SIXTEEN YEARS OF MOOSE BROWSE SURVEYS IN ONTARIO

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ABSTRACT

This paper summarizes 51 moose (*Alces alces*) browse surveys totalling 3,834 plots that were carried out by district staffs across the moose range of Ontario from 1955-1970. The purpose was to answer questions asked by moose managers concerning food availability and use. In 13 surveys, percentages of twigs browsed were estimated for all species; in the remainder, stems of 10 species were recorded as either browsed or not browsed. Twenty two of 33 recorded plant species were browsed by moose. Beaked hazel and mountain maple provided most food; mountain-ash, alternate-leaved dogwood and juneberry were preferred species but contributed less because of low availability. Balsam generally ranked low in availability and use, but contributed over 90% of the browse on an island. Browsing might have seriously affected the vegetation in 3 of 32 studies, two of them on islands. Since in most of these areas, moose populations were stable and hunting light, moose densities appeared to be regulated naturally below levels that would result in starvation or substantially reduced food supplies. The moose appeared to be generalists relative to major food species within the context of optimal foraging, but constraints imposed by chemical defenses greatly reduced or eliminated availability of some plant species.

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A review of moose (*Alces alces*) food habit studies by Peek (1974) reported only one browse survey for Ontario (Peterson, 1953). Since that time some additional browse studies in Ontario have been reported (Hamilton and Drysdale 1975; Kearney 1975; McNicol and Gilbert 1980; McNicol, Timmermann, and Gollat 1980; Todesco et al. 1985), but a relatively large body of information concerning winter foods of moose

remains unpublished. In this paper I have collated and presented these data.

The field work began in 1955 and continued as an organized program until 1970. It was initiated because the Ontario moose herd was perceived to be of value, but too little information was available for rational management programs. Since early reports from Isle Royale (Aldous and Krefting 1946, Krefting 1951) and Newfoundland (Pimlott 1953) suggested that moose might overbrowse their range in ways similar to the widely feared overbrowsing by white-tailed deer (*Odocoileus virginianus*), the people responsible for managing moose in Ontario were very concerned about what moose might be eating and how great their impact might be on the browse species, both because of the implications for other forest users and for the future of the moose themselves. Little information on moose foods was available from elsewhere. Following the initial work on Isle Royale (Aldous and Krefting 1946), Hosley (1949) summarized a few studies in the United States and several provinces of Canada; Krefting (1951) reported again on Isle Royale; and Peterson (1953) examined moose foods on St. Ignace Island, Lake Superior. The popularity of moose hunting was increasing in Ontario (Cumming 1972), and the moose herd appeared to be growing in size and expanding its range (Peterson, 1955). More information about food habits of moose became a priority for managers, especially information about winter foods which were considered most important because winter is widely acknowledged to be the critical time of year (e.g. Bryant and Kuropat 1980). After a few initial browse surveys to establish methods, the staff in forest districts were instructed to begin surveys to answer the most important questions. (1) How many plant species do moose eat during winter? (2) Which plants are most important in their diet? (3) Which species do moose prefer? (4) How great are variations in availability and preferences across northern Ontario? Most importantly, (5) are moose over-browsing their range or likely to do so in the near future?

STUDY AREA

Northern Ontario stretches about 1000 km east to west. Typical boreal forest grows over the Precambrian shield. Temperatures frequently range to -40^{0}C and precipitation averages about 70 cm of water per year. Snow depths exceed 1 m only in exceptional winters. Spruce species (*Picea mariana* and *P. glauca*) dominate the overstory in many areas but in some places are replaced by, or mixed with, jack pine (*Pinus banksiana*), trembling aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*). Disturbances include cutting, burning and infestations of spruce budworm (*Choristoneura fumiferana* Clem.) (Appendix Table 1). The only major variation in soil types resulted from glacial deposits of clay, sand and gravel in the eastern half of northern Ontario, that is, east of approximately 86^{0} longitude (Appendix Table 1).

METHODS

Surveys were carried out by district staffs of the Ontario Department of Lands and Forests under the direction and coordination of head office supervisors (H. G, Lumsden1955-59; H. G. Cumming 1959-62, 66-70; J. B. Dawson 1962-66). Since one of the questions to be answered concerned the possibility of over-browsing, district staffs were instructed to choose places with the highest known moose densities. In all but 2 cases, where a deliberate effort was made to find why moose densities were low, these instructions were followed. Each survey was independently organized and carried out; therefore, the results cannot be considered a series of sample plots in a carefully controlled experiment. Personnel varied from highly competent district biologists to temporary employees hired as untrained casuals. Despite all efforts toward standardization of methods, instructions were not always followed exactly. Variations in site, forest type and forest disturbance (Appendix Table 1) would be expected to produce

differing results even on nearby areas, and the surveys extended over most of the 1000 km wide area (Fig. 1). Varying moose densities would also be expected to affect browsing rates in different areas. To clean the data as much as possible for calculations the following steps were taken: 2 surveys were omitted entirely because data were not collected in standard ways; 6 surveys that had been surveyed by the same method on the same area at another time were set aside (surveys with most plots or least disturbance to the moose population were included). Except for 3 areas that were surveyed in 2 different ways and thus analysed separately, all surveys in the analyses were on different areas.

A complete analysis of large herbivore food habits requires an estimate of forage availability as actually encountered by the animals (e.g. Wetzel et al. 1975), biomass used, and chemical composition of the browse, but these methods are time consuming and costly. They would have been inappropriate for the kind of extensive initial surveys required in Ontario. A method was needed that would provide a reasonable approximation of availability and use but that would be relatively fast and inexpensive. In Ontario a method had been developed by Passmore and Hepburn (1955) for surveying winter range of deer that seemed promising for moose also. They suggested that surveys to estimate winter browsing should be timed as soon as possible after snow-melt and before leaf-out. Plots should be arranged in parallel pairs of transects (to facilitate easy return to point of access) across the topography so as to sample systematically all important habitat types within the study area. Plots 1 chain (20 m) long and 2 feet (0.6 m) wide would be much easier to count than round or square ones and they should be located at 5 chain (100 m) intervals. Their rule-of-thumb minimum of 64 plots on any study area (or 64 times the square root of the area, in square miles, for areas greater than 1 square mile) was based on the variability in data collected during early deer browse studies (on advice

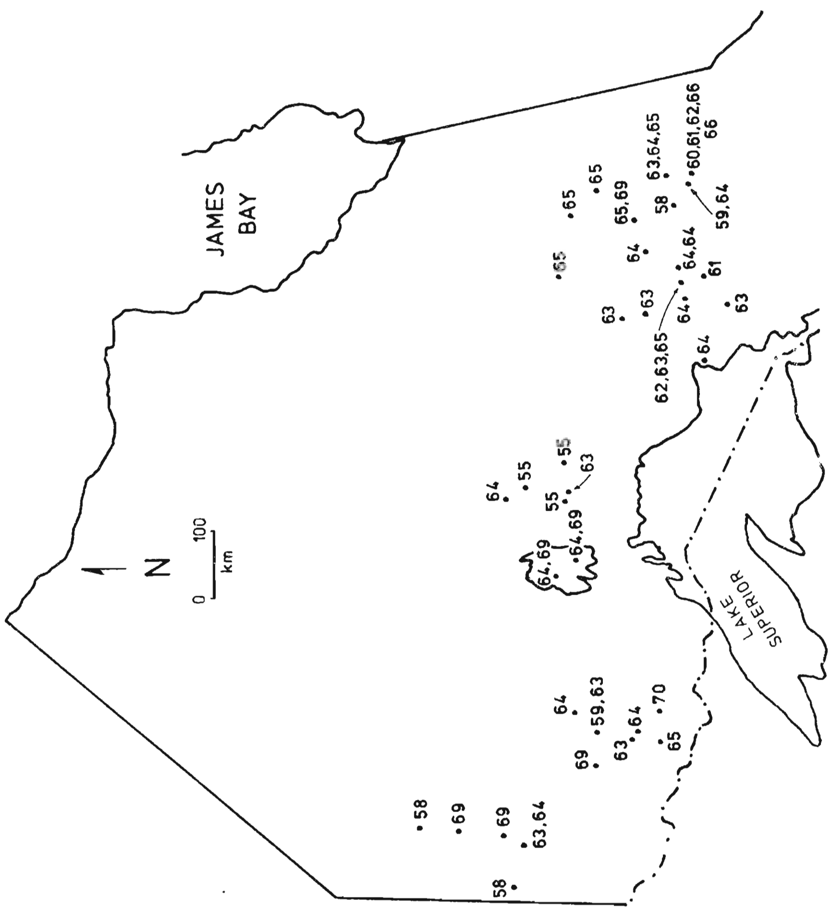

Fig. 1. Locations and dates of moose browse surveys.

of D. B. Delury, Director, Department of Mathematical Statistics, Ontario Research Foundation; Hepburn, pers. comm.). On each plot, they tallied by species the number of living stems arising from within the plot and providing twigs available to deer under average winter conditions (i.e. between 1.5 feet (0.45 m) and 6.5 feet (2 m) above ground level). The percentages of twigs that had some part of their length removed by deer were estimated (counted on every 10th plot) as mid-points of percentage ranges (e.g. 50 for 40-60%). The number of living stems on each plot would be multiplied by the degree of browsing to determine the number of "browse units", defined as "the quantity of food consumed when one percent of the twigs of one stem is removed by browsing". The average percentage of twigs browsed could then be calculated by dividing the number of browse units by the number of living stems for each species. The numbers of stems killed and mutilated by browsing were also recorded in each survey, along with descriptive data on the site, topography, and the forest overstory.

Method 1

Since browse species in northern Ontario were fewer (Soper and Heimburger 1982) and unlikely to be more abundant, the minimum figure of 64 plots on any study area was thought to be conservative and was adopted for the moose browse studies. The only modification that seemed necessary for surveying moose browse was raising the plot boundaries: (1) lower boundaries were raised to 2 feet (0.6m) because of the generally higher prolonged snow depths in northern Ontario and (2) upper boundaries to 10 ft (3 m) because of the greater heights of moose. This slightly revised method became the standard and continued to be used until 1962 (Appendix Table 1). However, there were problems. The heights to which moose browse are more variable than those reached by deer; in some cases moose break down stems well above 3 m. Thus the 3 m maximum height was at best a very rough approximation of the height to which twigs were available. Additionally, the Passmore and Hepburn (1955) method was designed for use by expert deer biologists who would compare methods and ensure that the estimated percentages of twigs browsed correlated well among observers. This standardization became difficult to ensure for the many people carrying out moose surveys in different districts.

Method 2

In 1960 Stephenson (pers. comm.) suggested that stems be tallied simply as living or browsed. The percentage of browsed stems would then become the major statistic. This modification was found to have the advantages of simplicity, speed of operation, ease of understanding, reduced subjectivity and fewer training requirements. Dawson (pers. comm.) examined the results of surveys from 1958-62 and found that 93% of all browse units (Passmore and Hepburn 1955) consumed by moose occurred on 10 plant species. In 7 of the 10 surveys, these species contributed over 97% of the total browse. He suggested that only those species be tallied. With these modifications a further series of surveys was carried out (Appendix Table 1).

All surveys were carried out during the month of May. Pellet group counts were on plots with the same centres but with 6 foot (2 m) widths. A deposition rate of 13 (Joyal and Richard 1986) was used to calculate moose densities for comparisons between areas (but not necessarily establishing actual densities). Some aerial counts were also available for comparison (Appendix table 1).

Despite the fact that samples were systematically located, I followed common practice and treated them as if they had been located randomly. Prior to combining data for generalizations, analyses of variance of stems per hectare were carried out. Calculations of preference and electivity followed Petrides (1975). T-tests, analyses of variance and regression analyses were carried out using Statview512 on a Macintosh

computer.

RESULTS

Method 1

In 13 browse surveys using method 1, plants were tallied and browsed twigs estimated on 998 plots (Appendix table 2). Twenty-two of the 33 recorded plant species were browsed by moose (Table 1). Beaked hazel and mountain maple each contributed over 10% of the total browse units. Additional species contributing over 1% to the diet included balsam fir, willow, trembling aspen, white birch, mountain-ash, pin cherry, juneberry , and alternate-leafed dogwood. (These species became the ones surveyed in method 2.) Jack pine, black spruce, eastern white cedar, balsam popular, speckled alder, green alder, red maple, black ash, raspberry, rose, honey suckle and viburnum, though commonly present, each contributed <1% to the total diet.

Stem counts by species (transformed log (x+1)) did not vary more among surveys than within surveys ($F=1.468$, $p=0.1329$). Browse unit variability was greater and significant at =0.05 ($F=1.929$, $p=0.0345$); however, this amount of variability was not considered great enough to prevent pooling for presentation of over-all averages. Heaviest browsing was on alternate-leafed dogwood at 53% average percentage of twigs browsed, followed by beaked hazel at 24%, juneberry at 23% and willow at 20%. Among the species that were browsed, use appeared to follow availability, e.g. hazel constituted 23% of the available browse and contributed 43% of the total browse units (Table 2). An obvious exception was speckled alder which made up 13% of the available browse but only 1% of the browse units. Raspberry and black spruce comprised over 4% of the available stems each, but only 0.1% of the browse units. Preferences cannot be calculated from these data because the "number of living stems" used for calculating average percentage of stems browsed on a plot would cancel out with

Table 1. Plant species available and used for food by moose, recorded during 13 surveys of all species

COMMON NAME	LATIN NAME	USE CATEGORY
Red pine	*Pinus resinosa Ait.*	
Eastern white pine	*Pinus strobus L.*	
Jack pine	*Pinus banksiana Lamb.*	#
Tamarack	*Larix laricina (Du Roi) K. Koch*	
White spruce	*Picea glauca (Moench) Voss*	
Black spruce	*Picea mariana (Mill.) B. S. P.*	#
Eastern white cedar	*Thuja occidentalis L.*	#
Balsam fir	*Abies balsamea (L.) Mill.*	# #
Ground hemlock	*Taxus canadensis Marsh.*	
Willow	*Salix spp.*	# #
Balsam poplar	*Populus balsamifera L.*	#
Trembling aspen	*Populus tremuloides Michx.*	# #
Yellow birch	*Betual alleghaniensis Britton*	
White birch	*Betual papyrifera Marsh.*	# #
Beaked hazel	*Corylus cornuta Marsh.**	# # #
Speckled alder	*Alnus incana rugosa**	#
Green alder	*Alnus viridis crispa**	#
Mountain-ash	*Sorbus spp. L.*	# #
Choke cherry	*Prunus virginiana L.*	
Pin cherry	*Prunus pensylvanica L.f.*	# #
Sugar maple	*Acer saccharum Marsh.*	
Red maple	*Acer rubrum L.*	#
Mountain maple	*Acer spicatum Lam.*	# # #
Black ash	*Fraxinus nigra Marsh.*	#
Elderberry	*Sambucus spp. L**	
Ribes	*Ribes spp. L.**	
Juneberry	*Amelanchier spp. Medik.**	# #
Raspberry	*Rubus spp. L.**	#
Rose	*Rosa spp. L.**	#
Alternate-leaved dogwood	*Cornus stolonifera Michx.**	# #
Honeysuckle	*Lonicera spp. L.**	#
Viburnum	*Viburnum spp. L.**	#
Ground juniper	*Juniperus communis L.*	

Sources
Hosie, R. C. 1973. Native trees of Canada. Canadian Forestry Service, Department of the Environment, Ottawa.
*Soper, J. H. and M. L. Heimburger. 1982. Shrubs of Ontario. Royal Ontario Museum. Toronto.
<1% ot total browse units
1-10% of total browse units
>10% of total browse units

Table 2. Total numbers of stems and browse units (number of stems times average percentage of twigs browsed) tallied for all species in 13 surveys using method 1.

SPECIES	TOTAL LIVING STEMS TALLIED	TOTAL ESTIMATED BROWSE UNITS	AVERAGE TWIGS BROWSED BY SPECIES	PERCENT TOTAL STEMS AVAILABLE BY SPECIES	PERCENT BROWSE UNITS BY SPECIES
White birch	1851	18553	10.0	7.2	5.6
Balsam fir	1503	13619	9.1	5.9	4.1
Mountain-ash	1150	19702	17.1	4.5	5.9
Willow	727	14858	20.4	2.8	4.5
Mountain maple	3676	60764	16.5	14.4	18.3
Alternate-leaved dogwood	386	20396	52.8	1.5	6.1
Pincherry	1597	5942	3.7	6.3	1.8
Juneberry	529	12297	23.2	2.1	3.7
Trembling aspen	847	13619	16.1	3.3	4.1
Beaked hazel	5942	142979	24.1	23.3	43.0
Red maple	220	1862	8.5	0.9	0.6
Sugar maple	2	0	0.0	0.0	0.0
Balsam poplar	9	140	15.6	0.0	0.0
Ground hemlock	4	0	0.0	0.0	0.0
White spruce	47	0	0.0	0.2	0.0
Tamarack	23	0	0.0	0.1	0.0
Jackpine	697	73	0.1	2.7	0.0
White cedar	228	70	0.3	0.9	0.0
Speckled alder	3277	4796	1.5	12.8	1.4
Mountain alder	114	560	4.9	0.4	0.2
Ribes	9	0	0.0	0.0	0.0
Raspberry	1022	335	0.3	4.0	0.1
Rose	238	1071	4.5	0.9	0.3
Honeysuckle	49	159	3.2	0.2	0.0
Black spruce	1160	2	0.0	4.5	0.0
Viburnum	96	428	4.5	0.4	0.1
Black ash	10	190	19.0	0.0	0.1
White pine	10	0	0.0	0.0	0.0
Yellow birch	1	0	0.0	0.0	0.0
Choke cherry	90	201	2.2	0.4	0.1
Red pine	1	0	0.0	0.0	0.0
Elder	13	0	0.0	0.1	0.0
Ground juniper	11	0	0.0	0.0	0.0

the "number of living stems" used when calculating preference. However, inspection of a comparative graph (Fig. 2) suggests that beaked hazel and mountain maple are used more than mere presence would warrant, while jack pine, speckled alder and black spruce were browsed less. These surveys including all browse species are of particular interest for establishing the species that were not browsed. Twenty three species constituting 28.5% of the total stems were not browsed at all or browsed on less than 1% of the stems available.

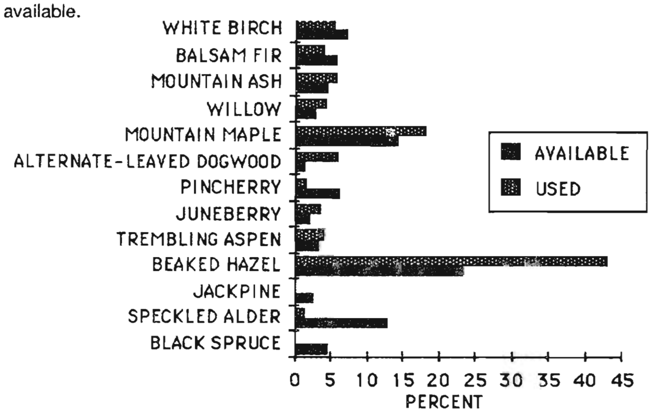

Fig. 2. Stems available and twigs used (in browse units) for 13 surveys tallying all species. (Only those contributing >1% are shown.)

Method 2.

In 32 surveys using method 2, stems were counted on 2836 plots (Appendix Table 3). On two early surveys, results were tallied by both method 1 (estimating percentages of twigs browsed in browse units) and method 2 (counting percentages of stems browsed); these results made comparison of the methods possible. The correlation coefficients for percentage of stems browsed by species compared with average browse units per species (R^2=0.909 for Vozeh 1961; R^2=0.976 for Vozeh 1962, Appendix

Table 1) and for percentage of total browsed stems supplied by each species compared with percentage of browse units supplied by each species (R^2=0.99, Vozeh 1961; R^2=0.89) confirmed that the counting of browsed stems would provide a useful alternative to estimating browsed twigs for obtaining approximations of browsing intensity.

Densities of all browse species recorded using method 2 varied from 4356/ha on one survey area to 412,363/ha on another. The regression of browse density on latitude was not significant (R^2=0.09); similarly, no significant trend related browse density to longitude (R^2=0.03). A 1-way ANOVA of living stems/ha by species in all studies showed evidence of some variability (F=1.663, p=0.0178). However, removing from the data the surveys on two islands in Lake Nipigon reduced the variation to insignificance (F=1.259, p=0.1757). Browsed stems showed more variability (F=2.525,p=0.0001). Most variation was in the eastern half of northern Ontario (F=2.437, p=0.0021) where 5 surveys had to be eliminated (on the basis of high numbers of differences shown by paired LSD tests) to reduce variability to non-significance (F=1.795, 0.0565). In the western half, overall variation was significant (F=2.291, p=0.0094) but elimination of the two islands eliminated all significance (F=1.344, p=0.2103); in fact, eliminating only one mainland study was enough to render variation insignificant (F=1.695, p=0.0764). In all these cases the F-values were low, and, apart from the islands, there seemed to be no reason to eliminate surveys that were slightly different; therefore surveys have been combined to allow presentations of average conditions in this fairly homogeneous boreal forest region.

The value of preference data has been questioned by several recent authors, usually with reference to optimal foraging theory. Nudds (1980), for example, pointed out that if use is correlated with availability, as predicted by optimal foraging theory for general foragers, then "preference ratios" may not really indicate preference. The percentage of food contributed by different plant species was indeed positively correlated (R^2=0.807, Fig. 3). Several observations fell outside the 99% confidence bands. Although there remains a small probability that they do belong, these outliers raise questions about the completeness of generalized foraging by moose. Some species recorded in method 1 were also clearly not eaten in the porportions encountered (especially, speckled alder).

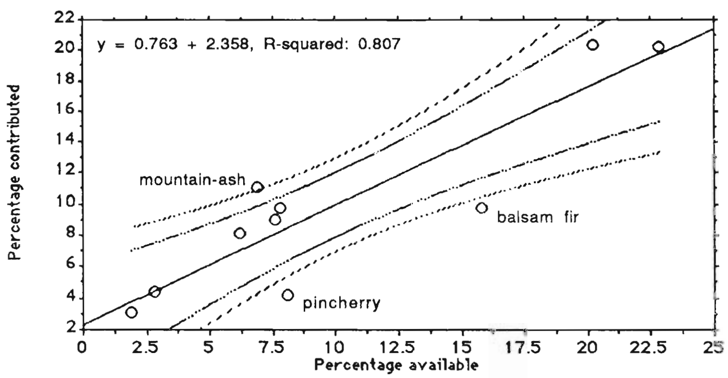

Fig. 3. Regression of percentage contributed on percentage available for 10 browse species (method 2). Bands represent 95% and 99% confidence limits on y.

Since the status of moose as specialist or generalist has not been firmly established, I have presented calculations of preference for method 2 in the traditional form (i.e. as described by Petrides 1975) to facilitate comparison with other studies. The importance of mountain maple and beaked hazel as staple foods (Leopold 1933) was apparent from their contributions of over 20% each to the moose diet (Table 3). Mountain-ash, alternate-leaved dogwood and juneberry, on the other hand, although rating high in the preference index, and so possibly worthy of the designation

Table 3. Preference ratings and electivity indices from 38 moose browse surveys where total stems and browsed stems were counted for 10 plant species (after Petrides 1975).

Browse species	Amounts: Stems available	Amounts: Stems removed	Percentages: Stems available	Percentages: Diet	Percentages: Browsing on stems	Indices: Preference	Indices: Electivity
White birch	3054	1041	7.6	9.0	34.1	1.18	0.1
Balsam fir	6383	1133	15.8	9.8	17.8	0.62	-0.2
Mountain ash	2774	1286	6.9	11.1	46.4	1.61	0.2
Willow	3133	1134	7.8	9.8	36.2	1.26	0.1
Mountain mape	8153	2360	20.2	20.3	28.9	1.01	0.0
Alternate-leaved dogwood	1144	515	2.8	4.4	45.0	1.56	0.2
Pincherry	3250	483	8.1	4.2	14.9	0.52	-0.3
Juneberry	757	362	1.9	3.1	47.8	1.66	0.2
Trembling aspen	2505	938	6.2	8.1	37.4	1.30	0.1
Beaked hazel	9197	2349	22.8	20.2	25.5	0.89	-0.1

used less than their availability would suggest. White birch, willow and aspen were intermediate in preference rating and in availability.

Perhaps a better approach is to look at the distribution of percentages browsed for each species. Mountain ash was generally most heavily browsed (Fig.4) and balsam fir was among the least. Dogwood and juneberry, rated highly by mean percentage browsed, were among the less browsed species in the box plots, indicating that the high mean percentage browse was due to heavy browsing in 2-3 locations where these species were also abundant (indicated by the higher individual values in Fig. 4).

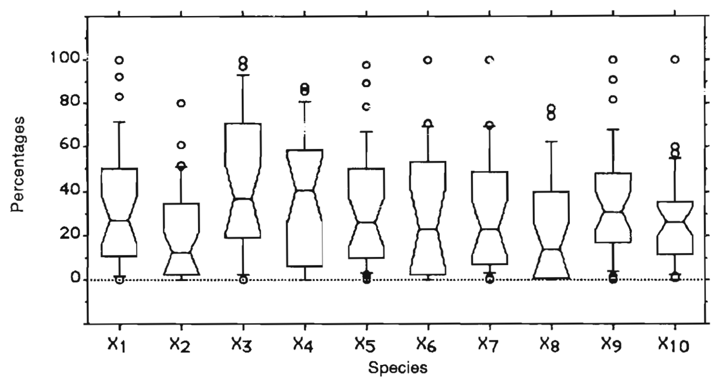

Fig. 4. Percentage browsing recorded by species in 32 surveys of 10 browse species (method 2). The 10th, 25th, 50th, 75th, and 90th percentiles are shown.

None of the species was browsed on average above 50% of the stems (Table 3). Looking at individual species over the whole range of studies, the 90th percentile exceeded 75% browsing only for mountain ash and willow (Fig. 4). Individual species showed browsing on 100% of the available stems only in

reported overall browse levels above 80%; one reported just under 80%; and 4 reported 40-50%. All others reported fewer than 40% of the stems showing any browsing. Thus, only in 3 of the 32 studies could browsing be seriously affecting the vegetation. Combining all results from method 2 allows a generalized picture of the staple moose foods of northern Ontario (Fig. 5).

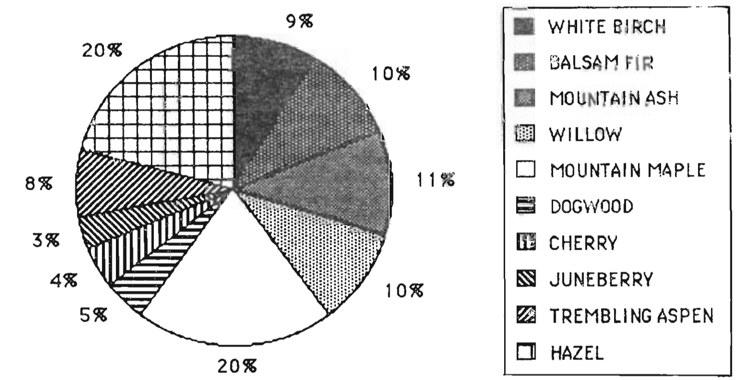

Fig. 5. Staple foods of moose in northern Ontario as determined by 32 surveys of 10 browse species (method 2).

Comparisons of stem counts on either side of 86° longitude showed no significant difference for total living stems/ha (transformed log (x+1), t=-0.185, d.f.=30, p=0.855) and only 1 species with a significant difference between numbers of stems/ha, mountain ash (t=3.860, d.f.=30, p=0.0006), with about twice as many stems per hectare in the east. However, significantly more browsed stems per hectare were recorded in the western portion (t=-4.754, d.f.=30, p=0.0001), and 2 individual species differed significantly in numbers of brwosed stems/ha, mountain-ash higher in the east (t=2.361, d.f.=30, p=0.025), and juneberry, higher in the west (t=-3.669, d.f.=30, p=0.001). The difference between total numbers of stems per hectare browsed may have related to the generally higher densities of moose in the west (t=-2.089, d.f.=29, p=0.0456).

Two repeated surveys by Gibson (Appendix Table 1) showed similar browsing differences related to moose densities. Shakespeare Island in Lake Nipigon during 1964 had an estimated population of 1.27moose/km^2 counted from the air (3.85/km^2 estimated from pellet groups) and nearby Kelvin Island supported 0.48/km^2 seen from the air (3.24/km^2 from pellet groups)· Prior to 1965 no hunting had been allowed on these islands for many years, but after the first surveys the season was opened. During the next 5 years, 300 moose were shot from the islands and nearby mainland, reducing populations on Shakespeare to 0.05/km^2 (0.14/km^2) and Kelvin to 0.09/km^2 (1.91/km^2). The total living stems increased on Shakespeare between 1964 and the second survey in 1969 (4992 to 6432 stems/ha) and decreased only slightly on Kelvin (8266 to 7259 stems/ha) but the number of stems browsed was reduced on both islands by about half (Shakespeare 4073 to 2802 stems/ha; Kelvin 6521 to 3286 stems/ha). Shakespeare Island also showed unusual species composition with 93% of the counted stems balsam fir (30% on Kelvin). Balsam fir constituted 92% of the diet on Shakespeare Island in 1964, decreasing to 89% in 1969; on Kelvin Island balsam fir made up only 19% of the diet in 1964, perhaps because of higher availability of alternate browse species, but it increased to 69% by 1969. The decreased moose densities changed some other aspects of browse data as well. Browsing on birch, mountain-ash and mountain maple also decreased. On Kelvin the living stems per hectare of balsam fir, birch, and mountain maple dropped. Thus some relationships exist between moose densities and percentages browsed. Efforts to find similar correlations across northern Ontario were not successful.

DISCUSSION.

The most important information derived from these surveys was that moose at current population densities in Ontario were not overbrowsing the range to an extent that would interfere with other forest users or seriously reduce the productivity of the forest for moose. Furthermore, the population would have to increase substantially before any real danger to the food supply would be forthcoming. This information began to change the emphasis in Ontario moose range management from concern over food to concern for cover and interspersion of food and cover (Euler 1981).

This finding was also of theoretical interest because these surveys were conducted at a time when moose populations in Ontario were relatively stable and little altered by hunting except in the most accessible areas (Cumming 1974). Thus moose in most places were naturally regulated below the limit that would be imposed by food shortage and starvation. Food supplies cannot be written off as of no importance, for moose populations have been commonly observed to increase following disturbance of a virgin forest (e.g. Cumming 1980); presumably the major change after disturbance is an increase in food abundance. Possibly food shortages limit moose populations at the low levels of availability in mature forests but outstrip increasing moose populations following disturbance. Most of the studies reported here were in disturbed areas and could therefore be seen as examples of food supplies increasing faster than moose populations. However, in Ontario we have never seen evidence of moose populations catching up, to the extent that shortage of food could be limiting , even in parks where no hunting is permitted (e.g. McNicol et. al. 1980, though the reduced availability of browse in this case might mean that the moose numbers would become limited by food eventually). Moose managers in Ontario speculated about other possible limiting factors - predation, social behaviour,, or perhaps some combination of factors, but no evidence was available at the time these surveys were completed. Bergerud (1981) and Bergerud et al. (1983) have supported the idea that predation alone could be controlling moose numbers. Further work will be required to find if that is true generally throughout unhunted portions of Ontario.

As predicted by optimal foraging theory (e.g. Pyke et al. 1977, Nudds 1980), moose followed the foraging pattern of a generalist eating a wide variety of the plant species available (66.7%), many at rates that varied with availability. But the model does not fit completely. Looking at the reverse side of these results, one third of the plant species were not eaten at all and among those that were eaten the linear relationship between use and availability only held for some. Apparently moose are generalists only among plant species that constitute major foods. The most likely explanation would seem to be plant defenses (Bryant and Kuropat 1980). Belovsky (1978) suggested that resins of species like birch and alder may be toxic to rumen microbes. He concluded that subarctic browsing animals do not select their diet on the basis of proximal nutrient content, but avoid feeding on plants that contain high concentrations of secondary chemical constituents. This idea of generalization within constraints imposed by plant defenses seems to fit the results of the surveys reported here for moose of the boreal forest better than the idea of a more complete generalization proposed by Nudds (1980) for white-tailed deer in southerly forest types. If such constraints actually exist, they must substantially reduce the carrying capacity of an area (in these studies by 1/3). Additional application of optimal foraging theory to the examination of these data could be undertaken but are beyond the scope of this paper.

Nudds (1980) cautioned about calculation of food preferences and some of his reservations certainly apply to the methods used in these studies. A systematic survey may not reveal availability of browse to a moose wandering from one patch to another; also food use to some extent varied with availability as discussed above. However, at least

the most extreme results obtained from the preference indices agree with field observations and with reports from elsewhere (e.g. Peek 1974). As pointed out by Trottier (1981) for western moose ranges, hazel was a key species, with mountain maple nearly of equal importance. Not so well known is the high preference for mountain-ash. One of the greatest surprises was the relative low importance of balsam fir. The only information available at the time these surveys were commenced (Aldous and Krefting 1946, Dyer 1948, Hosley 1949, Krefting 1951, Peterson 1953, Pimlott 1953) suggested that balsam fir was a major food item. In fact, conventional opinion held that moose differed from white-tailed deer in preferring balsam fir, rather than eastern white cedar. Therefore, the finding that balsam fir rated very low in preference and amount used was quite unexpected. The only really high values for occurrence and use of balsam fir came from Shakespeare Island in Lake Nipigon. This observation recalled two early studies showing high use of balsam that were also conducted on islands (Isle Royale, Krefting 1951 and St. Ignace Island, Peterson 1955). What circumstances cause moose on islands to eat more balsam than those on the mainland? In each island study the density of moose was high and balsam constituted a high proportion of the browse species available. Perhaps, moose use balsam as a staple food, rather than preferred, and turn to it for a major portion of the diet only when more preferred foods are scarce.

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APPENDIX TABLE 1. LOCATIONS , DESCRIPTIONS, AND ASSOCIATED DATA FOR BROWSE SURVEY PLOTS

AUTHORS OF SURVEY REPORTS	LOCATION	LATITUDE	LONGITUDE	FOREST DISTRICT	SIZE OF AREA (KM^2)	MOOSE/KM^2
METHOD 1. COUNTS OF STEMS AND ESTIMATES OF BROWSE UNITS FOR ALL SPECIES						
CUMMING, H. G. 1955a	PARTRIDGE LAKE	49 43	87 23	GERALDTON	2.6	1.5
CUMMING, H. G. 1955b	EAST SHORE LONG LAKE	49 48	86 31	GERALDTON	2.6	0.1
CUMMING, H. G. 1955c	FLEMING LAKE, EXTON TWP.	50 07	86 56	GERALDTON	2.6	1.1
JOHNSTON, F. 1962	MARSHALL TWP.	47 58	83 26	CHAPLEAU	4.5	N.A.
MACFIE, J. A. 1958	CARTER AND STETHAM TWPS.	47 49	81 50	GOGAMA	2.6	1.5;0.8A
O'SHAUGHNESSY, T. 1961	12E TWP.	47 38	83 18	CHAPLEAU	1.9	N.A.
SIMKIN, D. W. 1958a	OAK LAKE	50 25	94 50	SIOUX LOOKOUT	20.7	6.1;1.6A; DEER4.9
SIMKIN, D. W. 1958b	UPPER GOOSE LAKE	51 42	93 40	SIOUX LOOKOUT	11.7	2.0;1.7A
SIMKIN, D. W. 1959	24 KM W. OF IGNACE	49 25	91 40	SIOUX LOOKOUT	7.8	2.6;1.4A; DEER 0.4
VOZEH, G. E & A. ZIMMERMAN 1959	TOGO TWP.	47 43	81 31	GOGAMA	2.6	0.5A
VOZEH, G. E. 1960	NABAKWASI 3	47 33	81 27	GOGAMA	3.6	1.8;1.6A
VOZEH, G. E. 1961	NABAKWASI SW	47 33	81 27	GOGAMA	2.6	2.3 (1.8-2.7);1.7A
VOZEH, G. E. 1962	NABAKWASI 11	47 33	81 27	GOGAMA	4.9	0.5 (0.3-0.8)
METHOD 2. COUNTS OF STEMS ONLY FOR 10 SPECIES						
ARMSTRONG, A. E.1964	40 KM N. E. IGNACE	49 43	91 25	SIOUX LOOKOUT	7.8	1.5(1.1-1.9);0.2A
BROWN, P. R. 1965	CIRRUS LAKE, 23 KM S. W. ATITKOKAN	48 37	91 55	FORT FRANCES	2.6	1.5(0.7-2.2)
BUSCH, D. & GAGNE, D. 1969	26 MI. N.E. RED LAKE	51 03	93 49	SIOUX LOOKOUT	38.8	6.1(3.7-7.9);3.4A
CLOSE,R.W. 1966a (*= VOZEH 1960)	NABAKWASI LAKE 3	47 33	81 27	GOGAMA	3.6	2.1
CLOSE, R. W. 1966b (*= VOZEH 1962)	NABAKWASI LAKE 11	47 33	81 27	GOGAMA	4.9	0.5
CORNELL, F. 1964	RUPERT TWP.	50 18	87 03	GERALDTON	2.6	2.5
CREIGHTON, W. A. 1965a	SYDERE TWP.	49 07	81 45	COCHRANE	2.6	0.8(0.1-1.4)
CREIGHTON, W. A. 1965b	CARNEGIE TWP	48 45	81 24	COCHRANE	2.6	2.9(1.9-3.8)
CRICHTON, V. 1963a	STOVER	48 20	83 57	CHAPLEAU	6.5	1.2
CRICHTON, V. 1963b	MARSHALL	47 58	83 26	CHAPLEAU	33	2.0
CRICHTON, V. 1963c	MILDRED	48 44	83 55	CHAPLEAU	13	4.1
GIBSON, B. H. 1963	SALSBERG TWP.	49 37	87 01	GERALDTON	2.6	6.9
GIBSON, B. H. 1964a	SHAKESPEARE IS. (56 KM^2, 6 KM TO MAINLAND)	49 38	88 25	GERALDTON	2.6	3.8(2.5-5.2), 1.3A
GIBSON, B. H. 1964b	KELVIN IS. (68 KM^2, 10 KM TO MAINLAND)	49 51	88 40	GERALDTON	2.6	3.2(2.0-4.5), 0.5A
HALL,R. B. 1963	MAYNARD LAKE	50 22	93 54	KENORA	4.7	6.3
HENDRY, G. M. 1965	PARNELL AND ECCLESTONE TWPS.	49 23	82 58	KAPUSKASING	11.4	4.5(3.6-5.5);3.3-4.8A
LUCKING, E. H. 1963a	MOFFAT TWP	47 22	83 54	GOGAMA	1.3	1.1
LUCKING, E. H. 1964a	TOGO TWP	47 43	81 31	GOGAMA	2.6	0.8(0.1-1.4)
LUCKING, E. H. 1964b	CARTY TWP	48 09	82 40	GOGAMA	2.6	1.5(0.8-2.5)
LUCKING, E. H. 1965a	REEVES TWP.	48 16	82 06	GOGAMA	1	1.2(0.7-1.7)
LUCKING, E. H. 1965b	KEMP TWP. -GRASSY LAKE	47 49	81 19	GOGAMA	1.1	0.3
MACFADYEN. A. L. 1964	OLD WOMAN RIVER (L. SUPERIOR PROV. PARK.)	47 48	84 54	SAULT STE. MARIE	3.7	2.9
MILLER, J. 1963	CROW ROCK LAKE	48 58	91 49	FORT FRANCES	N.A.	N.A.
MONK, C. E. 1963 (*=SIMKIN 1959)	24 KM W. IGNACE	49 25	91 40	SIOUX LOOKOUT	7.1	1.9
O'SHAUGNESSY, T. AND W. KEAN 1965	N. E. CORNER MARSHALL TWP.	47 58	83 26	CHAPLEAU	2.6	0.8
O'SHAUGNESSY, T. J. 1964a	BORDEN TWP. I	47 54	83 11	CHAPLEAU	2.6	0.7
O'SHAUGNESSY, T. J. 1964b	BORDEN TWP. 2	47 54	83 11	CHAPLEAU	2.6	0.8
O'SHAUGNESSY, T. J. 1964c	STRATHEARN TWP.	47 54	83 34	CHAPLEAU	2.6	1.7
STASUS, A. 1970	PICKEREL LAKE, QUETICO PARK	48 40	91 20	FORT FRANCES	2.5	1.5(1.2-1.8);0.5A
SWIFT, E. J. 1964	TURTLE LAKE	48 57	91 57	FORT FRANCES	2.6	0.9(0.4-1.8)
THOMPSON, R. C. 1969a	WILCOX LAKE	50 31	93 47	KENORA	2.6	0.9A
THOMPSON, R. C. 1969b	STORMY LAKE	49 28	92 26	KENORA	2.6	1.2A
REPEATED SURVEYS						
GIBSON, B. H. 1969a(*= GIBSON 1964a)	SHAKESPEARE IS. (56 KM^2, 6 KM TO MAINLAND)	49 38	88 25	GERALDTON	2.6	0.1, 0.05A
GIBSON, B. H. 1969b(*= GIBSON 1964b)	KELVIN IS. ((68 KM^2, 10 KM TO MAINLAND)	49 51	88 40	GERALDTON	2.6	1.9, 0.09A
HALL, R. B. 1964(*= HALL 1963)	MAYNARD LAKE	50 22	93 54	KENORA	4.7	4.5(3.2-5.8);DEER 15.0
HERRON, G., & P. CARTER 1969 (*= LUCKING 1965a	REEVES TWP.	48 16	82 06	CHAPLEAU	2.6	N.A.
LUCKING, E. H. 1963b (*= LUCKING 1965b)	KEMP TWP -GRASSY LAKE	47 49	81 19	GOGAMA	1.1	1.2
LUCKING, E. H. 1964c(*= LUCKING 1963b)	KEMP TWP -GRASSY LAKE	47 49	81 19	GOGAMA	1.1	0.8 (0.4-0.8)

*= INDICATES ANOTHER SURVEY ON THE SAME SITE. SURVEYS WITH MOST PLOTS OR LEAST DISTURBANCE TO THE MOOSE HERD WERE CHOSEN TO BE INCLUDED.
N.A.- NOT AVAILABLE. NOTE: A DEPOSITION RATE OF13 PELLET GROUPS PER DAY WAS USED PELLET GROUP COUNTS (95% CONFIDENCE LIMITS IN BRACKETS); A - AERIAL COUNT.

APPENDIX TABLE 1, CONTINUED. LOCATIONS, DESCRIPTIONS, AND ASSOCIATED DATA FOR BROWSE SURVEY PLOTS.

SOIL AND TOPOGRAPHY	FOREST TYPE	DISTURBANCE
LOAM,PEAT 17CM-0.7M	BLACK SPRUCE, WHITE BIRCH, BALSAM	BUDWORM 1940
LOAM,PEAT 17CM-0.7M,LOW AND ROLLING	ASPEN, WHITE BIRCH, BALSAM	SPRUCE CUT 1940
SANDY HILLS WITH LOAMY SECTIONS AND SWAMPS	ASPEN, WHITE BIRCH, WILLOW, PIN CHERRY	BURNED 1936, 1945
SANDY WITH ROCK OUTCROPS	WHITE BIRCH, JACK PINE, BLACK SPRUCE, TREMBLING ASPEN	CUT 1956-57
GENTLY ROLLING, SANDY LOAM	MATURE BW, SB, SW	EARLY SELECTIVE LOGGING, BUDWORM, 1940'S
FLAT SANDS, BEDROCK, SWAMPS	TREMBLING ASPEN, WHITE BIRCH, JACKPINE, BLACK SPRUCE	BURNED 1930'S, CUT 1950'S, BLOWDOWN 1960
PRECAMBRIAN ROCK WITH PEAT 17cm-7m.	TREMBLING ASPEN, WHITE BIRCH, BLACK SPRUCE, BALSAM FIR	BURNED 1933
ROCK, 50% SAND WITH PEAT	JACKPINE, TREMBLING ASPEN, WHITE BIRCH, BLACK SPRUCE	BURNED ABOUT 1930
PRECAMBRIAN OUTCROPS OVERLAIN WITH 1-6" PEAT	JACKPINE, WHITE BIRCH, TREMBLING ASPEN, BLACK SPRUCE	BURNED 1922
HIGH RIDGE SLOPING TO SWAMP	MIXED YOUNG GROWTH, SPRUCE SWAMPS	BURNED 1941
ROLLING SANDY LOAM >0.7m	YOUNG MIXED WOOD WITH CONIFER PATCHES	BURNED 1941
ROLLING SANDY LOAM >0.7m	MIXED WOOD WITH CONIFER SWAMPS	BURNED 1941
ROLLING SAND PLAIN<0.7M DRY	HARDWOODS WITH JACKPINE	BURNED 1941
N. A.	BALSAM, JACKPINE, WHITE BIRCH, WILLOW, MOUNTAIN ASH	LOGGED 1952
ROCK RIDGES, SWAMPS	BLACK SPRUCE, WHITE BIRCH, TREMBLING ASPEN, JACKPINE	NONE
BOULDER MORAINE	TREMBLING ASPEN, WHITE BIRCH, JACKPINE REGENERATION	BURNED 1961
SANDY LOAM 0-8' DEPTH	MIXED CONIFER, HARDWOODS 30-40'	CUT, THEN BURNED IN 1941
SAND, SANDY LOAM, 2'	JACKPINE, TREMBLING ASPEN	BURNED 1941
LIGHT SAND TO CLAY	TREMBLING ASPEN, WHITE SPRUCE, JACKPINE	CUT 1960-61
WELL DRAINED CLAY	MIXED CONIFER, HARDWOODS, BLACK SPRUCE	CUT 1948-49
WELL DRAINED CLAY	WHITE BIRCH, BALSAM, BLACK SPRUCE, BALSAM POPLAR	EARLY SELECTION CUT
N. A.	TREMBLING ASPEN, WHITE BIRCH	BURNED 1955
ROLLING TERRAIN WITH SANDY, GRAVELLY SOILS AND BEDROCK	WHITE BIRCH, JACK PINE, SPRUCE, TREMBLING ASPEN,	HALF CUT
N. A.	N. A.	CURRENTLY BEING LOGGED
DUMP TILL, FINE TO COARSE GRAVEL, DAMP	BALSAM, JACKPINE, WHITE BIRCH	CUT 1943, 1951, 1952
ARCHEAN, 300 FT BLUFFS, SILTY SAND AND FROM OUTWASH PLAI	OVERMATURE BLACK SPRUCE, WHITE SPRUCE, WHITE BIRCH	BUDWORM 1943, BLOWDOWN
ARCHEAN, 300 FT BLUFFS, SILTY SAND AND FROM OUTWASH PLAI	OVERMATURE BLACK SPRUCE, WHITE SPRUCE, WHITE BIRCH	BUDWORM 1943, BLOWDOWN
CLAY LOAM, GRANITE OUTCROPS, ROLLING, WELL DRAINED	WHITE BIRCH, TREMBLING ASPEN, JACKPINE, BLACK SPRUCE	BUDWORM, BLOWDOWN
HIGH LIME SILTY CLA Y WITH SOME PEAT	ALDER, BIRCH, MOUNTAIN MAPLE	CUT 1946-55
PEAT OVER SAND WITH MUSKEG AREAS	TREMBLING ASPEN, WHITE BIRCH,TAMARACK	BURNED 1934
ROLLING TOPOGRAPH, STEEP CLIFFS	JACKPINE, TREMBLING ASPEN	BURNED 1941,1951
MAINLY PEAT WITH SOME SHALLOW SAND, ROCK	JACKPINE, TREMBLING ASPEN, BALSAM FIR, BLACK SPRUCE	NONE
THIN SOIL OVER BED ROCK, CEDAR SWAMPS	MIXED CONIFER, HARDWOODS, MATURE	NONE
BARE ROCK, SHARP CONTOURS	TREMBLING ASPEN, WHITE BIRCH	BURNED 1951
VERY RUGGED AND HILLY	OVERMATURE YELLOW BIRCH, HARD MAPLE, BALSAM, SPRUCE	NONE
ROLLING WITH ROCKY OUTCROPS	BLACK SPRUCE, MIXED	CUT DURING 1940'S
18" SOIL OVER PRECAMRIAN, MODERATE HILLS, ALDER SWALES	WHITE BIRCH, TREMBLING ASPEN, JACKPINE, BLACK SPRUCE	BURNED 1922
ROLLING TERRAIN WITH SANDY, GRAVELLY SOILS AND BEDROCK	WHITE BIRCH, JACK PINE, SPRUCE, TREMBLING ASPEN,	LIMITED CUTTING SINCE 1962
N. A.	HEAVY BALSAM REGENERATION	LOGGED 1950'S, BLOWDOWN
N. A.	TREMBLING ASPEN, BALSAM REGENERATION	BURNED EARLY 1940'S
N. A.	TREMBLING ASPEN, WHITE BIRCH REGENERATION	EARLY LOGGING, BLOWDOWN
SAND, GRAVEL, PEAK POCKETS. RELIEF 33M	WHITE BIRCH, TREMBLING ASPEN	BLACK SPRUCE, JACKPINE CUT 1964-65
ROLLING, JACKPINE SAND FLATS, BLACK SPRUCE SWAMPS	JACKPINE, BLACK SPRUCE, BALSAM	CUT 1946-47
SHALLOW SANDY TILL OVER BED ROCK	JACKPINE, BLACK SPRUCE, TREMBLING ASPEN, BALSAM	NONE
SHALLOW SANDY TILL OVER BED ROCK	JACKPINE, BLACK SPRUCE, TREMBLING ASPEN, BALSAM	NONE
ARCHEAN, 300 FT BLUFFS, SILTY SAND AND FROM OUTWASH PLAI	OVERMATURE BLACK SPRUCE, WHITE SPRUCE, WHITE BIRCH	BUDWORM 1943, BLOWDOWN
ARCHEAN, 300 FT BLUFFS, SILTY SAND AND FROM OUTWASH PLAI	OVERMATURE BLACK SPRUCE, WHITE SPRUCE, WHITE BIRCH	BUDWORM 1943, BLOWDOWN
CLAY LOAM, GRANITE OUTCROPS, ROLLING, WELL DRAINED	WHITE BIRCH, TREMBLING ASPEN, JACKPINE, BLACK SPRUCE	BUDWORM, BLOWDOWN
THIN SOIL OVER BED ROCK, CEDAR SWAMPS	IMMATURE TREMBLING ASPEN, JACK PINE, BALSAM, SPRUCE	BUDWORM 1946,47; CUTTING 1953;BURNED 1954
THICK PEAT OVER SAND , CONTOURS SHARP	TREMBLING ASPEN, WHITE BIRCH	BURNED 1951
THICK PEAT OVER SAND , CONTOURS SHARP	TREMBLING ASPEN, WHITE BIRCH	BURNED 1951

APPENDIX TABLE 2. DATA FROM METHOD 1 IN WHICH BROWSE UNITS WERE ESTIMATED FOR ALL SPECIES ENCOUNTERED

STEMS COUNTED BY SPECIES AUTHOR	NUMBER OF PLOTS	WHITE BIRCH	BALSAM FIR	MOUNTAIN-ASH	WILLOW	MOUNTAIN MAPLE*	ALTERNATE-LEAVED DOGWOOD	PINCHERRY	JUNEBERRY	TREMBLING ASPEN	BEAKED HAZEL
CUMMING, H. G. 1955a	64	114	108	37	0	377	3	0	0	0	0
CUMMING, H. G. 1955b	64	28	50	11	12	104	72	1	2	46	0
CUMMING, H. G. 1955c	64	190	23	0	105	37	0	182	9	91	10
JOHNSTON, F. 1962	64	55	179	79	2	432	13	11	4	36	116
MACFIE, J. A. 1958	64	89	365	186	2	399	0	8	43	0	171
O'SHAUGHNESSY, T. 1961	64	34	152	11	32	284	0	10	4	2	260
SIMKIN, D. W. 1958a	110	201	310	0	0	1073	212	34	179	176	2544
SIMKIN, D. W. 1958b	110	638	10	0	324	0	0	0	0	229	0
SIMKIN, D. W. 1959	110	51	132	18	17	333	0	2	5	3	110
VOZEH, G. E & A. ZIMMERMAN 1!	64	87	78	219	42	104	0	337	56	49	323
VOZEH, G. E. 1960	66	126	16	419	46	214	4	396	80	60	615
VOZEH, G. E. 1961	64	128	37	62	55	169	54	182	66	116	570
VOZEH, G. E. 1962	90	110	43	108	90	150	28	434	81	39	1223
BROWSE UNITS RECORDED BY SPECIES											
CUMMING, H. G. 1955a		3340	734	1304		5800					
CUMMING, H. G. 1955b		51	30			210	1925				
CUMMING, H. G. 1955c		1027	764		721	208		2730		163	
JOHNSTON, F. 1962		235	21	1439		587				110	538
MACFIE, J. 1958		176	255	4535		2642		30	417		863
O'SHAUGHNESSY, T. 1961		1495		300	180	7634					954
SIMKIN, D. W. 1958a		7161	8797			39896	16301	1595	9970	8992	135351
SIMKIN, D. W. 1958b		2883	440		6149					3370	
SIMKIN, D. W. 1958c		586	947	250	600	2921					825
VOZEH, G. 1959		332	175	4219	2710	90		454	240	395	402
VOZEH, G. 1960		211	215	4345	998	584		367		84	890
VOZEH, G. 1961		936	1095	1530	2570	106	2140	730	1220	415	1901
VOZEH, G. 1962		120	146	1780	930	86	30	36	450	90	1255

NOTE: BOTH ALDER SPECIES WERE TALLIED AS SPECKLED ALDER AND THE 3 MAPLE SPECIES WERE TALLIED AS MOUNTAIN MAPLE BY SOME CREWS.

APPENDIX TABLE 2 CONTINUED

	RED MAPLE*	SUGAR MAPLE*	BALSAM POPULAR	GROUND HEMLOCK	WHITE SPRUCE	TAMARACK	JACKPINE	WHITE CEDAR	SPECKLED ALDER*	MOUNTAIN ALDER*	RIBES	RASPBERRY
CUMMING, H. G. 1955a	0	0	1	0	0	0	0	77	26		0	40
CUMMING, H. G. 1955b	0	0	4	0	0	1	1	10	267		6	2
CUMMING, H. G. 1955c	0	0	3	0	0	0	58	1	84		0	18
JOHNSTON, F. 1962	5	0	0	0	0	0		9	72		2	64
MACFIE, J. A. 1958	36	0	0	0	14	0	0	70	214		0	0
O'SHAUGHNESSY, T. 1961	60	0	1	1	0	0	0	2	57		0	3
SIMKIN, D. W. 1958a	0	0	0	0	0	0	0	0	315		0	833
SIMKIN, D. W. 1958b	0	0	0	0	0	22	32	0	624		0	0
SIMKIN, D. W. 1959	36	0	0	0	0	0	0	0	542		1	18
VOZEH, G. E & A. ZIMMERMAN 1959	9	2	0	2	5	0	43	4	347		0	44
VOZEH, G. E. 1960	20	0	0	0	12	0	77	1	137		0	0
VOZEH, G. E. 1961	32	0	0	1	15	0	59	15	383	82	0	0
VOZEH, G. E. 1962	22	0	0	0	1	0	427	39	209	32	0	0
BROWSE UNITS RECORDED BY SPECIES												
CUMMING, H. G. 1955a									1			
CUMMING, H. G. 1955b												
CUMMING, H. G. 1955c			90				64	70				
JOHNSTON, F. 1962												90
MACFIE, J. 1958	165								45			
O'SHAUGHNESSY, T. 1961	455		50						1336			
SIMKIN, D. W. 1958a									2153			245
SIMKIN, D. W. 1958b							9		897			
SIMKIN, D. W. 1958c	1020								244			
VOZEH, G. 1959									60			
VOZEH, G. 1960	6											
VOZEH, G. 1961	216								30	560		
VOZEH, G. 1962									30			

NOTE: BOTH ALDER SPECIES WERE TALLIED AS SPECKLED ALDER AND THE 3 MAPLE SPECIES WERE TALLIED AS MOUNTAIN MAPLE BY SOME CREWS.

APPENDIX TABLE 2 CONTINUED

ROSE		HONESUCKLE	BLACK SPRUCE	VIBURNUM	BLACK ASH	WHITE PINE	YELLOW BIRCH	CHOKE CHERRY	RED PINE	ELDER	GROUND JUNIPER
2	CUMMING, H. G. 1955a	1	16	1	0	0	0				
27	CUMMING, H. G. 1955b	8	39	0	0	0	0	1			
1	CUMMING, H. G. 1955c	0	39	3	0	0	0				
0	JOHNSTON, F. 1962	0	34	4	0	0	0	1		1	
0	MACFIE, J. A. 1958	5	56	2	0	0	0				
·0	O'SHAUGHNESSY, T. 1961	0	0	0	0	0	0	10		4	11
203	SIMKIN, D. W. 1958a	19	34	75	9	0	0				
0	SIMKIN, D. W. 1958b	0	755	11	0	0	0				
1	SIMKIN, D. W. 1959	8	64	0	1	0	0				
0	VOZEH, G. E & A. ZIMMERMAN 1959	8	28	0	0	1	1	3		4	
0	VOZEH, G. E. 1960	0	36	0	0	0	0				
0	VOZEH, G. E. 1961	0	25	0	0	8	0	64	1	4	
4	VOZEH, G. E. 1962	0	34	0	0	1	0	11			
	BROWSE UNITS RECORDED BY SPECIES										
	CUMMING, H. G. 1955a	1									
	CUMMING, H. G. 1955b										
	CUMMING, H. G. 1955c										
	JOHNSTON, F. 1962										
	MACFIE, J. 1958										
	O'SHAUGHNESSY, T. 1961							31			
1071	SIMKIN, D. W. 1958a	158	2	428	190						
	SIMKIN, D. W. 1958b										
	SIMKIN, D. W. 1958c										
	VOZEH, G. 1959										
	VOZEH, G. 1960										
	VOZEH, G. 1961							170			
	VOZEH, G. 1962										

APPENDIX TABLE 3a. TOTAL NUMBERS OF LIVING STEMS RECORDED IN SURVEYS OF 10 SPECIES (METHOD 2)

AUTHORS	PLOTS	WHITE BIRCH	BALSAM FIR	MOUNTAIN ASH	WILLOW	MOUNTAIN MAPLE
ARMSTRONG 1964	113	292	238	424	840	541
BROWN 1965	64	92	11	0	61	26
BUSCH & GAGNE 1969	64	166	0	0	79	81
CLOSE1966a	80	80	5	170	56	169
CLOSE 1966b	84	117	16	45	31	103
CORNELL1964	64	28	155	12	7	166
CREIGHTON 1965a	64	186	135	244	446	465
CREIGHTON 1965b	64	181	289	83	31	110
CRICHTON 1963a	64	9	356	33	100	161
CRICHTON 1963b	120	139	299	217	106	784
CRICHTON 1963c	108	131	332	146	39	774
GIBSON 1963	64	141	398	70	391	91
GIBSON 1964a	64	10	364	2	0	14
GIBSON 1964b	64	146	194	66	8	186
HALL 1963	79	147	339	0	3	314
HENDRY 1965	136	199	938	111	150	419
LUCKING 1963a	64	26	31	27	6	187
LUCKING 1964a	59	36	3	264	6	119
LUCKING 1964b	64	48	458	109	7	408
LUCKING 1965a	120	88	670	158	71	330
LUCKING 1965b	128	82	16	136	209	45
MACFADYEN 1964	64	91	234	83	0	286
MILLER 1963	64	229	61	56	3	388
MONK 1963	106	23	52	64	238	269
O'SHAUGNESSY 1964a	64	47	208	64	12	107
O'SHAUGNESSY 1964b	64	5	72	3	4	243
O'SHAUGNESSY 1964c	64	74	262	112	5	365
O'SHAUGNESSY & KEAN 1965	64	38	93	41	42	268
STASUS 1970	69	44	0	33	96	230
SWIFT 1964	64	35	0	0	84	42
THOMPSON 1969a	69	124	154	1	2	462
THOMPSON 1969b	63	7	180	1	3	550
REPEATED SURVEYS						
GIBSON 1969a	64	27	429	28	2	2
GIBSON 1969b	64	199	324	16	1	13
HALL 1964	93	407	1076	10	22	327
HERRON & CARTER 1969	64	33	191	59	71	81
LUCKING 1963b	64	41	0	41	69	1
LUCKING 1964c	64	54	0	27	77	18

APPENDIX TABLE 3a CONTINUED. TOTAL NUMBERS OF LIVING STEMS RECORDED (METHOD 2).

AUTHORS	DOGWOOD	CHERRY	JUNEBERRY	TREMBLING ASPEN	HAZEL
ARMSTRONG 1964	45	86	233	76	116
BROWN 1965	2	10	0	31	109
BUSCH & GAGNE1969	0	357	9	191	191
CLOSE 1966a	0	143	1	17	150
CLOSE 1966b	12	126	6	8	214
CORNELL1964	2	0	0	129	43
CREIGHTON 1965a	98	159	4	140	276
CREIGHTON 1965b	132	0	8	72	56
CRICHTON 1963a	0	10	0	42	66
CRICHTON 1963b	9	39	7	46	607
CRICHTON 1963c	17	45	15	63	697
GIBSON 1963	219	83	15	458	125
GIBSON 1964a	0	0	1	1	0
GIBSON 1964b	33	0	5	11	0
HALL 1963	62	31	82	131	1558
HENDRY 1965	365	31	0	215	171
LUCKING 1963a	14	112	0	13	187
LUCKING 1964a	0	124	13	7	139
LUCKING 1964b	5	13	2	7	321
LUCKING 1965a	0	96	3	76	490
LUCKING 1965b	93	556	1	305	540
MACFADYEN 1964	0	8	14	0	80
MILLER 1963	0	136	51	24	42
MONK 1963	0	11	236	36	149
O'SHAUGNESSY 1964a	0	7	2	37	134
O'SHAUGNESSY 1964b	0	6	0	30	122
O'SHAUGNESSY 1964c	0	8	0	15	543
O'SHAUGNESSY & KEAN 1965	30	25	11	68	383
STASUS 1970	3	931	20	214	698
SWIFT 1964	0	47	0	22	485
THOMPSON 1969a	3	50	18	20	505
THOMPSON 1969b	13	0	10	10	380
REPEATED SURVEYS					
GIBSON 1969a	0	0	14	3	0
GIBSON 1969b	0	0	12	5	0
HALL 1964	256	44	73	414	1782
HERRON & CARTER 1969	114	97	0	70	479
LUCKING 1963b	49	323	0	121	177
LUCKING 1964c	11	299	0	127	167

APPENDIX TABLE 3b. NUMBERS OF BROWSED STEMS RECORDED IN SURVEYS OF 10 SPECIES (METHOD 2).

AUTHORS	NO. OF PLOTS	WHITE BIRCH	BALSAM FIR	MOUNTAIN-ASH	WILLOW	MOUNTAIN MAPLE
ARMSTRONG 1964	113	52	79	346	211	180
BROWN 1965	64	17	4	0	36	15
BUSCH & GAGNE 1969	64	138	0	0	44	13
CLOSE 1966a	80	19	0	139	49	28
CLOSE 1966b	84	11	0	15	19	10
CORNELL1964	64	0	11	6	6	87
CREIGHTON 1965a	64	10	18	78	23	36
CREIGHTON 1965b	64	34	68	41	6	35
CRICHTON 1963a	64	6	23	13	33	42
CRICHTON 1963b	120	42	28	91	44	205
CRICHTON 1963c	108	63	42	77	28	58
GIBSON 1963	64	82	176	37	230	57
GIBSON 1964a	64	10	293	2	0	11
GIBSON 1964b	64	135	96	64	7	166
HALL 1963	79	50	72	0	2	141
HENDRY 1965	136	98	64	67	86	172
LUCKING 1963a	64	12	19	9	0	98
LUCKING 1964a	59	0	0	42	0	1
LUCKING 1964b	64	1	7	11	0	24
LUCKING 1965a	120	9	8	22	5	25
LUCKING 1965b	128	4	1	12	19	0
MACFADYEN 1964	64	34	4	28	0	40
MILLER 1963	64	73	1	47	1	142
MONK 1963	106	13	27	64	183	263
O'SHAUGNESSY 1964a	64	2	1	13	0	8
O'SHAUGNESSY 1964b	64	1	0	0	1	26
O'SHAUGNESSY 1964c	64	14	2	23	0	63
O'SHAUGNESSY & KEAN 1965	64	6	11	11	18	6
STASUS 1970	69	22	0	28	49	7
SWIFT 1964	64	20	0	0	33	11
THOMPSON 1969a	69	63	24	0	1	224
THOMPSON 1969b	63	0	54	0	0	166
REPEATED SURVEYS						
GIBSON 1969a	64	12	196	2	0	2
GIBSON 1969b	64	64	177	2	1	8
HALL 1964	93	59	82	1	6	109
HERRON & CARTER 1969	64	2	3	13	15	3
LUCKING 1963b	64	13	0	7	18	0

APPENDIX TABLE 3b CONTINUED. NUMBERS OF BROWSED STEMS RECORDED IN SURVEYS OF 10 SPECIES (METHOD 2).

AUTHORS	DOGWOOD	CHERRY	JUNEBERRY	TREMBLING ASPEN	HAZEL
ARMSTRONG 1964	32	4	95	27	51
BROWN 1965	0	7	0	9	62
BUSCH & GAGNE 1969	0	122	7	100	66
CLOSE 1966a	0	27	0	5	48
CLOSE 1966b	0	4	1	1	22
CORNELL1964	1	0	0	58	26
CREIGHTON 1965a	28	15	0	12	1
CREIGHTON 1965b	26	0	3	24	14
CRICHTON 1963a	0	3	0	19	19
CRICHTON 1963b	1	18	2	10	212
CRICHTON 1963c	1	15	3	28	163
GIBSON 1963	120	33	6	255	67
GIBSON 1964a	0	0	0	1	0
GIBSON 1964b	33	0	1	10	0
HALL 1963	27	6	44	77	525
HENDRY 1965	214	19	0	71	73
LUCKING 1963a	3	30	0	4	47
LUCKING 1964a	0	4	0	2	15
LUCKING 1964b	0	2	0	1	34
LUCKING 1965a	0	4	0	3	19
LUCKING 1965b	11	9	0	1	8
MACFADYEN 1964	0	1	0	0	15
MILLER 1963	0	31	4	14	13
MONK 1963	0	11	175	16	149
O'SHAUGNESSY 1964a	0	0	0	2	1
O'SHAUGNESSY 1964b	0	4	0	9	17
O'SHAUGNESSY 1964c	0	4	0	3	28
O'SHAUGNESSY & KEAN 1965	13	1	1	4	9
STASUS 1970	2	48	8	104	247
SWIFT 1964	0	33	0	18	68
THOMPSON 1969a	0	28	11	5	228
THOMPSON 1969b	3	0	1	0	102
REPEATED SURVEYS					
GIBSON 1969a	0	0	8	0	0
GIBSON 1969b	0	0	3	3	0
HALL 1964	83	14	32	144	848
HERRON & CARTER 1969	25	12	0	5	71
LUCKING 1963b	13	28	0	11	10