

EFFECTS OF LATE PREHISTORIC AND EARLY HISTORIC ESKIMO HUNTING
OF DALL SHEEP IN NORTH ALASKA: EXAMPLES OF ABORIGINAL OVERKILL^{1/}

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There is a tendency among many to romanticize man's relationship with nature in bygone times as compared with his relationship with nature today. One cannot deny that during the past several decades North Americans have witnessed the accelerated destruction of the natural environments of this continent by human population growth and technological advance. Further, in spite of modern education and transportation most of us possess very little practical or theoretical knowledge of natural history. One may imagine, for example, what the results would be if one hundred people were chosen at random on the streets of Montreal or San Francisco and asked to describe one or two morphological differences between a mountain goat and a bighorn sheep. Probably the results would not be very much different if the same question were randomly asked of both students and faculty on just about any North American university campus.

On the other hand, it is false to think that in the old pre-agricultural (or nonagricultural), pre-industrial days, God, man and nature related together in unified and harmonious fellowship. It is true that the native hunting, fishing and gathering peoples of the New World had intimate practical knowledge of their natural environments. It is also true that the members of some or many of those native societies treated their lands with a certain reverence that is sadly lacking in modern day culture. Nevertheless, there is neither archaeological nor ethnographic evidence to support the proposition that as a general rule they intentionally practiced conservation in order to ensure continuing abundances of natural resources. Indeed, at least occasionally, aboriginal native American hunters severely reduced populations of food species over large land areas. The purpose of this essay is to document examples of how such overkill occurred.

The data presented here refer to (1) modern day populations of Dall sheep (*Ovis dalli*) in the central Brooks Range, Alaska (Figures 1 and 2); (2) relative numbers of Brooks Range Dall sheep as they have been observed over the past 90 years; (3) the economic history of the Nunamiut Eskimos; and (4) the effects of late prehistoric and early historic Nunamiut predations on Dall sheep.

Recent Sheep Populations. Figure 2 shows a central Brooks Range region of about 5000 square miles which between September 1, 1968 and September 1, 1971, contained an estimated total population of 4425 Dall sheep. Population density was therefore .88 individuals per square mile, a figure which falls within fairly high annual density ranges for this species elsewhere (Murie 1944, Geist 1971, V. Geist pers. comm.)^{2/} Numbers of sheep within areas A to R, inclusive, in Figure 2 are those observed in July and August of these years,

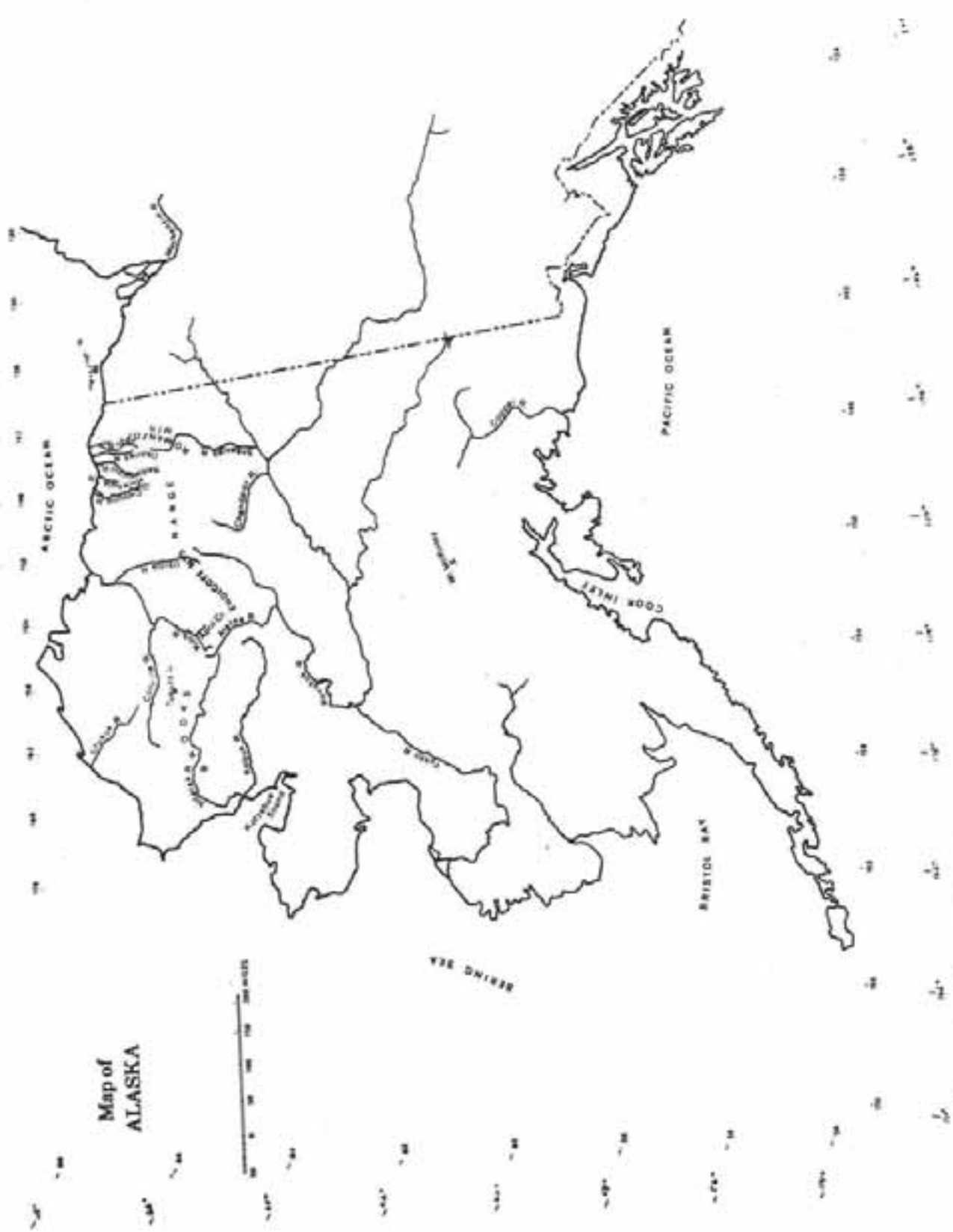


Figure 1 - Map of Alaska.

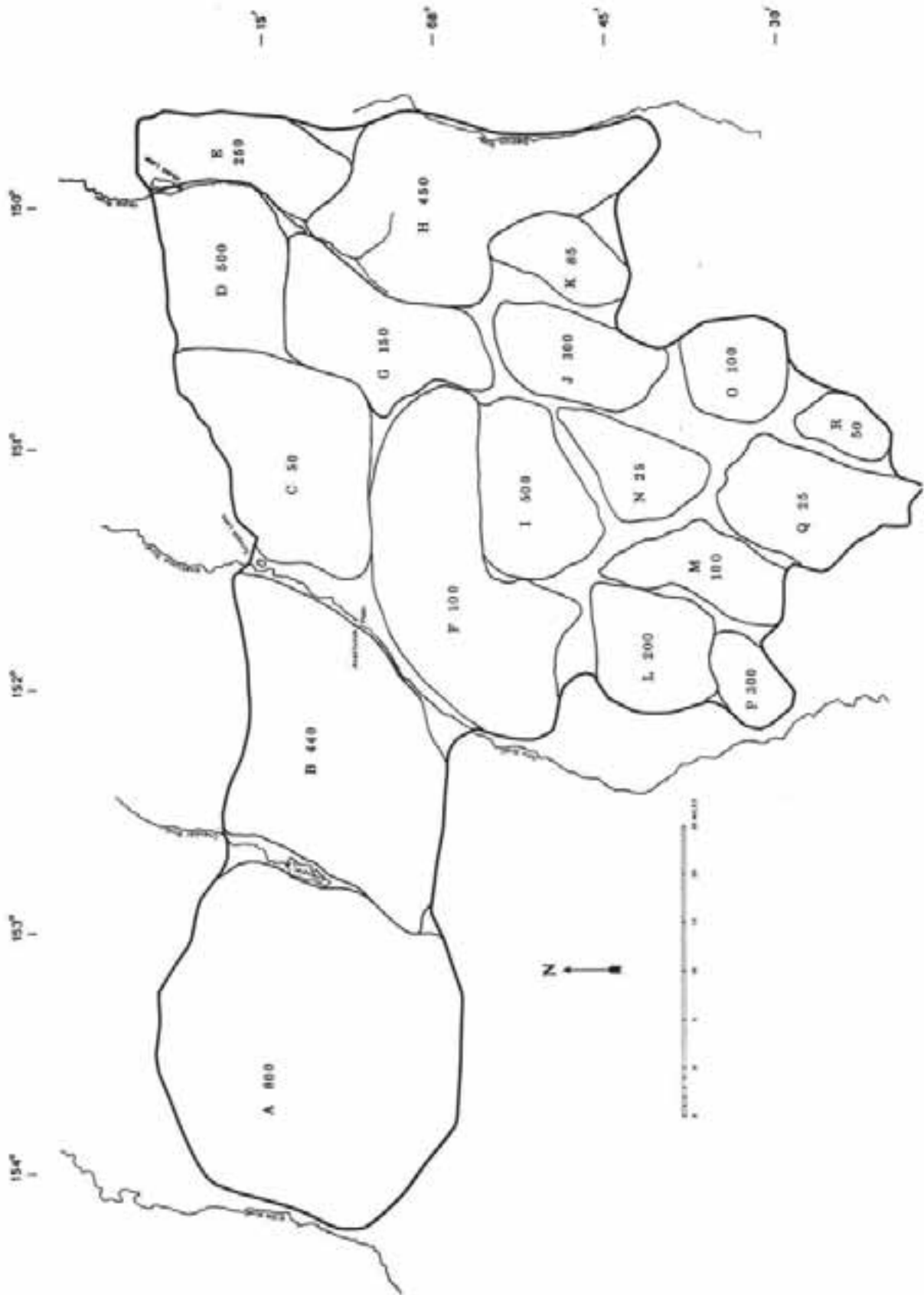


Figure 2. Modern day populations of Dall sheep in the central Brooks Range, Alaska.

but most of the areas annually contain more or less discrete populations of about the sizes noted. For example, the 440 sheep in Area B (Figure 2) seasonally migrate among its mountains, but generally remain within this area throughout the year.^{3/}

Nearly all regional sheep habitat lies either north of the tree line, which in the John River valley is 18 air miles southwest of the summit of Anaktuvuk Pass (Figure 2), or above timber line, which in the middle John River valley occurs at slightly more than 2000 feet. On the John River we have observed sheep as low as 1000 feet, but such exceptions are uncommon. Typically they are restricted to the barren uplands, from 2000 to 6000 feet. They only occasionally venture into the trees, and on the other hand they almost never occur north of the northern front of the Brooks Range (indicated by the upper, northern perimeter of the region depicted in Figures 1 and 2). Therefore, as reflected by these data, Dall sheep are relatively sedentary, and in this region their distribution is bounded on the north by the Arctic Slope, and on the south by the Boreal Forest.

No domesticated ungulates graze the sheep ranges shown in Figure 2, and the only other large, wild herbivores which are present in the region, moose (*Alces alces*) and caribou (*Rangifer arcticus*), do not compete for pasture. From both our own observations and those of Rausch (1951) the sheep of this region appear to be relatively free of disease. At present, regional human predation is minimal. Hunters now annually take fewer than 100 sheep from the total population of about 4500. In fact, many of these animals live out their lives without seeing man. Their two major natural predators are the golden eagle (*Aquila chrysaetos*) and the wolf (*Canis lupus*). The former is common, and the latter is abundant. Between them they annually take an undetermined, but probably fairly substantial, number of sheep, most of which are subadults. Considering these several factors and the fact that the sheep population density is high, the total regional sheep population probably is very close to that of the carrying capacity of this part of the Brooks Range (V. Geist, W. W. Huey, W. G. Freeman, W. S. Sandfort, pers. comm.).

Former Sheep Populations. Since shortly after 1910, sheep populations appear to have been large in most of the Brooks Range, including the region shown in Figure 2. Among other writers, Smith (1913) reports that they were fairly common on the upper Alatna River, and plentiful on the headwaters of the Noatak River (Figure 1). Smith and Mertie (1930) observed them to be common in 1924 on the upper Colville River, and fairly numerous on the head of the Killik River, and on April Creek (Figure 1). From 1929 to 1931 Marshall (1933, 1956, n.d.) reports them to have been numerous from the head of the Alatna River, eastward to about the Dietrich River (Figure 2). For the period 1940-1952 Bee and Hall (1956) remark that they were common to numerous in the mountains west of Chandler Lake (Figure 2) in parts of the Romanzof Mountains (Figure 1), and at the head of the Colville River. In a summary of observations they say "the Dall sheep is widely distributed in the Brooks Range and is generally a common mammal wherever steep slopes are present" (Bee and Hall 1956, 256).

The above references, while not exhaustive, are typical of the historical literature which testifies to the relative abundance of Brooks Range Dall sheep

during approximately the past six decades. By contrast, both ethnographic and historical accounts establish that from sometime before 1885 until about 1910 sheep were generally very scarce in the Brooks Range. Nunamiut Eskimo informants say that sheep were nearly absent from the central region (Figure 2) during the period of about 1900 to 1910, and as noted below they recall that sheep could hardly be found during the starvation winter of 1906-1907, nor again during the famine of 1910-1911.

The earliest written reference to the region shown in Figure 2 is that of Stoney (1899), who, traveling overland along the Brooks Range divide from the Kobuk River (Figure 1), reached and named Chandler Lake in 1885. He does not mention seeing Dall sheep on this journey, and in further general reference to the central and western Brooks Range, he remarks that "...sheep are not numerous; they live in the mountains and are very wild" (Stoney 1899, 839). Similar reports from the central and western Brooks Range are provided by Cantwell (1887), McLenegro (1887), Townsend (1887) and Mendenhall (1902), who, while they list other animals, either fail to mention Dall sheep, or remark on their remoteness or scarcity. Cantwell and McLenegro explored the Kobuk and Noatak River, respectively, in 1885, but do not mention this species. Townsend, who as naturalist accompanied Cantwell's party, says in reference to sheep only that "I saw a skin of a mountain sheep in the possession of a native of the lower Kowak (Kobuk) River, and saw several spoons made from their horns. The natives told us of its existence in the high hills inland" (Townsend 1887, 88).

Mendenhall, who explored the Kobuk and Alatna Rivers in 1901, says that "A few white mountain sheep are killed in the high country about the head of the Allen (Alatna), the Colville and the Kowak (Kobuk), but this game is not at all abundant (Mendenhall 1902, 56). The earliest written description of the upper John River and Anaktuvuk Pass (Figure 2) is that of Peters (1904). He traversed the John River valley twice in 1901; the second time crossing through the pass and down the Anaktuvuk and Colville Rivers to the Arctic Coast (Figure 1). It is doubtful that he and his companions actually sighted Dall sheep anywhere along this route, although they ascended a number of mountains along the John River, but he has left the somewhat cryptic observation that "...signs of goats were frequent on the mountain tops" (Peters 1904, 22).

By far the most detailed early historic accounts of Brooks Range Dall sheep are those of Leffingwell (1919) and Anderson (1913), and because these men explain the former scarcity of sheep, their remarks are worth quoting at some length. Leffingwell explored parts of the eastern Brooks Range in the years 1906 to 1908, 1909 to 1912 and 1913 and 1914. As of his last year in the field, he reported that a few Dall sheep were left on the headwaters of the Canning, Sadlerochit and Hulahula Rivers (Figure 1), but that the Eskimos could no longer depend on them for food. He explains that, "As the caribou decreased in number, the natives (Nunamiut Eskimos) began to hunt the mountain sheep more energetically. Dall's sheep formerly were abundant everywhere in the mountains, but they have already been cleaned out from the lower parts of the larger rivers."

And further that..."Until recently the Jago and Okpilak Rivers (Figure 1) were taboo (to the Nunamiut Eskimos, as also noted by Ingstad (1954)), and the sheep were undisturbed. The writer's party was the first to go far within

the mountains on the Okpilak. Sheep were constantly seen, as many as 40 or 50 in a day. The high Romanzofs will always be a refuge, so that these sheep will not be entirely exterminated"(Leffingwell 1919, 63).

Anderson, who in 1908 and 1909 reconnoitered parts of the eastern Brooks Range and Arctic Slope, as far west as the mouth of the Itkillik River (Figure 1), reports in even greater detail, as follows: "Sheep were formerly quite numerous on the heads of nearly all the rivers on the Arctic side of the (Brooks Range) divide, at least as far west as the Colville (River). It is probable that until comparatively recent times, before whaling ships began to winter at Herschel Island (Figure 1) in 1889, the sheep were not much hunted in this region. The population was sparse, and the caribou were larger, more abundant, and more easily taken. The gradual extermination of the caribou in northwestern Alaska, combined with other causes, has for many years induced Eskimo from the rivers at the head of Kotzebue Sound (Figure 1) to move across to the Colville, at the same time that many Colville (Nunamiut) Eskimo have gradually moved eastward, occupying one mountain valley after another until the sheep became too scarce to support them...(in) the Endicott Mountains (Figure 1) sheep (are) much more common on the north side of the divide than on the south side, although the south side is an uninhabited wilderness...On the Hulahula River...we found two families of (Nunamiut) Eskimo sheep hunters. One of these Eskimos had in this small river valley killed 30 or 35 sheep from June to August 1908, and 37 from September 1908 to May 1909, subsisting with his whole family almost entirely on sheep meat. This man's clothing from head to foot was made of sheepskins, his tent of sheepskins, and even his snowshoes strung with sheepskin thongs...Although the numbers of sheep have been greatly reduced, I believe that a few are still found near the head of every mountain river from the Colville to the MacKenzie (River, Figure 1). The natives (Nunamiut Eskimos and presumably others) hunt strictly for meat and skins, and the habitat of the sheep prevents the hunters in this particular region from picking up sheep as a sideline to other game hunting and trapping. When a local influx of hunters cuts down the number of sheep beyond a certain limit in some mountain valley, pressure of hunger soon causes the people to move out. Word is passed along that the said river is starvation country, and an automatic closed season affords the sheep a chance to recuperate" (Anderson 1913, 508-10).

As reviewed above, recent Brooks Range populations of Dall sheep are far greater than those which existed in the period which spanned from sometime before 1885 until about 1910. Further, as documented by Leffingwell and Anderson, the inland Eskimos, the Nunamiut, slaughtered large numbers of Brooks Range sheep, indeed they nearly exterminated some local sheep populations during at least the latter part of this period. As I will describe, on the basis of more recently collected data, Anderson's (1913) remarks, as quoted, appear partially incorrect as concerns the human history of north Alaska, as well as in regard to certain territorial characteristics of the interior Eskimos. Nevertheless, both his and Leffingwell's (1919) accounts of how the sheep were reduced are not only strongly supported, but are amplified by what is known of the former economy of the Nunamiut.

Nunamiut Eskimo Economic History. The members of several Eskimo and Indian societies hunted Brooks Range Dall sheep. From west to east on the south side of the mountains they included the Noatagmiut Eskimos of the lower and middle Noatak River; the Kovagmiut Eskimos of the Kobuk River; the Koyukon

Indians of the Koyukuk River (Figure 1), its southern tributaries and most of the lengths of its northern tributaries; and the Chandalar Kutchin Indians of the upper Chandalar and Sheenjek Rivers and their tributaries (Figure 1) (Osgood 1936, Giddings 1956, 1961, McFadyen 1966, McKennan 1965). North of the mountains, but extending slightly south of the divide in many localities, lay the territory of the Nunamiut Eskimos whose bands occupied nearly all of the northern Brooks Range, and Arctic Slope from the Utokuk River (Figure 1) on the west, to the Canning River on the east (Campbell 1962a, 1968b, Gubser 1965). All of these Eskimo and Indian groups shared numerous economic and demographic characteristics. Their hunting technologies were nearly identical, and among several of them, major food resources were the same or similar. Their populations were small and their population densities were low. For example, in late prehistoric times the Nunamiut held an area of about 66,000 square miles, yet their combined bands probably contained a total of no more than 1100 to 1400 individuals for a maximum density of .02 persons per square mile (Campbell 1962a, 1968b).

As noted above, Dall sheep were hunted by members of all of these several Eskimo and Indian societies, but the mountain bands of the Nunamiut had most direct access to sheep. Thus it is to them, and especially to their communities in the central region (Figure 2), that main attention is directed here. Nunamiut local bands, which usually contained 35 to 40 persons (6 to 10 families) and about an equal number of sled dogs, occupied the headwaters of nearly all major north-flowing streams lying within Nunamiut territory (Gubser 1965). Nunamiut oral history implies that they have lived in the Brooks Range and on the Arctic Slope for many centuries (Ingstad 1954, Gubser 1965), and it may be true that their culture memory includes events which occurred far back in time. However, from the archaeological evidence, one must conclude that Nunamiut occupations of the northern Brooks Range and Arctic Slope date only to perhaps 1600 A.D., and that they did not intensively settle these areas until approximately 200 years ago or slightly earlier. Further, it would appear that preceding the intensive Nunamiut colonizations and settlements of about two centuries ago there was a span of 600 to 800 years or more when most of the interior from the Brooks Range divide northward contained few if any human inhabitants (Irving 1953, 1954, 1962, Campbell 1962a, 1962b, E. S. Hall, Jr., as cited in Campbell 1968a). In other words, as reflected by the archaeology, one sees here an example of a hunting people quite rapidly moving into a region which had more or less lain fallow for several hundreds of years.

In the high valleys of the central region the positions of the largest as well as many of the smaller Nunamiut settlements were mainly predicated upon ease of access to migrating caribou - the animal which was by far the single most critical mainstay of Nunamiut economy (Solecki 1951, Ingstad 1954, Spencer 1959, Campbell 1962a, Gubser 1965), and the interception of which, during the spring and fall migrations, was facilitated by the enclosing mountain walls of the valleys (Campbell 1970). Because of their scarcity, food plants were very little used, and birds comprised only two or three percent of the annual diet. The major secondary Nunamiut food resource was fish of several species, which most importantly included the lake trout (*Salvelinus namaycush*). The Nunamiut therefore placed their largest settlements beside the scattered bodies of water which contained this and other fishes (Campbell 1968b), and which also lay in the paths of migrating caribou. Hence, for example, there were more or less permanent Nunamiut encampments at Chandler, Tuluak (Tulugak) and Ulu (Itkillik) Lakes (Figure 2). At these and similar lakes, herds of caribou were driven into

the water, where the animals were lanced from kayaks. In the nearby terrain the herds were also impounded and snared (Stoney 1899, Rausch 1951, 1953, Gubser 1965).

Among other food mammals, the arctic ground squirrel (*Citellus undulatus*) and Dall sheep, in that order, were next in importance to caribou (Campbell 1968b). Ground squirrels ranked high because of their widespread abundance on the high arctic slope and in the mountain valleys where in summer, a predictably lean period of the year, they were snared in large numbers. Sheep were pursued the year around, but also mainly during the warm season, and were killed with bows and arrows, and by snaring (Anderson 1913, Rausch 1951, Ingstad 1954, Gubser 1965). Nunamiut informants state that the latter technique was the more effective and most often employed.

Ground squirrels, and sometimes sheep as well, were taken close to the lakeshore encampments, the headquarters settlements of the various bands. Depending upon the season, members of each community also occupied other smaller settlements for purposes of caribou and sheep hunting as well as for other economic reasons. To obtain the necessities of life, each Nunamiut band therefore acquired a territory of some 3000 to 5000 square miles, portions of which were shared with other Nunamiut bands (Campbell 1968b).

Beginning probably as early as 1850, if not earlier, the Nunamiut, via native routes, infrequently began to receive items of European-American manufacture, among which were glass beads and steel blades. Later in the 19th century they acquired a few firearms - cap and ball smoothbores, followed by repeating, breech loading rifles (Campbell 1962a). Importantly, however, ethnographic accounts support the archaeological conclusion that in at least the central Brooks Range firearms did not come into use as everyday weapons until very shortly before 1900 (C. W. Amsden, L. R. Binford, pers. comm.). Until that time, fish and game were taken with a variety of projectiles, lances, leisters, deadfalls, snares, impoundments, hooks, gorges and nets; all of native manufacture and all highly effective. They were so effective, for example that Stoney (1899) notes that an 1884 water drive at Chandler Lake (Figure 2) resulted in the killing of far more caribou than could be consumed, and our archaeological surveys have revealed other early instances of hunts in which caribou overkill occurred elsewhere in the central region.

There is no similar regional evidence for overkill of Dall sheep in the sense that animals taken were permitted to go to waste, but an archaeological site near a mineral lick in the upper John River valley (Figure 2) illustrates the efficiency of late prehistoric Nunamiut sheep hunting. Probably this camp had been occupied by no more than four to six hunters, or possibly two or three families, and for only a few weeks if not for only a few days. Its ruined structures included a cache in which we counted mandibles and mandibular fragments of 18 to 20 adult (and perhaps large subadult) sheep. Because we did not excavate the locality, this count must be considered the absolute minimum of the number of individuals of this species it contained. Parallel examples could be cited regarding Nunamiut efficiency in taking fishes, birds and other mammals.

One sees here, therefore, a highly sophisticated aboriginal food getting technology which enabled the people to obtain fish and game with relative ease.

Indeed, following extensive excavations of a large Nunamiut settlement at Tukuto Lake (Figure 1), whose occupations spanned the period of about 1500-1900 A.D., E. S. Hall, Jr. (pers. comm.) concluded that the Nunamiut were able to take as many caribou before their adoption of modern arms as afterward, and our data imply this was also true in regard to sheep. Still, the Nunamiut chronically suffered from hunger, not because of inadequate tools and techniques, but because of the nature of their physical environment - the near absence of food plants, and the characteristics of the food animals, including most importantly the habits of the caribou.

As noted, summer was a predictable season of hunger, even though at certain seasons of the year the highly gregarious caribou, the Nuniamut mainstay, were usually extremely plentiful. For example, while one can reckon total present-day populations of Brooks Range Dall sheep in a few tens of thousands, within the past decade the total number of Brooks Range caribou, including the so-called Porcupine herd, has been quite possibly 500,000 (Skoog 1968). It is not unlikely that they were as abundant a century ago, but they travel so fast and are so migratory (on our own observations many of them in north Alaska annually travel 400 to 600 miles or more) that in their yearly rounds they cannot be followed overland, and in the mountain valleys they may usually be intercepted only in spring and fall.

Caribou killed during the spring migration could not be preserved as long as those taken in fall, which remained frozen until eaten. Thus, during much of each summer, when caribou were practically absent from the mountains, fish, ground squirrels and sheep were the animals most heavily relied upon. These and a few other minor resources, while usually adequate to see the people through until the fall caribou migration, were often barely sufficient to provide the actual daily food requirements of the combined human and canine population of a Nunamiut band.

I. Skarland, as cited by Solecki (1951), estimated that before 1950 an Arctic Slope Nunamiut family of six individuals (and presumably their dogs) required a minimum of 70 (adult) caribou a year, an estimate that is supported (as it applies to Nunamiut who live both on the Arctic Slope and in the mountains) by my own ethnographic work, and that of C. W. Amsden and L. R. Binford (pers. comm.) as it applied to the Nunamiut who lived both out of the Arctic Slope and in the mountains. Live weights of six adult male caribou taken near Anaktuvuk Pass in February, November and December averaged 192 pounds, and those of eight adult females taken in April and November averaged 178 pounds (Rausch 1951). Rausch (1951, 189) remarks that "all weights were taken when the bulls were thin and without antlers. A big bull in September would weigh as much as 350 pounds."

When one considers all the other food resources which were required in addition to these caribou, one appreciates why the people and their dogs were invariably more or less hungry during summer, or at any other time when they were without their single major food animal. Hunger affecting individuals, families and larger groups in varying degrees also resulted from human error, bad weather and bad luck. These are the usual concomitants of a hunting way of life, but they have more critical consequences in the arctic than in more southern regions which contain greater numbers of species and longer food chains.

Under these conditions of normal economic stress, including the lean summers, our Nunamiut ethnographic and ethnohistorical observations over the past 18 years, and the more recent studies of L. R. Binford (pers. comm.) imply that each mountain Nunamiut family annually consumed three or four adult Dall sheep, or their equivalent weights in subadults. Live weights of four adult males taken near Anaktuvuk Pass in February and October averaged 143.75 pounds, and an adult female taken in October weighed 115 pounds (Rausch 1951). Rausch (1951, 194) states that "some old rams probably weigh as much as 250 pounds and old barren females weigh more than the younger, breeding females." From these few weights of Barren Ground caribou and Dall sheep, and from their live weights in other regions (Burt and Grossenheider 1964), one must conclude that if at any time it became necessary to substitute the appreciably smaller sheep for the caribou as the main food animal, larger numbers of sheep would be required to provide the same amount of meat. Considering the unpredictable nature of the caribou, it is not surprising that occasionally the Nunamiut made, or attempted to make such substitutions.

For example, abnormally severe economic stress was suffered during those infrequent years when in spring or fall the caribou failed to travel one or more of their customary migration paths. As remarked below, the more extensive of these temporary disappearances of the caribou have not been fully explained, but it is documented that from time to time they occurred (Stefansson 1913, Anderson 1913, Leffingwell 1919, Larsen and Rainey 1948, Ingstad 1954, Gubser 1965), and that among both the interior Eskimos and the neighboring Indians they caused terrible hardship, including sometimes death by starvation (Gubser 1965, McKennan 1965, pers. comm.; C. W. Amsden and L. R. Binford pers. comm.). Obviously, secondary food resources, among which the Dall sheep was important, were exploited more intensively than usual during such periods.

Nunamiut populations and territories remained essentially as described above until about the end of the third quarter of the 19th century, but by approximately 1880 their numbers began to decline. These reductions were primarily initiated by the American whaling industry which drew some of the Nunamiut to the Arctic Coast for the purpose, among others, of filling the ranks of the coastal Eskimo whaling crews which were being rapidly decimated by introduced diseases (Stefansson 1913). In turn these same diseases, carried inland by Eskimos, took their toll of both those Nunamiut who emigrated and those who remained in the mountains (Brower 1942, Gubser 1965, S. Paneak pers. comm.). Somewhat later, beginning shortly after 1900, the fur industry and particularly the high cash value of the coastal dwelling arctic fox (*Alopex lagopus*) attracted other Nunamiut northward (Gubser 1965), and in about the same period, because of gold discoveries on the Koyukuk River (Camden 1902, Marshall 1933) still others immigrated to the south.

These were major reasons for the human depopulation of the Arctic Slope and northern Brooks Range, which by 1920 was literally complete. From about 1920 to 1938 it appears that not a single Nunamiut Eskimo remained anywhere in the interior north of the Brooks Range divide (Gubser 1965). Another decisive factor, however, was the virtual disappearance of the caribou from much of Nunamiut territory in the early years of the present century. Explanations for this decline include statements that they were nearly exterminated by

overhunting on their summering grounds near the Arctic Coast (Stefansson 1913) and that they emigrated eastward into Canada (Ingstad 1954). (See Skoog 1968 for a detailed historical review of movements and relative populations of north Alaska caribou herds during the period of roughly 1937 to 1957). In any case, between about 1900, or slightly earlier, and about 1912 or 1915, caribou were repeatedly either scarce or absent from their customary migration paths in the central Brooks Range and on the central Arctic Slope. As a direct consequence, 6 to 10 percent of the total number of Nunamiut who still resided in the central region starved to death in the winter of 1906-7 (C.W. Amsden pers. comm.). It is appropriate to the aims of this paper that when I asked an older Nunamiut informant why, during that winter, the Eskimos did not survive by hunting sheep, he expressed a shared opinion by saying, "There weren't any."

Beginning in 1938 some of the widely scattered surviving Nunamiut returned to the Brooks Range to reestablish one band in the upper Killik River valley and another at Chandler Lake (Gubser 1965), and to find that caribou and sheep were again abundant in these mountains. In 1950 the two communities joined forces in Anaktuvuk Pass, where in that year their combined population was 70 persons (Rausch 1951), and where today their total number is about 145. With these historical data one may now more specifically approach the question of why, during a span of years which extended from sometime before 1885 until about 1910, there were so few Dall sheep in the Brooks Range.

Interpretation and Conclusions. That the former scarcity of Dall sheep reflected a population low, or crash, caused by disease, extreme weather conditions, nonhuman predators or other natural factors cannot be ruled out. Murie (1944) describes a Dall sheep crash in the area of Mt. McKinley, Alaska (Figure 1) which resulted from a severe winter. Nunamiut oral history records that a long winter of extraordinarily deep snows occurred in the Brooks Range about 1885, but it makes no mention of resulting sheep mortality, and the equally severe Brooks Range winter of 1969-1970 caused no noticeable reduction of sheep.

Lungworm (*Protostrongylus stilesi*) infestations are at least as yet unknown in north Alaska, and as I have noted, sheep in the central region seem to be free of disease. Still, it is at least conceivable that sometime before 1885 disease decimated the Brooks Range herds. Possibly, other factors were involved. As a possible example, for unexplained reasons there was a nearly 100 percent lambing failure among Dall sheep in the Copper River watershed (Figure 1), southcentral Alaska, in the spring of 1972 (L. J. Johnson and N. Steen, pers. comm.). It is also possible that Brooks Range sheep habitats were formerly smaller or otherwise less suitable than at the present time. Porter (1966) believes that the climate of the central region has gradually and slightly ameliorated over the past century. There is at least the remote possibility that sheep range has improved as a result, although on available evidence this position cannot be argued.

Finally, one may assume that the caribou decline of 1900-1910 probably caused the wolves of north Alaska to kill more sheep than before, but the number of wolves must have soon come into balance with the numbers of available prey, and in any case the caribou crash, as I have noted, followed 15 years after historical records first refer to the scarcity of sheep. In sum, while one or more of these environmental variables may have caused the low sheep populations, one may only speculate concerning their possible effects. On the

other hand, both direct and inferential evidence explain how man, in two somewhat different ways, was the major factor.

As quoted, both Anderson (1913) and Leffingwell (1919) provide eye witness reports that in the absence of caribou the Nunamiut practically exterminated local sheep populations in areas lying immediately east of the central region. One assumes that at the time of these observations the Eskimos were armed with rifles, but as I have noted, firearms probably gave them relatively small advantage as concerns the total number of animals they were able to take.

Anderson's and Leffingwell's accounts thus provide one explanation of how aboriginal peoples may, over a large region, radically reduce populations of a game species. In the extended absence of a single critical food animal, they fall back intensively on another which, because it is more sedentary and less abundant than the first species, is nearly wiped out by short-term overkill. Yet the evidence permits another interpretation of prehistoric man's role in the regional reductions of the same type of game animal - aboriginal human invasions and intensive colonizations of previously unoccupied or little occupied areas may result, over a span of decades, and under general conditions of normal economic stress, in a gradual chronic overkill of a species. Referring to the region shown in Figure 2, the following model more specifically illustrates how both these short-term and long-term reductions may occur.

Using the data reviewed above, the model assumes: (1) that more than two centuries ago, before intensive Nunamiut settlement, this region contained the same number of Dall sheep as today, about 4500 individuals; (2) that beginning with the intensive Nunamiut colonizations, this population was annually hunted by about 500 Eskimos (125 families); and (3) that each of these families annually took four adult sheep of either sex (or their equivalent weights in subadults), for a yearly total kill of 500 adults, or an indeterminable but larger total kill of adults and subadults. As further explained below the model also assumes (4) that 200 Koyukon and Chandalar Kutchin Indians (50 families) annually took the same number of sheep per family from the region shown in Figure 2, for a grand total yearly kill of 800 adults, or an indeterminable larger grand total of both adults and young. If only adults were taken, the total hunter kill was, therefore, 17.77 percent in a hypothetical first year of these combined Eskimo and Indian predations.

Biologists and game managers agree that with some exceptions otherwise healthy populations of North American wild sheep, including the bighorn (*Ovis montanus*) and its races, and the present species and its races, will maintain their numbers if the sustained annual hunter kill does not exceed a figure which falls somewhere between 15 and 20 percent of the total animals in a given population, and if the kill more or less randomly includes animals of both sexes and all ages (W. I. Crump, W. G. Freeman, V. Geist, W. S. Huey, J. P. Russo, W. W. Sandfort pers. comm.). However, if a larger percentage than that permissible is annually taken and if the population remains otherwise stable, the total population will annually decline by approximately the percentage of overkill.

Referring to the above total population, and assuming a permissible annual hunter kill of 15 percent, one sees that if only adults were taken the percentage

of overkill in a hypothetical first year of human predation was 2.77 percent, and that in the following year the region contained 4375 instead of 4500 sheep. If one assumes, instead, a permissible annual hunter kill of 20 percent, then the above kill percentage would not deplete the population. It is certain, however, that in actual practice, aboriginal hunting was not restricted to adults. Therefore, even if the adult kill was reduced to less than 15 percent, if the required number of subadults (one year old or less) of randomly different weights were added to equal the weights of 800 adults, overkill would almost certainly occur because of the need to take more of the smaller individuals to make up the same weight. In this case it is very likely that more sheep were then taken than the maximum permissible 20 percent of both sexes and all ages.

Let us therefore assume that, in a hypothetical first year of human predation of this order of magnitude, the kill randomly included both sexes and all ages and that the kill was 24 percent (1080 animals) of the total population or 4 percent (180 animals) over the maximum permissible annual hunter kill of 20 percent of adults and young. If this 4 percent overkill was annually sustained, the total population of 4500 would be reduced to less than 10 animals in 150 years. If, however, the sustained annual kill remained at the number of animals taken the first year (1080), rather than at 24 percent of those remaining in each subsequent year, the total population would reach zero in only 7 years.

As noted, these rates of overkill, expressed either as a sustained average reduction of the total regional sheep population, or as an absolute constant number of sheep killed each year, refer to continuing conditions under which there were no periods when the people were forced to rely on sheep as a major food source. However, as documented, such periods occasionally occurred not only in early historic times, but as recorded in Nunamiut oral history, far back into the past, and they unquestionably increased the rates of reduction.

This model may be criticized as follows: (1) the stated numbers of late prehistoric Koyukon and Kutchin Indians are speculative, and may be slightly high, (2) it is not certain that Nunamiut and Indian families averaged four persons. If anything, they were larger, although at least the Nunamiut families did not average more than five persons. (3) It cannot be firmly established that each Eskimo and Indian family took a yearly average of four adult sheep or their equivalent in weight. Almost certainly some of them did not, as for example families of the Koyukon Athapaskans (A. M. Clark pers. comm.). On the other hand, because the Chandalar Kutchin considered sheepskin winter clothing essential, each Chandalar family annually took four or five adult sheep (R. A. McKennan pers. comm.). (4) Regardless of the average annual number of sheep taken by each family, some of the Eskimos and Indians referred to here did not confine their sheep hunting to the region shown in Figure 2.

Perhaps, therefore, the model is not sufficiently conservative. Nevertheless, it contains other imperfections which tend to balance the score. They include the following: first, while in all probability there were no more sheep in the central region 200 years ago than at present, they may have been considerably smaller. As described, the present total population seems to reflect approximate carrying capacity. However, because the southern Brooks Range Eskimos and Indians were probably established in the region well before the Nunamiut colonizations (Anderson 1970, Cook 1970, 1971, Giddings 1951, Morlan 1973), it is quite possible that sheep in parts of the area shown in Figure 2

had been more or less intensively exploited for centuries. Second, in former times the several "discrete" sheep populations in the central region (Figure 2) were certainly not equally hunted. As noted, major regional Nunamiut settlements were situated close by or just within the northern edge of the mountains, while those of the Indians lay along their southern flanks (McFadyen 1966, McKennan 1965, Osgood 1936). Thus, as examples, most of the sheep in areas G and I (Figure 2) were less accessible to the Nunamiut than those in areas A, B and C, and similarly, most of the sheep in areas G and I were less accessible to the Indians than were those of areas M, N and Q. This situation implies that some groups of sheep within the total region would survive these Eskimo and Indian predations far longer than would others, and it would seem that this is what happened.

Considering these several criticisms, one may propose a revised model which refers only to a portion of the region shown in Figure 2. It assumes: (1) that beginning with a hypothetical first year of intensive colonization and settlement, 100 Nunamiut families, averaging 5 persons each, hunted Dall sheep in areas A, B, C, D and E (Figure 2); (2) that in this initial year the combined total sheep population of these five areas was the same as the present (2040 animals); and (3) that beginning with the first year each of the 100 families took four adult sheep (or their equivalent in weight) from these five areas combined, for a total sustained yearly kill of a minimum of 400 sheep.

If only adults were taken, the 400 animals killed in the first year would constitute 19.61 percent of the total population, which, if the annual permissible hunter kill was 15 percent of the total, would have meant a 4.61 percent overkill (94 animals).

It follows that if in each subsequent year the steadily declining population was subjected to a 4.61 percent overkill the total population would reach less than 10 animals in 113 years. On the other hand, if in each subsequent year an absolute total of 400 adults was taken the population of 2040 sheep would reach zero in 8 years. If the annual permissible hunter kill was 20, instead of 15 percent, one sees that the 19.61 percent kill in the first year would have fallen barely within the margin of tolerance. As noted, however, adults were not exclusively taken, and one may again logically assume that an indeterminable number of subadults raised the kill above a permissible annual percentage of even 20 percent (if indeed the permissible annual hunter kill is as high as 20 percent, which, it may not be). One may, of course, revise the rate of reduction of this population of 2040 animals according to one's own estimates of the numbers of subadults killed annually.

One may assume that a number of factors prevented the total extermination of Dall sheep in the central region as well as elsewhere in the Brooks Range. For example, these factors probably include: that even the major Eskimo and Indian settlements were intermittently shifted (Campbell 1968b), with the result that small, local sheep populations were permitted to lie fallow for several years at a time; that once the sheep in a given area were reduced to a certain level, it became no longer worthwhile to pursue them, with the result that the population of that area was enabled more or less to recuperate; that because of distances and rough terrain some local sheep populations were practically inaccessible to the Eskimos and Indians; and most importantly, that beginning

about 1880, the total northern Brooks Range and Arctic Slope Nunamiut population itself entered into a decline and eventually reached zero in about 1920. Nevertheless, it would appear that over a span of less than two centuries the Nunamiut, aided by other Eskimos and by Indians, gradually reduced Brooks Range Dall sheep to very low levels.

To summarize, we have shown how human hunters, using aboriginal weapons and techniques radically reduced numbers of a game species over a large land area. In our first example we have documented how in the absence of their primary food resource, the highly migratory and usually abundant caribou, the Nunamiut Eskimos fell back on and nearly exterminated local and regional sheep populations of the relatively sedentary Dall sheep.

In our second example we have described how in large part the Dall sheep decline probably began with intensive Nunamiut colonizations of the 18th century which in subsequent decades resulted in average sustained annual kills of more sheep than their populations could withstand.

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FOOTNOTES

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2/ As the reader will note, the total region depicted in Figure 2 contains several hundred square miles which only seldom if ever are occupied by Dall sheep. Thus for the total of the actual sheep ranges shown (areas A to R, inclusive), population density was probably one or slightly more than one animal per square mile.

FIGURE CAPTIONS

1. The state of Alaska, showing the central Brooks Range region (hatched area) described in the text.
2. The central Brooks Range region of about 5000 square miles which between September 1, 1968 and September 1, 1971 was occupied by an estimated total of 4425 Dall sheep. Each more or less discrete sheep population within this region is designated by a letter followed by the number of sheep each population contained.