho
2 vs 3	21.858	15.275	1.431	2.639	Accept Ho
2 vs 4	32.092	14.284	2.247	2.639	Accept Ho
3 vs 4	10.235	9.426	1.086	2.639	Accept Ho

Ho = total number of stems is the same among cover types.

cc = 1 hw = 2 mw = 3 sw = 4

Table 5. Nonparametric Tukey-type multiple comparisons to identify the differences in the total number of stems among cover types in the Cape Breton study area.

Comparison	Difference in Means	SE	Q (Diff/SE)	Q 0.05,4	Conclusion
1 vs 3	8.160	14.032	0.582	2.639	Accept Ho
1 vs 2	25.108	15.818	1.587	2.639	Accept Ho
1 vs 4	39.208	14.316	2.739	2.639	Reject Ho
3 vs 2	16.947	11.300	1.500	2.639	Accept Ho
3 vs 4	31.047	9.080	3.419	2.639	Reject Ho
2 vs 4	14.100	11.651	1.210	2.639	Accept Ho

Ho = total number of stems is the same among cover types.
cc = 1 hw = 2 mw = 3 sw = 4

Table 6. Two-sample t-test with unequal variances to determine if there is a difference in mass of browsed stems in Queens versus Cape Breton.

	Queens	*Cape Breton*
Mean	0.052	0.391
Variance	0.002	0.090
Observations	1198	565
df	574	
t (calculated)	26.755	
t 0.05(2), 574	1.964	

Reject Ho = mean mass of browsed twigs is the same in Queens and Cape Breton.

Table 7. ANOVA test to determine if there is a difference in mean mass of browsed stems among cover types for Cape Breton.

	df	sum of squares	mean of squares	F (calculated)	F 0.05(1),1,563
cover	1	0.094	0.0940	1.645	3.85
residuals	563	50.577	0.0898		

Accept Ho = mean mass of browsed stems is the same for all cover types

Table 8. ANOVA test to determine if there is a difference in mean mass of browsed stems among cover types for Queens.

	df	sum of squares	mean of squares	F (calculated)	F 0.05(1),1,1196
cover	1	0.001	0.001	0.599	3.84
residuals	1196	1.976	0.002		

Accept Ho = mean mass of browsed stems is the same for cover types

Table 9. ANOVA test to determine if there is a difference in mean mass of browsed stems among species for Cape Breton.

	df	sum of squares	mean of squares	F (calculated)	F 0.05(1),1,563
species	1	1.067	1.063	12.114	3.85
residuals	563	49.604	0.088		

Reject Ho = mean mass of browsed stems is the same for both species

Table 10. ANOVA test to determine if there is a difference in mean mass of browsed stems among species for Queens.

	df	sum of squares	mean of squares	F (calculated)	F 0.05(1),1,1196
species	1	0.588	0.588	506.328	3.84
residuals	1196	1.389	0.001		

Reject Ho = mean mass of browsed stems is the same for all species

Table 11. Tukey test to determine what the differences are in the mean mass of browsed stems among species in Queens.

Comparison	Difference in Means	SE	q (Diff/SE)	q 0.05,400,3	Conclusion
4 vs 1	0.062	0.002	36.567	3.314	Reject Ho
4 vs 3	0.063	0.002	36.906	3.314	Reject Ho
1 vs 3	0.001	0.002	0.339	3.314	Accept Ho

Ho = mean mass of browsed stems is the same between species.

Red Maple =1 Witch Hazel = 3 Red Oak = 4

Table 12. Two-sample t-test with unequal variances to determine a difference in mean mass of current annual increment in Queens versus Cape Breton.

	Queens	*Cape Breton*
Mean	0.481	0.513
Variance	0.517	0.129
Observations	238	128
df	362	
t (calculated)	0.564	
t 0.05(2), 362	1.967	

Accept Ho = mean mass of current annual increment is the same in Queens and Cape Breton.

Table 13. ANOVA test to determine if there is a difference in mean mass of current annual increment among cover types for Queens and Cape Breton combined.

	df	sum of squares	mean of squares	F (calculated)	F 0.05(1),1,365
cover	1	16.918	16.918	21.531	3.87
residuals	365	286.798	0.786		

Reject Ho = mean mass of current annual increment is the same for all cover types

Table 14. ANOVA test to determine if there is a difference in mean mass of current annual increment among species for Queens and Cape Breton combined.

	df	sum of squares	mean of squares	F (calculated)	F 0.05(1),1,365
species	1	7.875	7.875	9.715	3.87
residuals	365	295.842	0.811		

Reject Ho = mean mass of current annual increment is the same for all species

Table 15. Tukey test to determine what the differences are in the mean mass of current annual increment among cover types.

Comparison	Difference in rank means	SE	q (Diff/SE)	q 0.05,365,4	Conclusion
4 vs 1	0.546	0.086	6.378	3.633	Reject Ho
4 vs 2	0.536	0.087	6.147	3.633	Reject Ho
4 vs 3	0.483	0.103	4.675	3.633	Reject Ho
3 vs 1	0.062	0.105	0.597	3.633	Accept Ho
3 vs 2	0.052	0.106	0.495	3.633	Accept Ho
2 vs 1	0.010	0.088	0.113	3.633	Accept Ho

Ho = mean mass of current annual increment is the same between cover types
mw = 1 sw = 2 hw = 3 regen = 4

Table 16. Tukey test to determine what the differences are in the mean mass of current annual increment among species.

Comparison	Difference in Rank Means	SE	q (Diff/SE)	q 0.05,365,4	Conclusion
3 vs 1	1.033	0.116	8.888	3.858	Reject Ho
3 vs 4	0.951	0.116	8.174	3.858	Reject Ho
3 vs 2	0.834	0.128	6.514	3.858	Reject Ho
3 vs 5	0.579	0.130	4.459	3.858	Reject Ho
5 vs 1	0.454	0.105	4.306	3.858	Reject Ho
5 vs 4	0.372	0.106	3.525	3.858	Accept Ho
5 vs 2	0.255	0.118	2.155	3.858	Accept Ho
2 vs 1	0.199	0.103	1.929	3.858	Accept Ho
2 vs 4	0.117	0.103	1.134	3.858	Accept Ho
4 vs 1	0.082	0.088	0.927	3.858	Accept Ho

Ho = mean mass of current annual increment is the same between species.
Wild Raisin = 1 Red Maple = 2
Red Oak = 3 Witch Hazel = 4
Aspen = 5

Table 18. Statistical summary of number of woody stems grouped by age (mature versus regenerating) in Queens.

Age group	Mean	SE of the Mean
Mature (mw,sw,hw)	8515.31	1675.49
Regenerating (cc)	61437.5	39757.80

Table 19. Statistical summary of number of woody stems grouped by cover type and age in Cape Breton.

Cover Type / Age	Mean	SE of the Mean
Mixedwood	31472.60	8539.00
Softwood	8941.67	1659.85
Hardwood	16616.67	5456.24
Cutover	45264.71	17649.21

Table 20. Statistical summary of mass of current annual increment grouped by cover type and age in both areas combined

Cover Type / Age	Mean	SE of the Mean
Mature (mw,sw,hw)	0.37	0.02
Regenerating (cc)	1.17	0.22

Table 21. Statistical summary of mass of current annual increment grouped by species in both areas combined

Species	Mean	SE of the Mean
1	0.24	0.02
5	0.69	0.06
2 & 4	0.39	0.02
3	1.27	0.26

Wild Raisin = 1 Red Maple = 2 Red Oak = 3 Witch Hazel= 4 Aspen = 5

Table 22. Mean mass of browsed portion of stem grouped by study area all cover types combined.

Area	Mean	SE of the Mean
Queens (all cover types)	0.05	0.001
Cape Breton (all cover types)	0.39	0.01

APPENDIX IV

DATE_______BY_______________

SAMPLE TREES

Tree No.	1	2	3	4	5
Species					
Point No.					
Age					
Total Height					
D.B.H.					

Tree No.	8	9	10	11	12
Species					
Point No.					
Age					
Total Height					
D.B.H.					

Tree No.	15	16	17	18	19
Species					
Point No.					
Age					
Total Height					
D.B.H.					

POINT SAMPLE TALLY SHEET

M.U.___TWP.___RGE.___

SECTION___STD. NO.___C.L. NO.___

SHEET NO.___OF___

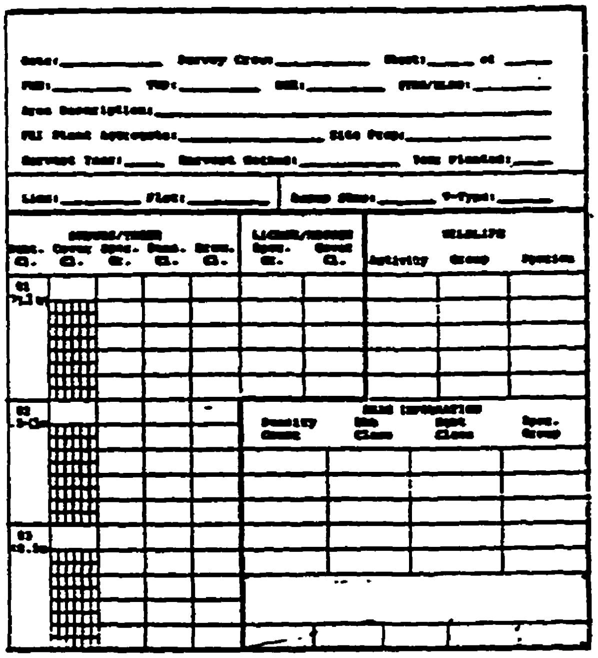
DATE_______BY_______________

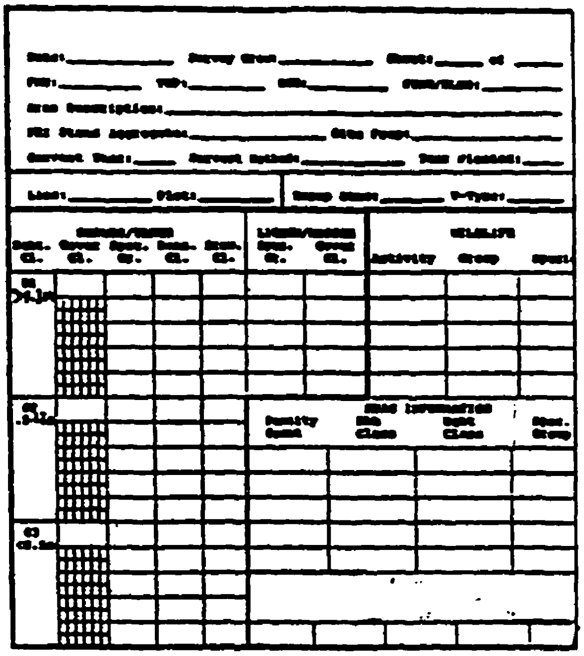
SAMPLE TREES

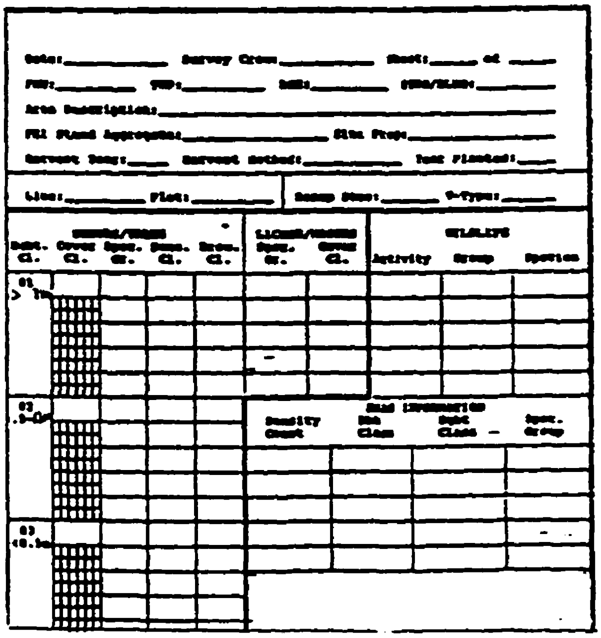
Tree No.	1	2	3	4	5	6	7
Species							
Point No.							
Age							
Total Height							
D.B.H.							

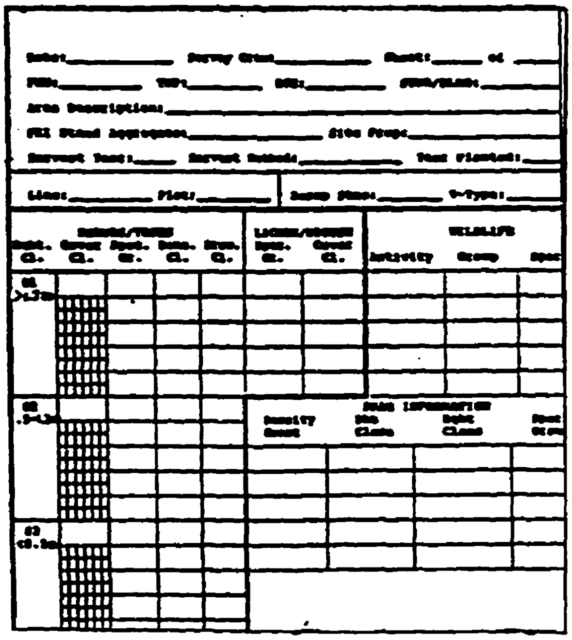
Tree No.	8	9	10	11	12	13	14
Species							
Point No.							
Age							
Total Height							
D.B.H.							

Tree No.	15	16	17	18	19	20	21
Species							
Point No.							
Age							
Total Height							
D.B.H.							


Survey Crew
Sheet: of
Activity
Species
Density
Class
Group


Survey Crew
Sheet: of
Activity
Density
Class
Group


Survey Crew
Sheet: of
Activity
Density
Class
Group


Survey Crew
Sheet: of
Activity
Density
Class

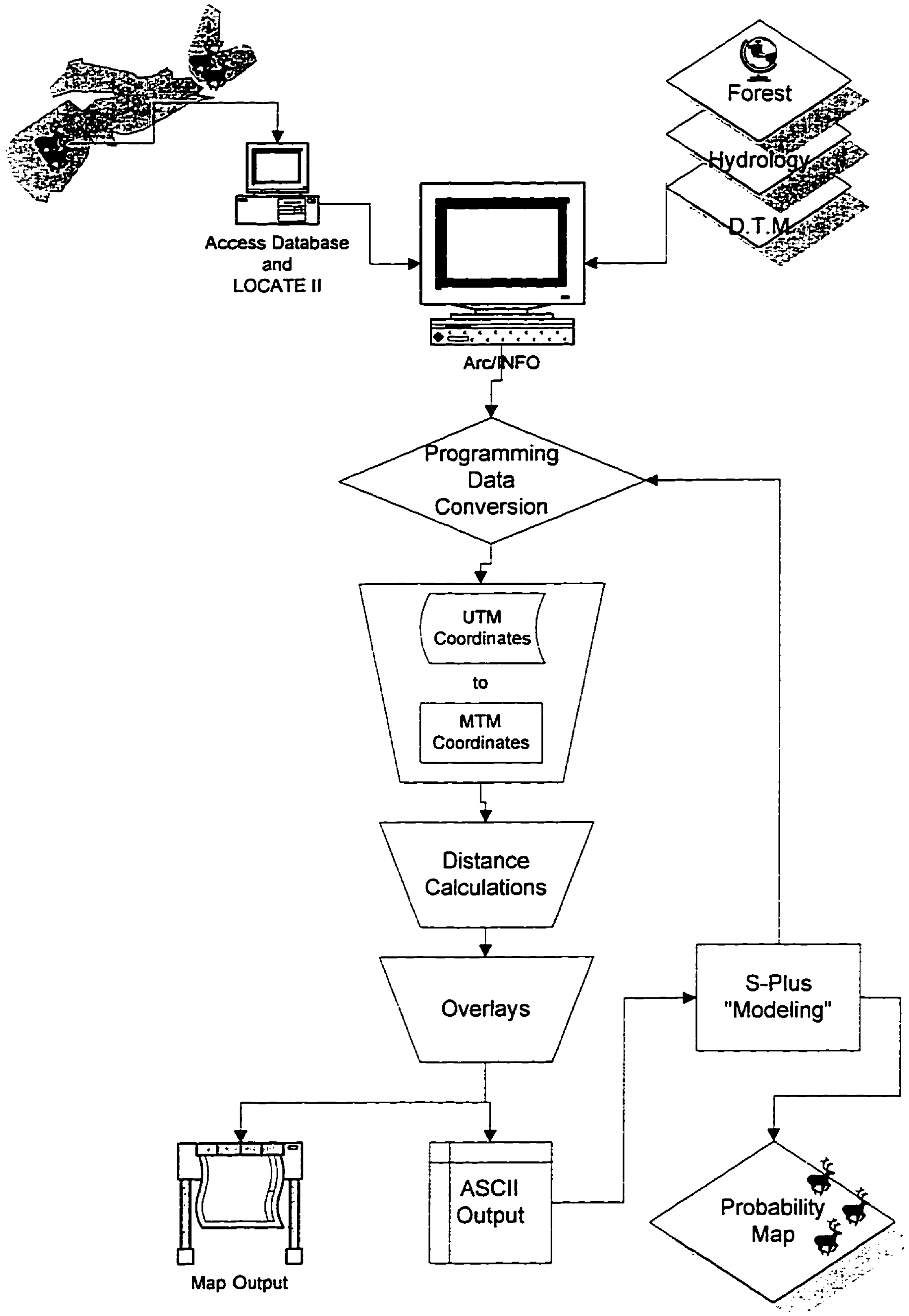
Stand No.________

Point Sample No.

TREE COUNT BY SPECIES AND D.B.H. CLASS

D.B.H.	WP	BS	BF	WS	RS	HE	L	TA	LA	WB	RM	SM	YB	BE	RP	Other
2																
4																
6																
8																
10																
12																
14																
16																
18																
20																
22																
24																
26																
28																
30																
32																
34																
36																
38																
40																
42																
44																
46																
48																
50																
52																
54																
56																
58																
60+																
TOT.																

APPENDIX V


Forest
Hydrology
D.T.M.
Access Database
and
LOCATE II
Arc/INFO
Programming
Data
Conversion
UTM
Coordinates
to
MTM
Coordinates
Distance
Calculations
Overlays
S-Plus
"Modeling"
Map Output
ASCII
Output
Probability
Map

APPENDIX VI

LOCAL VARIABLES

1) Total number of trees per hectare, regardless of species. (TOTALSTEMS)
2) Total number of softwood trees per hectare. (TOTALSOFTS)
3) Number of different overstory tree species in stand. (NUMBSPECIE)
4) Average diameter at breast height for all species pooled in centimeters. (AVEDBHALL)
5) Range of diameter at breast height, in centimeters. (DBHRANGEAL)
6) Number of trees per hectare with lichen. (LICHENTREE)
7) Average distance in meters from sample point to the nearest conifer tree (NCAVERAGE)
8) Range of nearest conifer distances within a stand (NCRANGE)
9) Stand age in years as determined with increment core (NEWAGE)
10) Height in meters as determined by clinometer (HEIGHTAVER)
11) Crown closure, determined with spherical densiometer (CROWN)
12) Number of hare pellets per hectare (RABBITSCAT)
13) Number of hare browsed twigs per hectare (RABBITBROW)
14) Proportion of sample plots which had a hare trail running through them (RABBITTRAI)
15) Proportion of sample plots with evidence of squirrels (SQUIRREL)
16) Type of soil in the stand (SOILTYPE)
17) Depth of the litter layer in centimeters (LFH)
18) Number of unique moss species present in the stand (MOSSSPECIE)
19) Average percent of ground covered by moss (MOSSCOVER)
20) Distribution of moss cover in a stand -none, patchy, homogeneous(MOSSDIST)
21) Number of understory species present that are greater than 1.3 meters in height (UNDERSPECA)
22) Average percent canopy cover of understory species with heights greater than 1.3 meters (UNDERCOVA)
23) Distribution of understory species greater than 1.3 meters high - none, patchy, homogeneous (UNDERDISTA)
24) Number of understory species present that are between 0.5 and 1.3 meters in height (UNDERSPECB)
25) Average percent canopy cover of understory species between 0.5 and 1.3 meters height (UNDERCOVB)
26) Distribution of understory species between 0.5 and 1.3 meters in height - none, patchy, homogeneous (UNDERDISTB)
27) Number of understory species present that are less than 0.5 meters in height (UNDERSPECC)
28) Average percent ground cover of understory species with heights less than 0.5 meters (UNDERCOVC)
29) Distribution of understory species less than 0.5 meters high - none, patchy, homogeneous (UNDERDISTC)

LANDSCAPE VARIABLES

1) Crown closure in percent. (CRNCL)
2) Common forest species types - 22 types. (SPSCD)
3) Stand area in hectares. (HECTARES)
4) Average stand height in meters. (HEIGHT)
5) Second story stand crown closure, in percent. (SS-CRNCL)
6) Site capability, in cubic meters per hectare per year. (SITE)
7) Edge to area ratio -total stand perimeter divided by total area. (RATIO)
8) Stand coniferous canopy closure. (SCCC) (Sabine 1994)
9) Average slope in percent. (SLOPE)
10) Aspect of stand - N, NE, E, SE, S, SW, W, NW. (ASPECT)
11) Elevation in meters. (ELEV)
12) Proximity to a stand with high SCCC. (PCCC) (Sabine 1994)
13) Distance from deer location to nearest hydrological feature. (WATER)
14) Distance from deer location to nearest agricultural field. (AGRI)
15) Distance from deer location to nearest road. (ROAD)
16) Distance from deer location to nearest to cut less than 10 years old. (CUT)
17) Distance from deer location to nearest softwood/hardwood edge. (SWHW)
18) Distance from deer location to nearest softwood/mixedwood edge. (SWMW)
19) Distance from deer location to nearest hardwood/mixedwood edge. (HWMW)
20) Neighborhood stand coniferous canopy closure. (NCCC) (Sabine 1994)
21) Number of unique SPSCD types within 300m radius of deer location. (DIVERSITY)
22) Cover type - hardwood, mixedwood, softwood. (COVER)

APPENDIX VII

Table 1. Results of Mann-Whitmey test for local level variables for Cape Breton

Variables	Mann- Whitmey Test Statistic	p-value	df	Table Value p=0.05, df=1	Ho=same in DC and NDC
slope*	1.1047	0.2693	1	1.960	Accept
aspect*	2.788	0.0053	1	1.960	Reject
water**	321	0.6048	1	190	Reject
road**	348	0.1349	1	190	Reject
cut**	240	0.0164	1	190	Reject
agri**	284	0.4421	1	190	Reject
div*	0.2929	0.7696	1	1.960	Accept
rabbitscat*	-4.3815	0	1	1.960	Reject
rabbitbrow*	-3.6662	0.0002	1	1.960	Reject
rabbittrai*	-0.8159	0.4145	1	1.960	Accept
squirrel*	-0.6399	0.5222	1	1.960	Accept
soiltype*	3.4252	0.0006	1	1.960	Reject
lfh*	-4.0157	0.0001	1	1.960	Reject
mossspecie*	0.7209	0.471	1	1.960	Accept
mosscover*	-0.7912	0.4288	1	1.960	Accept
mossdist*	0.0771	0.9385	1	1.960	Accept
allcover*	0.4722	0.6368	1	1.960	Accept
numbspecie*	-0.202	0.8399	1	1.960	Accept
swratio*	-0.0542	0.9567	1	1.960	Accept
avedbhall*	-0.0725	0.9422	1	1.960	Accept
dbhrangeal*	-1.6938	0.0903	1	1.960	Accept
lichentree*	0.2354	0.8139	1	1.960	Accept
ncrange*	-0.5507	0.5818	1	1.960	Accept
ncaverage*	0.7192	0.472	1	1.960	Accept
crown*	-2.8397	0.0045	1	1.960	Reject
hectares*	0.1266	0.8992	1	1.960	Accept

Table 2. T-test results for local scale variables for Cape Breton Ho = same in DC and NDC

						X means	Y means	CI x	CI y
Variables	t-test	p-value	df	Table t=.05(2),31		DC	NDC	DC	NDC
newage	0.751	0.4583	31	2.04	accept	62.944	57.533	-9.28	20.106
heightaver	2.316	0.0273	31	2.04	reject	14.13	11.49	0.3151	4.9648
totalstems	-0.1508	0.8811	31	2.04	accept	41.5	43.2	-24.69	21.29
hectares	0.2119	0.8336	31	2.04	accept	6.45	6.06	-3.353	4.131
water	0.781	0.4408	31	2.04	accept	160.71	134.409	-42.38	94.987
road	2.1317	0.0411	31	2.04	reject	311.335	176.228	5.84	264.37
cut	-2.7367	0.0102	31	2.04	reject	341.555	522.597	-315.96	-46.1222
agri	-0.5447	0.5898	31	2.04	accept	436.25	477.399	-195.21	112.917

Table 3. Results of Mann-Whitney test for landscape level variables in Cape Breton

Variables	Mann-Whitney Test Statistic	p-value	df	Table Value p=0.05, df=1	Ho=same in DC and NDC
slope*	3.9028	0.0001	1	1.960	Reject
aspect*	5.2774	0	1	1.960	Reject
elevation*	-11.415	0	1	1.960	Reject
pccc*	9.935	0	1	1.960	Reject
nccc*	5.4328	0	1	1.960	Reject
div*	1.8635	0.0624	1	1.960	Accept
crncl*	1.9914	0.0464	1	1.960	Reject
ss.crncl*	-7.1383	0	1	1.960	Reject
covertype*	-1.7564	0.079	1	1.960	Accept
site*	1.9689	0.049	1	1.960	Reject
maturity*	-4.1524	0	1	1.960	Reject
spscd*	2.5709	0.0101	1	1.960	Reject
nspscd*	2.9028	0.0037	1	1.960	Reject
sccc*	1.4426	0.1491	1	1.960	Accept
ratio*	-0.8157	0.4147	1	1.960	Accept

Table 4. T-test results for landscape scale variables for Cape Breton Ho = same in DC and NDC

Variables	t-test	p-value	df	Table t(.05(2), 462)		X means	Y means	CI x	CI y
water	0.7175	0.4734	462	1.965	Accept	149.433	142.147	-12.668	27.2383
road	-8.5622	0	462	1.965	Reject	225.956	427.834	-248.21	-155.55
agri	-10.1361	0	462	1.965	Reject	392.88	603.162	-251.05	-169.51
cut	-7.5056	0	462	1.965	Reject	366.02	555.165	-238.67	-139.62
swhw	4.5701	0	462	1.965	Reject	343.037	252.579	51.5618	129.354
swmw	4.5701	0	462	1.965	Reject	343.037	252.579	51.5618	129.354
hwmw	1.5471	0.1225	462	1.965	Accept	395.026	354.198	-11.03	92.686
height	-2.6411	0.0085	462	1.965	Reject	7.87736	9.4727	-2.7822	-0.4083
hectares	0.0715	0.9431	462	1.965	Accept	13.6318	13.5445	-2.3119	2.48641

Table 5. Results of Mann-Whitney test for local level variables in Queens

Variables	Mann-Whitney Test statistic	p-value	df	Table Value p=0.05, df=1	Ho=same in DC and NDC
slope*	0.2161	0.8289	1	1.960	Accept
aspect*	0.7427	0.4577	1	1.960	Accept
water**	333	0.001	1	271	Reject
road**	446	0.9037	1	271	Reject
cut**	367	0.022	1	271	Reject
agri**	360	0.0127	1	271	Reject
div*	4.7801	0	1	1.960	Reject
rabbitscat*	0.6874	0.4918	1	1.960	Accept
rabbitbrow*	0	1	1	1.960	Accept
rabbittrai*	0	1	1	1.960	Accept
squirrel*	-2.0694	0.0385	1	1.960	Reject
soiltype*	3.5352	0.0004	1	1.960	Reject
lfh*	-0.0956	0.9238	1	1.960	Accept
mossspecie*	-1.7252	0.0845	1	1.960	Accept
mosscover*	0.348	0.7278	1	1.960	Accept
mossdist*	0.6289	0.5294	1	1.960	Accept
allcover*	0.2598	0.795	1	1.960	Accept
numbspecie*	0.0828	0.934	1	1.960	Accept
swratio**	408	0.251	1	271	Reject
avedbhall*	3.3236	0.0009	1	1.960	Reject
dbhrangeal*	1.1462	0.2517	1	1.960	Accept
lichentree*	-0.5527	0.5805	1	1.960	Accept
ncrange*	0.3704	0.7111	1	1.960	Accept
ncaverage*	0.8502	0.3952	1	1.960	Accept
crown*	-1.4654	0.1428	1	1.960	Accept
hectares*	-3.5896	0.0003	1	1.960	Reject

Table 6. T-test results for local scale variables for Queens Ho = same in DC and NDC

Variables	t-test	p-value	df	Table t(.05(2),38)		X mean DC	Y mean NDC	CI x DC	CI y NDC
newage	-0.0114	0.991	38	2.024	Accept	72.09	72.16	-13.57	13.42
heightaver	1.337	0.1891	38	2.024	Accept	17.16	16.16	-0.51	2.506
totalstems	-1.564	0.1259	38	2.024	Accept	44.05	53.611	-21.94	2.809
hectares	-4.106	0.0002	38	2.024	Reject	3.759	7.177	-5.104	-1.733
water	-4.1988	0.0002	38	2.024	Reject	494.98	778.86	-420.74	-147
road	-0.1218	0.9037	38	2.024	Accept	168.67	173.46	-84.38	74.811
cut	-1.51	0.1377	38	2.024	Accept	198.48	247.88	-115.34	16.54
agri	-3.1233	0.0034	38	2.024	Reject	726.21	1060.5	-550.97	-117.61

Table 7. Results of Mann-Whitney test for landscape level variables in Queens.

Variables	Mann-Whitney Test Statistic	p-value	df	Table Value p=0.05, df=1	Ho=same in DC and NDC
slope*	3.008	0.0027	1	1.960	Reject
aspect*	1.3258	0.1849	1	1.960	Accept
elevation*	-6.6084	0	1	1.960	Reject
pccc*	-2.7813	0.0054	1	1.960	Reject
nccc*	-8.6391	0	1	1.960	Reject
div*	8.9849	0	1	1.960	Reject
crncl*	-0.6193	0.5357	1	1.960	Accept
ss.crncl*	-3.0937	0.002	1	1.960	Reject
covertype*	-1.5797	0.1142	1	1.960	Accept
site*	0.3489	0.7272	1	1.960	Accept
maturity*	-3.5409	0.0004	1	1.960	Reject
spscd*	1.3225	0.186	1	1.960	Accept
nspscd*	-1.5665	0.1172	1	1.960	Accept
sccc*	-2.2461	0.0247	1	1.960	Reject
ratio*	-6.2377	0	1	1.960	Reject

Table 8. T-test results for landscape scale variables for Queens Ho = same in DC and NDC

q6land	t-test	p-value	df	Table t(.05(2),948)		X means	Y means	CI x	CI y
water	-6.2457	0	948	1.96	Reject	326.42	435.0097	-142.7	-74.4658
road	-25.1619	0	948	1.96	Reject	133.017	399.374	-287.131	-245.58
agri	-9.593	0	948	1.96	Reject	243.3567	365.2609	-146.84	-96.9669
cut	-14.0017	0	948	1.96	Reject	572.5735	913.8135	-389.068	-293.412
swhw	7.264	0	948	1.96	Reject	235.0389	153.638	59.40199	103.3798
swmw	-9.5934	0	948	1.96	Reject	243.3567	365.2609	-146.842	-96.9669
hwmw	-6.808	0	948	1.96	Reject	244.5735	357.9313	-146.03	-80.6813
height	-4.5597	0	948	1.96	Reject	12.23234	13.7894	-2.22227	-0.88494
hectares	0.06567	0.5115	948	1.96	Accept	10.981	10.3722	-1.21052	2.428123

* Test statistic = Z and Critical value = $t_{0.05(2),\infty}$ (Zar 1984)

** Test statistic = U and Critical value = Mann-Whitney $U_{0.05(2),n1,n2}$ (Zar 1984)

APPENDIX VIII

> cmland

Call: glm(formula = DEER ~ ELEVATION + SS.CRNCL + SITE4 + SITE5 + PCCC, family = binomial, data = c8.land)

Coefficients:

(Intercept)	ELEVATION	SS.CRNCL	SITE4	SITE5	PCCC
1.728697	-1.604572	-0.5559375	-0.7096205	4.691137	6.834078

Degrees of Freedom: 424 Total; 418 Residual

Residual Deviance: 106.1613

Analysis of Deviance Table

Binomial model

Response: DEER

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			423	527.4670	
ELEVATION	1	210.0472	422	317.4198	0.00000e+000
SS.CRNCL	1	108.9298	421	208.4900	0.00000e+000
SITE4	1	39.6957	420	168.7943	2.96770e-010
SITE5	1	33.9925	419	134.8017	5.53242e-009
PCCC	1	28.6404	418	106.1613	8.71446e-008

> qmland

Call: glm(formula = DEER ~ sqrt(CUT) + SWHW + DIV + WATER + ELEVATION + SLOPE1.3 + ASPECT13 + SLOPE1.5 + sqrt(AGRI) + SWMW +NSPSCD.2 + NSPSCD.3 + sqrt(NCCC), family = binomial, data = q6.land)

Coefficients:

(Intercept)	sqrt(CUT)	SWHW	DIV	WATER	ELEVATION	SLOPE1.3	ASPECT13	SLOPE1.5	sqrt(AGRI)
11.17947	-0.1927992	0.00525276	0.4406453	0.003126887	-0.16206	-0.6429057	1.212181	0.9930625	-0.6364231

SWMW	NSPSCD.2	NSPSCD.3	sqrt(NCCC)
0.01522418	-1.549306	-2.184566	-0.1537787

Degrees of Freedom: 946 Total; 932 Residual

Residual Deviance: 747.3905

Analysis of Deviance Table

Binomial model

Response: DEER

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			945	1195.313	
sqrt(CUT)	1	195.7326	944	999.581	0.00000000
SWHW	1	58.1980	943	941.383	0.00000000
DIV	1	58.0236	942	883.359	0.00000000
WATER	1	23.1632	941	860.196	0.00000149
ELEVATION	1	24.5347	940	835.662	0.00000073
SLOPE1.3	1	14.7243	939	820.937	0.00012443
ASPECT13	1	11.2632	938	809.674	0.00079058
SLOPE1.5	1	8.7056	937	800.968	0.00317233
sqrt(AGRI)	1	5.5457	936	795.423	0.01852651
SWMW	1	12.4154	935	783.007	0.00042581
NSPSCD.2	1	18.8045	934	764.203	0.00001448
NSPSCD.3	1	6.3102	933	757.893	0.01200484
sqrt(NCCC)	1	10.5022	932	747.391	0.00119230

>qmlocal
Call:glm(formula = DEER ~ DIV, family = binomial, data = q3.local, maxit = 100)

Coefficients:
(Intercept) DIV
-55.69764 11.0276

Degrees of Freedom: 39 Total; 37 Residual
Residual Deviance: 14.4212

Analysis of Deviance Table
Binomial model
Response: DEER
Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			38	53.83448	
DIV	1	39.41328	37	14.42120	3.429563e-010

> cmlocal
Call: glm(formula = DEER ~ ASPECT1 + ASPECT2 + ASPECT4, family = binomial, data = cfix, maxit = 100)

Coefficients:
(Intercept) ASPECT1 ASPECT2 ASPECT4
1.386294 -10.58903 -5.294515 -0.4184941

Degrees of Freedom: 29 Total; 25 Residual
Residual Deviance: 24.5742
Analysis of Deviance Table
Binomial model
Response: DEER
Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			28	40.16805	
ASPECT1	1	6.516657	27	33.65139	0.01068687
ASPECT2	1	6.128359	26	27.52303	0.01330303
ASPECT4	1	2.948834	25	24.57420	0.02593956