The relationship between weather and caribou productivity for the La-Poile Caribou Herd, Newfoundland.

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Abstract: To describe the relationship between weather and caribou *(Rangifer tarandus)* productivity, we compared weather variables (snow on ground, winter temperature and measures of growing season) with measures of productivity (calves seen by hunters, calves and yearlings in the harvest and percent calves and yearlings and pregnancy rate for caribou classified during fall and spring surveys) for the LaPoile Caribou Herd in southwestern Newfoundland. Hunter statistics reliably estimated changes in population demography. Percent calves seen by hunters was correlated with calves/100 females classified in fall. Weather may have influenced productivity for the LaPoile Caribou Herd in Newfoundland. Colder winter temperatures were associated with fewer calves the next fall and pregnancy rates and yearlings/100 females in the spring were negatively correlated with snow on ground the previous winter. These relationships appear to be density related.

Keywords: caribou, *Rangifer*, weather, productivity, LaPoile Caribou Herd, Newfoundland, density dependence.

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Introduction

Studies indicate that forage limitations during late gestation may reduce birth weights, delay birthing schedules and reduce maternal milk production in a variety of ungulates, including *Rangifer* (Verme 1969; Blaxter and Hamilton 1979; White 1983). These variables have in turn been correlated with calf survival, and where present, may retard future somatic development and impair life time reproductive success (Haukioja and Salovaara 1978; Skogland 1983; Eloranta and Nieminen 1986). Extreme winter conditions have, in addition to their less immediate effects on forage availability, been associated with direct mortality of both juvenile and adult caribou and reindeer (Klein 1968; Bergerud 1971; Skogland 1984).

This study examines the relationship between weather and caribou *(Rangifer tarandus)* productivity in insular Newfoundland. We compare productivity and weather measures for the La-Poile Caribou Herd which occupies the coastal barrens of southwestern Newfoundland, a region with extreme winter conditions (Mahoney *et al.* 1989).

Methods

Weather data

We obtained daily weather data for the Burgeo meteorological station (Fig. 1) from 1960-1989 from the Scientific Services Branch of the Federal Department of Environment.

The following parameters were used to measure annual variation in weather: (1) length of the growing seasons in days; (2) mean daily snow on ground for days with snow; (3) number of days with snow on ground; (4) cumulative snow on ground during the winter; and (5) mean winter temperature.

Stewart *et al.* (1976) calculated growing season as the length (days) of the period between leaf flush and leaf abscission each year. We used maximum daily temperature (h) greater than 54°F (12.2°C) to calculate a mean level of 75 degree days ($\sum(h-54)/2=75$) which Stewart *et al.* (1976) considered the level of heat units necessary to initiate leaf flush. We considered the termination of positive energy balance to occur when the ambient temperature reached -5°C. Larcher (1973) considered -5°C the temperature required to cause cellular destruction or lysis in leaves of woody plants. The number of days from the initial spring accumulation of 75 heat units to the first fall minimum temperature of -5°C was thus accepted as the period of positive energy balance or growing season.

Three measures of growing season were calculated: (1) growing season length; (2) deviation from mean date of spring leaf flush (e.g. a positive number indicates the number of days *beyond* the mean spring leaf flush date before accumulation of 75 heat units); and (3) deviation from mean date of autumn leaf (e.g. a positive number indicates the number of days *beyond* the mean autumn leaf fall date before a minimum -5°C war recorded).

Three measures of snow accumulation on the ground were calculated: (1) total number of days snow was recorded on ground; (2) total cumulative snow on ground for all days over winter; and (3) mean daily snow on ground for days of the year with snow.

Mean minimum winter temperature was calculated using daily minimum temperatures for 1 November of the preceding year to 31 March of the year in question.

Productivity data

Three types of information were used to measure caribou productivity: (1) calves and yearlings per 100 females in the harvest (sample of mandibles sent in by hunters); (2) percent calves seen by hunters as reported on license questionnaires; and (3) calves and yearlings per 100 females and pregnancy rate derived from spring and fall classification surveys.

Lower mandibles were collected from hunters at check stations, via the mail, or from hand deliveries. Age was determined from tooth eruption pattern for calves and yearlings and by counting cementum annuli of the first incisor from older animals (Miller 1974).

Hunters were obligated to complete questionnaires attached to their licenses which provided the following information: hunter name, address, area hunted, length of time hunted, number and types of caribou and other wildlife observed, and for successful hunters, the date of kill, location of kill, age (adult or calf), sex and number of antler points for males. From this information we calculated the weighted mean percent calves seen by either sex and male only license holding hunters that voluntarily returned their questionnaire.

Caribou were classified as to age (calf, yearling, adult) and sex either from the ground using 15X-60X spotting scopes or from helicopter (Bell 206b or 206l). Classifications were conducted in fall, spring and at calving. Females were classified as pregnant based on the presence or absence of an udder.

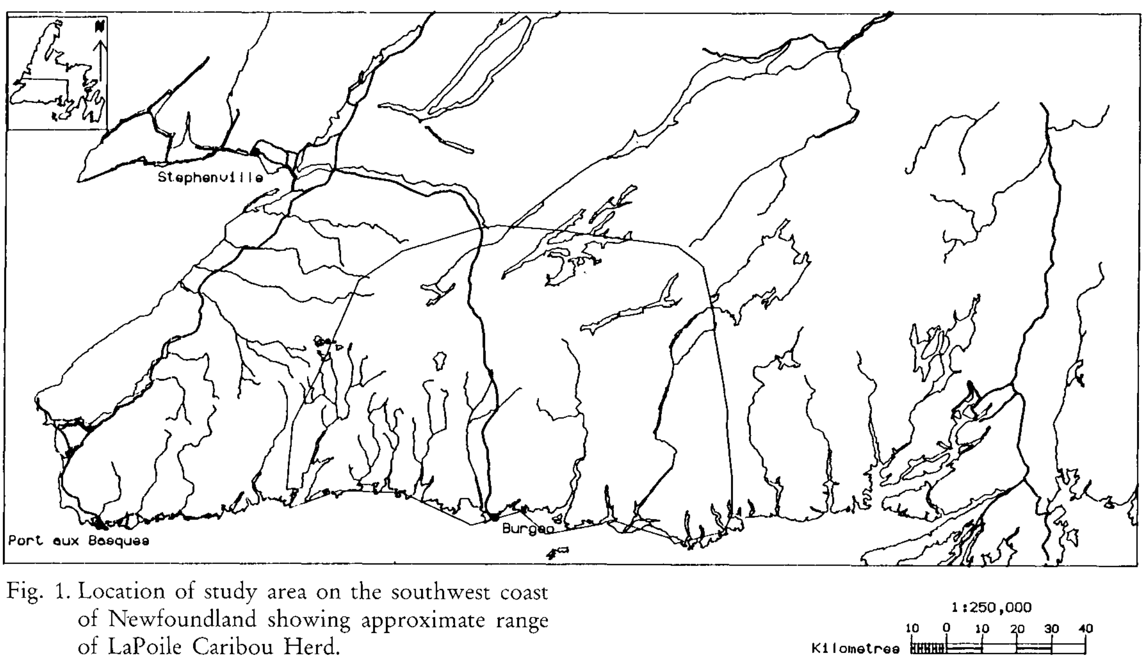

Fig. 1. Location of study area on the southwest coast of Newfoundland showing approximate range of LaPoile Caribou Herd.

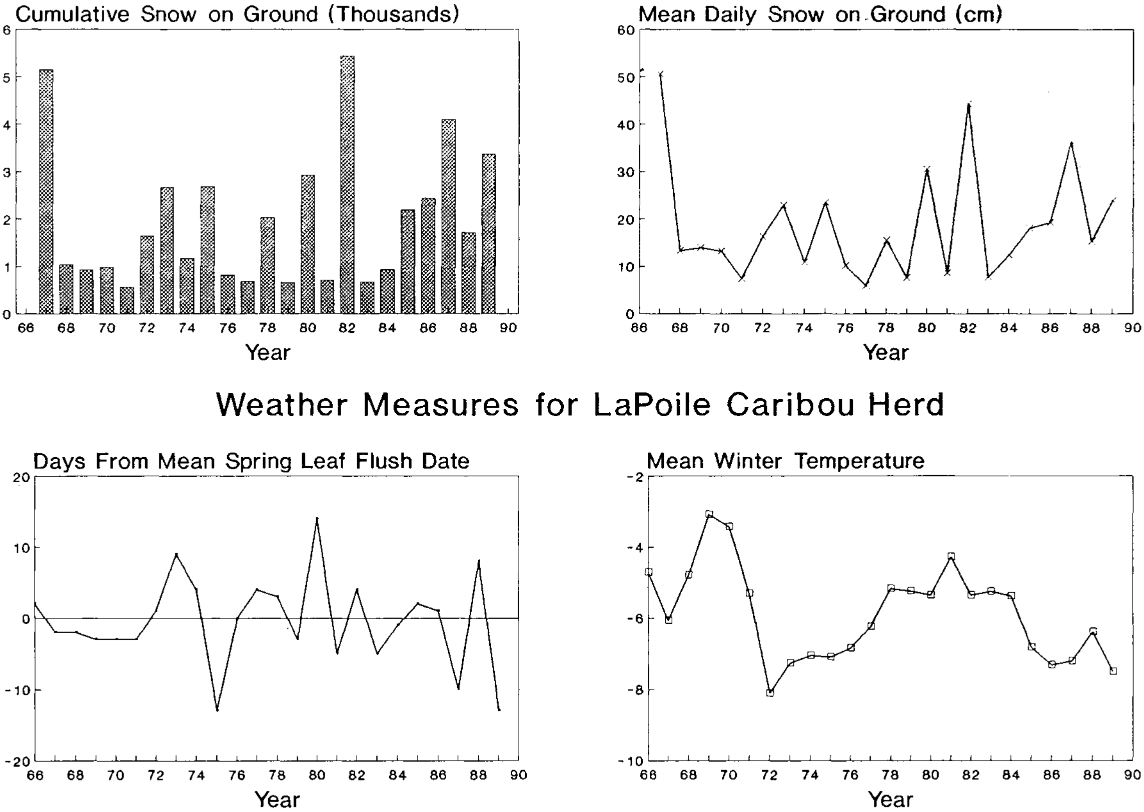

Fig. 2. Weather measures for LaPoile Caribou Herd range, 1966-1989. Includes (1) cumulative snow on ground (1000 cm); (2) mean daily snow on ground (cm); (3) difference from mean date of spring leaf flush; and (4) mean daily minimum winter temperature.

Statistical analysis

Data were organized and statistical analyses performed using micro SAS statistical packages (SAS Institute 1987). Standard parametric analysis of variance and regression analysis tests was used (Sokal and Rohlf 1969). Correlations were tested using the Pearson product-moment correlation coefficient. The least square technique was used to fit the variables to regression models.

The number of independent variables entered into the multiple regression functions were determined according to three criteria: (1) the absolute critical values for each independent variable entered stepwise (t test for significance of partial regression coefficient at $p < .10$); (2) comparison of value of residual mean squares and adjusted R^2 for different models; and (3) by plotting Mallows' (1973) C_p statistic against p (number of parameters including the intercept) and choosing the model were C_p first approaches p.

Weather/productivity schedule

Weather could conceivably affect caribou productivity in a number of ways. Parameters such as growing season length, could, for example, affect the ability of a female to conceive, or to carry a pregnancy to term, or to give birth to a viable calf. We therefore decided to compare all productivity measures directly with that year's timing of spring, snow on ground and winter temperature and with the previous year's timing of spring, snow on ground and winter temperature and with the previous year's timing of fall and growing season length. In addition, we also tested for a relationship between yearlings classified in spring and yearlings in the fall hunter harvest with weather variables from the previous year.

Results

No trend in the timing of leaf flush was documented for the LaPoile area although substanti-

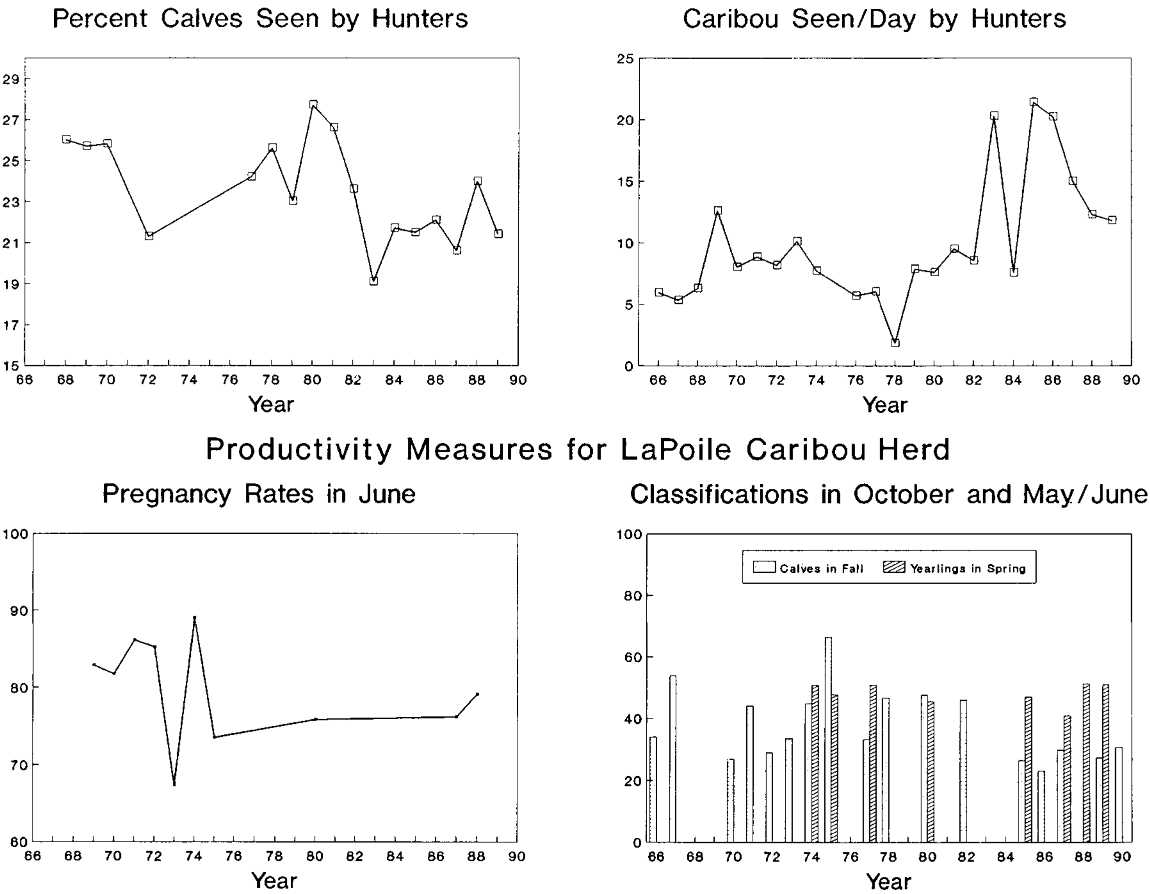

Fig. 3. Productivity measures for LaPoile Caribou Herd, 1966-1990. Includes (1) percent calves seen and (2) total caribou seen/day by resident hunters in the fall; (3) percent females that were observed to have calved in June classification survey; and (4) calves and yearlings/100 females observed on fall and spring classification surveys respectively.

al annual variation occured (mean date 11 July; range, 30 June to 26 July; Fig. 2). Cumulative (mean = 1980 cm) and daily snow (mean = 18.6 cm) on the ground also varied annually but 1967 (50.6 cm), 1982 (44.3) and 1987 (36.3) were years of appreciably deeper snow (Fig. 2).

Table 1. Multiple regression models predicting Y (caribou productivity) with X-variables (density and weather measures)[a]. (Dependent variable: Percent calves seen by hunters in fall).

Parameter	Coefficient value	S.E.	Beta values	Partials	R^2	R_a^2	VIF
Intercept (b_0)	30.6	1.93	–	–	–	–	–
Caribou seen/ Day (b_1)	-0.19	0.09	-0.430	0.446	–	–	–
Mean daily winter temperature (b_2)	0.86	0.35	0.468	0.297	0.391	0.487	1.15

[a] Basic model, adjusted (R_a^2) and unadjusted (R^2) coefficients of multiple determination, standardized regression coefficients (beta values), coefficients of partial determination (partials), variance inflation factors (VIF), and standard error of the regression coefficients.

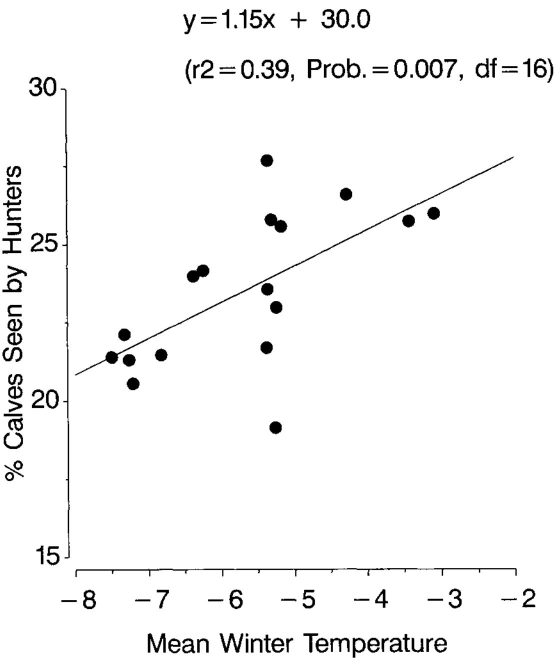

Fig. 4. The relationship between calves seen by hunters and mean winter temperature.

Winter temperatures (mean=5.7) were colder during the mid 1970's (1972-1976); mean=-7.3) and the late 1980's 1985-1989 (mean=-7.0; Fig. 2).

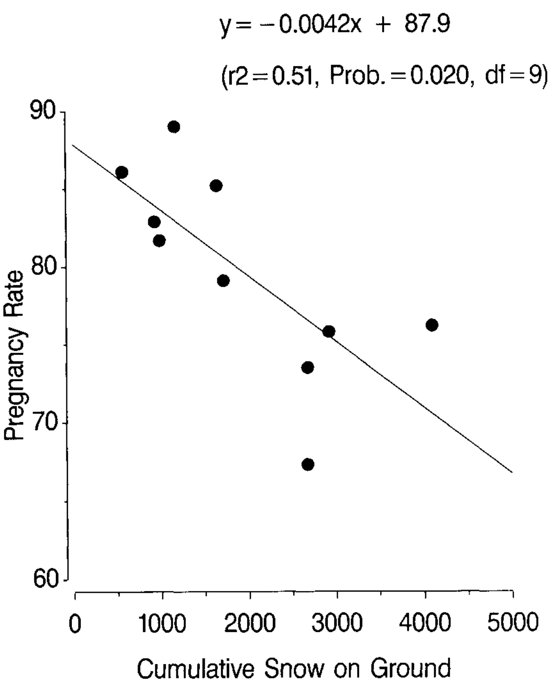

Fig. 5. The relationship between female pregnancy rate and cumulative snow on the ground (1000 cm) that winter.

For the LaPoile Caribou Herd, hunters reported seeing more caribou and fewer calves during the past decade (Fig. 3). Pregnancy rate in May-June surveys indicate fewer pregnant females since 1974 (Fig. 3).

Among weather variables, mean daily snow on the ground and cumulative snow on ground were highly correlated ($r^2=0.94$, $p=0.001$, $df=22$). Among caribou productivity variables, calves seen by hunters was correlated with calves/100 females classified in fall ($r^2=0.45$, $p=0.025$, $df=10$).

Productivity measures derived from hunter statistics were significantly correlated with weather variables provided that caribou density (caribou seen/day hunted) was included as an independent variable (Table 1). The dependent variable, percent calves seen by hunters in the fall was (1) negatively correlated with caribou density (model $p=0.04$ and (2) positively correlated with winter temperature (model $p=0.03$; Fig. 4; Table 1).

The productivity measures, derived from spring classifications, were also correlated with weather variables. Pregnancy rate of females in May-June was negatively correlated with cumulative snow on ground ($r^2=0.51$, $p=0.02$, $df=9$; Fig. 5). Yearlings/100 females in May- June was negatively correlated with mean daily snow on ground the previous year ($r^2=0.67$, $p=0.02$, $df=7$; Fig. 6).

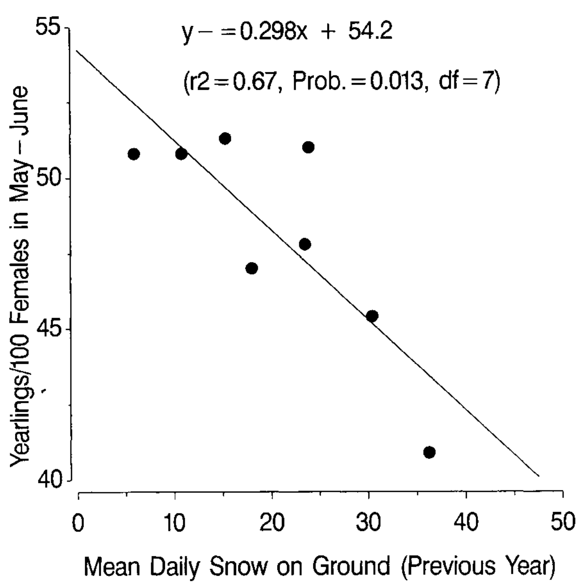

Fig. 6. The relationship between yearlings/100 females in spring and mean daily snow on the ground (cm) the previous year.

Discussion

Bergerud (1983) in a review of caribou population control suggested that caribou populations are limited by weather (1) on the northern edge of the species range in the tundra biome where severe weather (ice, snow and wind) resulted in mortality and decreased reproduction regardless of density (Vibe 1967; Miller *et al.* 1977; Thomas and Broughton 1978); (2) on islands (Scheffer 1951; Klein 1968; Bergerud 1971; Burris and McKnight 1973; Ferguson *et al.* 1988); and (3) in maritime conditions where icing can substantially reduce available food. This study documents the possible influence of weather on caribou demography for a maritime population in southwestern Newfoundland, although such influences appear to be density dependent.

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