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Western Arctic Caribou Herd Winter Habitat Monitoring and Utilization, 1995-1996

R.R. Jandt, C.R. Meyers, and M.J. Cole

Cover Photo
Darby Mountains, Seward Peninsula, Alaska.

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ABSTRACT

Daubenmire canopy cover transects established in 1981 were monitored in 1995 using the same methods. This data provided a comparison of range conditions over a 14-year span during which the Western Arctic Caribou Herd increased from 140,000 to 450,000 animals. Percent lichen composition declined from an average 33.3% in 1981 to 19.1% in 1995. Graminoid (primarily sedge) composition increased from 14.6% to 29.7% over the same period. The same 18 transects were also measured using point-intercept sampling, which will be used in future monitoring on both existing and newly established, permanent transects. In 1996, seven new transects were deployed in a systematic manner over caribou wintering concentration areas to bring the number of permanent transects to 25. Long-term monitoring of these transects at five-year intervals will provide managers with information on caribou winter range condition and forage utilization.

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INTRODUCTION

The Western Arctic Caribou Herd (WACH) is currently the largest caribou herd in the state and ranks as one of Alaska's major wildlife resources. This herd serves as an important source of food for 36 villages in northwestern Alaska comprising about 20,000 people. About 10,000-15,000 caribou are harvested annually, representing more than 500,000 kg of meat (Valkenburg 1994). The herd ranges over more than 140,000 mi^2 of tundra and taiga habitat in northwestern Alaska and calves mainly on the North Slope between the Lisburne Hills and the Colville River (Figure 1).

The herd has been increasing in size, although more slowly in recent years, after a drastic decline between 1970 and 1976, when it dropped from 240,000 to 70,000 animals (Davis and Valkenburg 1978). The decline was thought to be caused largely by excessive human harvest, although preda-

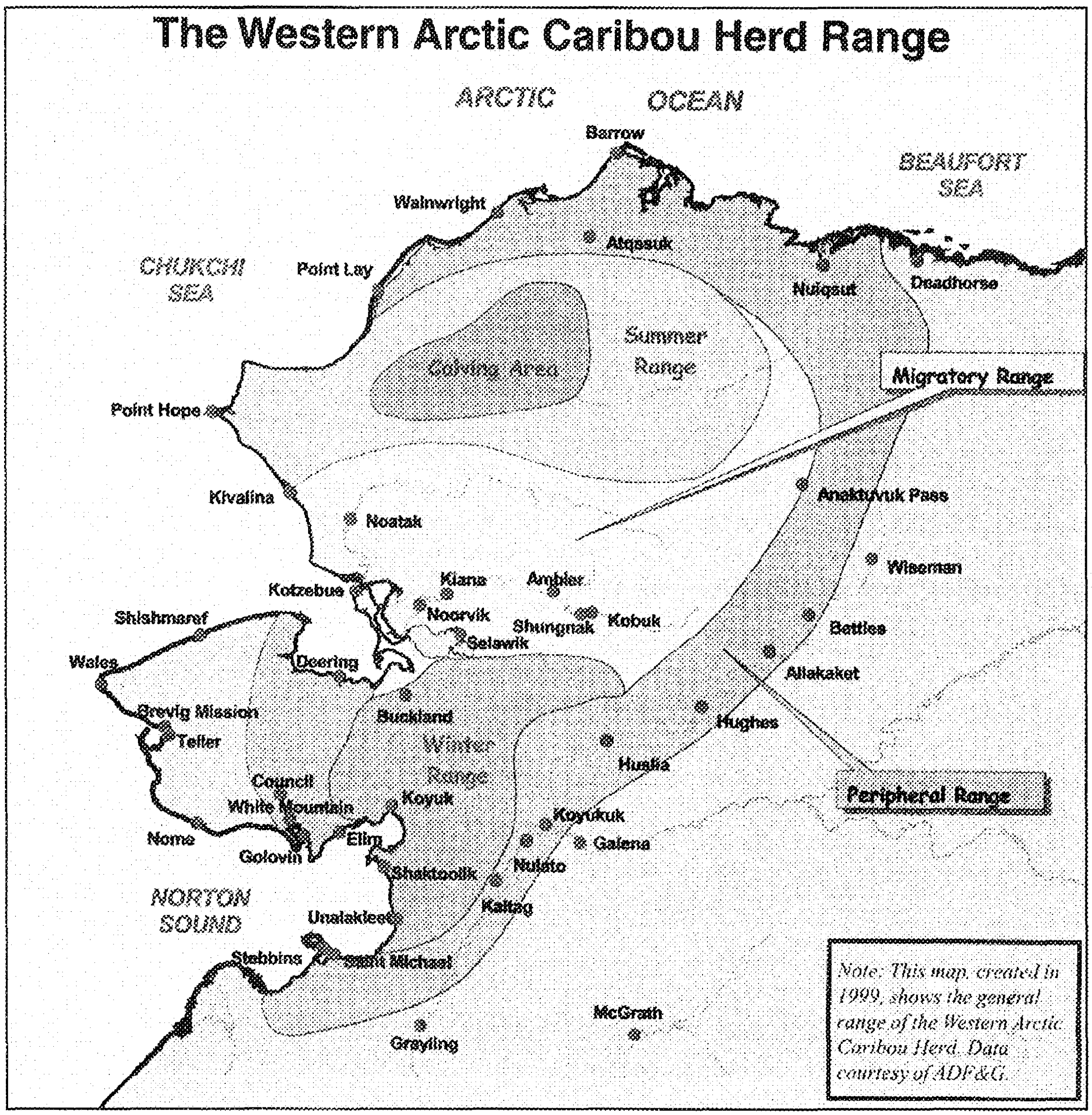

Figure 1. Western Arctic Caribou Herd Range Map.

tion, disease and possibly range conditions were also implicated. A 1993 photo census estimated a minimum herd size of 450,000 caribou (Machida and Dau 1995).

As the herd continues to increase, so does speculation about whether habitat conditions are deteriorating due to heavy utilization, and when and how the inevitable decline will occur. If the range size is taken at 140,000 mi^2, caribou density is now around 3.2 caribou/mi^2, which is considered in the high range for North American herds. Messier (1988) believed a density of 2.8/mi^2 to be excessive for the George River Herd of northern Quebec. He hypothesized competition for food resources (particularly on summer range) and the greater energy expenditure associated with range expansion as probable regulatory factors.

Because the WACH ranges over such a large and relatively inaccessible area that covers many land management jurisdictions, a comprehensive habitat monitoring plan would be extremely costly and logistically difficult. In addition, the WACH lacks the site fidelity to wintering range characteristic of some of the smaller caribou herds, such as the Galena Mountain herd. Rather, the WACH has expanded its wintering range southward as it has grown. Only after 1950 did large concentrations of caribou winter south of the Brooks Range. By 1986-1991, large wintering groups were observed in the drainages of the Ungalik, Inglutalik and Shaktoolik rivers (Machida 1993). Distribution data is far from complete, as only about 100 animals are carrying radios. However, Adams and Robus (1981) stated that the WACH used the tundra ranges of the Selawik Hills, Selawik Flats, and the Buckland Valley more consistently than any other portion of its winter range, and for the last 15-20 years this generalization probably holds.

In recent years a number of signs have served to increase the level of concern about possible overuse of winter lichen ranges of the WACH. Reports of some overwinter mortality caused by starvation have come in from the North Slope, indicating that local densities on some portions of the range are excessive (Machida 1993). On portions of the western Seward Peninsula, recent reports have indicated that 20-40% of lichen winter range is in fair or poor condition (Swanson and Barker 1992) due to a combination of caribou and reindeer grazing.

In July 1994, range experts from BLM and the Natural Resources Conservation Service (formerly Soil Conservation Service) made spot checks on lichen utilization and the condition of caribou and reindeer winter range (Figures 2 & 3). They noted that eastern reindeer allotments were receiving heavy caribou use. Utilization on five transects used by caribou and not by reindeer in the Shaktoolik allotment averaged 27% (range 7-48%), considered moderate. In the Koyuk allotment, use on two transects averaged 80% (range 76-83%), considered severe (C.R. Meyers, unpublished data, 1995). In addition, investigators conducted two utilization transects on Talik Ridge, an area that has been used consistently by migrating and wintering caribou, and noted 81% average utilization (range 78-84%).

The same crew of range experts made additional utilization and range condition checks on five different sites in the Shaktoolik allotment in July 1995. They noted heavy current and historic use, with severely damaged cottongrass tussocks, and very little lichen biomass and cover. Investigators visited one additional site in the

Figure 2. Bleached lichen fragments dropped by feeding caribou are signs of caribou utilization.

Figure 3. Area cratered by feeding caribou, exposing the mineral soil.

Koyuk allotment that has been used primarily by caribou in recent years. Utilization on two transects averaged 75% (range 55-95%). Much of the lichen on the ridge was fragmented and there were occasional small craters into the mineral soil (C.R. Meyers, unpublished data, 1996). Personal observations by two longtime observers of range conditions, D. Swanson of the Natural Resource Conservation Service and reindeer herder M. Henry, indicate that these heavy utilization rates became apparent only in the early 1990s.

During the winter of 1996-97 about 90,000 animals of the WACH moved into the Fish River Flats in southcentral Seward Peninsula. This area has not been used by significant numbers of caribou for many years and has been considered one of the most pristine and highest-producing lichen ranges on the Seward Peninsula. The area is managed by the BLM, which has refused applications by reindeer herders for grazing allotments on the area north of the Pargon River. This is due in part to the expectation of caribou incursions and the high value of the range for wildlife, including caribou.

Review of Existing BLM Policy and Mandates

The area of concern lies within two planning units, the Northwest and the Central Yukon. The BLM has a broad goal to protect crucial wildlife habitats as outlined in the Northwest Area Management Framework Plan of 1983 and the Central Yukon Resource Management Plan of 1986. This was further refined by the Buckland Valley Habitat Management Plan (Adams 1983a) as follows: "The primary goals... are to protect, maintain and enhance crucial caribou winter range and to improve or maintain habitat diversity by managing naturally ignited wildfire." Specific actions and studies are outlined under these two broad objectives, including: (1) restrict areas open to reindeer grazing when necessary to protect caribou winter range; (2) require specific restrictions or stipulations for activities, such as oil and gas exploration, that may impact caribou; (3) monitor caribou numbers and distribution on the Buckland Valley Wildlife Habitat Area annually in cooperation with Alaska Department of Fish and Game (ADF&G); (4) read permanent range transects, established in 1981, at three-year intervals to monitor range condition and trend; (5) complete vegetation mapping of the area; (6) develop a fire management plan; and (7) monitor transects established for the Ulukluk Creek fire recovery study.

More recent planning efforts include the formation of the Western Arctic Caribou Herd Working Group. This group began meeting in 1997 with the goal of ensuring the conservation of the WACH by integrating indigenous knowledge and western science. One of the functions of the group is to review and update the Western Arctic Caribou Herd Strategic Management Plan developed by the ADF&G in 1984. The objectives of this plan are to (1) protect and maintain the WACH and other components of the natural ecosystem upon which caribou depend, (2) provide opportunities for subsistence and recreational hunting on a sustained-yield basis, (3) provide opportunities for viewing and scientific study of caribou, and (4) perpetuate associated wild carnivore populations.

Issues for Habitat Monitoring

The previous discussion illustrates the need for quantitative habitat monitoring work. The monitoring strategy should be quantitative enough to be able to detect serious decline of winter range condition within acceptable confidence intervals. In addition, the strategy should use accepted methods that will be recognized by other agencies and co-managers of the WACH and the ecosystem it inhabits. The following issues need to be addressed when designing a meaningful study.

1. It will be difficult to reliably define a "core" winter range in which to distribute sampling in a random or systematic fashion, due to the erratic use patterns of the WACH.
2. It may be difficult to obtain a large enough sample size to achieve the desired statistical power due to the large size and inaccessibility of this wildlife habitat area.
3. Because the limiting factors of the WACH are not thoroughly known, detection of a decline in range conditions will have to be tied to direct impacts on herd health through other corroborating evidence. This could be a decline in nutritional status as reflected in body condition, population demography, fecal pellet composition or other indicators.
4. It will not be possible to inventory all types of forage available to caribou and still have a study that is logistically feasible and affordable.
5. Availability of forage varies greatly with ambient weather conditions, so that parts of the range that appear under-utilized may in fact be unavailable.
6. Methods for a long-term study need to be simple and repeatable, so that the study can be carried forward by new investigators under varying budgetary constraints.

History of Caribou Winter Distribution

The Buckland Valley Habitat Management Plan (Adams 1983a) presents a summary of caribou use of the Buckland River Valley and adjacent hills. It indicates that caribou regularly wintered in this area from 1950 to 1982. Davis and Valkenburg (1978) report that with the exception of three years, the WACH wintered in the Selawik Flats and Buckland Hills every year from 1959 to 1970. Davis et al. (1982) notes that the Buckland River drainage is one of the most heavily used winter ranges for the WACH (Figure 1).

The BLM, ADF&G and U.S. Fish and Wildlife Service (USFWS) cooperatively conducted aerial surveys from 1986-1990 to document seasonal migration patterns and winter range of the WACH in the Buckland River Valley and the Nulato Hills (Robinson and Field 1987, Robinson 1988, Robinson and Spindler 1989, Robinson and Leykom 1991). Radio-collared caribou were located monthly from October through March of each year. Over the course of the project, caribou were documented either wintering in or migrating through the Buckland River Valley. In 1986-87, the majority of animals migrated through the Buckland River Valley and wintered farther south in the Nulato Hills or on the Seward Peninsula (Robinson 1987). Many tens of thousands caribou occupied the Buckland Valley and the Nulato Hills during the winters of 1987-1990 (Robinson 1988, Robinson and Spindler 1989, Robinson and Leykom 1991).

More recent ADF&G data show that the Buckland River Valley, the Nulato Hills and the Selawik Flats continue to be important wintering areas for portions of the WACH (Figure 1). In the fall of 1992, 63% of the caribou with functioning radio-collars were located south of the Kobuk River and west of the Yukon and Koyukuk rivers (Valkenburg et. al. 1993). During the winter of 1992-93, five of 12 caribou cows equipped with platform satellite transmitters wintered in the Nulato Hills and the Buckland River Valley (Machida and Dau 1995). About 90% of the WACH wintered in the southwestern part of the range in the winter of 1993-94. Seventy-seven radio collars (90%) were found in the southwest winter ranges, including the drainages of the Kobuk, Selawik, Buckland and Koyuk rivers, and other drainages in the Nulato Hills (Valkenburg 1994). Aerial surveys during the winter of 1995-96 showed a large number of caribou using the area south of the Selawik Hills (Machida 1996).

One of the habitat monitoring issues is the difficulty in defining a core wintering area for monitoring studies. Given the available data on caribou wintering distribution, it is apparent that the WACH winter range varies over time and may include a much larger area than that encompassed by the Buckland Valley HMP. In addition, reindeer grazing is permitted on both federal and state lands. An effective habitat monitoring plan should also include lands under the jurisdiction of the state, Native corporations and other federal agencies.

STUDY AREA

The Buckland Valley study area is located mostly on BLM-managed public lands in Western Alaska (Figure 4). It extends from the base of the Seward Peninsula east to and including the Tagagawik River basin, and from the southern portions of the Selawik National Wildlife Refuge around the north slopes of the Selawik Hills and the Kauk and Mangoak rivers in the north, to the Ungalik, Inglutalik and Shaktoolik river drainages in the south. Topography over this large land area is varied, but is dominated by treeless tundra plains and rolling hills ranging from sea level to about 900 m. Mean annual precipitation is about 30-40 cm. Snow cover normally persists from November through May and can be hard and crusted with ice, especially in wind-scoured areas.

Vegetation in the valleys is predominantly tussock tundra, dominated by tussock-forming *Eriophorum vaginatum* and *Carex Bigelowii*. Tussock tundra is characterized by a "reindeer" lichen component, primarily *Cladina rangiferina*, *Cladina arbuscula / mitis* and *Cetraria cucullata*. Dwarf shrubs, such as *Ledum palustre*, *Betula nana*, *Vaccinium uliginosum* and *V. vitis-idaea* form another important component of tussock tundra. Higher elevations like the Selawik Hills support alpine tundra vegetation. Drainages are lined with willows (*Salix* spp.) and less frequently with spruce (*Picea* spp.). Around Talik Ridge and south, areas of black spruce (*Picea mariana*) forest can be found. Vegetation in the western portion of the study area has been mapped and surveyed for cover and biomass (Swanson et al. 1985). BLM staff completed field work for land cover mapping in the study area in 1999 and maps should be available in early 2003. The diversity of plant communities and species in tundra is extraordinary. Over 350 vascular plants and 60 lichen species have been collected from tundra communities in the Bering Land Bridge Park and Preserve on the Seward Peninsula (USDI 1987).

METHODS

In 1995, permanent transects established in the Buckland area in 1981 were relocated and monitored using the same methods used by the original investigators (Table 1). Of 20 transects established in 1981, only 17 were relocated in 1995. In 1996 we were able to relocate and measure one additional long-term transect (T7) with the use of a metal detector. Canopy coverage was measured with 20 cm X 50 cm Daubenmire (1959) quadrat frames in 25 locations along a 50 m transect. Data was recorded in the same cover classes and data forms used in 1981. Utilization was recorded as present or absent in each frame, and reported as frequency over the transect as a whole. Most of the transects were relocated from old maps and Loran-C coordinates obtained in

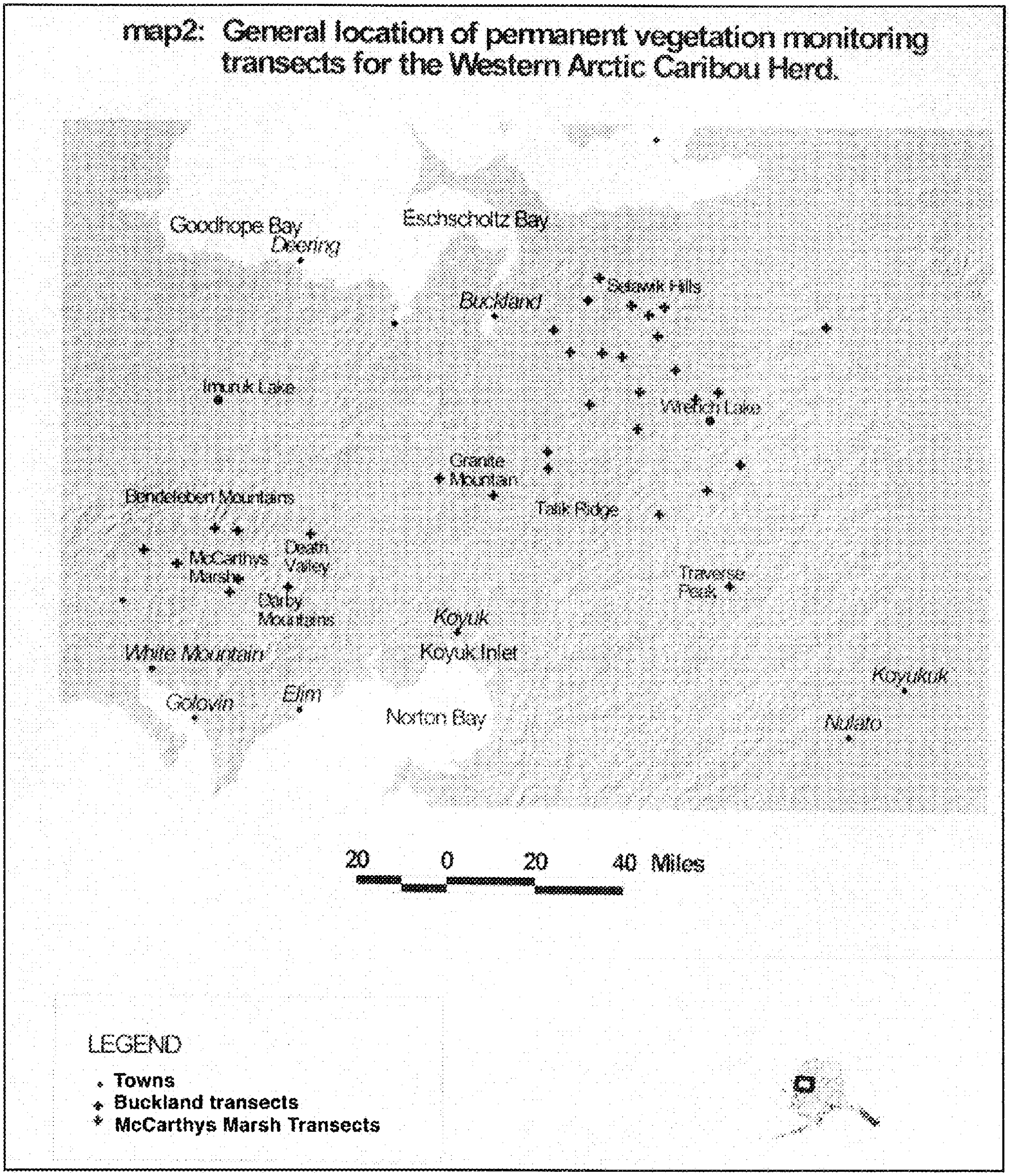

Figure 4. General locations of permanent vegetation-monitoring transects for the Western Arctic Caribou Herd.

1987 (L. Field, pers. comm.). Global positioning system (GPS) coordinates were recorded in 1995 and 1996 for future ease of relocation (Figure 5). Two transects (T8, T17) could not be relocated and were dropped from the study.

Each transect was then re-sampled using the point interception method described by Floyd and Anderson (1987) (Figure 6). A point sighting frame with 50 points in superimposed string grids covering a 1 m-by-0.5 m area was deployed in 12 locations (every 4 m) along the same 50 m transect. Observers recorded the first species encoun-

Table 1. Description and locations of long-term monitoring transects established in 1981 and 1996. Eighteen of the 1981 transects were located and sampled in 1995-96. Seven new transects were established in 1996. GPS locations were taken using North American Datum-27.

No.	Description	Dir.	Vegetation	GPS Lat	GPS Long	Elevation (ft)
1	VABM Timber	004°	Lich Alp Tundra	65 24.17	159 40.41	1505
2	upper Tag R. (1957 burn)	204°	Sedg/gr Alp Tund	65 35.25	159 04.59	1380
3	lower Fish River	194°	Lich Tuss Tundra	65 53.97	160 29.59	280
4	W. Fork Buckland River	303°	Lich Upl Tundra	65 34.04	160 35.29	920
5	VABM Boulder	250°	Lich Upl Tundra	65 58.85	159 49.04	1439
6	N. Fork Buckland River	360°	Lich Tuss Tundra	65 52.58	159 39.22	850
7	VABM Middle Fork	026°	Lich Tuss Tundra	65 47.30	159 28.35	890
8	Wrench Lake		Lich Tuss Tundra	Not found		
9	south of Fish River	290°	Lich Tuss Tundra	65 54.45	160 14.36	700
10	btw N. Fork and Mid. Fork	255°	Lich Tuss Tundra	65 47.57	159 54.84	520
11	mid-Selawik Hills	207°	Lich Tuss Tundra	66 04.35	160 02.87	950
12	east Selawik Hills	060°	Lich Upl Tundra	66 04.71	159 47.16	1635
13	VABM Alone	344°	Lich Tuss Tundra	65 57.89	160 38.65	505
14	headwaters Tag River	350°	Sedg/gr Tuss Tund	65 29.74	159 19.27	1600
15	south of Fish River	151°	Lich Tuss Tundra	65 54.14	160 04.69	1570
16	Brush Creek	252°	Dw Shr Tuss Tund	65 44.11	160 17.79	1020
17	South Fork (1968 burn?)	306°	Dw Shr Tuss Tund	Not found		
18	west of VABM View-SH	135°	Alp Tund Dryas FF	66 09.16	160 19.31	2000
19	west of VABM Mars-SH	360°	Lich Bldr field	66 02.87	159 54.12	960
20	north of VABM Dowey-SH	094°	Dw Shr Upl Tund	66 04.52	160 23.79	380
Transects Established in 1996						
21	N. of VABM Wrench Lake	124°	Lich Tuss Tundra	65 48.96	159 18.02	900
22	Traverse Peak	287°	Lich Tuss Tundra	65 11.32	159 04.98	1700
23	Talik Ridge	346°	Lich Tuss Tundra	65 30.08	160 34.02	1000
24	VABM Grizzley	183°	Lich Tuss Tundra	66 03.49	158 29.78	1400
25	Granite Mountain	230°	Dw Shr Tuss Tund	65 26.40	161 24.53	1500
26	W. Fork Buckland River	287°	Lich Tuss Tundra	65 24.42	160 58.47	1400
27	S. Fork Buckland River	320°	Lich Tuss Tundra	65 40.40	159 54.30	600

tered in the line of sight. Utilization was recorded as present or absent in each frame, and reported as frequency over the transect as a whole. The first year's data provided estimates of variance to aid in computing an optimal sample size required to detect differences over time and by location. As a result, an additional seven transects were added in 1996, bringing the total to 25 transects (Table 1).

Composite fecal samples consisting of 25 fecal pellets, one from each of 25 different pellet groups, were collected near each transect. In a few cases, when 25 groups were not available, more than one pellet was taken from each group. A replicate sample was also collected at each transect and stored for later paired analysis. The most reliable way to compare composition through time is by submitting samples from different years to a lab simultaneously (D. Klein, pers. comm.). Analysis of fecal

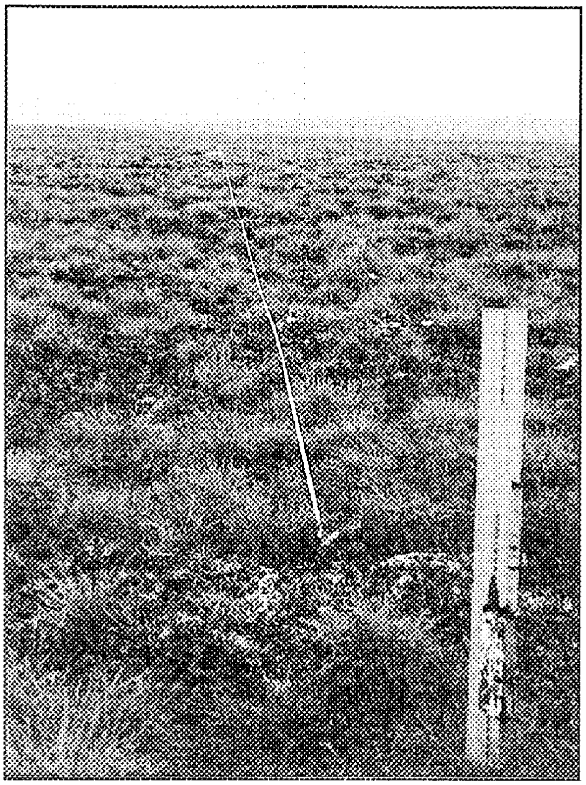

Figure 5. New transects established in 1996 were marked with yellow posts to facilitate future location of transects.

samples was conducted at the Composition Analysis Laboratory in Ft. Collins, Colorado. The relative density of plant fragments was based on 100 fields per sample. The composition of fecal matter was tested for correlation with forage cover values obtained from the respective transect. Student t-tests were used to test for differences in moss content among fecal samples collected from

Figure 6. Authors sample vegetation on a permanent monitoring transect established within the winter range of the Western Arctic Caribou Herd.

transects with differing lichen cover values.

Data on percent canopy cover of major species and vegetative classes from the two years was compared for significant changes using Wilcoxon matched pairs tests.[1] Although the data on lichen cover did not differ significantly from the normal distribution in a Kolmogorov-Smirnov test ($D_{0.05,17}$=0.19), the sample size was relatively small and graphically did not display a smooth, normal curve. Therefore, critical tests were done conservatively using nonparametric methods. Correlations among major vegetative classes and utilization frequency were analyzed using the nonparametric Spearman R statistic (Gibbons 1985). Minimal sample size was determined after Zar's (1984) technique for estimation of required sample size for a two-sample t-test.

RESULTS

Composition of transects varied greatly from 1981 estimates on some transects, and little on others (Table 2). However, some general trends were apparent. Forb and shrub classes changed little among the years studied, but graminoid classes and lichens changed significantly. The average graminoid cover doubled from 14.6 ± 1.9% in 1981 to 29.7 ± 3.8% in 1995-96 (n=18), while lichen cover declined from 33.3 ± 3.5% to 19.1 ± 2.8% (Table 3). Mean percent lichen cover was lower on the 1995 survey for 17 of 18 transect pairs (Table 2). In some cases the differences were striking. The observed lichen cover for Transect 1 in 1981 was 58%, while only 16% was recorded in 1995. Other transects showing the greatest negative change in lichen cover were T6 (-28%), T7 (-30%), T9 (-19%), T14 (-19%), T15 (-30%), T18 (-19%), and T20 (-16%). Most of these transects had high frequencies of utilization recorded by observers in 1981. The

[1] This test is a nonparametric alternative to the t-test for dependent samples. It assumes that the data are measured on an ordered metric scale and are symmetrical around the median (Zar 1984).

Table 2. Canopy cover data from Buckland Valley Transects, 1981 and 1995. Values are in percent cover. See Appendix 1 for species abbreviations

	T1_81	T1_95	T2_81	T2_95	T3_81	T3_95	T4_81	T4_95	T5_81	T5_95	T6_81	T6_95	T7_81	T7_96	T9_81	T9_95	T10_81	T10_95
HIERO	5.9	9.4	5.9	10.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ERVA4	0.0	0.0	0.0	0.0	13.3	23.2	2.0	12.7	0.5	1.8	5.4	34.2	18.8	38.3	24.9	36.6	24.1	51.5
ANPO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	0.3	0.1	0.1	0.0	0.0	1.6	1.1	0.0	0.0
LEPA2	0.2	2.6	0.1	0.0	18.0	17.7	6.8	13.3	3.2	9.7	3.9	3.3	13.5	17.1	6.6	4.6	11.4	9.2
VAUL	0.7	0.1	0.0	0.0	1.6	1.8	6.7	9.5	12.4	10.1	8.9	11.7	4.0	4.0	12.9	10.5	15.5	14.4
ARAL	4.5	1.5	2.5	2.5	1.5	1.3	0.7	0.1	0.0	0.0	0.0	0.0	5.8	1.2	0.0	0.0	0.0	0.0
CLRA	15.4	5.1	0.0	0.0	9.1	7.9	10.5	6.3	8.4	7.1	9.8	9.1	11.0	1.8	0.6	5.1	4.5	3.0
CLMI2AR	2.7	6.5	0.7	0.1	5.6	6.2	9.7	4.9	3.7	3.3	5.6	0.5	12.1	2.0	7.0	2.3	3.2	1.4
CLGR3	0.3	0.0	0.6	0.5	0.7	0.0	1.2	0.0	0.4	0.8	0.5	0.0	1.0	0.0	0.7	0.0	0.4	0.0
CLAL	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DRYAS	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LICHEN	58.2	15.5	2.5	2.0	35.8	32.4	38.5	21.1	37.8	29.8	48.5	19.6	41.8	11.6	30.1	10.6	26.2	14.8
GRAM	10.8	15.2	9.3	25.8	21.1	29.0	15.3	31.4	8.8	13.9	6.5	35.6	22.3	40.9	25.8	50.3	24.0	52.0
SHRUB	19.7	33.9	4.7	14.1	25.8	32.7	20.4	36.1	32.3	33.0	19.5	16.2	27.7	32.8	27.5	19.0	21.8	28.0
BARE GROUND	0.0	3.4	0.1	0.1	0.0	0.6	0.6	0.2	0.0	0.2	0.0	0.0	0.6	1.4	5.0	0.6	1.8	0.3

continued next page

Table 2 *(continued)* Canopy cover data from Buckland Valley Transects, 1981 and 1995. Values are in percent cover.

	T11_81	T11_95	T12_81	T12_95	T13_81	T13_95	T14_81	T14_95	T15_81	T15_95	T16_81	T16_95	T18_81	T18_95	T19_81	T19_95	T20_81	T20_95
HIERO	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.4	0.0	1.1	0.2	2.8	3.1
CAREX	3.1	5.3	5.6	34.3	1.0	1.8	0.0	2.0	0.7	2.5	9.1	9.5	1.0	1.3	2.1	1.0	7.7	9.0
ERVA4	7.2	35.7	2.1	12.2	9.7	14.3	10.3	43.2	7.8	41.1	7.4	15.6	0.0	0.0	0.0	0.0	0.0	0.0
RUCH	9.7	7.3	0.0	0.0	15.3	12.0	9.3	9.3	12.7	4.7	7.5	4.3	0.0	0.0	0.0	0.0	0.0	0.0
ANPO	0.0	0.2	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OXMI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LEPA2	6.4	5.4	5.2	4.0	6.5	4.9	9.7	14.5	9.9	9.6	15.3	24.3	0.0	0.0	0.2	0.6	9.1	5.2
VAVI	3.5	4.6	0.0	3.1	3.4	2.9	6.0	9.2	6.0	4.4	12.7	11.5	0.0	0.0	3.5	8.2	9.9	13.1
VAUL	.8	11.2	6.4	12.9	4.5	6.1	0.7	1.0	8.8	9.9	3.1	1.1	0.0	0.0	0.7	0.1	6.6	3.8
BENA	3.4	3.9	1.6	14.3	5.6	3.3	11.9	15.1	0.6	1.0	6.8	7.6	0.0	0.0	10.0	12.8	4.8	4.3
ARAL	0.0	0.0	0.0	0.0	0.0	0.6	0.7	0.0	0.0	0.0	5.1	2.1	0.0	0.1	4.4	4.8	27.1	33.6
EMNI	1.2	1.7	0.0	0.0	1.5	2.8	0.5	0.2	1.0	2.9	5.0	4.1	0.0	0.0	0.4	1.6	0.7	0.7
CLRA	13.6	10.1	14.1	5.3	17.1	10.8	6.5	0.8	10.5	0.0	2.9	3.7	0.0	0.0	2.3	4.0	0.8	1.6
CECU3	9.5	10.1	2.7	0.5	15.0	15.7	7.5	0.9	19.4	7.5	1.9	1.0	1.8	0.0	2.8	0.4	4.9	2.6
CLMI2AR	5.8	11.0	5.8	9.3	8.7	20.3	1.6	0.1	7.2	3.6	9.3	8.4	0.7	0.0	3.8	9.7	3.3	1.1
CEIS	3.2	4.2	3.2	0.9	2.5	2.0	3.1	0.0	7.8	1.8	1.8	0.3	1.2	0.1	1.0	0.0	3.6	0.3
CLGR3	1.6	0.0	0.2	0.1	0.8	0.0	2.4	0.0	0.2	0.0	1.7	0.0	1.2	0.0	0.0	0.2	0.0	0.0
THAMNO	0.2	0.0	1.0	0.2	0.0	0.0	1.7	0.2	0.0	0.0	0.0	0.0	2.5	0.2	1.1	0.3	0.2	0.0
CLAL	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0
CORNIC	1.1	0.6	2.4	0.7	0.0	0.0	3.2	0.1	0.1	0.0	0.0	0.0	7.5	0.1	14.4	6.9	2.2	0.3
DRYAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.8	48.6	0.1	0.0	0.9	0.9
SALIX	0.0	0.0	8.0	0.2	0.0	0.0	0.1	2.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	2.0	1.0
LICHEN	41.7	30.5	34.9	21.1	55.7	46.9	22.8	4.0	46.2	15.7	14.8	18.2	21.3	2.1	42.6	35.2	27.8	12.9
MOSS	12.4	7.1	15.5	9.3	12.7	7.7	23.0	8.2	38.9	25.9	16.9	6.3	6.4	3.4	0.5	4.6	9.7	5.6
GRAM	10.4	41.0	24.3	46.7	11.0	16.3	11.8	44.8	8.8	43.7	15.1	26.9	3.8	2.5	2.5	0.7	13.8	18.1
FORB	8.7	7.3	0.4	0.1	14.8	14.2	9.4	9.3	12.7	7.8	8.0	4.4	7.0	5.2	0.1	0.0	5.5	4.9
SHRUB	17.6	21.4	22.0	32.9	15.7	15.7	31.9	38.2	18.6	19.8	37.2	42.7	36.1	47.7	16.9	26.1	51.3	56.0
LITTER	19.2	9.2	34.5	13.7	10.3	5.4	13.2	5.0	9.8	10.0	20.2	6.9	20.9	11.9	41.7	14.4	23.1	19.2
BARE GROUND	0.0	0.9	0.0	2.4	0.0	0.0	0.6	2.2	0.0	0.0	1.8	0.1	8.4	8.6	3.0	1.4	0.1	0.7

only transect that showed an increase in estimated mean lichen cover was T16 (+3%). This transect was unique also in that the actual marker for the end of the transect could not be located by observers in 1995, so its precise replication is less certain than for the other transects.

Utilization on all 25 transects (measured as the number of plots in a transect showing signs of recent forage utilization) varied from a low of 0% for T2 and T18 to a high of 83% on T3 (Table 4 and Appendix 2). Signs of utilization, such as browsing, cratering or "drops" of lichen (Figures 2 and 3) occurred on 116/300 individual plots, or 39% of the total. Percent lichen cover showed a loose negative correlation (R^2adj=0.83, F=113) with utilization (Figure 7). A few individual lichen species, notably *Cetraria cucullata*, were positively correlated with utilization signs. Other forage groups showed little or no correlation with caribou use.

Sampling transects a second time using the point-intercept method took approximately half the time of the Daubenmire cover class method. Individual transect estimates of cover from each method are shown for major species and vegetation classes in Table 4. Estimates were similar for most species, with an overall mean difference of 0.7%. Of 22 species, 16 (73%) agreed within 1%. In general, the cover class estimates were slightly higher than the point estimates. The two methods seemed quite comparable even for the estimation of rare or inconspicuous species such as *Hierochloe* spp. and *Cladonia gracilis*. The largest mean difference was 2.2% for *Cladonia mitis/arbuscula* (Table 4). The only notable difference between estimates from the two methods is in the lichen and moss cover classes, where Daubenmire estimates averaged about 6% higher than corresponding point-intercept estimates (Table 4). Point-intercept estimates of percent litter exceeded those from the Daubenmire

Table 3. Average percent cover of vegetation types (determined by Daubenmire-type cover class estimation) on 18 transects sampled in 1981 and 1995-96. A change greater than 1% is indicated by a plus or minus sign, and p-values are given if the change was statistically significant. For species abbreviations, see Appendix 1.

Vegetation type	Mean 1981	Std err 1981	Mean 1995	Std err 1995	Change	Sig.
HIERO	0.8	0.4	1.3	0.8		
CAREX	3.9	0.8	7.3	2.1	+	P=0.03
ERVA4	8.7	2.1	20.0	4.3	+	P<0.01
RUCH	6.5	1.4	5.5	1.2	-	
ANPO	0.3	0.2	0.1	0.1		
OXMI	0.0	0.0	0.0	0.0		
LEPA2	8.0	1.5	8.1	1.6		
VAVI	5.4	0.8	5.8	1.0		
VAUL	5.5	1.1	6.0	1.2		
BENA	5.4	0.9	7.3	1.7	+	
ARAL	2.6	1.4	2.7	1.8		
EMNI	1.5	0.4	2.1	0.5		
CLRA	7.1	1.3	4.7	0.8	-	P=0.02
CECU3	8.9	1.5	5.2	1.2	-	P<0.01
CLMI2AR	5.6	0.9	5.0	1.2		
CEIS	3.4	0.5	1.2	0.4	-	P<0.01
CLGR3	0.8	0.1	0.1	0.1		
THAMNO	0.5	0.2	0.1	0.0		
CLAL	0.1	0.1	0.0	0.0		
CORNIC	2.0	0.9	0.9	0.5	-	
DRYAS	1.7	1.6	2.8	2.7	+	
SALIX	0.6	0.4	0.2	0.1		
LICHEN	33.3	3.5	19.1	2.8	-	P<0.01
MOSS	18.7	3.0	12.3	2.3	+	P<0.01
GRAM	14.6	1.9	29.7	3.8	+	P<0.01
FORB	7.8	1.2	7.6	1.0		
SHRUB	24.2	2.5	30.2	2.7	+	P<0.01
LITTER	23.6	2.9	11.5	1.3	-	P<0.01
BARE GROUND	2.6	1.5	1.3	0.5	-	

Table 4. Comparison of optical cramming (Daubenmive=D) and point-intercept methods to estimate canopy cover.

	HIERO	CAREX	ERVA4	LEPA2	VAVI	VAUL	CLRA	CECU3	CLMI 2AR	CEIS	CLGR3	LICHEN	MOSS	GRASS SEDGE	FORB	SHRUB	LITTER	BARE GROUND	UTIL Freq
T1	4.6	2.8	0.0	0.8	0.5	0.0	2.7	3.7	2.7	0.2	0.0	15.2	9.3	8.3	2.5	28.6	28.5	1.8	67.0
T1D	9.4	6.4	0.0	2.6	0.8	0.1	5.1	3.7	6.5	0.1	0.0	15.5	15.9	15.2	6.4	33.9	25.3	3.4	
T2	11.0	4.2	0.0	0.0	0.0	0.2	0.0	0.3	0.3	0.0	0.5	2.2	23.3	30.7	8.7	19.2	16.3	0.2	0.0
T2D	10.1	5.3	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.5	2.0	37.3	25.8	11.8	14.1	17.9	0.1	
T3	0.0	9.5	25.1	18.5	6.5	1.8	4.0	8.3	5.8	0.8	0.0	19.2	2.5	35.0	2.7	32.2	9.0	0.0	83.0
T3D	0.0	5.8	23.2	17.7	9.5	1.8	7.9	11.0	6.2	0.4	0.0	32.4	5.7	29.0	4.2	32.7	5.7	0.6	
T4	0.0	21.5	10.3	8.7	5.3	4.8	2.3	4.7	1.5	0.8	0.0	11.1	7.5	31.8	6.5	29.0	13.6	0.2	58.0
T4D	0.0	21.5	12.7	13.3	7.3	9.5	6.3	4.1	4.9	3.0	0.0	21.1	15.3	31.4	8.9	36.1	13.1	0.2	
T5	0.0	9.8	1.5	8.0	6.6	8.2	3.8	6.5	1.3	2.5	0.2	17.3	8.6	14.0	11.0	32.8	15.6	0.7	42.0
T5D	0.0	7.6	1.8	9.7	10.1	10.1	7.1	12.4	3.3	5.1	0.8	29.8	14.3	13.9	16.6	33.0	17.9	0.2	
T6	0.0	1.3	28.0	5.3	3.3	10.0	3.5	7.5	0.0	2.0	0.0	14.0	16.0	29.0	9.0	22.0	11.0	0.0	25.0
T6D	0.0	0.4	34.2	3.3	2.4	11.7	9.1	9.5	0.5	2.8	0.0	19.6	27.4	35.6	12.3	16.2	8.9	0.0	
T7	0.0	4.0	26.2	16.8	8.3	2.3	2.7	4.5	2.8	0.0	0.0	11.7	3.7	30.2	6.2	33.3	13.3	1.5	33.3
T7D	0.0	1.9	38.3	17.1	7.0	4.0	1.8	3.8	2.0	0.1	0.0	11.6	2.7	40.9	7.1	32.8	7.0	1.4	
T9	0.0	0.5	47.3	4.8	1.6	11.5	2.2	5.5	1.6	1.2	0.2	10.8	6.2	47.8	6.8	22.5	6.5	0.0	42.0
T9D	0.0	10.2	36.6	4.6	4.0	10.5	5.1	2.1	2.3	0.6	0.0	10.6	17.8	50.3	9.8	19.0	9.9	0.6	
T10	0.0	3.2	36.3	16.8	8.3	10.6	1.8	6.0	0.7	0.2	0.0	8.6	1.8	39.5	4.3	36.8	8.5	0.0	25.0
T10D	0.0	0.3	51.5	9.2	6.2	14.4	3.0	8.7	1.4	0.7	0.0	14.8	6.3	52.0	5.8	28.0	5.7	0.3	
T11	0.0	5.2	36.6	6.2	4.2	5.5	7.8	5.8	3.6	1.0	0.0	19.3	5.2	41.8	5.0	18.3	10.5	0.7	25.0
T11D	0.0	5.3	35.7	5.4	4.6	11.2	10.1	10.1	11.0	4.2	0.0	30.5	7.1	41.0	7.3	21.4	9.2	0.9	
T12	0.0	31.0	9.5	3.0	1.2	9.8	2.6	1.2	2.5	0.3	0.7	10.5	4.5	41.0	0.0	28.1	14.6	1.0	42.0
T12D	0.0	34.3	12.2	4.0	3.1	12.9	5.3	0.5	9.3	0.9	0.1	21.1	9.3	46.7	0.1	32.9	13.7	2.4	
T13	0.0	4.0	23.0	7.5	2.5	5.0	5.8	10.8	15.8	1.5	0.0	34.8	3.5	27.0	7.6	18.0	8.8	0.2	58.0
T13D	0.0	1.8	14.3	4.9	2.9	6.1	10.8	15.7	20.3	2.0	0.0	46.9	7.7	16.3	14.2	15.7	5.4	0.0	
T14	0.0	2.8	46.0	11.3	7.5	1.0	0.3	0.3	0.2	0.0	0.0	1.5	5.3	48.8	5.6	29.6	7.6	1.1	8.0
T14D	0.1	2.0	43.2	14.5	9.2	1.0	0.8	0.9	0.1	0.0	0.0	4.0	8.2	44.8	9.3	38.2	5.0	2.2	
T15	0.0	2.0	40.0	5.8	5.0	7.6	2.8	5.5	1.3	0.5	0.0	11.0	11.1	42.0	5.8	19.6	10.1	0.2	67.0
T15D	0.0	2.5	41.1	9.6	4.4	9.9	0.0	7.5	3.6	1.8	0.0	15.7	25.9	43.7	7.8	19.8	10.0	0.0	
T16	0.0	14.5	10.3	20.1	12.3	2.2	1.0	1.3	3.5	0.2	0.0	6.6	7.8	24.8	2.8	42.3	15.3	0.2	50.0
T16D	0.0	9.5	15.6	24.3	11.5	1.1	3.7	1.0	8.4	0.3	0.0	18.2	6.3	26.9	4.4	42.7	6.9	0.1	
T18	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	1.8	1.1	6.5	37.0	29.0	8.0	0.0
T18D	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	2.1	3.4	2.5	5.2	47.7	11.9	8.6	
T19	0.3	1.0	0.0	0.5	3.3	1.2	4.5	2.5	6.0	0.3	0.2	35.3	1.8	1.7	0.2	22.0	12.3	1.6	58.0
T19D	0.2	1.0	0.0	0.6	8.2	0.1	4.0	0.4	9.7	0.0	0.2	35.2	4.6	0.7	0.0	26.1	14.4	1.4	
T20	3.3	6.0	0.0	4.6	10.5	4.3	1.0	3.6	1.6	0.0	0.0	9.3	2.3	12.6	2.5	53.3	19.3	0.2	50.0
T20D	3.1	9.0	0.0	5.2	13.1	3.8	1.6	2.6	1.1	0.3	0.0	12.9	5.6	18.1	4.9	56.0	19.2	0.7	
DAVG	1.3	7.0	20.0	8.1	5.8	6.0	4.5	5.2	5.0	1.2	0.1	19.1	12.3	29.7	7.6	30.4	11.5	1.3	
PAVG	1.1	6.9	18.9	7.7	4.8	4.8	2.7	4.3	2.8	0.6	0.1	13.5	6.8	28.2	5.2	29.1	13.9	1.0	
MDIFF	0.2	0.1	1.1	0.4	1.0	1.2	1.8	0.9	2.2	0.6	0.0	5.6	5.5	1.5	2.4	1.2	-2.4	0.3	

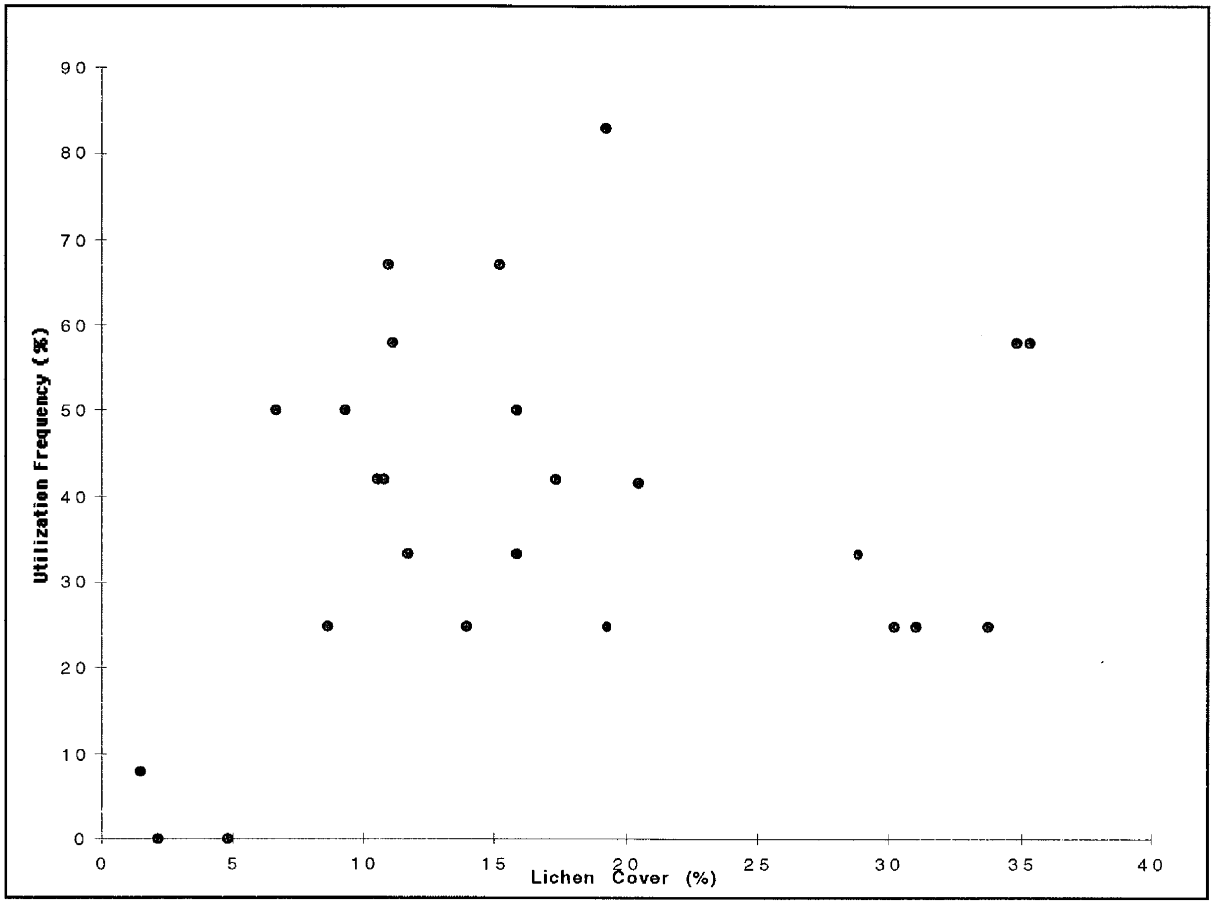

Figure 7. Correlation of frequency utilization vs. lichen canopy cover on transects in the winter range of the WACH.

method by an average of 2.4%.

An estimate of variance of percent lichen cover was obtained from the 17 point-intercept transects completed in 1995 for use in determining minimum useful sample size for continued monitoring of the WACH winter range. Lichen cover on these 17 transects ranged from 1.5% to 35.3% with a mean of 13.6 ± 2.3% (Table 5). For the new permanent transects established in 1996, T21-T27, percent lichen cover ranged from 15.8 to 33.7, with a mean of 25.1% (Table 6). Several potential transect sites were rejected because they had such little lichen cover it would be hard to detect a decline. Utilization on the new transects ranged from 25-50%, indicating that this area is available to caribou during the winter.

Lichen cover over all 25 permanent point-frame transects (representing eight vegetation types) was 16.8 ± 2.0% (Appendix 2). Graminoid cover averaged 25.5 ± 2.9%, and shrub cover 30.3 ± 2.0% (Appendix 2). The highest percent grass cover was recorded at T2 (figure 8), which is a transect believed to have burned in 1957. This alpine tundra transect had 11.0% *Hierochloe* spp. and 8.8% *Luzula* spp. cover, as well as the only recorded fireweed (*Epilobuim angustifolium*) at 2.7%. Total lichen cover was only 2.2% at this location, and no signs of utilization by caribou were detected. A birch and poplar sampled from the site were aged by J. Roessler (BLM-Alaska Fire Service) at 19-21 years and 23-26 years, respectively, placing them within the time frame of the presumed fire history.

The average percent of discerned plant fragments in fecal samples is shown in Table 7 and Appendix 3. Samples were fairly consistent in major plant components with the exception of one —Transect 27—which had

Table 5. Results of point-intercept sampling of 17 transects, in average percent canopy cover, that were used in determinations of optimal sample size. Utilization frequency represents the percent plots in a transect showing recent signs of browsing, cratering, or lichen "drops."

Cover	Min	Max	Mean	Std Err	Std Dev	Skewness
Lichen	1.5	35.3	13.62	2.3	9.6	1.24
Grass/ Sedge	1.1	48.8	28.05	3.8	15.5	-0.50
Moss	1.8	23.3	6.97	1.4	5.7	1.72
Forb	0.0	11.0	5.14	.75	3.1	0.01
Shrub	18.0	53.3	28.90	2.3	9.6	1.03
Litter	6.5	29.0	13.91	1.6	6.6	1.38
CLRA	0.0	7.8	2.71	0.5	2.1	0.83
CLMI2AR	0.0	15.8	2.84	0.9	3.8	2.73
CECU3	0.0	10.8	4.33	0.8	3.1	0.27
ERVA	40.0	47.3	18.46	4.3	17.8	0.37
LEPA2	0.0	20.1	7.17	1.5	6.3	0.90
Util Freq	0.0	83.0	41.18	5.9	24.2	-0.033

Table 6. Percent cover of eight vegetation or cover types for transects established in 1996 (T21-27) using the point-intercept method, Western Arctic Caribou winter range, Alaska.

Transect	SALIX	Lichen	Moss	Grass - sedge	Forb	Shrub	Litter	Bare Ground
T21	0.0	15.8	4.7	23.2	4.2	32.3	20.0	0.0
T22	4.0	28.8	1.3	24.2	6.5	26.0	12.2	0.2
T23	0.0	30.2	6.0	15.2	13.3	27.2	8.0	0.0
T24	3.2	31.0	3.0	4.3	6.2	35.3	12.8	5.7
T25	2.8	20.5	2.8	5.5	3.7	59.8	6.8	0.7
T26	0.0	33.7	3.6	24.3	6.2	22.2	9.8	0.0
T27	0.0	15.8	2.3	33.2	4.0	30.3	13.7	1.0
average	1.4	25.1	3.4	18.6	6.3	33.3	11.9	1.1

an unusually high *Eriophorum* spp. content of 50.3%. The next highest sample had only 16.9% *Eriophorum* spp. content. The sample from Transect 27 was thought to be an atypical due to either season or species, and is not included in the results. Uncorrected composition of fecal samples averaged 6.5 ± 1.0% graminoid, 6.3 ± 0.7% shrub, 2.3 ± 0.3% moss, 1.7 ± 0.6% forb, and 82.9 ± 1.3% lichen (Table 7).

DISCUSSION

The percent canopy cover of lichen species used by caribou has declined by an average 14% on the 18 long-term monitoring transects established in 1981. Since none of the transects burned during the 14-year span, the decline is presumably due to utilization and disturbance by caribou. In regression analysis, graminoid cover, primarily *Eriophorum vaginatum* and *Carex* spp., increased by 15% over the same period. The fact that different pairs of observers sampled the transects in respective years cannot be ruled out as a source of error. The

Figure 8. Transect 2 located in an area believed to have burned in 1957, had the highest percent grass cover of all the sites sampled.

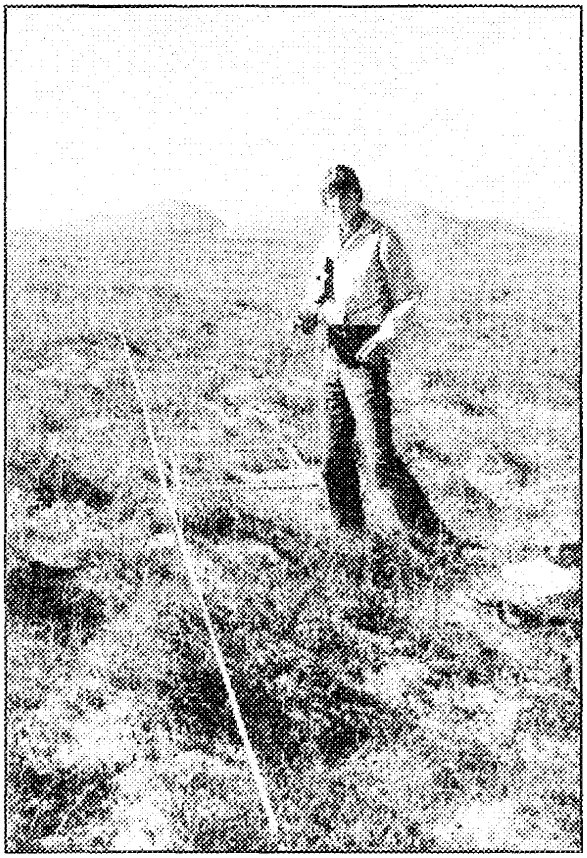

Figure 9. Sampling vegetation using the point intercept method described by Floyd and Anderson (1987).

1981 WACH and Ulukluk Creek fire study transects were established and read by one set of BLM observers, while the 1995/1996 WACH and fire study transects were established and monitored by a second set of BLM observers. Estimates obtained by optical cramming are subjective and require calibration and experience for consistent and reproducible results. However, the magnitude of the differences, and the fact that they were not uniform among transects, indicate that the observed changes were not due to observer bias. On the Ulukluk Creek fire recovery study conducted the same year, measured lichen cover in 1995 (27.2%) was almost identical to the 1981 estimate (28.4%) on control transects (Jandt and Meyers 2000). We recommend that future monitoring be conducted using a point-intercept technique to minimize the potential error due to observer bias.

Another concern with interpreting the statistical validity of the results is the fact that the transects were not random but were placed systematically, in an attempt to adequately represent vegetative zones important to caribou in the Buckland Valley. The statistics are only valid insofar as the sample is in fact representative. Subjectively, it appears to be representative of typical ecosites, and of areas used by caribou (utilization frequency of 40%: Table 5) but we have no quantitative means of verifying this assumption.

In comparing the two techniques, the point-intercept technique was more than twice as fast as the canopy cover (Daubenmire) method (Figure 10 & 11). Although half as many plots were deployed per transect with point-interception, the area actually sampled was 6 m^2 compared to 2.5 m^2. Floyd and Anderson (1987) found that canopy class estimation overestimated

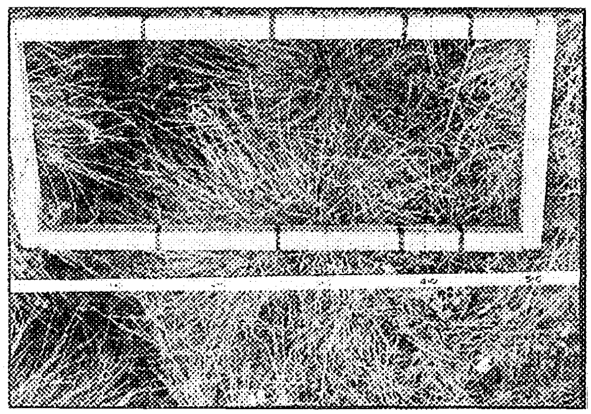

Figure 10. The Daubermire canopy-cover method was used to sample transects in 1981 and 1995.

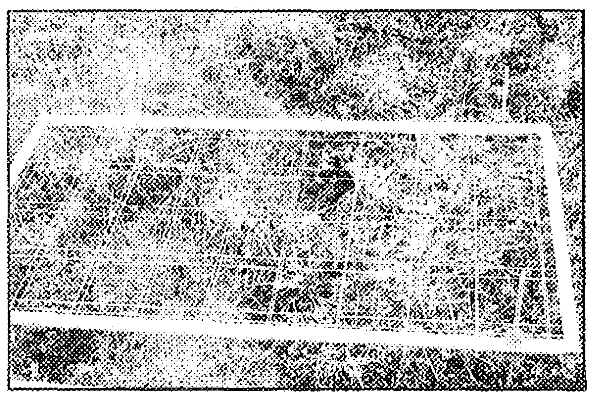

Figure 11. Frame used to sample vegetation using point-intercept method (Floyd and Anderson 1987) This method will be used in future monitoring.

Table 7. Mean percent discerned plant fragments from 24 caribou fecal samples collected from the Western Arctic Caribou winter range in 1995-1996. Sample T27 (Transect 27) is excluded from the results.

Plant Species	Min	Max	Mean (n=24)	Std err
CAREX	0.0	7.6	2.3	0.5
ERIOP	0.0	10.5	3.9	0.8
POA	0.0	3.3	0.2	0.1
Total Gram	0.0	16.9	6.5	1.0
CETRA2	0.0	4.7	1.2	0.3
CLADI3	65.3	92.4	80.5	1.5
PELTI2	0.0	5.7	1.1	0.4
Total Lichen	71.4	94.3	82.9	1.3
moss	0.0	5.1	1.7	0.3
SPHAG2	0.0	2.8	0.6	0.2
Total Moss	0.0	5.5	2.3	0.3
DRYAS	0.0	1.2	0.1	0.1
LEDUM	1.7	13.0	5.9	0.6
SALIX	0.0	7.5	0.6	0.3
Total Shrub	1.7	15.2	6.3	0.7
STELL	0.0	0.5	0.0	0.0
ASTRA-OXYTR	0.0	4.4	0.2	0.2
EQUIS	0.0	8.1	1.5	0.5
Total Forb	0.0	9.8	1.7	0.6

small understory plants and rare species, due to the assumption that cover values are uniformly distributed about the midpoints of the cover classes. This appears to be the case for mosses and lichens in the present study, and we believe the point-intercept estimates to be a better estimator of these classes. The same authors found that canopy class estimates of dominant shrub classes were almost identical to those obtained from point-interception, and that observation held for our data as well. Shrub composition was 30.2% using canopy class and 28.9% using point-interception. The point-interception method has been reported to be more efficient than line intercept and canopy coverage methods for estimating plant abundance in terms of precision and sampling time (Floyd and Anderson 1987) and has also been used to non-destructively estimate plant biomass (Jonasson 1988).

Estimates of cover were based on first hits at the point of interception, without attempting to sample successive layers of vegetation (Figure 11). This can create problems when the vegetation of interest is low-growing and covered by taller plants, i.e., lichen growing under a shrub overstory. It may not be possible to estimate biomass using the "first hit" method, but it seems a practical and efficient method for detecting change.

The estimate of variance in total lichen cover (Table 5) was used to determine a minimum sample size to detect a 10% change in lichen cover with 95% confidence[2]. Minimum sample size to detect a difference of 10% change in mean lichen was calculated at 25 transects, assuming the variables are normally distributed. As discussed earlier, the distribution of lichen cover did not differ significantly from the normal in critical tests, but graphically demonstrates positive skewness (Table 5: G=1.24). Cochran (1977:42) recommends a minimum sample size to use the normal approximation when dealing with a marked positive skewness (many small measurements, few

[2] After Zar (1984)$n>(2S^2/D^{2)*}(t_{a,2(n-1)}+t_{b(t),2(n-1)})2$, where n= minimum samplesize, d= smallest difference to detect, n_1= preliminary sample size, y_1= mean of preliminary sample, n is the "guess" of sample size for iterations, and s_2= variance estimate from preliminary sample.

large measurements) of $n>25G^2$, where G is Fisher's measure of skewness. For our population, this equals a minimum sample size of 38. In conclusion, a sample size of 25 transects should be sufficient to detect a change of 10% lichen cover with 95% confidence, but 38 transects would be preferable. Eighty transects would be required for a 90% chance of detecting a change in percent lichen cover of 5%, which might be more suitable with monitoring intervals of 3-5 years instead of the 14-year interval used for this study. Given current and projected BLM staff, funding and time constraints, eighty transects are not a practical option.

Composition (uncorrected) of discerned plant fragments in fecal pellets averaged 6.5 ± 1.0% graminoid, 6.3 ± 0.7% shrub, 2.3 ± 0.3% moss, 1.7 ± 0.6% forb, and 82.9 ± 1.3% lichen (Table 7). Adams (1981) reported composition of 14.4 ± 5.4% graminoid, 15.9 ± 6.1% shrub, 5.9 ± 3.6 % moss, 0.7 ± 1.3 forb%, and 63 ± 9.7% lichen from 75 winter pellet groups obtained in the Buckland Valley. In comparison, Denali Park caribou feces averaged 11% graminoid, 8% shrub, 10% moss, 7% forb, and 62% lichen during the winter (Boertje 1984). These figures for Denali Park are based on a combination of fecal analysis, field observations and forage digestibility. In all three studies, the same lab was used for the microhistoligic analysis, but fewer microscope views per sample were done in 1981. Fecal analyses are of limited utility in determining diet composition, without auxiliary information such as feeding observations, digestibility or paired rumen samples, due to the differential detectability of forage species in fecal material. However, a rough approximation of diet composition for the study area was calculated using correction factors derived from Denali Park caribou winter fecal pellets (Boertje 1981), as follows:

Lichen	69%
Graminoid	19%
Forb	7%
Shrub	5%
Moss	1%

With the exception of the slightly high value for graminoid content, there is nothing outstanding about this corrected diet composition that would be an indicator for declining range quality, such as high moss content or low lichen content. Considering the recognized limitations of using fecal analysis for estimating diet composition (Boertje et al. 1985), we are not sure of the significance of this result. It is apparent that a large portion—70 to 80%— of the winter diet of the WACH is composed of lichen, illustrating the importance of the old growth lichen habitat type. The total moss content of the fecal pellets correlated negatively with percent forage lichen on the transects ($r=-0.41$, $p<0.05$), indicating that more moss may be incidentally ingested when caribou are grazing stands with less lichen biomass.

MANAGEMENT IMPLICATIONS

Results must be analyzed with cooperators data on concurrent weather conditions, animal physiology, demographics and animal distribution to predict potential significance for caribou. However, if these transects are representative of the entire Buckland Valley, the winter forage value has declined substantially and the caribou will have to compensate by extending migrations to different areas (such as Unalakleet River, Seward Peninsula, Pah, Koyukuk and Yukon River Flats), or foraging more intensively. Either way, the relative cost of overwintering in terms of energy expended would be increased. The ADF&G has been monitoring recruitment and physiological indicators of nutritional stress, such as calf weight and bone marrow fat, which may help in the determination of whether the habitat is becoming a limiting factor for this caribou herd. At last report (Valkenburg 1994), calves collected in fall weighed an average of 9 kg less than in previous years and were noted to be in relatively poor condition. Hunters from the Kobuk Valley areas also reported the condition of harvested bulls to be poor in 1994. Recruitment of calves has been relatively low during recent years with 17 short yearlings/100 adults in 1995 and 22/100 in 1996 (ADF&G 1995, 1996), although calf/cow ratios have remained above 50%. Taken together, the habitat and physiological data indicate that the WACH may be beginning to show signs of nutritional stress. If combined with other events, such as a severe winter, deep snow or disease, large scale changes in habitat availability could trigger a precipitous population decline.

The BLM and other management agencies need to examine management strategies that may help mitigate the effects of such a population crash on those who rely on the caribou as a food source. Current hunting seasons and bag limits for the WACH are extremely liberal and further liberalization of the regulations are not likely to increase the number of caribou harvested or have any effect on the herd size at this point. Management strategies we may employ then include: (1) more intensive monitoring of biological indicators of the herd's status, (2) public education and awareness, and (3) more intensive habitat management to buffer the impact of a population decline. It should be noted that these declines are to a large extent natural and anticipated events, and will not or should not be eliminated by management.

Monitoring and Range Assessment

Other agencies recognize the need for stepped-up monitoring of current range conditions. The ADF&G's regional biologist stated: "Nutritional and range status are becoming important concerns as herd size increases. Because range studies have traditionally been conducted by various land management agencies such as the BLM, the Department should encourage the development of an adequate range assessment program by these agencies. These types of studies tend to be costly, and a range assessment program will probably need to be a multi-agency effort."(Machida 1993: p. 180). A long-term study underway at the University of Alaska Fairbanks by reindeer biologist Greg Finstad will be applicable to caribou as well. Finstad is documenting seasonal changes in nutritional value of reindeer forage as a way to evaluate range quality on various grazing allotments, and to evaluate the effects on fawn growth, adult antler and body weight, etc. (Finstad, pers. comm.). The Biological Research Division of the United States Geological Survey, working with the ADF&G, has initiated a study of the relationship of range condition, fire history and population demographics on the Nelchina caribou herd in Interior Alaska that may help with the understanding of complex ecological relationships. After extensive wildfires burned on the Seward Peninsula in 1977, a study was initiated to determine the effects of these fires on tundra soils and vegetation (Racine 1978). One site (Imuruk Lake) had pre fire soil and vegetation information; nine transects were established at this location. Reports summarized findings of the early vegetative succession (Racine et al. 1987), but "permanent" transects are rarely monitored long enough to document long-term fire effects, including the recovery times of slower-growing, non-vascular plants.

Monitoring vegetation condition and trend, and range recovery after fire are two of the management actions identified in the Buckland Valley Habitat Management Plan. BLM staff will continue to monitor habitat conditions within the WACH winter ranges (Figure 6). Transects should be read at about five-year intervals in the future. Annual assessment of reindeer grazing allotments will continue. In addition, more data is needed on regeneration of caribou forages, especially lichens, after fire as well as other long-term environmental effects of fire in western Alaska tundra and taiga vegetation types. The BLM proposes to continue monitoring the Ulukluk Creek fire transects and assist in resuming long-term monitoring of the Imuruk Lake fire transects.

Public Education and Awareness

The ADF&G has recently published a full-color glossy pamphlet with information on caribou management and biology. The USFWS at the Selawik Refuge conducts outreach programs to educate villagers. The BLM staff intended to cosponsor a public outreach position in Kotzebue, but this project has since fallen victim to budget cuts and staff reductions. BLM staff has been participating in efforts to form a cooperative management strategy for the WACH that will involve a variety of user publics and agencies. Scoping meetings have been held in various locations, including Barrow, Nome and Kotzebue. The BLM will continue to participate and provide input to these sessions, including the dissemination of the findings from our field work studies on caribou range assessment, utilization, and fire effects and management.

Conflicts within the reindeer herding industry due to caribou incursions into reindeer allotments have become more serious as the WACH has increased in size over the past decade. The winter of 1996-97 saw one of the largest migrations of caribou onto the Seward Peninsula in recent history, with close to 100,000 animals spending a significant portion of the winter there. Due to the observed decline in lichen cover at traditional wintering grounds, and the availability of lichen habitats in parts of the Seward Peninsula, we expect conflicts to increase for herders in the migration path. The BLM should continue to work with the herders and with the ADF&G to minimize the impact of conflicts by keeping herders apprised of caribou movements. This was one of the main goals of the Buckland Valley HMP, but has received less attention in recent years due to other management priorities.

Habitat Management

Management plans for other caribou herds in Canada and Alaska include management strategies such as: (1) minimizing development within caribou habitat, (2) allowing a natural fire regime, (3) modifying the fire regime to promote high quality lichen habitat, and (4) decreasing predation. Due to the large size of the WACH wintering range, its remote location, and the lack of herd fidelity to a specific wintering area, intensive management of the habitat is impractical. Human-caused impacts to the habitat are minimal and are limited to areas adjacent to towns and villages and within traditional reindeer grazing ranges. The potential for significant development within the winter range is low. Past reindeer grazing has likely been the most widespread, human-caused impact on habitat quality. However, current levels of reindeer grazing are very low due to caribou incursions into traditional reindeer ranges, resulting in loss of reindeer when they join the migrations of their wild cousins. Predator control is under the purview of the ADF&G.

More intensive fire management of the high-forage-value wintering areas currently being used by the caribou is one strategy that BLM could potentially employ to buffer the impact of a population decline. Currently, management of most of the wintering area is under a Limited fire suppression option management strategy, meaning that fires are allowed to burn naturally unless they pose a threat to human life or property. This includes both natural and human-ignited fires, although most of the wildfires are caused by lightning. The BLM has reconstructed known fire history of the region, and mapped and classified vegetation from satellite imagery over the past few years. These products, along with other ecosystem and human values, could provide a basis for goal-oriented fire management of the region. Such a management system has been designed for the Beverly Qamanirjuaq caribou herd in Canada (Beverly and Qamanirjuaq Caribou Management Board, 1994).

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APPENDIX 1: WACH habitat monitoring and utilization studies plant species codes.

SPECIES	ABBREVIATION
Graminoid species	
Grasses and forbs	GRAM
Carex spp.	CAREX
Eriophorum spp.	ERIOP
Eriophorum vaginatum	ERVA4
Hierochloe spp.	HIERO
Poa spp.	POA
Forbs	
Andromeda polifolia	ANPO
Astragalus spp.	ASTRA
Epilobium angustifolium	EPAN2
Equisetum spp.	EQUIS
Lupinus spp.	LUPIN
Oxycoccus microcarpus	OXMI
Oxytropis spp.	OXYTR
Rubis chameamorus	RUCH
Stellaria spp.	STELL
Shrubs	
Arctostaphylos alpina	ARAL
Betula nana	BENA
Dryas integrifolia	DRIN4
Dryas octopetala	DROC
Dryas spp.	DRYAS
Empetrum nigrum	EMNI
Ledum palustre decumbens	LEPA2
Ledum spp.	LEDUM
Salix spp.	SALIX
Vaccinium vitis-idaea	VAVI
Vaccinium uliginosum	VAUL

SPECIES	ABBREVIATION
Lichens	
Cetraria cucullata	CECU3
Cetraria islandica	CEI
Cetraria spp.	CETRA2
Cladina mitis/arbuscula	CLMI2AR
Cladina rangiferina	CLRA
Cladina alpestris	CLAL
Cladonia gracilis	CLGR3
Cladonia spp.	CLADI3
Cornicularia spp.	CORNIC
Peltigera spp.	PELTI2
Thamnolia spp.	THAMN3
Mosses	
Sphagnum spp.	SPHAG2

APPENDIX 2: Percent cover of seven vegetation or cover classes on 25 permanent point-frame transects in northwestern Alaska, 1995-1996.

Transect Number	*Lichen*	*Moss*	*Graminoid*	*Forb*	*Shrub*	*Litter*	*Bare Ground*	*Utilization Frequency*
T1	15.2	9.3	8.3	2.5	28.6	28.5	1.8	67.0
T2	2.2	23.3	30.7	8.7	19.2	16.3	0.2	0.0
T3	19.2	2.5	35.0	2.7	32.2	9.0	0.0	83.0
T4	11.1	7.5	31.8	6.5	29.0	13.6	0.2	58.0
T5	17.3	8.6	14.0	11.0	32.8	15.6	0.7	42.0
T6	14.0	16.0	29.0	9.0	22.0	11.0	0.0	25.0
T7	11.7	3.7	30.2	6.2	33.3	13.3	1.5	33.3
T9	10.8	6.2	47.8	6.8	22.5	6.5	0.0	42.0
T10	8.6	1.8	39.5	4.3	36.8	8.5	0.0	25.0
T11	19.3	5.2	41.8	5.0	18.3	10.5	0.7	25.0
T12	10.5	4.5	41.0	0.0	28.1	14.6	1.0	42.0
T13	34.8	3.5	27.0	7.6	18.0	8.8	0.2	58.0
T14	1.5	5.3	48.8	5.6	29.6	7.6	1.1	8.0
T15	11.0	11.1	42.0	5.8	19.6	10.1	0.2	67.0
T16	6.6	7.8	24.8	2.8	42.3	15.3	0.2	50.0
T18	4.8	1.8	1.1	6.5	37.0	29.0	8.0	0.0
T19	35.3	1.8	1.7	0.2	22.0	12.3	1.6	58.0
T20	9.3	2.3	12.6	2.5	53.3	19.3	0.2	50.0
T21	15.8	4.7	23.2	4.2	32.3	20.0	0.0	50.0
T22	28.8	1.3	24.2	6.5	26.0	12.2	0.2	33.3
T23	30.2	6.0	15.2	13.3	27.2	8.0	0.0	25.0
T24	31.0	3.0	4.3	6.2	35.3	12.8	5.7	25.0
T25	20.5	2.8	5.5	3.7	59.8	6.8	0.7	41.7
T26	33.7	3.6	24.3	6.2	22.2	9.8	0.0	25.0
T27	15.8	2.3	33.2	4.0	30.3	13.7	1.0	33.3
Min	1.5	1.3	1.1	0	18	6.5	0	0
Max	35.3	23.3	48.8	13.3	59.8	29	8	83
Average	16.8	5.8	25.5	5.5	30.3	13.3	1.0	38.6
Std err	2.0	1.0	2.9	0.6	2.0	1.2	0.4	4.1

APPENDIX 3: Mean percent of discerned plant fragments from caribou fecal pellets collected from the Western Arctic Caribou Herd winter range 1995.

	Transect number															
Plants	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T9**	**T10**	**T11**	**T12**	**T13**	**T14**	**T15**	**T16**	**T18**
Carex	0.6	0.0	2.4	0.0	1.7	1.2	7.3	0.0	4.5	0.0	2.1	4.3	0.6	1.3	1.2	0.0
Eriophorum	0.6	8.3	2.3	9.3	1.2	9.0	4.3	3.7	5.2	3.4	10.5	10.0	5.5	1.8	0.0	0.0
POA	0.6	0.0	0.5	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3
Total Gram.	1.7	8.3	5.2	9.3	2.9	10.2	12.3	3.7	9.7	3.4	12.6	14.2	6.0	3.1	1.2	3.3
Cetraria	1.1	0.6	0.6	4.0	0.0	1.2	0.7	1.1	0.7	0.0	1.3	0.0	0.0	0.6	2.3	3.8
Cladonia	88.4	84.5	86.3	74.7	87.1	84.3	73.5	83.8	73.1	92.4	73.6	79.4	86.7	82.2	81.8	80.3
Peltigera	0.0	0.0	0.0	0.0	1.2	0.0	2.1	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Lichen	89.5	85.1	87.0	78.8	88.3	85.6	78.4	85.0	74.4	92.4	74.9	79.4	86.7	82.8	84.1	84.1
Moss	5.1	4.3	1.6	2.0	2.3	0.0	2.7	2.3	0.8	0.0	2.0	0.0	2.8	1.8	1.1	1.3
Sphagnum	0.0	0.0	1.1	0.0	1.1	0.0	0.6	1.8	2.2	0.0	0.0	1.3	0.0	1.8	0.7	0.0
Total Moss	5.1	4.3	2.7	2.0	3.4	0.0	3.3	4.1	3.0	0.0	2.0	1.3	2.8	3.5	1.8	1.3
Dryas	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Ledum	2.8	2.3	4.5	8.7	5.4	3.7	6.5	6.7	13.0	3.8	10.5	5.1	4.5	7.6	11.8	5.0
Salix	0.0	0.0	0.6	0.0	0.0	0.0	0.7	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.5	3.8
Total Shrub	3.3	2.3	5.1	8.7	5.4	3.6	7.2	6.7	13.0	4.3	5.0	5.1	4.5	7.6	12.3	10.0
Stellaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Astrag/Oxytr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Equisetum	0.5	0.0	0.0	0.6	0.0	0.0	0.8	0.5	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0
Total Forb	0.5	0.0	0.0	0.6	0.0	0.0	0.8	0.5	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0
Picea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seed	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.6	0.7

APPENDIX 3: (continued) percent discerned plant fragments.

	Transect number											
Plants	**T19**	**T20**	**T21B**	**T22**	**T23**	**T24**	**T25**	**T26**	**Min**	**Max**	**Ave**	**Std**
Carex	0.0	0.7	3.1	3.0	4.9	7.5	2.1	7.6	0.0	7.6	2.3	0.5
Eriophorum	0.0	0.5	1.8	0.0	0.9	9.5	0.0	6.9	0.0	10.5	3.9	
POA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.2	
Total Gram.	0.0	1.2	4.9	3.0	5.8	16.9	2.1	14.6	0.0	16.9	6.5	1.0
Cetraria	4.7	0.8	1.3	0.4	0.0	0.4	1.6	0.4	0.0	4.7	1.2	
Cladonia	89.6	90.8	75.8	83.1	74.0	69.5	65.3	71.9	65.3	92.4	80.5	
Peltigera	0.0	0.0	5.7	5.7	4.4	1.4	5.5	0.8	0.0	5.7	1.1	
Total Lichen	94.3	91.6	82.8	89.2	78.4	71.4	72.4	73.2	71.4	94.3	82.9	1.3
Moss	1.8	2.7	0.0	2.1	1.9	1.0	0.5	0.0	0.0	5.1	1.7	
Sphagnum	0.0	2.8	0.0	0.0	0.5	0.5	0.0	0.5	0.0	2.8	0.6	
Total Moss	1.8	5.5	0.0	2.1	2.4	1.5	0.5	0.5	0.0	5.5	2.3	0.3
Dryas	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	1.2	0.1	
Ledum	4.0	1.7	7.8	2.9	4.3	5.4	7.1	5.3	1.7	13.0	5.9	
Salix	0.0	0.0	0.0	0.0	0.5	0.0	7.5	0.0	0.0	7.5	0.6	
Total Shrub	4.0	1.7	7.8	2.9	4.8	5.4	15.2	5.3	1.7	15.2	6.3	0.7
Stellaria	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	0.0	
Astrag/Oxytr	0.0	0.0	1.3	0.0	0.0	0.0	4.4	0.0	0.0	4.4	0.2	
Equisetum	0.0	0.0	4.1	2.7	8.1	4.8	5.0	6.1	0.0	8.1	1.5	
Total Forb	0.0	0.0	5.4	2.7	8.1	4.8	9.8	6.1	0.0	9.8	1.7	0.6
Picea	0.0	0.0	0.5	0.0	0.5	0.0	0.0	0.4	0.0	0.5	0.1	0.0
seed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.1	0.0