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A PHOTOGRAPHIC TECHNIQUE FOR ESTIMATING BROWSE GROWTH AND USE

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Techniques for studying dynamics of woody browse are largely based on destructive sampling (Telfer 1972, Pease et al. 1979, Keith et al. 1984). This is inefficient because of the high variance among samples, and thus large sample sizes are needed to produce narrow confidence intervals. This type of sampling cannot be used for a long-term study. We describe a nondestructive photographic technique that allows us to estimate growth and mortality of woody twigs browsed by snowshoe hares (*Lepus americanus*).

METHODS

We concentrated on the terminal branches of grayleaf willow (*Salix glauca*), bog birch (*Betula glandulosa*), and white spruce (*Picea glauca*) in the ≤5-mm-diam size range normally taken by hares (Sinclair and Smith 1984). These 3 species are the most important winter browse plants for hares around Kluane Lake in the southwestern Yukon. We have also studied the following plants, which are less common: russet buffaloberry (*Shepherdia canadensis*), quaking aspen (*Populus tremuloides*), balsam poplar (*P. balsamifera*), feltleaf willow (*Salix alaxensis*), and planeleaf willow (*S. planifolia*). We tagged terminal branches with soft wire and numbered aluminum tags at a branch point where the stem diameter was 2–5 mm. We wrapped the wire loosely to avoid girdling the twig.

Each tagged twig was photographed on a white acrylic board (61 × 30 cm) with a Konica Autoreflex 35-mm camera with a 28-mm wide-angle lens. The camera was mounted rigidly on an aluminum angular frame over the center of the board so that the focal plane was 30 cm vertical distance from the board. Ilford FP-4 black-and-white film and high contrast developing were used for all photographs. The top of the photo board had a rotating numbering device and space for the date to be written, so that each photograph included the date and the tag number of the twig.

We photographed 3,000–4,000 twigs twice a year in September (end of growing season) and in May (end of winter browse season, before start of summer growth). We used a systematic sampling scheme with 2 twigs tagged on the browse plant closest to 100

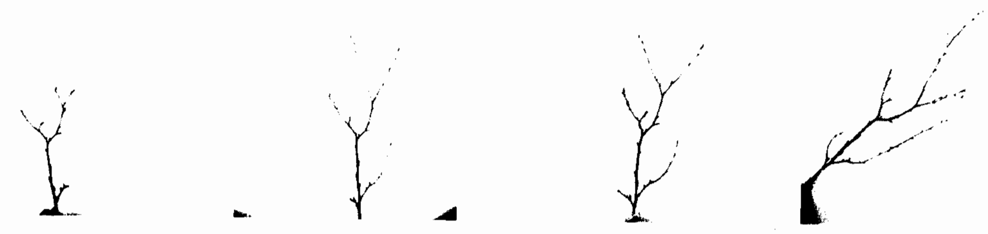

Fig. 1. Sample photographic record of 1 twig of bog birch. This twig was first tagged in the spring of 1980 (1.04 g). It grew to 1.82 g in the fall of 1980 (75% growth in biomass) and to 2.71 g in the fall of 1981 (46% growth in biomass).

checkerboard points on 10 × 10 grids with 30-m spacing. Most of the field sampling time was used in walking between sampling points. With a team of 2 people and 1 photo board, we could photograph about 100 twigs in 90 min.

During each photo session (spring, fall) we recorded the fate of each twig (unbrowsed, completely browsed, partly browsed, or nonbrowsing natural mortality) and we changed tags to new twigs when the previous twigs were dead or eaten. We recorded the height of each twig above ground to estimate exposure to hares. The wire tags did not deter browsing by snowshoe hares or by moose (*Alces alces*).

High contrast 35-mm negatives were scanned on a Bausch and Lomb Omnicon Alpha Image Analyzer. Each negative was placed on the Omnicon macro unit and viewed with transmitted light via a 50-mm Olympus television lens (Auto S, f1.8). The enlarged image was displayed on a monitor and the twig outline was positioned within a moveable and expandable frame on the image analyzer. The area of the twig image could then be read off the screen. Repeatability was within ±1% on consecutive measurements for photographs with excellent contrast and within ±5% for average photographs, and the area units were obtained by reading a standard reference area of 5 cm^2. Most of the error in the area measurements arose because of photographs with poor contrast and because of variable positioning of the lower node of the branch within the frame of measurement. One technician could process about 250 photographs on the image analyzer in 8 hours.

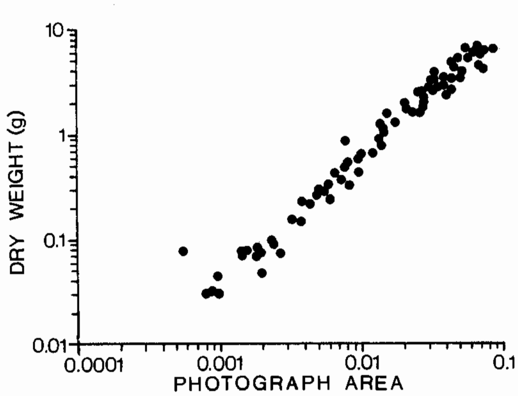

Fig. 2. Relationship between logarithm of photograph area of twig (arbitrary machine units) and logarithm of dry biomass of twig for bog birch ($r^2 = 0.97$, $n = 86$, $\log \hat{Y} = 2.1766 + 1.18966 (\log X)$.

RESULTS

We found it is best to analyze time series of individual twigs (Fig. 1) so that obvious measurement anomalies can be corrected. For all the browse species studied we have constructed area-biomass regressions (Fig. 2) from random samples of clipped twigs. The relationship between photographic area and biomass was linear over the range of twigs analyzed (0–7 mm diam) but the variance tended to increase with the mean so a log-log trans-

Table 1. Mean annual growth rate (%) and its coefficient of variation (CV) for the 3 dominant winter browse plants of snowshoe hares in the southern Yukon. Data are pooled from 3 locations for 1978–1982. Mean percent growth is defined for each twig as [(autumn biomass/spring biomass) − 1] × 100.

Species	$\bar{x}$	CV
Bog birch	38.6	134%
Grayleaf willow	18.7	103%
White spruce	24.4	111%

formation was required. These regressions fit well for all 9 species we have analyzed ($r^2 >$ 0.83, $n \geq 40$). We conclude that this technique provides a simple nondestructive way of monitoring growth and mortality in twigs of browse plants.

We have estimated growth rates of individual unbrowsed twigs over the growing season from the formula: growth rate (%) = [(autumn biomass/spring biomass) − 1] × 100. The utilization rate (or finite mortality rate) of twigs can also be estimated by enumeration of twigs that are browsed completely or otherwise die during a sampling interval.

Required sizes can be determined in standard statistical ways. For our 3 main browse species the mean growth rate (percent/year) was nearly equal to the standard deviation of the growth rates (Table 1). It may be necessary with animals like snowshoe hares to stratify the samples in height zones (Keith et al. 1984). If the coefficient of variation is 100%, we would require 100 samples of each species in each height zone to achieve a precision of ±20% confidence intervals for the mean, or 400 samples to achieve ±10% of the mean (Sokal and Rohlf 1981:262).

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