The Estimation of Winter Forage and Its Use by Moose on Clearcuts in Northcentral Newfoundland

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Highlight: This study was designed to evaluate the effect of clearcutting on moose (*Alces alces americana*) populations in northcentral Newfoundland. Fourteen logged areas of various size and age were sampled for potential standing forage and current use. Balsam fir (*Abies balsamea*), white birch (*Betula papyrifera*), pin-cherry (*Prunus pensylvanica*), and willow (*Salix* spp.) were the most common forage species. Moose browsed most heavily upon pin-cherry, followed by birch and willow. Balsam fir was only lightly used. The most efficient sized plot for measuring browse production was found to be 6 m^2. Available browse on balsam fir trees ≤5 m in height was measured by linear correlation with the product of stem diameter and height. Most winter browse was in cuts 8 to 10 years of age. The greatest use was in cuts 40 to 50 ha in size. A forest management plan which encourages a heterogeneous pattern of 40 to 50 ha block cuts and mature forest cover is suggested to be most compatible with the management of moose in northcentral Newfoundland.

The rapid growth of the wood fibre industry in Newfoundland, and the northeast in general, has promoted large-scale harvesting of softwoods by the most economical means. Clearcutting is the most prevalent method of harvesting, particularly in the spruce-fir forests in the northcentral portion of the province. This intensive disturbance to the climax forest has resulted in a proliferation of immature forest stands and increased the abundance of important moose forage species such as pin-cherry, white birch, and immature balsam fir.

The increase in logging activity has stimulated increases in moose densities and severe damage has resulted to regenerating balsam fir, causing concern to both the wildlife and forest managers (Pimlott 1955; Ellis 1960; Dodds 1960; Bergerud and Manuel 1968). Although moose densities have been reduced by closely regulated harvests throughout most of the province (Bergerud et al. 1968), the forests continue to be harvested with little regard to the potential impact upon wildlife or the ecosystem in general. Individual cuts are increasing in size, while little is known of the impact of such extensive forest removal upon wildlife, soil fertility, or water quality.

At the request of the Newfoundland Wildlife Division, Canadian Wildlife Service examined clearcuts in northcentral Newfoundland during the summer, 1976, to evaluate the impact of clearcuts of various sizes and ages upon moose forage production and use. This was a pilot study only; research will be expanded to evaluate the impact of forest cutting practices upon wildlife on a regional basis in other parts of the province.

Study Area

The clearcuts sampled were near Badger, an area which has long been the focal point of forest harvesting in Newfoundland, and one which has continually supported good densities of moose. Rowe (1972) places that area within the Grand Falls Section of the Boreal

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Forest Region of Canada. The most productive forests in insular Newfoundland are found there. It is a coniferous forest, with balsam fir and black spruce (*Picea mariana*) the most common species. Both white spruce (*Picea glauca*) and white birch are common pioneer species in cut-over and burned sites. Red maple (*Acer rubrum*) and white pine (*Pinus strobus*) are also present, but of minor importance.

Bogs, muskegs, lakes, and rivers are abundant throughout the forested plateau of low relief. The underlying strata are mostly palaeozoic sediments with some intrusive rocks, and the derived glacial tills that cover the surface are relatively fertile. The soils are humo-ferric and ferro-humic podzols on the uplands, gleysols and organic soils (peats) on the lowlands.

The climate of the Badger area is more continental than maritime. The mean July maximum temperature is 21°C; the mean January maximum temperature is −12°C. Mean annual precipitation is 101 cm; total snowfall approaches 381 cm. Maximum snow depths may reach 130 cm (Thomas 1953).

Methods

We experimented with fast and reliable methods for estimating available winter forage and its use by moose on clearcuts in north-central Newfoundland. Recent developments in ungulate browse inventories which rely on correlations between stem or twig measurements and available and removed browse (Shafer 1963; Telfer 1969; Basile et al. 1966; Ohmann et al. 1976) suggested that that was the approach we should pursue in this study.

We chose the twig-count method developed by Shafer (1963) as the technique to be applied for deciduous browse estimation and use. He proved it to be very efficient for estimating hardwood browse production and use by deer in Pennsylvania.

A total twig-count for balsam fir trees would have proven very time-consuming, so we investigated the presence of correlations between simple stem measurements and available browse. Our approach was a modification of the weight-diameter technique for total biomass estimates developed by Telfer (1969) in the Maritime Provinces.

The selection of clearcuts to be sampled was made possible through the co-operation of Price Pulp and Paper Company Limited, Grand Falls. Cutting records were examined to ensure a representative range in size and age of cuts. A number of cuts of desired age and size were not available, either by their absence or because their location made summer sampling impossible.

A selected cut was located on an aerial photograph (scale = 1:60,000), or superimposed on the photograph if the cut was more recent. We had little choice of characteristics other than size and age due to lack of availability. The original forest cover, however, was invariably a mature spruce-fir type.

Cuts were seldom uniform in shape, but rather their boundaries followed the irregular pattern of drainage and standing commercial trees. We did not, therefore, study the possible influences of the shape of cut (i.e. block, rectangular, etc.) upon intensity of browse removal by moose.

A selected cut was sampled with ten 2×5 m-plots (10 m^2) positioned along a transect at 30-m intervals. A randomly selected point from a grid over the cut on a photograph determined the starting location of the transect. The first plot was positioned 30 m from the selected point along the long axis of the cut. The 2×5-m plot was subdivided into five 2×1-m sub-plots. This permitted grouping the data into various combinations to calculate efficiency of plot size.

Preliminary measurements were taken of the diameter at the point of browsing (dpb) by moose for the important browse species. One hundred dpb measurements were taken for each species. It was determined from the formula

$$n_o = \left(\frac{1.96 \times \frac{s}{\bar{x}}}{20} \right)^2 \times 10^4$$

that that sample size provided a mean with at least 80% Precision at the 95% level of confidence. This measurement was applied when estimating the quantity of available deciduous forage. All deciduous twigs, ≥5 cm in length, and having a diameter within the predetermined dpb range, were tallied from ground to 3 m in height. Later, following the completion of annual growth in September, 25 twigs per species ≥5 cm in length, were clipped at the $\bar{x}$ dpb. These were oven-dried (60°C) for 24 hours) and the mean weight of an available twig calculated for each deciduous species. Total forage by species for each plot was a product of total twigs tallied and the mean weight per twig.

An additional 20 twigs were clipped with a range of diameter around the dpb to calculate correlations between dried weight measurements and twig diameters.

The amount of available balsam fir per plot was estimated from correlations developed between forage and the product of stem diameter and tree height. Thus, measurements of individual balsam fir tree heights (≤5 m in height) and stem diameter were later converted to

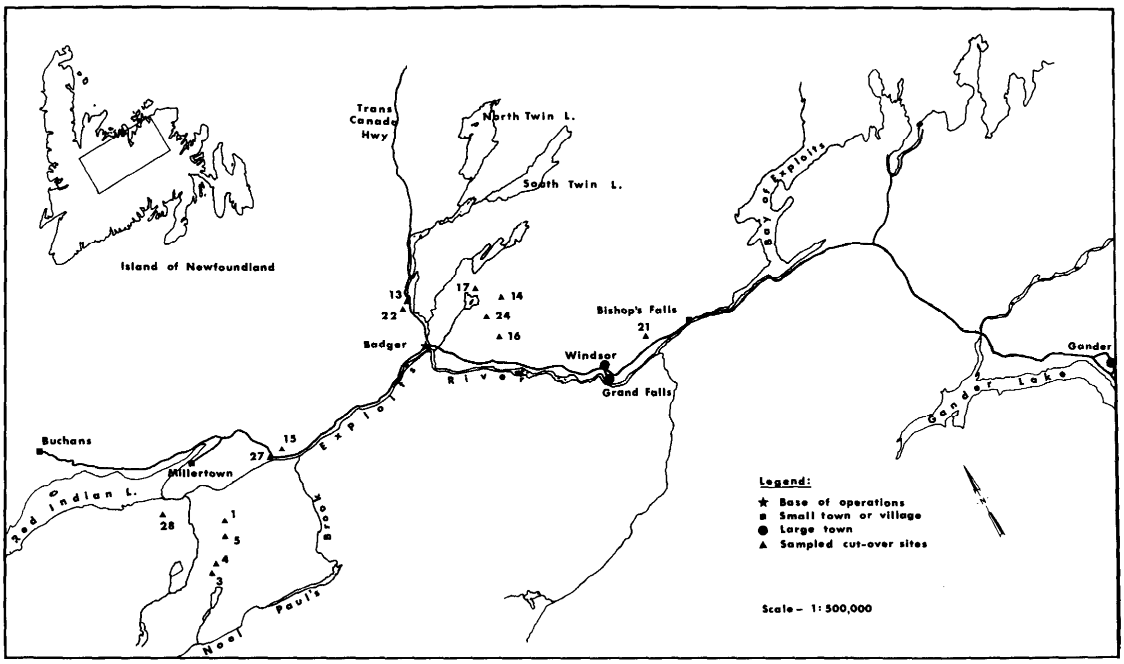

Fig. 1. *The locations of 14 clearcuts sampled near Badger in northcentral Newfoundland, summer, 1976.*

potential winter forage (0–3 m high) by reference to the preliminary correlations.

Utilization of deciduous species by moose was quantified by converting the number of browsed twigs tallied to air-dried weights. This was not done for fir, and for that species a simple index of use (% of twigs eaten during the previous winter) was recorded.

We measured browse from ground level to 3 m in height. We realize changing snow levels often create continuous changes in winter forage availability. We do not attempt to distinguish between potential and realized available forage for obvious reasons, and for this study, where data was collected during one field season, comparisons of forage use among cuts should be valid.

Results

In July and August, 1976, 14 cuts were sampled for total available winter forage and its use by moose in northcentral Newfoundland (Fig. 1). The cuts ranged in age from 2 to 15 years and in size from 3 to 200 ha (Table 1).

Table 1. The location, size, and age of 14 cuts sampled in central Newfoundland, July and August, 1976.

Location (see Fig. 1)	Size (ha)	Age (years)
1	3	2
3	26	2
4	40	2
5	80	2
13	4	7
14	10	6
15	16	6
16	40	7
17	92	7
21	17	11
22	40	10
24	200	8
27	28	15
28	44	15

A usable correlation was found for balsam fir between the product of stem diameter and tree height and the quantity of browse available to moose (Fig. 2). The correlation was expanded to provide a table of predicted weights for trees with given stem diameter-tree height products. The regression shown is linear, which gave the best fit for trees ≤5 m in height.

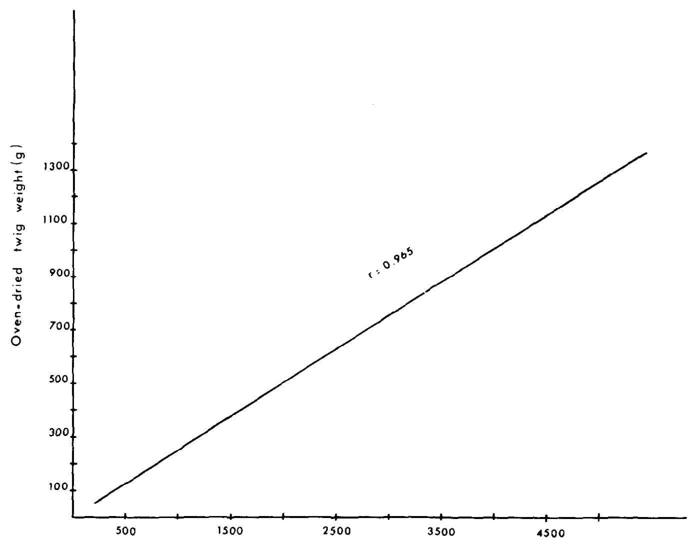

Fig. 2. *The line of regression for a correlation between the product of stem diameter and height and the quantity of balsam fir browse available to moose.*

Table 2. Twig weight prediction data for the polynomial regression log-log model equation log $y_i = B_0 + B_i$ (log x_i) for five deciduous forage species in central Newfoundland.

Species	Constants B_0	Constants B_i	R^2
Prunus pensylvanica	−4.0130	3.3550	0.98
Betula papyrifera	−4.0767	3.5506	0.89
Populus tremuloides	−4.4138	3.4158	0.97
Salix spp.	−5.5773	4.1626	0.98
Acer rubrum	−5.5419	3.9966	0.96

Thereafter, forage yields become more variable, and probably decrease with increasing height of tree.

We also applied regression analysis to diameter and dried weights of deciduous twigs (Table 2; Fig. 3). The best fit was from a log-log model,using the equation $y_i = B_0 + B_i$ (log x_i). As we were concerned only with evaluating winter forage, the analyses were restricted to the nonherbaceous twig material. There was a positive correlation between twig diameter and dried weights for all species. Predicted weights for twigs with various diameter measurements were developed from these regressions. It was impossible to accurately identify willow to species during field studies. Although there are 36 species of willow which occur on insular Newfoundland (Ryan 1974), the two most likely to occur in logged over sites are *Salix discolor* and *S. bebbiana*.

We tested the efficiency of various sized sub-plots for estimating forage production. By arranging various combinations of the 2 x 1-m sub-plots, we were able to compare the precision of forage estimates from plots of 2 m^2, 4 m^2, 6 m^2, and

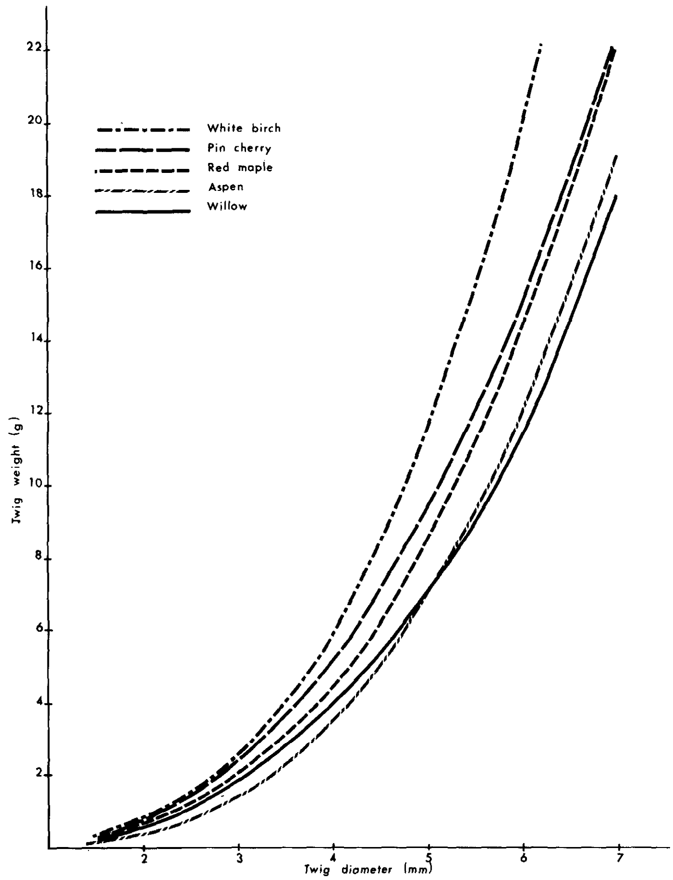

Fig. 3. *The lines of regression for correlation between twig diameter and dried weights for deciduous species important to moose as browse in clearcuts in northcentral Newfoundland.*

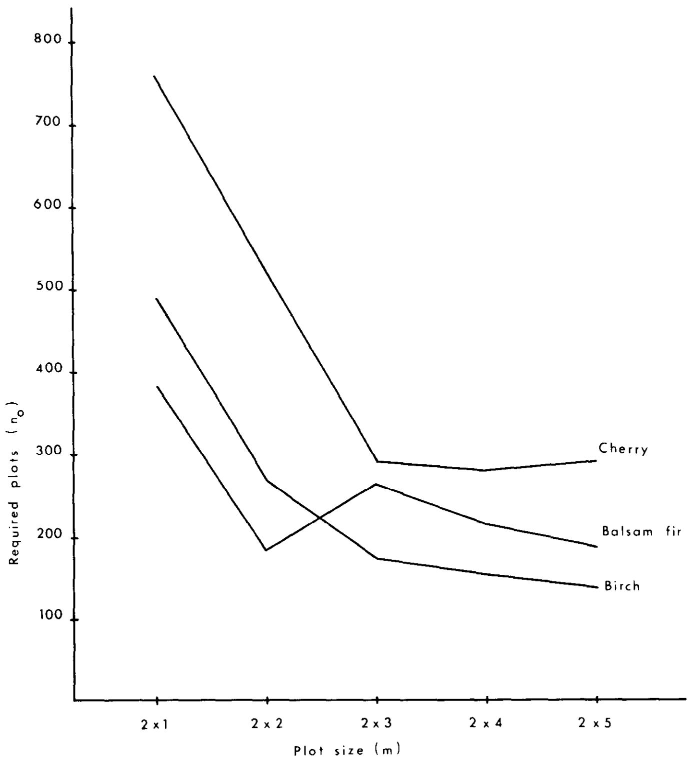

Fig. 4. *The number of various sized plots required to obtain estimates of potential moose forage with 80% precision 95% of the time.*

10 m^2. We calculated the required number of sub-plots of each size to obtain estimates with 80% precision 95% of the time. The mean for required plots was calculated by pooling the results of all cuts sampled. This was done for the species balsam fir, white birch, and pin-cherry (Fig. 4).

For both deciduous species, there was a sharp drop in the required number of plots as size of plot increased from 2 m^2 through 6 m^2. Increasing plot size beyond 6 m^2 did not significantly increase the precision of the estimate.

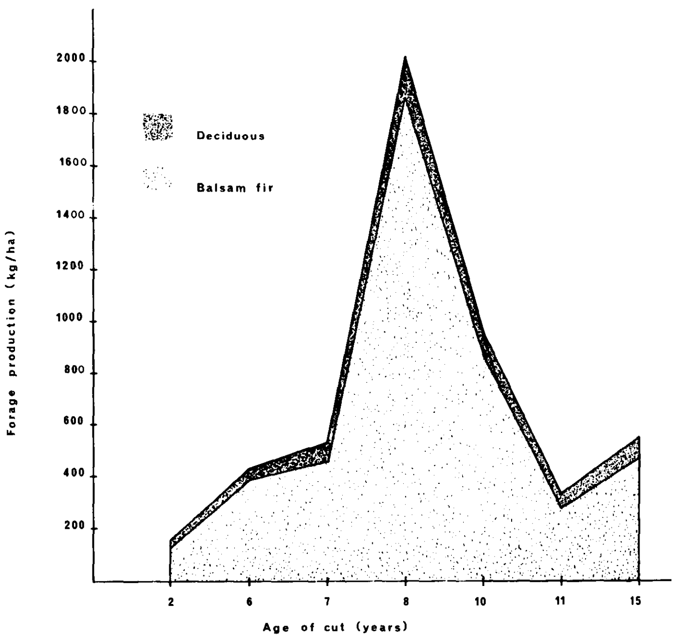

Fig. 5. *Total woody biomass available to moose in clearcuts ranging in age from 2 to 15 years.*

Browse production was calculated for each cut from those plots showing the greatest precision. There was an increase in total browse production through the first 8 years followed by a sharp decline thereafter (Fig. 5). Balsam fir comprised the bulk of available browse. Of the deciduous forage, the most abundant was white birch, followed in importance by pin-cherry, trembling aspen (*Populus tremuloides*), willow, and red maple.

All deciduous twigs tallied were recorded as being browsed or unbrowsed. The unbrowsed twigs were used to calculate available forage. This allowed an evaluation of the use being made of available browse by moose in cuts of various age and size. A similar quantitative assessment of utilization of balsam fir was not possible as twigs of that species were not counted. A subjective assessment of browsing intensity on balsam fir, however, was recorded for each plot.

There was no obvious relationship between percentage of twigs browsed and the age of the cut. There was, however, a relationship between use of deciduous forage and the size of cut (Fig. 6). The intensity of browsing increased steadily and peaked in cuts 40 to 50 ha in size. Thereafter intensity of browsing declined.

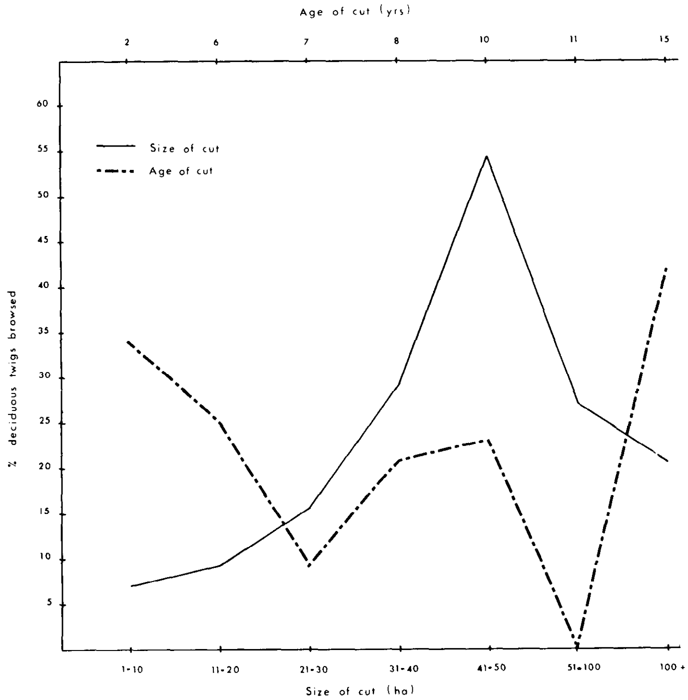

Fig. 6. *The relationship of use of browse by moose with the size and age of cut.*

Discussion

Balsam fir provides the greatest potential winter forage for moose in central Newfoundland. In the cuts sampled, balsam fir consistently accounted for 80 to 90% of the estimated forage. That species, however, was only lightly used in the cuts sampled, probably due to the abundance of the more preferred deciduous species. The most abundant deciduous species is white birch. Pin-cherry, willow, and trembling aspen are also common in recent cutovers. Although providing less in total available forage, pin-cherry was actively selected over the more abundant white birch in cuts of all ages. Willow had the highest percentage of use, but its lack of abundance reduced its importance in cutover sites.

The greatest amount of forage was found in cuts 7 to 10 years following forest disturbance. The greatest production was in the 8-year-old cut where available forage reached 2,000 kg/ha, of which 93% was balsam fir.

The highest percentage of twigs browsed was not in cuts where availability was the greatest. The greatest use of available forage was found in the oldest and most recent cuts, this probably being a function of decreased availability. When relating browsing intensity to total available forage, however, the greatest amount of browse was removed from the 8- to 15-year-old cuts, consistent with the fact those sites produced the greatest volume of forage.

Experimentation with plot size suggests that 6-m^2 (2 × 3 m) plot will provide the greatest precision of estimate with a minimum amount of sampling. Further increases in plot size do not measurably reduce the number of plots required to achieve a specific precision of estimate.

Our sampling suggests over 200 6-m^2 plots may be necessary to achieve an estimate with 80% precision 95% of the time. However, that estimate comes from combining the results (to increase sample size) of the 2 × 3-m plots (n × 140) in all cuts. Only ten plots were positioned in each individual cut. As sample size increases within a specific cut, it is to be expected the required sample will subsequently decrease, and probably approach 50 to 60 plots. The precision and confidence limits of the estimate may also be reduced to meet more realistically the available resources and time constraints.

The results of this study suggest that the most valuable cutover area to moose is one which is approximately 8 to 10 years old and 40 to 50 ha in size. Larger cuts probably become less available to moose in winter due to deep snows and increasing distances from cover. A forest management plan which encourages a heterogeneous pattern of 40 to 50 ha block cuts and mature forest cover is suggested to be most compatible with the management of moose in northcentral Newfoundland.

Literature Cited

Basile, J. V., and S. S. Hutchings. 1966. Twig diameter-length-weight relations of bitterbrush. J. Range Manage. 19:34-38.

Bergerud, A. T., and Frank Manuel. 1968. Moose damage to balsam fir-white birch forests in central Newfoundland. J. Wildl. Manage. 32:729-746.

Bergerud, A. T., and Frank Manuel, and Heman Whalen. 1968. The harvest reduction of a moose population in Newfoundland. J. Wildl. Manage. 32:722-728.

Dodds, D. G. 1960. Food competition and range relationships of moose and snowshoe hare in Newfoundland. J. Wildl. Manage. 24:52-60.

Ellis, R. C. 1960. An investigation of the length of the regeneration period and of the yield potential of pulpwood cutovers in Newfoundland. Rep. to Can. Dep. Northern Affairs and Natur. Resour., Forest Branch, St. John's, Nfld. 96 p.

Ohmann, L. F., D. F. Grigal, and R. B. Brander. 1976. Biomass estimation for five shrubs from northeastern Minnesota. U.S. Dep. Agr., Forest Serv. Res. Pap. NC-133. 11 p.

Pimlott, D. H. 1955. Moose and the Newfoundland Forest. Nfld. Dep. Mines and Res., St. John's. 26 p.

Rowe, J. S. 1972. Forest regions of Canada. Can. Forest. Serv., Pub. No. 1300, Ottawa. 172 p.

Ryan, A. G. 1974. Shrubs of Newfoundland. Dep. of Tourism, Prov. of Nfld. 79 p.

Shafer, E.L. 1963. The twig-count method for measuring hardwood deer browse. J. Wildl. Manage. 27:428-437.

Telfer, E. S. 1969. Weight-diamter relationship for 22 woody plant spcies. Can. J. Bot. 47:1851-1855.

Thomas, M. K. 1953. Climatological Atlas of Canada. Nat. Res. Council No. 3151. 253 p.