PLANT STUDIES RELATED TO MOOSE NUTRITION
A PRELIMINARY REPORT

Roger Bergström
Swedish Sportsmen's Association
Research Unit
Box 7002, S-750 07 Uppsala
Sweden

Abstract: A pilot study to estimate plant density from distance measurements is presented. One of the tested methods, corrected point distance, was used in combination with a shoot- and bite count technique to estimate the production and consumption of browse in two stand types (0-17 years and 18-40 years). Pine produced 90-93% of total browse production. Of pine and the birch species 0.1-24.6% of the production was used by, moose. About twelve times as much of last years growth was eaten in the older stand type compared to the younger one. The total consumption was about eight times higher in the older stand. Of the total amount of browse eaten 65-70% was last year's production. In connection with the study on browse yield and use simulated browsing was used to investigate the morphological changes after removal of different length fractions of long shoots on silver birch. The amount removed and growth site for the treated shrubs affected the number and proportions of different kinds of bud development.

The dramatic increase of many Swedish moose populations during the last two decades has been emphasized in several papers (Stålfelt 1977, Markgren 1978). The reasons for this rapid growth are believed to be changes in land use, hunting

policy and a series of mild winters (Markgren 1978). This increase in moose density has focused the interest on the carrying capacity of different ranges and on the influence of moose on forest stands and vegetation in general.

Studies within these fields together with management needs demand a collection of methods for estimation of production, consumption and utilization of browse. In Scandinavia and especially Sweden some methods have been developed or tested (Ahlén 1975, Bobek and Bergström 1978, Bergström and Skarpe unpubl. and Nyström unpubl.). Most methods have employed fixed area plots in order to relate recorded variables to unit area. The development of distance methods (eg. Cottam and Curtis 1956, Batcheler 1973) to estimate the number of plant individuals per unit area has offered a new tool in browse studies (Telfer 1974, Usher 1977, Nowlin 1978). These plot-less methods have many advantages over plots although the theoretical background in some ways is uncertain. Many studies have shown that distance methods give as good an estimation of density for various distributions as the traditional techniques (Lyon 1968, Batcheler and Bell 1970).

Five distance methods were used to estimate the density of shrubs within an area of known density. One method was then combined with the technique described by Ahlén (1975) to estimate the production and consumption of browse.

This blend of techniques has been described by Telfer (1974). He discussed the advantage of using trend survey and to expand this survey to a browse inventory by estimating the number of shrubs per unit area. The method published by Ahlén is one of the most refined techniques for estimation of browse yield and use.

The ability of shrubs to withstand use by herbivores is to some extent dependent on its ability to compensate for biomass removal. Many workers have studied the quantitative response after simulated clipping (Rutherford 1979). A general behavior of the shrub is that the browse yield does not decrease until after a substantial amount (often 50-60%) of the shoots have been clipped. This is probably due to removal of hormonal inhibition on the lateral buds after the apical bud is removed (Rubinstein and Nagao 1976). This will cause morphological changes which is one way for the shrub to compensate for the damage. Studies on these morphological effects can increase our understanding of how shrubs react to browsing.

The aim of the studies presented in this paper was to consider a part of the dynamic interaction between moose and the vegetation.

STUDY AREA

The studies were made within a moose pen (620 ha) at Sunnäs, close to the east coast in central Sweden. The number of enclosed moose corresponded to 0.8 moose/km^2. Other

large herbivores in the pen were roe-deer (*Capreolus capreolus*) and mountain hare (*Lepus timidus*). The area is dominated by Scots pine (*Pinus silvestris*) stands of different ages. Bogs cover about 15% of the area. Besides pine, silver birch (*Betula pendula*), common birch (*Betula pubescens*) and Norway spruce (*Picea abies*) are found in the tree-layer. The same species are also dominant in the shrub-layer where they are intermixed with juniper (*Juniperus communis*), mountain ash (*Sorbus aucuparia*), aspen (*Populus tremula*) and willows (*Salix spp.*).

Snow (40-50 cm) usually covers the ground from mid-November to mid-April.

METHODS

Before browse estimates were made a small study was conducted to test the accuracy of several distance methods to estimate shrub density. A plot (100 x 100 m) was established on a rather heterogenous area cleared 7 years earlier and planted with pine. All individual stems of pine and birch with a height between 30 and 250 cm were counted within the plot. Other species were omitted. 64 sample points were systematically spread over the plot. Following methods were tested:

1) Closest individual method (Cottam, Curtis and Hale 1953). A distance was measured between every sample point and the nearest pine and birch.

2) Nearest neighbor method (Clark and Evans 1954).
A distance was measured from the pine and the birch nearest the sample point to the nearest neighbor of the same species.

3) Point centered quarter method (Cottam and Curtis 1956).
A distance was measured from the sample points to the nearest pine and birch in quarters where the origin was at the sample point and the axes were oriented in the same directions at every point.

4) Morisita angle order method (Morisita 1957).
A distance was measured from the sample points to the third nearest pine and birch.

5) Corrected point distance method (Batcheler 1973).
A distance was measured from the sample point to the nearest pine and birch and from these individuals to their nearest neighbors and again to the neighbor of the neighbors.

The estimated densities were calculated according to the formulas in the references.

The "corrected point distance" method was then used in combination with the method presented by Ahlén (1975) (Fig.1) to estimate browse yield and use. The moose pen was stratified into four strata: forest stands (0-17, 18-40 and 40 + years) and bogs. Some areas from every stratum were randomly chosen and from these areas sampling points were objectively selected from a systematic pattern of points. The distance

was measured from every point to the nearest plant individual with browse within 50-250 cm. This was done independent of species. From this individual a new distance was measured to its nearest neighbor of the same species. These shrubs were also used for the routine data collections (Fig 1) which together with the distance measurements were made immediately after snow melt. The preliminary investigations were made in the autumn and winter.

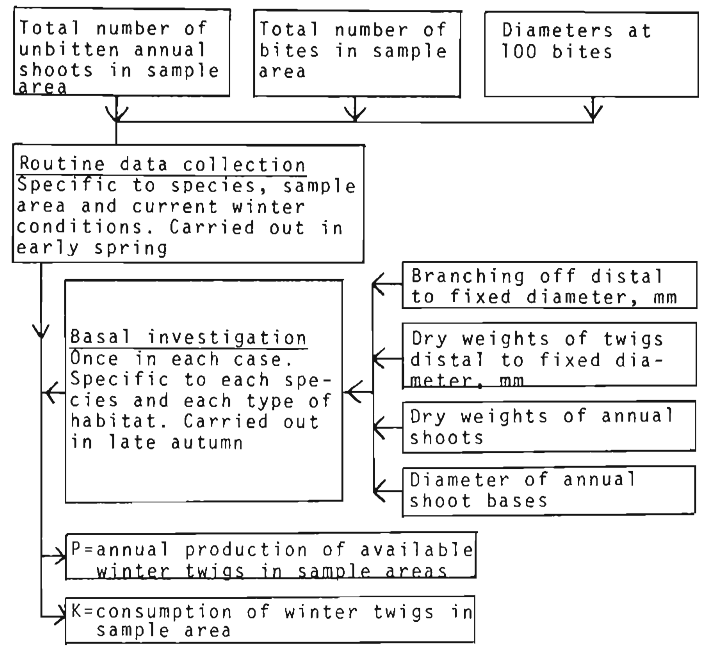

Figure 1. Method of estimating winter twig production and consumption (from Ahlén 1975).

In this paper only the pine and birch from the two youngest stands are included. These species and strata are quantitatively the most important to moose.

To study the morphological effects of simulated browsing, five current annual growth shoots of silver birch were subjectively chosen on each of 40 shrubs. All shrubs were between 50 and 250 cm in height. Care was taken to sample shoots from different positions of the crown. The shoots were numbered and the position and distance (cm) from shoot base of each bud was recorded. Four clipping intensities (50 shoots per intensity) were used to remove 0, 25, 50 or 75% of the shoot length. The plants were clipped on 12 April. In August every bud was rechecked and the development of each bud was recorded as lost, dead, resting, short shoot or long shoot. Every shoot growing one to few millimeters and carrying one bud was classified as short shoot. Salix spp. have usually not this type of shoot.

The results presented here about the morphology are some data from a study presented elsewhere (Gröning, in press), Bergström and Gröning (in prep.).

RESULTS AND DISCUSSION

Density

The results of the density estimates using five different methods are shown in Table 1. The first three methods gave underestimations. This was expected as they were all

developed for sampling populations with a random distribution. Method 4 was accurate for pine but strongly overestimated birch. This method was extremely sensitive to very short distances. A subtraction of the two shortest distances decreased the estimated number from 8244 to 6000.

Table 1. True Density and Accuracy of 5 Methods Used to Estimate Density of Shrubs at the Sunnäs Moose Pens.

	Pine		Birch	
Method	Density	% of true density	Density	% of true density
Total count	2063	100	4874	100
Closest individual	1052	51	1210	25
Nearest neighbor	1449	70	3006	62
Point centered quarter	1242±119 [1)]	60	1445±184 [1)]	30
Morisita angle order	1955	95	8244	169
Corrected point distance	1522±182 [1)]	74	4586±1110 [1)]	94

1) Standard error

Method 5 estimated the number of shrubs in the study plot to be 74% (pine) and 94% (birch) of the true density. This is similar to results obtained by Batcheler (1973). He found that in 93% of the tests, with a variety of distributions, the estimated density was within ±30% of the true value. The estimate was most accurate when an upper search distance limit was applied, which resulted in measurements on 50% of the points. This was also in agreement with Batcheler's findings.

For many distance methods no formulas have been developed to calculate variance of the density estimation. In this study the standard error was calculated for method 3 according to Lyon (1968) and for method 5 after Batcheler (1975). The variability is generally high for all density methods (Lyon 1968) and this is especially true when the distributions are clumped. After a literature review and the pilot study I chose to use the "corrected point distance" method.

Production and Consumption of Browse

The density of pine and birch in the youngest stand types (I and II) are in Table 2. All other species are quantitatively of minor importance in the study area.

Table 2. Estimated Density and Composition of Species Estimated with Corrected Point Distance Method within Two Forest Stand Types (I and II) at the Sunnäs Moose Pens.

	I		II	
Plant species	Plants/ha	% of total plants	Plants/ha	% of total plants
Scots pine	1973	56.3	1989	60.1
Silver birch	526	15.0	649	19.6
Common birch	526	15.0	208	6.3
Others	483	13.8	460	13.9
Total	3508±313[1)]		3306±242[1)]	

1) Standard error

The dominating species in this group was Norway spruce which is rarely eaten by moose. This group of species will not be discussed further in the paper. The density was about the same in the two stand types. This was expected as the pine was planted or thinned to a density suitable for the commercial timber production. In stand type I the birches were equally frequent but in II silver birch was dominant.

Pine was by far the most important producer of browse (Table 3). In stand types I and II it constituted 90% and 93% respectively of total browse yield. Looking at the three species together the percentage of the current annual growth which was eaten varied from 0.1% to 24.6%. The consumption of pine shoot production in I and II was 0.1% and 3.8% respectively. About twelve times as much of last year's available shoot production was consumed in II compared to I (0.4% and 4.7% respectively). Including both stands in one calculation about 1.7% of the production of 427 kg/ha was removed. The total consumption was also estimated. Of the total consumption about 65-70% was from last years production which means that even with such relatively low moose density they often include more than the last growth in many bites.

Table 3. Production and Consumption of Browse (kg/ha) in Two Forest Stand Types (I and II) at the Sunnäs Moose Pens.

Stand age	Plant species	Production (kg/ha)	Consumed kg/ha	Consumed production % of production	Total consumption kg/ha	Total consumption % of production
0-17 years	Scots pine	470.9	0.6	0.1	1.1	0.2
	Silver birch	32.9	1.1	3.3	1.4	4.3
	Common birch	15.2	0.2	1.2	0.2	1.3
	Total	519.0	1.9	0.4	2.7	0.5
18-40 years	Scots pine	282.5	10.8	3.8	15.2	5.4
	Silver birch	13.9	3.4	24.6	7.0	50.4
	Common birch	7.9	0.006	0.1	0.007	0.1
	Total	304.3	14.2	4.7	22.2	7.3

It can be concluded that only a small amount of produced dry matter was removed by the moose. Even if the total amount eaten was compared to production, the utilization was low (0.5% and 7.3% respectively in stand type I and II). These figures agree with values published by Usher (1977). He found that 2.5% of the produced browse was used in an area with a browse yield and moose density of the same order as at Sunnäs. My figure is lower than those reported by Dinesman (1967), who worked in an area with considerably less biomass and probably production. However he concluded that the influence of moose on shrubs was more an effect of lowered production of the whole shrub than just an effect of the weight of removed browse.

Pine and birches have long been regarded as less preferred species. As I have restricted this report only to these species they can not be compared with the more preferred species such as aspen, rowan and willows. But as pine and birches are the most common and economically important species it might be of interest to discuss possible differences between these three species. Sixtyfour percent of the total consumption was pine and this is in good agreement with Cederlund et al. (in press). They found that rumens collected in winter contained 60-70% pine and 15% birch on a dry weight basis. My relative value of birch consumption decreases slightly when all browse species are included. Table 4 shows the preference factors by weight as described by Telfer (1972), with the exception that I have used produced weight. The factors differ much between species and stands. Pine was consumed less in relation to browse weight availability.

The figures arrived at here indicate a higher consumption than the consumption obtained when number of moose days was multiplied by daily intake. One explanation might be the low but unknown number of roe-deer and hares within the pen.

Table 4. Preference Rating-Factor[1)] by Weight of 3 Species in Two Forest Stand Types (I and II).

Plant species	I	II
Scots pine	0.4	0.7
Silver birch	8.2	6.9
Common birch	2.5	0.01

1) A rating factor of 1.0 means that the plant is eaten in proportion to its production of forage. Higher values indicate preference for a species.

Morphological effect of simulated browsing

On average, an unclipped birch shoot in a 7 years old stand (area 1) had the same number of buds as shoots under an almost closed canopy (area 2). However, after the growing season, when the bud development was checked, differences in development were apparent (Table 5). About 40% of the buds in area I developed into long shoots while the corresponding value for area 2 was 20%. Short shoot formation was the dominating form of development in both ares

Table 5. The Effect of Different Clipping Intensities on Bud Development in Two Forest Stand Types (I and II). The Figures are Number of Bud Development Types on an Average Shoot. (e.g. on 46 Shoots 25% of the Length were Removed in April in Stand Type I and in August the Same Year 2.3 New Shoots had on an Average Developed on Each Treated Shoot).

Bud development type	Clipping intensity in % of shoot length							
	I Pine stand 7 years				II Pine stand 20 years			
	0	25	50	75	0	25	50	75
Resting	0.4	0.4	0.3	0.2	0.06	0.07	0.06	0.1
Short shoot	2.2	2.3	1.0	0.3	3.6	2.0	0.8	0.2
Long shoot	1.7	1.8	1.0	0.5	0.9	0.3	0.4	0.06
Number of shoots measured	49	46	48	50	50	45	50	47

although it was more pronounced in area 2. The clipping of different intensities in area 1 caused a change in the development of the remaining buds. The number of short shoots decreased in favour of long shoots. A clipping of the outer 25% of the shoot resulted in changes over the whole remaining shoot. Although one fourth of the shoots were clipped, the number of developed shoots was about the same. When 50% of length was removed the number of short shoots decreased even more than expected based on changes in the 0 or 25% treatments. This trend continued to the 75% clipping. The shoots in area 2 reacted in a slightly different way. A removal of the outer quarter affected only the nearest remaining quarter of the shoot. Furthermore the number of both short- and long shoots decreased even after this light clipping. When 75% of the shoot length was removed 39 of 50 shoots had no buds left and the probability of the remaining bud to develop to a long shoot was very low.

This small study showed that a low clipping intensity to some extent was compensated for by increasing the number of long shoots. But this response was also dependent on the growth site of the treated shrubs.

ACKNOWLEDGEMENT

I wish to acknowledge the assistance of Mats Vikberg with the field work and Per Gröning for permitting me to use some of our data on shrub morphology. I also wish to thank

Ingemar Ahlén for giving me permission to use one of his figures. Helpful comments on the manuscript were recieved from Wayne Regelin.

REFERENCES

Ahlén, I. 1975. Winter habitats of moose and deer in relation to land use in Scandinavia. Viltrevy 9:45-192.

Batcheler, C.L. 1973. Estimating density and dispersion from truncated or unrestricted joint point-distance nearest-neighbor distance. Proc. New Zealand Ecological Soc. 20:131-147.

Batcheler, C.L. 1975. Probable limit of error of the point distance neighbor distance estimate of density. Proc. New Zealand Ecological Soc. 22:28-33.

Batcheler, C.L. and D.J. Bell. 1970. Experiments in estimating density from joint point- and neighbor distance samples. Proc. New Zealand Ecological Soc. 17:111-117.

Bobek, B. and R. Bergström. 1978. A rapid method of browse biomass estimation in a forest habitat. J. Range Manage. 31:456-458.

Cederlund, G., H. Ljungqvist, G. Markgren and F. Stålfelt. Foods of moose and roe-deer at Grimsö in central Sweden - Results of rumen content analyses. Swedish Wildl. Research. (Viltrevy) in press.

Clark, P.J. and F.C. Evans. 1954. Distance to nearest neighbor as a measure of spatial relationships in populations. Ecology 35:445-453.

Cottam, G. and J.T. Curtis. 1956. The use of distance measures in phytosociological sampling. Ecology 37:451-460.

Cottam, G., J.T. Curtis and B.W. Hale. 1953. Some sampling characteristics of a population of randomly dispersed individuals. Ecology 34:742-757.

Dinesman, L.G. 1967. Influence of vertebrates on primary production of terrestrial communities. p. 261-266. In: Secondary Productivity of Terrestrial Ecosystems (ed. K. Petrusewicz), Warszawa.

Gröning, P. 1980. Simulerat bete på vårtbjörk samt morfologi och fenologi hos några viltbetesarter. Meddelanden från Växtbiologiska Institutionen 1980:4. Uppsala.

Lyon, L.J. 1968. An evaluation of density sampling methods in a shrub community. J. Range Manage. 21:16-20.

Markgren, G. 1978. Älgstammens explosionsartade tillväxt. Några troliga orsakssammanhang. Fauna och Flora Nr 1:1-48.

Morisita, M. 1957. A new method for the estimation of density by the spacing method applicable to non--randomly distributed populations. (In Japanese with English Summary.) Physiol. and Ecol. 7:134-144.

Nowlin, R.A. 1978. Habitat selection and food habits of moose in northeastern Alberta. Proc. 14th N. Am. Moose Conf. and Workshop, Halifax, Nova Scotia. p. 178-194.

Rubinstein, B. and M.A. Nagao. 1976. Lateral bud outgrowth and its control by the apex. Bot. Rev. Vol. 42:83-113.

Rutherford, M.C. 1979. Plant-based techniques for determining available browse and browse utilization: a review. Bot. Rev. Vol. 45:203-228.

Stålfelt, F. 1977. Älgstammens ökning kartläggs från flyg. Svensk Jakt 6:388-389.

Telfer, E. 1972. Browse selection by deer and hares. J. Wildl. Manage. 36:1344-1349.

Telfer, E. 1974. A trend survey method for browse ranges using the Shafer twig count technique. Paper presented at 10th N. Am. Moose Conf. and Workshop, Duluth, Minnesota.

Usher, R. 1977. Effects of forest clearing on browse production and use in the sand river area, Alberta. 13th N. Am. Moose Conf. and Workshop, Jasper, Alberta. p. 1-12.