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Assessment of Alaska reindeer populations and range conditions

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Abstract: Populations of reindeer *(Rangifer tarandus)* have fluctated greatly since their introduction to Alaska in 1891. In the 1930s, reported numbers exceeded 600,000. Presently, 38,000 reindeer graze 6.2 million ha of rangeland and woodland in Western Alaska (from 66°54′N to 52°07′N latitude). Condition of winter range producing fruticose lichens *(Cladina rangiferina, Cladina arbuscula, Cladina stellaris, Cetraria cucullata, Cetraria islandica)* is of major concern. Monitoring programs have been established for vegetation, fire, reindeer and wildlife. Reindeer have overgrazed lichen resources on some Bering Sea Islands. Wildfires have had the greatest impact on lichen range depletion on the mainland. Overgrazing has been a problem in localized areas. Moose *(Alces alces)* and muskox *(Ovibos moschatus)* rarely contribute to major lichen depletion. 60–80% of the mainland and 5–30% of most island winter lichen ranges are presently estimated to be in good to excellent ecological condition. Procedures for assessing condition of the lichen ranges are being further refined.

Keywords: Alaska, winter, pastures, lichens, population dynamics, sampling techniques

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Introduction

Sheldon Jackson, General Agent of Education in Alaska, toured the northern coasts of Siberia and Alaska in 1890. He noted that reindeer herding made Siberian natives more independent than Alaska natives. Private funds were used to transport 16 reindeer from Siberia to Unalaska and Amaknak Islands in September 1891, to improve living conditions and reduce starvation among Alaska natives. These reindeer starved to death for lack of lichen forage (Brickey, 1975). During 1892–1902, 1,280 reindeer from Siberia were shipped to Port Clarence on the Seward Peninsula (Churchill, 1906; Lomen, 1929). These reindeer were dispersed throughout northern and western Alaska.

Siberian reindeer herders were originally brought to instruct local natives in reindeer husbandry and herding techniques (Brickey, 1975). They were replaced by Saami herders from Norway in 1894 (Olsen, 1970). The pristine ranges provided excellent forage. With good animal husbandry practices, such as 24-hour herding, the population rapidly expanded. Net annual herd increase reached 25–33.5%/year (Palmer, 1934). By 1932, the reindeer population had grown to 641,100 (Mozee, 1933) (Fig. 1). Lomen (1929) reported that there were 90,688,259 ha of suitable reindeer range. Based on 12 ha/grazing unit, he optimistically estimated that Alaska could support 5 million reindeer.

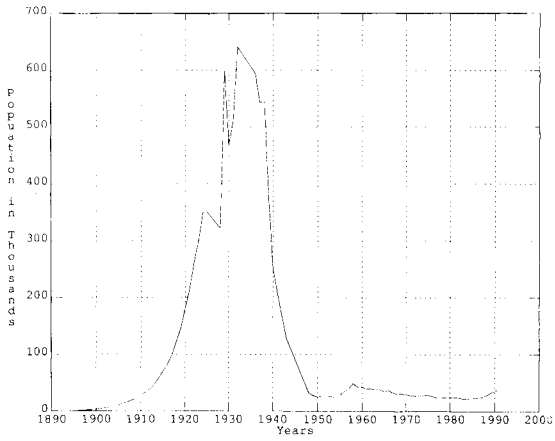

Fig. 1. Alaska reindeer populations, 1891–1991.

Reindeer became a valuable resource. Reindeer meat became a normal part of the local diet. During 1928–30, 2,500,000 kg of reindeer meat were shipped to markets in the lower 48 states (Palmer, 1934). By-product markets were developed for antlers, blood and viscera. Canned dog food was retailed. Antlers were exported and used for knife handles. Skins were used locally for making boots, parkas, trousers and sleeping bags (Palmer, 1934). Corrals slaughtering plants, underground storage tunnels and shipping facilities were constructed throughout the reindeer areas (Fig. 2).

By 1929, the non-native, profit-driven Lomen Corporation asserted much influence over the industry. The Corporation's prominence, combined with a change from subsistence to profit-driven motives, prompted congressional investigations from 1927–1938. On September 1, 1937, Congress passed the Alaska Reindeer Act, which excluded non-native ownership of reindeer. All reindeer, range grazing rights, equipment and handling facilities were transferred to a government trust.

Alaska reindeer populations began their decline in 1933. By 1950 only 25,000 reindeer remained. Population declines were attributed to inadequate herding, wolf predation, poor facilities, herder/owner conflicts and low profit margins caused by the economic depression (Abrahamson, 1968). Winter forage was destroyed by overgrazing, trampling and fire. There was poor planning of range use and insufficient knowledge of range management.

In 1920, the Bureau of Biological Survey, in cooperation with the Alaska College of Agriculture and School of Mines, initiated reindeer husbandry and range research. Investigations were conducted at the Reindeer Experiment Station at College and at the Nome and Nunivak substations. Detailed studies offeeding, breeding, forage, animals habits, diseases, insects, morphology, and caribou-reindeer crossbreeding were conducted. Of specific interest are those studies that focus on reindeer range mapping, reindeer grazing and lichen growth rates (Palmer, 1926, 1934, 1945). L. J. Palmer pioneered reindeer research in American with studies on forage plant abundance, forage palatability, and grazing strategies. Palmer and Rouse (1945) measured vegetation productivity, conducted vegetation recovery experiments, and monitored fire effects on lichens. From these and other recent efforts (Alaska and Circumpolar), principles of Alaska reindeer range management have been established.

In recent years, lucrative wet velvet antler markets and high-value speciality meat products have brought attention to potential economic development of rural Alaska. Reindeer herders, land owners and managers have expressed concerns over industry expansion. Although the industry has attempted to increase reindeer numbers over the past 15 years, statewide numbers have not significantly increased. The major causes are predation, brucellosis, induced handling stress (caused by snowmachines, helicopters, and velveting), spring harvest of pregnant females, reindeer loss to migrating caribou, and depletion of winter lichen range.

Although reindeer thrive in the more temperate Aleutian climates without a lichen winter diet, on most reindeer winter ranges, if lichens are available, they are highly preferred (Palmer, 1945; Andreev, 1954; Skjenneberg and Slagsvold, 1968; Pegau, 1968b). Lichen ranges frequently receive intensive use. The slow growth rate of lichens is widely recognized. Scotter (1963) in the North West Territories found that the average annual growth rate for *Cladina stellaris* was 3.4 mm and 4.1 mm for *Cladina rangiferina*. Pegau (1968a) found Seward Peninsula rates to be 5.0 mm and 5.3 mm/year respectively. Lichen recovery may take 20 years (25–40 years on upland ridges) following full cropping on coastal tundra (Palmer, 1934). Lichen recovery is further complicated by the competitive nature of the vascular plant community. Methods used to assess lichen ranges are discussed in the following.

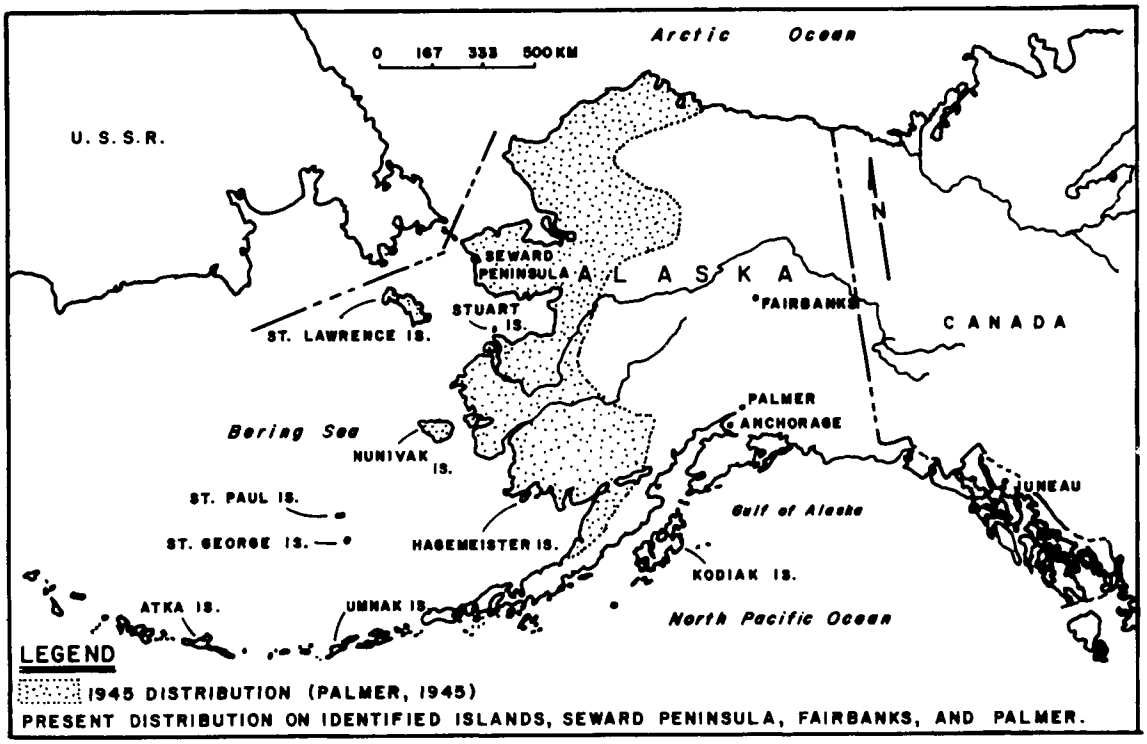

Fig. 2. Reindeer distribution, Alaska.

Methods

A variety of sampling and evaluation techniques has been used to monitor rangeland in Alaska. Data for this assessment has been consolidated from various vegetation surveys, range condition assessments, trend plot analyses and utilization checks. Historical reindeer population and range condition information has been reviewed where possible.

Ecological site descriptions were developed using data from historical climax relict areas (Soil Conservation Service, 1976). Site descriptions contain information on landscape factors, water features, soil factors, vegetation factors, wildlife, and community dynamics.

Ecological site maps were prepared using 1:250,000 scale topographic maps and false-color infrared photography at a scale of 1:60,000. Evidence was collected for fire history and grazing intensity. Crews traversed pre-established transects when possible to verify the accuracy of the maps. Procedures to evaluate ecological site include: canopy coverage, species frequency, height of vegetation, annual production, lichen and moss biomass, and soil information (Swanson *et al.*, 1983). Range condition was assessed where possible. Range condition (ecological condition) is the ecological status of vegetation for a specific site. It is an expression of the relative degree to which the kinds, proportions, and amounts in a community resemble the climax vegetation (Soil Conservation Service, 1976). Condition is divided into 4 classes: poor (0–25%), fair (26–50%), good (51–75%), and excellent (76–100%). Two separate values for condition are determined on ecological sites where lichens are the key for management and/or supporting > 130 kg/ha live lichen biomass. The first condition value represents vascular plants, and the second value represents condition of lichens. For example, a condition rating of 100/100 indicates that the plant community exhibits balanced floristic composition and matches its expected potential. The subsequent rating of the same community at 95/45 would indicate that a disturbance had occurred, and although the vascular plants had nearly recovered to climax potential, the lichen component had yet to reach half its climax potential. If lichens are not part of the potential vegetation, their component is expressed as not applicable (NA).

Trend data are important for use in determining the direction or change of ecological condition. Trend indicates whether the range is moving toward or away from its climax. Trend was evaluated by noting both quantitative and qualitative changes in vegetation characteristics while conducting surveys. Exclosures and permanent plots were also used to facilitate trend determinations.

Grazing intensity of key forage plants (utilization) was also determined during range surveys and field evaluations. Utilization is a measure of grazing intensity and extent of forage use at the end of a grazing season. Nine utilization cover classes were designated, ranging from no utilization (class 0) to extreme utilization (class 8) (Swanson and Knapman, 1986). Both lichen removal and physical damage to the habitat increase as numbers increase. Utilization classes are summarized in Table 1.

Result and discussion

The present population of reindeer in Alaska is approximately 38,000. They are found from Atka Island, 52°07′ N, 174°30′ W and other Bering Sea Islands, north to Kotzebue, 66°54′ N, 162°35′ W, (Fig. 2). Major reindeer populations occur on the Seward Peninsula and on Nunivak Island and smaller populations occur on Umnak, Atka, Kodiak, Hagemeister, Stuart, St. Lawrence, St. Paul and St. George Islands (Table 2).

Seward Peninsula

In 1892, 53 reindeer were introduced on the northeast side of Port Clarence at the site of the new Teller Reindeer Station (Brickey, 1975). The Seward Peninsula soon became the center of the Alaska reindeer industry. Stern *et al.* (1977) reported that 127,331 reindeer were on the peninsula in 1932. Numbers plummeted to 6,570 in 1951 (Fig. 3) and presently, 21,065 reindeer graze in 14 permit areas.

Also grazing on the Seward Peninsula are approximately 7,000 moose *(Alces alces)* and 700 muskox *(Ovibos moschatus)* (B. Nelson, pers. commun.). Moose and muskox have had a negligible effect on lichens, however, the lichen range has been subjected to use by increasing numbers of caribou from the Western Arctic Caribou herd. The caribou herd possibly numbers 400,000 animals at present and 200,000 caribou from that herd were observed utilizing reindeer range near Shaktoolik for part of the 1990–91 winter (P. Sagoonick, pers. commun.).

Table 1. Lichen utilization cover classes

Class	Disturbance
0 – None	No disturbance; pristine.
1 – Trace	Trace to 5%; no trampling.
2 – Slight	5% – 25%; slight grazing; no craters.
3 – Moderate	26% – 50%; slight grazing and/or trampling; often evidence of top cropping; may have shallow craters in the mat.
4 – Moderately heavy	51% – 75%; lichen use apparent, top cropping evident; craters visible from a distance of 6 m.
5 – Heavy	76% – 100%; trampling and/or craters evident; adequate lichen remains for regeneration.
6 – Severely heavy	Craters extend through the mat; trace – 25% mineral soil and/or organic material exposed.
7 – Severe	Craters extend through the lichen mat; 25% – 50% mineral soil and/or organic material exposed; lichen fragments are <2 cm.
8 – Extreme	Craters extend through the lichen mat; 50% – 100% mineral soil and/or organic material exposed; lichen fragments not adequate for regeneration.

Table 2. Alaska reindeer grazing areas, reindeer populations and ha/reindeer.

Grazing area	Area (ha)	Reindeer	Year	ha/Reindeer
Seward Peninsula	5,060,729[6]	21,065	91	240
Nunivak Island	427,115[3]	6,500	89	66
Umnak Island	100,000[5]	4,500	90	22
Atka Island	40,486[1]	2,00	90	20
Stuart Island	9,328[4]	1,500	91	6
Hagemeister Island	27,126[2]	952	91	28
St. Paul Island	10,729[4]	600	91	18
St. Lawrence Island	388,664[4]	400	91	972
Kodiak Island	unknown	250	91	NA
St. George Island	9,069[4]	100	91	91
St. Matthew Island	33,166[4]	0	90	NA

Source:
[1] Estimated by SCS, Anchorage, Alaska
[2] USFWS, Alaska Maritime, Homer, Alaska
[3] USFWS, IRM Division, Anchorage, Alaska
[4] BLM Public Room, Anchorage
[5] D. Tomlin, BIA, Anchorage, Alaska - (indicates area grazed, not area of island)
[6] L. Knapman, BLM, Fairbanks, Alaska

Lightning-caused fires in stands yielding high lichen biomass have resulted in loss of lichen forage. For example, in 1977, approximately 360,000 ha of mostly winter lichen range burned. Assessment of those areas two years after the fire revealed that *Calamagrostis canadensis* yielded >3,000 kg/ha (air-dry) annual production. Cover and biomass of *Eriophorum vaginatum* and *Ledum decumbens* have increased, however, to date, lichens have not made any significant recovery. The vegetation on the northern part of the peninsula is characterized by a complex pattern of seral stages as a result of fires. Unburned climax stands of lichens occur in many areas on the peninsula. In unburned and ungrazed decadent stands total lichen biomass accumulation has been found to exceed 27,000 kg/ha (Swanson *et al.*, 1985). (Decadent lichen stands contain over-mature lichens with >75% dead lichen biomass.) Although lichen forage is lost for the long term by fire, it is a natural cyclic event which occurs periodically on most Seward Peninsula tundra ranges. The resultant reduction of lichens by fire and subsequent plant succession stages are complex. Lichen recovery and appropriate grazing system information is being collected for burned areas.

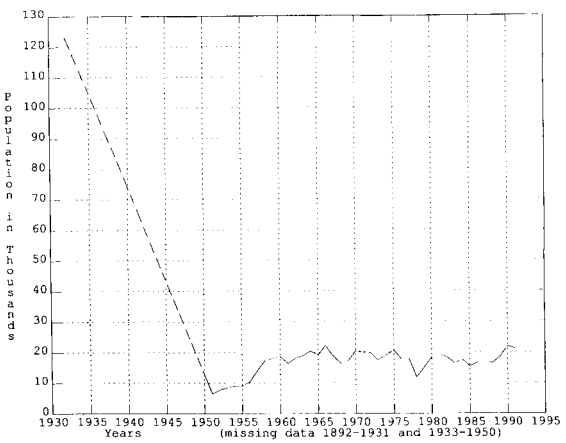

Fig. 3. Seward Peninsula, Alaska, reindeer population, 1932–1991. (sources: Stern *et al.*, 1977; Reindeer Herders Association and US Department of Interior, Bureau of Indian Affairs file).

Snow studies conducted on the Seward Peninsula winter range during 1980–1984 (SCS data files) have revealed that reindeer distribution and movement patterns create special concerns for lichen management. Although reindeer have been found to frequently alternate between low elevation thaw lakes and upland lichen habitats in winter, lichen uplands with shallow snow cover are susceptible to overgrazing during this period. Reindeer have also been observed making intensive use of the south and west facing slopes in the shallow snow foothill zone. In the foothill zone, snow depth is reduced as a result of sublimation and/or moved by wind. Most intense grazing has been found to occur in areas where the snow is <20 cm deep. Rein-

deer frequently calve in the foothill and mid-upland zones so these areas are extremely important for optimum herd production. Evaluations have revealed that many areas are in good/poor (60/20) condition and are characterized by moderate (Class 3) to heavy utilization (Class 5).

Favorite reindeer habitats in summer are windswept tide flats, beaches and spits. Inland, river gravel and thaw lakes (drained to partly drained) are also used, because they produce a select variety of herbaceous forage. Reindeer also graze upland zones and seek insect relief adjacent to snow field during hot periods. Although the summer range is subjected to concentrated herds of reindeer, the effect on the vascular plants is negligible. Seldom does overall use of the vascular plants exceed 5–10% of the current year's growth.

Trampling damage to lichens by reindeer in flight, attempting to escape insect harassment, has been found to be equal to and sometimes worse than the effects of winter grazing. Pegau (1969) in a study, assessed reindeer-vegetation interaction on 4,404 ha in the Nome area and found that 68% of the lichens were dislodged by 500 reindeer who were milling or attempting to escape insects. In an effort to protect winter lichen range, some herders presently attempt some grazing management, but such efforts are mostly confined to areas near villages. High fuel and equipment expenses, plus a lack of facilities, are the major factors that limit effective grazing management in remote areas. Damage due to fire, reindeer grazing, reindeer trampling and off-road vehicles have reduced lichens to poor and fair condition on an estimated 20–40% of the winter lichen range (Winter range supports >130 kg/ha of live lichen biomass.) Most summer ranges (predominately vascular plants) are in excellent condition in most areas.

Nunivak Island

Eighty-one reindeer from Golovin, Alaska were introduced to Nunivak Island in the fall of 1920 (Palmer, 1938). Additionally, ten woodland caribou bulls were introduced in 1925, and 523 female reindeer were added in 1928 (Palmer and Miller 1930). The island appeared to provide unlimited forage. The herd grew rapidly in the absence of predators (Fig. 4). The original estimated carrying capacity was 25,000 (Palmer and Miller, 1930). In 1938, Palmer revised the carrying capacity to 10,000. However, by that time herd increase was 33.7%/year. The population peaked at >30,000 in 1944, followed by a second peak of 23,000 in 1964. Both peaks were followed by population crashes (Fig. 4). During the 1944 and 1964 peaks, density was 1 reindeer/13 ha and 1 reindeer/18 ha, respectively. Herding and grazing management was limited. Because of lichen depletion, Rouse (1948) recommended reduction and maintenance of the reindeer population to 3,000 until lichens recovered. Extensive lichen trampling damage by reindeer was reported by Bos (1967). Fries (1977) also noted that reindeer populations had depauperated most lichens. Using microhistological techniques developed by Davitt and Nelson (1980), Swanson *et al.* (1986) reported that lichens made up 47% of the March diet for Nunivak reindeer and 36% for muskox.

Swanson *et al.* (1986) concluded that 68% of the 135,000 ha reindeer winter lichen range was in poor condition. In 1989, 6,500 reindeer were counted. A major management objective is to reduce reindeer number to 3,000 and muskox from 650 to 500.

Umnak Island

Eighty-six reindeer were introduced to the east half of Umnak Island in 1913. They increased to over 5,000 by the early 1980s. Umnak Island also supports other domestic livestock. For example, domestic sheep populations on Umnak

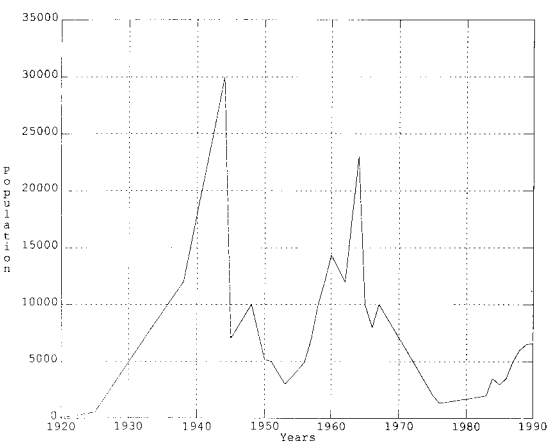

Fig. 4. Nunivak Island, Alaska, reindeer population, 1920–1990. (source: Bos 1967 and US Fish and Wildlife Service files).

peaked at 15,780 in 1969–70, but during the winters of 1970–71 and 1971–72, 60% of the flock died, due to weather and forage conditions (D. Tomlin, pers. commun.). In 1976, D. Tomlin (pers. commun.) observed *Lupinus nookatensis* (an aggressive increaser) on the upland areas on the southeastern part of the island. Preston and Fibich (1976) did not report finding any potential lichen producing sites during their survey, thus the potential for any Umnak site to produce significant quantities of lichens is assumed to be very low. Reindeer forage here is derived predominately from vascular plants, kelp and moss. In 1990, 4,500 reindeer were divided into northern and southern herds on the eastern part of the island. Recent reports of poor condition reindeer from the southern herd has created a major concern.

Atka and Kodiak Islands

As a result of Alaska Statehood in 1959, reindeer on Atka and Kodiak islands are now under the jurisdiction of the Alaska Department of Fish and Game. Overgrazing by approximately 2,000 reindeer on Atka was reported by M. Boylan (pers. commun.). On Kodiak Island, a herd of 250 utilizes a small part of the southwest corner. The herd remains stable and numbers are controlled by hunting (J. Bellinger, pers. commun.).

Hagemeister Island

Seventy-one reindeer from Nunivak Island were introduced to Hagemeister Island in 1965. An additional 73 females were imported in 1967. The purpose of the project was to develop a model management program, conduct technical studies, and help direct economic development for the Bristol Bay area. Early investigators set the carrying capacity at 1,000–3,000. Merrick (1973) made note of deteriorating range conditions during a field assessment. Historical population reports were inaccurate and inadequate and numbers exceeded the carrying capacity (Fig. 5). High populations and poor range conditions persisted, and Wiseman (1973) recommended reductions to 450. Swanson and LaPlant (1987) indicated that lowland summer range, dominated by *Carex aquatilis* and *Calamagrostis canadensis,* was in excellent condition. Mixed vascular-lichen sites (approximately 10,000 ha) were in poor condition. In a protected area, one decadent lichen stand which was

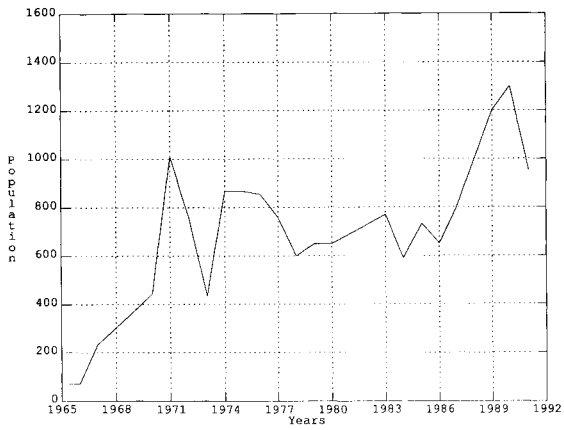

Fig. 5. Hagemeister Island, Alaska, reindeer population, 1965–1990. (source: US Fish and Wildlife Service files and Art Sowls, pers. commun.).

NOTE: Population represented depicts winter pre-calving census. The original census for years 1990 and 1991 included calves and adults. The census data for 1990 and 1991 was reduced approximately 17% to provide an estimate of the pre-calving population.

sampled, produced 10,680 kg/ha (air-dry) total lichen biomass of *Cladina stellaris, Cladina rangiferina, Cladina arbuscula* which clearly revealed the potential for lichen production. Eighty percent of the vascular-lichen areas were in fair/poor to poor/poor condition. In most areas, climax lichens were reduced to 1–1.5 cm in height. The most abundant lichens were *Thamnolia subuliformis, Sphaerophorus globosus, Cetraria delisei, Parmelia* spp., *Icmadophila ericetorum* and *Ochrolechia* spp., which have little or no value for reindeer. A total of 952 reindeer were counted on the island in 1991 (Art Sowls, pers. commun.). US Fish & Wildlife Service land managers and the reindeer owners have stablished a carrying capacity of 100 reindeer.

Stuart Island

Stuart Island has been used historically for both summer and winter grazing. The present Stebbins herd which uses Stuart Island, was brought in from Shishmaref (195 head) in the early 1980s by Ted Katcheak. Recently, the island reportedly has been grazed only during the summer months (F. Pete, pers. commun.). In previous years, the herd had used the mainland for the first half of the winter, then were driven to the island by herders over an ice bridge for co-

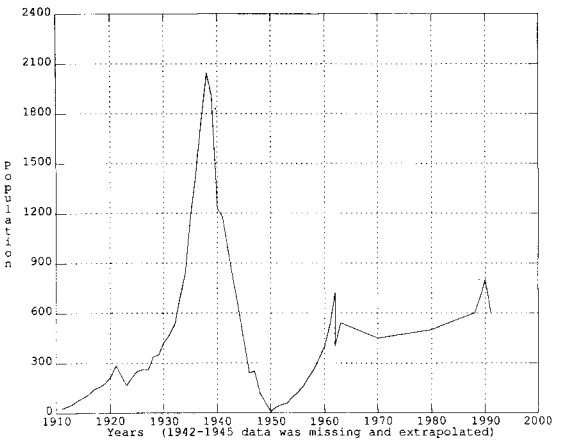

Fig. 6. St. Paul Island, Alaska, reindeer population, 1911–1991. (source: Scheffer 1951 and Davey 1963, 1970–1988 estimated).

ralling. During some years, the herd remained on the island until the reindeer swam back to the mainland during summer. Palmer and Rouse (1945) reported that in 1929 the island had been overgrazed as early as 1918. At that time, young lichens were 2–5 mm in height. Lichen cover increased rapidly then slowed as *Empetrum* and *Arctostaphylos* increased during the later stages of recovery. The estimated time for complete recovery was 25 years. The present herd numbers 1,500 (F. Pete, pers. commun.).

St. Lawrence Island

In 1940, approximately 10,000 reindeer were reported on St. Lawrence Island. Shortly afterwards, there was a major die-off caused by starvation and bad weather (J. Waghiyi, pers. commun.). Range condition and utilization were assessed on 50,000 ha during September, 1982 near Savoonga. Investigations of a wet meadow site dominated by *Carex aquatilis* showed little evidence of grazing. On the uplands, lichen utilization was found to be moderate, (Class 3), and overall condition was fair to good. The remainder of the island was not evaluated. The present reindeer population is estimated at 400 (D. Tomlin, pers. commun.), down from approximately 2,000 in 1980.

St. Paul Island

Twenty-five reindeer were introduced to St. Paul Island in the fall of 1911 from Unalakleet (Scheffer 1951). The numbers grew to >2,000 by 1938 (Fig. 6). At this peak population, reindeer reached a density of 1 reindeer/4.4 ha, 3 times greater than the carrying capacity of the range (Scheffer, 1951). With the disappearance of lichens, reindeer did not have adequate winter food reserves (Scheffer, 1951). Mid-winter temperatures fell below normal from 1938 to 1942, and large numbers of reindeer starved during this time. Klein (1968) noted that following the peak, this herd declined 37% in one year. During the 1940–41 winter, a glaze of ice developed, making grazing difficult. The following spring, local observers counted 150 reindeer carcasses on the island, mostly females and young (Scheffer, 1951). By 1950, the herd was reduced to 8 animals. A survey conducted in November 1979 when the estimated reindeer population numbered 450–550 animals, revealed that vascular plant communities dominated by *Calamagrostis* and *Empetrum* (the dominant communities on the island) were in excellent condition. Mixed vascular/lichen sites were in good/poor condition. Evidence of heavy (Class 5) to severely heavy utilization (Class 6) was observed. Reindeer were observed cratering into mineral soil and foraging on roots of *Angelica lucida, Ligusticum scoticum* and *Conioselinum chinense. Salix* spp. twigs were severely hedged, and roots had been dislodged and consumed by reindeer. Examination of rumen contents from two reindeer revealed that 40% of the rumen contents (by volume) were made up of mosses (*Aulaucomium, Sphagnum* and *Dicranum* spp.). The present population of 600 has been kept relatively stable due to hunting during recent years.

St. George Island

In 1911, 15 reindeer were placed on St. George Island. A population of 222 was reached in 1922 (Scheffer, 1951), (Fig. 7). The population declined to 168 in 1924 and to 60 by 1926. After this rapid decline, the herd continued to slowly decline until 1950 when it disappeared from over hunting. The lichen ranges remained in good condition (Scheffer, 1951). In 1980, 15 reindeer from Umnak Island were re-introduced, and the herd increased to 100 by 1991. At present, the winter lichen range is in excellent condition.

St. Matthew Island

Twenty-nine reindeer were introduced to St. Matthew Island in 1944 from Nunivak Island.

The average annual increase was possibly higher than 34% (Klein, 1959). By 1963, numbers reached 6,000 (Fig. 8). During the winter of 1963–64, most reindeer died of starvation. At peak population, density was 1 reindeer/13.2 ha. Only 42 remained in 1966 and they eventually disappeared (Klein, 1968).

The St. Matthew herd die-off was attributed to overgrazing and consequential depletion of the lichen range, intraspecific forage competition, poor reindeer condition, extreme weather conditions, and deep snow during the winter of 1963–64. Klein (1968) in the summer of 1963 noted heavy reindeer grazing pressure on summer forage but no significant lasting damage was noted, whereas the lichen mat was shattered and almost completely eliminated. Lichen conditions had not appreciably improved by 1966 (Klein, 1968). A follow-up assessment by Klein (1987), 22 years after heavy grazing use, revealed that lichen stands on St. Matthew had only recovered to 10% of the standing crop compared to those on Hall Island, an ungrazed relict area. Willows, grasses, forbs and mosses had all increased. St. Matthew Island is a classic example of unmanaged reindeer population increases followed by crash die-offs.

Summary and recommendations

Alaska reindeer populations have fluctuated dramatically over the years and at present are greatly reduced from historic high numbers. The population peaked over 600,000 in the

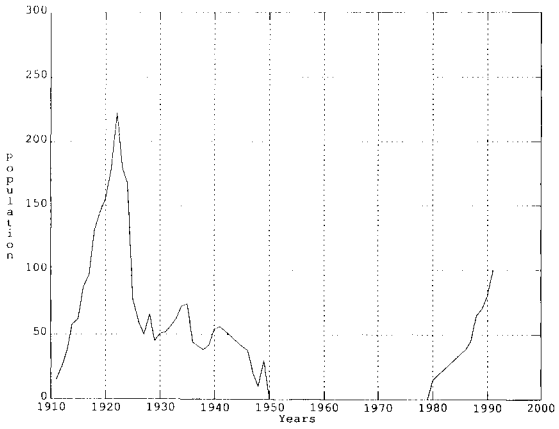

Fig. 7. St. George Island, Alaska, reindeer population, 1911–1991. (source: Scheffer 1951).

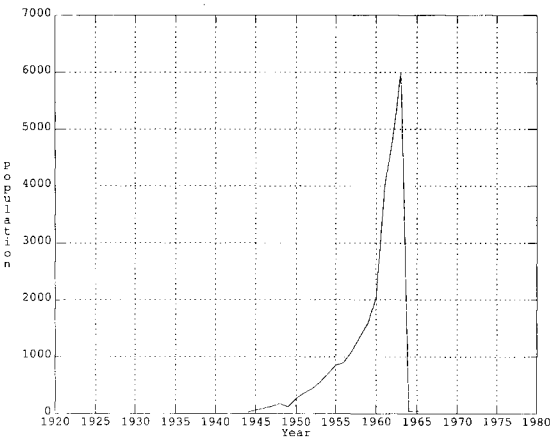

Fig. 8. Assumed population growth of the St. Matthew Island Reindeer Herd, 1944–1966. (source: Klein 1968).

1930s. Current populations are increasing slightly and are approximately at 38,000. The high numbers of reindeer in earlier years resulted in depletion of winter lichen range in many areas. Fire has also been a major factor in reducing lichen reserves on the mainland. On most islands, reindeer grazing and trampling are the major factors causing lichen depletion. Continued reindeer use of these sensitive sites prevents plant succession from reaching climax potentials. Overall, mainland winter lichen range is in better (60 to 80%) ecological condition than the islands (5 to 30%). The major reason for the difference is attributed to limited forage and space relative to the grazing populations for most insular habitats. In times of forage deficiency, mainland reindeer can move to more productive forage areas.

Reindeer grazing on sensitive tundra ecosystems epitomizes a worldwide range management dilemma. Overgrazing is not exclusively a result of high populations. It is frequently caused by poor herd management. For example, even if there were an 80% herd reduction on Hagemeister Island, overgrazing would still occur on preferred habitats. The net effect, however, would be fewer and smaller overgrazed areas. While plant composition is out of balance on poor condition ranges, plant communities have not been invaded by introduced plant species.

On low to mid elevation tundra with poor condition lichen winter range, climax lichens such as *Cladina* and *Cetraria* are greatly reduced. Poor condition indicators, such as *Thamno-*

lia, Stereocaulon, Sphaerophorus and crustose forms of *Icmadophila* and *Ochrolechia,* are increasing.

Grazing management systems are recommended to maintain or help restore ecological condition. One possible management system for tundra and taiga is rotational use of the winter grazing area. Using a three to five year rotation period and allocating 50–75 ha/reindeer of accessible (moderate to high producing) winter range that is in good to excellent condition, appears to be sufficient to maintain ecological condition. Population reductions or intensive grazing management systems (possibly both) need to be implemented on Nunivak, Atka, Hagemeister, Stuart and St. Paul Islands. In the absence of implementing management systems, populations should be reduced. The present ecological status of Umnak Island is not clear at this time.

If restoration to good or excellent condition lichen range is not possible, managers could focus grazing on preferred vascular forage plants at the expense of lichens. The potential for soil erosion and undesirable plant invasion could potentially be high. In some cases, during severe winters, reindeer would require supplements and additional forage to survive. Using this management approach, a general stocking rate of 1 reindeer for 20–40 ha/year would probably be adequate to assure a sustained yield of the vascular plants. This option is not recommended because of potential uneconomical feeding expenses and possible irreversible site alteration resulting in the permanent loss of lichen potential.

Both island and mainland reindeer populations need better monitoring if ecological range conditions are to be maintained or improved. A more accurate and expeditient accounting system for tracking reindeer numbers, grazing locations and duration of use, needs to be implemented. Timely on-site assessments are needed to evaluate utilization, range condition and trend on a regular basis. Adjustments of reindeer numbers need to be adjusted so they are commensurate with forage resources to improve social, economic and resource stability.

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References

Andreev, V. N. 1954. The growth of forage lichens and the methods for their regulation. - Transl. In: Proceedings of the V. L. Komarov Botanical Institute of the USSR Academy of Sciences, Ser. III *Geobotany.* 9: 11–74. (Translated from Russian).

Bos, G. N. 1967. Range types and their utilization by muskox on Nunivak Island, Alaska: A reconnaissance study. - *M. S. Thesis,* University of Alaska, Fairbanks. 113 pp.

Brickey, J. and **Brickey, C.** 1975. Reindeer, cattle of the arctic. - *Alaska Journal, Winter Edition.* pp. 16–24.

Churchill, F. C. 1906. Reports on the Condition of Educational and School Service and Management of Reindeer Service in the District of Alaska. - *59th Congress, 1st Session, Document No.* 483: 33–36.

Davey, S. P. 1963. Reindeer and their management on St. Paul Island, Alaska. *Bureau of Commercial Fisheries,* USDI, Seattle, Washington, 35 pp.

Davitt, B. B. and **Nelson, J. R.** 1980. A Method of Preparing Plant Epidermal Tissue for Use in Fecal Analysis. - *Circular 0628.* College of Agriculture Research Center, Washington State University. 5 pp.

Fries, J. 1977. The vascular flora of Nunivak Island, Alaska. - *Senior Thesis Project,* Middlebury College, Middlebury, Vermont. 58 pp.

Klein, D. R. 1959. St. Matthew Island reindeer-range study. - *Special Scientific Report No. 43,* USDI, Fish and Wildlife Service, Washington, D. C. 48 pp.

Klein, D. R. 1968. The introduction, increase and crash of reindeer on St. Matthew Island. - *Journal of Wildlife Management.* 32 (2): 350–367.

Klein, D. R. 1987. Vegetation recovery patterns following overgrazing by reindeer on St. Matthew Island. - *Journal of Range Management.* 40 (4): 336–338.

Lomen, C. J. 1929. Reindeer as a source of food. - *Scientific American.* 105–108.

Merrick, J. W. 1973. Letterto Bavilla and Gosuk in reference to reindeer permit. - *USDI, Bureau of Land Management,* Anchorage, Alaska. 2 pp.

Mozee, B. 1933. The reindeer problem in Alaska. - Nome, Alaska. *Gateway Publ.* 55 pp.

Olsen, D. F. 1970. Cooperative ownership experiences of Alaska Eskimo reindeer herders. - *Human Organization.* 29 (1): 57–652.

Palmer, L. J. 1926. Progress of reindeer grazing investigations in Alaska. - *USDA Bulletin 1423.* Washington, D. C. Govt. Printing Office. 37 pp.

Palmer, L. J. and **Miller, W. B.** 1930. Progress of reindeer-caribou crossbreeding experiments on Nunivak Island, Alaska. - *Biological Survey Files, Juneau, Alaska.* In: Archives, Seattle, Washington. 22 pp.

Palmer, L. J. 1934. Raising reindeer in Alaska. - USDA, Washington, D. C. *Misc. Pub. No. 207.* 41 pp.

Palmer, L. J. 1938. Management of muskoxen and reindeer on Nunivak Island, Alaska. - *U. S. Bur. Biol. Surv. Proj. Rep.* 25 pp. (mimeo).

Palmer, L. J. 1945. The Alaska tundra and its use by reindeer. - USDI, *Bureau of Indian Affairs.* 28 pp. (mimeo).

Palmer, L. J. and **Rouse, C. H.** 1945. The study of the Alaska tundra with reference to its reactions to reindeer and other grazing. - USDI, Fish & Wildlife Service, *Research Report No. 10.* Government Printing Office, Washington, D. C. 48 pp.

Pegau, R. E. 1968a. Growth rates of important reindeer forage lichen on the Seward Peninsula, Alaska. - *Arctic.* 21 (4): 255–259.

Pegau, R. E. 1968b. Reindeer range appraisal in Alaska. - *M. S. Thesis.* University of Alaska, Fairbanks. 128 pp.

Pegau, R. E. 1970. Effect of reindeer trampling and grazing on lichens. - *Journal of Range Management,* Vol. 23: (2) 95–97.

Preston, J. E. and **Fibich, W. R.** 1976. Soils and range sites of the Umnak-Unalaska area, Alaska. - *USDA, Soil Conservation Service,* Anchorage, Alaska. 41 pp.

Rouse, C. H. 1948. Muskoxen on Nunivak Island - *U. S. Bureau Biological Survey Project Report.* 9 pp. (mimeo.).

Scheffer, V. B. 1951. The Rise and fall of a reindeer herd. - *The Scientific Monthly.* 73 (6): 356–362.

Scotter, G. W. 1963. Growth rates of *Cladonia alpestris, Cladina mitis* and *Cladina rangiferina* in the Taltson River Region, N.W.T. - *Canadian Journal of Botany.* 41: 1199–1202.

Skjenneberg, S. and **Slagsvold, L.** 1979. Reindeer husbandry and its ecological principles. Anderson, C. M. and J. R. Luick, Editors; T. T. Deehr Translator. USDI, Bureau of Indian Affairs, Juneau, Alaska. Translated from *Reindriften og dens naturgrunnlag.* Universitetsforlaget, Oslo, 1968. 322 pp.

Soil Conservation Service. 1976. National Handbook for Native Grazing Lands. - *USDA, Soil Conservation Service,* Washington, D. C.

Stern, R. O., Arobio, E. L., Naylor, L. L. and **Thomas, W. C.** 1977. Socio-economic evaluation of reindeer herding in relation to proposed national interest (d)2 lands in northwestern Alaska. - Final Report for NationalPark Service. CX - 9000-6-0098, National Park Service, Pacific Northwest Region, USDI, *Institute of Arctic Biology,* University of Alaska, Fairbanks, Alaska 313 pp.

Swanson, J. D., Kinney, M. P. and **Scorup, P. C.** 1983. Reindeer range vegetation inventory procedures. - *Acta Zool. Fennica.* 175: 39–41.

Swanson, J. D., Schuman, M. and **Scorup, P. C.** 1985. Range survey of the Seward Peninsula Reindeer Ranges, Alaska. - *USDA, Soil Conservation Service,* Anchorage, Alaska. 81 pp.

Swanson, J. D., Lehner, D. and **Zimmerman, J.** 1986. Range survey of Nunivak Island, Alaska. - In: Vol I of III. *USDA, Soil Conservation Service,* Anchorage, AK. 67 pp.

Swanson, J. D. and **Knapman, L.** 1986. Criteria for evaluating lichen and other plants on reindeer ranges. (Draft) - *USDA, Soil Conservation Service,* Anchorage, AK. 27 pp.

Swanson, J. D. and **LaPlant, D.** 1987. Range survey of Hagemeister Island. - Vol. I and II. *USDA, Soil Conservation Service,* Anchorage, AK. 26 and 42 pp.

Wiseman, B. 1973. Reindeer management recommendatiaons. - *Letter to File AO63179.* USDI, Bureau of Land Management, Anchorage, Alaska. 1 p.

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