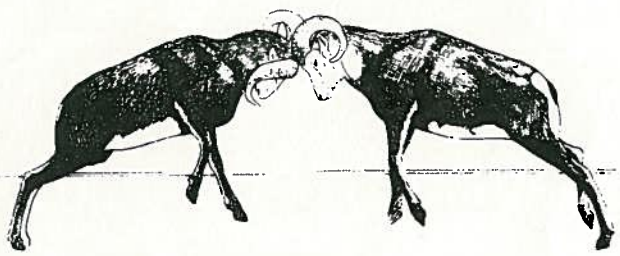
THE RELOCATION OF BIGHORN SHEEP IN THE SIERRA NEVADA OF CALIFORNIA



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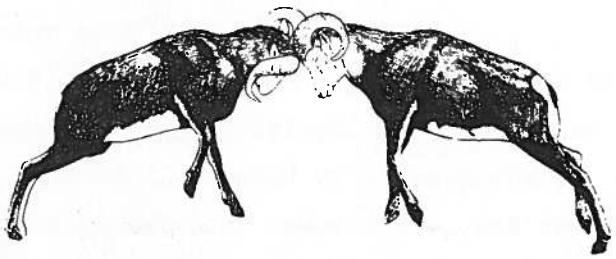

by Louis Andaloro and
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Environmental Field Program Publication No. 7
University of California, Santa Cruz

Accepted for publication January 1981. Printed May 1981.

ABSTRACT

The California populations of California bighorn sheep (Ovis canadensis californiana) began to decline in the late 1800s largely as a result of competition for forage with domestic sheep and the introduction of diseases. In the Sierra Nevada, the populations of bighorn sheep dwindled to include roughly 250 animals distributed in isolated ranges along the crest of the mountains. Efforts to protect the sheep beginning in 1873 were largely ineffective until the 1970s when the California Department of Fish and Game and the U.S. Forest Service undertook special bighorn protection measures: establishment of preserves and initiation of relocation programs.

On 6 March 1979 nine sheep were captured from an original bighorn herd located at Mount Baxter in Inyo National Forest. These sheep were released on Wheeler Crest, an area once occupied by bighorn sheep. Range expansion, seasonal movements, reproduction, competition, and causes of mortality were studied. On 27 March 1980, 11 more bighorn sheep were captured from the Mount Baxter herd and released on Wheeler Crest. The next day, 28 March, 21 additional bighorns were captured at Mount Baxter; 11 of these were released east of Mount Langley in the southern Sierra Nevada, and 10 were released in the Warner Mountains of Modoc County, California.

The herd movements, formation of seasonal ranges, and causes of mortality of all the relocated sheep were studied from the spring of 1979 through the winter of 1980-81. The sheep transplanted to Wheeler Crest appear to be successfully forming seasonal ranges and reproducing. The status of the Mount Langley herd remains in question.

Observing bighorns from great distances is fine when time is limited, but to see what is actually taking place in the distant locations, you have to use a little boot leather in order to get the picture.

Bill McIntyre

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FOREWORD

In the past, one of the problems associated with the introduction or reintroduction of wild animals to protected natural areas was the absence of any continuing follow-up study. The success or failure of the effort may have been noted from time to time, but the reasons for the outcome usually have not been observed. The California Department of Fish and Game is now involved in a number of activities aimed at restoring species to their original ranges--after a long period during which many habitats deteriorated and populations declined.

The restoration of the Sierra Nevada bighorn sheep herds is one such effort. We are fortunate that two enthusiastic students of wildlife were sponsored by the Environmental Field Program at the University of California, Santa Cruz to assist the department in monitoring the reintroductions of bighorn sheep to the Wheeler Crest and Mount Langley areas of the Sierra Nevada. Rob Ramey and Louis Andaloro have demonstrated their capability for hard work, careful field observation, insight, and endurance under difficult winter field conditions.

At the time of the study Ramey and Andaloro were senior students in environmental studies and biology under the direction of Professor Kenneth Norris. They have, I believe, demonstrated the truth of the belief we hold at UC Santa Cruz that undergraduate students can do field research of high competence and professional quality. We hope that similar opportunities for future students will be available to advance our knowledge of California wildlife.

It is too early to predict the success of the efforts to restore bighorn sheep to their original ranges in northern and central California. I hope that the observations and conclusions of this study will help to further the success of these important endeavers.

R. F. Dasmann

ACKNOWLEDGMENTS

This study would not have been possible without the support of several individuals and organizations. The Environmental Field Program at the University of California, Santa Cruz, supported us with a grant for our field research. Environmental Field Program staff members Larry Ford and Dan Warrick, along with our faculty sponsors Dr. Kenneth S. Norris and Dr. Roger Luckenbach, added their technical expertise in helping us to get our project underway.

Richard Weaver and Tom Blankinship of the California Department of Fish and Game supervised our field work and gave us their experience, support, and encouragement when we needed it most.

We are grateful to Larry White, who began the Wheeler Crest monitoring effort and provided us with the first 10 months of data included in this report.

Jerry Stefferud of the USFS offered maps, summer employment, and a government vehicle for us to use in the summer and fall of 1980.

Thanks, too, to John Wehausen for reviewing a draft of this document.

Jody and Doug Robinson gave us much support and always welcomed us into their home for dinner after days in the field. The people at the Rock Creek Winter Lodge often provided us with shelter. We offer our most hearty thanks to our fellow mountaineers at Wheeler's Boot Repair in downtown Bishop; on several occasions they gave new life to our deteriorating boots. And last but not least we thank the employees at the Union Carbide Pine Creek Tungsten Mine and Mill. They reported valuable bighorn sightings, fixed our broken telemetry antenna, and rescued one of us after a backcountry injury.

We gratefully acknowledge the permission of the University of Chicago Press to reproduce part of Figure 27 from Mountain Sheep by Valerius Geist, copyright 1971 by the University of Chicago Press. The portion of the illustration reproduced appears in the title box on the cover, half-title page, and title page of this publication.

INTRODUCTION

Before the immigration of American settlers to California, California bighorn sheep (Ovis canadensis californiana) inhabited an extensive though discontinuous range extending northward from the southern Sierra Nevada to beyond the northeastern California border at Modoc County. There were three separate geographic populations, although it is unlikely that these populations formed one race (Cowan 1940; Wehausen 1979). The northern population, centered around Lava Beds extended as far south as Mount Lassen and northward through Siskiyou, Lassen, and Modoc counties. Another population existed in the Truckee River drainage. The southern geographic group, the Sierra Nevada bighorn sheep, was known to exist from the Sonora Pass area south toward the southern end of the Sierra (Buechner 1960).

In the late 1800s and early 1900s California bighorn populations began to decline when the sheep were hunted for their meat on their low-elevation winter ranges. Domestic sheep grazing also affected California bighorn populations through competition for forage and the introduction of diseases. The sheep at Lava Beds were apparently unable to survive these influences. They were last sighted in 1927, and the population went extinct shortly thereafter (Jones 1949).

The extent of distribution and abundance of the Sierra Nevada bighorns also declined around the turn of the century. Jones (1949) described only five herds, containing 390 animals, during his field studies in 1948. Dunaway (1971) found only two definite herds numbering approximately 200 animals. In the early 1970s bighorn sheep preserves (California Bighorn Sheep Zoological Areas) were established on the ranges of these two remaining herds, one at Mount Baxter and another at Mount Williamson. Subsequently, Wehausen (1979) concluded that Jones's 1949 population estimates were inaccurate; Wehausen believed that there had been no significant population decline since that time. Wehausen's thorough censusing of the Mount Baxter herd from 1975 to 1978 showed that a population increase was taking place.

As is well documented by Geist (1971) bighorn sheep rarely expand their range or colonize new areas on their own; they prefer to occupy their herd's traditional home range. When a herd disappears, other nearby herds of sheep do not readily colonize this open range, although it may remain excellent bighorn habitat. For this reason, Wehausen (1977) recommended that sheep from the Mount

Baxter range could be used as stock for bighorn transplants in other parts of the Sierra Nevada. Because these sheep were to be relocated on previously occupied historic bighorn ranges, these efforts were called reintroductions.

The first reintroduction was conducted on 6 March 1979. Employees of the California Department of Fish and Game, U.S. Forest Service, Bureau of Land Management, and volunteers captured nine sheep on the winter range of the Mount Baxter herd near Sawmill Canyon in Inyo County, California. The sheep were released at a predetermined site on the lower eastern escarpment of Wheeler Crest in Pine Creek Canyon, 38 air-miles north of the capture site.

Following their release, this group of sheep was tracked with the aid of radio telemetry. Range expansion, seasonal movements, home range formation, mortality, and predation were monitored from the time of their release until 14 September 1980. They were first followed and observed by Lawrence H. White for the California Department of Fish and Game. We took over the monitoring program on 2 January 1980 and conducted a winter survey that ended on 14 April 1980. California Department of Fish and Game biologists in Bishop then continued the monitoring until 23 July 1980, when we resumed our observations until September 1980.

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HISTORIC DISTRIBUTION AND CURRENT STATUS OF SIERRA NEVADA BIGHORN SHEEP

The historic range of the California bighorn sheep (Ovis canadensis californiana) originally included rocky mountainous areas from central British Columbia south to the vicinity of Olancha Peak in the Sierra Nevada of California. In California they were situated in two specific areas. The Lava Beds sheep herd was located in the northeastern portion of the state, but it has since disappeared. A second group, the Sierra Nevada herd, inhabited the crest of the Sierra Nevada. Before the California gold rush in the mid-1800s, virtually nothing had been written concerning the distribution of numbers of these sheep. Not until the late 1800s were observations compiled, and by that time severe depletion of these bighorn herds was well underway.

"The Sierra Nevada geographic group seems to have had its northern limits at Donner Pass from which area the animals disappeared sometime between 1850 and 1900" (Buechner 1960). The original southern distributional limit of the Sierra Nevada bighorn sheep is poorly known. They were known to have inhabited the Olancha Peak area, but were also sighted as far south as the town of Glenville in northern Kern County (Jones 1949). Unfortunately, these early sightings are unreliable. Jones (1949) believed that the southernmost sightings could have been desert bighorn (O. c. nelsoni) that wandered across the Owens Valley from the Inyo Mountains.

The ranges of the Sierra Nevada bighorn herds were quite discontinuous. Bighorn sheep do not readily cross forests, deep snows, or dense riparian zones; these areas act as natural barriers to range expansion. The distribution was also restricted by available habitat. The general habitat requirements are a summer range located high on the crest of the Sierra, and a winter range located below snowline on the eastern flank of the Sierra. In the northern Sierra, where the snowline is lower than the base of the mountains, the sheep probably wintered east of the Sierra (Wehausen 1979). Another limiting habitat requirement is the presence of a suitable migration corridor between the two seasonal ranges. Though once abundant in the Sierra, bighorn sheep were not omnipresent; they formed herds only in areas that met all of the habitat requirements.

Some of the original Sierra bighorn populations were located at Mount Langley, Taboose Creek, Mount Tom, Wheeler Crest, Convict Creek, northern Yosemite, Sonora Pass, Truckee River, Kaweah Peaks, Birch Mountain, Mount Baxter,

The Distribution of California Bighorn Sheep (*Ovis canadensis californiana*), Prior to 1936.

After map by Jones (1949)

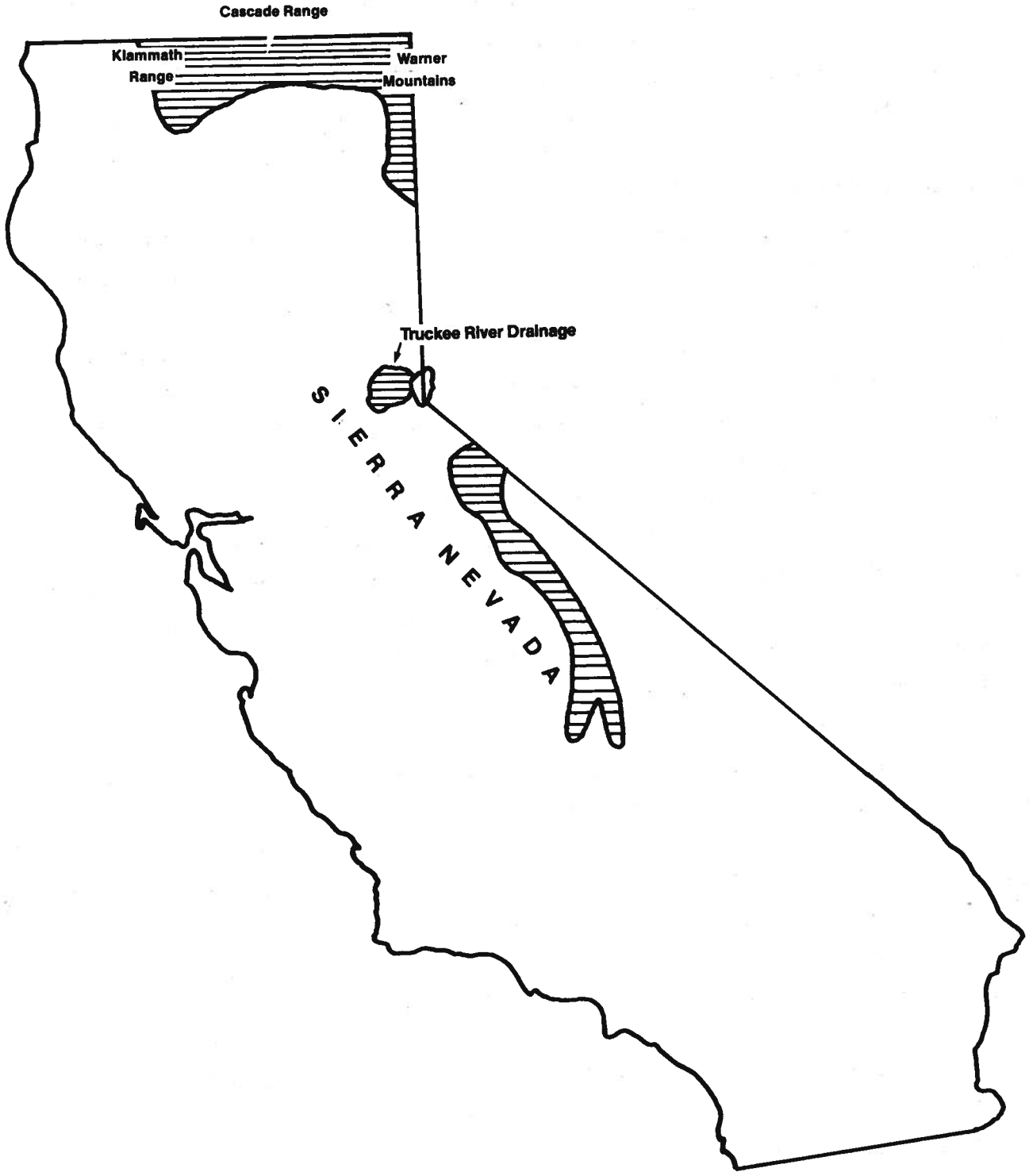

Figure 1

and Mount Williamson. At present only the Mount Baxter, Mount Williamson, and Birch Mountain areas support native bighorn populations (Wehausen 1980).

Beginning in the mid-1800s the northern distributional limit of Sierra Nevada bighorn sheep began to recede. As noted by Buechner (1960), the Truckee River drainage population disappeared sometime after 1850. The herd located at Sonora Pass "vanished several years prior to 1916" (Manly 1916). Grinnell wrote in 1933 that the bighorn sheep "now exist only from the vicinity of Mammoth Pass in Mono County then south to the vicinity of Olancha Peak."

The decline of Sierra Nevada bighorn sheep apparently began soon after the arrival of American settlers. Before that time, however, they were hunted by California Indians:

> Before the coming of the white man, the Owens Valley Paiute were known to hunt bighorn sheep. . . . They were primarily hunted in the White and Inyo Mountains where access was feasible all year round. Sheep were not hunted in the Sierra unless heavy snows drove the animals down (Buechner 1960).

Buechner implies that the Sierra bighorn sheep were not hunted extensively by this tribe, although while on their winter range the Sierra sheep were undoubtedly easier to hunt than the nearby desert sheep. The effect of California Indians on bighorn numbers was probably slight; the radical decline in bighorn distribution and numbers paralleled that of the California Indians.

During the late 1800s mining activity and domestic sheep grazing became widespread throughout the Sierra Nevada and adjacent areas. These activities were not regulated or restricted; their impacts on the native flora and fauna were not a concern at that time. As John Muir wrote in 1894:

> Man is the most dangerous enemy of all [to bighorn sheep] but even from him our brave mountains dweller has little to fear in the remote solitudes of the high sierra. But it will be long before man will care to take the highland castles of the sheep. And when we consider how rapidly entire species of noble animals such as the elk, moose, and buffalo, are now being pushed to the very verge of extinction, all lovers of wildlife will rejoice with me in the rocky security of Ovis montana [O. canadensis], the bravest of the Sierra mountaineers.

The serious decrease in the numbers of Sierra Nevada bighorn was well underway when this praise was first published in Scribners Family Magazine. Twenty years later his writing took on a more realistic tone:

> Few wild sheep, I fear, are left hereabouts; for though safe on the high peaks, they are driven down the eastern slopes of the mountains when the deer are driven down the western, to ridges and outlying spurs where the snow does not fall to a great depth, and they are within reach of the cattlemen's rifles (Muir 1901).

As indicated by Muir, hunting had been responsible, at least partially, for the decimation of Sierra bighorns. The extent of this destruction is largely undocumented, but "most likely the first herds to disappear were those shot for their meat on the vulnerable winter range" (Wehausen 1979). Hunting (and later poaching) were probably not the central cause for their decline because bighorns could only be hunted easily when on the low-elevation winter range.

The original sheep die-offs may be more plausibly explained by the presence of domestic sheep herds. Domestic sheep were numerous throughout the Sierra at the same time that bighorns were declining most rapidly, during the late 1800s and early 1900s. Their most serious impact was the overuse of bighorn forage. Huge herds of domestic sheep were pastured along the Sierran crest during all but the winter months. Domestic grazing on bighorn winter range during the spring, summer, and fall months probably lowered both the quality and quanity of the forage. Because bighorns on the winter range are more densely distributed over a smaller area, a shortage of food brought on by the summer grazing by domestic sheep could have significantly decreased the winter range's carrying capacity.

An even more subtle factor affecting bighorn was the permanent degradation of historic ranges brought on by long-term domestic grazing. Though suitable bighorn range still exists in many areas of the Sierra, we cannot estimate the amount of acreage within historic range areas irrevocably altered by overgrazing. Heavy overuse by domestic sheep herds could have brought on successional vegetation changes from grasses to shrubs, creating brush-covered areas unsuitable for bighorn use. Changes of this type undoubtedly led to increased nutritional stress, causing a decrease in the number of bighorns inhabiting such an area. Because bighorn ranges in the Sierra have not been analyzed until recently (Dunaway 1971; Wehausen 1979), the extent of these changes will remain unknown.

That the overuse of bighorn habitat by domestic sheep altered the character of the vegetation is certain, but an even more destructive effect came with it. During the late 1800s domestic sheep diseases were introduced to Sierra bighorn populations. The first known example of a domestic sheep disease transmitted to bighorn sheep was the scabies epizootic, which decimated most, if not all, of the sheep in the Kaweah Peaks during the 1870s (Jones 1949). Other outbreaks of this disease during the late 1800s afflicted bighorn populations throughout the western United States (Buechner 1960). Possibly other serious scabies epidemics that went unrecorded caused unknown losses to now extinct sheep herds.

Other diseases and parasites may have also been transmitted to Sierra bighorn from domestic sheep. Recent analysis of Sierra bighorn scat has shown the presence of internal parasites, primarily the intestinal nematode (Nemotodirus spathiger) and lungworm (Protostrongylus spp.) (McCullough and Schneegas 1966; Wehausen 1980). Wehausen (1979) has determined that the small, static Mount Williamson herd has ten times the internal parasites found in the large and growing Mount Baxter herd.

Another parasite that has not been discussed in studies of Sierra Nevada bighorns is the botfly (Gastrophilus sp.), which causes chronic sinusitis. This affliction is currently affecting bighorn herds in Utah. Dr. Thomas Bunch, a parasitologist at Utah State University, is now studying this problem. He has also examined the Sierra bighorn skull collection located at the University of California Museum of Vertebrate Zoology at Berkeley and believes that several of the skulls show strong evidence of this disease.* Another example of this disease was described by Jones (1949), who found a bighorn ram that had fallen into the Los Angeles aqueduct in 1938. "Shortly before the animal died, its horn sheaths fell off. It was found that there were large abcesses between each horn sheath and its core." Although Jones said that an autopsy was not performed, these symptoms indicate that botfly-induced chronic sinusitis probably caused this death.

Land uses east of the Sierra Nevada, may also have affected bighorn herds by eliminating the migration corridors and winter habitat of herds situated north of the Owens Valley. As Wehausen (1979) pointed out, southern Sierra bighorn herds found suitable winter habitat along the eastern escarpment of this mountain range. North of the Owens Valley, where the escarpment base is approximately 3,000 feet higher, suitable winter range is absent because deep snows blanket the lower flank of the Sierra all winter long. According to Muir (1894), "When the winter storms set in, loading their highland pastures with snow, then, like the birds, they gather and go to the lower climates, usually descending the eastern flank of the range to the rough volcanic tablelands and treeless ranges of the Great Basin adjacent to the Sierra." Bighorn sheep north of the Owens Valley were believed to have wintered in areas such as the Owens River and Rock Creek gorges, Glass Mountains, Mono Craters, Walker River gorge, Bodie hills, and Sweetwater Mountains (Wehausen 1979).

*Dr. Thomas Bunch 1980: personal communication

these ranges. Roads, fences, buildings, farmlands, and other human intrusions acted as barriers to prevent sheep from migrating.

Past Studies

Early studies on Sierra Nevada bighorn sheep are few in number. Researchers such as Grinnell (1912), Ober (1914, 1931), and Manly (1916) were concerned with presenting general overviews of the Sierra Nevada sheep populations. Taxonomy, distribution, and the historic decline were examined in a broad, general format. Annual fish and game reports prepared by the Inyo National Forest staff between 1921 and 1949 gave superficial estimates of bighorn numbers in the forest; however, regular, systematic censusing was not conducted (Dunaway 1970). Before 1948 no long term studies had been carried out, and virtually nothing was known about remnant herd locations or the status of the larger Mount Baxter and Mount Williamson herds.

The first in-depth baseline study was initiated in 1948 by Fred L. Jones, a graduate student at the University of California, Berkeley. He compiled a thorough list containing all of the reliable past sightings of bighorns in the Sierra. From this he estimated the size of their historic range. He then explored most of these areas and mapped what he believed were the current Sierra bighorn populations. Jones (1949) estimated that there were five herds containing 390 animals. These herds were located at Mount Baxter, Mount Williamson, Birch Mountain, Convict Creek, and Mount Langley. He did all of his field work from July to December while the sheep were high in the rugged summer range and difficult to census. But as Jones admitted, "No completely reliable census method was developed that could be used during the summer period." His estimate of 390 sheep was based on scattered observations of tracks, scat, bedding sites, and only 54 direct sightings of individual sheep.

Following Jones's study, no research was conducted until the 1960s. From 1963 to 1965 Riegelhuth (1965) conducted a winter survey of the five ranges described by Jones. McCullough and Schneegas (1966) carried out a similar project for the U.S. Forest Service. In 1969 Dunaway began another study of a similar nature. His population estimates coincided with those of Riegelhuth (1965) and McCullough and Schneegas (1966). Dunaway (1971) estimated the number of Sierra bighorn to be 215 animals. Dunaway (1971) found no evidence of bighorn use in either the Birch Mountain or Convict Creek areas, while Jor-

genson and Schaub (1972) and Weaver (1972) each concluded that the Mount Langley herd no longer existed. Dunaway also concluded that bighorn numbers had declined almost 50 percent since Jones's study and that the number of herds had dropped from five to two. Dunaway believed that human disturbances, especially backpacking and other back-country activities, were the key factors in this decline.

In the summer of 1975, John Wehausen of the University of Michigan began a comprehensive study of Sierra Nevada bighorn sheep. He compiled a considerable amount of data concerning the population trends of the two (known) remaining herds. His seasonal censusing indicated that the population of the Mount Baxter herd was increasing, and his research suggests that the 50 percent decline reported by Dunaway reflected primarily an overestimate by Jones rather than an actual major population decline (see Table 1).

Wehausen also initiated comprehensive disease and forage-use studies at Mount Baxter and Mount Williamson, while supervising a search for remnant herds elsewhere in the Sierra. He discovered through thorough censusing that the Mount Baxter herd was experiencing a temporary population increase.

TABLE 1

POPULATION ESTIMATES FOR SIERRA NEVADA BIGHORN SHEEP HERDS

Herd	1948[a]	1949[b]	1970[c]	1972[d]	1978[e]	1980
Convict Creek	-	25	0	0	0	0
Birch Mountain (Goodale Creek)	Tracks of 6	15	0	0	0	16[f]
Mount Baxter	22	135	95	-	214	198[f]
Mount Williamson	27	127	75	-	30	-
Mount Langley (Lubkin Creek)	7 (rams)	90	45	25	0	8-10[g]
Wheeler Crest	-	-	-	-	-	20-25[g]
TOTAL	60	390	215		244	242-279

a number of different sheep seen by Jones in 1948
b Jones (1949)
c Dunaway (1970)
d Weaver (1972)
e Wehausen (1979)
f Number of different sheep observed during winter 1980 census (CDFG and USFS)
g Andaloro, Ramey, and White (1980a and 1980b)

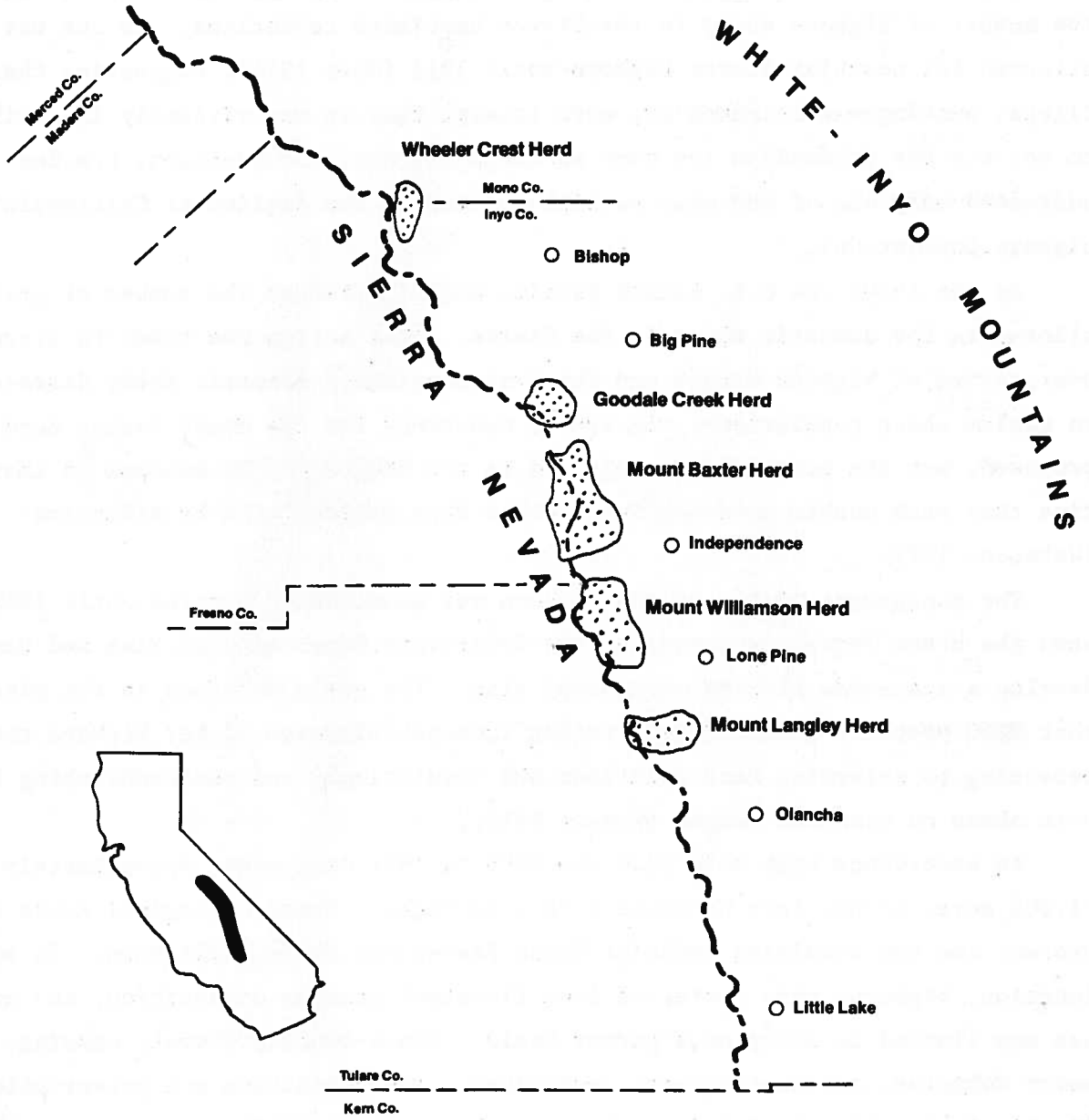
WHITE - INYO MOUNTAINS
SIERRA NEVADA
Merced Co.
Madera Co.
Wheeler Crest Herd
Mono Co.
Inyo Co.
Bishop
Big Pine
Goodale Creek Herd
Mount Baxter Herd
Independence
Fresno Co.
Mount Williamson Herd
Lone Pine
Mount Langley Herd
Olancha
Little Lake
Tulare Co.
Kern Co.

Figure 2

Bighorn Management in California

The first management policy affecting bighorn in California was enacted in 1873 when the state legislature gave full protection to all of the bighorn sheep in the state. Unfortunately, this legislation proved ineffective, and the number of bighorn sheep in the Sierra continued to decline. No one was arrested for poaching Sierra bighorn until 1911 (Ober 1914), suggesting that illegal hunting was uncommon or, more likely, that it was virtually impossible to enforce the protection law over so large an area. In addition, the law addressed only one of the many possible causes of the decline of California's bighorn populations.

In the 1930s the U.S. Forest Service began to reduce the number of grazing allotments for domestic sheep in the Sierra. This action was taken to prevent overgrazing of bighorn ranges and the transmission of domestic sheep diseases to native sheep populations. In 1940 a sanctuary for the Mount Baxter herd was proposed, but the proposal was rejected by the USFS and CDFG because at that time they were unable to determine whether this action would be effective (Wehausen 1979).

The management of the Sierra bighorn was essentially ignored until 1968 when the state legislature ordered the California Department of Fish and Game to develop a statewide bighorn management plan. The goals outlined in the plan that CDFG prepared included restricting incompatible uses of key bighorn ranges, censusing to determine herd locations and populations, and re-establishing bighorn sheep on historic ranges (Weaver 1972).

In accordance with this plan the USFS in 1971 designated approximately 41,000 acres within Inyo National Forest as Bighorn Sheep Zoological Areas to protect the two remaining herds at Mount Baxter and Mount Williamson. In each location, bighorns were protected from livestock grazing competition, and human use was limited to entry on a permit basis. Cross-country travel, camping, motor vehicles, and hunting were restricted. The protection and preservation of this land, which included the last two known Sierra bighorn herds, was the first management effort implemented since the sheep were protected by the legislation enacted 98 years earlier. Also in 1971 California initiated its reintroduction program by releasing 10 bighorn sheep from British Columbia in an enclosure at Lava Beds National Monument in the northeastern corner of the state.

*Richard Weaver 1980: personal communication

These animals were to be used as stock for reintroductions in the northern part of California, while Sierra Nevada reintroduction stock was to come from one of two herds still existing there.

BIGHORN HABITAT REQUIREMENTS AND SOCIAL STRUCTURE

Recent studies have yielded much information about the habitat requirements of Sierra Nevada bighorn sheep. Primarily, they need open terrain that offers a high degree of visibility. Keen eyesight is their primary defense against predation, and for this reason bighorns avoid forested areas and dense riparian vegetation. Bighorns are most commonly found on steep talus slopes and broken cliffs. This topography provides excellent escape terrain and secluded sites for giving birth to lambs.

Seasonal Ranges

Sierra Nevada bighorn herds have been observed to occupy at least two seasonal ranges (Jones 1949; Wehausen 1980). These can be divided into two major herd movements--one into the winter range and the other into the summer range.

The habitat often believed typical for Sierra Nevada bighorns is the high elevation summer range, where most of their time is spent. During the spring thaw, when the snowline begins to recede, ram groups move upslope towards the summer range. At this time, ewes will move off individually into steep rocky areas, where they bear their yearly lamb (White 1979a). The timing of these tw movements coincides with the spring growth of bighorn forage plants. During the summer months as the alpine snowline recedes, sheep continue moving upward.

In the fall, the rut (mating period) occurs before the herd moves down ont the winter range. This movement is usually initiated by the first big snowstor of the season, which may come as early as mid-November or as late as mid-Februa as in the drought year of 1976 (Wehausen 1976). Sierra bighorn traditionally winter below snowline along the eastern flank of the range, although as we observed in the winter of 1980 this is not always the case. Generally, the winte range is smaller than the summer range, and the sheep are found in habitat less rugged than in the summer range areas.

Social Structure

Sierra Nevada bighorn sheep are social animals that usually range in bands Ewe groups are composed of ewes, lambs, and yearlings; ram groups contain mostl rams two years of age or older. Individual rams are also seen ranging independently of all other sheep, but only during the summer months; at this time, you

rams may wander great distances from their established home ranges. This type of behavior is extremely rare for ewes.

In bighorn sheep society, the young follow the older, more experienced sheep and learn the traditional home ranges and migration corridors. Young ewes obtain this information by following the ewe that raised them, whereas young rams learn their seasonal ranges and traditional migration corridors from whichever ram band they join after leaving their ewe. This highly social behavior has a number of advantages: "Lambs are not driven off by the females after weaning or prior to bearing another lamb; rather, the juveniles desert their mothers, and follow adults of their choice" (Geist 1971). Lambs are accepted by all other older sheep, and are permitted to follow whichever they choose. Lambs are rarely alone and are persistent in following other, older sheep at all times. This decreases the possibility of their getting lost or being killed by predators. Another advantageous aspect of the bighorns' tendency to feed, bed down, and travel in groups is that they can readily detect the approach of predators. We have observed repeatedly that each member of a group faces in a different direction during feeding or bedding down.

As a consequence of this social system, individual sheep do not choose home ranges for themselves; they learn to occupy ranges from following the elders of their herd, regardless of that range's condition. Bighorn sheep do not readily colonize nearby areas of unoccupied, high-quality habitat. In the southern Sierra Nevada where bighorns were once distributed all along the main crest, individual populations or herds were isolated in population "islands." If there had been much interaction or exchange between members of nearby herds, the disappearance of one herd would have resulted in exploration and colonization of unoccupied habitat by the remaining herd. Except for individually wandering young males, bighorn sheep will not readily explore any territory outside of their traditional, inherited home ranges (Geist 1971).

According to all of the recent researchers cited in this report, all but two of the native bighorn populations in the Sierra have disappeared. A substantial quantity of prime bighorn habitat still exists in the Sierra; however, natural colonization of unoccupied ranges has never been observed in Sierra bighorn populations. The discovery this winter of 16 bighorn sheep in the vicinity of Goodale Creek (roughly 5 miles north of the Mount Baxter herd's winter range) has opened speculation that this area had been colonized recently by members of the Mount Baxter herd. Bighorns had not been seen at Goodale Creek

since 1940 (Jones 1949).

There are several plausible though unverified explanations for the preser of sheep in this area. The Goodale Creek bighorn herd (or Birch Mountain herc as it was referred to by Jones) may share a common summer range with the Mount Baxter herd before migrating to a separate winter range near the Shingle Mill Bench. This explanation is unlikely, however, because Wehausen (1979) found no signs of bighorn use north of Mount Perkins. In addition, Bill McIntyre (USFS) found no evidence of bighorn use between the Goodale Creek and Mount Baxter herd areas while conducting an extensive search of this area in the winter of 1979-80.

The Goodale Creek-Birch Mountain herd may also be a remnant population tl has somehow managed to elude bighorn researchers for the last 40 years. The only evidence to substantiate this possibility is a statement by David McCoy the Rocking K Ranch near Bishop who had seen bighorns in the Goodale Creek ar as recently as the 1940s.

The sheep located at Goodale Creek may have recently travelled a few mil north from the high elevation fall range of the Mount Baxter herd, and coloni the unoccupied historic range of the extinct Birch Mountain herd. If this pr to be a recent colonization, it may be explained as a response the increasing size of the Mount Baxter herd.

Geist (1971) noted that when rams formed large congregations in the spri following a large population increase, the young and old rams would segregate by age class. According to Geist, younger rams, being less sedentary and mor playful than the older rams, would "periodically go on excursions into the ti bered valleys beyond the herd's normal range. After this they would return in a great arc back to the familiar range."

Nearly all of the recent sightings of bighorn sheep outside of the estab lished herd boundary of the Mount Baxter herd have been young rams.* We beli that this segregation between age groups is due to the failure of sexually mature, subordinate rams to mate with estrous ewes. This behavior is brought about by a complex social hierarchy in which dominant rams remain with the es rous ewes with whom they have already copulated. Unmated estrous ewes reject young rams' attempts to mate. As a result, young rams wander beyond the herc established range boundaries in search of other ewes. Geist (1971) also thec

*John Wehausen 1980: personal communication

ized that these groups of wandering rams cross through timbered valleys and other barriers to find open and favorable habitat. He also states:

> Whereas the single young ram would not likely return to the patch of unoccupied habitat that he found, a group of young rams may remember it as habitat with companions and return again, stay longer to explore new terrain and incorporate it into next spring's excursions. Once some two-year-old ewes follow the rams across, they may well choose this terrain as a secluded lambing area, and eventually lead other sheep across.

The final step in establishing a permanent new herd would take place as the lambs of this colonizing group imprinted on the new range, and the former range was forgotten by all the members of the group.

THE 1979 WHEELER CREST REINTRODUCTION

Wehausen's thorough censusing of the Mount Baxter bighorn sheep herd led him to believe that the population there was expanding. He concluded that the Mount Baxter herd could provide the sheep for the relocation program proposed by the California Department of Fish and Game. Further studies (Wehausen et al. 1977) identified Wheeler Crest as the best location in the Sierra Nevada for a reintroduced bighorn herd.

Wheeler Crest is a large, precipitous massif located 10 miles northwest of Bishop, California on the eastern escarpment of the Sierra Nevada. It rises from the Owens Valley floor at 5,600 feet and reaches 12,966 feet at its highest point. It extends due north for 15 miles from its southern terminus in the Pine Creek drainage. Much of its eastern flank provides bighorn sheep with excellent winter range; it is steep and open along its entire length, while the sagebrush scrub vegetation offers good winter forage. From this extensive winter range area there are a number of potential migration corridors leading to excellent high-elevation summer ranges.

> The summer range along the Wheeler Crest can be divided into two sections. The northern section beginning just south of Round Valley Peak contains on the ridgetop considerable krumholtz whitebark pine in amongst the boulders with sandy flats. While topographically and vegetatively the northern section is adequate for bighorn, the southern section beginning at the base of peak 12,541 is substantially better (Wehausen et al. 1977).

This area contains alpine mat, talus, and meadow plant communities (See Appendi C).

The 1921 and 1923 Inyo National Forest Annual Fish and Game Reports each specified that 30 sheep occupied Wheeler Crest. (These were referred to as the Pine Creek-Rock Creek herd.) Ober (1914) described a herd of 40 to 50 shee that wintered at the base of Elderberry Canyon on Mount Tom, 2 or 3 miles from Wheeler Crest. But there have been no reports of sheep in either area since that time, and it is assumed that the herd disappeared roughly 50 years ago.

Wheeler Crest lies almost entirely within the boundary of the John Muir Wilderness Area of Inyo National Forest; the northern half is located in Mono County and the southern portion lies in Inyo County. The only private land is a large tract southeast of Mount Morgan owned by the Union Carbide Corporation.

This mine, Union Carbide Pine Creek tungsten mine, is the world's second largest tungsten mine, with 400 miles of underground tunnels. The associated

mill is one of the few tungsten mills in the western United States; consequently, ore is also brought to the mill from other mines. Union Carbide is a major employer in the Bishop area, employing approximately 500 people.

During his research with the Mount Baxter herd, Wehausen (1979) noted that mining activities had little or no effect on sheep behavior:

> The Rex Montis Mine on Kearsarge Peak in bighorn summer range was in operation up to 1976, but showed no discernable impacts on sheep use. Miners commonly observed sheep on the rocks around the mine despite operation of large and noisy diesel generators and other equipment.

Consequently, in spite of nearby mining activities, Wheeler Crest was chosen as the release site for the captured sheep.

On 6 March 1979 government employees and volunteers participated in the successful capture of nine bighorn sheep from the Mount Baxter herd. Seven of the sheep were caught with a drop net set up over a bait site on the north side of Sawmill Creek. The two other sheep, both mature rams, were captured a mile to the south in the Sand Mountain area. Both were shot with immobilizing darts fired from a helicopter.

All of the captured bighorn were transported via truck to a nearby camp where they were examined by California Department of Fish and Game veterinarians. All four of the ewes were determined to be pregnant; the overall health of each sheep was excellent, and lungworm infection was insignificant. All but two of the sheep were eartagged. Six of the nine received radio collars so they could be more easily followed. (see Table 2).

TABLE 2

THE FIRST WHEELER CREST REINTRODUCED BIGHORN HERD 6 MARCH 1979

identification no.	eartag no.	collar channel	sex	age
1	4562	1	m	lamb
*2	4566	2	f	adult
*3	4567	3	f	adult
*4	4573	4	f	adult
5	none	5	m	adult
6	none	6	m	adult
*7	4571	-	f	adult
8	4563	-	m	lamb
9	4572	-	m	yearling

*-These ewes were pregnant when captured, and all produced lambs.

The sheep were then transported by horse trailers to a release site in Pine Creek Canyon, 38 air-miles north of the capture site. This area contains habitat similar to the Mount Baxter herd winter range: open sagebrush, scrub-covered slopes, and rock outcrops. Following release, some of the bighorn formed small bands while others chose to range independently. All remained within 2 air-miles of the release site until lambing was completed in June.

Tracking methods

Information on the numbers, range, and behavior of bighorn sheep was collected by 1) the use of radio telemetry, 2) direct observations, 3) reported sightings, and 4) interpretation of sign.

Radio Telemetry

Radio telemetry proved to be extremely valuable for tracking the movements of reintroduced bighorn sheep through the rugged terrain of Wheeler Crest. Three to six members of each reintroduced group were fitted with radio collars that emitted signals at different frequencies. (See Tables 2, 3, 6, and 8 for radio collar numbers). Signals were then monitored with the use of a hand-held Telonics multi-frequency receiver and antenna. As the antenna was turned on a horizontal plane, increases in the signal strength indicated the direction of the radio-collared sheep. In approximately the central 30 degrees of the arc, a change in signal strength was almost impossible to detect. This angle was then plotted on a 15-minute USGS map, and the angle was bisected to give the approximate location of radio-collared sheep.

Occasionally, turning the antenna on a vertical plane was useful for estimating the elevation of bighorn sheep. Signals could be monitored from a distance of several miles if the sheep were on a line-of-sight path. This distance, however, was greatly reduced if bighorn were in rugged terrain, where radio signals reflecting off of canyon walls frequently confused location efforts.

Direct Observations

Observations of bighorn sheep were made by thoroughly examining an area using 7 x 50 binoculars, a 15-to-60-power spotting scope, or a 750-mm telescope. Such searches were most often done following a location estimate by telemetry. The location of sheep without radio collars, however, required a slow, systemati scan of all visible terrain. All sightings were plotted on 7.5-minute and 15-minute USGS maps.

Identification of individual sheep was based on the color code of radio collars (collars were marked using brightly colored plastic tape) and for other sheep by age, sex, and individual physical characteristics (e.g., scars or broken horns).

Bighorn were classified into seven classes on the basis of horn size, body size, head shape, and behavior: lambs, yearling ewes, yearling rams, adult ewes, and adult rams having quarter, half, and full curl horns. Some difficulty was found distinguishing yearling rams from adult ewes at long distances. Yearling rams have a slightly wider horn base and more divergent horns.

During the 1980 Mount Baxter herd census, we learned a method for approaching and observing bighorns. We would wander gradually towards a group of sheep, picking objects up along the way with our eyes downcast, as if looking for a lost wallet. Using this method, we were able to approach within 20 meters before the sheep retreated.

When people were encountered in the field, they were asked if they had seen or heard of any bighorns in the area. On Wheeler Crest, sightings of bighorn sheep were made by mine personnel at the Union Carbide Pine Creek tungsten mine.

Sign

The location and interpretation of bighorn sign was was an important factor in identifying areas of bighorn use. The types of sign encountered were bedding sites, tracks, scat, and remains. A typical bedding site consists of a circular area scraped free of rocks, 1 to 3 feet across and 1 to 6 inches deep. If several bighorns were ranging together, bedding sites were clustered and had numerous pellet groups. Tracks of bighorns and deer were very difficult to distinguish unless they were recently made. Fresh bighorn tracks are distinctly less pointed than those of deer.

On five occasions, the remains of dead bighorn sheep were found; three of these were located because the sheep were fitted with mortality-sensing radio collars. The other dead bighorns, which were killed by an avalanche, were located by more unconventional means. A bighorn lamb was discovered after many ravens were observed near the terminus of the avalanche. A bulldozer was then used to uncover a dead ram buried deep within the avalanche.

Access to bighorn summer ranges was gained on foot during all but the winter months. During this time cross-country skis were necessary for negotiating the high-elevation, snow-covered range of the Wheeler Crest herd.

Spring and summer herd movements 1979

After being released on Wheeler Crest, a group of bighorn sheep consisting of three ewes (no. 3, no. 4, and no. 7) and a lamb (no. 1) moved onto a prominent ridge 1 mile north of the release site and remained there for two weeks. During the third week in their new location, this group traversed a canyon filled with deep snow to reach another ridge farther north, directly below point 12,541. Throughout the lambing period, they remained on the south-facing exposure of this canyon or on the ridge itself. Presumably, the ewes moved into the safety of this rocky canyon to bear their lambs in an attempt to avoid a variety of predators--including coyotes, mountain lions, and golden eagles, all of which are found on Wheeler Crest.

On 1 May 1979, lambs were observed with ewes no. 4 and no. 7 at an elevation of 8,200 feet. On 19 May 1979, ewe no. 3 was observed with her new lamb; they were running with ewes no. 4, no. 7, their lambs, and sub-adults no. 8, no. 9.

From the time of release ewe no. 2 chose to remain separate from the large band of bighorns. This ewe and sub-adult no. 8 remained on a broad ridge a half mile north of the release site until 18 March 1979. At this time they were joined by sub-adult no. 9 who had also been ranging independently. This band of bighorn remained together until 12 May 1979 when they met up with the larger ewe-lamb group, and was observed on 2 June 1979 with a lamb. They remained amon rock towers along a prominent ridge for two weeks before moving onto the main crest. For the remainder of the summer, this pair ranged independently of all other sheep.

After 12 May 1979, the large ewe-lamb group moved south along the east side of the crest, traversing a series of steep canyons before settling into a summer range. This summer range was between 11,800 feet and 13,000 feet at the southern extremity of Wheeler Crest.

The two mature rams (no. 5 and no. 6) began extensive movements following release. Ram no. 5 was the most active of the pair, moving as far as 5air -iles north of the release site and a short time later returning to an area high above it. The two rams joined sometime during May 1979, at which time the transmitter on no. 6 stopped functioning; it may have been damaged during horn clashes. These two rams remained together during May, June, and part of July, ranging between 8,500 and 11,000 feet west of the release site. By mid-July, telemetry contact with no. 5 was lost, due to another radio collar malfunction. An aerial

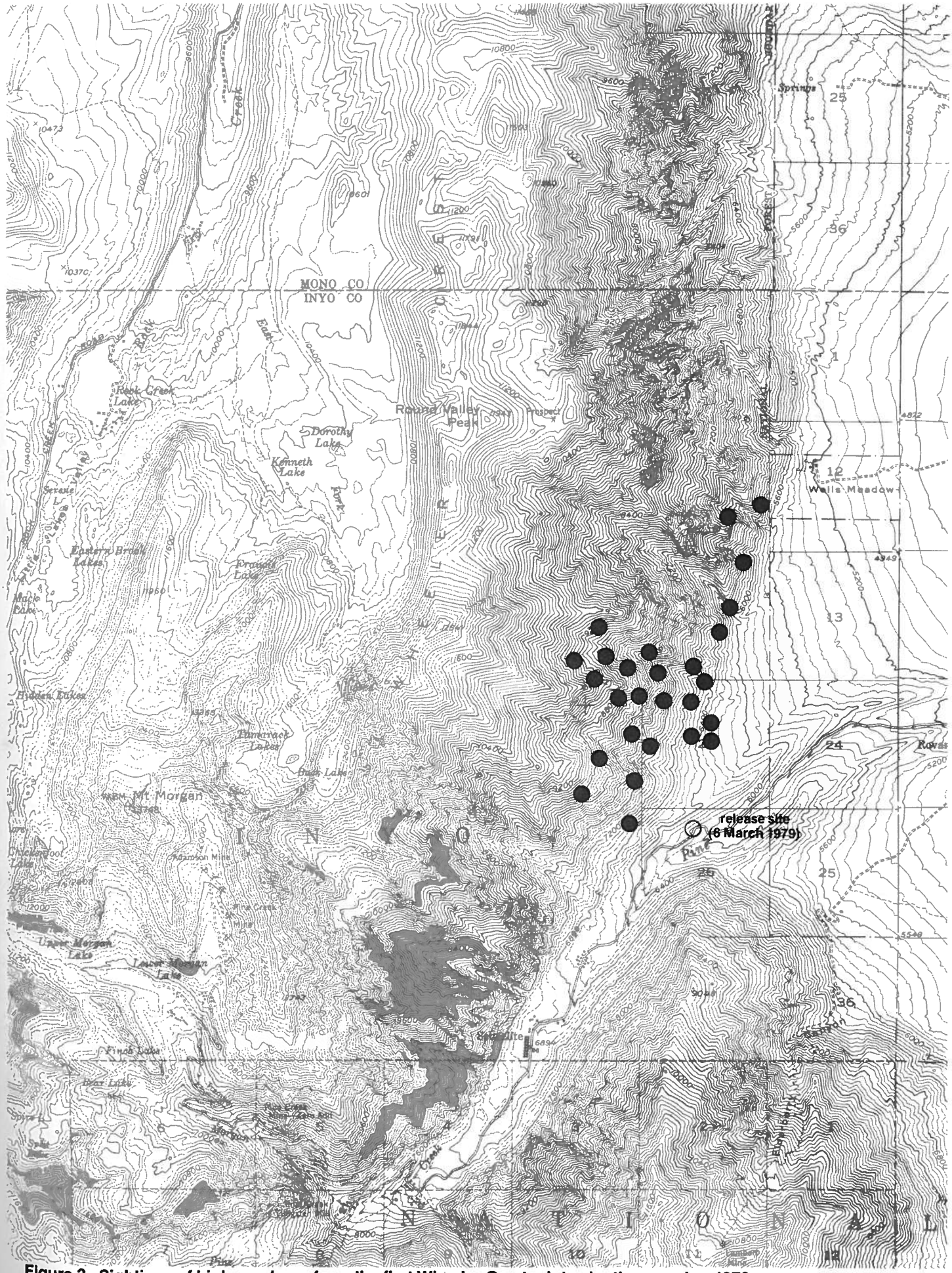

Figure 3 Sightings of bighorn sheep from the first Wheeler Crest reintroduction - spring 1979.

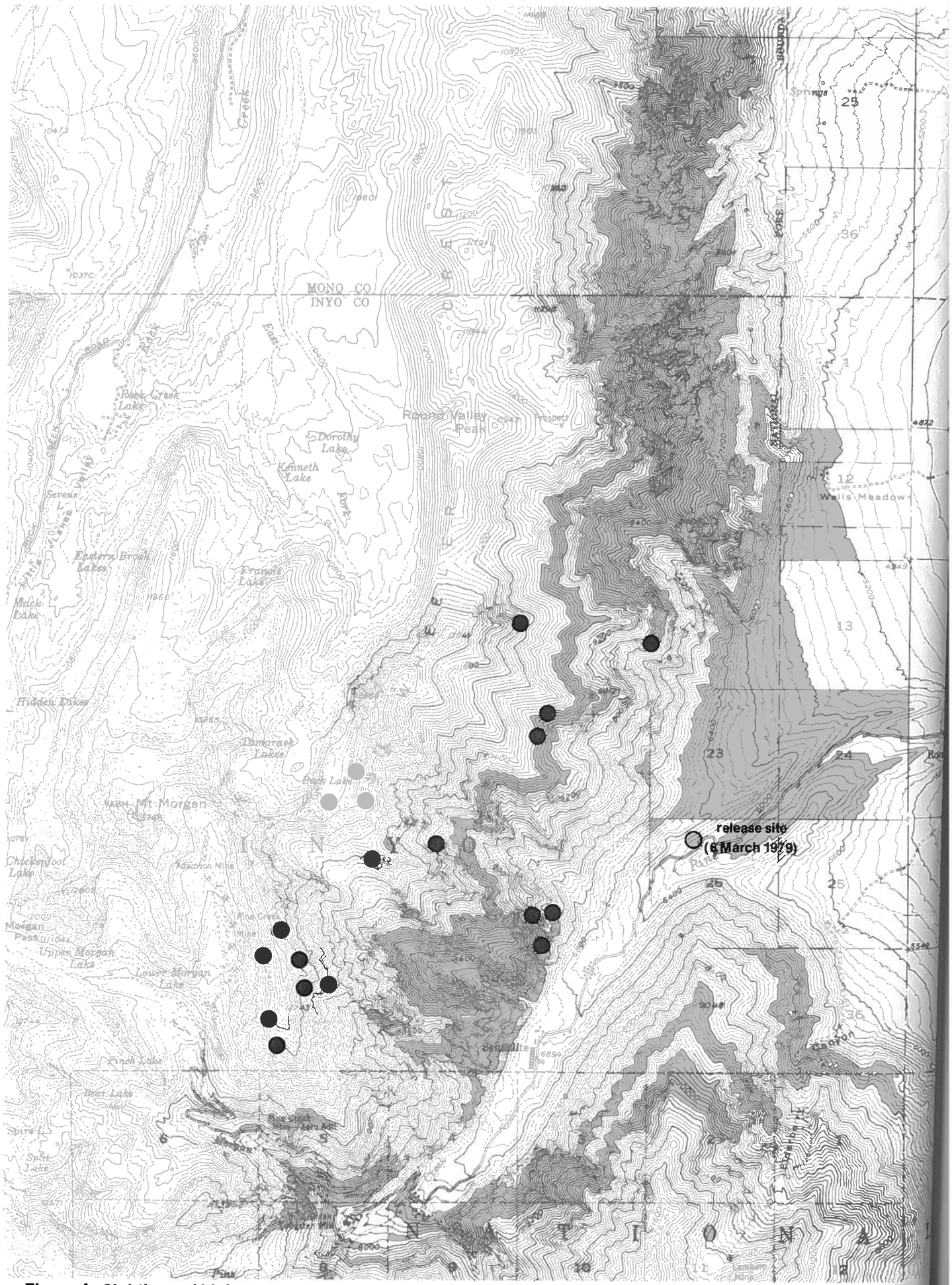

Figure 4 Sightings of bighorn sheep from the first Wheeler Crest reintroduction - summer 1979.

search by the California Department of Fish and Game failed to pick up any signals, and no other sightings of this pair were made until the fall.

Fall herd movements 1979

Nearly all of the bighorn sheep on Wheeler Crest continued to range at elevations above 10,000 feet during the fall. During this time, the Wheeler Crest sheep established an autumn range on the east side of the crest somewhat lower than the summer range. Ram no. 5, however, appeared on the floor of Pine Creek Canyon at 6,200 feet during early November. From 6 November to 26 November 1979, this ram ranged alone in the canyon and nearby slopes of Mount Tom.

On 15 November and 30 November 1979 ram no. 6 was observed with ewes no. 4 and no. 7. Ram no. 5 was observed very near ewe-lamb groups from 13 December 1979 to 2 January 1980. (At this time, ewes normally become estrous. No copulation was observed; however, sightings at this time were infrequent and of short duration.) Both yearling rams were apparently ranging with ewes.

Ewe no. 2 and her lamb continued to range separately, except for a brief period during late October when they were observed with the large ewe-lamb group. This ewe and lamb began their descent to a low-elevation winter range on 12 December 1979, when they were observed at 11,600 feet, 3 miles north of their observed autumn range. The next sighting of this pair was made on 31 December 1979 on the floor of Pine Creek Canyon at 5,700 feet.

Winter herd movements 1979-1980

Despite two large snowstorms during December, nearly all of the Wheeler Crest herd remained above 10,000 feet on the southern reaches of Wheeler Crest. The only exception was ewe no. 2 and her lamb; this pair descended during mid-December to a low elevation winter range on the eastern escarpment. Sightings of this ewe and her lamb were made between the elevations of 5,600 feet and 9,600 feet throughout the remainder of the winter.

Even though a substantial amount of snow accumulated on Wheeler Crest during this period, there were extensive snow-free areas, particularly on south-facing and windswept ridges. On 3 January 1980 tracks, fresh droppings, and six tightly clustered bedding sites were found at 11,900 feet along an exposed snow-free ridge one-quarter mile north of point 12,743. We were led to this area by radio signals from ram no. 1, ewe no. 3, ewe no. 4, and ram no. 5. It was evident, however, that this group fled during our approach. Ram no. 6 was seen

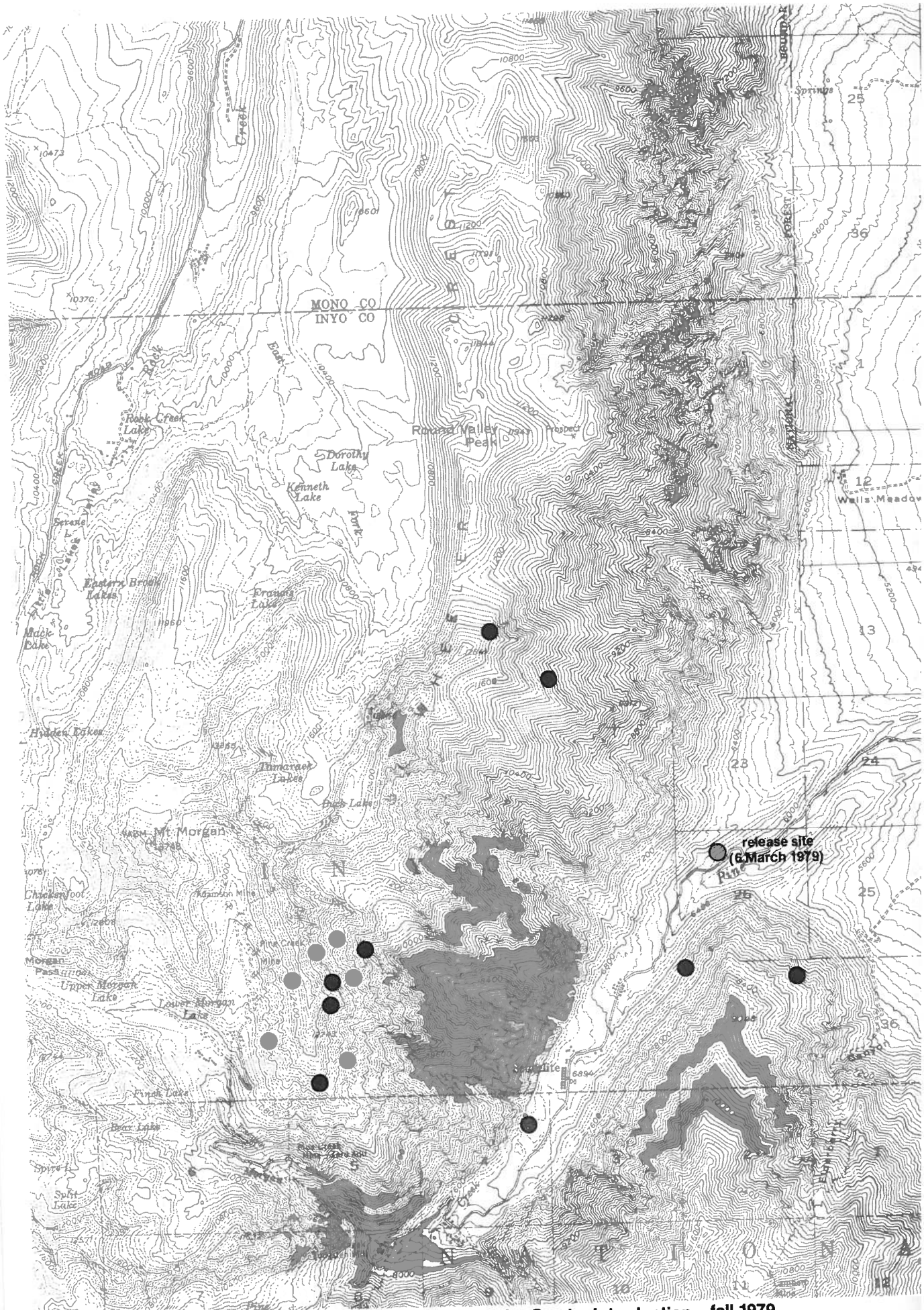

Figure 5 Sightings of bighorn sheep from the first Wheeler Crest reintroduction - fall 1979.

alone that day at 9,600 feet, 1 mile south of our location. This area was characterized by precipitous cliffs and talus fields of sharp-edged, shattered metamorphic rock separated by steep, snow-filled gullies. Avalanches regularly swept down these gullies following snowstorms, creating an exceptional hazard to both humans and sheep. While in this area, bighorn tracks were seen traversing these gullies, some of which were as steep as 50 degrees. Forage species along this ridge consisted primarily of grasses and subalpine perennials scattered over talus slopes. In the immediate vicinity of the bedding sites, numerous preferred forage species (see Appendices C and D) were abundant and only moderately grazed.

Temperatures were mild throughout the days in this area, though they fell well below freezing at night. Compared to the east slope of Wheeler Crest, this southern exposure receives several hours more daylight and relatively warm daytime temperatures during fair weather. The longer days and warmer temperatures on the high elevation southern end of Wheeler Crest provided more favorable habitat during early winter than the snow-covered slopes on either the east or west sides of the crest.

Throughout the month of January, deep snows accumulated in the high country, leaving only the windward side of exposed ridges snow free; this effectively isolated the sheep from the typical low-elevation winter habitat found in the Mount Baxter herd. Snow-filled canyons, deep drifts at lower elevations, and forested slopes formed barriers to downward movements of the herd. The behavior of the Wheeler Crest herd contrasts sharply with that of the Mount Baxter herd, which descended to a winter range between 5,400 feet and 7,200 feet in early January of 1979.

Beginning on 11 January 1980 radio telemetry contact with ewe no. 4 was lost; the last estimation of her location was made at 1600 hours the previous day, when she was near the southern terminus of Wheeler Crest. At that time avalanche activity was extremely high throughout the entire eastern Sierra. The loss of telemetry contact led us to believe that this ewe and possible other sheep were the victims of an avalanche.

This guess was later confirmed by a Union Carbide bulldozer operator who sighted a dead bighorn ram in avalanche debris just north of the Pine Creek mine tailings ponds.

The avalanche had released at approximately 400 hours on 13 January 1980 from a point above 11,000 feet in a canyon immediately north of the Pine Creek

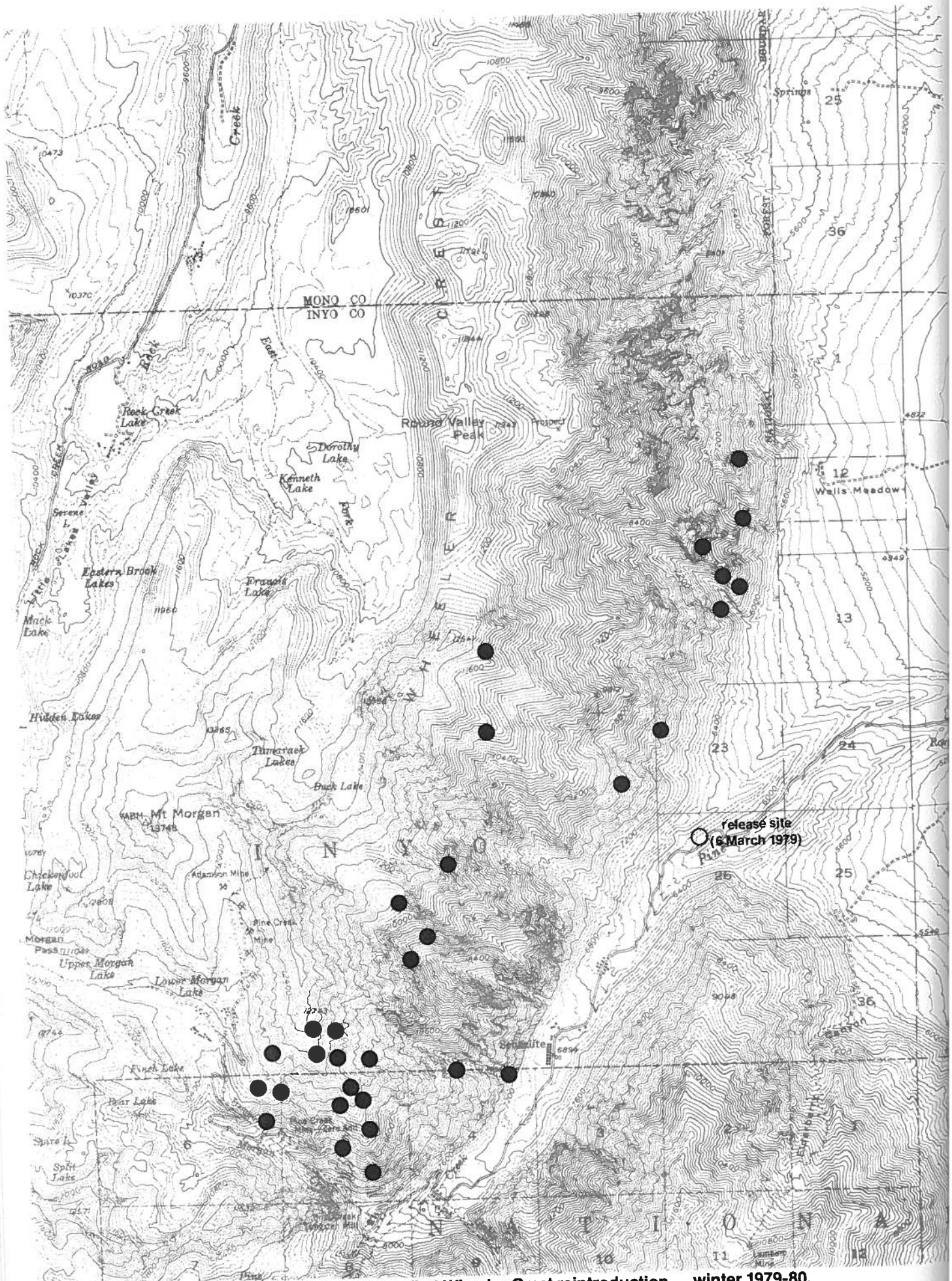

Figure 6 Sightings of bighorn sheep from the first Wheeler Crest reintroduction - winter 1979-80.

mine tailings ponds. It swept the full length of the canyon, covering approxmately 5 acres to a depth of up to 50 feet in the runout zone. The carcass of a two-year-old ram was uncovered from this slide on 2 February 1980. The presence of coyotes and ravens loitering in a different part of the slide, prompted a more extensive search for dead sheep. Eventually, the pelt and lower jawbones of a lamb were found near the terminus of the slide. Although the carcass of ewe no. 4 was not recovered, we believe that she died during this event and that the pelt and lower jawbones found were those of her lamb.

The identification eartag of the ram discovered in the slide was missing but the carcass was determined to be that of ram no. 9 on basis of horn growth-ring aging. An autopsy of the intact carcass was performed by the California Department of Fish and Game pathologists at their Sacramento laboratory. The body was found to have substantial fat reserves, indicating that adequate forage was being obtained by the sheep in their high elevation winter range.* It is also possible that a large fat supply put on earlier had not been depleted.

An expedition to the wintering area of ram no. 5 was made on 6 February 1980. Recent tracks made by a mature ram and two bedding sites were found adjacent to crags and in snow at 11,500 feet, 1 mile east of lower Morgan Lake. Radio telemetry aided in locating this site but no actual observations of this ram or other sheep were made because of poor visibility caused by a severe snow storm with winds of over 40 miles an hour and air temperatures of -18°C. We were surprised by the movements of this ram under these conditions as the wind chill factor brought the temperature to -47°C.

In contrast with the other bighorn sheep on Wheeler Crest, ewe no. 2 and her lamb occupied a low altitude winter range on the eastern slope of the crest. This pair had been extremely elusive during this time, their movements being followed mainly by the use of telemetry. Throughout the winter, these sheep ranged between 5,600 feet and 8,400 feet south of Wells Meadow. The extreme wariness exhibited by this pair may be due to the fact that they were ranging separately.

On 25 February 1980 ram no. 1, ewe no. 3, ewe no. 7, and an unidentified lamb (either no. 3a or no. 7a) were observed. Telemetry data to this date showed that ram no. 1 and ewe no. 3 had not moved any significant distance from

*Dave Jessup, D.V.M. 1980: personal communication. Dave Jessup is an associate wildlife pathologist for the California Department of Fish and Game.

this area. All of the sheep observed appeared to be in good health. Their coats were full and they looked to be of normal weight. The sheep showed obvious concern over our presence, even though we were well over a mile away. At least two of the four sheep were watching us at all times. They were also foraging on grasses (primarily Oryzopsis hymenoides), or pawing the ground for low-lying buckwheat. Telemetry indicated that ram no. 5 continued to range independently of this group, remaining in the same area since early February. The first movement of the Wheeler Crest herd to low elevations did not begin until 8 March 1980, when tracks descending a steep snow slope from the area occupied by ram no. 5 were discovered. On 19 March 1980, ram no. 6 was observed at 7,800 feet elevation 300 yards above the Pine Creek tungsten mine. Two days later, ram no. 1, ewe no. 3, and ewe no. 7 were seen in the same area while rams no. 5 and no. 6 ranged together one quarter mile to the north. No lambs were observed with the ewes and we assumed that they died during the winter.

The movements of this group of sheep corresponded with the rapid spring growth of stipegrass (Stipa sp.) and other preferred forage species below snowline. At the time of those sightings, the snow at the southern end of Wheeler Crest had melted up to 9,000 feet to 9,500 feet. This allowed the sheep to move freely and exposed vast slopes for foraging.

Rams no. 5 and no. 6 moved north from the Pine Creek mine area during the first half of May and were observed 1 mile southwest of Wells Meadow on 13 May 1980, within 200 yards of ewe no. 2. The Pine Creek road and tailings ponds proved to be a less significant barrier to herd movements in the spring than they did in the winter.

Spring and summer herd movements 1980

Mid-June telemetry readings indicated that the four remaining collared sheep from this group were dispersed over a wide area; ewe no. 2 was located high on a mountain about 1 mile south of Wells Meadow. Ram no. 5 was situated perhaps 1 mile farther south, while rams no. 1 and no. 3 were located several miles to the southwest at the southern end of Wheeler Crest above the Union Carbide tungsten mine.

At the beginning of August telemetry readings indicated that rams no. 1 and no. 5 were together, 1 mile north of the 13 May 1980 observation of rams no. 5 and no. 6, and several thousand feet higher. The other two collared sheep, ewe no. 2 and ram no. 3, were located very close to each other 1 1/2

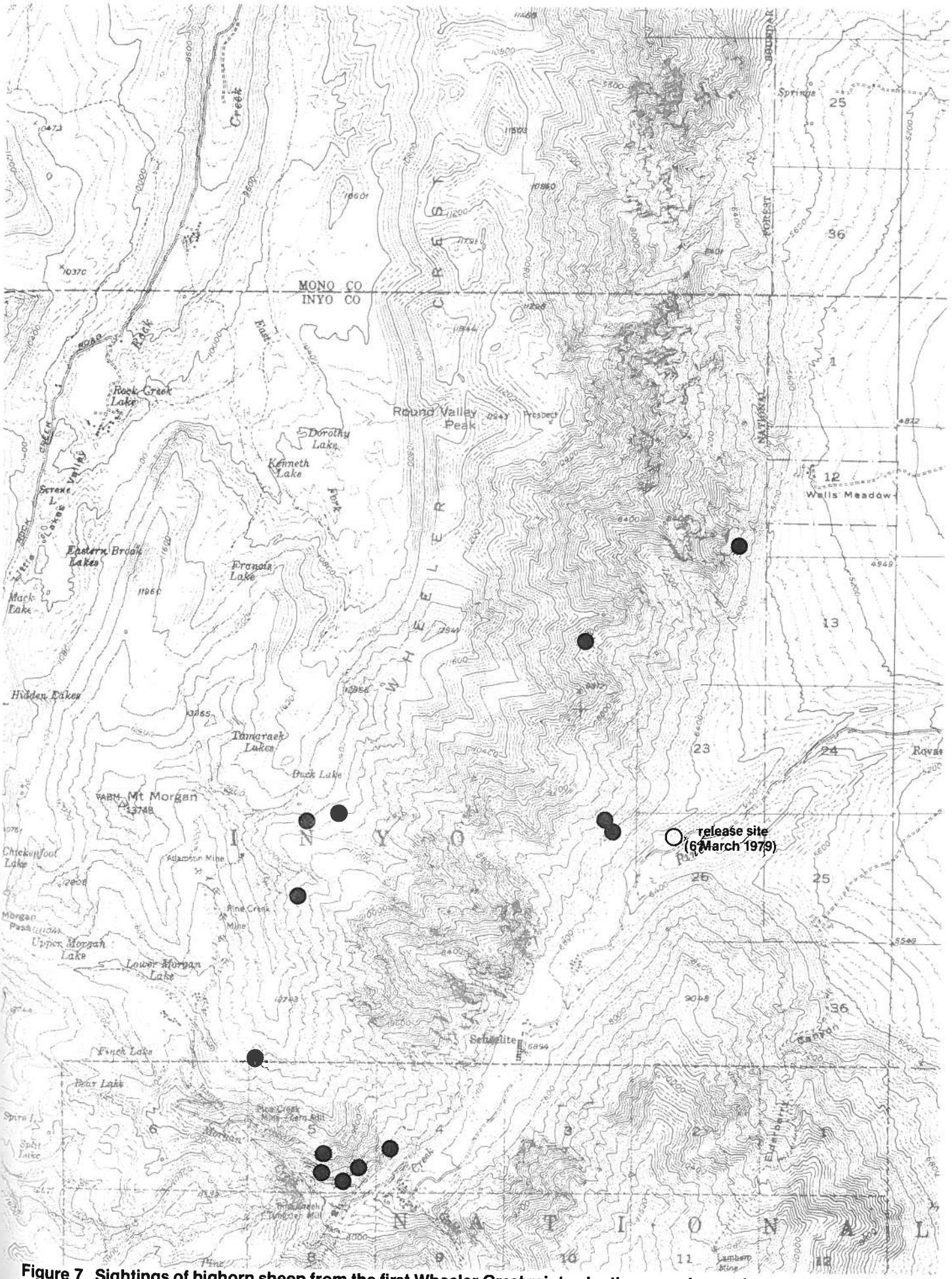

Figure 7 Sightings of bighorn sheep from the first Wheeler Crest reintroduction - spring and summer 1980.

miles southeast of Mount Morgan directly above the Pine Creek and Adamson mines. On August 1980, ram no. 6 (with a non-functioning radio collar) was seen 1 mile south of no. 2 and no. 3.

Spring and summer sightings of these sheep did not yield any new information. The sheep were travelling in small groups that ranged throughout the southern half of Wheeler Crest and had not yet developed into a cohesive herd.

The most significant observation of the summer came on 16 August 1980. Approximately 1/2 mile south of Buck Lake (1 mile east of Mount Morgan), all but one of the surviving sheep from the 1979 transplant were observed on a single south-facing slope at 11,900 feet. They were seen ranging in two distinct groups, a ewe-lamb band and a ram band. Three rams (no. 2, no. 3, and no. 9) from the first transplant were grazing on a steep, gravelly ravine just a few hundred feet from the ewe group. Of the six sheep present in this ewe-lamb group, all three surviving ewes from the previous winter were present, accompanied by two new lambs and yearling ewe no. 2. Ewe no. 2 and lamb no. 2a, which were the only sheep to find a good low elevation winter range, had obviously been joined by the other two ewes.

The reproductive status of this group is encouraging. The only surviving lamb from 1979 (no. 2a) is a female, and one of the two lambs born in 1980 year has been positively identified as a female. Four female sheep were initially transplanted on Wheeler Crest and five remained one year later, after the death of one adult ewe (no. 4) and the addition of two female lambs.

THE 1980 WHEELER CREST REINTRODUCTION

In accordance with California's bighorn management plan (Weaver 1972), another bighorn transplant was carried out by CDFG late in the winter of 1980. Sheep were captured from the Mount Baxter herd while it was on its winter range. Prior to the capture effort, a thorough census of the Mount Baxter herd was conducted by CDFG and USFS personnel to obtain an accurate population estimate and identify areas of heavy bighorn use. If enough sheep could be captured, they planned to introduce bighorn into the historic range areas of Mount Langley in the southern Sierra, and the Warner Mountains in northeastern California.

The primary goal of this capture was to augment the previously relocated herd on Wheeler Crest. By the summer of 1979 the herd size had increased from 9 to 13; by late winter of 1980, 5 of these had died due to severe winter conditions at high elevations.

Prior to the 1980 capture at Mount Baxter, all involved personnel underwent an intensive training by CDFG veterinarians on the proper handling of captured bighorn. Bighorn sheep are physiologically sensitive to stress, and serious complications leading to fatality can occur if they are handled improperly. Such a tragedy occurred on 19 February 1970, when six of the ten bighorn captured at Lava Beds National Monument died during the attempted transplant operation. These sheep were overheated and greatly stressed from running long distances during the roundup, and they had been handled primarily by an untrained crew. No tranquilizing drugs were used to reduce stress. A great deal was learned from this failure, and CDFG has since refined its bighorn capture and handling techniques.

Following this incident, press releases brought widespread public concern to the attention of the agencies involved (CDFG, BLM, NPS, USFWS, and USFS). A moratorium was then quickly placed on all subsequent bighorn relocations until mid-March of 1980.

The next bighorn capture attempt was staged at the Mount Baxter herd's winter range from 12 March 1980 to 17 March 1980 by CDFG and the USFS. This attempt failed, however, when strong, gusty winds dispersed the sheep over a wide area. They also avoided the drop net, which howled and flapped in the wind.

A successful capture was carried out two weeks later. On 27 March 1980, ten sheep were captured using a drop net on the Sand Mountain area of the Mount Baxter herd's winter range. Once the net was dropped, the trained handling crew

was shuttled up the mountain by helicopter. Captured sheep were injected with tranquilizers and flown by helicopter 3 miles to the processing facility (see Appendices A and B for a detailed description of capture and handling techniques).

Upon arrival at the processing facility, sheep were eartagged for identification while blood, hair, skin, and fecal samples were taken to determine levels of disease and parasitism. Temperatures, respiration rates, and pulse were continually monitored by the veterinary crew. An injection of penicillin, tetanus toxoid, and clostridium perferinges (for blackleg infection) was given to all sheep to prevent infection from the lacerations and scrapes incurred during capture and handling.

Patches of bare skin on the necks and backs of bighorn were found to be tick scars produced by the sheep rubbing areas irritated by ticks with their horns. It has been observed that these scars disappear by early summer when the winter coat is shed (White 1979).

To facilitate the tracking of the relocated bighorn bands, several sheep were selected from each group and fitted with radio collars.

After processing the animals were placed within the totally dark confines of two modified horse trailers. The sheep were then transported to Wells Meadow at the base of Wheeler Crest, a site chosen over the 1979 release site for the following reasons:

1) Sheep would not have to travel as far to reach suitable habitat.
2) Because the 1980 site was 2 miles north of the 1979 site, researchers hoped that those sheep would establish a summer range above Wells Meadow that would allow them easier access to suitable winter range.
3) The areas adjacent to the 1980 release site contained higher quality bighorn habitat than that of the 1979 release site.
4) Wells Meadow is at the end of a quiet, secluded dirt road, unlike the 1979 release site; fewer spectators would be attracted.

The sheep were released from the trailers late in the afternoon, approximately four hours after being captured. Before the horse trailer gates were opened the sheep were high strung, nervously kicking and jostling about inside. When the doors were opened, the sheep burst out one and two at a time. Six of them ran for high ground, scattering individually into the nearby cliffs and gulleys. The other four bolted through a line of people flanking the trailer; these sheep ran in the opposite direction, toward the sage-covered flats to the east. Three of these confused sheep were pursued on foot and herded back towards

Wheeler Crest. The forth from this group, radio collared ram no. 8, returned to Wheeler Crest the next day (28 March 1980). With the exception of two ewe-lamb pairs, none of the other sheep were observed grouping together until 14 April 1980.

Drive nets were then used to capture an additional 21 bighorns on the following day (29 March 1980). Eleven ewes and four lambs were captured in the Sand Mountain area, and six rams were caught from the north side of Sawmill Creek (see Appendices A and B). The processing and handling of these sheep was similar to that of the sheep captured on the previous day, with the following exceptions: sheep caught in the drive nets were tranquilized with Rompun (or Rompun and Atropine), no M-99 was used. These sheep were also held overnight in the horse trailers for release the following morning.

Richard Weaver (CDFG), who was in charge of this capture operation, decided that these 21 sheep provided a large enough number to allow two more reintroductions. The first of these sites was located at Lubkin Creek, on the east side of the Sierra, 27 air-miles south of the Sawmill Canyon capture site. The other release site was located in the Warner Mountains of northeastern California (see Table 5).

TABLE 3

SIERRA NEVADA BIGHORN SHEEP CAPTURED AND TRANSPLANTED IN 1980

release site	radio collared bighorns		uncollared bighorn		total
	♂	♀	♂	♀	
Wheeler Crest	1	2	0	7	10
Mount Langley (Lubkin Creek)	2	4	1	4	11
Warner Mountains	2	1	3	4	10
					31

In contrast to the release at Wheeler Crest, where the sheep immediately scattered over a wide area, the sheep released at Lubkin Creek left the horse trailer in two groups. The ram group ran uphill until they were out of sight. The lambs and ewes moved off more slowly, pausing to feed when 100 yards away.* (The Warner Mountains sheep exhibited similar behavior upon their release.**)

*Tom Blankinship 1980: personal communication.
**Richard Weaver 1980: personal communication.

There are a few possible explanations for this difference in behavior. The Wheeler Crest sheep were released shortly after their capture; the side effects of the drugs may not have completely worn off, and the sheep may have been dazed from the capture, processing, and subsequent handling. The Mount Langley and Warner mountains sheep stayed in the horse trailer overnight. We believe that this additional time allowed the effects of the tranquilizing drugs to wear off more completely.

Approximately 40 people were present at the Wheeler Crest release. They formed a line on either side of the trailer in an attempt to prevent the sheep from running in the wrong direction. The presence of these people, however, may have frightened and confused the already high-strung animals. In addition, a photographer was allowed to position himself in the path of the sheep. His presence may have caused them to panic by partially blocking their escape. In contrast, at both the Mount Langley and Warner Mountains releases, relatively few people were present. All of them remained well behind the trailers, and the sheep had no trouble deciding which way to go. Another factor that contributed to the scattering of the Wheeler Crest sheep may have been that they were released late in the afternoon. The timing did not allow them to locate each other before dark or become familiar with their new home. Holding the sheep overnight for release the next morning, limiting the number of people present, and keeping everyone quietly behind the trailer during the release seemed to be factors leading to the rapid formation of a cohesive herd.

Herd Movements

On 29 March 1980, two days after release, only 8 of the 11 transplanted sheep were observed (see Table 6).

With the exception of the two ewe-lamb pairs, all other sheep were ranging independently, spread out over a 1-square-mile area, just west of Wells Meadow. This scattering is abnormal bighorn behavior; the sheep usually gather in groups in order to detect and avoid predators. This dispersion may have been responsible for the death of radio collared ram no. 8, a 2 1/2-year-old killed by a mountain lion sometime during the week after the release. His remains were found 1/2 mile west of Wells Meadow.

By mid-April the sheep from the second Wheeler Crest transplant had coalesced into two bands. One group of five (collared ewe no. 7, two ewes, and two lambs) were located 3/4 mile north of Wells Meadow at 7,000 feet. The other

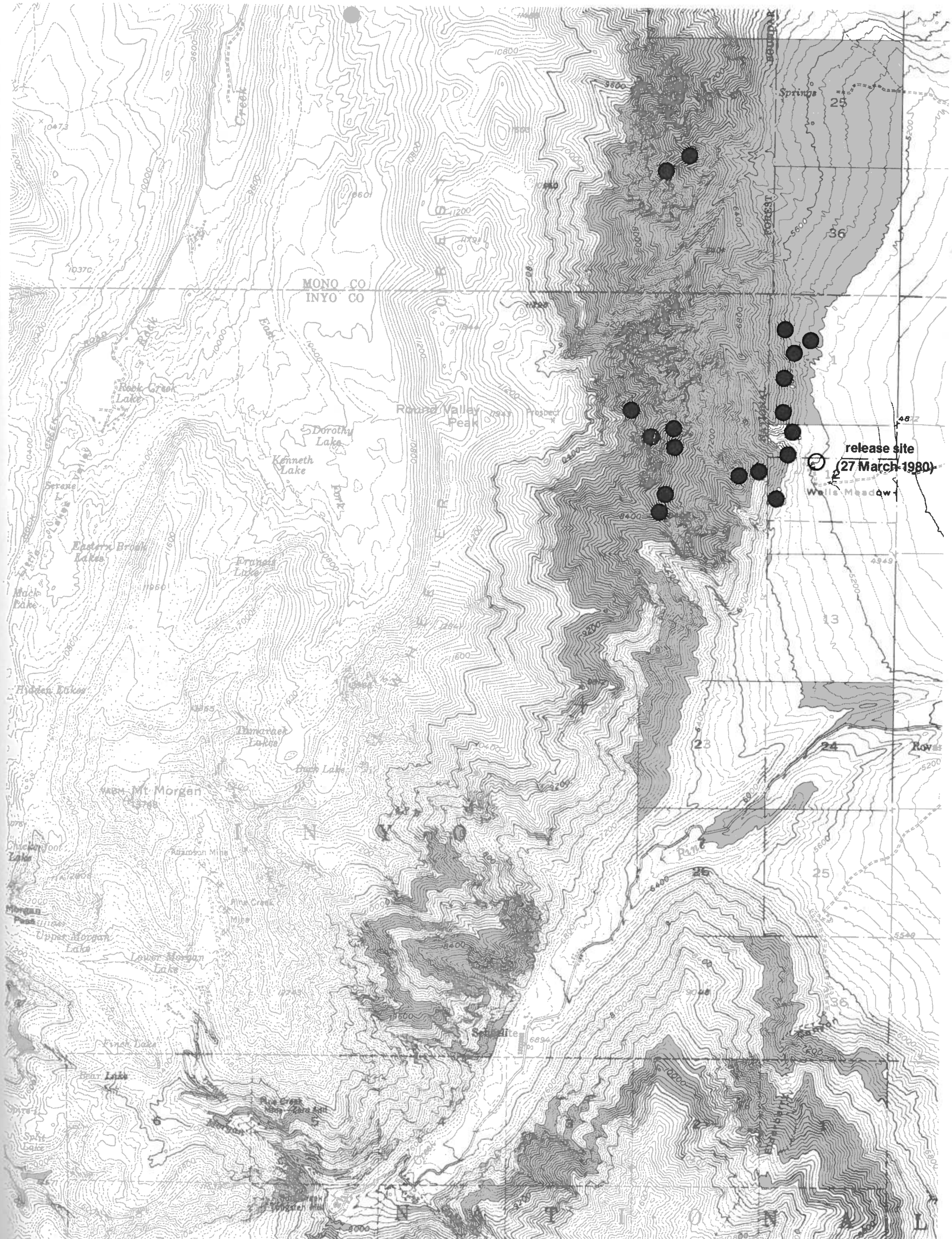

Figure 8 Sightings of bighorn sheep from the first Wheeler Crest reintroduction - spring and summer 1980.

group of four (collared ewe no. 6, another ewe, one yearling, and one unidentified sheep) were seen 1/2 mile west of Wells Meadow at 7,000 feet. Direct sightings, and location estimations with telemetry for the months of May and June did not provide any new information. Collared ewes no. 6 and no. 7 remained in their areas at the same elevations.

TABLE 4

THE SECOND WHEELER CREST REINTRODUCED BIGHORN HERD 27 MARCH 1980

eartag no.	collar channel	sex	age
5063		f	adult
5065	8	m	yearling
5178	7	f	adult
5181		f	lamb
5182	6	f	adult
5183		f	adult
5184		f	lamb
5185		f	adult
5187		f	adult
5064		f	adult

By 7 July 1980 an important herd movement occurred. The separately ranging bands of ewe no. 6 and ewe no. 7 had united into a single band of at least eight sheep. These sheep were observed at over 11,000 feet, 1/2 mile east of Round Valley Peak. Since they had been observed, they had moved upward 3,000 to 4,000 feet into an area that did not appear to be high-quality habitat. In that area the vegetation was sparse and not optimal as bighorn summer forage (see Appendix C). By the early part of August this group had travelled 2 miles north and was situated in the steep exposed granite canyons 1 mile east of peak 11,503 in the northeastern portion of Wheeler Crest. By mid-September, all of these sheep again moved, this time 2 1/2 miles south, back down into their original summer range 1 mile west of Wells Meadow.

Apparently, this group of bighorn spent much of the summer exploring the northern half of Wheeler Crest. Their exploratory wanderings may have led them back to the familiar terrain located directly above the release site. Throughout the duration of the summer only one individually wandering bighorn sheep was sighted in this area, all of the others from this release remained together. This lone sheep was an adult ewe with a lame rear leg, observed 3 miles north of the group in a dense lodgepole forest. She had probably become

separated because of her injured leg; injured bighorns are sometimes found to wander far from their group. This may be attributed to their being too weak to climb upwards, remaining capable of only downslope movements.

THE MOUNT LANGLEY REINTRODUCTION

Mount Langley, approximately 10 miles southwest of Lone Pine, California, is the southernmost 14,000-foot peak in the Sierra Nevada. Much of this area is excellent bighorn habitat and has received sheep use in the past. For these reasons it was chosen as a site for a second release in 1980. The Mount Langley area differs from Wheeler Crest because it is much more heavily used as a recreation area. Many visitors are attracted by the easy high-country access from the Horseshoe Meadow road. Most of this use, however, is concentrated in the Cottonwood Lakes Basin, where backpackers, fishermen, and horseback riders are numerous in the summer. Fortunately for the sheep, very few people travel cross-country out of this basin into bighorn summer habitat. New Army Pass, located 1 mile southwest of the Cottonwood Lakes Basin, receives heavy summer use and may be within bighorn summer range, but this use is unlikely to significantly disturb the sheep. During the entire summer of 1980, we found only one group of backpackers that had encountered bighorns there.

The Mount Langley herd was described by Jones (1950) as being the southernmost bighorn sheep range in the Sierra; he estimated that 90 sheep inhabited this range, although we believe that his estimate was extremely high. Dunaway (1972) estimated a population of 45, but this too was unsubstantiated. Jorgenson and Schaub (1972) conducted a survey in this area and found little evidence of bighorn use. This led Weaver (1972) to speculate that this herd contained no more than 25 sheep. From 1966 to 1972, the CDFG, USFS, and NPS had made several concerted efforts to locate this elusive remnant population; neither ground searches nor helicopter surveys indicated that the area was receiving regular sheep use. Sheep have not been seen here since 1975 (Wehausen 1979).

On 28 March 1980, 11 bighorn sheep, captured on the Mount Baxter herd's winter range, were released at 5,600 feet between the north and south forks of Lubkin Creek approximately 6 miles east of Mount Langley. Six of these were fitted with radio collars (see Table 5).

After their release, the sheep immediately found favorable winter range habitat. Two weeks later the remains of one collared ewe were discovered by Tom Blankinship (CDFG). Apparently, it had been killed by a mountain lion.

On 9 April 80 six sheep including radio-collared sheep nos. 5, 6, and 7, were observed at 6,500 feet, 1 mile southwest of the release site. At this

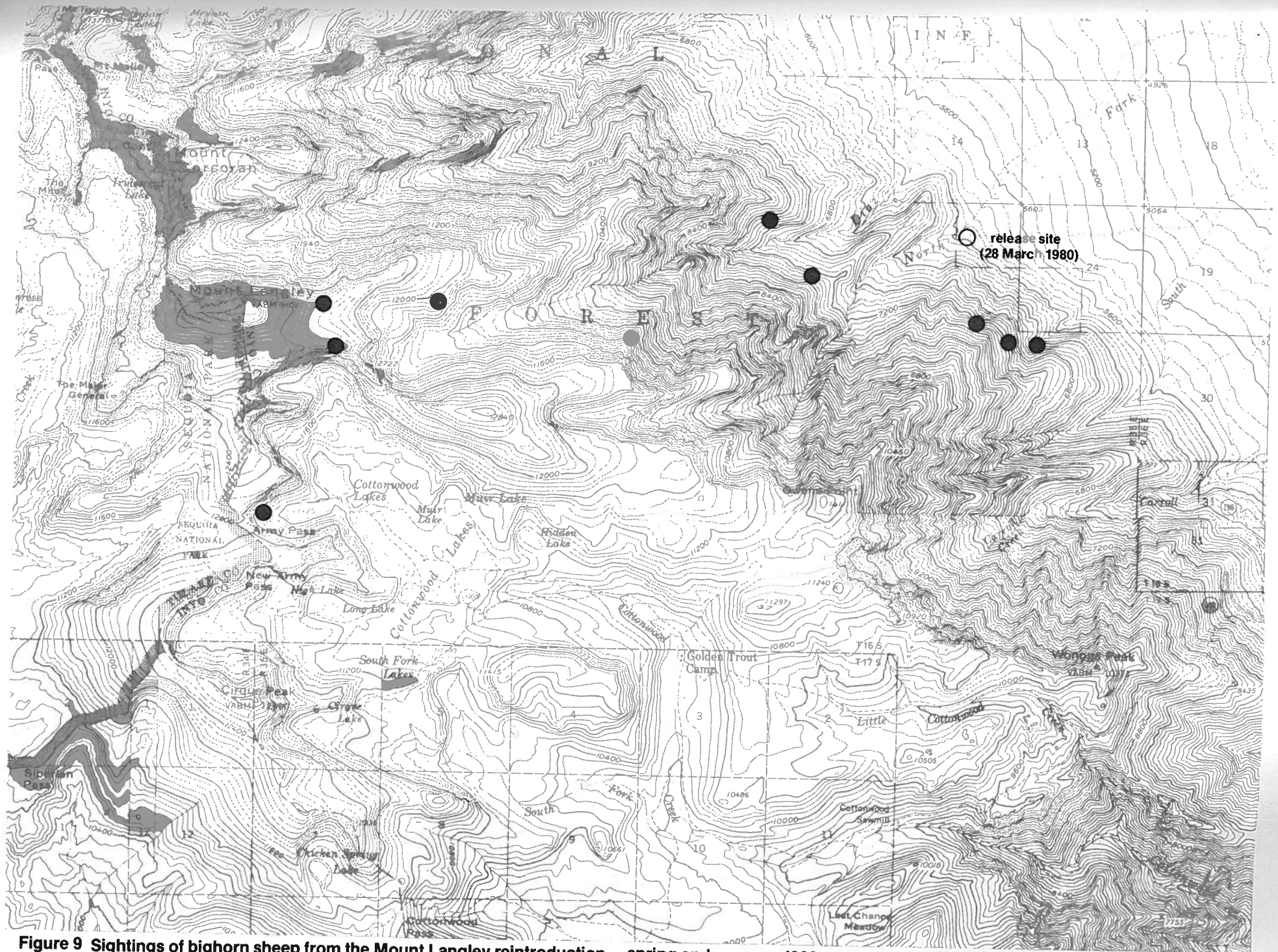

Figure 9 Sightings of bighorn sheep from the Mount Langley reintroduction - spring and summer 1980.

time, signals from the two collared rams (nos. 9 and 10) indicated that they were ranging independently of each other, though their locations could not be pinpointed. Shortly thereafter, their radio collars failed, and they were not sighted again.

TABLE 5

THE MOUNT LANGLEY REINTRODUCED BIGHORN SHEEP HERD

eartag no.	collar channel	color	frequency	sex	age
5177				f	adult
5180				f	lamb
5188	1	brown	159.333	f	adult
5189				f	adult
5191	9	yellow-green	159.420	m	2 1/2
5407	7	yellow	159.390	f	adult
5411	10	red/white	159.435	m	adult
5412				m	2 1/2
5415				m	6 1/2
5418	6	white	159.375	f	adult
5419	5	red	159.390	f	adult

On 16 June 1980 the remains of radio-collared ewe no. 5 were found at 7,200 feet on the north side of Diaz Creek. This ewe was old (her teeth were worn), and the cause of death is unknown.*

By the end of July the two collared ewes had moved up into the expected ewe-lamb summer range; telemetry indicated that ewe no. 6 was at approximately 12,000 feet, just above the headwaters of Diaz Creek, while ewe no. 7 was observed directly at 13,000 feet, 1/2 mile east of Mount Langley's summit.

On 1 August 1980 an uncollared ewe was seen 2 1/2 miles east of Mount Langley at 10,800 feet. None of these ewes had been seen with lambs. Backpackers on top of New Army Pass reported a bighorn on 11 August 1980, but its sex or age was not known. The final (and most encouraging) summer sighting was obtained on 18 August 1980; ewe no. 7 was seen with an uncollared ewe and a lamb. From this evidence we know that at least one lamb was born and survived the summer.

Trying to record the locations and seasonal movements of the new Mount Langley herd has proven exceedingly difficult. From the time of their release on 28 March 1980 through 16 June 1980, two of the collared sheep (nos. 1 and 9) had died, two additional collars (9 and 10) had stopped functioning, and of the two remaining collars (6 and 7), one (6) seemed to be functioning intermittently.

*Tom Blankinship 1980: personal communication.

There may also be a remnant bighorn population at Mount Langley; the last recorded sightings of bighorns there were made in 1975 (Wehausen 1979). If a remnant population does exist, they would be indistinguishable from the non-radio-collared transplanted sheep.

Four out of the seven sheep observed in the summer of 1980 did not have radio collars; some of them could have been members of the original Mount Langley herd.

The winter range of this transplanted herd extended northward from the south fork of Lubkin Creek, reaching its northern limit just north of Diaz Creek. The herd's elevational distribution was confined to the areas between 5,600 and 7,200 feet.

The summer range boundaries are not well known because so few sheep were observed. Excellent ram habitat, which is located west of the Sierra crest, was not thoroughly examined this summer. We spent most of our time exploring the area inhabited by the collared ewes; no rams were observed. We assume therefore that their summer range is elsewhere. The ewe-lamb summer range extended eastward from the 13,000-foot level of Mount Langley's east side, down toward the steep canyons and cliffs located between Diaz Creek and the north fork of Lubkin Creek at roughly 10,800 feet.

CONCLUSION

1979 Wheeler Crest Reintroduction: Summary

In the first reintroduction of California bighorn sheep in the Sierra Nevada, on 6 March 1979, nine bighorn sheep were captured from the Mount Baxter herd and released on Wheeler Crest. The reintroduced Wheeler Crest herd demonstrated movements similar to those of the Mount Baxter herd during the first nine months following release. During May all four ewes produced lambs, increasing the herd size from 9 to 13. As expected, by the end of June, all sheep had moved into a summer range high on Wheeler Crest. When the winter snows began to fall, however, all but two of the sheep (a ewe and her lamb) remained at high elevations, above 10,000 feet, throughout a relatively severe winter. During this time, three bighorn were killed by an avalanche, and at least two lambs died of other causes.

The behavior of this reintroduced herd during the winter of 1980 was contrary to that of the Mount Baxter herd, which winters at elevations between 5,400 feet and 7,200 feet east of the Sierra crest. There are a few possible explanations for this behavior.

1) The absence of traditional migration corridors may have prevented the timely movement of the herd to a low-elevation winter range. Also, deep snows may have isolated the sheep before they could descend to a winter range. The fact that adequate forage could be found on windswept, southerly exposed ridges enabled most of them to survive. 2) The presence of predators in the Morgan Creek drainage may have prevented the sheep from descending to a low-elevation winter range. Mountain lion tracks were observed 1/2 mile west of the Pine Creek Mine zero adit on 3 January 1980 and coyote tracks were commonly noted in the area throughout the winter. Bighorn sheep are known to avoid areas of mountain lion use and retreat to escape-terrain in the presence of coyotes (Jones 1949). 3) Historically, bighorn sheep in the Sierra Nevada have been known to winter high on windswept plateaus and ridges (Jones 1949). This behavior is also sometimes found in Rocky Mountain bighorn sheep. Wehausen (1980) states, that the abandonment of winter ranges east of the Sierra Crest in response to grazing and hunting pressures, forced bighorns to remain at high elevations throughout the winter.

By mid-April 1980, the five surviving bighorns that wintered at high elevations had descended to lower elevations near the southern end of Wheeler Crest. The movement was probably a response to the spring growth of preferred

forage species at lower elevations. The pressure for ewes to come down for lambing may have been a contributing factor.

Eventually this group moved north to an area adjacent to Wells' Meadow in May 1980 and then migrated to a high-elevation summer range above there in June 1980. During this time, the ewe and lamb (that wintered separately from the herd at low elevations) had joined the large band of bighorns in their summer range. We hope that other bighorns will follow this ewe to a low elevation winter range in the winter of 1980-81 where they will stand a better chance of survival.

The reproductive status of the Wheeler Crest sheep presented an encouraging picture in spring of 1980 when contrasted with the previous winter's losses. All of the ewes remaining from the first transplant successfully produced lambs in the spring.

1980 Wheeler Crest Reintroduction: Summary

A group of 10 bighorns was transplanted on Wheeler Crest on 27 March 1980 to augment the surviving sheep from the previous reintroduction. This new group has remained separate from the original herd. Largely due to the handling of this group at the time of release, the animals scattered over a wide area and ranged independently until mid-April. During the first week after its release on Wheeler Crest, the only mature ram of this group was killed by a mountain lion.

At first glance, it would seem that bighorns would be more susceptible to predation if they were ranging independently in a new area. Investigation of two other mortalities at Mount Langley, however, suggests that this increased predation may be more closely tied to the presence of radio collars on reintroduced sheep. All three bighorns killed were radio-collared. The highly reflective surface on the telemetry package of these collars appears to be responsible for increasing their visibility from great distances and therefore their vulnerability to predators.

By July the bighorns of this release had coalesced into one large group of at least eight sheep and occupied a summer range directly above their release site. During the next two months this group ranged extensively over the northeastern section of Wheeler Crest. They eventually returned to the area above Wells Meadow by late September.

1980 Mount Langley Reintroduction: Summary

In the fall of 1980, the status of the Mount Langley herd was largely unknown. The group cohesion observed early in April appeared to have disintegrated; no group of more than three had been observed since then. The summer range of the rams remained completely unknown; no rams were seen all summer. There are probably no more than 6 or 7 sheep remaining.

If the reintroduction program fails to establish successful new bighorn herds, and the 40 sheep taken from the Mount Baxter herd are lost, the population of the Mount Baxter herd will not be lower than when the relocation program began. This is because of the population increase which has been taking place in the Mount Baxter herd for the past several years. If, however, the reintroductions prove to be a success in the Sierra Nevada, the survival of these sheep will be virtually assured.

Geist (1971) states that reintroduction may not save the endangered mountain sheep populations. Although many bighorn transplants have been successful, introduced sheep have the tendency to remain in the general vicinity of their release site. Once they find suitable habitat, they rarely choose to explore or colonize adjacent areas containing appropriate habitat. This observation applies to the first group of bighorns released on Wheeler Crest. They were released near suitable winter range, which they immediately occupied. When the winter snows retreated, they climbed up into an area containing good summer range, but chose not to explore other nearby areas containing equally good habitat. The adult rams explored the central and southern portions of the area, but none of the other sheep followed or explored--except for a single ewe-lamb pair that spent the summer in a high-elevation summer range, 1 mile north of the others. These sheep (no. 2 and no. 2a) were the only ones from the first transplant to return in 1980 to the winter range where all of the sheep were released in March 1979. Apparently they have formed seasonal ranges in this new area; however, they were not followed by any other sheep. All of the other sheep remained on the summer range throughout the winter and had not developed the migratory patterns that lead to the formation of seasonal ranges.

Several examples of movements and behavior, however, indicate that seasonal ranges may be developing. Several sheep from the 1979 Wheeler Crest reintroduction came down more than 2,000 feet in April of 1980 to feed on the new spring growth well below their high-elevation winter range. Also, in the sum-

mer of 1980 two surviving ewes from the initial transplant (no. 3 and no. 7) had joined ewe no. 2 and lamb no. 2a on their summer range; they may follow them back down onto the low-elevation winter range.

The sheep from the second Wheeler Crest transplant have demonstrated some encouraging herd movements. Their summer and fall movements indicated that extensive exploration of the central portion of Wheeler Crest was taking place. The ewes and lambs from this transplant were observed travelling in two distinct bands, both of which covered large areas independent of each other. By mid-July of 1980, they had coalesced into one band. In September they returned to their initial summer range, located directly above the release-site winter range. This behavior indicates that seasonal ranges are developing.

The status of the Mount Langley herd remains unknown; rugged habitat, wide-ranging individuals, and radio collar failures have hindered all attempts to monitor this population. The decision either to augment this herd with an additional transplant or to leave them be cannot be made until the status of that population is accurately assessed.

The development of optimal migration patterns by reintroduced herds may take a long time. At the onset of this study, there were expectations that the bighorns on Wheeler Crest would descend to an appropriate low-elevation winter range. When this failed to take place, the success of this herd appeared to be in jeopardy. The failure of this migration to occur, however, does not mean that these patterns will not develop in the future. The development of optimal migration patterns for reintroduced sheep may simply be a slow process.

Recommendations

Based on our observations of the Wheeler Crest, Mount Langley, and Mount Baxter bighorn herds, the following recommendations are suggested for the future management of reintroduced bighorn sheep. These recommendations are intended for the USFS, NPS, CDFG, and the other agencies responsible for the management of Sierra Nevada bighorn sheep.

1) Continue year-round monitoring of all reintroduced bighorn herds to determine range expansion, formation of seasonal ranges, seasonal movements, predation and other causes of mortality, incidence of disease and parasitism, reproductive success, and long-term population trends.

2) If sheep on Wheeler Crest remain at high elevations above the Pine Creek Tungsten Mill next winter, snow samples in that area should be analyzed for harmful toxins.

3) The Union Carbide Pine Creek Mine should be queried regularly for records of bighorn sightings by their personnel.

4) For future bighorn transplants a temporary holding facility should be constructed at each release site. Sheep could be observed for up to several days in order to determine their overall health and to allow the effects of tranquilizing drugs to wear off completely. If a holding facility is not available, the animals should be kept in horse trailers for release the next morning.

5) If possible, the sheep should be released early in the morning so they have a full day to explore their new home range and find a safe place to bed down for the night.

6) During transplant operations personnel should be kept well behind the trailers when the sheep are released. This minimizes the likelihood that the sheep will panic and run off in separate directions.

7) An annual census of the Mount Baxter herd should be undertaken to determine its long-term population trends. This herd should be used only as reintroduction stock when it exhibits a healthy, growing population.

8) When transplanting sheep, 20 animals should be the minimum size for a new herd. We expect that a higher rate of mortality will occur in the first year for a new herd; consequently, a higher proportion of ewes and female lambs should be included in each reintroduction.

9) Inducing artificial range expansion for the Mount Baxter herd may be possible by transplanting sheep to nearby canyons where they would form new winter ranges while retaining their traditional summer range.

10) The recently discovered Goodale Creek herd is either a recent colonization by the Mount Baxter herd or a remnant population. An intensive ground survey should be undertaken in order to estimate the length of time bighorn have inhabited this area.

11) Sheep with radio collars are apparently more susceptible to mountain lion predation. The shiny metal transmitters should be painted a non-reflective, neutral color to reduce their visibility.

12) There has been a high incidence of radio collar failure in transplanted Sierra Nevada bighorn populations. If the transmitters were encased in a waterproof epoxy coating, the possibility of a moisture-induced short-circuit or battery failure would be reduced. Biologists studying radio-collared black bears in Yosemite National Park have found that epoxy-sealed transmitters have a much lower incidence of failure than identical non-coated transmitters.*

13) Any future reintroductions should occur as early in winter as possible. Heavy snow cover will keep the sheep at low elevation for two more months, allowing them to establish a winter range. This should greatly increase the possibility of their returning there the following winter.**

*Dave Parsons and Dave Graber 1980: personal communication. Dave Parsons and Dave Graber are wildlife biologists for Sequoia National Park.
**John Wehausen 1980: personal communication.

POSTSCRIPT: THE WHEELER CREST AND MOUNT LANGLEY HERDS WINTER 1980-81

As this report was being prepared for publication we returned to the eastern Sierra to satisfy a strong curiosity regarding the bighorn sheep transplanted to Wheeler Crest and Mount Langley. Observations during February and March of 1981 yielded much new information on the success of these transplants. Also, monitoring of radio-collared sheep indicated where these bighorns will probably be found in the future, after their radio collars cease functioning.

Wheeler Crest

At least 20 bighorn sheep were observed on Wheeler Crest between 11 February and 12 March 1981; as many as 25 sheep may have been present. The sightings included four rams, ten ewes, three male lambs, two female lambs, and one lamb of indeterminate sex. Except for two ewe-lamb pairs, the sheep were ranging in two main groups: one at the southern end of Wheeler Crest above the Pine Creek tungsten mill, and the other group 2.5 miles northeast of Wells Meadow (see Table 6 and Figure 10).

TABLE 6

WHEELER CREST BIGHORN GROUPS, WINTER 1981

southern Wheeler Crest

ram no. 1 *
ewe no. 3 *
ewe no. 7* (uncollared)*
1 unidentified ewe
1 male lamb
1 female lamb

2.5 miles northwest of Wells Meadow

ram no. 5 *
ewe no. 6
4 ewes
1 yearling ram
1 2 1/2 year old ram (probably ram no. 8)
1 male lamb
1 female lamb

1 mile southwest of Wells Meadow

ewe no. 2 *
1 male lamb

1 mile northwest of Wells Meadow

ewe no. 7
1 lamb

*from first release (6 March 1979).

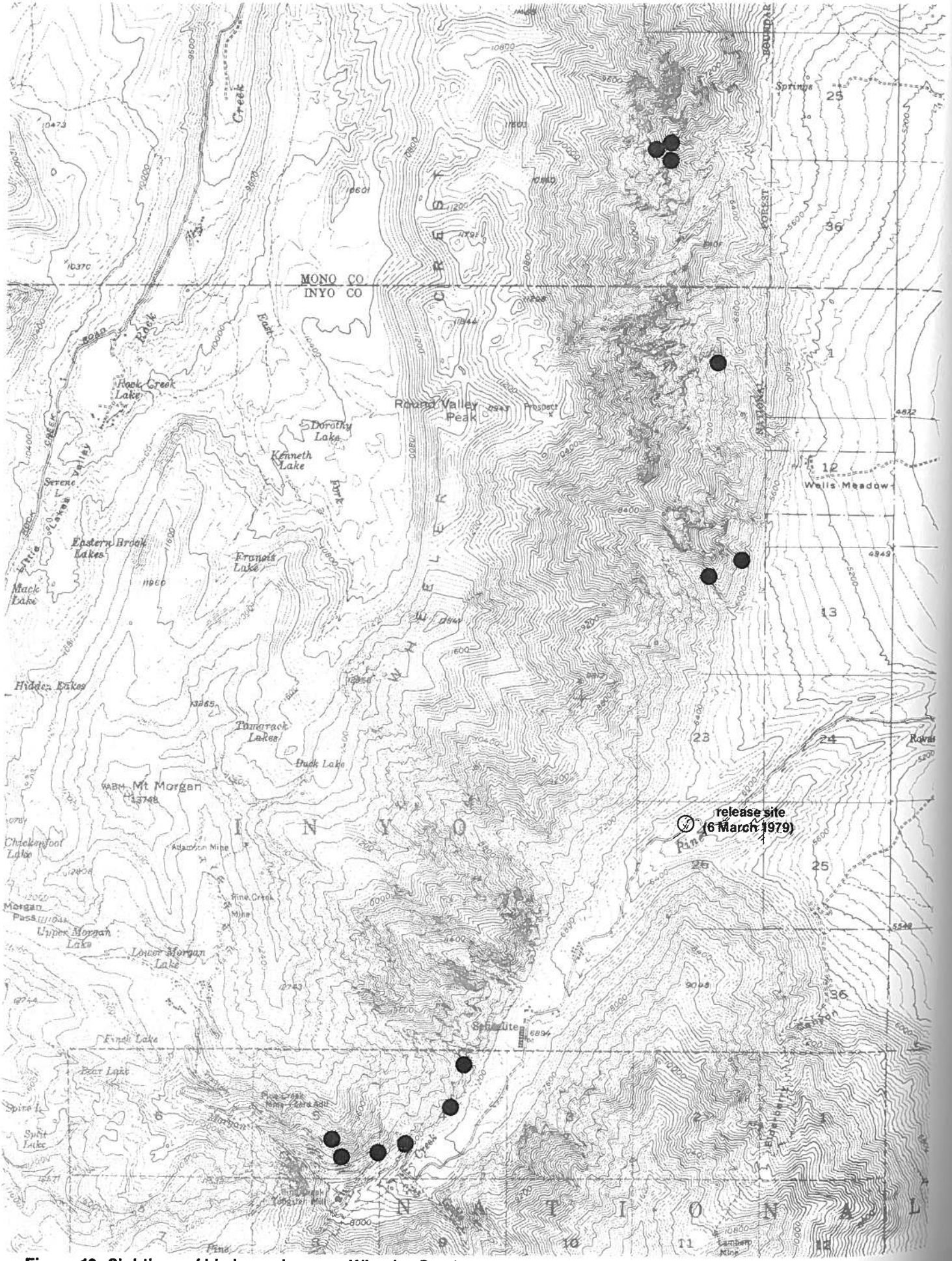

Figure 10 Sightings of big horn sheep on Wheeler Crest - winter 1980-81.

The bighorns wintering at the southern end of Wheeler Crest were observed regularly on the south-facing slopes above the Pine Creek tungsten mill by mine workers. According to security guards at the mill entrance, this group of sheep would occasionally descend to within 200 yards of the mill area. On 7 March 1981 this same group of sheep appeared on top of a small crag 30 yards from the Pine Creek Road, one-half mile from the mill. The sheep showed little concern over nearby human activities. When a helicopter flew overhead, however, the sheep ran rapidly uphill.

The population of 20 to 25 bighorn sheep at Wheeler Crest suggests that the transplant is a success. Following the birth of lambs this spring, the population will increase. Also, a winter mortality rate lower than that of 1980 can be expected in the future, because all bighorns observed in winter 1981 were found at or below snowline.

The sheep from the first transplant appear to be forming seasonal range patterns; they are using winter range areas similar to those used last year. Ewe no. 2 was found in the canyon occupied the previous winter, and the southernmost group of sheep was found at a lower elevation, within 1 mile of the 1980 winter range. When last observed on 16 March 1981, this group had moved 2 miles north of the Pine Creek mill area. This movement corresponds with the group's movements during March and April 1980, when the entire group moved north to an area near Wells Meadow. Presumably, the sheep migrated in response to the spring growth of preferred forage species in that area.

As anticipated, bighorns from the second reintroduction descended to an appropriate winter range below snowline north of Wells Meadow. This group of bighorns was joined by at least two sheep (rams no. 5 and no. 8) from the first reintroduction.

Mount Langley

No observations of the bighorns on Mount Langley were made this winter, despite extensive observation (with field glasses and scopes) of suitable winter range areas from Wonga Peak north to Lone Pine Peak. Apparently, all of the radio collars for this group had stopped functioning. The last radio telemetry location was made by Tom Blankenship (CDFG) during an early January 1981 flight over the Sierra crest. At that time radio-collared sheep no. 6 was located near the Mount Williamson herd, in the Bairs Creek drainage. (The Mount Williamson

herd is approximately 10 air-miles north of Mount Langley.) No signal was received during a subsequent search of the area from Independence Creek south to George Creek on 3 March 1980. The location of the Mount Langley herd remains unknown.

APPENDIX A

BIGHORN SHEEP CAPTURE TECHNIQUES

The trapping of bighorn sheep in North America for management purposes dates back to 1922 (Yoakum 1963). Since then, there have been numerous capture and transplanting operations, using a variety of techniques. The techniques described here have all been used by the CDFG in their recent efforts to re-establish Sierra Nevada bighorn on their historic ranges. The key to a successful capture and transplant operation may well be the ability to rapidly change capture strategies to fit the immediate situation. Variables such as herd movements, high winds, topography, and the availabilty of helicopters and trained personnel determine what method should be used.

Drop Net

A typical drop net used for capturing big game animals measures 70 feet on each side and is made of strong 1/3-inch nylon cord having a 6-inch mesh pattern. For ease of transport and to simplify the removal of captured sheep, it unsnaps into four triangular sections. The net is suspended from a 15-foot-high center pole with four 10-foot-high side poles and four 10-foot-corner poles. When properly pitched, the lowest point of the net is at least 7 feet off the ground. A blasting cap is taped onto each cord where it attaches the poles to the net. These are detonated when the sheep come under the net, severing the cord and causing the net to fall on the sheep.

Prior to erecting the drop net, bighorn are baited at several sites with fermented apple pulp, alfalfa, and salt blocks. This is supposed to "hook" the sheep, so they will return frequently to the bait site. Once the sheep begin to regularly use a bait site, the net is erected. Patience is essential at this point, because the wary sheep will usually avoid going under the net for a few days.

The drop net minimizes stress to the captured sheep because unlike operations using darting or drive nets, the sheep are not chased or herded before capture. The primary disadvantage of using the drop-net capture technique is the length of time it takes to bait the capture sites. Several areas must be regularly baited and observed before choosing the one with the most sheep use. If deer find the bait, or if mountain lions develop an interest in the site,

sheep will abandon it.

Drop nets catch ewe-lamb bands more frequently than they catch ram bands. Due to the higher nutritional needs of pregnant ewes and the low-quality winter-range forage, ewes are easily "hooked." To catch rams, other capture techniques are needed. Tranquilizing darts and drive nets have been successfuly used to catch rams from the Mount Baxter herd in 1979 and 1980.

Drive Net

Drive nets used in the live capture of big game animals measure 100 feet in length and are 8 feet high. They are constructed of nylon cord in a 1-foot mesh pattern and are supported by poles located every 30 feet. A series of drive nets is set up in a semi-circle, and nearby bighorn sheep are driven into them with a helicopter. When the sheep run into the nets they become entangled and the net falls over, trapping them.

A drive net can be set up or moved almost anywhere in a few hours. A drop net, on the other hand, requires a major commitment of resources and personnel over an extended period of time. Another advantage of drive nets is that they allow personnel to choose individual sheep and herd them into the nets. With this method, sheep may be captured from several different areas in one day, reducing the possibility of depleting one particular herd or sub-herd. For these reasons, the drive net is by far the most flexible and successful method of capture.

The primary disadvantage is that the captured animals are extremely stressed, physically traumatized, and exhausted from the helicopter chase.

Darting

Darting allows specific animals to be selected from a group. This technique requires the use of a helicopter and is the most expensive and dangerous method for capturing sheep. Once darted, the sheep will continue to flee the helicopter until the tranquilizing drugs take effect. If they reach rocky and precipitous escape terrain, the possibility of a fatal fall is greatly increased. If the sheep elude the helicopter and ground crew before succombing, they can die before they are reached. In these situations the cause of death is usually shock, sensitivity to the drugs, or asphyxiation from choking on their rumen contents. With a highly skilled pilot, an expert marksman, and a well-organized ground crew, these risks are minimized.

APPENDIX B

THE HANDLING OF CAPTURED BIGHORN SHEEP

Bighorn sheep are highly susceptible to physiological stress; therefore, complications may arise following capture. Mortality induced by over-heating, shock, or choking on regurgitated rumen contents is likely if the animals are handled improperly.

To reduce these complications, several veterinarians and a trained handling crew were used to handle bighorns at the 1980 Mount Baxter capture operation. When approaching captured animals, personnel remained quiet and avoided hurried motions. Undue fright may be caused by a noisy crew running up to the capture site. A minimum of handling and physical restraint was also necessary to reduce the amount of stimulus the animal received; physical restraint appears to produce an extreme amount of stress in these animals. Hobbles were used to restrain movements, and blindfolds placed over the eyes helped keep the sheep calm.

Following capture the sheep were kept upright. If a bighorn is allowed to lie on one side for too long, the position of the stomach may allow gases to accumulate causing regurgitation of the rumen contents. When the sheep are overstressed, drugged, or in shock, involuntary muscle actions may also cause regurgitation. Such vomiting causes choking and may initiate lung infections if the bacteria-rich rumen contents are inhaled.

Rectal temperatures were also monitored on all bighorn sheep during capture and processing. The normal body temperature of a bighorn is between 102° and 103° F. Although captured sheep undergo stress that raises their temperature as high as 110° F, the average temperature recorded during processing was 105° F. Lambs were found to have consistently higher temperatures than adults. Dousing the animals with water cooled them effectively. A supply of intravenous sodium bicarbonate was kept on hand for cases of extreme overheating, though none occurred.

To further reduce stress, sheep were injected with Etorphine (M99, American Cyanamid Co.) and/or Rompun plus Atropine immediately after being captured in the nets. Etorphine is a narcotic analgesic derived from morphine; it has been developed for live-trapping big game. The dosage for each animal was determined by its weight; 3.9 milligrams were injected per 100 pounds bodyweight. After processing, the sheep that had been injected with M99 were given a shot of M50/

50. This drug quickly counteracts the narcotic effects of the M99, leaving the sheep alert and ready for release.

Since complications may arise from using M99 exclusively, it was mixed with Rompun, a tranquilizer. Rompun is a muscle relaxant of short duration, and no reversal drug is needed, as its effects typically wear off within 45 minutes. The normal dosage for this drug was an intramuscular 10 milligrams per 100 pounds of body weight.

APPENDIX C

WHEELER CREST SUMMER RANGE PLANT SPECIES

NORTHERN WHEELER CREST

*Carex rossii
C. leporinella
Calamagrostis purpurascens
Ribes cereum
*Sitanion hystrix
*Leptodactylon pungens
Eriogonum ovalifolium
*Poa sp.
*Aquilegia pubescens
Draba sp.
Arabis sp.
Selaginella watsoni
*Haplopappus macronema
H. peirsonii
*Hulsea algida
*Potentilla fruticosa
*Penstemon davidsonii
Festuca brachyphylla
Raillardella argentea

SOUTHERN WHEELER CREST

*Carex helleri
*C. rossii
*C. vernacula
*C. exserta
C. leporinella
C. breweri
*Calamagrostis purpurascens
Ribes cereum
*Sitanion hystrix
*Leptodactylon pungens
Eriogonum ovafolium
*Poa sp.
*Aquilegia pubescens
Draba sp.
Arabis sp.
Selaginella watsoni
*Haplopappus macronema
H. peirsonii
*Hulsea algida
*Potentilla fruticosa
*Penstemon davidsonii
Festuca brachyphylla
Raillardella argentea
Trisetum spicatum
Phlox covillei
Erigeron pygmaea
Antennaria sp.
*Silene sargentii
Arenaria kingii compacta
*Polemonium eximium
Pteryxia petraea
*Oryzopsis hymenoides
Bromus tectorum

*-species preferred by Sierra Nevada bighorn (Wehausen et al. 1977)

APPENDIX D

WHEELER CREST LOW ELEVATION WINTER RANGE PLANT SPECIES

*Artemisia tridentata
*Prunus andersonii
Ephedra nevadensis
*Chrysothamnus nauseosus
C. viscidiflorus
*Stipa speciosa
*Bromus tectorum
Encelia sp.
*Eriogonum nudum
E. umbellatum
*Leptodactylon pungens
*Purshia tridentata
Monardella sp.
Haplopappus cuneatus
Cercocarpus ledifolius
Salix sp.
*Oryzopsis hymenoides
Baccharis pilularis

*-species preferred by Sierra Nevada bighorn (Wehausen et al. 1977)

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