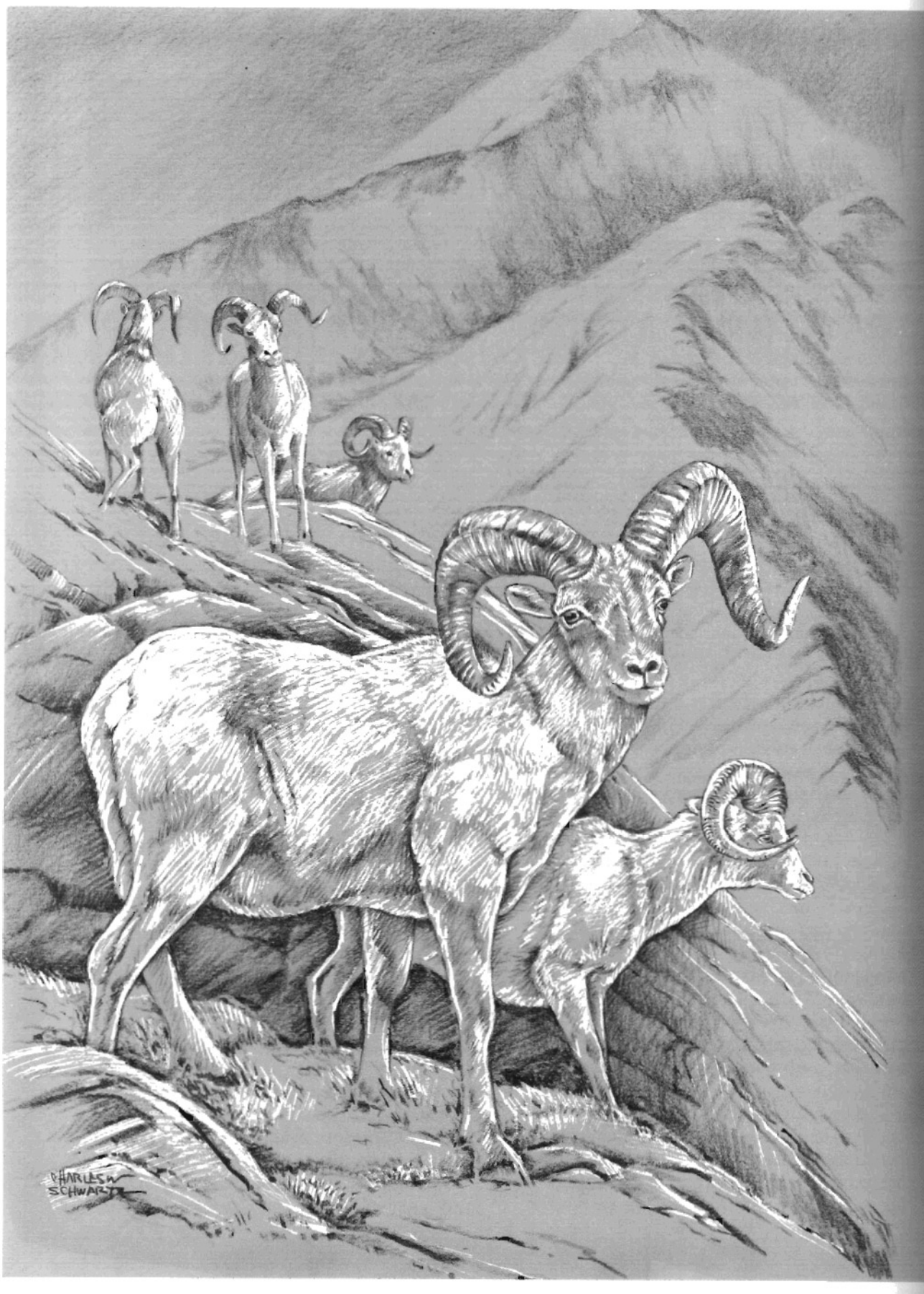

CHARLES W
SCHWARTZ

#2254

DALL'S SHEEP

Lyman Nichols, Jr.
Wildlife Biologist
Alaska Department of Fish and Game
Cooper Landing, Alaska

The thinhorn group of North American sheep includes both the Dall's and Stone's sheep, found in Alaska and northwestern Canada. Both are wilderness animals residing for the most part in spectacular alpine and subalpine mountain habitat. They are considered among the best of North America's trophy species; their horns and meat are highly prized by hunters. Because these sheep are highly visible in their white coats against the treeless green of their summer alpine environment, Dall's sheep in particular are favored subjects of amateur and professional photographers alike. In some particularly accessible areas, Dall's sheep are valued above all else for viewing and photography.

TAXONOMY

There is some debate among taxonomists whether American thinhorn sheep actually are separate species or, in fact, are subspecies of Siberian snow sheep, which are very similar in size and appearance to Stone's sheep (Cherniavski 1962, Cowan 1940, Rausch 1961). Arguments tend to favor the American thinhorn sheep as a distinct species, *Ovis dalli*.

At present, two subspecies of American thinhorn sheep are recognized. One is the "true" Dall's sheep *(O.d. dalli)*, also commonly referred to as the Alaskan Dall's sheep. It is found in Alaska, the Yukon and Northwest Territories, and the extreme northwestern part of British Columbia. The other is Stone's sheep *(O.d. stonei)* of northern British Columbia and the southern part of the Yukon Territory. Both subspecies were named after persons, W.H. Dall and A.J. Stone, respectively. Consequently, their common names should be capitalized and used in possessive forms rather than the frequently used but incorrect forms "Dall sheep" and "Stone sheep." To avoid confusion, further reference in this chapter to Dall's sheep will indicate the subspecies by that name and differentiate it from Stone's sheep. Readers should keep in mind, however, that both Dall's sheep and Stone's sheep subspecies are of the Dall's sheep species.

Two other subspecies formerly were recognized, the white sheep *(O.d. kenaiensis)* of the Kenai Peninsula, Alaska (Buechner 1960a), and the gray or saddleback Fannin's sheep *(O.d. fannini)* found between the main ranges of Dall's and Stone's sheep. The former now is considered identical to other Dall's sheep, and the latter is recognized as no more than a color gradation between the white Dall's and dark Stone's sheep.

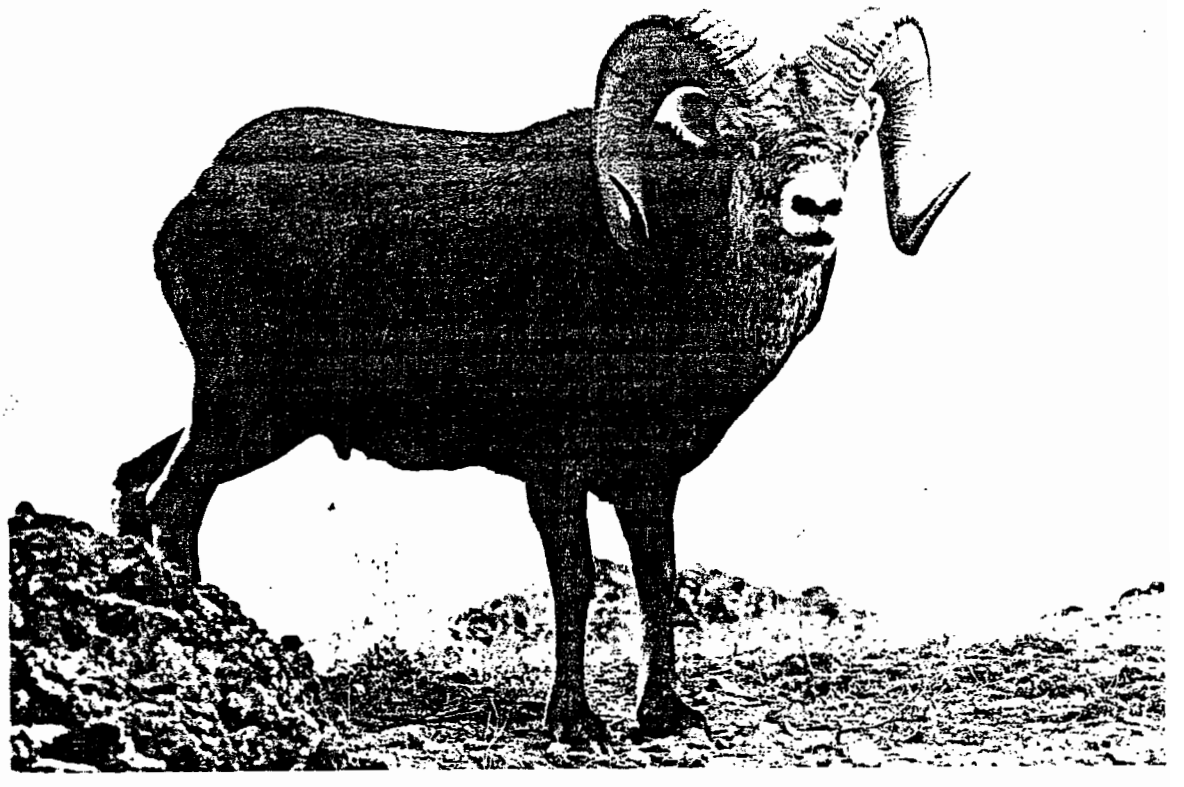
DESCRIPTION

The pelage of Dall's sheep consists of pithy, crinkled guard hairs with an undercoat of fine wool. It may be more than 5.1 centimeters (2 inches) thick in winter. The coat is typically all-white in color, although a few black hairs on the tail are not uncommon. Some newborn lambs have a considerable amount of brown in their coats with a dark middorsal line and dark hairs on the brisket, tail surface and elsewhere. These neonatal coats are lost or overgrown shortly after birth. All lambs appear white within a week or two. Dall's sheep often appear yellowish or grayish due to staining of their white coats.

Stone's sheep are typically dark brown or black with lighter-colored heads and white muzzles. They have white rump patches, bellies and rear portions of the legs. However, they may vary greatly in color, from nearly white to black. In both the Mentasta Mountains and the mountains northeast of Eagle in eastern Alaska, occasional sheep are found with gray or brown markings. Such color variations are more common in the northwestern part of Canada between the ranges of the true Dall's and Stone's sheep. These are Stone's sheep, formerly called Fannin's sheep.

The amber-brown horns of both Dall's and Stone's sheep are lighter in constuction than those of the bighorn sheep. Both sexes have horns which continue to grow throughout the animals' lives (Figure 36). Horns of rams are massive at the bases and taper to relatively fine tips. They grow in a spiral form as

Young Dall's sheep ram (left) and mature ewe in winter pelage. Note black hairs in ram's tail and thickness of coat. Photo courtesy of the Alaska Department of Fish and Game.



Mature Stone's sheep ram in late summer pelage. Photo by Leonard Lee Rue III.

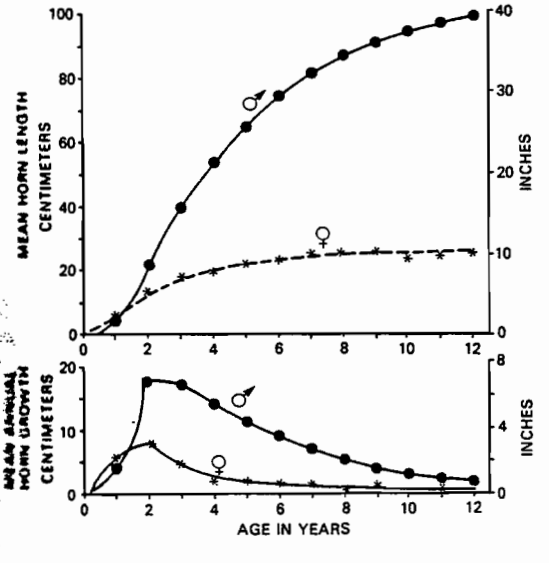


Figure 36. Dall's sheep horn growth by age and sex. Data courtesy of W. E. Heimer, Alaska Department of Fish and Game.

viewed from the side. Outside diameters of the curls of adult Dall's rams' horns average about 27 centimeters (10.5 inches), and basal circumferences average about 36 centimeters (14 inches). Exceptionally large horns may have bases more than 36 centimeters (14 inches) in circumference. The average length of a full-curl ram's horns in Alaska is about 90.1 centimeters (35.5 inches); the largest recorded horns from a Dall's ram measured 123.5 centimeters (48.6 inches) in length. Most Alaskan rams have horns of three-quarter curl by age six and reach full-curl by about eight to nine years of age. Most rams attain about 90 percent of their potential horn growth (by volume) by the time their horns are full curl. There is considerable variation in horn size among Alaskan Dall's sheep populations. This is believed to be related to "population quality" which, in turn, probably is dependent upon population density (Heimer and Smith 1975).

Mature Dall's sheep ram in summer pelage. Photo by Len Rue, Jr.

Similar data on horn curl and age are not available for Stone's sheep, but in a sample of six horns from eight-year old rams, the average length was 90.5 centimeters (35.6 inches) (Geist 1971a). Measurements of the 50 top-scoring horns (using only right horn measurements) for both subspecies as listed in the Boone and Crockett Club's record book show an average length of 111.3 centimeters (43.8 inches) for Dall's sheep and 111.5 centimeters (43.9 inches) for Stone's sheep (Nesbitt and Parker 1977). Basal circumferences averaged 36.3 centimeters (14.3 inches) and 37.1 centimeters (14.6 inches), respectively, suggesting almost identical horn growth. The largest recorded set of horns taken from a Stone's ram measured 131.6 centimeters (51.8 inches) in length.

Ewes' horns are much shorter, slimmer and less curved than rams'. In cross section, female horns form a rather narrow oval, whereas ram horns are roughly triangular. A sample of 52 horns from female Dall's sheep more than six years old averaged 24.5 centimeters (9.7 inches) long (Heimer 1972, Nichols 1971). Stone's sheep ewes probably have horns of about the same length.

Thinhorn sheep, like most northern ungulates, are heaviest and fattest in late fall and are lightest in spring after rigors of winter have taken their toll. A sample of 13 Dall's ewes weighed in the fall averaged about 56 kilograms (124 pounds) (Nichols, Unpublished), but exceptionally large ones may reach 63.6 kilograms (140 pounds) or more. By later winter and early spring, average weight in a sample of 45 ewes dropped to about 48 kilograms (105 pounds), a loss of 18 percent of average fall body weight (Nichols 1971). Data on fall weights of Dall's rams are scanty, but estimates place the

average weight of adult rams from 82–100 kilograms (180–220 pounds) with some very large rams possibly exceeding 114 kilograms (250 pounds). A spring sample of nine adult Dall's rams in Alaska showed an average weight of 69.6 kilograms (153 pounds) (Heimer 1972). Average weight of adult Stone's rams is estimated to be somewhat heavier in the fall, from 100–104 kilograms (220–230 pounds). Exceptional individuals possibly exceed 114 kilograms (250 pounds). Whether or not a real weight-size difference exists among the subspecies has not yet been demonstrated.

Mean height at the shoulder for nine Dall's rams more than six years old was 93.3 centimeters (36.8 inches), and 84.4 centimeters (33.2 inches) for 62 ewes older than six years.

LIFE HISTORY

The life cycle of thinhorn sheep begins with the rut, which takes place in early winter, generally extending from mid-November to early December. For two successive years in Alaska's Kenai Mountains, the peak of rutting activity in one herd was found to be November 30 (Nichols, In press).

Lambing occurs during late May and early June, following a gestation period of about 171 days. Chronology of lambing appears to vary somewhat from year to year and among herds in Alaska. Whether it is a function of variation in the rutting season is not yet known. It may be merely an anomaly of data resulting from variable mortality at birth which, in turn, affects the numbers of living newborn lambs observed. Single births are the rule for both subspecies, although twinning occurs infrequently.

Lambs weigh about 3.2–4.1 kilograms (7–9 pounds) at birth and grow rapidly during their first summer, reaching an average weight of about 30.4 kilograms (67 pounds) by fall. Weaning usually takes place by October even though most lambs appear capable of fending for themselves by two to three months of age. Lambs remain with their mothers during their first winter, and nursing occasionally may be observed during winter and even the following summer. There is some evidence on poor ranges in Alaska that many Dall's ewes nurse their lambs throughout the winter and only bear one lamb every other year (Heimer 1976). If these behaviors are general rules, they may function as adaptations to reduce the birth rate and increase survival of lambs born on depleted ranges. The sex ratio at birth is probably about equal, although the few data available suggest a preponderance of males (Geist 1971a, Nichols, In press).

Yearlings of both sexes may be sexually mature by 18 months of age, although some do not mature until the following fall. Maturity in domestic sheep is related to physical condition and weight rather than age alone, and this may apply to wild sheep as well. If so, well-fed, larger individuals tend to mature faster than smaller, less adequately nourished sheep. Male yearlings, even though physiologically capable of participating in reproductive activities, seldom do. Dominance order among males prevents most rams from breeding until they are about seven years of age (Geist 1971a).

Ewes and rams probably are capable of reproducing throughout their life-spans. In several seasons of observing Dall's sheep during the rut, I saw no old rams which were not active participants. I collected two pregnant Dall's ewes which, from horn annuli, were estimated to be more than 13 years old. I also found one 15-year old ewe that died after giving birth. Another ewe, 16 years old when captured and marked, was accompanied by a lamb. She was observed for three more years, but without lambs.

During a study of a Dall's sheep herd in Alaska believed to have reached or exceeded the carrying capacity of its range, all 18 adult ewes taken were found to be pregnant. Three of four yearling (18-months old) ewes collected also were pregnant (Nichols, In press). Thus, even under conditions of environmental stress, Dall's sheep can have a pregnancy rate of as high as 100 percent in adult ewes and, in this case, 75 percent in

yearling females. The effective natality rate—the number of lambs that survive long enough to be observed—normally is much lower than this, however. A ratio of only 20 lambs to 100 ewes was observed in the above herd the following spring, reflecting an approximate 80 percent loss from potential reproductive gains. Average productivity of Dall's sheep in Alaska was about 37 lambs per 100 ewes over a number of years and within a number of herds (sample = 57; standard error of mean = 2.10). However, great variability among herds and years was noted—the range was 8–81 lambs per 100 ewes.

Life-span of a wild sheep is believed to be limited primarily by teeth condition and corresponding feeding ability. The oldest Dall's ram skull found in a large series of naturally occurring mortalities in an overcrowded population was 12 years old at death (Murie 1944). Ewes tend to live longer than rams. In addition to the aforementioned Dall's ewe that was captured and marked at age 16 and lived at least three more years, Geist (1971a) reported a Stone's ewe that reached 16 years of age.

MORTALITY AND LIMITING FACTORS

Nutrition

A number of factors can affect the productivity of thinhorn sheep which, in turn, is a major determinant of herd status. In a herd with adequate winter forage, pregnant ewes receive sufficient nutrition to maintain their own physical condition and allow growth of fetuses to optimum size. Healthy, well-nourished ewes give birth to well-developed lambs and are able to provide them with ample milk, thereby assuring maximum production and early survival of young. Furthermore, these young grow quickly during their first summer and have a better chance of surviving their first winter. Under these conditions, expected mortality of adults would be low and herd increase probably would occur. On the other hand, in a herd that has reached or exceeded its winter range's carrying capacity and thus faces a shortage of winter feed because of crowding and competition, pregnant females are unable to obtain sufficient nourishment to maintain their own physical conditions or enable optimum growth of fetuses. As a result, the pregnant ewe may experience fetal mortality through resorption or abortion to enhance her own chance of survival. Neonatal mortality, because of weakness and consequent hypothermia, and/or abandonment, also increases—sometimes drastically. Furthermore, surviving lambs may be small and grow slowly because of dams' inadequate milk supplies. They are poorly prepared to face their first winter, during which they may succumb in large numbers.

Density-dependent natality factors appear to be the most important limiting factors affecting thinhorn sheep. These sheep usually occur at near-maximum densities in relatively stable, climax habitats which are subject to harsh winters. The availability of food in these habitats may be limited severely by deep snow cover. Once a sheep herd reaches a certain density on its winter range, natural controls limit reproduction and survival, and its population becomes stable or begins to decline.

During normal winters and when snow remains soft, sheep are able to dig feeding craters down to good quality forage that is still green. Strong winds, prevalent in alpine winter ranges of thinhorn sheep, remove much of the snow from open ridges and slopes, exposing forage. By late winter, however, snow may be wind packed and impenetrable. Sheep then are forced to depend on limited amounts of poor quality feed on the few, windscoured ridges that remain snow free. At this time, sheep are in a potentially negative energy-balance situation; they may use more energy than they can take in feeding. From this time until spring, they depend heavily on stored body fat for nutritional needs. Body fat reserves

Three Dall's sheep ewes feeding in pawed-out snow craters in early winter. Photo courtesy of the Alaska Department of Fish and Game.

decline rapidly; the last to be catabolized are those stored in the bone marrow. Both lambs and yearlings, with limited fat reserves, suffer more than adults do (Figure 37).

Mortality among lambs surviving the initial rigors of birth normally is very low the first summer but high during the first winter, reaching about 40–50 percent or more in stable or declining herds. The winter of their second year is another critical period in the lives of northern sheep. Much of a yearling's summer nutrient intake supports growth rather than being stored as fat, and nutrition is not supported by mother's milk. Therefore, yearlings are more vulnerable to nutritional scarcity in winter than are adults. Few data are available on mortality rates of sheep in their second winters, but those rates appear to approach 15–20 percent.

After sheep are two years old, mortality rates decrease, presumably because their physiological growth rates decline and more nutrition is available for the production of fat reserves needed during winter. Geist (1971a) found that bighorn sheep mortality averaged about 4 percent per year from ages two to seven, then increased to 23 percent per year thereafter. Murie's (1944) data indicated a similar pattern for Dall's sheep.

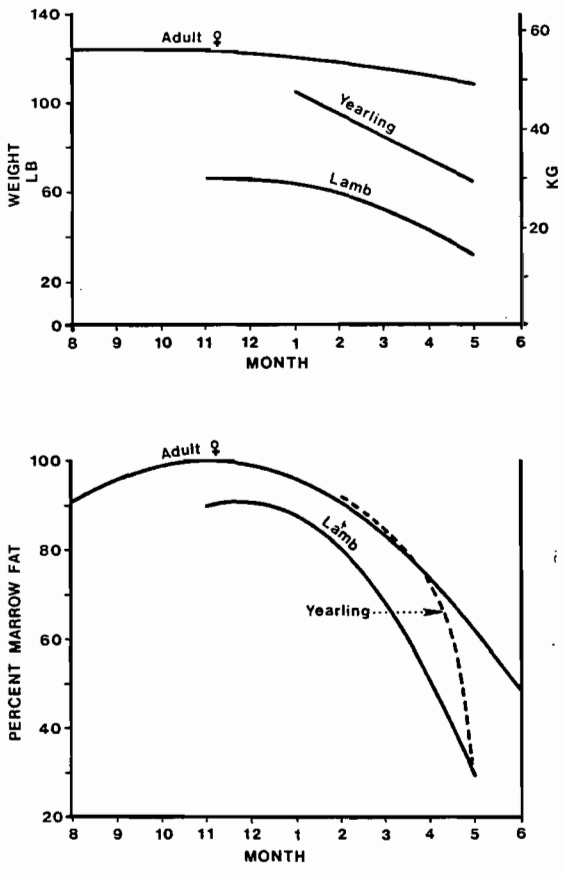


Figure 37. Changes in Dall's sheep weights and percentage fat in bone marrow by month and age classes. Least squares curves fitted to data from a series of sheep collected in the Kenai Mountains, Alaska (after Nichols, Unpublished).

Winter weather

At present, the main influence on thinhorn sheep numbers appears to be winter weather. Exceptionally severe winters may cause drastic "crashes" in sheep numbers regardless of population densities or range conditions. Successive severe winters occurred in Mount McKinley National Park, Alaska, between the late 1920s and the mid-1940s and probably elsewhere in the state. Unusually deep and crusted snow resulted in high mortality, and herds dropped to a fraction of their former abundance. Other, more localized declines have since been documented following severe winters. These were not winters of exceptional cold, but of above-normal temperatures and more-than-usual precipitation. During normal winters, snow remains light and fluffy and is blown free of alpine feeding areas. Wet snows, or thaws and subsequent refreezing, fix snow in place with a hard crust, preventing removal by wind or digging by sheep. Snow depth and hardness, maximum winter winds and temperatures the previous winter are correlated inversely to lambing success (Murphy 1974, Nichols 1976). The inferences are that lambing success is depressed by deep and hard snow, above-freezing temperatures lead to crusting, and high winds along with thawing temperatures pack snow to rock hardness. Dall's sheep are adapted to continuing cold, high winds and normally light snowfall of winters in northern interior mountain ranges.

Disease and parasites

Disease, such as actinomycosis, and parasites including lungworms and gastrointestinal nematodes are present in northern sheep, but have not been shown to be main causes of any herd declines. Neilsen and Neiland (1974) suspected, however, that gastrointestinal nematodes in particular may contribute significantly to spring mortality because of the coincidental "spring rise" in internal parasite loads and weakened condition of sheep at that time. It is probable that parasite infestations and disease exert more influence on sheep survival during times of maximum population density and environmental stress than during other times.

Predation

Thinhorn sheep are capable mountaineers, able to negotiate rugged terrain with speed and grace. They depend on this terrain for protection from predators. Ex-

cellent eyesight and a well-developed sense of smell enable them to detect potential threats before most predators become dangers. The hearing of sheep appears to be very acute, but this sense may be heeded somewhat less than others because sheep environments often are disturbed by such natural sounds as falling rocks.

Although coyotes, wolverines, lynx, black bears, grizzly bears and golden eagles occasionally take adults and lambs, the only serious predator of thinhorn sheep is the wolf. Although wolves have been observed capturing sheep both in summer and winter, they do not appear to exert any major influence on sheep numbers except in times of population overabundance, when sheep may be weakened or forced by competition and food scarcity to feed far from escape terrain.

From 1947–1961, when wolves were protected and presumably abundant, the McKinley National Park sheep herd increased at an average annual rate of approximately 11 percent (Murphy 1974). Average annual increase rates of 11–14 percent were observed in three Kenai Peninsula herds where no wolves were present (Figure 38).

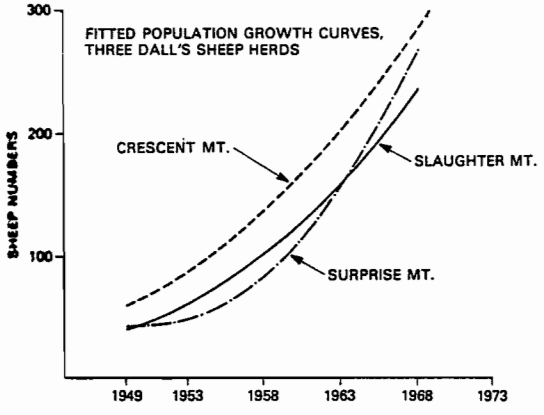


Figure 38. Increase patterns of three Dall's sheep herds in the Kenai Mountains, Alaska, two of which (Surprise Mountain and Crescent Mountain) were heavily hunted for rams, while the third (Slaughter Mountain) was closed to hunting (after Nichols 1976).

Accidents

Accidental falls take a small number of sheep, as do avalanches and other accidents. Nevertheless, it is winter weather which—by restricting both food supplies and movements—exerts the only known mortality of significance to thinhorn sheep populations at the present time.

BEHAVIOR

In general, sheep are diurnal, although some movement may occur at night. Summer daylight in the North is long, so sheep may be found moving or feeding at almost any time. Major feeding periods generally occur during early morning and late afternoon with occasional shorter periods of grazing activity about mid-day. Much of the time between feeding is spent resting and ruminating. Preferred resting sites, particularly at night, are on or very close to cliffs or large rock outcrops which serve as escape cover. Daily movements generally consist of moving out of rugged terrain to preferred feeding areas in the morning, then drifting back before dark. During the short winter days, morning and evening feeding periods are interrupted by a brief midday rest. Most rumination probably occurs at night when feeding and movement are relatively difficult.

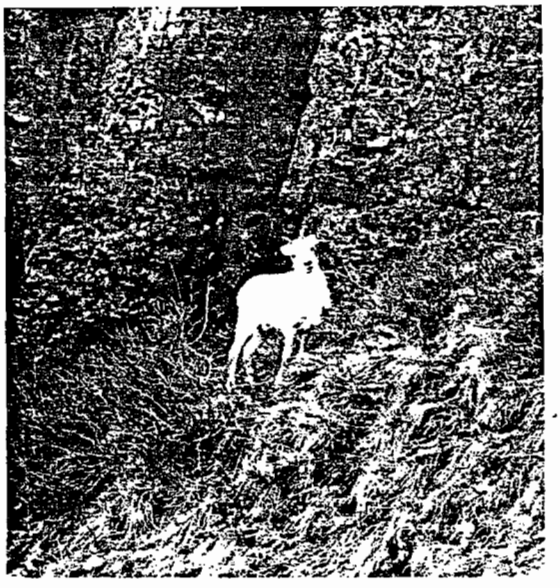
During summer, thinhorn sheep may move considerable distances from winter home ranges to occupy nearly all suitable alpine habitat in an area. By late summer, they begin to drift back to wintering ranges, where they congregate before the rut begins. Winter range usually is a small part of the overall range and is limited by snow conditions to those areas where snow-free feeding sites and escape terrain lie in close proximity. In early spring, sheep usually move lower on slopes, often into the upper limits of subalpine timber. They seek the first emergent green vegetation when snow lines begin to recede. Sheep move upward with the receding snow line until they are free to leave their winter-spring ranges.

Mid-day rests between morning and evening feedings are common during short winter days. Photo by William E. Ruth.

Where summer and winter ranges are contiguous, annual movements can be characterized as dispersal over all suitable habitat during summer, and withdrawal to smaller areas that provide necessary winter habitat. Actual migrations may occur along traditional routes in spring and fall where summer and winter home ranges are separated by unsuitable habitat such as forests or wide river valleys. Visits to mineral licks are an important part of winter-to-summer range movements of Dall's sheep. Sheep, especially ewes with lambs, may linger in the vicinity of licks for days, weeks or even much of the summer. Heimer (1974) and Geist (1971a) reported high incidence of individual adults returning to their previously occupied seasonal ranges year after year.

Sheep society centers about two basic groupings: maternal ewe, lamb and yearling groups which often merge into larger herds; and ram groups. As parturition approaches, pregnant ewes leave their past year's lambs and seek isolation in the most rugged terrain available, where births take place. They remain there for several days following parturition (Pitzman 1970). They then move away from lambing cliffs, which usually are merely part of the spring range, and join other ewes with new lambs. Meanwhile, abandoned yearlings frequently form small groups which follow one or more barren ewes. Frequently male yearlings begin to follow older rams.

Nursery groups, consisting of ewes with new lambs and occasional yearling females, persist for a few weeks after parturition, then gradually merge with groups of barren females and yearlings to form loose herd associations that occupy summer ranges. The basic unit of these groupings is a lactating ewe, her lamb and frequently her yearling female. However, some male yearlings remain with ewe-lamb combinations.



Dall's sheep ewe seeks solitude and rugged terrain just prior to parturition in the spring. Photo courtesy of the Alaska Department of Fish and Game.

After the rut, during which all ages and sexes are intermixed, older rams usually seek the company of other rams even though they may remain on the same winter range as the ewe groups. As soon as snow conditions permit in the spring, groups of rams which have begun congregating on spring range move toward summer range, frequently assembling in large groups en route. During these movements, smaller rams follow the largest ram in the group. At this time, many yearling rams and most two-year-old rams leave the association of ewes and follow older rams. Rams' summer range may overlap that of ewes' or may be geographically separate. Most rams remain separate from ewes even when occupying the same areas.

Social behavior, like that of other members of the genus *Ovis,* is well-developed in thinhorn sheep. Ram behavior revolves about the establishment and maintenance of a dominance hierarchy based on the size of horns. Interactions among rams, including horn displays and the well-known clashing, may become quite complicated and occur throughout the year except during stress conditions of late winter.

Sheep interactions are well-documented by Geist (1971a). Rams determine and maintain social orders with limited confusion and damage to individuals through visual recognition of each other's horn size-dominance status. Large-horned rams are socially dominant, treating all smaller individuals as "females," while small-horned rams are aggressive toward dominant rams. Ewes are largely ignored by rams since they react passively except during estrus periods. When in estrus, ewes behave somewhat like small males and encourage social and sexual behaviors by adult males. During the rut, the established dominance pattern between rams may be disrupted temporarily when a ewe comes into estrus, with all nearby classes of mature rams jostling and clashing for possession of the ewe. Possession is established quickly by the largest ram, who then remains with the ewe through her approximately one-day estrus, defending her against other rams and breeding her repeatedly.

Rams neither maintain territories nor gather harems. Instead, they seek out one ewe at a time and eventually leave her at the end of her one-day estrus for another. They travel widely among ewe groups just before and during the rut seeking receptive females. Although sexually mature at 1.5–2.5 years of age, rams generally do not become behaviorally mature and participate seriously in reproduction until the age of 7 (Geist 1971a). Where mature rams are removed from a herd through hunting, younger males become sexually active. In at least one Alaskan herd of Dall's sheep, all rams with horns of three-quarters curl (about six to seven years of age) and older were removed by hunting for a number of years (Nichols 1976). The remaining young rams in the four-to-six year age classes carried out all rutting activity, behavior in which they would not normally be allowed to participate. The rates of increase in this herd and another nearby herd subject to

Clashing or horn displays among rams may occur at slightest provocation during much of the year as well as during the rut. Ram on right provoked this short-lived clash to take over a hollowed out resting site. Photo by William E. Ruth.

similar hunting pressure and age structure were nearly the same as that of a third herd which was not hunted. The results infer little short-term effect on the rate of reproduction by the removal of large rams.

Serious formal clashes generally occur only among rams of nearly equal horn size and who are unable to identify each other's dominance status. Clashing and other breeding and social interactions appear to be less intense among Stone's rams than among bighorn rams, and even less intense among Dall's rams than among Stone's rams. This circumstance may be an adaptation to conserve energy resources of species facing long and severe winters in northern latitudes.

Ewe social behavior is much less apparent than that of rams. Except during the estrus period, it consists of little more than maternal treatment of lambs and occasional aggressive behavior towards others for space or food, as well as banding together loosely for companionship. Lambs interact frequently in play, running and jumping, and in the learning process, they exhibit many of the behaviorisms of adults. On occasion, adults will run and leap in play for short periods.

HABITAT

Dall's sheep habitat is typically alpine: steep, open grasslands interspersed with broken cliffs and talus slopes on recently glaciated mountains. It usually lies almost entirely above timberline which, in Alaska, is variable in elevation but averages about 765 meters (2,500 feet) above sea level. Winter snowfall is comparatively light, averaging 31.9 centimeters (12.5 inches) over a five-year period on three Kenai Mountains

sheep ranges (Nichols 1976). Temperatures normally remain below freezing during the winter, and high winds sweep many ridges and slopes free of snow.

Vegetation consists largely of sedges, bunchgrasses, low shrubs such as blueberry, crowberry, dwarf willow, mountain avens, and mosses and lichens. The lower portions of sheep habitat may have large stands of dwarf birch interspersed with larger willows and dense alder and alpine hemlock thickets. In some places where broken cliffs extend suitable habitat below timberlines, sheep utilize benches supporting stands of twisted cottonwood, aspen and occasional white spruce.

Stone's sheep habitat is somewhat more subalpine in nature, and in mountains less recently glaciated and with higher precipitation than Dall's sheep habitat. There are fewer open alpine grasslands, and much of the higher slopes are covered with thickets of dwarf birch and alpine fir. Aspen, Engelmann spruce and lodgepole pine are common.

Both subspecies are primarily grazing animals, although many forbs and browse plants are eaten as well. A study of three herds of Dall's sheep in Alaska found that sedges and bunchgrasses made up the bulk of their diet, followed by lesser amounts of browse (mainly dwarf willow), moss and lichens (Figure 39). During summer, forage of good nutritional quality and great diversity is available. Sheep eat a greater variety of plants in summer than in winter when the variety, quantity and quality of available forage are reduced greatly. As indicated by amounts of crude protein, gross energy and total available carbohydrates in their summer diets, Dall's sheep obtain more than adequate nutrition during that season—which allows them to accumulate fat. By late winter, however, diet quality, as indicated by the relative amounts of the same components, deteriorates to a level below that presumed necessary for physical maintenance.

In addition to suitable climate, terrain and food, mineral licks appear to be necessary components of Dall's sheep habitat. Licks are found on most of Alaska's sheep ranges. Use is highest in late spring and early summer, and diminishes by late summer. Some licks are quite large; one serves a population of about 1,500 sheep that travels as much as 19.3 kilometers (12 miles) to the lick (Heimer 1974). Hebert (1967) found that sodium was the element most sought in natural licks by mountain goats. He suggested that lick use was the result of a high water intake on a low sodium diet (initiated by feeding on succulent forage in the spring) rather than a winter dietary deficiency. Geist (1971a) suggested that sheep use licks to replace skeletal minerals lost through catabolism during winter.

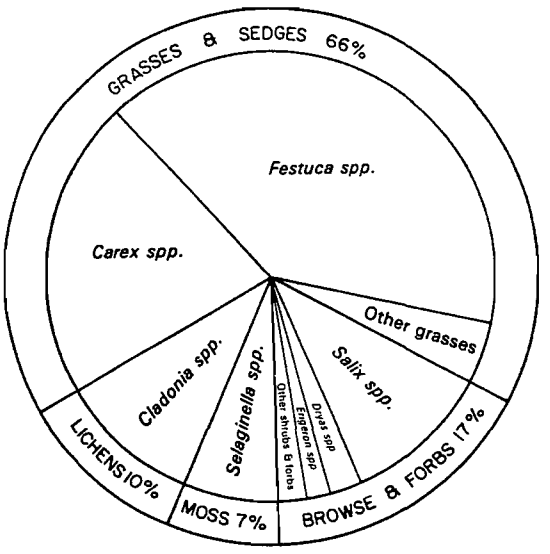


Figure 39. Diet of Dall's sheep in Alaska (after Nichols, Unpublished).

MANAGEMENT

Distribution and status

In Alaska, Dall's sheep occupy suitable habitat in the Brooks Range, the Alaska Range from the Canadian border to Lake Clark, the Wrangell Mountains, the Chugach Range, the Talkeetna Mountains and parts of the Kenai Mountains. Small

isolated herds are found in the White Mountains and Tanana Hills north and east of Fairbanks (Figure 40). Estimates place the state's population from 30,000–50,000 sheep. Early market hunting and possibly hunting by natives depleted a few local herds which appeared to recover by the 1920s. In response to a series of severe winters, a major decline apparently occurred in the 1930s and early 1940s, leaving many of Alaska's sheep populations at very low levels. Since that time, herds have recovered and now appear to have stabilized in most areas while declining gradually in a few others (Nichols 1975).

Management in Alaska mainly has consisted of allowing only the harvest of rams with horns of three-quarter curl or larger in annual August-September hunting seasons. Nonresident hunters are required to have a licensed guide. One ram is allowed per hunter each year. Approximately 1,000–1,200 rams are harvested annually (Figure 41). Recently initiated management practices include establishment of restricted access areas and full-curl ram-only hunts as well as limited either-sex hunts.

In the Yukon Territory, Dall's sheep are found in all ranges between the Yukon River and the Alaska border to the west and the British Columbia border to the south. They occur north of the Yukon River in the

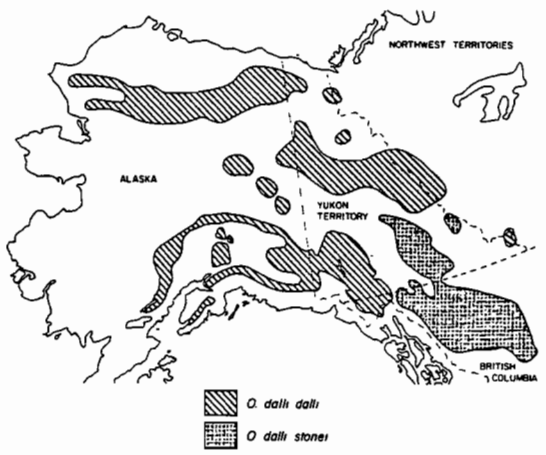


Figure 40. Current distribution of Dall's and Stone's sheep.

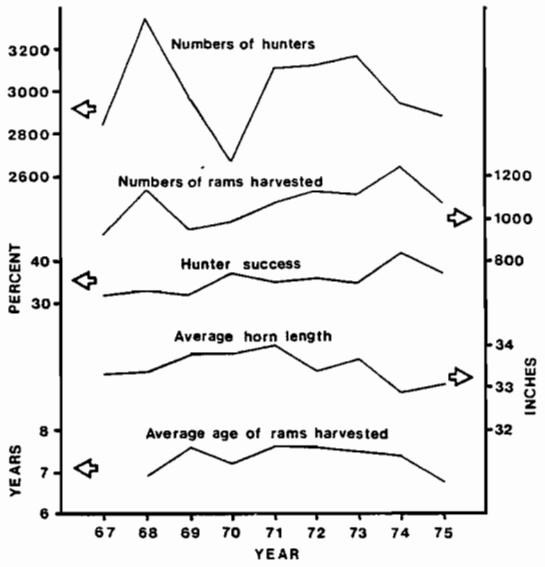


Figure 41. Dall's sheep harvest statistics in Alaska, 1967–1975.

British, Richardson, Warnecke, and Ogilvie mountains. An estimated 18,000 Dall's sheep occur in the Yukon Territory, and populations are believed to be generally stable. Stone's sheep are found in relict populations in the Cassiar, Pelly and Selwyn mountains, and the Salmon Range; a few occur in the Ogilvie Mountains. There are some 4,500 present, mostly in small and scattered bands. Populations are thought to be relatively stable (Hoefs 1975). Both subspecies are hunted under the three-quarter curl regulation, with one ram per hunter per year allowed. Guides are required for nonresident hunters, and natives are allowed unrestricted hunting of both sexes. The estimated annual harvest of thinhorn sheep in the Yukon Territory is about 250 rams.

From 3,000–8,000 Dall's sheep are estimated to inhabit the MacKenzie Mountains in the Northwest Territories (Stelfox 1975). Populations are stable. As elsewhere, nonresidents must hire a guide, and hunting by natives is unrestricted. Approximately 150 rams are taken annually under the three-quarter curl restriction, with one ram per non-native hunter allowed each year.

Small herds of Dall's sheep totaling about 200 animals are found in the northwest corner of British Columbia (Demarchi 1975). Stone's sheep occur on the Yukon and Stikine plateaus, and in the Skeena, Cassiar, Omineca and Rocky mountains north of the Peace River. From 9,000–15,000 Stone's sheep inhabit British Columbia. Market hunting reduced some populations in past years, but most herds are thought to have recovered and now are relatively stable or possibly declining slightly. Most herds are harvested on the basis of the three-quarter curl, ram-only regulation, but a seven-eighths curl law now applies to rams of Rocky Mountains populations. Relatively heavy harvests have decreased the male segment of some accessible herds. Also, predator control, primarily poisoning of wolves, has been undertaken in some Stone's sheep ranges.

In general, management of thinhorn sheep in both Alaska and Canada has had the primary objective of furnishing trophies to hunters. Harvesting only adult rams has not been shown to adversely influence thinhorn sheep populations' capacity to reproduce, nor is it effective to control or reduce herd numbers where desired. Intensive ram-only hunting reduces the number of available rams. Some individuals contend that if selective ram-only hunting is carried out over a long enough time, there may be a genetic effect in selecting for the survival of small-horned males. However, this has not yet been demonstrated. Accumulated evidence reported earlier in the chapter shows breeding by young rams and herd reproduction are not reduced.

Recent innovations of controlling access, limiting numbers of hunters harvesting from select herds, and increasing the minimum size of rams to be harvested should have even less impact on populations while increasing opportunities for enjoyment of recreational hunters. Controlled hunting of ewes will enable manipulation and management of sheep herds by making possible control or reduction of populations, alteration of sex ratios in favor of rams, and improvement of reproduction and survival rates in overcrowded herds. In addition, need has been recognized in both Canada and Alaska to set aside certain sheep herds for nonconsumptive uses, such as viewing, photography and scientific study.

Estimating populations

Because of the size and ruggedness of sheep habitats, aerial surveys are the most economical and efficient way to evaluate population status. Thinhorn sheep can be classified by sex and age classes on the basis of horn and body sizes and conformations. Aerial surveys are applicable especially to Dall's sheep, which reside in treeless alpine regions and usually are highly visible in the summer. Light, fixed-wing aircraft are relatively economical and can provide the means of determining distributions and population sizes with fairly high degrees of accuracy. Using fixed-wing aircraft to determine sex and age classes is possible also, but requires considerable flying and observing skills.

Use of helicopters allows for more accurate surveys, but generally is economically impractical except under special circumstances. Also, sheep react more to low-flying helicopters than to small airplanes—a harassment factor that must be considered, especially when young lambs are present.

Use of ground surveys to examine samples of a herd, combined with aerial surveys to estimate total herd size and distribution, generally is preferable to exclusive use of either aerial or ground surveys. Because rams usually are not with the ewe bands after lambing, detailed sex-age classifications are best conducted just prior to the lambing season. The objective is to obtain the best ram-ewe and yearling-ewe ratios and ram size class estimates before the ram portion of the herd becomes segregated. During aerial surveys conducted just after lambing, the proportion of new lambs (which are readily visible from the air) and total herd size may be estimated effectively. Popula-

tion models then may be constructed mathematically by combining results of both surveys; and population parameters—such as reproduction, survival, and herd composition—may be estimated (Nichols 1970).

Up close, thinhorn rams may be aged accurately by their horn annuli (Geist 1966, Hemming 1969). These annuli, reflecting a cessation of horn growth each fall, are readily visible to the trained eye. They may be used to estimate age of carcasses or just horn specimens to within about one month if the date of death is known. Ages of ewes also may be estimated from horn annuli, but more careful examination is required because these annuli are closer together and difficult to distinguish in older-aged specimens.

THE FUTURE

At present, Dall's sheep in Alaska and Canada have no serious man-related habitat problems. They inhabit rugged and remote terrain, for the most part inhospitable to man. However, the future may bring several types of human activity that could cause habitat damage or reduction. The well-publicized trans-Alaska oil pipeline has already pushed a road through the heart of sheep habitat in the formerly remote Brooks Range. The road does no significant damage in itself, but undoubtedly will open the area to further mineral exploration and possible development. Harassment of sheep by helicopters during mineral exploration already is common in many ranges. Mineral development in sheep habitat may affect sheep populations adversely by severely disturbing habitat and forcing sheep to abandon vital ranges. One major mineral lick already has been staked out (but not developed) as a mineral claim. A planned hydroelectric project on Alaska's Susitna River, although probably doing no damage to sheep habitat in itself, will open heretofore remote sheep ranges to boat traffic and possible further development.

The greatest danger facing Dall's sheep in Alaska is a plan now being considered to open large tracts of sheep habitat to grazing by domestic livestock, including domestic sheep. Should this materialize, wild sheep populations may be depleted as a result of competition for forage and diseases brought in by livestock.

In Canada, Stone's sheep already are faced with loss of habitat to a large hydroelectric project as well as to mineral developments. A railroad has been constructed through the heart of sheep habitat and a highway is planned, both of which will open sheep ranges to further exploitation. A potential problem facing both Dall's and Stone's sheep in northern Canada is the increasing commercial value of their horns and capes. Since natives have no restrictions on the number of sheep they can kill, there is a potential for wholesale destruction of populations. A management approach is needed immediately to permit use of sheep populations only within biological limits.

Although not necessarily harmful to sheep, large tracts of land will be withdrawn soon from unrestricted public use under the Alaska Native Claims Settlement Act. Included will be large blocks of sheep habitat probably set aside as national parks on which all hunting will be restricted, and large areas to be under the control of private, native corporations, on which the future of sheep hunting is unknown as yet. These withdrawals not only will remove presently available sheep herds from public hunting, but will concentrate hunters on the remaining open lands. This undoubtedly will necessitate more intensive management and restrictive harvests.

The most important future need of thinhorn sheep will be habitat protection. This will require a herd-by-herd inventory of critical sites, including mineral licks, lambing and wintering areas, and migration routes. Once known, these sites and the sheep that use them will need protection from human development and undue harassment. Unless undertaken promptly,

such habitat protection may come too late for many sheep populations.

Continuing and long-term research is vital to understanding of thinhorn sheep ecology and management needs. Research to date has been limited in scope, area and time. In particular, comparative studies of sheep occupying different habitats are needed. To make more efficient use of the thinhorn sheep resource, management policy makers will have to provide more money and manpower for sheep management and research, and managers will have to make better use of modern management techniques and research findings.