Wildfires in Relation to the Habitat of Barren-Ground Caribou in the Taiga of Northern Canada

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Of various factors which might limit barren-ground caribou (*Rangifer tarandus groenlandicus*) populations, destruction of range by fire is one. Fire, caused by lightning or man, generally affects only the caribou's winter range in the taiga or northern region of the boreal forest. On the summer range in northern Canada, fires are rare and usually limited in extent because of the heterogenous mixture of wet and dry tundra and barren areas of rock or sand.

The Canadian Wildlife Service's intensive caribou research program included an evaluation of the effects of fire on four key upland wintering areas within the taiga. Some primary objectives were (1) to determine the portion of burned winter range and whether it has increased in recent years; (2) to determine the effects of fire on the usable standing crops of terrestrial forage and arboreal lichens; and (3) to determine the effects of fire on range use by barren-ground caribou and moose (*Alces alces*).

THE STUDY AREAS

The winter range of barren-ground caribou is restricted largely to the taiga of northern Canada. It covers approximately 295,000

square miles in northern Manitoba, northern Saskatchewan, northeastern Alberta, and the District of Mackenzie (Fig. 1). Intensive study was made of key wintering areas rather than an extensive study over such a large expanse, for data collected on these study areas would presumably be applicable to the entire winter range. It was desirable that study areas be important on key winter ranges and contain burns of various ages. In addition, they had to be as accessible as possible, since travel was limited to airplanes and boats. Federal and provincial biologists with previous experience in caribou research helped select four areas of 5,000 to 8,000 square miles (Fig. 1).

The forest on the winter range is largely coniferous, with deciduous trees occurring in disturbed regions. The major tree species are black spruce (*Picea mariana*), white sprue (*Picea glauca*), jack pine (*Pinus banksiana*), white birch (*Betula papyrifera*), tamarack (*Larix laricina*), and quaking aspen (*Populus tremuloides*).

METHODS

Survey of History and Extent of Forest Fires

Information on the history and extent of forest fire on the winter range of barren-ground caribou came from three sources. First, literature pertinent to caribou and caribou ranges was reviewed. Second, fire control reports on forests within the winter range were obtained from various government agencies in Alberta, Saskatchewan, Manitoba, and the District of Mackenzie for the period 1961 through 1964. The reports provided data on numbers, sizes, and causes of fires. Third, vegetation cover maps of the northern Saskatchewan study area were prepared by interpreting recent aerial photographs. Forests and burned areas were classified as 1-15, 16-30, 31-50, 51-75, 76-120, or over 120 years of age. The area of each class was determined from the cover maps by using a dot-grid overlay. The average annual destruction by fire was determined by dividing the acres in an age class by the number of years in that class.

Determining Effects of Fire on the Standing Crop of Forage

Effect of fire on the standing crop of usable forage was determined in forest stands from each of the four study areas. A stand

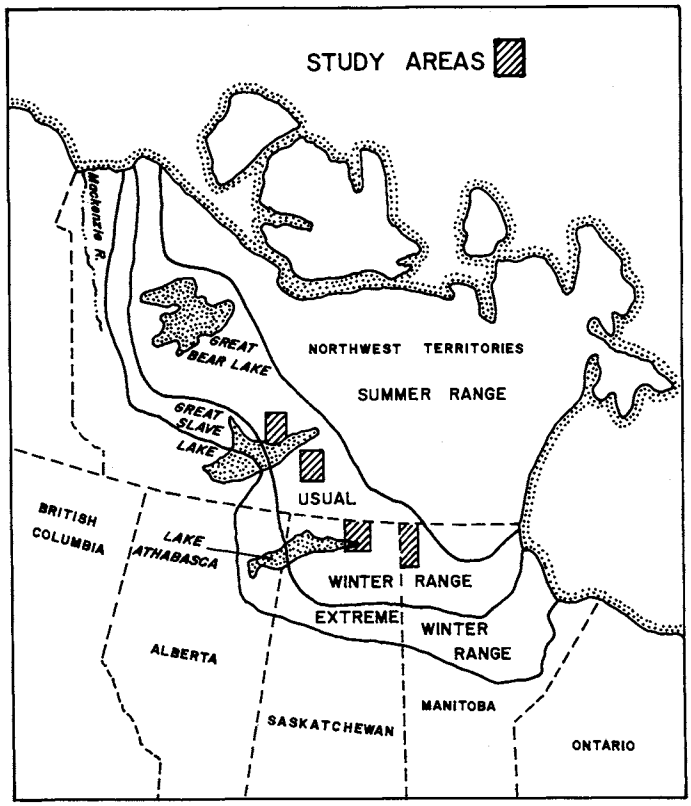

FIG. 1. Map of northern Canada showing the distribution of summer and winter ranges of barren-ground caribou and the locations of major study areas.

consisted of a spruce forest, or a seral stage of white birch or jack pine which precede the spruce, on an upland site within one of six age classes and with similar floristic composition and cover throughout. Forest stands were divided into six age classes extending from 1-10, 11-30, 31-50, 51-75, 76-120, and over 120 years. Each stand was sampled using the weight-estimate method of forage inventory (Pechanec and Pickford, 1937; and Campbell and Cassady, 1955).

The usable standing crop was measured for 126 forest stands distributed among 38 locations on the four study areas. Five sites, each 100 feet square in area, were chosen for sampling in each stand and, were selected, if possible, on the north, south, east, and west slopes, and on a level area. The positions represented, as nearly as possible, the slope or level area under consideration. Sites were 0.1 to 2 miles apart, depending on topography and size of the forest stand.

Sixteen randomly selected sample plots were located within each of the five sites and stratified so that four fell into each quarter of the square. The sample plots were circular and covered 9.6 square feet each.

Usable standing crop was determined by clipping and weighing, or by estimating the grams of forage in the circular plots. Forage was removed from the plots and separated into species or groups before being weighed on a spring scale. Actual and estimated weights were recorded to the nearest 5 grams of green weight.

Weight of the current growth was recorded for forbs, grasses, grass-like plants and deciduous shrubs. Leaf growth was removed from evergreen shrubs, such as mountain cranberry (*Vaccinium vitis-idaea* var. *minus*) and common Labrador tea (*Ledum groenlandicum*). Lichen growth was removed to the level where decomposition of the podetia was first observed. Caribou probably do not like the pungent odour of decaying portions of podetia. Bryophytes were not included since caribou probably eat them only incidentally with other forage.

Green weights obtained in the field were converted to air-dried weights. Samples collected daily from each major forage species were stored at room temperature in 100-gram amounts until no fluctuation in weight could be detected. Lichens, in particular, could be compared only on an air-dried basis, since moisture content varied from 20 to 85 percent depending on weather conditions. Before field work began training was given in checking estimates against actual weights. Also, field estimates were checked daily throughout the season.

Usable standing-crop data were considered with respect to the barren-ground caribou's winter food habits. Shrubs and lichens were assigned high, moderate or low values as caribou winter food, pri-

marily on the basis of information gathered from Loughrey (1952), Banfield (1954), Kelsall (1957, 1960) and Scotter (1967). This information was supplemented by summer observations of plants grazed during the previous winters, and by winter observations. Assigned values were not based on nutritive content. The high, moderate, and low values compare only the forage within a group.

The standing crop of arboreal lichens was determined in the northern Saskatchewan study area by the following method: four black spruce and four jack pine trees, each one representative of its forest stand, were selected as sample trees. After felling and measuring, the trunks were divided into 10-foot sections. Lichens were removed by hand from the trunk and branches of each section, and the relative abundance of different species noted. The masses of lichens were placed in cotton bags, air-dried at approximately 72°F., and weighed. The number of trees per acre was estimated at each site by taking five wedge prism readings and measuring the diameter of all trees viewed in each 360° horizontal sweep. Standing crops of arboreal lichens above and below the 10-foot level were calculated in pounds per acre.

Determination of Range Use by Caribou and Moose

Within each 9.6-square-foot circular plot used for calculating the standing crop of usable forage, pellet groups were counted to compare the use by barren-ground caribou and moose in each forest age class. Six or more winter pellets of one type found in a plot were recorded as a pellet group. Kelsall (1957) regarded six or more pellets as a group because barren-ground caribou generally drop their pellets while moving, leaving a point of concentration and several widely scattered pellets. Each pile of summer moose droppings was considered a group. Pellet groups per stand were converted to pellet groups per acre.

RESULTS

History and Extent of Fires on Caribou Ranges

Historical Review:—Journals of early explorers and their modern day counterparts confirm that forest fires were prevalent in earlier

times throughout the winter range of barren-ground caribou in northern Canada. A review of references concerning fires on the winter range of barren-ground caribou can be found in other publications (Scotter, 1964; 1968).

Fire Control Reports:—Government agencies in the District of Mackenzie and the provinces of Alberta, Saskatchewan and Manitoba provided fire control reports from 1961 through 1964 for the portion of winter range within their region. Total known destruction during that period was 5,005,872 acres (Table 1), or approximately 2.7 percent of the winter range, a rather alarming total when no records are available from vast portions of the winter range.

Seventy-two percent of the fires were apparently caused by lightning (Table 2). Changes in the summer weather pattern in recent decades may have resulted in more lightning strikes or in conditions more suitable to the spread of fire. As would be expected, most fires caused by man occurred near the centers of population.

Cover Maps:—Forest cover maps, prepared from interpretation of recent aerial photographs, show that average fire destruction in the 1-15, 16-30, 31-50, 51-75, 76-120 year age classes was 20,779, 14,080, 15,040, 14,310, and 6,599 acres per year, respectively. Fire destruction in the 1 to 15 year age class was 1.4 times higher than in the 16-30, 31-50, 51-75 year age classes, where the annual rate was almost constant; and 3.1 times higher than in the 76-120 year age class. Destruction rate in the 16-30, 31-50, and 51-75 year age classes was 2.2 times greater than in the 76-120 year age class. These increases coincide with mining activity and white settlement. That some forests may have been burned more than once during the interval was not considered. Multiple burning would increase the area of young forests and reduce the area of more mature forests.

The historical review and fire control reports reveal that ecological relationships have existed for a long time between forest fires and barren-ground caribou. However, the cover-map data on forest age classes suggest that the amount of destruction in recent years has increased.

Effects of Fire on the Forage Supply

The relationship of forest fires to barren-ground caribou is com-

TABLE 1. NUMBER OF FOREST FIRES AND KNOWN ACREAGE BURNED-OVER ON THE WINTER RANGE OF BARREN-GROUND CARIBOU FROM 1961 THROUGH 1964

Location	Number and size of forest fires										Total number of fires	Total acreage destroyed
	0.1–10 acres		11–100 acres		101–1,000 acres		1,001–10,000 acres		10,001 acres or more			
	No.	Acres	No.	Acres	No.	Acres	No.	Acres	No.	Acres		
1961												
Alberta	17	34	1	75	2	1,492	3	8,341			23	9,942
Saskatchewan	144	266	39	1,318	20	7,730	15	72,108	12	1,177,760	230	1,259,182
Manitoba[a]	26	88	11	367	20	10,465	19	73,540	17	582,530	93	666,990
District of Mackenzie and Wood Buffalo National Park	55	165	11	429	11	4,547	21	78,160	17	684,530	115	767,831
Subtotal	242	553	62	2,189	53	24,234	58	232,149	46	2,444,820	461	2,703,945
1962												
Alberta	3	7									3	7
Saskatchewan	103	225	12	424	9	5,150					124	5,799
Manitoba[a]	11	42	10	331	9	3,480	4	11,020			34	14,873
District of Mackenzie and Wood Buffalo National Park	3	28	2	62			2	3,153			7	3,243
Subtotal	120	302	24	817	18	8,630	6	14,173			168	23,922
1963												
Alberta	20	48	2	72			2	5,870			24	5,990
Saskatchewan	109	172	18	603	11	5,160	6	29,330	1	75,000	145	110,265
Manitoba[a]	14	37	4	170	10	4,600	3	6,140			31	10,947
District of Mackenzie and Wood Buffalo National Park	19	55	3	149	5	1,803	1	1,040			28	3,047
Subtotal	162	312	27	994	26	11,563	12	42,380	1	75,000	228	130,249
1964												
Alberta	25	54	3	52	4	4,302					32	4,408
Saskatchewan	147	279	21	808	23	8,658	11	33,444	12	861,044	214	904,233
Manitoba[a]	14	52	20	711	8	2,510	12	54,980	18	751,060	72	809,313
District of Mackenzie and Wood Buffalo National Park	28	126	10	384	14	4,731	11	71,074	12	353,487	75	429,802
Subtotal	214	511	54	1,955	49	20,201	34	159,498	42	1,965,591	393	2,147,756
Totals	738	1,678	167	5,955	146	64,628	110	448,200	89	4,485,411	1,250	5,005,872

[a] Few records from the 57th to 60th parallel.

TABLE 2. CAUSES OF FOREST FIRES ON THE WINTER RANGE OF BARREN-GROUND CARIBOU FROM 1961 THROUGH 1964

Location	Causes of forest fires						
	Lightning	Campers or campfires	Smokers	Settlers	Incendiary	Industrial operations	Unknown or miscellaneous
1961							
Alberta	16	3	1	1	—	—	2
Saskatchewan	148	57	12	—	8	—	5
Manitoba	65	20	5	—	—	1	2
District of Mackenzie and Wood Buffalo National Park	112	1	—	—	—	—	2
Subtotal	341	81	18	1	8	1	11
1962							
Alberta	—	2	—	—	—	—	1
Saskatchewan	80	27	6	3	1	3	4
Manitoba	22	6	3	—	—	3	—
District of Mackenzie and Wood Buffalo National Park	7	—	—	—	—	—	—
Subtotal	109	35	9	3	1	6	5
1963							
Alberta	17	1	—	—	3	1	2
Saskatchewan	94	26	5	3	8	1	8
Manitoba	19	3	2	—	—	—	7
District of Mackenzie and Wood Buffalo National Park	10	18	—	—	—	—	—
Subtotal	140	48	7	3	11	2	17
1964							
Alberta	22	4	2	1	2	—	1
Saskatchewan	158	29	7	1	12	—	7
Manitoba	62	6	4	—	—	—	—
District of Mackenzie and Wood Buffalo National Park	63	7	—	—	—	—	5
Subtotal	305	46	13	2	14	—	13
Totals	895	210	47	9	34	9	46

plex, but one of the most obvious effects on the winter range is the reduction in the amount of forage available. Both terrestrial and arboreal forage plants are affected. Of the forage plants, lichens are regarded as the principal winter food of caribou (Banfield, 1954; Kelsall, 1960, 1968) comprising nearly 60 percent of the winter forage, according to data obtained from rumen samples collected in northern Canada (Scotter, 1967).

Terrestrial Forage:—Average air-dried weight of the usable standing crop ranged from 177 pounds per acre in the 1-10 year class to 1,085 pounds per acre in the oldest age class (Fig. 2). Yields of grass, grass-like plants and forbs were highest in the 1-10 year age class, but never exceeded a few pounds per acre in subsequent age classes. Shrub production was low in the first age class, but was reasonably consistent throughout the remaining age classes. The standing crop of lichens increased consistently from 3 pounds per acre in the youngest age class to 469 pounds per acre in the 51-75 year age class. The amount of lichens was slightly less in the next age class because caribou made moderate to heavy use of many forest stands. Despite similar use in the oldest age class, the standing crop of usable lichens increased to 725 pounds per acre. The increase in high-value lichens was more important than the increase in the standing crop of lichens. The high-value group included the so-called "reindeer" lichens, such as *Cladonia alpestris*, *C. mitis* and *C. rangiferina*. Average standing crop of high-value lichens varied from 1 pound per acre in the 1-10 year old class to an average of 560 pounds per acre in the class exceeding 120 years of age. Moderate-value lichens reached their peak abundance in the oldest age class, and low-value lichens in the 31-50 year age class. Although it varied within each age class, lichen abundance was related to maturity of the forest. Older forests occasionally produced less forage than younger forests in the same age class because of variations in tree density, soil type, caribou utilization, and other factors.

The destruction of lichens is critical because of their slow succession, slow growth rates and importance as winter forage for barren-ground caribou. Fire appears to be as destructive to the major forage lichens as to the mature conifers, when the rate of recovery is considered. Major forage lichens usually take from

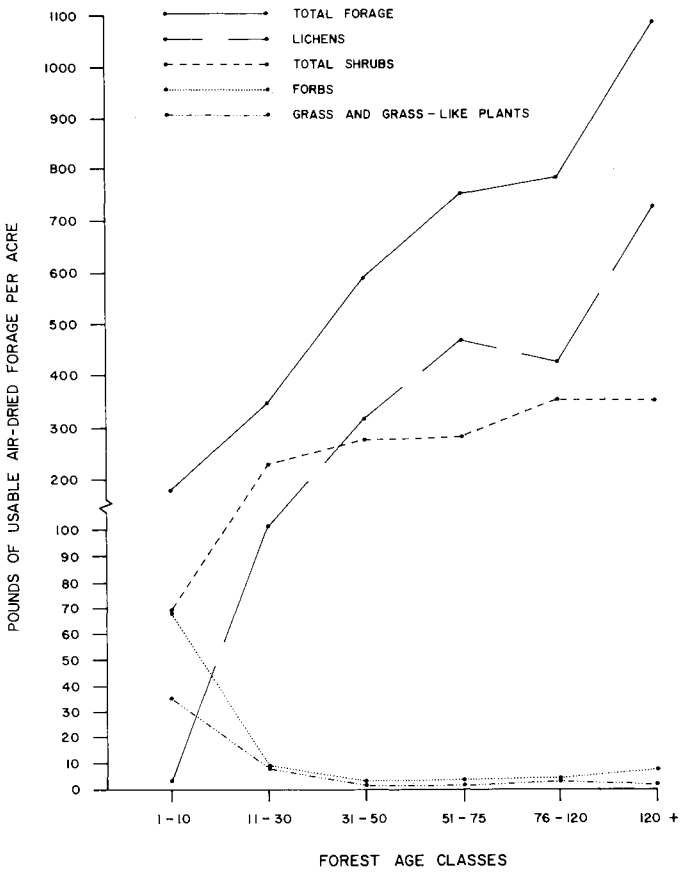

FIG. 2. Average standing crop of usable air-dried forage, in pounds per acre, in upland forests by age classes.

70 to more than a 100 years to recover their former abundance and composition, according to observations made during this study. Part of that time is required for the return of suitable biological conditions for lichen growth, part for the succession of lichens through a number of seral stages and part because of the slow rate of growth of the major forage species. As determined from a number of sample sites in three of the study areas, the major for-

age lichens attained an average growth rate ranging from about 3-5 millimeters per year depending on the species (Scotter, 1963).

Arboreal Forage:—Forest fires on the winter rangelands of barren-ground caribou destroy terrestrial vegetation, as well as arboreal lichens. In northern Saskatchewan, the standing crop of arboreal lichens within 10 feet of the ground was estimated at 605 pounds per acre in mature black spruce and 339 pounds per acre in mature jack pine (Table 3). Standing crop on many other segments of the winter range of barren-ground caribou appeared to be lower. Lichens on fallen trees and lichens dislodged by wind or snow from above the 10-foot level increased the available amount to some extent.

TABLE 3. STANDING CROP OF ARBOREAL LICHENS IN BLACK SPRUCE AND JACK PINE FORESTS IN NORTHERN SASKATCHEWAN EXPRESSED IN POUNDS PER ACRE (AIR-DRIED WEIGHT)

Forest type	Pounds of arboreal lichen per acre (air-dried weight)		
	Below 10 foot level	Above 10 foot level	Total
Black Spruce	605	464	1,069
Jack Pine	339	1,490	1,829

Arboreal lichens may be an important food source, particularly as emergency food during periods of deep or ice-crusted snow (Scotter, 1964). Destruction by fire of these extremely slow-growing plants must be considered a serious loss of winter caribou forage. As a forage source, *Alectoria*, *Evernia* and *Usnea* are thought to be the most important of the arboreal lichens.

EFFECTS OF FIRE ON RANGE USE BY CARIBOU AND MOOSE

An important indirect effect of fire in the boreal forest is the change of a climax community—with its cover of trees, shrubs, bryophytes, and lichens—into a tangle of fallen snags and exposed soil, and later, a fireweed-grass-shrub community. Fire alters plant cover in kind and quantity. These changes subsequently modify wildlife populations.

The densities per acre of barren-ground caribou and moose pellet groups for the various forest age classes are shown in Fig. 3.

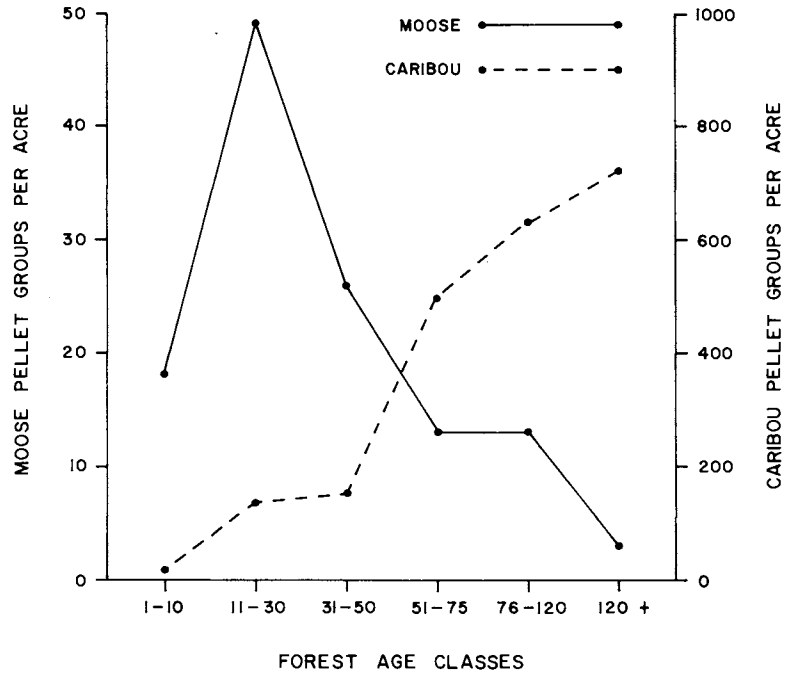

FIG. 3. Average number of caribou and moose pellet groups per acre in upland forests by age classes.

Forests over 120 years old yielded 722 caribou pellet groups per acre compared with only 18 per acre in the 1-10 year age class. There were 47 moose pellet groups per acre in the 11-30 year age class and only 3 per acre in forests over 120 years old. Moose apparently prefer habitats under 50 years old, and barren-ground caribou those over 50 years old.

Barren-ground caribou feeding patterns were noted in northern Saskatchewan and the southern Mackenzie District during the winter by aerial observations. Feeding craters dug in the snow by barren-ground caribou were easily observed from the air. Visual impressions of the frequency and distribution of those feeding craters in the forest age classes agreed with the pellet-group counts. Such craters were confined largely to mature forests. Occasional

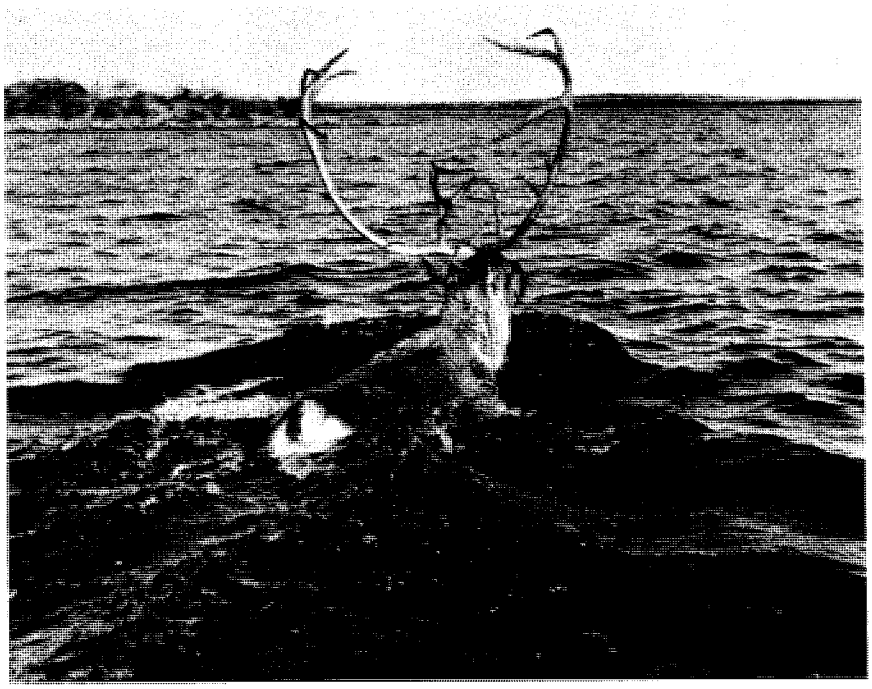

FIG. 4. The barren-ground caribou (*Rangifer tarandus groenlandicus*) roams the tundra and taiga, spending the summer months on the open tundra north of tree-line and the winter within the forest. Photo by Manitoba Game Branch.

trails and feeding craters in recent burns were caused by animals crossing from one mature forest to another.

In some areas of North America, such as the Kenai Peninsula of Alaska, forest fires have resulted in improved moose ranges and subsequent higher moose populations (Leopold and Darling, 1953a, 1953b; Spencer and Hakala, 1964). A large moose population, however, was not evident in the four study areas. Some preferred moose browse plants, such as willows (*Salix*, spp.), were present in only small amounts in the post-fire vegetation. White birch, a good moose food, was abundant in many of the younger forest stands which had been disturbed by fire.

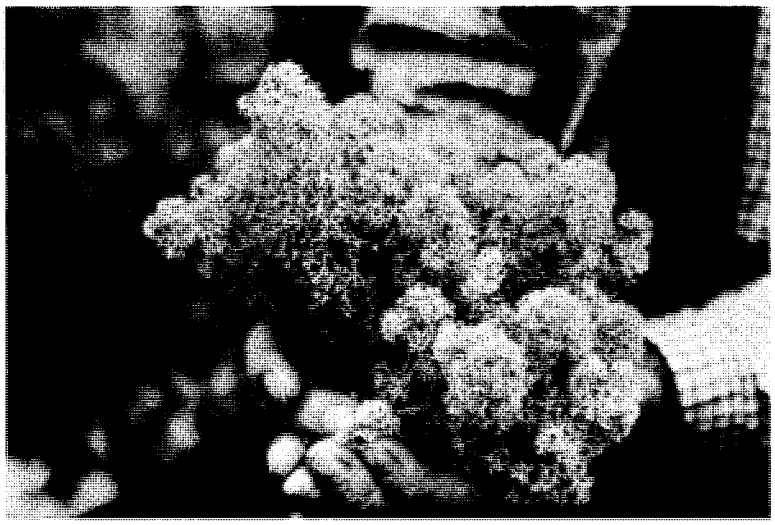

FIG. 5. Lichens, such as *Cladonia* spp., are the principal winter forage of barren-ground caribou.

DISCUSSION

The results discussed earlier apply only to upland lichen forests which are considered the most susceptible to long-term destruction by fire and the most important single source of forage for barren-ground caribou. It should also be remembered that the research was oriented to a single species and advantages or disadvantages to other animals inhabiting the region, except for moose, were not considered. Nor is it implied that fires are always deleterious to caribou habitat.

Fires in the southern limits of the winter range of barren-ground caribou are sometimes beneficial in destroying thick carpets of bryophytes in certain upland forests thereby making them more productive for lichens and other forage plants. This, however, is important only in the more closed forest stands. Fires also improve certain muskeg areas for caribou by destroying *Sphagnum* spp. and other bryophytes which are replaced with more preferred forage.

Ahti and Hepburn (1967) suggested that the lichen supply could

FIG. 6. Arboreal lichens may be important winter forage for barren-ground caribou, particularly during deep or crusted snow conditions.

be increased in the northern boreal lichen belt of Ontario by burning the *Sphagnum fuscum* peatlands, treeless bogs, or wooded muskegs. They also suggested that black spruce-feather moss forests and black spruce muskegs could be burned in more southerly latitudes to increase the amount of lichen available for woodland caribou. In addition, they recommended removing black spruce seedlings and thinning jack pine stands to keep the woodlands from reverting to a black spruce-feather moss community. In contrast to Ontario, much of the upland lichen woodlands within the winter range of barren-ground caribou are sparsely treed and no thinning is necessary to maintain lichen stands in a favorable condition.

Some of my research has suggested that fires may beneficially affect nutrient cycling, increase summer soil temperatures, remove excessive humus layers, and promote increased browse for moose in many areas (Scotter, 1964, 1968). Kayll (1968) summarized other beneficial influences of fire in the boreal forest region of Canada, although some of his comments may not apply to the taiga of that region.

Skoog (1968) concluded that range destruction by fire had little influence on known caribou population fluctuations in Alaska. He stated that losses of range due to fires were greatly mitigated because caribou were not dependent for forage upon lichen growth in spruce forests. Forages in other communities such as tundra, alpine meadows, and other areas could be utilized. He considered it doubtful that fires had much influence on fluctuations in caribou numbers in Alaska. There is a marked contrast, however, between much of the winter range used by barren-ground caribou in Canada and the winter range used by caribou in Alaska. If a winter range burned in the relatively flat taiga of northern Canada it might cause caribou to move many miles in search of food; in Alaska, the caribou might merely have to move a short distance up the mountain side into the alpine region to find lichens and other forage to meet their nutrient requirements.

Bergerud (1969) suggested that range destruction by fire has had a negligible effect on caribou numbers in Newfoundland, although he provides no data to support this view. He stated (p. 941):

> For decades wildlife biologists have thought that caribou require mature undisturbed lichen stands and that range destruction by fire and overgrazing was the antithesis of caribou abundance. Yet no proponent of this view has documented reduced reproduction or increased mortality among lichen-deprived free-ranging caribou. A significant correlation between lichen abundance and caribou distribution is not sufficient evidence that lichen abundance also limits caribou numbers.

While there is little evidence to show a direct relationship between fire-destroyed lichen winter ranges and declines in barren-ground caribou populations in northern Canada, it must be re-

FIG. 7. Dense carpets of lichens are present in most mature upland forests. Note the open nature of the taiga.

FIG. 8. Fireweed (*Epilobium angustifolium*) and pale corydalis (*Corydalis sempervirens*) are early invaders following forest fires.

membered that most of the research started after the caribou population had decreased to near its lowest known level. Therefore, the documentation that Bergerud would like is nearly impossible to obtain. There is, however, excellent documentation to show the potential reduction in the carrying capacity of lichen winter ranges as a result of fire. There is no doubt that food preferences of caribou are largely met in climax plant communities and that lichens generally constitute a large portion of the winter diet, whether necessary to the animal's survival or not. It may well be that ecological succession following fire is more rapid in Newfoundland which is further south and has a maritime climate.

The potential carrying capacity of the upland winter range of caribou in the taiga has decreased because of fire, while that of the moose range has increased, but the potential meat yields are not necessarily the same. It should be remembered that barren-ground caribou spend approximately half of the year in the tundra, which might otherwise go unutilized, and half of the year in the taiga. Moose are more solitary and depend on an appropriate mixture of habitat within a localized area. There can be no question that barren-ground caribou are the only native ungulate in the region adapted to using the lichen-rich components of the taiga forest. This does not imply that lichens are required, but only that caribou are adapted to utilizing this high energy and low protein forage.

Symptoms of range deficiencies or starvation, such as poor physical condition, emaciation, lack of fat, and severe outbreaks of disease and parasitism, have not been found to be wide spread; although some possible symptoms of nutritional deficiencies have been identified. McEwan (1963) reported that only 68.8 percent of the females over 3 years of age were pregnant during the severe winter of 1961-62. Calf mortality has also been high during certain years (Kelsall, 1968). Bergerud (1969, p. 941) questioned whether early calf mortality during certain years was ". . . an evolutionary imperative . . . or an artifact of range destruction and inadequate maternal nutrition, hence, low viability of calves at birth?".

Other influences of forest fires are less direct than the reduction in the potential carrying capacity of upland lichen winter ranges.

For example, Banfield (1954) observed that recent burns deflect barren-ground caribou migrations in a way similar to topographical obstructions. Kelsall (1957) and Scotter (1968) have noted that barren-ground caribou tend to avoid areas in the young successional stages, and were consistently more abundant in open mature forests of spruce or jack pine. Snow conditions, low forage production and windfallen trees made recent burns unattractive to caribou.

CONCLUSIONS

Although damage by fire to winter range of barren-ground caribou occurred before the white man came to North America, the increased rate of forest destruction by fire accompanying settlement and exploitation, as well as possible changes in the summer weather pattern, has contributed to the loss of potential habitat. Fires adversely affect the standing crop of both terrestrial and arboreal forage utilized by the caribou. Lichens appear to be more seriously affected by fire than other forage plants because of their delay in re-establishment and slow growth rates.

In considering only two big-game species, fire appears to reduce the quantity of winter range for barren-ground caribou and improve it for moose on upland forests of the study areas. Based on the pellet group data collected during this study, the biomass of caribou per acre of mature forest appears higher than that of moose on early subclimax forests on upland sites. Thus, for meat production, the upland lichen forests may be best suited to barren-ground caribou.

Referring to the winter range of caribou in interior Alaska, Leopold and Darling (1953a) wrote ". . . fire had played so dominant a part in destroying the lichen range that we feel quite safe in attaching to that one factor the major blame for caribou decrease." Research data from northern Canada may not justify the same bold conclusion. Data are insufficient to determine the extent to which forest fires have influenced directly the recent decline of the barren-ground caribou population. With the effect of fire on the standing crop of forage, plant succession and animal use

there can be little doubt that forest fires may have been one of the principal causes of the decline. Regardless of the reason for the recent decline, the present winter range, with its vast fire-destroyed areas, will not permit an increase in numbers to the level of 60 or 70 years ago. However, the reduced potential carrying capacity of the winter range does not appear to be the factor limiting the caribou population to the present low levels. And yet it may well have been the cause of the reduction of caribou numbers until men, wolves, and other factors were effective in maintaining the population at low levels.

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