WHITE-TAILED DEER MOVEMENTS, HABITAT USE, AND BROWSING EFFECTS ON VEGETATION IN THE UPPER PENINSULA OF MICHIGAN

By

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ABSTRACT

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Habitat use and movement patterns of 61 white-tailed deer (Odocoileus virginianus) were monitored in the Whitefish River Basin (WRB) and Stonington Peninsula (SP) in the Hiawatha National Forest (HNF) during 1993 and 1994. Home ranges were calculated. Vegetation types used by deer were compared to availability determined with Landsat thematic mapper data and ARC/INFO. Relative productivity of deer in the 2 study areas was compared. A long-term exclosure study was initiated to quantify the effects of deer on the northern white-cedar (Thuja occidentalis) forest type; baseline vegetation characteristics of the cedar stands were measured. Spring/summer mean home range size for WRB and SP deer was 640.9 ha and 89.8 ha, respectively. Vegetation types were not used in proportion to availability; selected types were aspen/birch, mixed pine, and white-cedar (Thuja occidentalis). Types with high percentages (>15%) of use included northern hardwoods, wet hardwood/conifer mix, and lowland conifers. Productivity estimates were not different (P>0.10) between the 2 study areas. Vegetation types selected by deer should be maintained throughout the landscape to help reduce the possibility of high concentrations of deer and possible impacts on plant communities.

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INTRODUCTION

Forests and white-tailed deer (Odocoileus virginianus) are valuable natural resources in Michigan. Forests cover approximately 7.5 million ha in Michigan and provide recreation, timber products, and habitat for wildlife. Of the 7.5 million ha of forest land, 7.1 million ha has been classified as commercial forest land and is available for the above uses depending on the owner's objectives (Michigan Department of Natural Resources 1983).

Forest lands in Michigan are important economically because of their recreation and timber value. Approximately 8.1 million people used state forests in 1976 (Michigan Department of Natural Resources 1977) and Michigan's national forests had 4,916,400 visitor-days in 1990 (U.S.D.A. Forest Service 1990). Michigan's raw timber products were valued at $310.6 million in 1992 (Potter-Witter 1995). Michigan's Forest Resources Plan (Michigan Department of Natural Resources 1983) set targets for forest outputs by 2000 at 138 million user-activity days for wildlife, fish, and other recreational activities and approximately 14 million cubic meters for timber harvests.

Forest wildlife, the most well-known probably being the white-tailed deer, has both consumptive and nonconsumptive users throughout the United States. Williamson and Doster (1981) estimated the capitalized value of white-tailed deer in the United States to be approximately $27.3 billion or approximately $1,657 per animal.

In Michigan, there were an estimated 1.6 to 1.8 million deer in October, 1992 (Michigan Department of Natural Resources 1992). Approximately 1,250,000 deer hunters spent over $400 million during all 3 deer hunting seasons in 1992 (Michigan Department of Natural Resources 1992). Nationally, the values received by hunters is estimated at $1.8 billion (Williamson and Doster 1981). Langenau (1979) found 3 times more people in Michigan participated in nonhunting activities than the number who hunted deer. The estimated value of benefits received by nonhunters from the national deer herd is substantial--approximately $5.4 billion annually (Williamson and Doster 1981).

Forest lands and white-tailed deer numbers have undergone dramatic changes during the past 150 years (Blouch 1984). Mature forests covered the state until the mid-19th century; correspondingly, white-tailed deer numbers were very low. Extensive logging in the Great Lakes states in the last half of the 19th century created more favorable habitat for deer and their numbers increased. Excessive hunting and repeated wildfires resulted in low deer numbers by the early 1900s. Regeneration of large cutover and burned areas began by the 1930s and 1940s and deer numbers once again increased. This cycle of forest-white-tailed deer interaction has provided biologists with valuable information for the management of forest ecosystems. As forests mature, setting back succession is required to maintain optimal habitat conditions for white-tailed deer throughout its range.

With the passage of the Multiple Use-Sustained Yield Act of 1960, national forest managers are required to manage for multiple uses of "recreation, range, timber, watershed, and wildlife and fish purposes" (Hunter 1990). With these policy requirements, land management decisions on national forest lands must be oriented toward maintaining wildlife and timber resources to meet multiple-use demands without detrimental effects to either resource.

Local concentrations of deer in forested areas may impact forest vegetation by affecting tree regeneration (Dahlberg and Guettinger 1956, Case and McCullough 1987), growth and development (Tilghman 1989), and reduced stocking (Marquis 1974). Providing high quality summer range is important to the over-winter survival of deer because of the role of summer forages in fat accumulation (Mautz 1978). Reducing locally abundant deer numbers may help maintain the general welfare of the deer herd, habitat quality, and the forest ecosystem composition and structure.

The recent goal for deer herd size in Michigan is 1.3 million animals (Michigan Department of Natural Resources 1992). Once the goal is reached, management must include accurate harvest quotas to maintain herd size in all areas that will not detrimentally impact forest vegetation and agricultural lands. Currently, deer population numbers and distribution are estimated from deer check station data, highway counts, and field reports (Michigan Department of Natural Resources 1991). However, because of seasonal habitat use and movement patterns, harvest quotas set for regions of Michigan may not reflect the number of deer which should be harvested.

Quantification of white-tailed deer spring, summer, and early fall habitat use and movement patterns will provide information to help attain more accurate estimates of herd demographic and habitat requirements in various regions of Michigan's Upper

Peninsula. Management across the landscape for vegetation types used by deer can reduce concentrations of deer but still provide a population to meet recreational demands.

Managing Michigan's forest lands to meet the demand for timber and wildlife is a complex problem. A study to investigate the deer-forest land relationship in Michigan's Upper Peninsula was initiated in 1992. A concurrent project with this study quantified deer population dynamics and winter habitat use (Van Deelen 1995). The focus of this project was to quantify forest vegetation types used by white-tailed deer during spring, summer, and fall; determine deer seasonal movement patterns and home ranges; assess the impacts of white-tailed deer on forest vegetation, specifically northern white-cedar (Thuja occidentalis); and provide management recommendations for optimal use of the deer herd and timber resources.

OBJECTIVES

Specific objectives for this project were to:

1. Determine quantitative estimates of white-tailed deer spring, summer, and early fall habitat use patterns in the central portion of Michigan's Upper Peninsula.
2. Determine deer seasonal movement patterns and home ranges.
4. Evaluate effects of deer browsing on the composition and structure of northern white-cedar stands.
5. Quantify deer browse use of selected tree species.
6. Attain productivity estimates of deer.
7. Provide management recommendations to enhance the ability to manage forest-deer relationships to achieve multiple-use objectives for forest ecosystems.

STUDY AREA

The study area was centered in the Whitefish River Basin (WRB) and Stonington Peninsula (SP) in the Hiawatha National Forest (HNF) in the central portion of the Upper Peninsula of Michigan (Fig. 1). The HNF lies within Delta, Alger, and Schoolcraft Counties and encompasses approximately 4050 km^2. Lake Michigan and Lake Superior border the area to the south and north, respectively.

Approximately 90% of the study area is wooded, primarily owned by federal and state governments and several large corporations (Berndt 1977). Recent (1991) Landsat thematic mapper data (MacLean Consultants Ltd.) estimates that approximately 14% of the land in the SP is comprised of agricultural and herbaceous openland vegetation types compared to approximately 3.5% of the WRB. Major industries in the area are timber, especially pulp production, and recreation.

Modern physiography and soils are a result of post-glacial erosion and soil formation processes acting on the glacial deposits (Albert et al. 1986). Low elevations (207 to 235 m) dominate the flat, glacial lake plains and consist of poorly drained sand and clay soils, exposed limestone and dolomite bedrock, or thin soils over bedrock (Albert et al. 1986). Soils on the SP are primarily the Nahma-Ensley-Cathro and the Rubicon associations. The majority of the WRB consists of the Tawas-Carbondale-Roscommon, Kiva-Chippeny-Summerville, Rubicon, and Kalkaska associations. The

Figure 1. Location of the western zone of the Hiawatha National Forest in Michigan's Upper Peninsula.

remaining portion of the study area in the HNF is primarily Dawson-Tawas-Rousseau and the Kalkaska-Tawas-Carbondale soil associations (Berndt 1977).

The climate is dominated by lacustrine influences (Albert et al. 1986). Prevailing westerly winds result in a quasi-marine climate near the Great Lakes changing to a semi-continental climate over the inland areas. Spring is delayed because of the cooling of warm southerly air by Lake Michigan. Summers are cool because of lake breezes (Fig. 2) (National Oceanic and Atmospheric Administration 1993-1994). The growing season averages 120 days (Berndt 1977). Winter (November to March) averages 19 days of -17.8 C or below and summer temperatures are rarely (once every 2 years) higher than 32.2 C (Berndt 1977).

Precipitation (Fig. 3) (National Oceanic and Atmospheric Administration 1993-1994) is greatest during the growing season; 60% of annual totals fall from April to September (Berndt 1977). Snow flurries are frequent with snowfall averaging <152.4 cm annually in the southern region to 355.6 cm annually near Lake Superior (Eichenlaub et al. 1990).

Vegetation on the SP is both deciduous and evergreen, such as balsam fir (Abies balsamea), sugar maple (Acer saccharum), paper birch (Betula papyrifera), and hemlock (Tsuga canadensis). In the WRB, vegetation consists of evergreen stands dominated by tamarack (Larix laricina), black spruce (Picea mariana), and white-cedar; broadleaf deciduous forests composed of sugar maple, yellow birch (Betula lutea), beech (Fagus grandifolia); along with hardwood-conifer mixes (Kuchler 1964). Vegetation on the well-drained end moraine and ground moraine ridges is dominated by northern

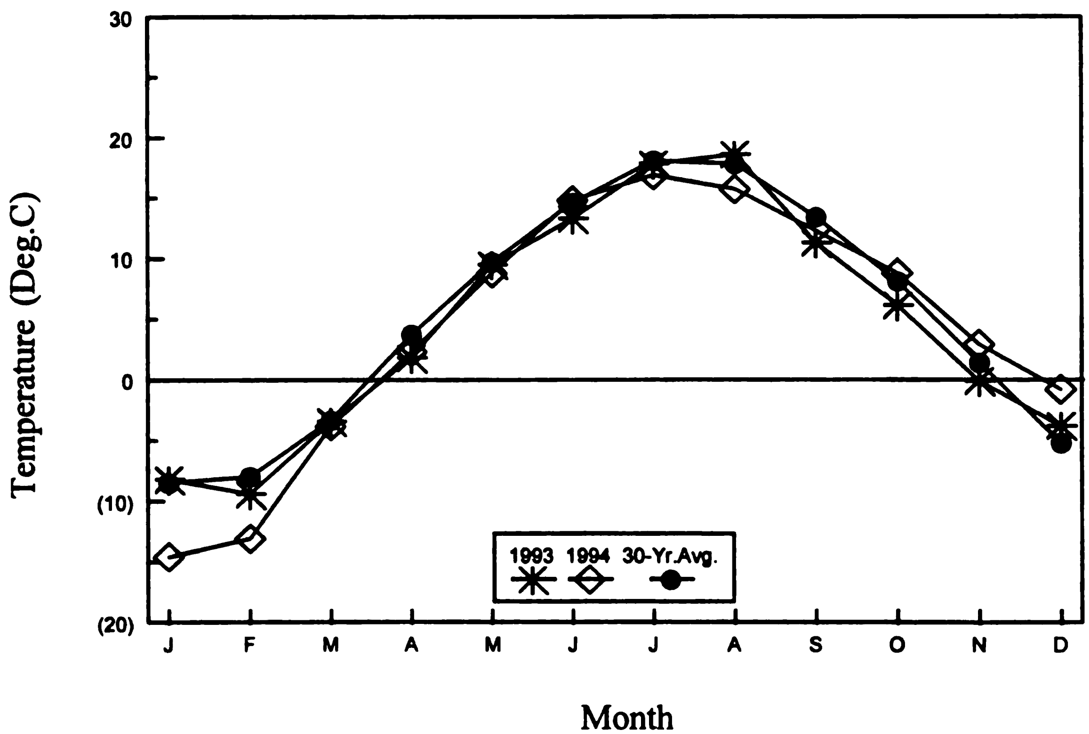

Figure 2. Mean monthly temperature at Manistique, Michigan, during the study (1993-94) and the 30-year average (1951-80) (National Oceanic and Atmospheric Administration 1993, 1994).

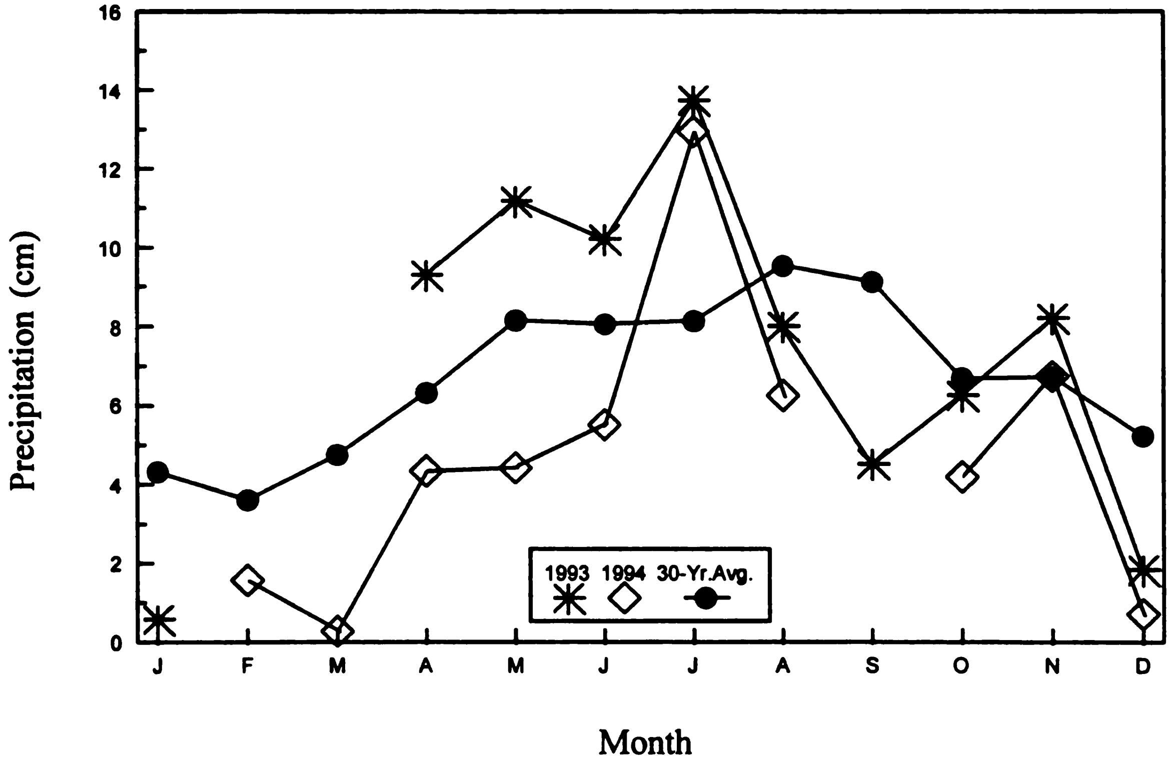

Figure 3. Total monthly precipitation at Manistique, Michigan, during the study (1993-94) and the 30-year average (1951-80) (National Oceanic and Atmospheric Administration 1993, 1994).

hardwoods. Eastern hemlock, red pine (Pinus resinosa), and white pine (Pinus strobus) are species whose abundance has been altered from cutting and fire (Albert et al. 1986). Conifer swamps are primarily white-cedar, balsam fir, and white spruce (Picea glauca) (Albert et al. 1986); red pine and jack pine (Pinus banksiana) grow on dry sands (Berndt 1977).

METHODOLOGY

CAPTURING AND RADIO-COLLARING

White-tailed deer were live-trapped using Stephenson (McBeath 1941) and Clover (Clover 1954) traps from January through mid-April in 1992, 1993, and 1994 in the WRB and SP deeryards (Fig. 4). Trapping was conducted in cooperation with U.P. Whitetails Association's program and field assistants. Traps were baited with shelled corn. Deer were manually restrained, ear-tagged, and radio-collared (Telonics Inc., Mesa, Ariz. and Lotek Engineering Inc., Ontario, Canada). Radio-collars were equipped with mortality switches that doubled the pulse rate if collars remained still for 12 hours. Collars were distributed to each sex in 3 age classes (adults, yearlings, and fawns) in each deeryard.

Age of fawns and yearlings was determined through tooth development and wear criteria developed by Severinghaus (1949); age of adult deer was determined by canine tooth extraction and analysis of the cementum annuli (Gilbert 1966, Van Deelen 1995).

GENERAL LOCATION TECHNIQUE

Seasonal movement patterns and habitat use of deer were determined using a portable TR-2 receiver (Telonics Inc., Mesa, Ariz.) with a hand-held 2-element yagi antenna. Deer were located throughout the winter for another component of the study investigating winter habitat use and population dynamics (Van Deelen 1995).

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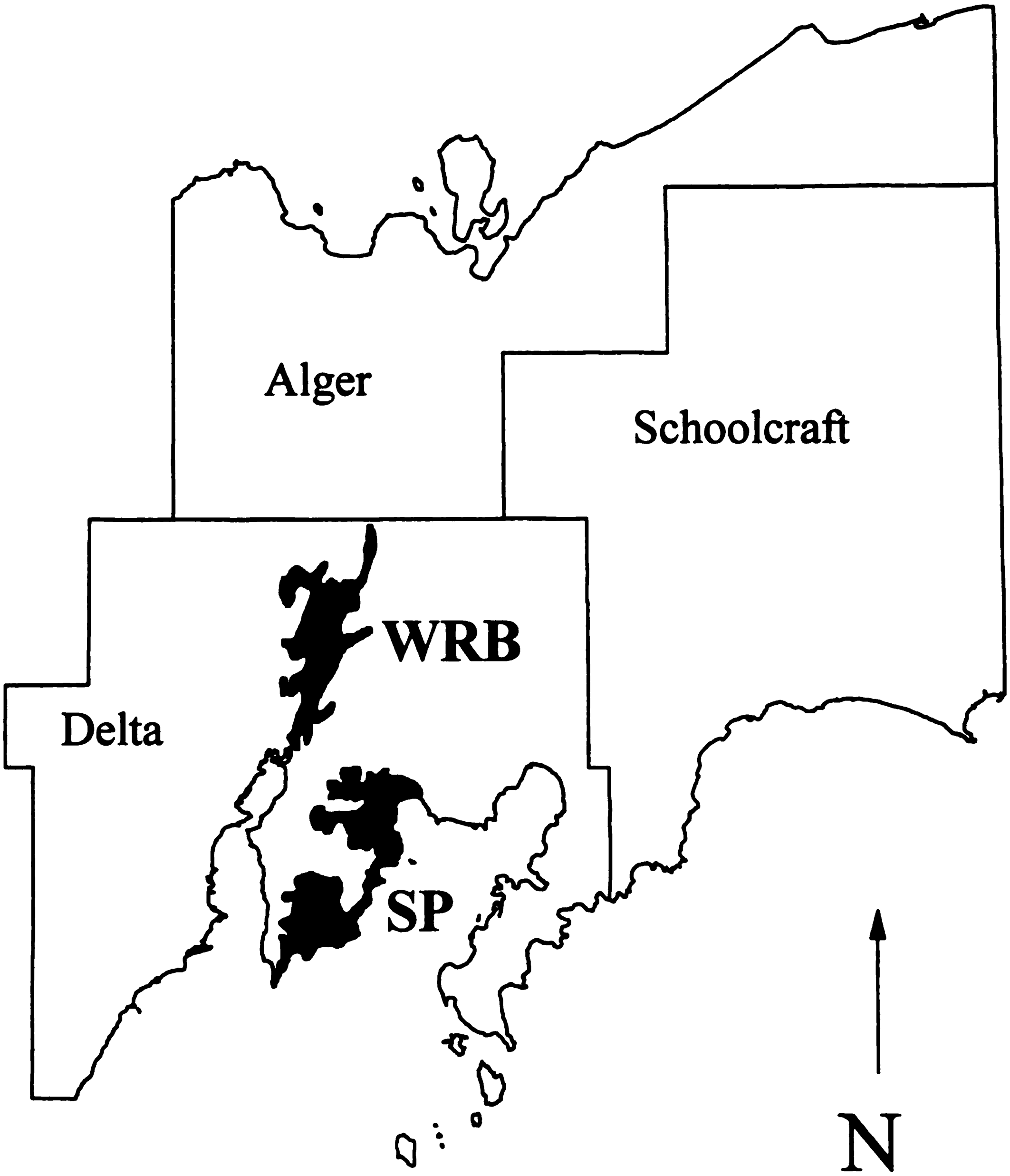

Figure 4. Location of Whitefish River Basin (WRB) and Stonington Peninsula (SP) deeryards in Michigan's Upper Peninsula.

Radio-telemetry data for spring/summer and fall were collected from mid-May through September 22 for spring/summer and September 23 through December 20 for fall. Mid-May was the approximate time when all radio-collared deer appeared to be on their spring/summer home ranges as determined by having 2 or more consecutive weekly location points in the same vicinity. For home range analysis, deer were grouped by the area where they established their spring/summer home range; for habitat use analysis, deer were grouped by where they were trapped because their availability area was based on trap location (e.g., a deer trapped on the SP but moved to the WRB for its spring/summer home range was grouped with the WRB deer for home range analysis and with SP deer for habitat use analysis).

MOVEMENTS AND HOME RANGES

Seasonal movement locations were obtained weekly for all deer using triangulation techniques. If a weekly location point was located in a vegetation type adjacent to the road according to Forest Service compartment maps, the data was recorded for habitat analysis. The order in which deer were located was alternated each week to obtain varied times for individual deer. Triangulation bearing error angle was estimated with 50 sets of 3 bearings obtaining an overall standard deviation using LOCATE II (Pacer 1993).

Seasonal home ranges were calculated using the adaptive kernel with 95% contours (Worton 1989) with CALHOME (Kie et al. 1994) and the minimum convex polygon (Mohr 1947) and the harmonic mean with 95% contours (Dixon and Chapman

1980) with TELEM88 (Coleman and Jones 1988). Home ranges were separated by year and season (spring/summer and fall) for analysis.

Prior to home range comparisons between study areas, a parametric analysis of variance was performed on the ranked data (Conover and Iman 1981) using SAS (SAS Inst., Inc. 1993) to detect possible interactions between and among the 3 factors: sex, age, and area. When interactions between main effects exist, significant differences detected between the main effects would not be meaningful (Sokal and Rohlf 1981); in this project, a comparison of study areas was of primary interest. If interactions were not significant ($P>0.10$) and if sample size allowed ($n\geq10$), the Mann-Whitney U test was used to test for significant differences between the study areas.

Spearman rank correlation coefficients were calculated using SYSTAT (1992) to compare home range sizes estimated by the adaptive kernel, minimum convex polygon, and harmonic mean methods.

HABITAT USE

Habitat use data were collected during 3 time periods: 0800 to 1559, 1600 to 2359, and 0000 to 0759. The 24-hour sampling technique was used to avoid potential bias involved in sampling just during daylight hours (Beyer and Haufler 1994). Sampling deer was alternated within and among time periods to obtain unbiased data and equal sampling intensities. Vegetation types used by deer were determined by triangulating along edges of vegetation types or walking around deer along the perimeter of stands a minimum of 3 sides to pinpoint locations. Habitat use data points were included with weekly location data for movement analysis.

Percent availability of each vegetation type was determined with a circle centered at a central trap site coordinate for the 2 trapping areas (WRB and SP). The circle, with a radius equal to the 85th percentile of the maximum distance moved by a single deer from that trapping area, was overlayed on Landsat thematic mapper vegetation data (Michigan Department of Natural Resources, Wildlife Division, Lansing, Mich.) using the geographic information system ARC/INFO (Environmental Systems Research Institute, Redlands, Calif.); the 85th percentile included 95% of the deer from each trapping area.

Satellite vegetation classifications (Maclean Consultants Ltd. 1991) were combined into 12 categories for project purposes (Table 1). Satellite areas designated as water were not included in the total land area available; areas designated urban and non-vegetative were grouped into the "other" category. Agricultural-cropland is comprised of row crops only; hay-related crop fields would fall into the herbaceous openland designation. The red, jack, and other (mixed) pine satellite vegetation categories were grouped into the mixed pine category. Tamarack, black spruce, white spruce, balsam fir, and mixed conifer vegetation types were combined into the lowland conifer category. White-cedar was kept as a separate category because the focus of part of this project quantified possible impacts deer have on the composition and structure of cedar stands. Five satellite vegetation types did not have any land area in the 2 study areas and were not included in the project list (Table 1).

Table 1. Vegetation type classifications for Michigan's central Upper Peninsula, 1993-1994.

Michigan DNR Deer Habitat Project Classifications[a]		Deer Habitat Use Thesis Project Classifications
Non-Coniferous		Non-Coniferous
Urban		Agricultural-Openland
Non-Vegetative		Herbaceous Openland
Agricultural-Cropland		Shrubland
Herbaceous Openland		Northern Hardwood
Shrubland		Aspen/Birch
Northern Hardwood		Dry Hardwood/Conifer Mix
Oak[b]		Wet Hardwood/Conifer Mix
Aspen/Birch		Wetlands
Lowland Hardwoods[b]		Other
Dry Hardwood/Conifer Mix		
Wet Hardwood/Conifer Mix		Coniferous
Wetlands		Mixed Pine
Water		Lowland Conifers
		White Cedar
Coniferous		
Pines	Red Pine	
	Jack Pine	
	White Pine[b]	
	Other (Mixed) Pine	
Tamarack		
Hemlock[b]	<70% Crown Closure	
	>70% Crown Closure	
Black Spruce	<70% Crown Closure	
	>70% Crown Closure	
White Spruce	<70% Crown Closure	
	>70% Crown Closure	
Balsam Fir[b]	<70% Crown Closure	
	>70% Crown Closure	
White Cedar	<70% Crown Closure	
	>70% Crown Closure	
Mixed Conifer	<70% Crown Closure	
	>70% Crown Closure	

[a]Data obtained from 1991 Landsat thematic mapper (Maclean Consultants Ltd.).
[b]Vegetation type with no land area in the 2 study areas (Whitefish River Basin and Stonington Peninsula).

Habitat use analysis combined data from all animals for both years. A chi-square goodness-of-fit test was used to determine if deer used vegetation types in proportion to their availability as described by Neu et al. (1974). In this analysis, the observed value is the number of data points in a vegetation type; the expected value is the proportion of total acreage of that vegetation type times the total number of deer observations. These partial chi-square values for each vegetation type are summed for a total chi-square to be compared to the table value. A confidence interval is then constructed around the proportion observed in each vegetation type to determine which types are being used more than, less than, or as expected. Use is considered to be more than, less than, or as expected if the proportion of the vegetation type available to the deer is lower than, higher than, or within the confidence interval, respectively, built around the proportion of use of that vegetation type.

PRODUCTIVITY

Productivity estimates were initially determined through direct observation of radio-collared females in 1993. After locating individual deer in specific vegetation types, animals were observed closely to determine if they had fawns. Due to the difficulty in directly observing individual radio-collared deer, 3 standardized driving surveys were conducted at dusk in both study areas during mid-summer in 1994. The number of deer observed in each area was recorded by sex and age. A Mann-Whitney U test was used to compare the fawn:doe ratio in the SP and WRB using SYSTAT (1992).

VEGETATION SAMPLING

Composition and Structure of Northern White-Cedar Stands

To assess the impacts of deer browsing on the composition and structure of mature cedar stands, 2 paired areas within selected stands were delineated and 1 was randomly chosen for exclosure construction and the other to be left open to browsing. Twelve mature, well-stocked (70%) stands were selected in sets of 3 on a north-south snow depth gradient (Eichenlaub et al. 1990) resulting in 4 study area gradients in the WRB and SP (WRB-North and -South and SP-North and -South). Snow depth has been shown to be related to deer use of tamarack swamps (Beier and McCullough 1990), with lowest deer densities believed to be in the WRB-North area and highest numbers in the SP-South area. One stand selected in the SP-South area was not used due to inaccessibility; no replacement stand could be located that met established criteria.

Exclosures are 30 m x 30 m x 2.4 m. Three exclosures were built in the WRB-North study area in 1993; 1 exclosure was constructed in each of the 3 remaining study areas in 1994. Remaining exclosures will be constructed by the U.S. Forest Service and Michigan State University personnel potentially by 1996. All site locations are listed in Table 2. For the remainder of this document, the sites chosen for exclosure construction will be referred to as exclosure sites even if construction has not been completed.

Vegetative sampling for baseline structural and compositional components was conducted on exclosure sites and their respective paired areas open to browsing. A 2-m

Table 2. Locations of exclosure and areas open to browsing sites in the Whitefish River Basin-North and -South (WRB-North and -South) and Stonington Peninsula-North and -South (SP-North and -South) study areas in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

Study Area	Site	Legal Description	Compt.	Stand	Exclosure Site Location (UTMs)[a]	Open Area[b]
WRB-North	1	T43N,R20W Sec. 19	143	27	511025-5106651	South
	2	T43N,R20W Sec. 30	143	36,37	511109-5104876	North
	3	T43n,R21W Sec. 24	143	20,21	510068-5105394	Southeast
WRB-South	1	T41N,R19W Sec. 19	64	69	520494-5085756	Northeast
	2	T41N,R21W Sec. 3	94	3	505685-5091006	East
	3	T42N,R20W Sec. 20	103	25	512165-5095398	South
SP-North	1	T40N,R20W Sec. 33	28	27	517259-5072983	West
	2	T40N,R20W Sec. 20	39	31,32	515563-5076573	East
	3	T40N,R20W Sec. 20	39	33,34	515864-5076637	Southeast
SP-South[c]	1	T39N,R21W Sec. 27	9	2	509216-5065470	Northwest
	2	T39N,R21W Sec. 33	10	22	507210-5064156	Northwest

[a]Universal Transverse Mercator.
[b]Open area direction is in relation to the exclosure site and distances are 25-30 m.
[c]Third site in SP-South was not used due to inaccessibility; no replacement site could be located.

buffer was established along the inside perimeter of all sites, so the area disturbed by exclosure construction would not be included in data collection.

Vertical cover of vegetation was quantified using the line intercept method (Canfield 1941) and was recorded in 3 height strata: <0.5 m, 0.5 to 2.0 m, and >2.0 m. Line intercepts were systematically located within exclosure and areas open to browsing sites. Downed woody material cover was also recorded for descriptive purposes.

Horizontal cover was determined using a profile board described by Nudds (1977) at randomly selected points in each sample area. The standard observing distance was 4 m determined by recording cover at different distances (3, 4, and 5 m) and choosing the one with the greatest variation (Gysel and Lyon 1980). The height strata for the board were <0.5 m, 0.5 to 1.0 m, 1.0 to 1.5 m, 1.5 to 2.0 m, and 2.0 to 2.5 m.

The stem densities of dominant tree species (northern white-cedar, balsam fir, and sugar maple) were determined by conducting complete counts at each site of each species. Other woody stem densities and frequency of herbaceous species were determined using randomly located nested quadrats 1 x 8 m and 1 x 4 m, respectively. Densities of woody species were determined using the same 3 height strata used for vertical cover. The height strata used for the above measurements is based on the growth forms of vegetation and structural requirements of deer (Alverson et al. 1988).

Due to exclosure construction only being partially complete, analysis was conducted 2 ways:

1. combining exclosure site and open area data within study area gradients for comparisons among gradients.
2. keeping the exclosure site and open area data separate for comparisons within and among study area gradients.

Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) was used to compare study area gradients with both combined and separated data using SYSTAT (1992). A Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988) was used to detect where the differences occurred among the study areas. The paired t-test (Steel and Torrie 1980) was used to determine significant differences ($P<0.10$) for all vegetation characteristics between exclosure and open area sites within a study area. Quality control of all vegetative sampling was assured by determining statistically adequate sample sizes (Freese 1978). An 80% confidence level was used to determine sample sizes. Allowable error was set at 20% of the mean.

Browsing Sampling

Browsing estimates were conducted in the 2 study areas in spring 1994 using 12 randomly established 25-m belt transects in vegetation types adjacent to mature cedar stands used as wintering areas. To allow for sufficient sampling area, stands were selected based on the length of the perimeter of the stand adjacent to the cedar stand. The number of current annual growth stems available of the dominant tree species and the number browsed of the dominant tree species only < 2 m in height were recorded.

RESULTS

CAPTURING AND RADIO-COLLARING

One hundred one white-tailed deer were radio-collared in the WRB and SP during the 3 years of trapping (Table 3). Due to mortality occurring prior to spring/summer, location data for this portion of the study were gathered on only 61 of these deer, 22 (36%) males and 39 (64%) females. Of the 61 deer, 17 (28%) were radio-tracked during both seasons and years of the study.

MOVEMENTS AND HOME RANGES

The median date for movement of wintering deer from the 2 deeryards was March 29 in 1993 and April 4 in 1994 (Van Deelen 1995). Two-thousand four-hundred sixty-five locations were obtained during the 2 years, including 790 (39%) habitat use data points.

Maximum migration distances during the 2 years by a single deer from the 2 trapping areas were 54.4 and 52.9 km from the WRB and SP, respectively. In 1993, 9 (28%) of 32 deer with summer ranges in the WRB had been trapped in the SP; in spring/summer 1994, 6 (26%) of 23 WRB deer were SP-trapped deer. Mean telemetry triangulation bearing error angle standard deviation for observers was 8 degrees.

Table 3. Number of white-tailed deer radio-collared in the Whitefish River Basin (WRB) and the Stonington Peninsula (SP) in the Hiawatha National Forest in Michigan's Upper Peninsula, 1992-1994.

			Study Area		
Year	Sex	Age	WRB	SP	Total
1992	Male	Adult	2	0	2
		Yearling	2	1	3
		Fawns	5	5	10
	Female	Adult	7	10	17
		Yearling	1	0	1
		Fawn	5	5	10
1993	Male	Adult	0	0	0
		Yearling	4	0	4
		Fawn	5	5	10
	Female	Adult	8	5	13
		Yearling	1	0	1
		Fawn	6	5	11
1994	Male	Adult	0	0	0
		Yearling	0	0	0
		Fawn	5	5	10
	Female	Adult	0	0	0
		Yearling	0	0	0
		Fawn	4	5	9
Total			55	46	101

Adaptive Kernel Home Range Results

Analysis of variance of home range data showed an interaction between area and sex for spring/summer 1993 ($P<0.10$) for the adaptive kernel (AK) method. Due to the interaction of these 2 factors, the test to determine a significant difference between the 2 study areas for spring/summer 1993 had to be separated by sex first. No interactions were evident for either season in 1994. CALHOME (Kie et al. 1994) was not able to produce an AK home range with 95% contours for 4 deer; 80% contours worked for 3 of these deer and 50% contours worked for the other deer (Tables A1 and A2, Appendix).

In 1994, mean spring/summer and fall home ranges of deer in the WRB were significantly larger ($P<0.01$) than home ranges of deer in the SP (Tables 4 and 5). WRB female home ranges were significantly larger than SP female home ranges in spring/summer 1993 and 1994 (Table 4). Low sample size did not allow testing of females in fall 1994 or males for all seasons. Male mean spring/summer home ranges ranged from 76.0 ha to 1354.7 ha in the SP and WRB, respectively (Tables A1 and A2, Appendix). Male mean home ranges for SP deer were smaller than WRB deer home ranges during the study, except fall 1993 when a mean for SP male deer could not be determined with only 1 male deer being monitored (Tables 4 and 5).

Minimum Convex Polygon and Harmonic Mean Home Range Results

Analysis of variance of home range data showed an interaction between area and sex for spring/summer 1993 ($P<0.10$) for the harmonic mean (HM); in fall 1993, an interaction between age and area for the minimum convex polygon (MCP) and HM

Table 4. Mean spring/summer home ranges (ha) (and standard errors) of white-tailed deer in the Whitefish River Basin (WRB) and Stonington Peninsula (SP) using adaptive kernel with 95% contours in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

	1993		1994	
	WRB	SP	WRB	SP
Females	219.6[a]	90.9	817.1[a]	78.7
	(49.4)	(22.6)	(655.5)	(7.8)
Males	1354.7	283.3	223.6	76.0
	(1147.4)	(94.0)	(80.7)	(17.7)
Study Area	645.3	96.7	636.5[b]	82.8
	(431.1)	(31.6)	(455.7)	(8.2)

[a]Significantly different from SP ($P<0.05$) with Mann-Whitney U test using SYSTAT (1992).
[b]Significantly different from SP ($P<0.01$) with Mann-Whitney U test using SYSTAT (1992).

Table 5. Mean fall home ranges for white-tailed deer in the Whitefish River Basin (WRB) and Stonington Peninsula (SP) using adaptive kernel with 95% contours in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

	1993		1994	
	WRB	SP	WRB	SP
Female	1252.2	109.2	2147.7[a]	39.2
	(657.4)	(24.0)	(1746.0)	(12.2)
Male	238.4	-----[b]	297.6	31.5
	(99.2)	-----	(216.8)	(8.8)
Study Area	914.3	107.7	1563.4[c]	37.8
	(445.9)	(21.9)	(1198.3)	(10.0)

[a]N too small (<10) to conduct test.
[b]Only one animal in this category; no mean available.
[c]Significantly different (P<0.01) from SP with Mann Whitney U test using SYSTAT (1992).

methods was detected. Due to the interactions of these factors, tests to determine a significant difference between the 2 main effects of interest (study areas) were not conducted for these seasons and methods. No interactions were evident for either season in 1994.

TELEM88 (Coleman and Jones 1988) was not able to produce an HM home range with 95% contours result for 3 deer; 80% contours were used for these deer (Tables A1 and A2, Appendix). Results for the MCP and HM methods were similar to the AK results. Mean spring/summer home ranges for deer in the WRB were significantly larger than for deer on the SP using MCP for 1993 and 1994 and HM in 1994 (Table 6). Mean fall home ranges for deer in the WRB were significantly larger than deer in the SP in 1994 (Table 7) with both methods. In spring/summer 1993 and 1994, WRB female home ranges were significantly larger than SP female home ranges (Table 6) for the MCP and HM home range methods. Low sample size did not allow testing of females in fall 1994 or males for all seasons.

Spearman rank correlation coefficients comparing the 3 home range methods ranged from 0.546 to 0.979 for the SP and from 0.852 to 0.989 for the WRB. The low coefficient for the SP was spring/summer 1994, HM versus AK method. Disregarding study area, the coefficient ranged from 0.817 to 0.979 for the 3 sets of correlations (MCP vs. HM, MCP vs. AK, and HM vs. AK).

Table 6. Mean spring/summer home ranges (ha) (and standard errors) of white-tailed deer in the Whitefish River Basin (WRB) and Stonington Peninsula (SP) using minimum convex polygon (MCP) and harmonic mean (HM) with 95% contours in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

	1993				1994			
	MCP		HM		MCP		HM	
	WRB	SP	WRB	SP	WRB	SP	WRB	SP
Females	136.7[a] (32.0)	48.9 (10.1)	343.3[a] (171.6)	65.7 (14.5)	185.8[a] (76.0)	52.6 (6.3)	490.4[b] (318.3)	71.5 (10.6)
Males	159.2 (43.5)	124.8 (42.2)	693.5 (511.7)	294.0 (115.7)	150.0 (37.6)	56.8 (14.9)	204.9 (49.8)	98.5 (35.2)
Study Area	145.1[a] (25.4)	64.1 (13.4)	474.6 (216.9)	111.3 (33.3)	174.9[c] (53.6)	53.4 (5.6)	366.7[c] (194.4)	76.9 (10.7)

[a]Significantly different (P<0.05) from SP with Mann Whitney U test using SYSTAT (1992).
[b]Significantly different (P<0.10) from SP with Mann Whitney U test using SYSTAT (1992).
[c]Significantly different (P<0.01) from SP with Mann Whitney U test using SYSTAT (1992).

Table 7. Mean fall home ranges (ha) (and standard errors) of white-tailed deer in the Whitefish River Basin (WRB) and Stonington Peninsula (SP) using minimum convex polygon (MCP) and harmonic mean with 95% contours (HM) in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

	1993				1994			
	MCP		HM		MCP		HM	
Group	WRB	SP	WRB	SP	WRB	SP	WRB	SP
Females	354.7 (230.6)	62.3 (11.4)	613.4 (314.6)	87.3 (19.0)	371.6 (162.7)	21.7 (7.5)	1727.9 (1140.3)	27.9 (9.8)
Males	98.8 (38.0)	122.8 (54.3)	------ (----)	------ (----)	137.1 (96.5)	22.8 (6.8)	207.5 (133.8)	34.2 (10.3)
Study Area	269.4 (154.6)	60.3 (10.6)	449.9 (213.7)	89.1 (17.5)	297.6[a] (116.4)	21.9 (6.2)	1247.7[b] (789.0)	29.1 (8.0)

[a]Significantly different ($P<0.05$) from SP with Mann Whitney U test using SYSTAT (1992).

[b]Significantly different ($P<0.01$) from SP with Mann Whitney U test using SYSTAT (1992).

HABITAT USE

Habitat availability was based on the maximum migration distance by a single deer from the 2 trapping areas. The circle radii, centered at a central trap site coordinate, for the WRB and SP were 46.2 and 45.0 km, respectively. The dominant vegetation types for the 2 areas were northern hardwoods for the WRB and wet hardwood/conifer mix for the SP area, respectively, averaging 24.7% of the land. Northern white-cedar was the least available (<1%) in both study areas.

Habitat use in the 2 areas was not in proportion to availability for spring/summer (Table 8). Aspen/birch and mixed pine were used significantly more than expected in the WRB; aspen/birch, mixed pine, and northern white-cedar were used significantly more than expected by SP deer (Table 8). Vegetation types used less than expected were agricultural-croplands and other by both WRB and SP deer and northern hardwoods and wetlands by WRB and SP deer, respectively. All other vegetation types were used as expected in the 2 study areas (Table 8). Agricultural-croplands and "other" were not used by deer in either area, but an observed value of 0.0001 was used in the analysis so a result of being used less, more, or as expected could be determined.

Fall habitat use for the 2 areas was similar to spring/summer use. Approximately 87% of the habitat use data points occurred in the same 5 vegetation types in the WRB and SP (northern hardwoods, aspen/birch, wet hardwood/conifer, mixed pine, and lowland conifer) (Table 9). The highest use was lowland conifers--21.77% and 26.85%

Table 8. White-tailed deer spring/summer habitat use and availability in the Whitefish River Basin (WRB) and Stonington Peninsula (SP) study areas in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

	WRB n[a]=27 m[b]=246		SP n=33 m=277	
Vegetation Type	%Avail	%Use	%Avail	%Use
Agricultural-Cropland	9.29	0.00004[c]	12.86	0.00004[c]
Herbaceous Openland	4.74	4.88	5.95	10.47
Shrubland	1.90	4.47	2.04	5.05
Northern Hardwoods	27.31	20.33[d]	17.75	18.41
Aspen/Birch	4.57	11.79[e]	2.92	13.36[e]
Dry Hardwood/ Conifer Mix	5.11	9.35	5.98	3.61
Wet Hardwood/ Conifer Mix	21.46	15.85	23.38	19.49
Wetlands	2.13	0.81	2.25	0.00004[c]
Mixed Pine	5.96	14.23[e]	5.55	11.19[e]
White Cedar (*Thuja occidentalis*)	0.20	1.63	0.25	3.25[e]
Lowland Conifers	15.96	16.67	19.30	15.16
Other	1.38	0.00004[c]	2.10	0.00004[c]
Chi-square value	134.83**		295.32**	

[a]Total number deer monitored.
[b]Total number of locations.
[c]Used significantly less than ($P<0.01$) percent available with Bonferroni normal statistic (Neu et al. 1974).
[d]Used significantly less than ($P<0.10$) percent available with Bonferroni normal statistic (Neu et al. 1974).
[e]Used significantly more than ($P<0.10$) percent available with Bonferroni normal statistic (Neu et al. 1974).
**Significantly different ($P<0.0001$) from availability by chi-square analysis (Neu et al. 1974).

Table 9. White-tailed deer fall habitat use in the Whitefish River Basin (WRB) and Stonington Peninsula (SP) study areas in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

Vegetation Type	% Use WRB n[a]=27 m[b]=124	 SP n=23 m=149
Agricultural-Cropland	0.00	0.00
Herbaceous Openland	6.50	2.68
Shrubland	0.81	1.34
Northern Hardwoods	14.50	15.44
Aspen/Birch	16.94	10.74
Dry Hardwood/Conifer Mix	6.45	2.01
Wet Hardwood/Conifer Mix	12.90	19.46
Wetland	0.00	0.00
Mixed Pine	18.55	16.10
White Cedar (*Thuja occidentalis*)	1.61	5.37
Lowland Conifers	21.77	26.85
Other	0.00	0.00

[a]Total number of deer monitored.
[b]Total number of locations.

for the WRB and SP, respectively. Agricultural-croplands, "other," and wetlands were not used in either study area. Because of the low sample size for fall, no analyses were conducted.

A breakdown of the habitat use data points by the 3 time periods used to record data had similar results as the total percentages. The 2 vegetation types with the highest percentage of use during the spring/summer (disregarding time periods) were northern hardwoods (20.33%) and lowland conifers (16.67%) by WRB deer and wet hardwood conifer mix (19.49%) and northern hardwoods (18.41%) by SP deer. Northern hardwoods, lowland conifers, and wet hardwood/conifer mix had the highest percentage of use by time period (Table 10).

Table 10. Vegetation types with highest percentage of use by white-tailed deer by time period in the Whitefish River Basin and Stonington Peninsula study areas in Michigan's Upper Peninsula, 1993-94.

	Study Area	
Time Period	Whitefish River Basin	Stonington Peninsula
0800-1559	Northern Hardwoods	Wet Hardwood/Conifer Mix
1600-2359	Lowland Conifers	Wet Hardwood/Conifer Mix
0000-0759	Lowland Conifers	Wet Hardwood/Conifer Mix, Northern Hardwoods, and Lowland Conifers[a]

[a]All 3 vegetation types with same level of use.

PRODUCTIVITY

During the first year of the project, the attempts to estimate productivity through direct observation of radio-collared females resulted in only 8 of 19 deer being observed. The difficulty in observing radio-collared females at close range led to the use of road driving surveys in the 2 study areas to estimate productivity. The highest fawn:doe ratio for the WRB and SP was 0.44 and 0.42, respectively; the lowest fawn:doe ratio for the WRB and SP was 0.0 and 0.07, respectively (Table 11). The mean fawn:doe ratio was not significantly different ($P>0.10$) between the WRB and SP in mid-summer 1994 (Table 11).

VEGETATION SAMPLING

Composition and Structure of Northern White-Cedar Stands

The mature cedar stands selected for the exclosure study differed among study area gradients in ways that were evident by direct observation. The 3 paired sites in the WRB-North were wetter (i.e., more standing water) than the sites in the other 3 study areas; the understory was also much more dense in the WRB-North sites. The majority of the surrounding vegetation in the WRB-North was northern hardwoods, primarily maple. These factors may contribute to some of the differences found in the vegetation data among the study areas. The 2 sets of analyses (exclosure and open area site data combined and exclosure and open area site data separated) are reported; all tables for the exclosure and open area data separated are contained in the Appendix.

Table 11. Mean productivity and standard error (S.E.) of white-tailed deer in the Whitefish River Basin (WRB) and Stonington Peninsula (SP) study areas in the Hiawatha National Forest in Michigan's Upper Peninsula, 1994.

		Number Observed		
Study Area	Survey Replicate	Does	Fawns	Fawns:Doe
SP	1	12	5	0.42
	2	8	2	0.25
	3	14	1	0.07
	Mean	11.3	2.7	0.25[a]
	(S.E.)	(1.8)	(1.2)	(0.10)
WRB	1	15	0	0.00
	2	9	4	0.44
	3	13	2	0.15
	Mean	12.3	2.0	0.20
	(S.E.)	(1.8)	(1.2)	(0.13)

[a]No significant difference (P>0.10) between study areas with Mann Whitney U test using SYSTAT (1992).

Exclosure and Open Area Site Data Combined

Vertical cover was significantly different (P<0.10) among the study areas in all 3 strata (Table 12). The largest difference was seen in the 0.5-2.0 m stratum where the mean percent vertical cover in the WRB-North was substantially higher than found in the other 3 study areas (Table 12). Downed woody material cover ranged from 2.1% to 5.5%.

Mean percent horizontal cover was significantly greater (P<0.10) in the WRB-North than the other 3 study area gradients for the upper 3 strata (1-1.5 m, 1.5-2.0 m, and 2.0-2.5 m) (Table 13). For the <0.5 and 0.5-1.0 m strata, mean percent horizontal cover in the WRB-North was significantly greater (P<0.10) than cover in the SP-North and -South and SP-South, respectively (Table 13).

Stem densities of 3 dominant tree species (northern white-cedar, balsam fir, and sugar maple) were significantly different (P<0.10) among the study areas in the 4 strata except for balsam fir and sugar maple in the >2.0 m, >12.67 cm dbh stratum (Table 14). Northern white-cedar stem densities in the <0.5 m stratum ranged from 987 to 12,475 stems/ha but from 0 to 202 stems/ha in the 0.5-2.0 m stratum.

Forty-four non-dominant woody species were identified in the 4 study area gradients (Table 15). Densities were substantially different depending on the study area gradient and stratum for a few of the species. For instance, black ash (Fraxinus nigra) had 29,069 stems/ha in SP-North in the <0.5 m stratum compared to 0 stems/ha in this stratum in the WRB-North. Stem densities were significantly different (P<0.10) among

Table 12. Mean percent vertical cover (and standard error) for height strata in the 4 study areas (Whitefish River Basin-North and -South [WRB-North and -South] and Stonington Peninsula-North and -South [SP-North and -South]) in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

	Study Area			
Stratum (m)	WRB-North	WRB-South	SP-North	SP-South
<0.5	89.5A[a]	78.9AB	73.5B	72.4B
	(1.8)	(4.2)	(2.2)	(5.3)
0.5-2.0	69.1A	5.2B	7.3B	1.5B
	(6.1)	(1.1)	(3.8)	(0.5)
>2.0	82.4A	92.8B	88.3AB	92.8B
	(1.8)	(1.5)	(2.4)	(1.1)
DWM[b]	5.5	2.1	4.3	3.4
	(1.1)	(0.4)	(1.2)	(0.4)

[a]Means with different letters within a stratum were significantly different ($P<0.10$) among study areas with the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992) and the Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988).

[b]Downed woody material; descriptive only, no tests conducted.

Table 13. Mean percent horizontal cover (and standard error) for height strata in the 4 study areas (Whitefish River Basin-North and -South [WRB-North and -South] and Stonington Peninsula-North and -South [SP-North and -South]) in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

	Study Areas			
Stratum (m)	WRB-North	WRB-South	SP-North	SP-South
<0.5	68.0A[a] (6.7)	29.2AB (3.0)	21.0B (2.7)	18.4B (2.7)
0.5-1.0	48.6A (6.7)	17.4AB (4.4)	17.9AB (4.4)	9.9B (1.3)
1.0-1.5	50.4A (4.5)	15.0B (3.2)	12.5B (2.7)	9.4B (2.6)
1.5-2.0	37.6A (9.7)	14.7B (3.2)	13.0B (3.1)	8.5B (2.6)
2.0-2.5	44.0A (4.1)	14.8B (3.7)	17.7B (4.6)	6.0B (3.0)

[a]Means with different letters within a stratum were significantly different ($P<0.10$) among study areas by the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992) and the Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988).

Table 14. Mean stem densities per hectare (and standard error) of dominant tree species in the 4 study areas (Whitefish River Basin-North and -South [WRB-North and -South] and Stonington Peninsula-North and -South [SP-North and -South]) in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

		Study Area			
Species	Stratum (m)	WRB-North	WRB-South	SP-North	SP-South
Northern white cedar	<0.5	11484A[a] (909)	12475AB (4373)	1620B (684)	987AB (209)
Thuja occidentalis	0.5-2.0	202A (108)	0B (0)	39AB (39)	0B (0)
	>2.0, <12.67 cm dbh	15A (5)	1857B (601)	515B (296)	207AB (43)
	>2.0, >12.67 cm dbh	500A (61)	1109B (183)	708AB (39)	843B (60)
Balsam fir	<0.5	8664A (1326)	17697AB (7275)	2515AB (931)	1158B (912)
Abies balsamea	0.5-2.0	9228A (1502)	195B (114)	94B (82)	11B (7)
	>2.0, <12.67 cm dbh	1839A (208)	192B (66)	217B (125)	115B (69)
	>2.0, >12.67 cm dbh	71A (44)	37A (20)	59A (22)	48A (22)
Sugar maple	<0.5	740A (347)	187AB (118)	37AB (20)	0B (0)
Acer saccharum	0.5-2.0	126A (71)	0B (0)	0B (0)	0B (0)
	>2.0, <12.67 cm dbh	10[b] (3)	0 (0)	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	5A (5)	0A (0)	0A (0)	0A (0)

[a]Means with different letters within a species and stratum were significantly different ($P<0.10$) among study areas with the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992) and the Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988).

[b]Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988) was unable to detect where the significant difference occurred within a species and stratum among the study areas as detected by the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992).

Table 15. Mean stem densities per hectare (and standard error) of non-dominant woody species in the 4 study areas (Whitefish River Basin-North and -South [WRB-North and -South] and the Stonington Peninsula-North and -South [SP-North and -South]) in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

		Study Area			
Species	Stratum (m)	WRB-North	WRB-South	SP-North	SP-South
Alder-leaved buckthorn	<0.5	2361A[a] (1060)	208AB (98)	56B (28)	21B (21)
Rhamnus alnifolia	0.5-2.0	1556A (929)	0AB (0)	0B (0)	0B (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
Alternate-leaved dogwood	<0.5	625[b] (432)	14 (14)	28 (28)	104 (40)
Cornus alternifolia	0.5-2.0	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
American black currant	<0.5	0A (0)	0A (0)	14A (14)	0A (0)
Ribes americanum	0.5-2.0	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
American elm	<0.5	56A (28)	97A (62)	0A (0)	0A (0)
Ulmus americana	0.5-2.0	28A (18)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
American mountain ash	<0.5	69A (26)	153A (92)	15A (15)	63A (21)
Sorbus americana	0.5-2.0	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
American red raspberry	<0.5	14A (14)	0A (0)	0A (0)	0A (0)
Rubus idaeus	0.5-2.0	0A (0)	0A (0)	69A (69)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0 A (0)	0A (0)	0A (0)	0A (0)
Balsam poplar	<0.5	0A (0)	556A (401)	3597B (1050)	104AB (79)
Populus balsamifera	0.5-2.0	0A (0)	111A (82)	417B (136)	42AB (42)
	>2.0, <12.67 cm dbh	69A (55)	0A (0)	14A (14)	21A (21)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	125B (42)	0AB (0)

Table 15 (cont'd).

Species	Stratum (m)	Study Area: WRB-North		WRB-South		SP-North		SP-South	
Beaked hazelnut	<0.5	111A	(70)	222A	(190)	0A	(0)	0A	(0)
Corylus cornuta	0.5-2.0	0[b]	(0)	28A	(28)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Beech	<0.5	0A	(0)	28A	(18)	0A	(0)	0A	(0)
Fagus grandifolia	0.5-2.0	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Black ash	<0.5	0A	(0)	7389AB	(4713)	29069B	(18215)	26042B	(18112)
Fraxinus nigra	0.5-2.0	0[b]	(0)	389A	(235)	14A	(14)	0A	(0)
	>2.0, <12.67 cm dbh	14A	(14)	194A	(163)	14A	(14)	42A	(24)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	21A	(21)
Black currant	<0.5	1431[b]	(551)	28A	(18)	1791A	(1242)	979A	(313)
Ribes lacustre	0.5-2.0	139[b]	(63)	0A	(0)	0A	(0)	42A	(42)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Black spruce	<0.5	1861A	(545)	347AB	(219)	28B	(18)	42B	(42)
Picea mariana	0.5-2.0	1375A	(690)	0B	(0)	14B	(14)	0B	(0)
	>2.0, <12.67 cm dbh	778A	(577)	14A	(14)	14A	(14)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	42A	(28)	28A	(28)	0A	(0)
Choke cherry	<0.5	0A	(0)	125A	(80)	0A	(0)	0A	(0)
Prunus virginiana	0.5-2.0	0A	(0)	14A	(14)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Eastern hemlock	<0.5	0A	(0)	0A	(0)	14A	(14)	0A	(0)
Tsuga canadensis	0.5-2.0	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)

Table 15 (cont'd).

Species	Stratum (m)	Study Area: WRB-North		WRB-South		SP-North		SP-South	
Flowering dogwood	<0.5	542[b]	(356)	0A	(0)	0A	(0)	0A	(0)
Cornus florida	0.5-2.0	42A	(28)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Honeysuckle	<0.5	1167A	(365)	1500A	(270)	944A	(570)	1354A	(950)
Lonicera spp.	0.5-2.0	361[b]	(168)	42A	(28)	69A	(69)	21A	(21)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Hop hornbeam	<0.5	28A	(28)	278A	(136)	111A	(73)	125A	(99)
Ostrya virginiana	0.5-2.0	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	14A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Ironwood	<0.5	236A	(133)	139A	(56)	153A	(50)	83A	(59)
Carpinus caroliniana	0.5-2.0	111A	(73)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	28A	(28)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Labrador tea	<0.5	19389[b]	(10893)	4472A	(2982)	0A	(0)	0A	(0)
Ledum groenlandicum	0.5-2.0	1944[b]	(990)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Low sweet blueberry	<0.5	0[b]	(0)	1236A	(896)	0A	(0)	0A	(0)
Vaccinium angustifolium	0.5-2.0	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Mountain maple	<0.5	28[b]	(28)	472A	(205)	4458A	(3097)	5563A	(4676)
Acer spicatum	0.5-2.0	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)

Table 15 (cont'd).

Species	Stratum (m)	Study Area: WRB-North		WRB-South		SP-North		SP-South	
Flowering dogwood	<0.5	542[b]	(356)	0A	(0)	0A	(0)	0A	(0)
Cornus florida	0.5-2.0	42A	(28)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Honeysuckle	<0.5	1167A	(365)	1500A	(270)	944A	(570)	1354A	(950)
Lonicera spp.	0.5-2.0	361[b]	(168)	42A	(28)	69A	(69)	21A	(21)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Hop hornbeam	<0.5	28A	(28)	278A	(136)	111A	(73)	125A	(99)
Ostrya virginiana	0.5-2.0	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	14A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Ironwood	<0.5	236A	(133)	139A	(56)	153A	(50)	83A	(59)
Carpinus caroliniana	0.5-2.0	111A	(73)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	28A	(28)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Labrador tea	<0.5	19389[b]	(10893)	4472A	(2982)	0A	(0)	0A	(0)
Ledum groenlandicum	0.5-2.0	1944[b]	(990)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Low sweet blueberry	<0.5	0[b]	(0)	1236A	(896)	0A	(0)	0A	(0)
Vaccinium angustifolium	0.5-2.0	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Mountain maple	<0.5	28[b]	(28)	472A	(205)	4458A	(3097)	5563A	(4676)
Acer spicatum	0.5-2.0	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)

Table 15 (cont'd).

Species	Stratum (m)	Study Area: WRB-North	WRB-South	SP-North	SP-South
Paper birch	<0.5	139B (98)	0A (0)	375B (243)	167AB (59)
Betula papyrifera	0.5-2.0	42A (42)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	167A (114)	0A (0)	28A (18)	21A (21)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	21A (21)
Populus spp.	<0.5	0A (0)	0A (0)	194A (130)	0A (0)
	0.5-2.0	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	56A (41)	0A (0)
Prickly gooseberry	<0.5	0A (0)	0A (0)	42A (42)	21A (21)
Ribes cynobasti	0.5-2.0	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
Red maple	<0.5	2708A (1400)	21319A (11001)	4306A (1317)	16854A (9243)
Acer rubrum	0.5-2.0	306A (208)	28AB (18)	0B (0)	0AB (0)
	>2.0, <12.67 cm dbh	14A (14)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	14A (14)	0A (0)	0A (0)
Red-osier dogwood	<0.5	625A (432)	264A (73)	153A (69)	208A (158)
Cornus stolonifera	0.5-2.0	69A (55)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
Red oak	<0.5	0A (0)	14A (14)	0A (0)	0A (0)
Quercus rubra	0.5-2.0	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
Ribes spp.	<0.5	0A (0)	0A (0)	0A (0)	63A (63)
	0.5-2.0	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)

Table 15 (cont'd).

Species	Stratum (m)	Study Area: WRB-North		WRB-South		SP-North		SP-South	
Rosa spp.	<0.5	125A	(109)	0A	(0)	14A	(14)	0A	(0)
	0.5-2.0	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Rubus spp.	<0.5	0A	(0)	14A	(14)	0A	(0)	21A	(21)
	0.5-2.0	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Smooth gooseberry	<0.5	14A	(14)	0A	(0)	0A	(0)	42A	(42)
Ribes hirtella	0.5-2.0	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Speckled alder	<0.5	1903[b]	(625)	542A	(336)	28A	(18)	21A	(21)
Alnus rugosa	0.5-2.0	1806A	(349)	56AB	(28)	0B	(0)	0B	(0)
	>2.0, <12.67 cm dbh	208[b]	(98)	56A	(41)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Swamp red currant	<0.5	361A	(159)	56A	(18)	652A	(603)	104A	(79)
Ribes triste	0.5-2.0	28A	(28)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
Tamarack	<0.5	28A	(28)	0A	(0)	0A	(0)	0A	(0)
Larix laricina	0.5-2.0	42A	(28)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	42A	(42)	28A	(28)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	14A	(14)	0A	(0)	0A	(0)
Trembling aspen	<0.5	0A	(0)	0A	(0)	28A	(18)	0A	(0)
Populus tremuloides	0.5-2.0	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, <12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)
	>2.0, >12.67 cm dbh	0A	(0)	0A	(0)	0A	(0)	0A	(0)

Table 15 (cont'd).

Species	Stratum (m)	Study Area			
		WRB-North	WRB-South	SP-North	SP-South
Vaccinium spp.	<0.5	28A (28)	69A (69)	0A (0)	0A (0)
	0.5-2.0	14A (14)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
Velvet-leaved blueberry	<0.5	0A (0)	861A (796)	0A (0)	0A (0)
Vaccinium myrtilloides	0.5-2.0	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
Virgin's bower	<0.5	14A (14)	0A (0)	0A (0)	0A (0)
Clematis virginiana	0.5-2.0	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
Virginia creeper	<0.5	0A (0)	69A (45)	0A (0)	0A (0)
Parthenocissus quinquefolia	0.5-2.0	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
White pine	<0.5	0A (0)	0A (0)	0A (0)	0A (0)
Pinus strobus	0.5-2.0	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	28A (0)	0A (0)	0A (0)
White spruce	<0.5	0A (0)	28A (28)	14 A (14)	42A (42)
Picea glauca	0.5-2.0	56A (41)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	56A (41)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
Willow	<0.5	42A (28)	28A (28)	0A (0)	0A (0)
Salix spp.	0.5-2.0	69A (69)	14A (14)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	83A (68)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)

Table 15 (cont'd).

Species	Stratum (m)	Study Area			
		WRB-North	WRB-South	SP-North	SP-South
Winterberry holly	<0.5	14A (14)	1222B (458)	56AB (28)	146AB (98)
Ilex verticallata	0.5-2.0	0[b] (0)	139A (82)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	42A (28)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
Yellow birch	<0.5	111A (56)	1528AB (900)	69A (26)	7438B (2441)
Betula lutea	0.5-2.0	42A (28)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	14A (14)	0A (0)	21A (21)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	14A (14)	0A (0)
Other	<0.5	28A (18)	63A (45)	56A (18)	63A (63)
	0.5-2.0	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, <12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)
	>2.0, >12.67 cm dbh	0A (0)	0A (0)	0A (0)	0A (0)

[a]Means with different letters within a species and stratum were significantly different (P<0.10) among study areas with the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992) and the Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988).

[b]Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988) was unable to detect where the significant difference occurred among study areas as detected by the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992).

study area gradients for 26 species (Table 15). The Kruskal-Wallis multiple comparison test was only able to detect where these differences occurred for 13 of the species.

Ninety-five herbaceous species were identified in the 4 study areas; 20 (21%) were common to all 4 areas. Species richness ranged from 49 to 59 among the 4 study areas; Canada mayflower (Maianthemum canadense), naked miterwort (Mitella nuda), goldthread (Coptis groenlandica), and/or starflower (Trientalis borealis) were the most common species among the study area gradients (Table 16). Thirty-three species occurred once in the 4 study areas. Mean relative frequency for 38 of the 95 herbaceous species was significantly different ($P<0.10$) among the 4 study area gradients (Table 17). A Kruskal-Wallis multiple comparison was able to detect where the difference occurred for 20 of these 38 species.

Exclosure and Open Area Site Data Separated

Differences in vertical cover between exclosure and areas open to browsing sites were detected in the SP-South study area for <0.5 and 0.5-2.0 m strata (Table A3, Appendix). Vertical cover comparisons were significantly different ($P<0.10$) among the study area gradients for exclosure sites (0.5-2.0 and >2.0 m strata) and open area sites (0.5-2.0 m stratum) (Table A3, Appendix). Downed woody material cover at the sites ranged from 2.0 to 6.3%.

No significant differences in horizontal cover were detected between exclosures and open areas for all 4 study areas (Table A4, Appendix). Significant differences ($P<0.10$) in horizontal cover comparisons were detected among the study area gradients

Table 16. Herbaceous species summary for the 4 study areas (Whitefish River Basin-North and -South [WRB-North and -South] and Stonington Peninsula-North and -South [SP-North and -South]) in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

Study Area	Species Richness	3 Most Common Species	No. Species With Single Occurrence in Study Area
WRB-North	49	Bunchberry Cornus canadense Canada mayflower Maianthemum canadense Goldthread Coptis groenlandica	7
WRB-South	59	Goldthread Naked miterwort Mitella nuda Starflower Trientalis borealis	14
SP-North	56	Canada mayflower Violet Viola spp. Starflower	3
SP-South	52	Canada mayflower Naked miterwort Starflower	13

Table 17. Mean relative frequencies (and standard errors) of herbaceous species in the 4 study areas (Whitefish River Basin-North and -South [WRB-North and -South] and the Stonington Peninsula-North and -South [SP-North and -South]) in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

	Study Areas			
Species	WRB-North	WRB-South	SP-North	SP-South
Anemone spp.	0AB[a] (0)	0AB (0)	0.3A (0.2)	0B (0)
Arrow arum Peltranda virginica	0A (0)	0A (0)	0.2A (0.2)	0A (0)
Aster spp.	1.8A (0.6)	1.3A (0.5)	2.1A (0.6)	0A (0)
Bedstraw Galium spp.	0A (0)	0.5A (0.5)	0.2A (0.2)	0.2A (0.2)
Blunt-lobed woodsia Woodsia obtusa	0A (0)	0A (0)	0.1A (0.1)	0A (0)
Boot's wood fern Dryopteris boottii	0A (0)	0A (0)	2.4B (0.7)	0.8AB (0.6)
Bracken fern Pteridium aquilinum	0A (0)	0.3A (0.2)	0.3A (0.3)	0A (0)
Bugleweed Lycopus spp.	0A (0)	0.5AB (0.2)	0.8AB (0.4)	2.7B (1.0)
Bulbet fern Cystopteris bulbifera	0A (0)	0A (0)	0.1A (0.1)	0A (0)
Bunchberry Cornus canadensis	5.6A (0.5)	3.6AB (1.3)	1.6B (0.8)	3.1AB (1.0)
Buttercup Ranunculus spp.	0A (0)	0A (0)	2.4A (1.7)	0A (0)
Canada mayflower Maianthemum canadense	4.6A (0.3)	5.7AB (0.4)	7.0B (0.9)	5.8AB (0.6)
Cinnamon fern Osmunda cinnamomea	0.1A (0.1)	0.4A (0.3)	0A (0)	0A (0)
Cinquefoil Potentilla spp.	0A (0)	0A (0)	0.1A (0.1)	0A (0)
Clover Trifolium spp.	0[b] (0)	0 (0)	0.7 (0.3)	0 (0)
Club moss Lycopodium spp.	0A (0)	0.6A (0.4)	0.2A (0.2)	0A (0)
Club-spur orchid Habenaria clavellata	0A (0)	0.1A (0.1)	0A (0)	0A (0)

Table 17 (cont'd).

Species	WRB-North	WRB-South	SP-North	SP-South
	Study Areas			
Columbine Aquilegia spp.	0A (0)	0.1A (0.1)	0A (0)	0A (0)
Common wood sorrel Oxalis montana	0.1A (0.1)	0A (0)	0A (0)	0A (0)
Coralroot Corallorhiza spp.	0[b] (0)	0 (0)	0 (0)	0.5 (0.3)
Crested wood fern Dryopteris cristata	0.4A (0.3)	0.6A (0.4)	0.1A (0.1)	1.1A (0.6)
Dandelion Taraxacum spp.	0[b] (0)	0 (0)	0.7 (0.3)	0 (0)
Dewberry Rubus hispidus	0A (0)	4.2A (0.6)	2.2A (1.1)	5.3A (0.9)
Dryopteris spp.	4.4[b] (1.3)	0.1 (0.1)	1.2 (0.6)	0.5 (0.5)
Dwarf enchanter's nightshade Circaea alpina	0.1AB (0.1)	0A (0)	1.6AB (1.0)	3.8B (0.7)
Equisetum spp.	0.3A (0.2)	0.1A (0.1)	3.1A (1.1)	0.6A (0.6)
False Solomon's seal Smilacina racemosa	0A (0)	0A (0)	0.1A (0.1)	0A (0)
Fragile fern Cystopteris fragilis	1.7A (0.5)	0.1AB (0.1)	0B (0)	0.9AB (0.6)
Fringed brome Bromus ciliatus	0.1A (0.1)	0A (0)	0A (0)	0A (0)
Fringed polygala Polygala paucifolia	0B (0)	5.5A (0.6)	0B (0)	0.2AB (0.2)
Golden ragwort Senecio aureus	0A (0)	0.5A (0.4)	0.1A (0.1)	0.2A (0.2)
Goldenrod Solidago spp.	3.1A (1.0)	2.2A (0.7)	3.2A (0.7)	0.7A (0.4)
Goldthread Coptis groenlandica	5.4A (0.8)	6.7A (0.5)	0B (0)	4.0AB (0.6)
Grass spp.	2.4A (1.1)	4.0A (1.2)	4.1A (1.0)	4.3A (1.8)
Grass/sedge spp.	0A (0)	0A (0)	4.9B (1.2)	1.4AB (0.9)

Table 17 (cont'd).

Species	Study Areas			
	WRB-North	WRB-South	SP-North	SP-South
Hawkweed	0.6AB	0B	4.0A	0B
Hieracium spp.	(0.3)	(0)	(1.9)	(0)
Hooked crowfoot	0A	0A	0.2A	0A
Ranunculus recurvatus	(0)	(0)	(0.2)	(0)
Intermediate wood fern	0.2[b]	0	0.7	2.9
Dryopteris intermedia	(0.2)	(0)	(0.2)	(1.7)
Interrupted fern	0A	0.1A	0A	0.3A
Osmunda claytoniana	(0)	(0.1)	(0)	(0.3)
Jack-in-the-pulpit	0[b]	0.5	0	2.5
Arisaema spp.	(0)	(0.5)	(0)	(1.3)
Jewelweed	0.3[b]	0.7	0	0.9
Impatiens spp.	(0.3)	(0.7)	(0)	(0.4)
Joe-pye weed	1.3[b]	0.7	0	0.2
Eupatorium spp.	(0.5)	(0.3)	(0)	(0.2)
Large-leaved aster	0.6A	0.4A	0A	0A
Aster macrophyllus	(0.3)	(0.4)	(0)	(0)
Lesser pyrola	0A	0.5A	0A	0A
Pyrola minor	(0)	(0.5)	(0)	(0)
Long beech fern	0[b]	0.1	0	2.0
Thelypteris phegopteris	(0)	(0.1)	(0)	(0.8)
Manna grass	0.6A	0A	0A	0A
Glyceria spp.	(0.6)	(0)	(0)	(0)
Marsh bedstraw	1.8[b]	0.1	0.3	0
Galium palustre	(0.6)	(0.1)	(0.2)	(0)
Marsh fern	0A	0.3A	0A	0.9A
Thelypteris phegopteris	(0)	(0.3)	(0)	(0.5)
Marsh marigold	0.5A	0.2A	0A	0A
Caltha palustris	(0.5)	(0.2)	(0)	(0)
Marsh skullcap	0A	0A	0A	0.2A
Scutellaria epilobifolia	(0)	(0)	(0)	(0.2)
Milkweed	0A	0A	0.1A	0A
Asclepias spp.	(0)	(0)	(0.1)	(0)
Mint	0[b]	0	0.2	0.4
Mentha spp.	(0)	(0)	(0.1)	(0.3)
Moss spp.	6.7A	7.1A	8.1A	7.3A
	(0.3)	(0.2)	(1.0)	(0.4)

Table 17 (cont'd).

Species	Study Areas			
	WRB-North	WRB-South	SP-North	SP-South
Naked miterwort Mitella nuda	5.4AB (1.0)	6.2AB (0.5)	3.3A (1.0)	7.5B (0.3)
Oak fern Gymnocarpium spp.	1.2A (0.5)	0.3A (0.3)	2.4A (1.0)	2.4A (1.2)
One-flowered pyrola Moneses uniflora	0A (0)	0.1A (0.1)	0A (0)	0A (0)
Orchidaceae spp.	0.4A (0.2)	0.1A (0.1)	0A (0)	0A (0)
Ostrich fern Matteucia struthiopteris	0A (0)	0A (0)	0.1A (0.1)	0A (0)
Pyrola spp.	0.7A (0.3)	1.5A (0.5)	1.1A (0.6)	0.2A (0.2)
Rattlesnake fern Botrychium virginianum	1.3A (0.4)	1.8A (0.8)	3.3A (0.6)	2.6A (1.0)
Rattlesnake plantain Goodyera spp.	0.1[b] (0.1)	0 (0)	0 (0)	0.7 (0.4)
Rough bedstraw Galium asprellum	0A (0)	3.2B (0.5)	2.8AB (0.8)	5.3B (0.5)
Royal fern Osmunda regalis	0.1A (0.1)	1.1A (0.5)	0A (0)	1.1A (1.1)
Sedge Carex spp.	5.9AB (0.1)	5.8A (0.9)	3.8AB (1.2)	1.6B (0.7)
Self-heal Prunella vulgaris	0.5[b] (0.3)	0.4 (0.3)	1.6 (0.2)	0.6 (0.6)
Sensitive fern Onoclea sensibilis	0A (0)	0.4A (0.2)	0.1A (0.1)	0.9A (0.9)
Showy lady's slipper Cypripedium reginae	0.3A (0.2)	0A (0)	0A (0)	0A (0)
Silvery glade fern Athyrium thelypterioides	0[b] (0)	0 (0)	1.0 (0.6)	0.7A (0.7)
Skullcap Scutellaria spp.	0A (0)	0A (0)	0.2A (0.2)	0A (0)
Small-flowered cranberry Vaccinium oxycoccos	0.4A (0.2)	0.6A (0.6)	0A (0)	0A (0)

Table 17 (cont'd).

Species	Study Areas			
	WRB-North	WRB-South	SP-North	SP-South
Snowberry Gaultheria hispidula	3.3AB (0.9)	5.0A (0.9)	0B (0)	0B (0)
Spinulose wood fern Dryopteris spinulosa	0A (0)	0A (0)	0.5A (0.4)	0A (0)
Spurred gentian Halenia deflexa	0A (0)	0A (0)	1.3A (1.0)	0A (0)
Starflower Trientalis borealis	3.1A (1.0)	6.2A (0.5)	4.5A (1.1)	6.0A (1.3)
Strawberry Fragaria spp.	4.9A (0.5)	1.8AB (1.1)	1.2B (0.5)	0.8AB (0.3)
Sundew Drosera spp.	0.1A (0.1)	0A (0)	0A (0)	0A (0)
Sweet coltsfoot Petasites palmatus	0.9[b] (0.6)	0.1 (0.1)	3.2 (1.5)	0 (0)
Sweet-scented bedstraw Galium triflorum	2.4[b] (0.9)	0.1 (0.1)	0 (0)	0 (0)
Tall buttercup Ranunculus acris	0A (0)	0A (0)	0.5A (0.5)	0A (0)
Tall meadow rue Thalictrum polygamum	0A (0)	0.1A (0.1)	0A (0)	0A (0)
Thistle Cirsium spp.	3.4A (0.7)	1.9AB (0.5)	2.8A (0.7)	0.2B (0.2)
Three-leaved Solomon's seal Smilacina trifolia	4.6A (0.8)	2.1AB (0.6)	0B (0)	0B (0)
Trailing arbutus Epigaea repens	0.1A (0.1)	0.5A (0.3)	0A (0)	0A (0)
Trillium spp.	0[b] (0)	0 (0)	0 (0)	0.2A (0.2)
Turtlehead Chelone spp.	0A (0)	0A (0)	0A (0)	0.2A (0.2)
Twinflower Linnaea borealis	5.5A (0.4)	3.5AB (1.3)	0.4B (0.2)	0.2B (0.2)
Twisted stalk Streptopus amplexifolius	0A (0)	0.4A (0.4)	0.2A (0.2)	0.3A (0.3)

Table 17 (cont'd).

Species	Study Areas			
	WRB-North	WRB-South	SP-North	SP-South
Violet	5.2A	3.4A	6.2A	5.7A
Viola spp.	(0.3)	(0.8)	(0.5)	(0.7)
White adders mouth	0A	0A	0A	0.2A
Malaxis brachypoda	(0)	(0)	(0)	(0.2)
Wild ginger	0A	0.1A	0A	0A
Asarum canadense	(0)	(0.1)	(0)	(0)
Wild sarsaparillo	3.3A	2.1A	3.8A	3.5A
Aralia nudicaulis	(0.6)	(1.1)	(1.0)	(0.9)
Wintergreen	0.9[b]	1.1	0	0
Gaultheria procumbens	(0.3)	(0.5)	(0)	(0)
Wood anemone	0.5AB	0A	2.2B	0.6AB
Anemone quinquefolia	(0.4)	(0)	(0.7)	(0.6)
Wood sorrel	0.6A	0.9A	0A	3.9A
Oxalis spp.	(0.6)	(0.7)	(0)	(2.3)
Yellow lady's slipper	0A	0.3A	0A	0.7A
Cypripedium calceolus	(0)	(0.2)	(0)	(0.4)

[a]Relative frequencies with different letters within a species were significantly different ($P<0.10$) among study areas with the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992) and the Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988).

[b]Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988) was unable to detect where the significant difference occurred within a species among the study areas as detected by the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992).

for exclosure sites (0.5-1.0 and 2.0-2.5 m strata) and open area sites (1.5-2.0 and 2.0-2.5 m strata) (Table A4, Appendix); however, 4 of the 8 multiple comparisons were not able to detect where the difference occurred using the Kruskal-Wallis multiple comparison test.

Stem densities of balsam fir in WRB-North was the only dominant species that showed a significant difference between exclosures and paired open areas in the 0-0.5 m stratum (Table A5, Appendix). Northern white-cedar in the WRB-North study area had significantly more stems in both >2.0 m in height strata than the WRB-South study area (Table A5, Appendix). Eight other Kruskal-Wallis multiple comparisons were not able to detect where the significant difference occurred as indicated by the Kruskal-Wallis one-way analysis of variance.

Densities of other woody species showed no significant differences between exclosure and open area sites for the WRB-North and SP-South study area (Tables A6 and A9, Appendix). Densities of ironwood (Carpinus caroliniana) and balsam poplar in exclosure sites (0-0.5 m stratum) were significantly greater ($P<0.10$) than open area sites for WRB-South and SP-North, respectively; density of alder-leaved buckthorn (Rhamnus alnifolia) in the open area was significantly greater than in the exclosure for SP-North (Tables A7 and A8, Appendix). Densities of 8 woody species in exclosures and 5 species in open areas were significantly different from other study areas (Table A10, Appendix). However, the Kruskal-Wallis multiple comparison test was only able to detect where the difference occurred in 7 of 13 of these cases (Table A10, Appendix).

Only a few herbaceous species were significantly more frequent in exclosure or open area sites (Tables A11-A14, Appendix). Thirteen species in exclosures and 11 species in open areas showed significantly different relative frequencies (Table A15, Appendix) among the study area gradients with the Kruskal-Wallis one-way analysis of variance. The Kruskal-Wallis multiple comparison test was only able to detect where the difference occurred for 4 species in exclosures and 3 species in open areas (Table 15, Appendix).

Browse Sampling

The 3 tree species sampled for browse use were black ash (Fraxinus nigra), balsam poplar (Populus balsamifera), and maple (Acer sp.); the 3 species were the dominant species in stands adjacent to the cedar stands and were common to both study areas (WRB and SP). The mean percent browse use of sugar maple was substantially less than black ash and balsam poplar in both the WRB and SP: 8.7 and 1.2% for sugar maple, 42.3 and 42.5% for black ash, and 45.3 and 31.3% for balsam poplar, respectively.

DISCUSSION

MOVEMENTS AND HOME RANGES

The maximum distance moved from wintering areas to summer range by a single deer was 54.4 and 52.9 km from the WRB and SP, respectively. These results are comparable to 51.5 km found by Verme (1973) in Michigan's Upper Peninsula, but were greater than maximum distances traveled by deer in Wisconsin (Dahlberg and Guettinger 1956, Larson et al. 1978). Although several deer moved north-northeast off the SP for their summer range both years of the study, the majority (70%) of SP-trapped deer remained on the SP for their summer range and are considered a resident population.

Interactions were detected for all home range methods in 1993 in either spring/summer or fall. The interactions involved area and sex (HM and AK in spring/summer) or age (MCP and HM for fall). The main objective was to compare home ranges between the 2 study areas, but with sex or age interacting with area, a comparison of the main effects was not conducted for the above cases.

The smallest adaptive kernel (AK) home range during the study was 6.3 ha in fall 1993 (Tables A1 and A2, Appendix) and may be attributed to having few weekly locations (4-5) recorded during the season due to not being able to locate the individual deer because of its movement away from what appeared to be its home range. AK home ranges for 4 WRB deer (2 adult females, 1 yearling female, and 1 yearling male) were 5,000+ ha (5,274.0 to 22,830.0 ha), which was 5 to 21 times higher than the study area mean for that particular season and year (Tables A1 and A2, Appendix). These large home ranges were due to mid-season travel by the deer, sometimes returning to their original summer or fall ranges, others remaining at their new location. Reasons for the travel may have been attributed to dispersal or some type of disturbance. In South Dakota, Sparrowe and Springer (1970) had an adult doe move 12.8 km from her summer range in September and returned in October. This type of behavior is either uncommon or is not reported in the literature.

In addition to the AK home range method, the MCP was used for comparisons to previous deer studies. The mean spring/summer home range (MCP estimator) for WRB deer (160 ha) for the 2 years was comparable to deer home ranges documented in Minnesota (162 ha) (Nelson and Mech 1984) and Wisconsin (178 ha) (Larson et al. 1978) in contrast to the much smaller mean spring/summer ranges of SP deer (58.8 ha). Larger home range sizes for WRB deer than SP deer may be attributed to the smaller percentage of land in herbaceous openings in the WRB (3.5%) compared to the SP (14%), which provides forage for deer during the spring/summer period. Use of this vegetation type was 10.47% in the SP compared to only 4.88% in the WRB. With a higher percentage of land in herbaceous openings and potentially other early successional stages, deer may not have needed to travel as far to meet their nutritional requirements.

Female summer home range size was similar to the home range size of the entire sample. This is probably a result of the high percentage of females in the radio-collared sample and averaged 161.3 ha and 50.8 ha for the WRB and SP, respectively. These data compare to Minnesota studies that found female deer summer home ranges of 282.7 ha (Kohn and Mooty 1971) and 120 ha (Nelson and Mech 1984).

In the WRB, mean fall home ranges for deer were larger than spring/summer home ranges for both years. These results are in contrast to data reported by Mooty et al. (1987) in Minnesota where the trend was for ranges during summer intervals to be larger than ranges during November-December and other winter intervals.

Supplemental feeding may also affect home range size. Although this topic was not addressed in this project, personal communication with residents on the SP indicates supplemental feeding may be an extensive practice. The degree of feeding during each season is unknown. This practice may impact home range size and habitat use more in the SP than the WRB, because the SP appears to have a higher density of permanent human residents than the WRB. The effects of supplemental feeding and the higher percentage of herbaceous openland in the SP versus the WRB would need to be separated to determine their respective impacts on home range sizes and habitat use.

Home Range Estimator Comparison

In seven of the 8 time periods for the 2 study areas (spring/summer-WRB and SP for 2 years; fall-WRB and SP for 2 years), AK mean home ranges were the largest followed by HM and MCP. Analyzing deer individually, though, only 63% followed this pattern; 27% resulted with HM>AK>MCP. For comparisons to previous studies, MCP was one of the home range methods used. A major disadvantage to this method, though, is that the size of the home range increases as the number of location points increases

(Jennrich and Turner 1969); the number of location points per deer in this study ranged from 4 to 30.

The HM and AK methods describe the intensity of use at a specific point. Additionally, the AK method provides a probability density function and a means of smoothing data to make more efficient use of the data (Worton 1989). No assumption is made about the form of the utilization distribution, and therefore, 30 to 100 observations per animal should be collected to obtain an accurate estimate (Worton 1987). Being able to detect use intensity provides more detailed information about habitat requirements of the animal being observed. For example, Naef-Daenzer (1993) showed density estimates from a modified kernel estimation for a male blue tit were highly correlated with caterpillar density on individual trees and the distance of the trees from the nest.

HABITAT USE

Habitat availability was based on a circle centered around a central trap location in the 2 trapping areas. Most deer movements from wintering areas to summer range appeared to be in a north-northeast direction during this study. Although this pattern existed, a circle instead of a wedge was used to estimate habitat availability because deer movement patterns may change (e.g., northwest-southwest) direction if habitat quality would change.

The 2 vegetation types with the highest percentages of use for the 2 study areas were northern hardwoods (20.33%) and lowland conifers (16.67%) in the WRB and wet hardwood/conifer mix (19.49%) and northern hardwoods (18.41%) in the SP. Although these types had high use, they also cover a large amount of land area and, except for northern hardwoods in the WRB, had use approximately equal to availability.

The overall chi-square goodness-of-fit tests were significantly different ($P<0.0001$) for each study area for both years showing that deer were not using vegetation types in proportion to availability (Table 8). Vegetation types used more than expected during spring/summer were aspen/birch and mixed pine in the WRB and aspen/birch, mixed pine, and white-cedar in the SP. In Wisconsin, McCaffery and Creed (1969) found significantly more deer track crossing in aspen than in northern hardwood types. Kohn and Mooty (1971) also found deer preferred birch and aspen-birch-conifer cover types in Minnesota.

The aspen/birch vegetation type provides forage during the summer period and has been shown to dominate the deer diet through early and late summer (McCaffery et al. 1974). Forbs have also been found to be an important part of deer summer diet (McCullough 1985) and may be provided in the northern hardwood vegetation type. Mixed pine types being used more than expected may be due to an understory and herbaceous component encroaching from adjacent hardwood stands.

Vegetation types used less than expected included northern hardwoods, agricultural-croplands, and the other category in the WRB and wetlands, agricultural-croplands, and the other category in the SP. In a study in Minnesota, deer were found to avoid red pine, aspen-conifer, and birch-conifer (Kohn and Mooty 1971); trees in the red pine stands were usually 3 to 6 m apart, approximately 15 m tall and 35 to 45-years-old.

The authors did find distance between trees and height influenced their use by deer, so avoidance or selection differences between studies may be due to stand characteristics.

The agricultural-cropland vegetation type was not used in the WRB or SP in either year of the study, although availability ranged from 9.3 to 14.6% for the 2 study areas. Although the study area was not designated as one of the problem deer damage areas of the state, many farmers report deer damage in neighboring Menominee County and other regions of Michigan (Michigan State University 1989). No use by deer of the agricultural-cropland vegetation type during this study may appear unusual but could be due to a couple of factors.

The designation of agricultural-cropland in the vegetation database used for this study is specifically for row crops and does not include open, grassy areas such as hayfields; these areas would be classified as herbaceous openland. Alfalfa and mixed hay fields occupied approximately 1.5% and 0.8% of the land in Delta and Alger Counties, respectively (Farm Service Agency pers. comm.). Approximately 3,109 ha of corn, dry beans, and potatoes are grown in Delta County; none of these row crops are grown in Alger County (Michigan Dept. of Agriculture 1993). Secondly, a higher percentage of areas classified as agricultural-cropland occur in areas of the availability circles radio-collared deer did not use, e.g., the west side of Little Bay de Noc where approximately 20.2% of the land is agricultural-cropland compared to approximately 9.5% in the SP.

Cedar vegetation type availability was low for both study areas (<1%). Spring/summer use of this vegetation type was 1.63% and 3.25% for the WRB and SP, respectively, which was as expected for the WRB and more than expected for the SP.

The low use may be due to other foods being available in other vegetation types (e.g., northern hardwoods, herbaceous openland) during the spring/summer.

PRODUCTIVITY

There was not a significant difference in the fawn:doe ratio between the WRB and SP. The total number of does and fawns observed during the 3 driving surveys was 34 and 8, respectively, for the SP and 37 and 6, respectively, for the WRB (Table 11). Initially, 3 driving surveys were conducted June 15th to 20th with only 5 fawns being observed between both areas. Although experienced does give birth in late May or early June (Ozoga et al. 1994), the majority of fawns were probably still spending a high percentage of their time bedding during this first set of surveys.

Testing the fawn:doe ratio did not show a significant difference between the WRB and SP. Although there is more open area on the SP and an expected greater opportunity to see deer, does are secretive for the first 4 to 6 weeks after giving birth (Ozoga et al. 1994), possibly equating the observation level for both study areas and resulting in a non-significant difference. Dense understories also reduces opportunity for viewing deer; this has also been shown to be a problem of night spotlighting (McCullough 1982).

A low sample size may also have contributed to the non-significant difference. According to sample size requirement calculations (Freese 1978), 409 and 1066 surveys would be required in the SP and WRB, respectively, to obtain an accurate estimate of the fawn:doe ratio.

VEGETATION SAMPLING

Composition and Structure of Northern White-Cedar Stands

Long-term studies of deer browsing on various forest types and on timber products has not been well documented. A 20-year study (1942 to 1962) on the Allegheny National Forest in Pennsylvania reported declines in the understory of a virgin hemlock-hardwood forest (Hough 1965). A more recent study in Pennsylvania reported changes in species composition, growth impacts, and dramatic stocking differences between fenced and unfenced areas 9 to 22 years after clearcutting (Marquis 1981). The exclosure study initiated in this project will provide the opportunity to document long-term impacts of deer on the structure and composition of the cedar type. Although data recorded for baseline purposes were extensive, monitoring may focus on specific aspects of the community, e.g., cedar and rare herbaceous plant species.

The herbaceous component of forest communities is an important part of a deer's diet, but few studies have investigated the impacts of deer foraging on herbaceous species (Miller et al. 1992). Herbaceous plants comprised 87% of the summer diet of white-tailed deer in Wisconsin (McCaffery et al. 1974). This grazing impact is especially important regarding rare plants. Of the 95 species identified in the 4 study areas, several species of the Orchidaceae family were observed including showy and yellow lady's slipper which are favored by deer (Alverson et al. 1988). The intensity of herbaceous plant use in the cedar stands was not documented during this project but could be incorporated into the long-term monitoring to be conducted at these sites.

Exclosure and Open Area Site Data Combined

Significance tests among the study area gradients in which the exclosure and open area site data were combined revealed significant differences for all the vegetation components measured. Some of the differences were much more evident even ocularly (e.g., WRB-North vertical cover 0.5-2.0 m stratum compared to the other 3 study areas). With the densities of non-dominant woody species and the frequency of herbaceous species, many multiple comparison tests detected a difference among study areas, but the multiple comparison could not detect where the difference occurred. This may be due to the small sample sizes involved.

Trends were evident when comparing the study area gradients. Mean percent vertical cover dropped dramatically in the 0.5-2.0 m stratum from WRB-North to other study areas; this may be due to the higher amount of water found in the WRB-North sites. Stem densities of northern white-cedar in the 0-0.5 m stratum were much higher in the WRB than the SP. This may be due to site variation among the study areas or lower deer densities. The greater stem densities in the 0-0.5 m stratum compared to the 0.5-2.0 m stratum in the WRB may indicate the problem with cedar is being recruited into higher height classes and not regeneration. Once cedar grows above snow levels, browsing pressure may impact growth. Stem densities of other woody species often appeared to be related to the vegetation types surrounding the cedar stands, e.g., black ash had 14,444 stems/ha in SP-North (where a black ash stand was adjacent to the cedar stand) versus no stems in WRB-North where the cedar stands were surrounded primarily by northern hardwoods.

A wide variety of herbaceous species (95) were identified in the 4 study areas, but species richness was similar for the areas ranging from 49 to 59. Twenty species were common to the 4 areas with several of these species also being the most common within the study area gradients, e.g., bunchberry (Cornus canadensis), Canada mayflower, naked miterwort, and starflower, indicating their ability to exist in variable habitats. Thirty-three species, though, were identified in only 1 study area gradient indicating more specific habitat requirements.

Exclosure and Open Area Site Data Separated

Paired t-tests comparing composition and structure data of exclosure to open area sites showed minimal significant differences (Tables A3-A14, Appendix), due to the fact that, even on sites where exclosures have been constructed, enough time has not elapsed for vegetation differences to be detected. Differences that were detected were probably due to natural variation and microhabitat differences between exclosure and open area sites.

The comparisons among study areas resulted in 47 occurrences of significant differences primarily in the density of other woody species and frequency of herbaceous species. Multiple comparison tests for each of the species showing a significant difference were not always able to detect where the difference occurred probably due to the small sample size from each study area.

Browse Sampling

Deer browsing affects forest vegetation in different ways. Regeneration may decrease as reported in several studies (Dahlberg and Guettinger 1956, Beals et al. 1960, Behrend et al. 1970, Anderson and Loucks 1979, Frelich and Lorimer 1985, Case and McCullough 1987). Vegetation may be able to regenerate and be recruited, but their growth may be detrimentally impacted by deer browsing (Tilghman 1989). Some species, though, are able to repair injuries received from deer browsing and recover to grow beyond the reach of ungulates (Graham 1958). In contrast, mountain maple (Acer spicatum) has been found to slightly increase as browse pressure increases (Beals et al. 1960).

To compare the relative difference in browsing of selected tree species in the WRB and SP, browsing estimates of 3 tree species in stands adjacent to cedar stands were obtained in the 2 study areas. Sugar maple browsing (<10%) appeared to be much lower than that for balsam poplar and black ash (ranging from 31.3% to 45.3%) in each study area. The lower browsing levels for sugar maple may be due to a couple of reasons. First, the lower average height of sugar maple stems at the SP sampling site making the stems unavailable due to snow pack. Secondly, the extensive land area of northern hardwoods available where the sugar maple was sampled at the WRB sampling site (and in the WRB in general [27.31%]), which may spread the browsing intensity over a larger area reducing the percent browsed in the sampling area.

CONCLUSIONS

1. Overall use of vegetation types in the 2 areas (WRB and SP) was not in proportion to availability in either year. During spring/summer, vegetation types used more than expected were aspen/birch and mixed pine in the WRB and aspen/birch, mixed pine, and white-cedar in the SP. Deer use of the agricultural-cropland and "other" vegetation type categories was not observed in either study areas. Fall habitat use was similar to spring/summer use. Deer primarily used 5 vegetation types during the fall: northern hardwoods, aspen/birch, wet hardwood/conifer mix, mixed pine, and lowland conifers.
2. Deer movement from wintering areas to spring/summer home ranges reached maximum distances of 54.4 and 52.9 km from the WRB and SP trapping areas, respectively. During the 2 years of the study, 27% of WRB summer range deer were SP-trapped deer. Spring/summer home ranges were significantly larger in the WRB than the SP for both years. Fall home ranges were significantly larger in the WRB than the SP in 1994. Female spring/summer home ranges were significantly larger in the WRB than the SP in 1993 and both seasons in 1994.
3. Few significant differences were detected in vegetation characteristics between exclosure sites and open areas in all 4 study area gradients. Quantifying the vegetation characteristics over time, however, may provide natural resource

managers with a greater understanding of the long-term impacts of deer on the northern white-cedar type.

5. Sugar maple had a lower browsing intensity than black ash and balsam poplar in the WRB and SP.

6. Productivity (fawns:doe) was not significantly different between the WRB and the SP.

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MANAGEMENT RECOMMENDATIONS

Long-term forest management practices in the Hiawatha National Forest (HNF) should focus on maintaining vegetation types throughout the landscape that meet wildlife, timber, and other multiple use objectives. Maintaining vegetation types for deer populations can provide habitat for other species, both game and non-game, and be a part of the overall management scheme for the HNF.

Deer movements can be extensive from wintering areas to spring/summer ranges, so selected vegetation types should be provided to minimize the effects of locally abundant numbers on vegetation communities. A review of the distribution of vegetation types across the landscape may indicate the possibility of high concentrations of deer in local areas. Locations of future timber harvests should be planned to help reduce deer concentrations and alleviate browsing pressure on some forest species.

Spring supply of vegetation types that provide foods used by deer, such as graminids and evergreen ground plants (McCaffery et al. 1974) in close proximity to wintering areas will provide deer with the necessary food component to recover from reduced food intake during the winter months (Ozoga and Verme 1970). Spring food supply is also important for pregnant does that are nearing the fawning period.

Deer population goals for the state are set at 1.3 million; population size as of October 1994 was approximately 1.6 million (Ozoga et al. 1994). Seasonally high concentrations of deer may impact the forest community through changes in species composition (Marquis 1981) and impaired regeneration (Behrend et al. 1970, Anderson and Loucks 1979, Case and McCullough 1987). In areas where plant community composition and structure is a concern and deer are locally abundant, further herd reduction by removing more antlerless deer should be considered.

The spatial relationships of seasonal habitat use patterns and movements of deer need to be considered when setting harvest regulations and delineating Deer Management Unit boundaries. A challenge in setting harvest regulations is determining where wintering deer that are impacting vegetation are located during hunting season (e.g., what Deer Management Unit). Education of the hunting public needs to be conducted about management objectives and how antlerless deer hunting helps maintain forest ecosystem composition and structure and why deer seasonal demographics need to be considered when setting harvest quotas.

APPENDIX

Table A1. Seasonal home ranges (ha) of white-tailed deer in the Whitefish River Basin (WRB) and Stonington Peninsula (SP) using minimum convex polygon (MCP), harmonic mean (HM) with 95% contours, and adaptive kernel (AK) with 95% contours in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993.

				Spring/Summer Home Ranges (ha)		
Study Area	Sex	Age	Deer #	MCP	HM	AK
WRB	Female	Adult	1091	4.5	61.9	78.1
			750	9.5	90.6	145.1
			691	4.5	98.8	128.4
			1340	30.0	393.7	415.1
			591	16.0	326.5	273.6
			1011	20.0	160.5	174.4
			990	9.5	39.6	74.5
			1290	48.5	771.4	624.2
			1320	3.5	63.5	87.0
			411	3.0	66.7	77.7
			850	40.5	146.2	118.4[a]
			480	06.0	236.9	186.9
		Female Adult Mean		24.6	204.7	198.6
		(S.E.)		33.5)	(60.9)	(48.1)
		Yearling	540	217.0	319.7	362.1
			390	151.0	209.4	249.3
			550	77.5	78.7	129.9
			499	127.5	175.9	166.1
			420	8.0	6.7	34.9
			400	54.0	70.8	99.0
			370	576.0	3517.0	928.4
			1300	27.0	31.3	38.7
		Female Yearling Mean		154.8	551.2	251.1
		(S.E.)		(64.9)	(425.3)	(104.2)
	Female Mean			136.7	343.3	219.6
	(S.E.)			(32.0)	(171.6)	(49.4)
	Male	Adult	791	193.5	266.8	234.2
			710	247.5	287.3	382.8
			1230	99.0	257.1	172.8
			060	133.5	163.4	242.4
			079	11.0	39.1	50.3
		Male Adult Mean		136.9	202.7	216.5
		(S.E.)		(40.5)	(46.1)	(53.9)
		Yearling	490	85.5	136.4	145.6
			270	559.0	6313.7	13970.0
			360	37.5	63.3	77.3
			520	90.5	175.3	197.7
			439	265.5	354.4	466.2
			460	22.0	51.5	60.4
			1370	165.5	222.5	257.0
		Male Yearling Mean		175.1	1044.0	2167.7
		(S.E.)		(71.2)	(879.1)	(1967.7)
	Male Mean			159.2	693.5	1354.7
	(S.E.)			(43.5)	(511.7)	(1147.4)
WRB Study Area Mean				145.1	474.6	645.3
(S.E.)				(25.4)	(216.9)	(431.1)

Table A1 (cont'd).

Study Area	Sex	Age	Deer #	Spring/Summer Home Ranges (ha) MCP	HM	AK
SP	Female	Adult	731	19.5	28.6	39.4
			811	55.0	78.3	97.5
			1270	44.5	76.2	94.9
			771	104.5	106.8	178.4
			1221	45.0	59.6	73.1
			601	37.5	49.6	74.0
			831	37.5	31.6	43.9
			1110	133.5	205.7	305.3
		Female Adult Mean (S.E.)		59.6 (13.7)	79.6 (20.2)	113.3 (31.4)
		Yearling	510	32.5	48.8	51.7
			570	28.0	37.3	46.3
			350	23.0	31.4	48.7
			1280	26.0	34.4	38.0
		Female Yearling Mean (S.E.)		27.4 (2.0)	38.0 (3.8)	46.2 (2.9)
	Female Mean (S.E.)			48.9 (10.1)	65.7 (14.5)	90.9 (22.6)
	Male	Adult	1310	138.0	337.7	354.4
		Male Adult Mean (S.E.)		-----	-----	-----
		Yearling	530	46.0	75.3	97.1
			1330	190.5	468.9	398.5
		Male Yearling Mean (S.E.)		118.3 (72.3)	272.1 (196.8)	247.8 (150.7)
	Male Mean (S.E.)			124.8 (42.2)	294.0 (115.7)	283.3 (94.0)
SP Study Area Mean (S.E.)				64.1 (13.4)	111.3 (33.3)	96.7 (31.6)

Table A1 (cont'd).

Study Area	Sex	Age	Deer #	Fall Home Ranges (ha) MCP	HM	AK
WRB	Female	Adult	1091	308.0	559.3	816.7
			750	36.5	51.8	60.5
			691	50.0	54.0	56.4
			591	3742.0	1971.3	9411.0
			1011	27.5	43.6	54.4
			990	735.5	1842.5	3404.0
			1290	19.5	25.2	59.1
			1320	24.5	32.9	58.4
			411	44.0	48.9	82.6
			850	290.0	4702.0	5274.0
			480	166.0	196.6	313.6
		Female Adult Mean		494.9	866.2	1781.0
		(S.E.)		(331.2)	(442.1)	(923.8)
		Yearling	390	92.0	104.0	157.3
			550	46.0	61.0	100.0
			499	2.5	7.2	6.3
			400	66.5	81.6	119.4
			370	25.0	32.0	61.4
		Female Yearling Mean		46.4	57.2	88.9
		(S.E.)		(15.6)	(17.2)	(25.8)
	Female Mean			354.7	613.4	1252.2
	(S.E.)			(230.6)	(314.6)	(657.4)
	Male	Adult	791	343.5	472.3	909.2
			710	34.0	56.3	163.9
			1230	121.0	179.0	230.2
			060	48.0	31.5	141.7
		Male Adult Mean		136.6	184.8	361.3
		(S.E.)		(71.5)	(101.1)	(183.6)
		Yearling	270	99.5	148.6	139.8
			360	31.0	25.5	84.7
			520	4.0	8.8	8.5[a]
			460	109.0	60.7	228.9
		Male Yearling Mean		60.9	60.9	115.5
		(S.E.)		(25.7)	(31.2)	(46.4)
	Male Mean			98.8	122.8	238.4
	(S.E.)			(38.0)	(54.3)	(99.2)
WRB Study Area Mean				269.4	449.9	914.3
(S.E.)				(154.6)	(213.7)	(445.9)

Table A1 (cont'd).

Study Area	Sex	Age	Deer #	Fall Home Ranges (ha) MCP	HM	AK
SP	Female	Adult	811	70.0	70.9	98.2
			1270	46.0	90.7	81.6
			771	34.0	54.0	59.2
			1221	39.5	50.8	86.6
			601	35.5	36.8	67.3
			831	24.5	29.9	28.3
			1110	60.5	72.8	103.3
		Female Adult Mean		44.3	58.0	74.9
		(S.E.)		(6.0)	(8.1)	(9.8)
		Yearling	510	150.0	257.1	322.8
			570	72.5	131.5	98.1
			350	111.0	74.0[b]	175.8
			1280	42.0	91.8	79.5
		Female Yearling Mean		93.9	138.6	169.1
		(S.E.)		(23.4)	(41.3)	(55.3)
	Female Mean			62.3	87.3	109.2
	(S.E.)			(11.4)	(19.0)	(24.0)
	Male	Adult	1310	38.5	109.1	91.6
		Male Adult Mean		-----	-----	-----
		(S.E.)				
	Male Mean			-----	-----	-----
	(S.E.)					
SP Study Area Mean				60.3	89.1	107.7
(S.E.)				(10.6)	(17.5)	(21.9)

[a]80% contour; CALHOME program (Kie et al. 1994) was not able to calculate 95% contour.
[b]80% contour; TELEM88 program (Coleman and Jones 1988) was not able to calculate 95% contour.

Table A2. Seasonal home ranges (ha) for white-tailed deer in the Whitefish River Basin (WRB) and Stonington Peninsula (SP) using minimum convex polygon (MCP), harmonic mean (HM) with 95% contours, and adaptive kernel (AK) with 95% contours in the Hiawatha National Forest in Michigan's Upper Peninsula, 1994.

				Spring/Summer Home Ranges (ha)		
Study Area	Sex	Age	Deer #	MCP	HM	AK
WRB	Female	Adult	1091	187.0	300.3	309.4
			691	168.0	207.1	232.3
			591	239.0	797.5	480.1
			1011	161.0	195.6	191.9
			390	51.0	94.4	77.8
			990	161.5	177.9	181.1
			499	152.5	110.0[a]	208.1
			550	74.5	85.1	103.3
			1320	56.5	51.5	69.8
			400	38.5	61.0	57.9
			411	110.0	24.7[a]	155.5
			370	45.5	63.4	61.8
			480	58.0	79.3	83.6
		Female Adult Mean (S.E.)		115.6 (18.3)	192.1 (65.1)	170.2 (33.6)
		Yearling	530	1302.0	4573.0	10640.0
			1310	40.5	53.3	61.0
			360	126.5	126.7	159.9
		Female Yearling Mean (S.E.)		489.7 (406.9)	1584.3 (1494.5)	3620.3 (3510.0)
	Female Mean (S.E.)			185.8 (76.0)	490.4 (318.3)	817.1 (655.5)
	Male	Adult	270	90.0	137.9	104.5
			1230	150.5	185.5	169.9
			460	328.5	483.4	693.0
		Male Adult Mean (S.E.)		189.7 (71.6)	268.9 (108.1)	322.5 (186.2)
		Yearling	640	40.5	60.6	62.8
			520	235.0	179.3	226.0
			079	115.5	185.6	169.0
			710	90.0	201.8	140.0
		Male Yearling Mean (S.E.)		120.3 (41.3)	156.8 (32.4)	149.5 (34.0)
	Male Mean (S.E.)			150.0 (37.6)	204.9 (49.8)	223.6 (80.7)
WRB Study Area Mean (S.E.)				174.9 (53.6)	366.7 (194.4)	636.5 (455.7)

Table A2 (cont'd).

Study Area	Sex	Age	Deer #	Spring/Summer Home Ranges (ha) MCP	HM	AK
SP	Female	Adult	1221	53.5	84.2	81.0
			771	58.0	73.2	98.6
			601	61.0	76.4	68.9
			831	96.5	105.0	116.4
			1110	27.0	10.4	87.2
			570	28.5	45.1	49.0
			350	65.5	111.8	94.7
			1280	31.0	17.9	44.1[b]
		Female Adult Mean		52.6	65.5	80.0
		(S.E.)		(8.3)	(13.3)	(8.8)
		Yearling	1330	75.0	129.3	111.0
			490	59.0	73.1	98.4
			730	51.0	91.5	61.2
			790	25.0	40.4	33.4
		Female Yearling Mean		52.5	83.6	76.0
		(S.E.)		(10.4)	(18.5)	(17.7)
	Female Mean			52.6	71.5	78.7
	(S.E.)			(6.3)	(10.6)	(7.8)
	Male	Yearling	620	27.5	51.8	51.3
			1170	67.0	76.1	150.6
			1370	76.0	167.5	96.1
		Male Yearling Mean		56.8	98.5	76.0
		(S.E.)		(14.9)	(35.2)	(17.7)
	Male Mean			56.8	98.5	76.0
	(S.E.)			(14.9)	(35.2)	(17.7)
SP Study Area Mean				53.4	76.9	82.8
(S.E.)				(5.6)	(10.7)	(8.2)

Table A2 (cont'd).

Study Area	Sex	Age	Deer #	Fall Home Ranges (ha) MCP	HM	AK
WRB	Female	Adult	691	474.0	1527.1	517.0
			591	1595.0	14952.0	22830.0
			1011	28.5	64.5	32.9
			990	917.0	1772.9	3736.0
			499	38.0	204.2	50.2
			550	22.5	32.9	52.7
			1320	40.0	55.6	89.4
			400	79.0	82.6	95.5
			411	27.5	46.8	48.8
			480	36.0	45.4	61.0
		Female Adult Mean		325.8	1878.4	2751.4
		(S.E.)		(168.7)	(1467.5)	(2260.2)
		Yearling	530	50.0	120.1	126.7
			1310	1516.0	3544.0	259.7[c]
			360	7.5	14.0	19.8
		Female Yearling Mean		524.5	1226.0	135.4
		(S.E.)		(495.9)	(1159.4)	(69.4)
	Female Mean			371.6	1727.9	2147.7
	(S.E.)			(162.7)	(1140.3)	(1746.0)
	Male	Adult	270	20.5	13.8	42.3
			1230	69.0	149.0	164.8
		Male Adult Mean		44.8	81.4	103.6
		(S.E.)		(24.3)	(67.6)	(61.3)
		Yearling	640	105.5	197.3	162.7
			520	7.5	12.5	23.4
			079	7.0	15.9	19.2
			710	613.0	856.4	1373.0
		Male Yearling Mean		183.3	270.5	394.6
		(S.E.)		(145.1)	(200.0)	(327.8)
	Male Mean			137.1	207.5	297.6
	(S.E.)			(96.5)	(133.8)	(216.8)
WRB Study Area Mean				297.6	1247.7	1563.4
(S.E.)				(116.4)	(789.0)	(1198.3)

Table A2 (cont'd).

Study Area	Sex	Age	Deer #	Fall Home Ranges (ha)		
				MCP	HM	AK
SP	Female	Adult	1221	42.5	55.8	77.0
			771	6.0	9.2	11.1
			601	10.5	10.2	21.9
			831	45.6	46.5	82.1
			350	64.0	89.0	100.5
		Female Adult Mean		33.7	42.1	58.5
		(S.E.)		(11.0)	(15.0)	(17.7)
		Yearling	1330	9.0	17.3	27.0
			490	5.5	8.1	8.7
			730	4.5	6.7	11.9
			790	7.5	8.6	12.6
		Female Yearling Mean		6.6	10.2	15.1
		(S.E.)		(1.0)	(2.4)	(4.1)
	Female Mean			21.7	27.9	39.2
	(S.E.)			(7.5)	(9.8)	(12.2)
	Male	Yearling	620	16.0	23.9	22.7
			1370	29.5	44.5	40.3
		Male Yearling Mean		22.8	34.2	31.5
		(S.E.)		(6.8)	(10.3)	(8.8)
	Male Mean			22.8	34.2	31.5
	(S.E.)			(6.8)	(10.3)	(8.8)
SP Study Area Mean				21.9	29.1	37.8
(S.E.)				(6.2)	(8.0)	(10.0)

[a]80% contour; TELEM88 program (Coleman and Jones 1988) would not calculate 95% contour.
[b]80% contour; CALHOME program (Kie et al. 1994) would not calculate 95% contour.
[c]50% contour; CALHOME program (Kie et al. 1994) would not calculate 95% contour.

Table A3. Mean percent vertical cover (and standard error) for height strata in exclosure and areas open to browsing sites in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

		Site	
Study Area	Stratum (m)	Exclosure	Open Area
Whitefish River Basin-North	<0.5	90.7A[a] (1.2)	8.4A (3.6)
	0.5-2.0	60.3A (5.6)	77.9A (8.7)
	>2.0	80.7A (2.9)	84.2A (2.1)
	DWM[b]	5.3 (1.4)	5.8 (1.9)
Whitefish River Basin-South	<0.5	74.4A (8.0)	83.3A (1.8)
	0.5-2.0	5.2AB(2.1)	5.1AB(1.3)
	>2.0	94.0B (0.3)	91.6A (3.2)
	DWM	2.2 (0.7)	2.0 (0.3)
Stonington Peninsula-North	<0.5	73.2A (4.4)	73.7A (2.3)
	0.5-2.0	4.3AB(1.8)	10.2AB(7.7)
	>2.0	90.5AB(1.7)	86.0A (4.5)
	DWM	2.3 (0.7)	6.3 (1.7)
Stonington Peninsula-South	<0.5	66.6A* (7.2)	78.2A (6.9)
	0.5-2.0	0.7B* (0.1)	2.4B (0.4)
	>2.0	91.7AB(2.2)	93.8A (0.6)
	DWM	4.0 (0.3)	2.8 (0.5)

[a]Means with different letters within a site and stratum were significantly different (P<0.10) among study areas with the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992) and Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988).

[b]Downed woody material; descriptive only, no tests conducted.

*Significantly different (P<0.10) from open area with paired t-test (Steel and Torrie 1980).

Table A4. Mean percent horizontal cover (and standard error) for height strata in exclosure and areas open to browsing sites in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

		Site	
Study Area	Stratum (m)	Exclosure*	Open Area
Whitefish River Basin-North	<0.5	75.3[a] (5.2)	60.6A (12.0)
	0.5-1.0	58.3A[b] (7.1)	38.9A (8.9)
	1.0-1.5	54.9[a] (5.5)	46.0[a] (7.1)
	1.5-2.0	39.5[a] (6.1)	35.7A (6.1)
	2.0-2.5	44.2A (6.3)	43.8A (6.7)
Whitefish River Basin-South	<0.5	29.2 (3.4)	29.2A (5.8)
	0.5-1.0	13.8AB (5.9)	21.0A (6.9)
	1.0-1.5	11.5 (4.2)	18.6 (4.7)
	1.5-2.0	8.8 (2.2)	20.6AB (3.4)
	2.0-2.5	7.9B (1.3)	21.6AB (4.3)
Stonington Peninsula-North	<0.5	24.0 (4.2)	18.1A (3.2)
	0.5-1.0	14.0AB (2.7)	21.8A (8.6)
	1.0-1.5	14.5 (3.9)	10.4 (4.1)
	1.5-2.0	16.7 (4.6)	9.3B (3.8)
	2.0-2.5	22.4AB (7.5)	13.0AB (5.2)
Stonington Peninsula-South	<0.5	21.6 (4.0)	15.2A (3.0)
	0.5-1.0	8.1B (0.0)	11.8A (2.0)
	1.0-1.5	7.8 (4.1)	11.0 (4.1)
	1.5-2.0	7.9 (6.1)	9.1AB (1.3)
	2.0-2.5	9.5AB (7.1)	11.7B (0.4)

*No significant differences (P>0.10) between exclosure and open area sites for all study areas and strata with paired t-test (Steel and Torrie 1980).

[a]Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988) was unable to detect where the significant difference occurred within a site and stratum among the study areas as detected by the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992).

[b]Means with different letters within a site and stratum were significantly different (P<0.10) among study areas by the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992) and Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988).

Table A5. Mean stem densities per hectare (and standard error) of dominant tree species in exclosure and areas open to browsing sites in the 4 study areas (Whitefish River Basin-North and -South [WRB-North and -South] and the Stonington Peninsula-North and -South [SP-North and -South]) in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

			Site			
Study Area	Species	Stratum (m)	Exclosure		Open Area	
WRB-North	Northern white cedar	0-0.5	12179A[a]	(360)	10789A	(1875)
	Thuja occidentalis	0.5-2.0	148[b]	(64)	256[b]	(227)
		>2.0, <12.67 cm dbh	20A	(10)	10[b]	(5)
		>2.0, >12.67 cm dbh	523A	(120)	478A	(61)
	Balsam fir	0-0.5	9472A*	(2112)	7855A	(1918)
	Abies balsamea	0.5-2.0	10695[b]	(1319)	7761[b]	(2718)
		>2.0, <12.67 cm dbh	1622A	(240)	2056[b]	(334)
		>2.0, >12.67 cm dbh	104A	(89)	39A	(26)
	Sugar maple	0-0.5	296A	(281)	1183A	(571)
	Acer saccharum	0.5-2.0	168[b]	(153)	84[b]	(13)
		>2.0, <12.67 cm dbh	10A	(5)	10A	(5)
		>2.0, >12.67 cm dbh	10A	(10)	0A	(0)
WRB-South	Northern white cedar	0-0.5	12288A	(6783)	12663A	(7042)
	Thuja occidentalis	0.5-2.0	0	(0)	0	(0)
		>2.0, <12.67 cm dbh	1736B	(1098)	1977	(765)
		>2.0, >12.67 cm dbh	1203B	(242)	1016A	(317)
	Balsam fir	0-0.5	19305A		16090A	(8730)
	Abies balsamea	0.5-2.0	(13632)		138	(110)
		>2.0, <12.67 cm dbh	251	(223)	237	(101)
		>2.0, >12.67 cm dbh	148A	(97)	54A	(39)
			20A	(10)		
	Sugar maple	0-0.5	212A	(212)	163A	(155)
	Acer saccharum	0.5-2.0	0	(0)	0	(0)
		>2.0, <12.67 cm dbh	0A	(0)	0A	(0)
		>2.0, >12.67 cm dbh	0A	(0)	0A	(0)
SP-North	Northern white cedar	0-0.5	878A	(431)	2362A	(1265)
	Thuja occidentalis	0.5-2.0	0	(0)	79	(79)
		>2.0, <12.67 cm dbh	325AB	(260)	705	(580)
		>2.0, >12.67 cm dbh	720AB	(35)	695A	(78)
	Balsam fir	0-0.5	1893A	(1154)	3136A	(1616)
	Abies balsamea	0.5-2.0	20	(13)	168	(168)
		>2.0, <12.67 cm dbh	207A	(171)	227	(219)
		>2.0, >12.67 cm dbh	84A	(36)	35A	(21)
	Sugar maple	0-0.5	25A	(13)	49A	(42)
	Acer saccharum	0.5-2.0	0	(0)	0	(0)
		>2.0, <12.67 cm dbh	0A	(0)	0A	(0)
		>2.0, >12.67 cm dbh	0A	(0)	0A	(0)

Table A5 (cont'd).

Study Area	Species	Stratum (m)	Site			
			Exclosure		Open Area	
SP-South	Northern white cedar	0-0.5	1065A	(459)	910A	(200)
	Thuja occidentalis	0.5-2.0	0	(0)	0	(0)
		>2.0, <12.67 cm dbh	207AB	(74)	207	(74)
		>2.0, >12.67 cm dbh	888AB	(133)	799A	(0)
	Balsam fir	0-0.5	1938A	(1938)	377A	(126)
	Abies balsamea	0.5-2.0	7	(7)	15	(15)
		>2.0, <12.67 cm dbh	74A	(74)	155	(141)
		>2.0, >12.67 cm dbh	52A	(52)	44A	(15)
	Sugar maple	0-0.5	0A	(0)	0A	(0)
	Acer saccharum	0.5-2.0	0	(0)	0	(0)
		>2.0, <12.67 cm dbh	0A	(0)	0A	(0)
		>2.0, >12.67 cm dbh	0A	(0)	0A	(0)

[a]Means with different letters within a site, species, and stratum were significantly different ($P<0.10$) among study areas with the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992) and Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988).
[b]Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988) was unable to detect where the significant difference occurred within a site, species, and stratum among study areas as detected by the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992).
*Significantly different ($P<0.10$) from open area with paired t-test (Steel and Torrie 1980).

Table A6. Mean stem densities per hectare (and standard error) of non-dominant woody species in exclosure and areas open to browsing sites in the Whitefish River Basin-North study area in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

		Site	
Species	Stratum (m)	Exclosure*	Open Area
Alder-leaved buckthorn	0-0.5	1972 (1188)	2750 (2014)
Rhamnus alnifolia	0.5-2.0	1194 (989)	1917 (1792)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Alternate-leaved	0-0.5	417 (417)	611 (611)
dogwood	0.5-2.0	0 (0)	0 (0)
Cornus alternifolia	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
American elm	0-0.5	83 (48)	28 (28)
Ulmus americana	0.5-2.0	28 (28)	28 (28)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
American mountain ash	0-0.5	56 (28)	83 (48)
Sorbus americana	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
American red raspberry	0-0.5	0 (0)	28 (28)
Rubus idaeus	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Balsam poplar	0-0.5	0 (0)	0 (0)
Populus balsamifera	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	28 (28)	111 (111)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Beaked hazelnut	0-0.5	111 (111)	111 (111)
Corylus cornuta	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Black ash	0-0.5	0 (0)	0 (0)
Fraxinus nigra	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	28 (28)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Black currant	0-0.5	833 (567)	2028 (916)
Ribes lacustre	0.5-2.0	83 (83)	194 (100)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)

Table A6 (cont'd).

Species	Stratum (m)	Site	
		Exclosure	Open Area
Black spruce	0-0.5	2639 (709)	1083 (614)
Picea mariana	0.5-2.0	2000 (1380)	750 (289)
	>2.0, <12.67 cm dbh	1167 (1167)	389 (389)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Flowering dogwood	0-0.5	1028 (628)	56 (56)
Cornus florida	0.5-2.0	83 (48)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Honeysuckle	0-0.5	1361 (320)	972 (724)
Lonicera spp.	0.5-2.0	417 (293)	306 (227)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Hop hornbeam	0-0.5	0 (0)	56 (56)
Ostrya virginiana	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	28 (28)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Ironwood	0-0.5	194 (100)	278 (278)
Carpinus caroliniana	0.5-2.0	139 (139)	83 (83)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Labrador tea	0-0.5	20139 (18740)	18639 (15541)
Ledum groenlandicum	0.5-2.0	889 (889)	3000 (1732)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Mountain maple	0-0.5	56 (56)	0 (0)
Acer spicatum	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Paper birch	0-0.5	83 (83)	194 (194)
Betula papyrifera	0.5-2.0	0 (0)	83 (83)
	>2.0, <12.67 cm dbh	222 (222)	111 (111)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Red maple	0-0.5	1583 (756)	3833 (2821)
Acer rubrum	0.5-2.0	139 (56)	472 (431)
	>2.0, <12.67 cm dbh	0 (0)	28 (28)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Red-osier dogwood	0-0.5	278 (139)	972 (890)
Cornus stolonifera	0.5-2.0	139 (100)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)

Table A6 (cont'd).

Species	Stratum (m)	Site	
		Exclosure	Open Area
Rosa spp.	0-0.5	28 (28)	222 (222)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Smooth gooseberry	0-0.5	0 (0)	28 (28)
Ribes hirtella	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Speckled alder	0-0.5	1139 (901)	2667 (747)
Alnus rugosa	0.5-2.0	1389 (578)	2222 (320)
	>2.0, <12.67 cm dbh	56 (56)	361 (147)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Swamp red currant	0-0.5	389 (309)	333 (173)
Ribes triste	0.5-2.0	56 (56)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Tamarack	0-0.5	0 (0)	56 (56)
Larix laricina	0.5-2.0	56 (56)	28 (28)
	>2.0, <12.67 cm dbh	83 (83)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Vaccinium spp.	0-0.5	83 (48)	0 (0)
	0.5-2.0	28 (28)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Virgin's bower	0-0.5	28 (28)	0 (0)
Clematis virginiana	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
White spruce	0-0.5	0 (0)	0 (0)
Picea glauca	0.5-2.0	111 (73)	0 (0)
	>2.0, <12.67 cm dbh	111 (73)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Willow	0-0.5	28 (28)	56 (56)
Salix spp.	0.5-2.0	0 (0)	139 (139)
	>2.0, <12.67 cm dbh	28 (28)	139 (139)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Winterberry holly	0-0.5	0 (0)	28 (28)
Ilex verticallata	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)

Table A6 (cont'd).

Species	Stratum (m)	Site	
		Exclosure	Open Area
Yellow birch	0-0.5	56 (56)	167 (96)
Betula lutea	0.5-2.0	56 (56)	28 (28)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Other	0-0.5	28 (28)	28 (28)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)

*No significant differences (P>0.10) between exclosure and open area sites for any species and strata with paired t-test (Steel and Torrie 1980).

Table A7. Mean stem densities per hectare (and standard error) of non-dominant woody species in exclosure and areas open to browsing sites in the Whitefish River Basin-South study area in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

		Site	
Species	Stratum (m)	Exclosure	Open Area
Alder-leaved buckthorn	0-0.5	56 (56)	361 (147)
Rhamnus alnifolia	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Alternate-leaved	0-0.5	28 (28)	0 (0)
dogwood	0.5-2.0	0 (0)	0 (0)
Cornus alternifolia	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
American elm	0-0.5	83 (83)	111 (111)
Ulmus americana	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
American mountain ash	0-0.5	250 (173)	56 (56)
Sorbus americana	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Balsam poplar	0-0.5	306 (306)	806 (806)
Populus balsamifera	0.5-2.0	56 (56)	167 (167)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Beaked hazelnut	0-0.5	417 (376)	28 (28)
Corylus cornuta	0.5-2.0	56 (56)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Beech	0-0.5	56 (28)	0 (0)
Fagus grandifolia	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Black ash	0-0.5	5889 (5847)	8889 (8639)
Fraxinus nigra	0.5-2.0	333 (333)	444 (403)
	>2.0, <12.67 cm dbh	333 (333)	56 (56)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Black currant	0-0.5	28 (28)	28 (28)
Ribes lacustre	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)

Table A7 (cont'd).

Species	Stratum (m)	Site	
		Exclosure	Open Area
Black spruce	0-0.5	194 (73)	500 (459)
Picea mariana	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	28 (28)
	>2.0, >12.67 cm dbh	28 (28)	56 (56)
Choke cherry	0-0.5	111 (111)	139 (139)
Prunus virginiana	0.5-2.0	28 (28)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Honeysuckle	0-0.5	1528 (434)	1472 (420)
Lonicera spp.	0.5-2.0	83 (48)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Hop hornbeam	0-0.5	167 (167)	389 (227)
Ostrya virginiana	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Ironwood	0-0.5	250*(48)	28 (28)
Carpinus caroliniana	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Labrador tea	0-0.5	1361 (1361)	1472 (420)
Ledum groenlandicum	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Low sweet	0-0.5	361 (217)	2111 (1788)
blueberry	0.5-2.0	0 (0)	0 (0)
Vaccinium angustifolium	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Mountain maple	0-0.5	694 (313)	250 (250)
Acer spicatum	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Paper birch	0-0.5	3000 (928)	3778 (2749)
Betula papyrifera	0.5-2.0	56 (28)	83 (83)
	>2.0, <12.67 cm dbh	28 (28)	111 (111)
	>2.0, >12.67 cm dbh	28 (28)	0 (0)
Red maple	0-0.5	30611 (21759)	12028 (6731)
Acer rubrum	0.5-2.0	28 (28)	28 (28)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	28 (28)	0 (0)

Table A7 (cont'd).

Species	Stratum (m)	Site	
		Exclosure	Open Area
Red-osier dogwood Cornus stolonifera	0-0.5	139 (28)	389 (100)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Red oak Quercus rubra	0-0.5	0 (0)	28 (28)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Rubus spp.	0-0.5	28 (28)	0 (0)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Speckled alder Alnus rugosa	0-0.5	444 (444)	639 (598)
	0.5-2.0	28 (28)	83 (48)
	>2.0, <12.67 cm dbh	0 (0)	111 (73)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Swamp red currant Ribes triste	0-0.5	56 (28)	56 (28)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Tamarack Larix laricina	0-0.5	0 (0)	0 (0)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	56 (56)
	>2.0, >12.67 cm dbh	0 (0)	28 (28)
Vaccinium spp.	0-0.5	139 (139)	0 (0)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Velvet-leaved	0-0.5	111 (111)	1611 (1611)
blueberry	0.5-2.0	0 (0)	0 (0)
Vaccinium myrtilloides	>2.0, <12.67 cm dbh	111 (111)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Virginia creeper	0-0.5	56 (56)	500 (459)
Parthenocissus	0.5-2.0	0 (0)	0 (0)
quinquefolia	>2.0, <12.67 cm dbh	0 (0)	28 (28)
	>2.0, >12.67 cm dbh	0 (0)	56 (56)
White pine Pinus strobus	0-0.5	0 (0)	0 (0)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	56 (56)

Table A7 (cont'd).

Species	Stratum (m)	Site	
		Exclosure	Open Area
White spruce	0-0.5	56 (56)	0 (0)
Picea glauca	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Willow	0-0.5	56 (56)	0 (0)
Salix spp.	0.5-2.0	28 (28)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Winterberry holly	0-0.5	1500 (542)	944 (823)
Ilex verticallata	0.5-2.0	111 (73)	167 (167)
	>2.0, <12.67 cm dbh	28 (28)	56 (56)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Yellow birch	0-0.5	1833 (1792)	1222 (864)
Betula lutea	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	28 (28)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Other	0-0.5	0 (0)	139 (73)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)

*Significantly different ($P<0.10$) than open area using paired t-test (Steel and Torrie 1980).

Table A8. Mean stem densities per hectare (and standard error) of non-dominant woody species in exclosure and areas open to browsing sites in the Stonington Peninsula-North study area in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

		Sites	
Species	Stratum (m)	Exclosure	Open Area
Alder-leaved	0-0.5	0*(0)	111 (28)
buckthorn	0.5-2.0	0 (0)	0 (0)
Rhamnus alnifolia	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Alternate-leaved	0-0.5	0 (0)	56 (56)
dogwood	0.5-2.0	0 (0)	0 (0)
Cornus	>2.0, <12.67 cm dbh	0 (0)	0 (0)
alternifolia	>2.0, >12.67 cm dbh	0 (0)	0 (0)
American black	0-0.5	28 (28)	0 (0)
currant	0.5-2.0	0 (0)	0 (0)
Ribes americanum	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
American mountain ash	0-0.5	0 (0)	28 (28)
Sorbus americana	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
American red	0-0.5	0 (0)	0 (0)
raspberry	0.5-2.0	0 (0)	139 (139)
Rubus idaeus	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Balsam poplar	0-0.5	5778*(609)	1417 (625)
Populus balsamifera	0.5-2.0	472 (100)	361 (282)
	>2.0, <12.67 cm dbh	28 (28)	0 (0)
	>2.0, >12.67 cm dbh	139 (56)	111 (73)
Black ash	0-0.5	14444 (10729)	43694 (36469)
Fraxinus nigra	0.5-2.0	0 (0)	28 (28)
	>2.0, <12.67 cm dbh	0 (0)	28 (28)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Black currant	0-0.5	1111 (1070)	2472 (2472)
Ribes lacustre	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Black spruce	0-0.5	28 (28)	28 (28)
Picea mariana	0.5-2.0	28 (28)	0 (0)
	>2.0, <12.67 cm dbh	28 (28)	0 (0)
	>2.0, >12.67 cm dbh	56 (56)	0 (0)

Table A8 (cont'd).

Species	Stratum (m)	Site	
		Exclosure	Open Area
Eastern hemlock	0-0.5	28 (28)	0 (0)
Tsuga canadensis	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Honeysuckle	0-0.5	1167 (1125)	722 (556)
Lonicera spp.	0.5-2.0	0 (0)	139 (139)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Hop hornbeam	0-0.5	83 (83)	139 (139)
Ostrya virginiana	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Ironwood	0-0.5	139 (73)	167 (83)
Carpinus caroliniana	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	56 (56)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Mountain maple	0-0.5	2806 (2806)	6111 (6111)
Acer spicatum	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Paper birch	0-0.5	694 (437)	56 (56)
Betula papyrifera	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	28 (28)	28 (28)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Populus spp.	0-0.5	250 (250)	139 (139)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	28 (0)	83 (83)
Prickly gooseberry	0-0.5	0 (0)	83 (83)
Ribes cynobasti	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Red maple	0-0.5	5000 (1849)	3611 (2183)
Acer rubrum	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Red-osier dogwood	0-0.5	222 (111)	83 (83)
Cornus stolonifera	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)

Table A8 (cont'd).

Species	Stratum (m)	Site	
		Exclosure	Open Area
Rosa spp.	0-0.5	28 (28)	0 (0)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Speckled alder Alnus rugosa	0-0.5	28 (28)	28 (28)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	28 (28)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Swamp red currant Ribes triste	0-0.5	83 (83)	1222 (1222)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Trembling aspen Populus tremuloides	0-0.5	28 (28)	28 (28)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
White spruce Picea glauca	0-0.5	28 (28)	0 (0)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Winterberry holly Ilex verticallata	0-0.5	56 (28)	56 (56)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Yellow birch Betula lutea	0-0.5	56 (28)	83 (48)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	28 (28)
Other	0-0.5	56 (28)	0 (0)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)

*Significantly different (P<0.10) from open area using paired t-test (Steel and Torrie 1980).

Table A9. Mean stem densities per hectare (and standard error) of non-dominant woody species in exclosure and areas open to browsing sites in the Stonington Peninsula-South study area in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

Species	Stratum (m)	Site	
		Exclosure*	Open Area
Alder-leaved buckthorn Rhamnus alnifolia	0-0.5	42 (42)	0 (0)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Alternate-leaved dogwood Cornus alternifolia	0-0.5	42 (42)	167 (0)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
American mountain ash Sorbus americana	0-0.5	42 (42)	83 (0)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Balsam poplar Populus balsamifera	0-0.5	42 (42)	167 (167)
	0.5-2.0	0 (0)	83 (83)
	>2.0, <12.67 cm dbh	0 (0)	42 (42)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Black ash Fraxinus nigra	0-0.5	12167 (10667)	39917 (38333)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	42 (42)	42 (42)
	>2.0, >12.67 cm dbh	42 (42)	0 (0)
Black currant Ribes lacustre	0-0.5	750 (583)	1208 (375)
	0.5-2.0	0 (0)	83 (83)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Black spruce Picea mariana	0-0.5	83 (83)	0 (0)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Honeysuckle Lonicera spp.	0-0.5	583 (250)	2125 (2042)
	0.5-2.0	42 (42)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Hop hornbeam Ostrya virginiana	0-0.5	42 (42)	208 (208)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)

Table A9 (cont'd).

Species	Stratum (m)	Site: Exclosure	Site: Open Area
Ironwood	0-0.5	42 (42)	125 (125)
Carpinus caroliniana	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Mountain maple	0-0.5	1292 (1125)	9833 (9667)
Acer spicatum	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Paper birch	0-0.5	125 (125)	208 (42)
Betula papyrifera	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	42 (42)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	42 (42)
Prickly gooseberry	0-0.5	0 (0)	42 (42)
Ribes cynobasti	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Red maple	0-0.5	15125 (13625)	18583 (17917)
Acer rubrum	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Red-osier dogwood	0-0.5	83 (83)	333 (333)
Cornus stolonifera	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Ribes spp.	0-0.5	0 (0)	125 (125)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Rubus spp.	0-0.5	42 (42)	0 (0)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Smooth gooseberry	0-0.5	0 (0)	83 (83)
Ribes hirtella	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Speckled alder	0-0.5	0 (0)	42 (42)
Alnus rugosa	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)

Table A9 (cont'd).

Species	Stratum (m)	Site	
		Exclosure	Open Area
Swamp red currant	0-0.5	0 (0)	208 (125)
Ribes triste	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
White spruce	0-0.5	0 (0)	83 (83)
Picea glauca	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Winterberry holly	0-0.5	83 (83)	208 (208)
Ilex verticallata	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Yellow birch	0-0.5	9208 (375)	5667 (5417)
Betula lutea	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	42 (42)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)
Other	0-0.5	0 (0)	125 (125)
	0.5-2.0	0 (0)	0 (0)
	>2.0, <12.67 cm dbh	0 (0)	0 (0)
	>2.0, >12.67 cm dbh	0 (0)	0 (0)

*No significant differences (P>0.10) between exclosure and open area sites for any species and strata with paired t-test (Steel and Torrie 1980).

Table A10. Mean stem densities per hectare (and standard error) of non-dominant woody species that were significantly different (P<0.10) within site and stratum among study areas (Whitefish River Basin-North and -South [WRB-North and -South] and Stonington Peninsula-North and -South [SP-North and -South]) in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

			Site			
Study Area	Species	Stratum (m)	Exclosure		Open Area	
WRB-North	Alder-leaved buckthorn	0-0.5	1972A[a]	(1188)	2750A	(2014)
	Rhamnus alnifolia	0.5-2.0	1194[b]	(989)	1917[b]	(1792)
	Balsam poplar	0-0.5	0A	(0)	------[c]	
	Populus balsamifera	0.5-2.0	0[b]	(0)	------	
		>2.0, >12.67 cm dbh	28[b]	(28)	------	
	Black ash Fraxinus nigra	0-0.5	0[b]	(0)	0[b]	(0)
	Black spruce	0-0.5	2639A	(709)	------	
	Picea mariana	0.5-2.0	2000[b]	(1380)	750[b]	(289)
	Paper birch Betula papyrifera	0-0.5	83A	(83)	194[b]	(194)
	Red maple Acer saccharum	0.5-2.0	139[b]	(56)	------	
	Speckled alder Alnus rugosa	0.5-2.0	1389[b]	(578)	2222A	(320)
	Winterberry holly Ilex verticallata	0-0.5	0A	(0)	------	
WRB-South	Alder-leaved buckthorn	0-0.5	56AB	(56)	361AB	(147)
	Rhamnus alnifolia	0.5-2.0	0	(0)	0	(0)
	Balsam poplar	0-0.5	306AB	(306)	------	
	Populus balsamifera	0.5-2.0	56	(56)	------	
		>2.0, >12.67 cm dbh	0	(0)		
	Black ash Fraxinus nigra	0-0.5	5889	(5847)	8889	(8639)
	Black spruce	0-0.5	194AB	(73)	------	
	Picea mariana	0.5-2.0	0	(0)	0	(0)
	Paper birch Betula papyrifera	0-0.5	3000B	(928)	3778	(2749)
	Red maple Acer rubrum	0.5-2.0	28	(28)	------	

Table A10 (cont'd).

Study Area	Species	Stratum (m)	Site: Exclosure		Site: Open Area	
WRB-South (cont'd.)	Speckled alder <u>Alnus</u> <u>rugosa</u>	0.5-2.0	28	(28)	83AB	(48)
	Winterberry holly <u>Ilex</u> <u>verticallata</u>	0-0.5	1500B	(542)	------	
SP-North	Alder-leaved buckthorn <u>Rhamnus</u> <u>alnifolia</u>	0-0.5	0B	(0)	111AB	(28)
		0.5-2.0	0	(0)	0	(0)
	Balsam poplar <u>Populus</u> <u>balsamifera</u>	0-0.5	5778B	(609)	------	
		0.5-2.0	472	(100)	------	
		>2.0, >12.67 cm dbh	28	(28)		
	Black ash <u>Fraxinus</u> <u>nigra</u>	0-0.5	14444	(10729)	43694	(36469)
	Black spruce <u>Picea</u> <u>mariana</u>	0-0.5	28B	(28)	------	
		0.5-2.0	28	(28)	0	(0)
	Paper birch <u>Betula</u> <u>papyrifera</u>	0-0.5	694AB	(437)	56	(56)
	Speckled alder <u>Alnus</u> <u>rugosa</u>	0.5-2.0	0	(0)	0A	(0)
	Red maple <u>Acer</u> <u>rubrum</u>	0.5-2.0	0	(0)	------	
	Winterberry holly <u>Ilex</u> <u>verticallata</u>	0-0.5	56AB	(28)	------	
SP-South	Alder-leaved buckthorn <u>Rhamnus</u> <u>alnifolia</u>	0-0.5	42AB	(34)	0B	(0)
		0.5-2.0	0	(0)	0	(0)
	Balsam poplar <u>Populus</u> <u>balsamifera</u>	0-0.5	42AB	(34)	------	
		0.5-2.0	0	(0)	------	
		>2.0, >12.67 cm dbh	0	(0)	------	
	Black ash <u>Fraxinus</u> <u>nigra</u>	0-0.5	12167	(8709)	39917	(31299)
	Black spruce <u>Picea</u> <u>mariana</u>	0-0.5	83AB	(68)	------	
		0.5-2.0	0	(0)	0	(0)
	Paper birch <u>Betula</u> <u>papyrifera</u>	0-0.5	125A	(102)	208	(34)

Table A10 (cont'd).

Study Area	Species	Stratum (m)	Site: Exclosure	Site: Open Area
SP-South (cont'd.)	Red maple Acer rubrum	0.5-2.0	0 (0)	------
	Speckled alder Alnus rugosa	0.5-2.0	0 (0)	0AB (0)
	Winterberry holly Ilex verticallata	0-0.5	83AB (68)	------

[a]Means with different letters within a site, species, and stratum were significantly different (P<0.10) among study areas with the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992) and the Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988).
[b]Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988) was unable to detect where the significant difference occurred within a site, species, and stratum among the study areas as detected by the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992).
[c]Species not identified in any study area for this site type.

Table A11. Mean absolute (AF) and relative frequencies (RF) (and standard errors [SE]) of herbaceous species in exclosure and areas open to browsing sites in the Whitefish River Basin-North study area in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

	Site			
	Exclosure		Open Area	
Species	AF[a] (SE)	RF (SE)	AF (SE)	RF (SE)
Aster spp.	20.8 (11.0)	1.4 (0.8)	37.5 (19.1)	2.3 (1.1)
Bunchberry Cornus canadensis	79.2 (4.2)	5.4 (0.4)	87.5 (12.5)	5.8 (1.1)
Canada mayflower Maianthemum canadense	66.7 (4.2)	4.5 (0.4)	70.8 (8.3)	4.7 (0.6)
Cinnamon fern Osmunda cinnamomea	0 (0)	0 (0)	4.2 (4.2)	0.3 (0.3)
Common wood sorrel Oxalis montana	0 (0)	0 (0)	4.2 (4.2)	0.3 (0.3)
Crested wood fern Dryopteris cristata	4.2 (4.2)	0.3 (0.3)	8.3 (8.3)	0.5 (0.5)
Dewberry Rubus hispidus	62.5 (31.5)	4.3 (2.2)	62.5 (25.0)	4.4 (1.9)
Dwarf enchanter's nightshade Circaea alpina	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Equisetum spp.	4.2 (4.2)	0.3 (0.3)	4.2 (4.2)	0.2 (0.2)
Fragile fern Cystopteris fragilis	29.2 (8.3)	2.0 (0.6)	25.0 (14.4)	1.5 (0.8)
Fringed brome Bromus ciliatus	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Goldenrod Solidago spp.	41.7 (22.0)	2.7 (1.4)	50.0 (19.1)	3.5 (1.6)
Goldthread Coptis groenlandica	70.8 (23.2)	4.7 (1.5)	91.7 (4.2)	6.1 (0.4)
Grass spp.	8.3 (8.3)	0.5 (0.5)	62.5 (21.7)	4.2 (1.5)

Table A11 (cont'd).

	Site			
	Exclosure		Open Area	
Species	AF (SE)	RF (SE)	AF (SE)	RF (SE)
Hawkweed Hieracium spp.	8.3 (8.3)	0.6 (0.6)	8.3 (4.2)	0.6 (0.3)
Intermediate wood fern Dryopteris intermedia	0 (0)	0 (0)	4.2 (4.2)	0.3 (0.3)
Jewelweed Impatiens spp.	8.3 (8.3)	0.6 (0.6)	0 (0)	0 (0)
Joe-pye weed Eupatorium spp.	20.8 (11.0)	1.4 (0.8)	16.7 (11.0)	1.2 (0.9)
Large-leaved aster Aster macrophyllus	12.5 (7.2)	0.8 (0.5)	4.2 (4.2)	0.3 (0.3)
Manna grass Glyceria spp.	0 (0)	0 (0)	20.8 (20.8)	1.2 (1.2)
Marsh bedstraw Galium palustre	25.0 (14.4)	1.7 (1.0)	25.0 (12.5)	1.8 (0.9)
Marsh marigold Caltha palustris	0 (0)	0 (0)	12.5 (12.5)	1.0 (1.0)
Moss spp.	100 (0)	6.8 (0.2)	100 (0)	6.6 (0.6)
Naked miterwort Mitella nuda	95.8 (4.2)	6.5 (0.5)	62.5 (26.0)	4.4 (2.0)
Oak fern Gymnocarpium spp.	12.5 (7.2)	0.9 (0.9)	20.8 (11.0)	1.4 (0.7)
Orchidaceae spp.	4.2 (4.2)	0.3 (0.3)	8.3 (4.2)	0.5 (0.3)
Pyrola spp.	12.5 (7.2)	0.9 (0.5)	8.3 (8.3)	0.5 (0.5)
Rattlesnake fern Botrychium virginianum	8.3 (4.2)	0.6* (0.3)	33.3 (11.0)	2.1 (0.6)
Rattlesnake plantain Goodyera spp.	0 (0)	0 (0)	8.3 (4.2)	0.5 (0.3)

Table A11 (cont'd).

	Site			
	Exclosure		Open Area	
Species	AF (SE)	RF (SE)	AF (SE)	RF (SE)
Royal fern _Osmunda regalis_	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Sedge _Carex_ spp.	91.7 (4.2)	6.2* (0.1)	87.5 (7.2)	5.7 (0.1)
Self-heal _Prunella vulgaris_	8.3 (8.3)	0.6 (0.6)	8.3 (4.2)	0.5 (0.3)
Showy lady's slipper _Cypripedium reginae_	0 (0)	0 (0)	8.3 (4.2)	0.6 (0.3)
Small-flowered cranberry _Vaccinium oxycoccos_	4.2 (4.2)	0.3 (0.3)	8.3 (8.3)	0.5 (0.5)
Snowberry _Gaultheria hispidula_	75.0 (12.5)	5.0* (0.7)	25.0 (14.4)	1.5 (0.9)
Starflower _Trientalis borealis_	37.5 (12.5)	2.5 (0.7)	62.5 (31.5)	3.8 (1.9)
Strawberry _Fragaria_ spp.	83.3 (11.0)	5.6 (0.6)	66.7 (16.7)	4.3 (0.8)
Sundew _Drosera_ spp.	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Sweet coltsfoot _Petasites palmatus_	8.3 (4.2)	0.6 (0.3)	8.3 (8.3)	0.5 (0.5)
Sweet-scented bedstraw _Galium triflorum_	62.5 (0)	4.2 (0.1)	20.8 (20.8)	1.2 (1.2)
Thistle _Cirsium_ spp.	45.8 (4.2)	3.1 (0.2)	54.2 (20.8)	3.6 (1.5)
Three-leaved Solomon's seal _Smilacina trifolia_	75.0 (19.1)	5.0 (1.2)	66.7 (22.0)	4.2 (1.1)
Trailing arbutus _Epigaea repens_	0 (0)	0 (0)	4.2 (4.2)	0.2 (0.2)
Twinflower _Linnaea borealis_	91.7 (8.3)	6.2 (0.5)	75.0 (7.2)	4.9 (0.1)

Table A11 (cont'd).

	Site			
	Exclosure		Open Area	
Species	AF (SE)	RF (SE)	AF (SE)	RF (SE)
Violet Viola spp.	75.0 (12.5)	5.0 (0.7)	83.3 (8.3)	5.5 (0.3)
Wild sarsaparillo Aralia nudicaulis	37.5 (12.5)	2.6* (0.9)	62.5 (14.4)	4.0 (0.8)
Wintergreen Gaultheria procumbens	16.7 (8.3)	1.1 (0.6)	12.5 (7.2)	0.7 (0.4)
Wood anemone Anemone quinquefolia	12.5 (12.5)	0.8 (0.8)	4.2 (4.2)	0.2 (0.2)
Wood Sorrel Oxalis spp.	16.7 (16.7)	1.2 (1.2)	0 (0)	0 (0)
Other	29.2 (4.2)	2.0 (0.2)	29.2 (23.2)	1.7 (1.3)

[a]Significant differences between exclosure and open area sites were not determined for absolute frequencies, only relative frequencies.
*Significantly different (P<0.10) from open area with paired t-test (Steel and Torrie 1980).

Table A12. Mean absolute (AF) and relative frequencies (RF) (and standard errors [SE]) of herbaceous species in exclosure and areas open to browsing sites in the Whitefish River Basin-South study area in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

	Site			
	Exclosure		Open Area	
Species	AF[a] (SE)	RF (SE)	AF (SE)	RF (SE)
Aster spp.	12.5 (0)	0.9 (0)	25.0 (14.4)	1.8 (1.1)
Bedstraw Galium spp.	0 (0)	0 (0)	16.7 (16.7)	1.1 (1.1)
Bracken fern Pteridium aquilinum	4.2 (4.2)	0.3 (0.3)	4.2 (4.2)	0.3 (0.3)
Bugleweed Lycopus spp.	4.2 (4.2)	0.3 (0.3)	8.3 (4.2)	0.6 (0.3)
Bunchberry Cornus canadensis	37.5 (19.1)	2.9 (1.6)	62.5 (31.5)	4.5 (2.2)
Canada mayflower Maianthemum canadense	70.8 (11.0)	5.1* (0.6)	91.7 (4.2)	6.3 (0.2)
Cinnamon fern Osmunda cinnamomea	8.3 (8.3)	0.6 (0.6)	4.2 (4.2)	0.3 (0.3)
Columbine Aquilegia spp.	0 (0)	0 (0)	4.2 (4.2)	0.3 (0.3)
Club-spur orchid Habenaria clavellata	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Crested wood fern Dryopteris cristata	16.7 (8.3)	1.2 (0.6)	0 (0)	0 (0)
Dewberry Rubus hispidus	54.2 (11.0)	4.0 (0.8)	66.7 (16.7)	4.5 (0.9)
Dryopteris spp.	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Equisetum spp.	16.7 (11.0)	1.1 (0.8)	4.2 (4.2)	0.3 (0.3)
Fragile fern Cystopteris fragilis	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)

Table A12 (cont'd).

Species	Site: Exclosure AF (SE)	Site: Exclosure RF (SE)	Site: Open Area AF (SE)	Site: Open Area RF (SE)
Fringed polygala Polygala paucifolia	75.0 (12.5)	5.6 (1.2)	79.2 (4.2)	5.5 (0.5)
Golden ragwort Senecio aureus	4.2 (4.2)	0.3 (0.3)	12.5 (12.5)	0.8 (0.8)
Goldenrod Solidago spp.	29.2 (16.7)	2.1 (1.2)	33.3 (15.0)	2.2 (0.9)
Goldthread Coptis groenlandica	95.8 (4.2)	7.0 (0.6)	91.7 (8.3)	6.4 (0.8)
Grass spp.	62.5 (31.5)	4.4 (2.2)	54.2 (25.3)	3.6 (1.6)
Interrupted fern Osmunda claytoniana	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Jack-in-the-pulpit Arisaema spp.	0 (0)	0 (0)	16.7 (16.7)	1.1 (1.1)
Jewelweed Impatiens spp.	0 (0)	0 (0)	20.8 (20.8)	1.3 (1.3)
Joe-pye weed Eupatorium spp.	12.5 (7.2)	0.9 (0.5)	8.3 (4.2)	0.6 (0.3)
Large-leaved aster Aster macrophyllus	0 (0)	0 (0)	12.5 (12.5)	0.8 (0.8)
Lesser pyrola Pyrola minor	0 (0)	0 (0)	12.5 (12.5)	0.9 (0.9)
Long beech fern Thelypteris phegopteris	0 (0)	0 (0)	4.2 (4.2)	0.3 (0.3)
Marsh bedstraw Galium palustre	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Marsh fern Thelypteris palustris	8.3 (8.3)	0.6 (0.6)	0 (0)	0 (0)
Marsh marigold Caltha palustris	0 (0)	0 (0)	4.2 (4.2)	0.3 (0.3)

Table A12 (cont'd).

	Site			
	Exclosure		Open Area	
Species	AF (SE)	RF (SE)	AF (SE)	RF (SE)
Moss spp.	100 (0)	7.3 (0.4)	100 (0)	6.9 (0.3)
Naked miterwort *Mitella nuda*	83.3 (11.0)	6.2 (1.1)	91.7 (8.3)	6.3 (0.4)
Oak fern *Gymnocarpium* spp.	8.3 (8.3)	0.6 (0.6)	0 (0)	0 (0)
One-flowered pyrola *Moneses uniflora*	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Orchidaceae spp.	0 (0)	0 (0)	4.2 (4.2)	0.3 (0.3)
Pyrola spp.	16.7 (8.3)	1.2 (0.6)	25.0 (14.4)	1.8 (1.0)
Rattlesnake fern *Botrychium virginianum*	16.7 (4.2)	1.2 (0.3)	37.5 (26.0)	2.5 (1.8)
Rough bedstraw *Galium asprellum*	54.2 (15.0)	3.9 (0.9)	37.5 (0)	2.6 (0.1)
Royal fern *Osmunda regalis*	16.7 (11.0)	1.2 (0.7)	12.5 (12.5)	0.9 (0.9)
Sedge *Carex* spp.	83.3 (11.0)	6.2 (1.1)	79.2 (20.8)	5.6 (1.6)
Self-heal *Prunella vulgaris*	8.3 (8.3)	0.6 (0.6)	4.2 (4.2)	0.3 (0.3)
Sensitive fern *Onoclea sensibilis*	8.3 (4.2)	0.6 (0.3)	4.2 (4.2)	0.3 (0.3)
Small-flowered cranberry *Vaccinium oxycoccos*	0 (0)	0 (0)	16.7 (16.7)	1.1 (1.1)
Snowberry *Gaultheria hispidula*	75.0 (14.4)	5.6 (1.3)	62.5 (19.1)	4.4 (1.4)
Starflower *Trientalis borealis*	91.7 (8.3)	6.7 (0.8)	83.3 (4.2)	5.8 (0.4)

Table A12 (cont'd).

	Site			
	Exclosure		Open Area	
Species	AF (SE)	RF (SE)	AF (SE)	RF (SE)
Strawberry Fragaria spp.	20.8 (15.0)	1.5 (1.1)	33.3 (33.3)	2.1 (2.1)
Sweet coltsfoot Petasites palmatus	0 (0)	0 (0)	4.2 (4.2)	0.3 (0.3)
Sweet-scented bedstraw Galium trifolum	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Tall meadow rue Thalictrum polygamum	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Thistle Cirsium spp.	33.3 (11.0)	2.4 (0.7)	20.8 (11.0)	1.5 (0.8)
Three-leaved Solomon's seal Smilacina trifolia	37.5 (7.2)	2.8 (0.5)	20.8 (15.0)	1.4 (1.0)
Trailing arbutus Epigaea repens	4.2 (4.2)	0.3 (0.3)	8.3 (8.3)	0.6 (0.6)
Twinflower Linnaea borealis	50.0 (28.9)	3.8 (2.3)	45.8 (23.2)	3.3 (1.6)
Twisted stalk Streptopus amplexifolius	0 (0)	0 (0)	12.5 (12.5)	0.8 (0.8)
Violet Viola spp.	45.8 (8.3)	3.4 (0.8)	50.0 (25.0)	3.4 (1.7)
Wild ginger Asarum canadense	0 (0)	0 (0)	4.2 (4.2)	0.3 (0.3)
Wild sarsaparillo Aralia nudicaulis	29.2 (18.2)	2.0 (1.3)	33.3 (33.3)	2.1 (2.1)
Wintergreen Gaultheria procumbens	8.3 (8.3)	0.7 (0.7)	20.8 (11.0)	1.5 (0.8)
Wood Sorrel Oxalis spp.	25.0 (19.1)	1.7 (1.3)	0 (0)	0 (0)

Table A12 (cont'd).

	Site			
	Exclosure		Open Area	
Species	AF (SE)	RF (SE)	AF (SE)	RF (SE)
Yellow lady's slipper <u>Cypripedium calceolus</u>	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Other	4.2 (4.2)	0.3 (0.3)	4.2 (4.2)	0.3 (0.3)

[a]Significant differences between exclosure and open area sites were not determined for absolute frequencies, only relative frequencies.
*Significantly different (P<0.10) from open area with paired t-test (Steel and Torrie 1980).

Table A13. Mean absolute (AF) and relative frequencies (RF) (and standard errors [SE]) of herbaceous species in exclosure and areas open to browsing sites in the Stonington Peninsula-North study area in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

	Site			
	Exclosure		Open Area	
Species	AF[a] (SE)	RF (SE)	AF (SE)	RF (SE)
Anemone spp.	0 (0)	0 (0)	6.1 (3.0)	0.5 (0.3)
Arrow arum *Peltranda virginica*	0 (0)	0 (0)	3.0 (3.0)	0.4 (0.4)
Aster spp.	37.5 (12.5)	2.8 (1.0)	12.1 (6.1)	1.4 (0.7)
Bedstraw *Galium* spp.	4.2 (4.2)	0.4 (0.4)	0 (0)	0 (0)
Blunt-lobed woodsia *Woodsia obtusa*	0 (0)	0 (0)	3.0 (3.0)	0.2 (0.2)
Boot's wood fern *Dryopteris boottii*	41.7 (15.0)	3.1 (1.2)	21.2 (10.9)	1.7 (0.9)
Bracken fern *Pteridium aquilinum*	0 (0)	0 (0)	6.1 (6.1)	0.6 (0.6)
Bugleweed *Lycopus* spp.	8.3 (8.3)	0.5 (0.5)	15.2 (10.9)	1.1 (0.7)
Bulbet fern *Cystopteris bulbifera*	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Bunchberry *Cornus canadensis*	29.2 (18.2)	1.9 (1.1)	21.2 (21.2)	1.3 (1.3)
Buttercup *Ranunculus* spp.	0 (0)	0 (0)	42.4 (23.7)	4.9 (2.9)
Canada mayflower *Maianthemum canadense*	91.7 (4.2)	7.1 (1.0)	72.7 (15.7)	6.9 (1.9)
Cinquefoil *Potentilla* spp.	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Clover *Trifolium* spp.	4.2 (4.2)	0.3 (0.3)	9.1 (5.2)	1.0 (0.6)

Table A13 (cont'd).

Species	Site			
	Exclosure		Open Area	
	AF (SE)	RF (SE)	AF (SE)	RF (SE)
Club moss Lycopodium spp.	4.2 (4.2)	0.4 (0.4)	0 (0)	0 (0)
Crested wood fern Dryopteris cristata	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Dandelion Taraxacum spp.	4.2 (4.2)	0.3 (0.3)	9.1 (5.2)	1.0 (0.6)
Dewberry Rubus hispidus	33.3 (22.0)	2.2 (1.3)	33.3 (33.3)	2.1 (2.1)
Dryopteris spp.	25.0 (12.5)	2.0 (1.1)	6.1 (6.1)	0.4 (0.4)
Dwarf enchanter's nightshade Circaea alpina	29.2 (29.2)	1.8 (1.8)	21.2 (21.2)	1.3 (1.3)
Equisetum spp.	50.0 (26.0)	3.6 (1.8)	36.4 (27.8)	2.7 (1.7)
False Solomon's seal Smilacina racemosa	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Golden ragwort Senecio aureus	4.2 (4.2)	0.3 (0.3)	0 (0)	0 (0)
Goldenrod Solidago spp.	41.7 (8.3)	3.3 (0.9)	33.3 (12.1)	3.1 (1.3)
Grass spp.	37.5 (0)	2.9 (0.3)	60.6 (21.2)	5.4 (1.9)
Grass/sedge spp.	75.0 (7.2)	5.6 (0.4)	42.4 (21.9)	4.1 (2.6)
Hawkweed Hieracium spp.	16.7 (11.0)	1.4 (1.0)	60.6 (23.7)	6.7 (3.2)
Hooked crowfoot Ranunculus recurvatus	0 (0)	0 (0)	6.1 (6.1)	0.4 (0.4)
Intermediate wood fern Dryopteris intermedia	12.5 (7.2)	0.8 (0.4)	6.1 (3.0)	0.5 (0.3)

Table A13 (cont'd).

Species	Site: Exclosure AF (SE)	Site: Exclosure RF (SE)	Site: Open Area AF (SE)	Site: Open Area RF (SE)
Marsh bedstraw	8.3	0.5	3.0	0.2
Galium palustre	(8.3)	(0.5)	(3.0)	(0.2)
Milkweed	0	0	3.0	0.2
Asclepias spp.	(0)	(0)	(3.0)	(0.2)
Mint	4.2	0.3	3.0	0.2
Mentha spp.	(4.2)	(0.3)	(3.0)	(0.2)
Moss spp.	91.7	7.0	93.9	9.2
	(8.3)	(0.9)	(3.0)	(1.8)
Naked miterwort	54.2	3.8	39.4	2.8
Mitella nuda	(23.2)	(1.2)	(30.8)	(1.9)
Oak fern	54.2	4.0	12.1	0.8
Gymnocarpium spp.	(15.0)	(1.2)	(12.1)	(0.8)
Ostrich fern	4.2	0.3	0	0
Matteuccia struthiopteris	(4.2)	(0.3)	(0)	(0)
Pyrola spp.	29.2	2.1	3.0	0.2
	(15.0)	(1.0)	(3.0)	(0.2)
Rattlesnake fern	58.3	4.3*	24.2	2.2
Botrychium virginianum	(11.0)	(0.7)	(8.0)	(0.7)
Rough bedstraw	33.3	2.2*	42.4	3.4
Galium asprellum	(22.0)	(1.3)	(21.2)	(1.2)
Sedge	45.8	3.9	33.3	3.8
Carex spp.	(23.2)	(1.9)	(16.9)	(2.0)
Self-heal	25.0	1.8	15.2	1.4
Prunella vulgaris	(7.2)	(0.4)	(3.0)	(0.4)
Sensitive fern	4.2	0.3	0	0
Onoclea sensibilis	(4.2)	(0.3)	(0)	(0)
Silvery glade fern	25.0	1.8	3.0	0.2
Athyrium thelypterioides	(12.5)	(0.9)	(3.0)	(0.2)
Skullcap	0	0	6.1	0.4
Scutellaria spp.	(0)	(0)	(6.1)	(0.4)

Table A13 (cont'd).

	Site			
	Exclosure		Open Area	
Species	AF (SE)	RF (SE)	AF (SE)	RF (SE)
Spinulose wood fern *Dryopteris spinulosa*	8.3 (8.3)	0.7 (0.7)	3.0 (3.0)	0.3 (0.3)
Spurred gentian *Halenia deflexa*	8.3 (8.3	0.7 (0.7)	18.2 (18.2)	1.9 (1.9)
Starflower *Trientalis borealis*	62.5 (14.4)	4.7 (1.2)	51.5 (26.9)	4.2 (2.1)
Strawberry *Fragaria* spp.	20.8 (11.0)	1.4 (0.7)	15.2 (15.2)	1.0 (1.0)
Sweet coltsfoot *Petasites palmatus*	45.8 (22.0)	3.8 (2.0)	21.2 (21.2)	2.6 (2.6)
Tall buttercup *Ranunculus acris*	12.5 (12.5)	1.1 (1.1)	0 (0)	0 (0)
Thistle *Cirsium* spp.	33.3 (11.0)	2.4 (0.7)	33.3 (10.9)	3.2 (1.3)
Twinflower *Linnaea borealis*	4.2 (4.2)	0.3 (0.3)	6.1 (6.1)	0.4 (0.4)
Twisted stalk *Streptopus amplexifolius*	4.2 (4.2)	0.4 (0.4)	0 (0)	0 (0)
Violet *Viola* spp.	75.0 (12.5)	5.5 (0.3)	72.7 (10.5)	6.8 (1.0)
Wild sarsaparillo *Aralia nudicaulis*	66.7 (4.2)	5.1 (0.7)	36.4 (27.8)	2.6 (1.7)
Wood anemone *Anemone quinquefolia*	20.8 (15.0)	1.7 (1.2)	27.3 (5.2)	2.7 (0.9)
Other	12.5 (7.2)	1.0 (0.6)	21.2 (10.9)	1.9 (1.1)

[a]Significant differences between exclosure and open area sites were not determined for absolute frequencies, only relative frequencies.

*Significantly different (P<0.10) from open area with paired t-test (Steel and Torrie 1980).

Table A14. Mean absolute (AF) and relative frequencies (RF) (and standard errors [SE]) of herbaceous species in exclosure and areas open to browsing sites in the Stonington Peninsula-South study area in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

	Site			
	Exclosure		Open Area	
Species	AF[a] (SE)	RF[b] (SE)	AF (SE)	RF (SE)
Bedstraw <u>Galium</u> spp.	0 (0)	0 (0)	6.3 (6.3)	0.4 (0.4)
Boot's wood fern <u>Dryopteris</u> <u>boottii</u>	12.5 (12.5)	1.2 (1.2)	6.3 (6.3)	0.5 (0.5)
Bugleweed <u>Lycopus</u> spp.	31.3 (31.3)	2.3 (2.3)	43.8 (6.3)	3.1 (0.3)
Bunchberry <u>Cornus</u> <u>canadensis</u>	43.8 (18.8)	3.9 (2.1)	31.3 (6.3)	2.2 (0.4)
Canada mayflower <u>Maianthemum</u> <u>canadense</u>	81.3 (6.3)	6.8 (0.4)	68.8 (6.3)	4.9 (0.3)
Coralroot <u>Corallorhiza</u> spp.	6.3 (6.3)	0.6 (0.6)	6.3 (6.3)	0.4 (0.4)
Crested wood fern <u>Dryopteris</u> <u>cristata</u>	6.3 (6.3)	0.5 (0.5)	25.0 (12.5)	1.8 (1.0)
Dewberry <u>Rubus</u> <u>hispidus</u>	50.0 (12.5)	4.4 (1.6)	87.5 (0)	6.3 (0.2)
<u>Dryopteris</u> spp.	0 (0)	0 (0)	12.5 (12.5)	0.9 (0.9)
Dwarf enchanter's nightshade <u>Circaea</u> <u>alpina</u>	37.5 (12.5)	3.0 (0.6)	62.5 (12.5)	4.5 (1.1)
<u>Equisetum</u> spp.	0 (0)	0 (0)	18.8 (18.8)	1.3 (1.3)
Fragile fern <u>Cystopteris</u> <u>fragilis</u>	18.8 (18.8)	1.4 (1.4)	6.3 (6.3)	0.4 (0.4)
Fringed polygala <u>Polygala</u> <u>paucifolia</u>	0 (0)	0 (0)	6.3 (6.3)	0.4 (0.4)
Golden ragwort <u>Senecio</u> <u>aureus</u>	6.3 (6.3)	0.5 (0.5)	0 (0)	0 (0)

Table A14 (cont'd).

	Site			
	Exclosure		Open Area	
Species	AF (SE)	RF (SE)	AF (SE)	RF (SE)
Goldenrod *Solidago* spp.	6.3 (6.3)	0.5 (0.5)	12.5 (12.5)	0.9 (0.9)
Goldthread *Coptis groenlandica*	43.8 (18.8)	3.5 (1.1)	62.5 (12.5)	4.4 (0.7)
Grass spp.	50.0 (50.0)	3.7 (3.7)	68.8 (31.3)	4.8 (2.1)
Grass/sedge spp.	18.8 (18.8)	1.8 (1.8)	12.5 (12.5)	0.9 (0.9)
Intermediate wood fern *Dryopteris intermedia*	31.3 (31.3)	3.0 (3.0)	37.5 (37.5)	2.8 (2.8)
Interrupted fern *Osmunda claytoniana*	6.3 (6.3)	0.6 (0.6)	0 (0)	0 (0)
Jack-in-the-pulpit *Arisaema* spp.	37.5 (37.5)	2.8 (2.8)	31.3 (18.8)	2.3 (1.4)
Jewelweed *Impatiens* spp.	12.5 (12.5)	0.9 (0.9)	12.5 (0)	0.9 (0)
Joe-pye weed *Eupatorium* spp.	6.3 (6.3)	0.5 (0.5)	0 (0)	0 (0)
Long beech fern *Thelypteris phegopteris*	18.8 (18.8)	1.4 (1.4)	37.5 (12.5)	2.7 (1.0)
Marsh fern *Thelypteris palustris*	12.5 (12.5)	0.9 (0.9)	12.5 (12.5)	0.9 (0.9)
Marsh skullcap *Scutellaria epilobifolia*	0 (0)	0 (0)	6.3 (6.3)	0.4 (0.4)
Mint *Mentha* spp.	6.3 (6.3)	0.5 (0.5)	6.3 (6.3)	0.4 (0.4)
Moss spp.	93.8 (6.3)	7.8 (0.5)	93.8 (6.3)	6.7 (0.2)
Naked miterwort *Mitella nuda*	93.8 (6.3)	7.8 (0.5)	100 (0)	7.2 (0.3)

Table A14 (cont'd).

	Site			
	Exclosure		Open Area	
Species	AF (SE)	RF (SE)	AF (SE)	RF (SE)
Oak fern *Gymnocarpium* spp.	43.8 (31.3)	3.3 (2.2)	18.8 (18.8)	1.4 (1.4)
Pyrola spp.	0 (0)	0 (0)	6.3 (6.3)	0.4 (0.4)
Rattlesnake fern *Botrychium virginianum*	31.3 (18.8)	2.8 (1.9)	31.3 (18.8)	2.3 (1.4)
Rattlesnake plantain *Goodyera* spp.	0 (0)	0 (0)	18.8 (6.3)	1.3 (0.4)
Rough bedstraw *Galium asprellum*	68.8 (6.3)	5.7 (0.2)	68.8 (18.8)	4.9 (1.2)
Royal fern *Osmunda regalis*	0 (0)	0 (0)	31.3 (31.3)	2.2 (2.2)
Sedge *Carex* spp.	12.5 (12.5)	0.9 (0.9)	31.3 (18.8)	2.2 (1.3)
Self-heal *Prunella vulgaris*	0 (0)	0 (0)	18.8 (18.8)	1.3 (1.3)
Sensitive fern *Onoclea sensibilis*	0 (0)	0 (0)	25.0 (25.0)	1.7 (1.7)
Silvery glade fern *Athyrium thelypterioides*	0 (0)	0 (0)	18.8 (18.8)	1.4 (1.4)
Starflower *Trientalis borealis*	81.3 (18.8)	7.1 (2.5)	68.8 (18.8)	5.0 (1.5)
Strawberry *Fragaria* spp.	12.5 (0)	1.1 (0.1)	6.3 (6.3)	0.5 (0.5)
Thistle *Cirsium* spp.	6.3 (6.3)	0.5 (0.5)	0 (0)	0 (0)
Trillium spp.	6.3 (6.3)	0.5 (0.5)	0 (0)	0 (0)
Turtlehead *Chelone* spp	6.3 (6.3)	0.5 (0.5)	0 (0)	0 (0)

Table A14 (cont'd).

Species	Site: Exclosure AF (SE)	RF (SE)	Site: Open Area AF (SE)	RF (SE)
Twinflower	0	0	6.3	0.4
Linnaea borealis	(0)	(0)	(6.3)	(0.4)
Twisted stalk	6.3	0.6	0	0
Streptopus amplexifolius	(6.3)	(0.6)	(0)	(0)
Violet	75.0	6.2	75.0	5.3
Viola spp.	(12.5)	(0.2)	(25.0)	(1.6)
White adders mouth	0	0	6.3	0.4
Malaxis brachypoda	(0)	(0)	(6.3)	(0.4)
Wild sarsaparillo	56.3	4.7	31.3	2.3
Aralia nudicaulis	(6.3)	(0.1)	(18.8)	(1.4)
Wood anemone	12.5	1.2	0	0
Anemone quinquefolia	(12.5)	(1.2)	(0)	(0)
Wood sorrel	43.8	4.3	50.0	3.7
Oxalis spp.	(43.8)	(4.2)	(50.0)	(3.7)
Yellow lady's slipper	0	0	6.3	0.4
Cypripedium calceolus	(0)	(0)	(6.3)	(0.4)
Other	12.5	0.9	6.3	0.4
	(12.5)	(0.9)	(6.3)	(0.4)

[a]Significant differences between exclosure and open area sites were not determined for absolute frequencies, only relative frequencies.
[b]No significant differences (P>0.10) of relative frequencies between exclosure and open area sites for any species with the paired t-test (Steel and Torrie 1980).

Table A15. Relative frequency (and standard error) of herbaceous species that were significantly different (P<0.10) among study areas (Whitefish River Basin-North and -South [WRB-North and -South] and Stonington Peninsula-North and -South [SP-North and -South]) in the Hiawatha National Forest in Michigan's Upper Peninsula, 1993-1994.

		Site	
Study Area	Species	Exclosure	Open Area
WRB-North	Aster spp.	1.4AB[a] (0.8)	------[b]
	Boot's wood fern Dryopteris boottii	0[c] (0)	------
	Canada mayflower Maianthemum canadense	4.5[c] (0.4)	------
	Crested wood fern Dryopteris cristata	------	0.5[c] (0.5)
	Dryopteris spp.	0[c] (0)	------
	Dwarf enchanter's nightshade Circaea alpina	------	0[c] (0)
	Fringed polygala Polygala paucifolia	0[c] (0)	0[c] (0)
	Goldthread Coptis groenlandica	2.7AB (1.4)	6.1AB (0.4)
	Grass-sedge	0[c] (0)	------
	Hawkweed Hieracium spp.	------	0.6AB (0.3)
	Jack-in-the-pulpit Arisaema spp.	------	0[c] (0)
	Long beech fern Thelypteris palustris	------	0[c] (0)
	Rattlesnake fern Botrychium virginianum	0.6A (0.3)	------
	Rough bedstraw Galium asprellum	0A (0)	0[c] (0)

Table A15 (cont'd).

Study Area	Species	Site	
		Exclosure	Open Area
WRB-North (cont'd.)	Snowberry Gaultheria hispidula	5.0[c] (0.7)	1.5[c] (0.9)
	Sweet coltsfoot Petasites palmatus	0.6[c] (0.3)	------
	Sweet-scented bedstraw Galium triflorum	4.2[c] (0.1)	------
	Three-leaved Solomon's seal Smilacina trifolia	5.0[c] (1.2)	4.2[c] (1.1)
	Wood anemone Anemone quinquefolia	------	0.2[c] (0.2)
WRB-South	Aster spp.	0.9AB (0)	------
	Boot's wood fern Dryopteris boottii	0 (0)	------
	Canada mayflower Maianthemum canadense	5.1 (0.6)	------
	Crested wood fern Dryopteris cristata	------	0 (0)
	Dryopteris spp.	0.3 (0.3)	------
	Dwarf enchanter's nightshade Circaea alpina	------	0 (0)
	Fringed polygala Polygala paucifolia	5.6 (1.2)	5.5 (0.5)
	Goldthread Coptis groenlandica	7.0A (0.6)	6.4A (0.8)
	Grass-sedge	0 (0)	------
	Hawkweed Hieracium spp.	------	0A (0)

Table A15 (cont'd).

		Site	
Study Area	Species	Exclosure	Open Area
WRB-South (cont'd.)	Jack-in-the-pulpit Arisaema spp.	------	1.1 (1.1)
	Long beech fern Thelypteris palustris	------	0.3 (0.3)
	Rattlesnake fern Botrychium virginianum	1.2AB (0.3)	------
	Rough bedstraw Galium asprellum	3.9AB (0.9)	2.6AB (0.1)
	Snowberry Gaultheria hispidula	5.6 (1.3)	4.4 (1.4)
	Sweet coltsfoot Petasites palmatus	0 (0)	------
	Sweet-scented bedstraw Galium triflorum	0.3 (0.3)	------
	Three-leaved Solomon's seal Smilacina trifolia	2.8 (0.5)	1.4 (1.0)
	Wood anemone Anemone quinquefolia	------	0 (0)
SP-North	Aster spp.	2.8A (1.0)	------
	Boot's wood fern Dryopteris boottii	3.1 (1.2)	------
	Canada mayflower Maianthemum canadense	7.1 (1.0)	------
	Crested wood fern Dryopteris cristata	------	0 (0)
	Dryopteris spp.	2.0 (1.1)	------

Table A15 (cont'd).

Study Area	Species	Site	
		Exclosure	Open Area
SP-North (cont'd.)	Dwarf enchanter's nightshade <u>Circaea alpina</u>	------	1.3 (1.3)
	Fringed polygala <u>Polygala paucifolia</u>	0 (0)	0 (0)
	Goldthread <u>Coptis groenlandica</u>	0B (0)	0B (0)
	Grass-sedge	5.6 (0.4)	------
	Hawkweed <u>Hieracium</u> spp.	------	6.7B (3.2)
	Jack-in-the-pulpit <u>Arisaema</u> spp.	------	0 (0)
	Long beech fern <u>Thelypteris palustris</u>	------	0 (0)
	Rattlesnake fern <u>Botrychium virginianum</u>	4.3B (0.7)	------
	Rough bedstraw <u>Galium asprellum</u>	2.2AB (1.3)	3.4AB (1.2)
	Snowberry <u>Gaultheria hispidula</u>	0 (0)	0 (0)
	Sweet coltsfoot <u>Petasites palmatus</u>	3.8 (2.0)	------
	Sweet-scented bedstraw <u>Galium triflorum</u>	0 (0)	------
	Three-leaved Solomon's seal <u>Smilacina trifolia</u>	0 (0)	0 (0)
	Wood anemone <u>Anemone quinquefolia</u>	------	2.7 (0.9)

Table A15 (cont'd).

Study Area	Species	Site: Exclosure	Site: Open Area
SP-South	Aster spp.	0B (0)	------
	Boot's wood fern Dryopteris boottii	1.2 (1.0)	------
	Canada mayflower Maianthemum canadense	6.8 (0.3)	------
	Crested wood fern Dryopteris cristata	------	1.8 (0.8)
	Dryopteris spp.	0 (0)	------
	Dwarf enchanter's nightshade Circaea alpina	------	4.5 (0.9)
	Fringed polygala Polygala paucifolia	0 (0)	0.4 (0.4)
	Goldthread Coptis groenlandica	3.5AB (0.9)	4.4AB (0.6)
	Grass-sedge	1.8 (1.5)	------
	Hawkweed Hieracium spp.	------	0AB (0)
	Jack-in-the-pulpit Arisaema spp.	------	2.3 (1.2)
	Long beech fern Thelypteris palustris	------	2.7 (0.8)
	Rattlesnake fern Botrychium virginianum	4.3B (0.7)	------
	Rough bedstraw Galium asprellum	2.2AB (1.3)	4.9AB (1.0)
	Snowberry Gaultheria hispidula	0 (0)	0 (0)

Table A15 (cont'd).

Study Area	Species	Site: Exclosure	Site: Open Area
SP-South (cont'd.)	Sweet coltsfoot *Petasites palmatus*	3.8 (2.0)	------
	Sweet-scented bedstraw *Galium triflorum*	0 (0)	------
	Three-leaved Solomon's seal *Smilacina trifolia*	0 (0)	0 (0)
	Wood anemone *Anemone quinquefolia*	------	0 (0)

[a]Means with different letters within species and site were significantly different (P<0.10) among study areas with the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992) and the Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988).

[b]Species not identified in any of the study areas for this site type.

[c]Kruskal-Wallis multiple comparison test (Siegel and Castellan 1988) was unable to detect where the significant difference occurred within species and site among the study areas as detected by the Kruskal-Wallis one-way analysis of variance (Siegel and Castellan 1988) using SYSTAT (1992).

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