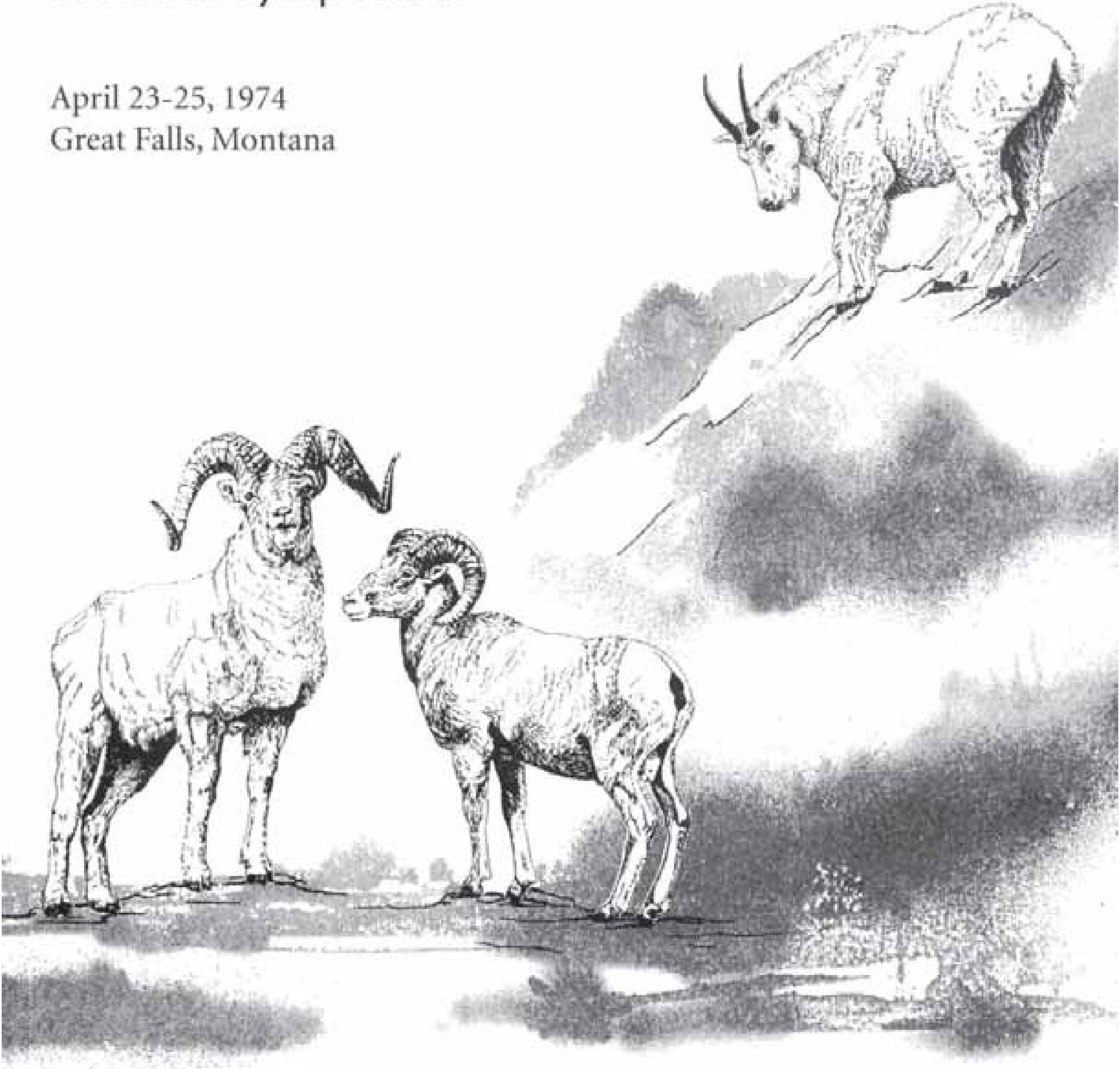
Northern Wild Sheep Council

Proceedings of the Biennial Symposium

April 23-25, 1974
Great Falls, Montana



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OF THE

BIENNIAL SYMPOSIUM

OF THE

NORTHERN WILD SHEEP COUNCIL

GREAT FALLS, MONTANA
APRIL 23-25, 1974

CO-CHAIRMEN -
KERRY J. CONSTAN
JAMES L. MITCHELL

COMPILED BY

MONTANA DEPARTMENT OF FISH AND GAME

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WELCOME AND OPENING REMARKS

By
Wesley R. Woodgerd, Director
Montana Department of Fish and Game
Helena, Montana

It's really a pleasure today to welcome you to the Northern Wild Sheep Council meeting - particularly the out-of-state people who are attending. I would like to give you a key to the city, but of course I can't do that. However, if there are any services that I or any member of my department can provide, please let me know.

It really pleases me to see such a group of experts gathered here to exchange ideas and information on a big game animal that is such an important resource in Montana. Surely this meeting is bound to result in better information for all of us to operate under - a better understanding of bighorn management and the problems which I am sure we all face, many of us in common.

Of course, the one problem I know we all face is the threat of the antihunting movement that we see growing at such a rapid pace and increasing at an alarming rate. The only way I believe we can counteract something like this is to have good information on our populations, which is what we are here to provide today, and then exchange it with one another to get good public dissemination of that information to the hunting public - particularly to the young folks who are coming up and will be the hunters of tomorrow.

If we have a united organization and a united front to provide the public with the factual information they need, then they will provide for us the sport hunting we all enjoy. This is the place where the experts can gather and exchange information and ideas and fight about them and argue about them and stomp and shout - but the stomping, shouting and arguments should be confined to meetings such as this where I believe a difference of opinion is normal and logical, and not take the fights to the public, because if the experts begin to fight publicly in the media the do-gooders will move in and there will be nothing really harmed except the sheep. I think this is primarily what we are all interested in - the welfare of our wild sheep populations.

As an administrator, all I can ask is that I be provided with the very best information that is possible on which to base the management decisions that must be made, and I am sure a meeting such as this will go a long way toward providing myself and the various other administrators of the areas you represent the best information on which we can base our management decisions - so I think I will just say good luck in your meeting, and I'm looking forward to a lot of good things to come out of it.

WILD SHEEP FROM AN ECONOMIC AND CONSUMER VIEWPOINT

By
Jack Atcheson
Butte, Montana

Good morning. I'm very pleased to be here. Basically I'm going to speak on the consumer's view on sheep, and also I have some slides on sheep hunting and some other types of hunting throughout the world to use as a basis of comparison so you can see how other types of hunting compare with sheep hunting. After the slides I have some other material to present.

Slide presentation (given to hunters to give them some idea of what they're getting into).

This has to do with all game, basically Africa. I'm going to read something concerning Africa: Eland are almost exterminated and are on the protected list. In Ngorongoro no game such as impala. I never saw a dik-dik or elephants. The authorities refused a license to shoot an elephant in Mt. Kenya. Arthur Neuman, another hunter, describes his fruitless trek from Mombasa to the Tana through a particular area - there was no game. We saw too many people crossing the Tana, which is one of the best elephant areas there are. There was hardly any game. I saw only one bush buck in all my trip - 14 months. At the foot of Mt. Kenya there is hardly any game besides elephant. I only saw three giraffe, a small herd of zebra and two lions. I bagged two eland and I never set sight on a single buffalo. The reinderpest epidemic, the buffalo are now nearly extinct. The spoor of the white buffalo is a rarity, ...but this article, I'll bet you thought it was written today - it was written in 1890 so nothing has really changed too much. Everyone thinks that Africa is a game paradise, always has been and always will be. This is not so, they have the same problems we have here.

Another article I cut out of a newspaper - it was released April 7: elephant hunting is banned in Kenya. The hunting is deteriorating, the poaching is increasing. Actually almost the same article as the one written in 1890. The problems and situations as you can see are the same there as they are here, it is no different.

Now we're going to cover some points concerning sheep. For instance, what does a sheep license cost throughout the world and what does sheep hunting cost? Well, here in Montana for those who are unaware of it, our license for a nonresident is $151 plus $50 for a sheep license. If you go to Alaska the license is $20 for the initial license and $150 for the sheep. You go to British Columbia and it's $75 for your initial license and $250 for the sheep. Now as a basis of comparison where the licenses are high, if you go to Kenya to shoot an elephant you pay $750 for the elephant plus $6 a pound for all the ivory under 70 pounds and $11 if it is over 100 pounds, so an elephant could cost you $3,000. If you go to Botswana to hunt lion the license itself costs $780, so I can assure you that the cost of licenses and hunting throughout the world is far more than you realize.

If any license increases that we have here, to buy more game habitat, etc. are opposed by anyone who says it's too much, they don't really know what they are talking about. As far as what you pay on a sheep hunt, the most expensive hunt you can go on is in Mongolia - the cost to hunt there, on the border of China on the Gobi Desert is a minimum of $400 a day with a minimum of 10 days. If you go higher into the mountains of Mongolia, the cost of the hunt is $800 a day with a minimum of 14 days plus all your travel and other expenses.

Now another point people ask about concerning sheep is how much time does sheep hunting take. Do people want to spend a lot of time (from the consumer's view)? Some people have peculiar ideas about this. If you go for a Dall sheep, 10 days is considered the proper length of time. Fourteen days is the proper time to hunt stone sheep. Bighorns should be selectively taken in 10 days. When you ask these sheep hunters what size ram they want they state they want a decent ram. I don't know what a decent ram is, but they seem to think it is something between 38 and 40 inches, which is kind of a myth. I can tell you this from experience, that the third time a man climbs a mountain he'll shoot any damn ram he sees. It's a hate killing after that.

After 7 days of hunting the man's spirit is broken - the status seeker or to some extent the mixed-bag hunter, who, after 7 days gives up on sheep then goes after other game. The avid hunter will go on and on. The unfortunate thing is that too many biologists (in my opinion) and too many game departments give in to the unhappy man. One man bitches and it automatically makes it bad for the rest of them, because of one complaint.

People say they don't see enough big sheep and there aren't enough old sheep. Besides arranging hunting trips, I have a taxidermy business. At one time we had 26 employees, so it was a pretty fair-sized place. This was several years ago. I kept track of 500 rams that came through our place, and of the 500 rams (this is all kinds of sheep taken from everywhere), 10 percent were over 8 years old. Ninety percent were 8 years or younger. Only 1 percent reached 39 inches or more, so 38 and 40 inch sheep are a myth - they just seldom get that long.

All animals have a magic number. Moose is 60 inches, goats is 10 inches, antelope is 16 inches. All brown bears should be 10 foot, all grizzly bears should be 9 feet. With sheep it is 40 inches. Most people feel they've got to get a 40 inch sheep and it's just not possible, there aren't very many 40 inch sheep. However, I think the trend is going the other way, because I hear more people saying that they're happy with just a nice adult sheep or a nice full curl ram which is not too difficult to get as far as Dall or stone sheep go. Most of the sheep that we get in now are older sheep - they're 8-9 years old. Very few 9. They seem to be between 34-36 inches. They probably weren't going to get any older.

There's a lot of people who seem to indicate that the bighorn sheep hunting is done. We're going to discuss this in the Boone and Crockett syndrome this afternoon. I will mention it now to give you something to think about. Of the last 5000 Dall sheep that were shot in Alaska, 17 made the record book. There have been way less bighorns shot, but there are 19 bighorn sheep in the record book, so theoretically even though they're under more pressure, bighorns are doing better than Dalls as far as records go.

We have a very emotional situation over sheep. A lot of people believe there is a lot more poaching than there actually is. I don't believe it.

I believe it is about one third as much - I believe that each illegally taken sheep is heard about two or three times. I read recently that someone said there are 300 rams legally killed in the U. S. each year and the illegal kill is many times that. To me that would mean 1,000 rams were killed a year illegally. I can't quite swallow that, and I think it is misleading and it's making the hunter look like he's somewhat of a poacher. Sometimes I wonder if a lot of people or magazines aren't too eager to sell short stories and get their points across. Maybe they are just badly worded. Maybe the writers have guilt complexes. It could be that the material is not as factual as it could be. It's very disturbing to me and very disturbing to the public who don't really understand what real hunting is. There's probably some truth to all of it, too, but I think that this should be brought up in this meeting. I would like to see more facts condensed to where I can understand them and I can give them to other people.

I would like to see more biologists and more fish and game departments start fighting back instead of turning the other cheek. Sometimes this is a little on the hard side, but I have met a few biologists who sometimes forget who is paying their wages. Actually the hunter is paying the bill, and we should be given first consideration. Remember that the hunter pays 11 percent excise tax on sporting goods, yet 11 times more nonhunters benefit from this money than the hunters do. We're paying for the rest of them. I don't think we should let the public, actually only a few individuals, sway us on minor issues and hunting policy. I'm afraid this is the trend that people are giving in to too quickly. There are some people who suggest that many ex-hunters or other individuals are interested in photography safaris. This is a falacy.

It doesn't exist. Few will pay for a photo hunt. If you would, I would book the trip. Few people will pay money to go on photography trips. Very few outfitters are successful in the summertime because they can't get people to pay any money to go back into the mountains. Very few outfitters are filling up.

Actually, all you'd need for a photo trip would be one of each species of wild animals, available in an area, standing near a road - just keep them good and tame and with a good background. People who want to take pictures won't walk and the animal has to be tame. You can hardly take a photograph of an animal back in the wilderness - they're too wild and the average man hasn't the ambition or ability to try and get closer. What they want for a photographic trip the national parks provide adequately. Too much of this seems to be based on 10 percent fact and 90 percent emotion. It should be the other way around.

Here's something else interesting, and it scares me as a consumer. I'm interested in endangered species and whether or not they're going to be put on or taken off an endangered list. Leopards a couple years ago were put on an endangered species list. I personally wrote to five game departments in Africa and all of them denied that leopards were endangered and the minister from Kenya wrote back and said that Americans should mind their own business. In December 1973 the president signed a new endangered species bill which supposedly will allow legally taken leopard skins into the U. S. The Department of Interior has never implemented the law, as it will take $200,000 to write the new regulations and they don't have the money. According to this bill (it's difficult to understand), bureaucrats really have no authority to decide which laws they will enforce. This is why I'm concerned about sheep and other animals. If they are put on these lists they'll never be taken off.

In this same bulletin it says, "Public hunting on national refuges, July 1973. The Department of Interior has decided to overrule the traditional policy toward hunting on national wildlife refuges." The new policy states flatly that providing hunting opportunity is no longer in any way an obligation. That just might be of interest to you.

I have something here I want to read - I'm concerned about kids - this is from the Weekly Reader. You've all read the Weekly Reader. It mentioned at first there were only a few examples of endangered animals. Then it stated, "Hunters have been the big reason for the drop in numbers of tigers and horned desert animals. The skins and horns make very fine trophies." Then at the end are questions - "Large numbers of horned desert animals have been killed off by (fill in the blank)?" I would like to see, and I think everyone would like to see, more good wildlife management education of the young. This is where it starts.

I would like to share with you some of the unusual stories and letters I have received in past years:

One time we had a hunter from Washington, New Jersey. His name was Zimmerman. He wanted to come to Montana to shoot an elk so he came and the first time he was here he brought seven duffle bags. This made it a little difficult for the guide - when he came back the guide told him not to bring so many duffle bags. The guy didn't get an elk, so he came back. Next time he arrived he had 16 pairs of boots and 7 Weatherby rifles to pack into the mountains. One hunter and one guide. Very difficult hunting. Every time the guide would show the client an elk he would miss it, so finally they saw a goat on a mountainside and he had a goat permit so he started to shoot at the goat at 9 a.m. and he fired his last shot at 1 in the afternoon. The goat wouldn't leave his sheer rock and kept wandering back and forth. He shot 80 times at it and never hit the goat. Finally the guide took him back to camp and this went on for two weeks. The guide was becoming very exasperated with the client, so finally he said, "Zimmerman, you are the world's worst hunter. I can't stand you any longer. Get on a horse, we're leaving." Right in the middle of the road there's a big bull elk and right beside the elk is a pass with some heavy timber. Zimmerman's last chance was right there. The guide told him to go in the pass and he would scare the elk past him and he could shoot him. The elk had moved down and was running really fast when he went through the pass and Zimmerman still didn't get an elk and Ray took him out.

I get a lot of letters asking questions - a man once said, "The first 8 days of the hunt you arranged for me were very good, but the last day of the hunt the guide became very disturbed. He took my horse away from me and he made me walk back to camp. It was 12 miles." I asked the guide, "Why did you take his horse away?" The guide said, "Because he shot my horse." This is all true.

Four clients came one time and we arranged a hunt. They took three 6-point bulls, but they told me if I couldn't find a better place for them to hunt next year I could take them off the list of my satisfied clients.

Here's a letter that says, "There will be some confusion with a batch of horns and heads that will arrive at your taxidermy shop. I saw my partner switch tags so he would get the bigger sheep."

"Dear Mr. Atcheson - please send me any spare heads and horns you have. I hear you're rich and hunt all over the world."

"Dear Mr. Atcheson - I don't believe you any more. You said this was a good area. I did get 18 trophies in 21 days, but expected to get a larger elk and you misled me and I think I'm going to bring suit against you."

"You are a murderer. You and your friends kill animals. I wish animals would kill people. I hope all hunters kill each other. I hope that they or I could kill you. My teacher told me to write. We believe in live and let live."

"Dear Mr. Atcheson - can you get me a discount on a license? I hear you have pull in the game department."

"We've been planning this hunt for a long time and it means a lot to us. I'm sure you understand. We're both over 60 and probably won't be able to go again. If you'll put up a $5,000 bond and guarantee we'll get all the game we want we'll send you a deposit."

"I'm really sorry about what happened, but when I shot I thought it was an elephant. I didn't know it was a safari car."

"I want to hunt in Africa with a spear. Down our way I'm noted for killing pigs by jumping on their backs. I'd like to send you some photographs."

"I would like to go on a safari. I'm 28 years old. I will try very hard and I'm willing to do my part. I really can't afford to go, but I'm told that I'm a very attractive woman. Do you know anyone interested?"

"You are a bastard. You tell my husband where to hunt and he leaves me for some stupid animal."

I have quite a collection, and some we really can't read.

You people here and the hunters are supposed to know more than the general public does about wildlife management, so I think that more facts instead of emotion should be used as a basis for open and closed seasons. I want everybody to fight back. I hope everybody will leave this meeting with more desire to back up what you say to the public, thus protecting hunting.

Thank you.

A BRIEF RESUME OF THE STATUS, MANAGEMENT, RESEARCH EFFORTS ON AND PROBLEMS OF DALL SHEEP IN ALASKA - 1974

By
Wayne E. Heimer
Department of Fish and Game
Fairbanks, Alaska

The abundance and distribution of Dall sheep in Alaska has received much attention throughout the brief history of sheep investigations in the state. The general distribution is well understood, and is presented in the Alaska Department of Fish and Game publication, Alaska's Wildlife and Habitat. Dall sheep in Alaska occur in seven mountain ranges throughout the state; the Brooks Range, Tanana Hills-White Mountains, Alaska Range, Talkeetna Mountains, Wrangell Mountains, Chugach Mountains and the Kenai Mountains (Fig. 1).

Information on abundance is currently lacking in many areas of Alaska where sheep are known to occur. The information which exists is largely the product of aerial surveys. Areas which have been systematically surveyed have been the Alaska Range, the Wrangell Mountains, the Tanana Hills-White Mountains, the Kenai Mountains and portions of the Chugach and Talkeetna Mountains. Table 1 gives the current estimates of numbers of Dall sheep in each of the seven mountain ranges of Alaska as well as a qualitative expression of the confidence which can be placed in each estimate.

Table 1. Dall sheep numbers in the mountain ranges of Alaska - 1974.

Mountain Range	Estimated Number	Qualitative Confidence Level
Brooks Range	20 - 25,000	Low
Tanana Hills-White Mountains	700	High
Alaska Range	10,000	High
Wrangell Mountains	10,000	High
Talkeetna Mountains	3,000	Low
Chugach Mountains	3,000	Medium
Kenai Mountains	3,000	High

It can be seen that the current estimate of Dall sheep numbers in Alaska is 50 - 55,000. This is thought to be a conservative estimate by most members of the Alaska Department of Fish and Game staff.

It is impossible to state whether there is a trend in the numbers of sheep throughout the state. Some populations are known to be quite high, and others are lower than they have been in the recorded past. It is not known whether Dall sheep in Alaska follow cyclic population fluctuations. It does, however, appear that in total there are as many sheep present throughout the state as there have ever been in recorded history.

MANAGEMENT: Management of Dall sheep in Alaska has consisted of a limited fall season and a 3/4 curl regulation for the last 25 years. Hunting throughout this period was generally light until recent years. The combinations of weather influences in the hunting season, difficulty of access and low human populations regulated the harvest at low levels in the past. However, within the last five years increases in affluence, human population and hunting technology have resulted in localized hunting pressures which are capable of producing overharvest. For this reason the "voluntary" system of harvest rotation from accessible area to accessible area has become insufficient to perpetuate reasonable harvests of trophy rams in all areas of Alaska.

In an effort to cope with increasing hunting pressure and the increasing number of dissatisfied hunters, the Alaska Department of Fish and Game has established special management areas for Dall sheep throughout the state. Areas exist which are zoned for limited access and transportation types. In addition to these areas, a management area was recently established in the eastern Alaska Range which allows harvest of full curl rams and an equal number of ewes by permit only. Future trends of hunting pressure and harvest will dictate whether further restrictive regulations are necessary.

HARVEST: For the last five years Alaska has harvested about 1,000 sheep and supported about 4,000 hunters each fall. This has been a fairly stable number, but an upward trend is evident in both hunter numbers and harvest. About 40 percent of the annual Dall sheep harvest is attributable to nonresidents, and about 60 percent to resident hunters. In the past, and at the present time, there have been no restrictions on nonresident hunters. The cost to nonresident hunters is approximately $200 in fees and licenses, and the additional expense of engaging a registered guide. Alaska law dictates that a nonresident sheep hunter must be accompanied either by a relative within the second degree of kindred or a registered guide. A guide will cost from $100 to $200 per day depending on accommodations and location.

RESEARCH: Research on Dall sheep is currently being carried out by the Alaska Department of Fish and Game, the Cooperative Wildlife Research Unit at the University of Alaska, and some members of the Biology Department at the University of Alaska. Efforts of the Department of Fish and Game are centered in the Alaska Range and the Kenai Peninsula.

Lyman Nichols, sheep biologist for the Southcentral Region of Alaska, is conducting a study on the Kenai Peninsula which is designed to determine the effects of non-trophy sheep harvest on population parameters and forage production on winter range. His study area contains three discrete sheep populations which are subjected to differing hunting schemes. One receives ram-only hunting in accordance with statewide management practice, one non-trophy hunting, and one no hunting at all. Results are not conclusive at this time, but much information has been gathered on food habits, breeding biology and the effects of weather on Dall sheep of the Kenai Peninsula.

In the Interior Region of Alaska, I work in the Alaska Range. My work has centered around Dall sheep population definition, the importance of mineral licks to Dall sheep, and movement patterns. Some of this work will be presented during later sections of this symposium. A study of the dynamics of horn growth has also been undertaken of sheep throughout the state. Future plans call for assessment of the environmental determinates of population quality.

The Cooperative Wildlife Research Unit at the University of Alaska is conducting a study relating to pipeline construction and the effects of disturbance on Dall sheep in the Brooks Range. The Biology Department at the University of Alaska has a study of population dynamics, age structure and range ecology underway in Mt. McKinley National Park. A consulting firm, Renewable Resources Ltd., is persuing a pipeline-related investigation of the population composition, numbers and mineral licks of the sheep on the Canning River in the Eastern Brooks Range.

PROBLEMS AND FUTURE OUTLOOK: Alaska is facing a period of rapid and intense development which is currently manifest in the construction of the Trans-Alaska Oil Pipeline. This development seems certain to result in habitat destruction to at least some degree. In an effort to head off the wholesale destruction of wildlife habitat the Department of Fish and Game has recommended to the legislature (as provided for by state law) certain areas as "critical wildlife habitat." In the case of Dall sheep this recommendation consists of numerous important mineral licks. If so designated by the legislature these lands would be protected from development because of their wildlife value.

Further problems result from the political development which is occurring in Alaska. As a result of the Alaska Native Claims Settlement Act of 1968 the Federal Government may select and withdraw 80,000,000 acres in Alaska as National Interest (d-2) Lands. These tentative selections, if they are approved, would provide preservation of much Dall sheep habitat, but may result in the loss of hunting on areas which now support about 35 percent of the statewide harvest of Dall sheep.

These two problems in concert may not spell doom for the Dall sheep of Alaska, but they are sufficient to evoke great concern from Alaska sportsmen and the resource management personnel of the State of Alaska.

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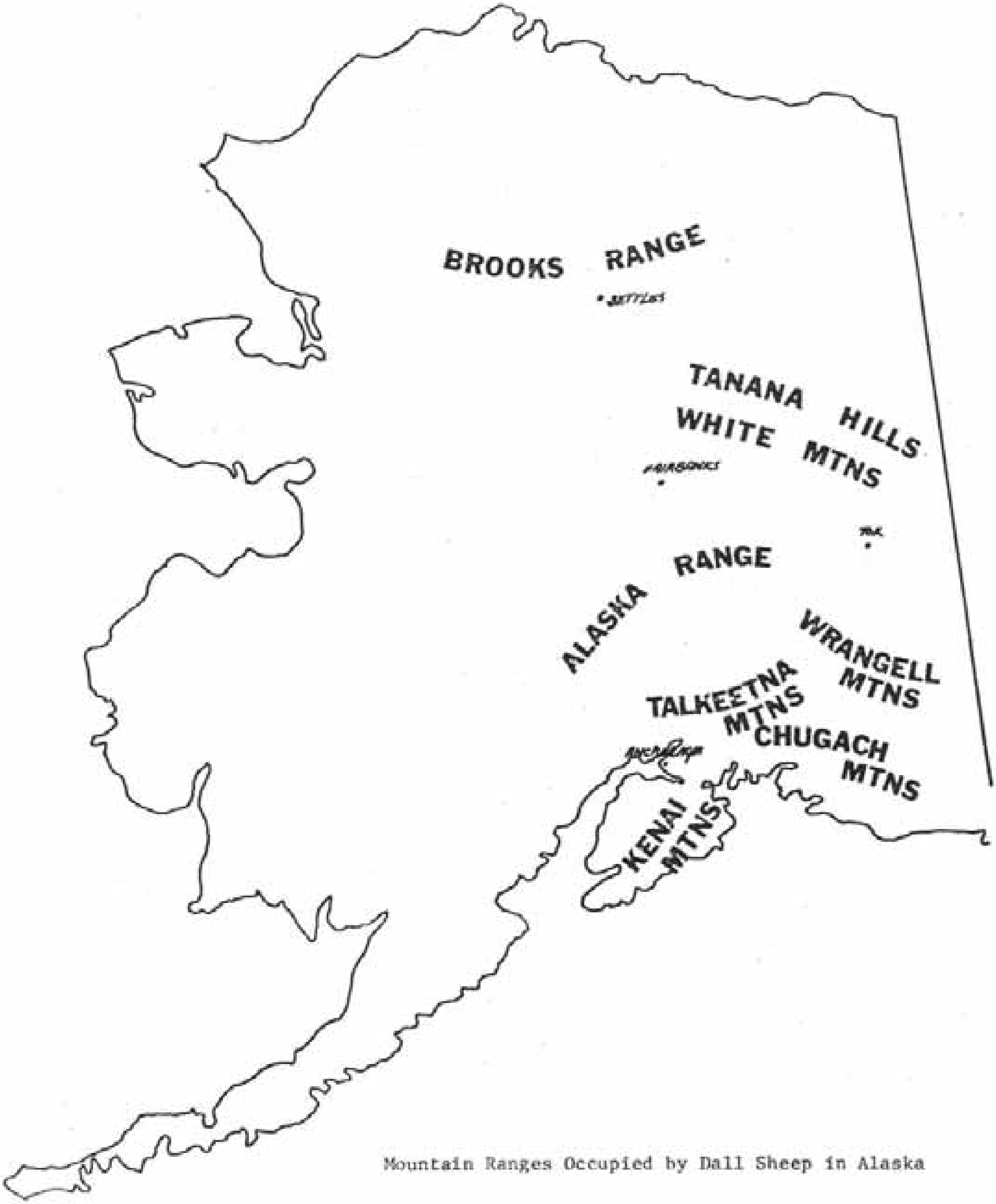

Mountain Ranges Occupied by Dall Sheep in Alaska

SHEEP MANAGEMENT IN KLUANE NATIONAL PARK,
YUKON TERRITORY

By
J. M. Christiansen
Kluane National Park
Yukon, Canada

Kluane National Park is situated in the southwest part of the Yukon Territory and covers 8500 square miles. Of this area, approximately 70 percent is comprised of glaciers and permanent snowfields.

In March of 1973 an aerial distribution survey was made over the area for all ungulates, with sheep distribution being considered most important.

This census showed sheep were present throughout the ice-free areas, with main populations being more concentrated along the northern boundary of the park.

In January 1974 a classified count of Dall sheep was made by air. The classification was not a total success, but the census did show that we were wintering 1500 sheep.

We have 150 hours of helicopter time allotted for this year to further our knowledge of the movements and number of ungulates within the boundaries of the park. This project is being set up to census at three seasons of the year.

At completion of this project we should have a good idea of population numbers and classification.

At this time the Dall sheep population appears to be healthy. It also appears that the wolf plays a very important role in the Dall sheep population as a control.

RESUME OF SHEEP MANAGEMENT IN THE NORTHWEST TERRITORIES

By
Norman Simmons
Canadian Wildlife Service
Fort Smith, Northwest Territories

I. Five year study on Dall sheep that stretched to seven years - Mackenzie Mountains

   A. Designed to become management package for NWT Game Management Division, whom we advise

   B. Study covered -
      1. Population dynamics
      2. Movements
      3. Hunter impact

II. Study completed this winter (March 1974)

   A. Analysis of data in progress

   . Monograph will result

III. Management under NWT Game Management Division supervision

   A. Monitor hunts by -
      1. Hunter report forms
      2. Collection of sheep mandibles

   B. Assignment of exclusive outfitting areas for nonresident hunters

   C. Three-quarter curl restriction

   D. Number of hunters restricted only by outfitters' abilities to handle hunters

   E. Can take one sheep per year - residents or nonresidents

IV. Situation

   A. Stable population - under-harvested - good potential for high quality hunts

COMMENTS ON BRITISH COLUMBIA

By
Kerry Constan
Montana Department of Fish and Game
Livingston, Montana

I had a chance to talk on the phone to Ray Demarchi, game biologist in British Columbia. Ray mentioned that the bighorn sheep herds that collapsed a few years back along the southern border of British Columbia and in the Kootenai are coming back.

Their fish and game department has made another large purchase of land which is winter range for the sheep. They have had a range problem there, primarily competition with domestic livestock, but they have been wise enough to get into the business of buying winter range for their sheep.

RESUME OF BIGHORN MANAGEMENT IN ALBERTA

By
William Wishart
Fish and Wildlife Division
Edmonton, Alberta

We've been harvesting in Alberta about 150 rams and 110 ewes annually out of a population of 4-5,000 bighorns. That's in the order of about a 5 percent harvest. We've been gradually cutting down on nonresidents, but I'll talk about that later on this afternoon.

One of the studies we have been doing is on Ram Mountain, an isolated mountain range, testing the survival of orphaned lambs. There's a lot of problems in conducting an experiment like this. You mark lambs and ewes in a trap and then you have quite a time sorting them out afterwards - what lambs belong to what ewes. Sometimes you have to observe the lamb suckling as you try to match them up after trapping.

So far we've had 11 orphaned lambs in the past 2 years and we've had about equal survival of orphans and nonorphans. We have a couple of students, one just wrapping up a study and another just starting a study.

Corm Gates, will you comment on your work?

Corm Gates
Fish and Wildlife Division
St. Albert, Alberta

I just came into town after spending 18-19 months in the field in the mountains of Alberta in the Yawhaw Timber Range. I was studying the two herds of sheep involved and I was looking at the relationship between lungworm larval output and the seasonal nutritional cycle between years and between these two herds. I was also counting the eggs of some of the helmuths in the feces, the more readily identifiable eggs and coccidiae and trying to relate this to seasonal nutritional regimes of both herds.

I've gotten 20 months of forage and fecal samples from the fall of 1972 until this present spring. I was looking at feeding behavior as well as feeding in terms of vegetation types and areas used seasonally for both herds to gather this nutritional business.

The seasonal nutritional values for sheep on native forage species have been presented by Dr. Hebert in some work he did in British Columbia. It has been particularly valuable to my study because I'm able to extrapolate from his values and I can determine fecal nitrogen content and using forage samples collected in the study area I can quantify monthly changes in the nutritional regime of the two herds of sheep that I'm working with. So far I've come up with some interesting data on stress and lungworm larval output in some penned sheep I had, as well as some seasonal differences in larval output between herds and between seasons. Before I get anything down on paper, I probably have another 3 months of laboratory analysis to do.

Randy Chappel
Fish and Wildlife Division
Edmonton, Alberta

The study that I'm going to be starting is sort of an offshoot of a program that we started last summer on range improvement. We fertilized 1200 acres of bighorn sheep and elk winter range in order to rejuvenate the range. The basis for this was a declining condition of some of these ranges due to either overuse by the native ungulates themselves or the ungulates in combination with heavy summer grazing by beef cattle.

The material we used in this program was a 34-0-18 fertilizer at an application rate of close to 200 pounds per acre which allowed for 66 pounds of nitrogen and 33 pounds of phosphorus. The method of application was by helicopter. We contracted it out to a company in Alberta called Agricopter. They used a Hiller H-12 helicopter equipped with a Pace agricultural seeding fertilizer bucket.

The helicopter flew laterally along the slopes, using men as markers, and overlapped the swaths. In 40 tests of the application rate we found an average of 190 pounds per acre, which is within 2 pounds of our sort of optimum rate and a maximum variation of 5 pounds per acre, so it's a fairly accurate method of fertilizer distribution and the only one possible under the conditions.

Most of the slopes we were looking at were 35-40 percent, and it would be pretty difficult to run a vehicle up and down them. The evaluation of that program is being carried on at one of the ranges we fertilized, which is a sheep range at Sheep River. We fertilized a much smaller area there, a total of 48 acres, and we're currently carrying on an evaluation of the change in range production and range quality. The latter, range quality, we're doing through analysis for protein, nitrogen, phosphorus, calcium, crude fiber and moisture.

My study, which is going to be commencing this year, is a little bit more extensive study of the use of three different types of fertilizer at three different application rates, the use of native and domestic grasses, seeding in addition to already established but poor cover range, and the use of spring and midsummer burning. I'll be carrying out both vegetative evaluation along the same lines as that which is going on in our present study, and also an animal evaluation in terms of choice preferences and nutritional work with the sheep.

RESUME OF OREGON'S BIGHORN MANAGEMENT

By
James Blaisdell
National Park Service
Klamath Falls, Oregon

I'm going to give the state report with what little information I was able to get over the phone Friday.

Incidentally, I hope that state employees from the state of Alaska will take some comfort in the fact that I think the National Park Service areas in Alaska, wherever they might be, will probably always be a pool for any transplants you may need in your hunting areas - if that's any comfort, and incidentally you might get the idea that I'm against hunting. I'm not, I worked for the state of California for 10 years.

About all I can give you about the state of Oregon are populations, and as I understand it, all of the bighorns have been transplanted at one time or another.

Hart Mountain National Wildlife Refuge, which is an antelope refuge but has a pen with California bighorns in it, started with 20 sheep in 1954 and now has 85. Twenty-one rams were harvested during seasons, and transplants to other areas have come from this pen.

Sheldon National Antelope Refuge is actually in Nevada. Their stock came from Hart Mountain, starting with 8 sheep in 1968 and now has 28. We at Lava Beds National Monument got one of their rams, so they have supplied some animals to other areas. The Steins Mountains animals came from Hart Mountain. They transplanted 4 in 1960, 7 in 1971, and they now feel that they have between 75-100. Hunting is allowed there.

The Owyhee Mountains started with 17 in 1975 from Hart Mountain. I must add that the Hart Mountain animals originally came from British Columbia, so that's the source of all these animals. The Owyhee Mountains started with 17 in 1975, they now have 60-75, and they hunt them.

The Strawberry Mountain unit started with 21 in 1971, and is typical of so many of these areas, they don't really know how many they have because they scattered pretty badly, but they expect them to do well and they'll find them one of these days.

There are two or three transplants from Jasper, and I think some came from Colorado and Montana. The Rocky Mountain bighorns are in the Snake River area and Silver Creek. In the Snake River, again, they dispersed for a while, but they have located them. They're having some disease or parasite problems with this population. I don't think I can answer any questions for this state, so I'll leave you with what little information I have provided.

A SYNOPIS OF CURRENT BIGHORN SHEEP MANAGEMENT AND RESEARCH IN IDAHO

William O. Hickey
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Idaho Fish and Game Department

INTRODUCTION

In the following discussion I have tried to briefly cover the major management decisions, programs, and research projects concerning wild sheep in Idaho. Hopefully, this resumé will give the reader some understanding of past bighorn sheep management and research in Idaho and the direction they will take in the coming years. Also, I have included some historical background.

HISTORIC DISTRIBUTION

Historically, Idaho, like other western states, had abundant populations of bighorn sheep. They inhabited most of the mountain ranges from the Salmon River drainage southward, Hells Canyon of the Snake River, and an area along the border between Montana and Idaho from a point northwest of Missoula, Montana to Yellowstone Park. Sheep inhabited the mountain ranges along the Idaho-Wyoming border from the South Fork of the Snake River to Utah.

Originally, two races of bighorn sheep, *Ovis canadensis canadensis* and *Ovis canadensis californiana*, inhabited Idaho. The California race occupied the Owyhee country of southwestern Idaho and the Rocky Mountain race ranged over the rest of the historic habitat. Several explorers, trappers, and naturalists left written and verbal accounts that indicate the historic abundance of these sheep. Captain Bonneville's party camped along the Salmon River north of Salmon, Idaho, during the winter of 1832. They found large flocks of bighorn sheep in the area, and in the 1850's, the first settlers of the Lemhi Valley found bighorns in abundance (Smith, 1954). Abe Leeds, a guide for E. Thompson Seton, saw thousands of sheep in the Lost River Mountains of Idaho in the late 1800's. Leeds saw sheep usually in small groups of 15 to 20 animals, but as many as 500 in a day. Seton received a letter from M. W. Miner reporting an estimated 2,000 to 2,500 sheep in the upper part of the Middle Fork of the Salmon River (Seton, 1929). The California variety was apparently no less numerous. Early inhabitants of the Hart Mountain area told Luther J. Goldman that at one time wild sheep occurred in greater numbers than antelope in that area (Buechner, 1960). Although this account came from Oregon, it probably applies equally to Idaho.

Major losses began to occur in Idaho sheep populations during the period from 1870 to 1880, when large numbers of them reportedly died from scabies. About 1890, a severe winter occurred and this, coupled with scabies, reputedly caused a second decline. A third decline occurred about 1910, and since then sheep numbers have remained far below historic numbers. Old-timers frequently mentioned domestic stock competition for forage and space, human activity on sheep habitat, and hunting pressure as causing heavy losses.

Scabies epidemics probably occurred as a result of habitat destruction and masked the real cause for severe sheep losses. The pneumonia complex may have played an important part in the rapid decimation of sheep populations. George Post (1971) recounted a conversation he had with a man who had traveled Idaho's back country during the declines. After listening to Post describe pasteurellosis in sheep and looking at color photographs of gross s-mptoms, the gentleman said the insides of sheep supposedly dying from scabies looked like the photographs and appeared rotten inside soon after death occurred.

Sheep populations apparently reached a low of about 1,000 animals by the 1920's and early 1930's. The California bighorn completely disappeared from the state. Just 10 years ago they were brought back to their former haunts in Owyhee County. By 1954, the Rocky Mountain sheep had increased to the point that Dwight Smith estimated 2,500 head in the state at that time. History of individual populations vary with some bands disappearing, some remaining relatively stable, and others declining and rising again. Now both species occur in isolated populations on a fragment of their original habitat. At this time, no accurate estimate of statewide populations exists, but a total number of 2,500-3,000 sheep would seem a reasonable guess.

CURRENT STATUS

The greatest concentration of sheep occurs along the main Salmon River from and including Panther Creek, 26 miles west of North Fork, Idaho, down to the road end 40 miles east of Riggins, Idaho, and the Middle Fork of the Salmon River.

The most intensive population data in recent years has been collected from the Middle Fork sheep. During the winter of 1973-74, population data were collected from the Panther Creek bands. Table 1 contains a summary of this data and a comparison of the data with that collected by Smith (1954). For the present, the data appear to indicate a static population in the Middle Fork and it appears that it has been so for perhaps the last 35 years. Yearlings are hard to identify from the air. This creates a bias by inflating the ewe numbers and decreases the lamb-yearling to ewe ratios when the real lamb-yearling to ewe ratios may be higher. This same error would tend to increase the ewe to ram ratio.

Two remnant herds of sheep, one on the East Fork of the Salmon River and one using Morgan Creek near Challis, Idaho, have received national attention, especially those using Morgan Creek. These sheep have suffered from severe competition with livestock and, to a lesser degree, mule deer. James K. Morgan studied these two groups of sheep during the late 1960's to define the problems and develop solutions to them. Particularly, those problems associated with the Morgan Creek area. Due to his efforts, the Forest Service, Bureau of Land Management, and Morgan Creek Range Users developed a rest-rotation grazing plan. A total of 7,500 acres of critical sheep range was fenced to exclude cattle yearround; however, 3,500 acres is currently used by cattle as a part of one pasture in the system. The deer population was substantially reduced by long seasons and two deer bag limit. Starting in 1972, livestock grazing conformed to the rotation system. Not enough time has elapsed since the start of this program for detectable results to take place. A monitoring plan was drawn up to assess the effects and value of rest-rotation grazing on the sheep winter range. Essentially, this program will measure changes or responses of the plant communities, shifts in distribution and winter range use by bighorns, and changes in the sheep and deer populations.

Table 1. A comparison of the mean ratios of sheep classified during the winter along the Middle Fork of the Salmon River and Panther Creek.*

	RATIOS		
Winter	Ewe:Lamb	Ewe:Yearling	Ewe:Ram
1949-1950	0.41	0.24	1.35
1950-1951	0.70	0.38	1.61
1951-1952	0.52	0.30	1.13
1972-1973	0.51	0.23	1.70
1973-1974	0.54	0.09	2.0
1973-1974**	0.81	0.11	1.4

* Data for winters prior to 1972-73 taken from Smith (1954). His ratios include from the Middle Fork and central part of the main Salmon River. Ratios for the 1972-73 winter include data for the Middle Fork from the Mormon Ranch to Waterfall Creek. The data for 1973-74 covers sheep bands from the Mormon Ranch to the mouth of the Middle Fork (helicopter classification).

** Helicopter classification of Panther Creek sheep bands.

Land use planning on the East Fork of the Salmon River has given a different direction to management for the remnant herd there. These sheep summer in the White Cloud Mountains which lie in the Sawtooth National Recreation Area. Currently, the Forest Service has the administrative authority for the area and their program gives the bighorns priority over livestock grazing on land used by sheep. It also provides for future reintroduction, habitat improvement, and expansion of the sheep population. Most of the presently used winter range lies outside the Challis National Forest-NRA boundary and on BLM administered lands. Here, again, the management policy favors bighorns over all other uses and provides for habitat improvement and an expanded bighorn sheep population.

These management policies have evolved during the last year. Consequently, field personnel of the Forest Service, BLM, and Fish & Game Department have not had time to develop specific programs to implement these policies.

REINTRODUCTIONS

Idaho has reintroduced bighorns to two areas of former habitat. The first reintroduction took place in October of 1963, with 19 young California bighorns from British Columbia released in the Owyhee River Canyon. Two additional releases of 9 and 10 sheep from British Columbia were made in 1965 and 1966, at the original site. A fourth release of 12 sheep from British Columbia was made in 1967 at Jacks Creek, Owyhee County. Since then the sheep in both areas have expanded considerably with some dispersal to adjacent canyon complexes.

During the period from June 1968 through November 1969, a Master Degree candidate studied these sheep to define population size, structure, productivity, and factors favorable and unfavorable to the bighorns. Additional data collected covered distribution, behavior, and food habits. Tables 2 and 3 contain population data taken from Drewek's thesis (1970). Drewek estimated that the sheep had increased to a minimum of 80 animals by 1969. His actual population growth curve indicates a total population of a little more than 100 animals by 1970, and the theoretical curve indicates the population would reach a little more than 200 animals by the same date. The present population estimate is 325 animals for both areas; 75 in the Big and Little Jacks Creeks and 250 in the East Fork of the Owyhee River.

Only one reintroduction of Rocky Mountain bighorns has taken place. In August 1970, Idaho obtained 24 sheep of this race from Banff National Park, Alberta. These sheep were released near Mount Borah on Mahogany Creek, a tributary to the Pahsimeroi River. The sheep occupied an area about 36 square miles in size from 1970 until the late spring of 1973. Then they moved about 13 airline miles southeast to the upper part of the Pahsimeroi River drainage. Some of the sheep moved back to the 36 square mile area by mid-October of 1973. Others stayed in the Donkey Hills on the northeast side of the drainage. If this pattern of movement and dispersal continues, these sheep will have incorporated an additional 72 square miles into their range.

The population increased from 23, the oldest ram died in October 1970, to about 43 animals including lambs of the year by August 1972. The first lambing season after the release, the adult ewes, 2.5 years and older, produced at least 5 lambs. The second lambing season, 1972, they produced a minimum of 15 lambs. The population increased by 83 percent in the first two years after release. I would expect the total population to number about 60 animals now.

Table 2. Age and sex of sheep released into the Owyhee River drainage and the age-sex classification of the minimum population in 1968 and 1969.

Date	Females				Males				Combined
	Adult	Yrl	Lamb	Total	Adult	Yrl	Lamb	Total	Total
10/31/63	8	4	2	14		2	3	5	19
11/18/65	6		1	7	1		1	2	9
11/2/66	7		1	8	1	1		2	10
Total	21	4	4	29	2	3	4	9	38

Table 3. The age and sex class of the minimum population of bighorn sheep in Owyhee River drainage in 1968 and 1969.

Year	A/Ewes	Lambs	Yrl. Ewes	A/Rams	Yrl. Rams	Total
1968	23	21	3	13	4	64
1969	26	20	9	14	11	80

Table 4. Sex and age of sheep released at Mahogany Creek, and classification of sheep in succeeding years.

Date	A/E	Lambs	Yrl/E	Yrl/R	Rams				Unclass.	Total
					I	II	III	IV		
8-26-70	15		4		2	2	1*			24
1-20-72	13	5				2	1			21
8-18-72	14	12		2	2	1	2			33
2-8-73	12	15		2		2	1			32
10-17-73	10	9		3	1	1			11	35

* This ram died in October 1970.

Jim Morgan located and surveyed 20 potential reintroduction sites. Nine of these sites have good potential for reintroduction. The cooperative agreement between the Forest Service and Idaho Fish & Game Department has been signed for the best site. The inability to obtain sheep both from within and outside the state has delayed this reintroduction.

Currently, a trapping operation, unsuccessful to date, is under way on the lower Salmon River to supply sheep for a release in Granite Creek, tributary to the Snake River, Hells Canyon area.

In addition to these areas mentioned above, we have encouraged the BLM and Forest Service personnel to plan for reintroductions in Multiple Use Planning Units that have potential reintroduction sites.

HUNTING

Like most of the western states, Idaho has a long and varied history with respect to hunting seasons and bag limits. In the early years after Idaho Territory became a state, the taking of big game was prohibited between February 1 and June 30. By the late 1800's, the season was shortened to the period of September 1 to December 30, and the bag limit allowed the taking of four sheep. During the early 1900's, the bag limit on sheep was reduced to 1 (Anonymous 1967).

In the years prior to 1947, 125 bighorn sheep were taken during open seasons. The season was closed for 5 years, until 1952. Since this time, a controlled season, general season or both, have been held on sheep.

Tables 5, 6, and 7 contain summaries of the general and controlled sheep hunts for the past 22 years. During this time, hunters have taken 777 rams at a mean rate of 35 per year and have had a mean success ratio of 22.8 percent. In Colorado, hunters took 817 sheep at an average of 48 per year with a 23.8 percent success ratio during the 18 years from 1953 to 1970 (Sandfort and Rutherford, 1971). During this same period of time, Arizona hunters took 455 rams at a mean rate of 24 per year and had a success ratio of 42 percent (Russo, 1971).

In 1971, Idaho went to control hunts in all units open to sheep hunting and increased the season length from two weeks to 30 days with the opening date falling on the second Saturday in September. This effectively reduced the harvest of rams and number of hunters in the field. Quite possibly, we have enhanced the quality of the hunt for those who participate. Sheep hunting in Idaho will probably continue on a controlled hunt basis, at least for the foreseeable future.

RESEARCH

The first research project began with Dwight Smith's study in 1949. Smith continued this study through 1954 and concluded it with "The Bighorn Sheep in Idaho, Its Status, Life History, and Management".

Jim Morgan began the next research project in 1966 to define the causes for declines in the Morgan Creek and East Fork of the Salmon River bands. As a result of his work, a rest-rotation grazing system, referred to earlier, was initiated in the Morgan Creek drainage as a solution to the winter range problem. It will take several years before we can determine the success or failure of this program.

Table 5. A summary of general bighorn sheep hunt tag sales and harvest in Idaho.

Year	General Season Permits Res.	Non-res.	Total	Tags Sold	Minimum No. Participating Hunters	Total Kill	% Participating Hunter Success
1956	64	11	75	75		1	
1957	147	46	193	193		23	
1958	Lic.& tag summary sheet		255	255		29	
1959	250	129	379	379	364	59	16
1960	301	116	417	417		62	
1961	333	222	555	555	455	51	11
1962	343	179	522	522	336	58	17
1963	324	228	552	552	436	49	11
1964	288	143	431	431	397	35	9
1965	328	123	451	451	406	53	13
1966	279	175	454	454	420	14	3
1967	338	178	516	516	452	32	7
1968	350	249	599	599	525	47	9
1969	334	251	585	585	585	43	7
1970	374	322	696	696	469	61	13
Total 15	4053	2372	6680	6680	4845	617	
$\bar{x}$	290	169	445	445	441	41	11

Table 6. A summary of controlled bighorn sheep seasons and harvest in Idaho.

	Year	Controlled Hunt Permits	Res.	Non-Res.	Tags Sold	Number Partici-pating Hunters	Total Kill	% Success of Participating Hunters
	1952	45			45	44	13	30
	1953	50			50	47	18	38
	1954	50			50	41	15	37
	1955	50			50	48	22	46
	1956	60			55	45	19	42
	1957	40			40		6	
	1958	40			40		10	
	1962	5	4	1	5	5	1	20
	1964	5	5		5	5		0
	1965	5	4	1	5	5		0
	1966	5	3	2	5	5		0
	1968	2	1	1	2	2	1	50
	1969	7	7		7	7	3	43
	1970	9	8	1	9	9	3	33
	1971	67	61	6	67	64	13	20
	1972	89	79	10	89	81	21	26
	1973	86	70	8	78	65	15	23
Total	17	615	242	30	602	473	160	
	$\bar{x}$	36	24	4	35	32	12	34

Table 7. Summary of sheep harvest by year for general and control hunts.*

	1952	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73
General Hunts					1	23	29	59	62	51	58	49	35	53	14	32	47	43	61			
Control Hunts	13	18	15	22	19	6	10				1						1	3	3	13	21	15
Total	13	18	15	22	20	29	39	59	62	51	59	49	35	53	14	32	48	46	64	13	21	15

YEARS

Grand Total: 777; $\bar{x}$ 35 sheep/yr.

* Prior to 1952 approximately 125 rams were taken on legal hunts.

The current research program has several facets aimed at refining our understanding of movements, migrations, and seasonal ranges; defining the type of habitat preferred by sheep during different seasons; assessing the physiological condition of individual animals through blood constituent analysis as conducted by Franzmann and Thorne (1970), Franzmann (1971, 1972), and correlate the health of the animals with the quality of ranges, and defining the population dynamics and recruitment rates. These studies have centered on the Middle Fork sheep because they exist under nearly pristine conditions and the reintroduced population of sheep near Mount Borah.

The current research program also includes trapping and reintroduction and an appraisal of hunter harvest and general public opinion concerning bighorn sheep hunting and management in Idaho.

Dr. Ables, Professor of Wildlife Management at the University of Idaho, has proposed to define the effects of ram removal on the productivity and survival of a bighorn population. More specifically, he proposes a two-phased study of at least six years' duration. In the first phase the population structure, social organization, reproductive behavior, herd productivity, movement patterns and daily activity patterns will be defined for a specific sheep population. During the second phase, selective removal of dominant rams would take place and then define the effect this removal has on social organization and stability, breeding efficiency and physical condition of both sexes during the rut, natality and survival of young, and home-ranging and migratory behavior.

The population of bighorn sheep in Big Creek, tributary to the Middle Fork of the Salmon River has been selected for this study. The project should begin within the year. Adequate funding has temporarily delayed the initiation date set for this summer, 1974.

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RESUME OF MONTANA'S BIGHORN MANAGEMENT

By
Joe Egan
Montana Department of Fish and Game
Helena, Montana

Years back we put out a little book some of you, I am sure, have seen, and we have a section in there on bighorns, and it is only a few pages long. I think in general that gives the basic management program for Montana.

I think in Montana we consider animals, including the bighorn, as products of and dependent upon the range. Now everybody knows that, and that's not a very profound statement, but in the travels through management which includes the setting of seasons, it appears that from time to time we forget that statement. But we consider the range as quite important. As a matter of fact, we consider the bighorn, the elk, whatever, nothing more than the range baled up in that particular hide, so what we are probably doing is trying to manage the baler and sometimes we forget about what we are baling.

Mr. Atcheson made a statement that sometimes biologists are swayed by opinion. That's right, we are. I heard a term the other day by a lady giving a talk at the North American, and I sort of got the drift that she was sort of upset with the Department of Interior and I don't think she would mind if I sort of quoted her. She was talking about the hierarchy in the Department of the Interior and she finally concluded her little rundown about the hierarchy by making the statement that she was appalled that they didn't even have a biostitute on their roster. That probably doesn't even fit here, but I thought you would be interested.

All of the discussion, I think, relating to both range and management is as I have stated before, toward the range. Now we have always had some difficulty in Montana determining numbers of animals, and I don't know whether we're backward or what, but we seem to have a great deal of problem in trying to come up with estimates and this sort of thing. Since we do have this problem, we make every effort to steer clear of it, and when people ask us we have sort of a pat answer that we give them when they ask how many sheep or whatever we have. We simply say we don't know.

So if you're wondering about that, don't, because we don't know so let's not spend any time talking about it.

Now we also recognize there is an intense interest in the trophy aspect of bighorns and again I don't think it's a matter of apologizing, but there are a lot of things we have to admit we don't completely and fully understand. Now we understand, I think like everybody else does, I guess we call it the crude principles of standard biology that a nice big three-quarter or full curl ram at some point in time was a lamb. And that at some point in time he had a mother - again, everybody knows these things, but sometimes it appears like when we're discussing seasons we forget some of these basic things and it appears to us that in order to have X number of nice trophy rams, someplace along the line you have to have more younger males and some place you have to have mother sheep. And another thing we stumbled onto is that all of these animals eat, and so again we keep coming back to the same basic thing, the plant.

Now maybe we understand this crude biology, but we can't always work out the solutions like maybe we think they ought to be worked out, but we try. This year we have nine areas that are going to be open to sheep hunting, and this is about what we've had in the past. On one of the tables I think there is a map of these areas, and it tells you about permits, but I thought maybe I would go over them very quickly.

Among these nine areas there will be 20 permits for three-quarter curl and 25 permits for ewes. I think you'll notice, if you look on that map, there's one place where it says "adult ewes" and another place that says "ewes." I think that's pretty damn fine management, wouldn't you say? We also have 57 either-sex permits and then you'll notice we have two areas in the southcentral part of the state that we call unlimited. Now we have had those for quite some time and we've caught hell on them for quite some time. I expect we'll continue to catch hell over them and one of these days we'll do something different. The permit sheep, for those areas, are on a drawing basis.

In Montana we limit the nonresident. Our locals buy a 25 cent conservation license which is a prerequisite to the $25 sheep permit. However, it costs the nonresident $1 for the conservation permit and $150 for what we call the big game license plus another $50 for the sheep.

There is a 7 year waiting period - that is, killing period - if you get a permit and don't kill a sheep you can turn in your permit and try for another permit the following year. If you kill a sheep it is 7 years before you can try again.

One of our seasons opens the first of September and the other the 15th of September. Now that rather briefly is the basics of our management, and we're going to hear a couple of papers today that talk about range. We feel in general that management constitutes trying to balance populations with the range.

I have stated we don't always accomplish this, but we try. Removal of animals from the range, we feel is a reasonable way to seek this balance. We do this by sport hunting and we do this by trapping, and you are going to hear a paper today about this trapping.

I think one of the problems, and Montana does not have a corner on it, is that both as people and as biologists we have trouble communicating and trying to understand what the other fellow is doing. Again there are some things you know and you probably have forgotten, but it's sort of like the sheep hunter that was going to go sheep hunting and first took a physical. He went in to see how good his pump and everything was and the doctor said, "Why don't you strip to the waist?" He did. He took off his pants.

RESUME OF BIGHORN SHEEP IN NORTH DAKOTA

By
Jim McKenzie
North Dakota Game and Fish
Bismarck, North Dakota

North Dakota is included in the historic range of the now extinct Audubon bighorn sheep. The last recorded Audubon sheep was shot on the Magpie Creek drainage of the badlands in about 1905. The badlands include the Little Missouri River drainage of western North Dakota.

Eighteen California bighorns were obtained from British Columbia in 1956 - so after an absence of 51 years, bighorns were again resident to a portion of their historic range.

We have utilized a total of three holding pastures and have made six releases into the wild - one other release is planned.

There is an estimated population of somewhere between 250 and 300 animals, and they have resulted entirely from the initial reintroduction in 1956.

Our present management is directed toward perfecting a reliable population trend census technique. We are attempting to utilize our regular mule deer census technique.

We have not been able to hunt bighorns due to a quirk in our big game permit law. Legislation is needed to accomplish this.

RESUME OF WYOMING'S BIGHORN SHEEP MANAGEMENT

By
Bill Helms
Wyoming Game and Fish
Lander, Wyoming

Wyoming's current sheep management program consists of establishing hunting seasons, setting the number of permits in each area, and transplanting sheep to areas to establish or augment existing herds.

The number of bighorn sheep permits issued annually has increased until there are approximately 400 allotted. It appears these numbers will stabilize in this area for a while.

Hunter success ranges roughly between 30 and 40 percent, with slightly over 100 animals taken on the average.

The trapping and transplanting program has furnished 722 bighorns since 1956. This program has had varying degrees of success. Sheep hunting has been initiated in some areas as a direct result of the transplanting program. Some areas have shown no influence from additional sheep being introduced. Recent transplants in two areas have not had enough time to determine their success.

RESUME OF UTAH'S BIGHORN MANAGEMENT

By
Homer Stapley
Division of Wildlife Resources
Salt Lake City, Utah

Utah State Division of Wildlife Resources' present management of Rocky Mountain bighorn is geared solely toward its reestablishment in the state. Habitat evaluations and vegetative inventories were taken on an area in north-central Utah where bighorn originally existed, but had vanished before the turn of the century. The site was additionally selected because of the absence of domestic livestock and elk competition for forage and space. Mule deer would be the major competitive force.

Plans to reintroduce bighorn started in earnest in 1959; however, it was not until 1965 that the Wyoming Game and Fish Commission and the Canadian Department of Northern Affairs and Natural Resources favorably responded to Utah's request for transplant stock.

Original plans called for a holding paddock to be constructed on division property immediately east of Brigham City along the Wasatch Range. A paddock of 60 acres was constructed during the summer of 1965. Three separate trapping and releases were made during the next winter.

Trapped March 7, 1966 - Wind River Mountains, Dubois, Wyoming
Released March 6, 1966

Composition:	8 mature ewes
	1 two year old ram
	1 two year old ewe
	4 ram lambs

Trapped April 6, 1966 - Waterton Lakes National Park, Waterton, Alberta

Composition:	3 rams
	4 ewes
	1 year old ram
	2 year old ewes

Trapped April 28, 1966 - Waterton Lakes National Park, Waterton, Alberta

Composition:	2 rams
	6 ewes
	1 two year old ewe
	1 year old ewe

Total:	11 rams
	23 ewes
	34 head

Wyoming's 9 adult ewes produced 5 lambs and Waterton Lakes 11 adult ewes and 3 yearling ewes produced only 2 lambs.

During the summer of 1966 a larger paddock was completed encompassing 1,200 acres to include both summer and winter ranges. Thirty-seven bighorn were released into the large paddock in the fall of 1966, 30 of the original animals and the 7 lambs born in the spring (4 animals of the original herd died during the summer).

During subsequent winters, snowdrifts and strong winds which ripped down portions of the fence allowed most of the herd to escape to Wellsville Mountain north of the paddock and to Weber Canyon 40 miles to the south. Observations have shown at least two generations of bighorn have been born in the state. The single largest sighting outside of the paddock is 11 head with most observations in the 2 to 4 category. There has been some mortality from shooting by deer hunters and some malicious shooting inside the paddock with no attempt to take the meat or horns.

Several modifications of the fence were made, including relocations of certain sections and using telephone poles in high wind areas. It was the intent of the division to use the stock received from Canada and Wyoming as parent stock and as numbers reached satisfactory levels, some would be released onto other habitats once supporting bighorn and now free of major forage competitors.

After modifications were completed, 8 rams and 18 ewes were captured using a capchur gun and sucostrin between December 9, 1969 and January 13, 1970 from Banff National Park in Canada. Shortly after the release in the small paddock, respiratory problems developed swiftly throughout the new stock. Cultures taken from the lungs of one adult ewe and a sacrificed lamb showed animals were inflicted with *Pasturella multocida*. It was recommended all animals be recaptured and confined in small pens and treated with shot series. With the exception of one adult ewe, all were successfully confined and vaccinated with a vaccine created from the culture. In addition, neoterramycin was administered in the drinking water. While confined, sheep were fed alfalfa hay and elk pellets. No losses after treatment were noted; however, escapes from the paddock occurred again when snowdrifts allowed passage over the fence.

Very little is known about the current status of our bighorn sheep population. Although the information is quite sketchy, we have return information on 24 sheep lost. Of these, all but about 6 were introduced animals. Of the 24 reported losses, at least 4 sheep were known illegal kills or poaching losses.

Our 1st good sightings of wild sheep were:

November 1973 - A mature ram (probably from Canada) observed in Weber Canyon
- A young ram, and a ewe and a lamb all observed near Inspiration Point on Willard Peak. The untagged lamb should represent at least a second generation wild birth.
- Personnel observed one ram and possibly two ewes inside the large paddock last fall (1973).

February 1974 - In Box Elder Canyon near Mantua 3 mature and 2 younger animals were observed.

It is still the objective of the division to create a parent stock within the paddock. Immediate efforts, however, will be directed toward determining populations and areas of occurrence.

RESUME OF BIGHORN MANAGEMENT IN COLORADO

By
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Division of Wildlife
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Basically I'll take the opposite approach of Wyoming. For all practical purposes we don't have a bighorn sheep management program in Colorado. Our herds for the most part are being ignored. We don't know our population structure, our ranges or migration patterns.

In considering the human population pressures that some of our herds are experiencing, this is rather appalling, but I have to give management the benefit of the doubt. We are using two management tools in Colorado - those being a limited amount of hunting as well as some trapping and transplanting.

Could I have some slides, please. Presently in Colorado we are hunting 15 separate areas with rifles and we also have 4 new areas which are open only for archery hunting. Our season structure looks something like this. In 1972 we had both 23 days for rifles and archery. In 1973 the season days were increased to 25 for rifle and 30 for archery. We had 14 areas open for rifle in 1972 and one for archery. We've increased the archery areas to 4 in 1973 and to 15 areas for rifle.

The permits available have been steadily increasing since the early 1970's for rifle and archery, from 20 to 60 in 1973. In 1974 our permits haven't been issued, but we anticipate a slight increase in the number issued. The number of applicants is also appalling in Colorado, as we're having a tremendous population explosion along with increased numbers of hunters who are interested in bighorn sheep hunting. You notice for rifles we had 633 applicants in 1972, 743 in 1973 and this has been the trend since our first bighorn sheep seasons were established in 1953. Just a tremendous increase in the number of people who want to go bighorn sheep hunting. The annual harvest has pretty well stayed the same. We're harvesting somewhere around 26-27 head a year. In 1972 our archery hunters did not harvest a sheep, but in 1973 they did harvest 2 animals.

Our commission has just said that we can, in some of our areas, harvest half-curl rams. Up to this time we have played around with full curl regulations as well as half curl. It's bounced back and forth, and personally I meet this new regulation, where a hunter can take a half-curl ram, with mixed emotions. As I say, we've been playing with different types of curl regulations in the harvest. This is about a 10 percent sampling of the number of rams that have been harvested from our areas since our 1953 season. You can see that most of our rams are harvested before they're 10 years of age. Also we're taking very few full curl animals, as we have found in some of our observations and our hunting seasons that most of our rams are broomed-off before they can be harvested. We've even some rams that are broomed so badly that they will be half curls for the remainder of their lives.

Now there are two methods of trapping that are presently being employed in Colorado - that being our normal corral trap, which I'm sure is being used in Whiskey Basin, and a drop net that was first used by Jim Erickson in the Yukon, I believe, to trap Dall sheep. Our drop net trapping season has been very successful for the last two years. This is baited with an apple mash and alfalfa. Last year we trapped somewhere around 75 animals and in this past year we're over 100 head. What this trap net does is allow us to go right into the sheep range. We don't have to wait for the sheep to come to us, but we can go right to the sheep. You can see what it is like after the trap is dropped. It is like trying to wrangle pretzels out from under this net. The first time we dropped it, it took us 3 hours to work 6 sheep out of the net, but as I say, with this technique we can go right up into the sheep area and trap. Some of the animals are held in captivity for our research program and many of them are released. Management for the most part has continued to use the normal corral trap that has been used in Colorado for a number of years.

Our research program has been kind of extensive, and in 1971 our commission designated us within our Colorado Division of Wildlife to try to determine the cause of the continual decline of our sheep populations. We approached this problem from the hypothesis that poor nutrition was the probable cause of our decline. We jumped into a tremendous research program to determine some of our range attributes and to compare ranges that we considered good to what we considered poor sheep ranges and try to really determine what a good sheep range was, based on the sheep population using that range at the present time.

This is Daubenmire's system that we used on our range transects. Sometimes our transects were very easy to read and sometimes, as you can see, reading what was in the Daubenmire frame wasn't easy. Along with this we tried to determine food habits of our bighorn sheep on three ranges and you can see here that sedges and grass species made up most of the diet. We determined food habits by the fecal microanalysis technique which does have some inherent errors.

Along with determining food habits, we wanted to determine the nutrient availability to the sheep on these ranges, so we looked at such things as protein, as this graph shows, the seasonal changes in protein availability to the sheep on the range and the majority of our trace elements. These were all determined by atomic absorption techniques and for the most part are deemed fairly accurate. Another study that we had was to try to manipulate the amount of vegetation and increase the amount of forage available on both our alpine and subalpine sheep ranges. This sounds very similar to what Alberta has just mentioned they are starting to do.

We used four different levels of nitrogen, an atrazine herbicide to manipulate the vegetation and phosphorus on the test plots. This is our alpine study areas (it was also tried on our subalpine areas) and you can see that the vegetation responses are readily apparent from our first year's work.

Our second year's work and many of our phosphorus fertilizations or nitrogen fertilizations are very dependent on water availability, and since last year was a very dry year we did not get much of a vegetation response.

Along with some of our other studies, we're attempting to trap and treat sheep as a means of trying to relieve the lungworm burden of the sheep to try to get a lamb survival the following spring. Last year we trapped a number of sheep and they were treated with four or five different drugs, neckbanded and released. We also kept some of these sheep in captivity as a means of control to see what the lungworm larval output was in their fecal samples. This particular ewe was right up on top of Pike's Peak which is 14,000 feet, during the dead of winter, and you can see the type of trapping conditions that we're experiencing.

Probably one of the things we're most interested in is the causes and nature of our lamb mortalities. We knew from previous studies that our poor recruitment into the herd was directly due to just insufficient survival of our lambs. This part of our study really looked at the pathology of what was occurring in some of our bighorn sheep herds and why our lambs were not surviving.

That is, in a nutshell, what our research has been looking at. For the future our research efforts are going to be looking again at drug trials to try and relieve the lungworm burden within the sheep, but also we're going to be trying to treat heavily used concentration areas of sheep with various insecticides to try to eliminate the snail and/or the first stage of larva before it has a chance to go back and reinfect the sheep. We're also going to look at trying transplanting to extend sheep range. I think this is probably an output of some of Geist's theory that we're going to have to learn how to move sheep onto different ranges to get migration patterns reestablished. One of the things we also hope to do is to start looking a little more deeply into fire ecology as a means of improving some of our sheep ranges.

That's about the extent of Colorado's program at the present time.

SOME QUESTIONS ABOUT TROPHY HUNTING

By
James K. Morgan
Stevensville, Montana

I am questioning trophy hunting for three major reasons. They are:

I. Objective scientists have an obligation to question everything until it can be repeated or tested until it stands proven.

It has been my observation, in dealing with the Forest Service, Bureau of Land Management and Fish and Game Departments, that a tendency toward manager/user alliances seems to creep into management philosophy. We are basically an exploitive-consumptive society and exploitive attitudes have a way of permeating our activities. The battle cry about which this exploitation rallies is, for the Forest Service, "Trees not cut are wasted," for the BLM, "Grass not eaten by cows is wasted," and the Fish and Game, "Rams not harvested by hunters are wasted." I'm waiting for an ecologically pure definition of "waste."

Is the science of ecology advanced enough to prove that unused trees, grass and rams are wasted? Is there always such a thing as "excess"? I think those are unanswered questions, particularly in view of the cyclic nature of living systems. Energy flows are dependent on a matrix of physical and behavioral interactions. Can you remove anything from an ecosystem without affecting its energy flows? Without affecting its capacity for life processes? Ecologically, our definitions of waste and excess should be carefully questioned because of our presumptuous flair for making definitions that serve our desires.

When speaking of the manager/user alliance, it is important to understand the insidious nature of bias and to recognize that the manager is often the last to become aware of his own subservience to economic exploitation. He cannot see the forest for the trees. In fact, the pro-hunting bias is just as real as the anti-hunting bias. Both are biases because they reflect the desires of humans, sometimes to the detriment of the animal involved. Biases are best dealt with by admitting them and keeping them out front. They become dangerous only when we fail to recognize them, fail to admit them, or define our own bias as good and the other guy's bias as bad. Man has long hunted bighorns for food. That could be considered neutral, since it is part of the evolutionary pattern of both species. But head hunting for trophies and recreation is a pro-hunting bias that serves up rams as fodder for the recreation mill to feed the gross national product; an activity that exploits bighorns to serve the economics of recreation. Let us be aware of our bias.

There is substantial evidence for the pro-hunting bias. People who license the recreational hunting of bighorns on a rams-only basis have applied this treatment to bighorns for some 20 years or more without first investigating the effects of rams-only hunting. Then, when questioned, they point to the lack of evidence to show that there are any effects from head hunting. This is an abdication of their responsibilities, since those who license the killing are responsible to provide the evidence that it is not harmful. And one can draw small comfort from the lack of data to show head hunting harmful to bighorns since no one has ever looked for that possibility. An analogy to the head hunting treatment applied to bighorns would be the release of a new drug on the market without prior testing, haphazard monitoring of its effects, and defense of the drug based on the lack of evidence which was never collected. And, of course, if the new drug is used until its effects do appear, the question of how damaging and irreversible those effects might turn out to be becomes rather crucial. If I had a herd of bighorns and someone applied for the job of managing them under a "shoot now, pay later" plan I wouldn't hire him.

Fish and Game Departments have not displayed capacity for self-examination in their research or management. Monitoring data which might reveal effects from hunting has been incomplete, and often not diligently collected. Research has been heavily slanted to support and facilitate hunting. Gunners are sent after transplanted herds before the herds get their feet on the ground, and isolated remnant herds are hunted until they literally disappear. For example:

(a) The Morgan Creek herd in Idaho declined drastically during the early 1900's and then recovered somewhat under subsequent protection from hunting. It was opened to hunting again in 1953 and hunted continuously under three-quarter curl open season regulations for 19 years, and closed again in 1972. A study was initiated on the herd in 1966 because it was known to be declining and the study documented the fact that it was indeed in a serious decline. Yet hunting was continued on the herd for 7 years after it was known to be declining and was not closed until the herd dropped well below 100 animals. The herd shows no sign of recovery at present. Although range deterioration is known to be this herd's major problem, the herd has declined much faster than the range condition and the possibility that trophy hunting and associated stresses, when added to the already serious habitat problems, were not contributing factors in this herd's decline have yet to be disproven.

(b) The East Fork of the Salmon River herd also declined drastically during the early 1900's and then recovered somewhat under subsequent protection from hunting. It was again opened to hunting under the three-quarter curl regulation in 1954 and hunted until 1961, a total of 8 years. During this period of hunting the population declined in both ram component and numbers, as did the Morgan Creek herd. The average population count, verified by intensive helicopter counts of a rather small winter range, was 49 animals for the last 5 years it was hunted. Hunting was closed after the helicopter count revealed only three mature rams left on the winter range. This herd has shown no signs of recovery after 12 years of protection. Again, habitat was the major problem, yet the role of trophy hunting was never questioned as a contributing factor, despite the fact that such reduced, isolated, remnant herds with habitat and human accessibility problems would be most vulnerable to the effects of hunting and losing large rams. Inbreeding becomes a mathematical possibility in a population that has dropped below 50 animals and is constantly losing breeding rams.

Similar situations have occurred with the Rock Creek herd in Montana, the Billy Creek herd on Charles M. Russell Wildlife Range, and the Two Calf herd on Charles M. Russell Wildlife Range. For the sake of time I will not elaborate on them.

The point is that remnant, isolated herds with severe problems and high accessibility to human activities may be particularly vulnerable to the effects of trophy hunting.

I submit that there is a pro-hunting bias and that it is not accompanied by a healthy recognition of self-examination. It is my belief that, in the future, game managers will increasingly be forced to confront the moral and ethical questions of hunting small, isolated remnant herds until they reach the point of no return.

II. My second reason for questioning trophy hunting has to do with diversity. It is a well established fact that diversity is health in living systems. And that applies to management as well. Although some generalities apply to all bighorns, still each herd has its own specific potentials, conditions and problems. A diversity conscious management approach would be to devise management systems, or systems of nonmanagement if called for, to fit the needs of each herd. There are tremendous probabilities against a single dominant approach being beneficial to or suiting the needs of all bighorn herds. I submit that rams-only hunting is a nonmanagement approach, applied to all bighorn herds regardless of their needs, and that it is neither a diverse or healthy approach to management. For example, Alaska has a larger ratio of habitat and bighorns to its human population and demands and therefore can probably continue to hunt bighorns for some time yet. But for those of us with a reversed ratio, human demands will require new, imaginative, diverse approaches to cope with the future lest the manager himself become an endangered species.

Another disadvantage of rams-only hunting is that it tends to narrow your management options. If you have a herd that seriously needs some ewes removed, you may be shackled by public resistance created by long dependence on and ritualization of trophy hunting. The thing that frightens me about the continued socialization of trophy hunting is that it effectively forces managers into programs to fit a social demand instead of the biological necessity. That is a strong reason for curbing trophy hunting. One of the major problems with dominant management concepts is that they tend to mask or suppress alternatives and then use the lack of alternatives as a reason why the dominant concept should prevail.

Diversity also relates to the political future of managers. A diversity of management philosophies would command that bighorns be managed to suit the desires of both hunters and nonhunters. For example, Idaho's Salmon River Wilderness is an area where man's influence is minimal, less in many ways than even in national parks. This area would be a perfect place to preserve a primal gene pool without worrying about overpopulation and range degradation, and if not hunted, would offer bighorn experiences to far more people, since recreationists now outnumber hunters. The few hunting permits given for the area each year keep the bighorns wild and unavailable to other users and represent special treatment for a hunter minority. Nonmanagement of bighorns would serve both bighorns and the needs of more people. Continued hunting of such an area illustrates the lack of diversity in philosophical approaches that feed the anti-hunting movement.

The hunters' "I pay your wages so should receive preferential treatment" argument is an encroachment on the biologist's objectivity. Hunting is a tool of wildlife management, not the reason for its existence. The Wyoming example impressed me. Hunters in Idaho mostly finance the facilitation of their own activities, but when hunters start buying habitat, then they have a valid point and should be allowed to hunt those areas. The hunters' argument on money loses much of its force when it is noted the activities that directly benefit the hunter and fisherman consume most of their monetary input.

The state of California has legislation prohibiting hunting of bighorns in California. People who seek nonconsumptive experiences with animals increasingly feel that trophy hunting, because it involves killing, is a barbaric practice. They increasingly resent the lack of management tailored to fit nonconsumptive needs and they are growing in awareness, numbers, and political power. The predatory outlook of management biologists is becoming increasingly repugnant to these people. An anti-hunting tide, similar to the one that swept the country in the early 1900's, is slowly rising in the country for much the same reasons - declining numbers of wildlife. Preventative diversity, because it would recognize the needs and desires of these people as well as hunters, would be a good tool to help slow the tide. If managers continue to defend trophy hunting, my prediction is that they will only hasten the day of confrontation between hunters and nonhunters. Survival for the manager, as for any creature is to diversify.

III. The third and final reason I'm opposed to rams-only hunting is because I feel that isolated, remnant bighorn herds with high accessibility to human activities and poor ranges are highly vulnerable to the effects of any human activities that could increase stress, remove strong individuals or disrupt social organization.

Bighorns are vulnerable, because of their habitat preferences and behavior, to efficient selection for large rams by hunters where their numbers are reduced, habitats altered, and herds fragmented and isolated. Their social systems may be adversely affected by reductions in herd size, impact of human activities on habitat, fragmentation of herds, removal of important individuals from small herds, and the stresses of hunting. Bighorns have specific problems and the application of elk biology is a dangerous over-simplification that does not recognize bighorn's needs. The study of diseases and parasites, because it diverts money that could be put into habitat, tends to relegate bighorns to the "free-roaming domestic herd" category, (and I do feel it is very important to draw distinctions between wild bighorns and free-roaming domestic herds). An acre of ground that the bighorn can call his own is more valuable to him than a dozen disease and parasitologists.

Bighorns are vulnerable to over-simplified application of elk biology, to the impact of human activities, and to nonmanagement based on the manager/user alliance. Because of this vulnerability, I am opposed to management as the only alternative, believing that nonmanagement is also an important alternative. And because our preoccupation with technology tends to blind us to the aesthetic, I am opposed to turning all bighorns, or even very many of them, into free-roaming, doctored, babied and fed domestic herds.

It is my recommendation to this group that:

(1) Trophy hunting as a dominant management concept be deemphasized and either sex hunting, reversed three-quarter curl hunting, and no hunting at all be initiated in those situations where such changes are compatible with the needs of bighorns in order to diversify bighorn management and philosophy.

(2) That all hunting be stopped on isolated, remnant herds of less than 250 total bighorns.

(3) That the Idaho Salmon River Wilderness be set aside as a bighorn sheep primal gene pool and all trapping, tagging and management be curtailed in the area.

(4) Data from hunter-killed bighorn sheep be scrupulously collected and analyzed to monitor the possible effects of hunting.

(5) The definition of the three-quarter curl regulation be revised so that only rams 10 years old or older may be legally hunted, and that all hunters attend mandatory training sessions prior to hunting bighorns. Hunting bighorn sheep is a rare privilege and requires a high degree of responsibility from hunters, which is a minimal price to pay for the right to hunt them.

(6) Curtail all noncontrolled hunting and hunt bighorns only on permits in order to maintain strict control over hunter distribution and harvest.

(7) Research on the effects of trophy-type hunting on bighorn sheep be initiated in all states where they are hunted.

(8) Ask Boone and Crockett Club to take bighorns from the record book and seek to deemphasize trophy hunting as a means of managing bighorn sheep.

(9) That the Bureau of Sport Fisheries and Wildlife be asked to place certain diminished, isolated herds on the endangered species list so that greater control can be exercised over the conflicting uses of their habitat as provided for in the newly passed public law 93-205 relating to endangered species. This law provides for the inclusion of species on a regional basis, if needed.

WHAT ARE THE EFFECTS OF BIGHORN TROPHY HUNTING?

By
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My presentation today will be in three parts as follows: What does the trophy sheep hunter want? What are some of the biological consequences of his activities? And finally what are some of the influences of the Boone and Crockett Club on trophy sheep hunting?

In Alberta, during the winter of 1972, we surveyed approximately 500 resident sheep hunters by questionnaire and asked their views on sheep hunting (Carr 1972). Some of the highlights were as follows: we were surprised to find that there appeared to be considerable recruitment of new sheep hunters each year, since the greatest percentage of hunters indicated that it was the first year that they had hunted bighorns. However, a large percentage of sheep hunters persisted for about 10 years before they began to drop out.

With reference to horn size, we found about half of the respondents were satisfied with our present "4/5 curl" size limit. About 25 percent of the hunters wanted a full curl law and the other 25 percent would have been satisfied with a 3/4 curl law. Most hunters were looking for horn bases of 14-16 inches and horn lengths of 36-40 inches. About 20 percent wanted broomed horns and about 20 percent wanted unbroomed horns. The majority would have been satisfied with either. Several other criteria were mentioned by hunters with reference to horn size, and many listed their personal standards based on Boone and Crockett scores. About 15 percent of the respondents had killed a trophy sheep that had met their expectations; however, they continued to hunt bighorns.

We asked the hunters if Alberta bighorns should be managed so that only large trophies (8-12 years) are made available to a few people, or smaller rams (4-6 years) are made available to more people, or somewhere between. We did not elaborate on the biological implications of such a program, i.e., the range requirements are nearly double when managing for an old herd compared to the range required when managing for a young herd (Wishart 1970). Forty-five percent of the hunters wanted management for the larger rams, 15 percent wanted smaller rams and 40 percent wanted management for the 6-8 year age class.

From 1966 to 1968 we had a November season during the bighorn rut in Alberta and the result was a very high harvest rate of older and larger rams, so we asked about having a hunting season during the rut again. About a third of the hunters were not in favor of having a hunting season during the rut. Most of the reaction was to have a separate definition for a larger legal trophy for rut hunting seasons.

Finally, we asked what percentage of the ram kill should go to nonresidents. (Incidentally, about 60 percent of the nonresident sheep hunters that hunt in Alberta come from the eastern USA and about 10 percent from California.) Approximately 85 percent of the resident sheep hunters in Alberta felt that 30 percent of the ram kill or less was fair to all nonresidents. I might add, the answers ranged from no kill to no restrictions for nonresidents.

The foregoing was presented to give some idea of the hopes and expectations of a sample of sheep hunters. Next, I would like to discuss some of the biological consequences of trophy sheep hunting. In recent years I have read some rather disturbing articles by my colleagues (Geist 1971, Morgan 1973) suggesting that shooting mature rams is detrimental to the quality and survival of bighorns. I question their rationale and I would like to present a rebuttal.

First, not only would sheep hunters like to harvest large horned (36+") rams, but they are obliged by regulations to harvest rams with a good horn curl. However, it does not follow that rams with good curls have large horns. Rams that have small, slow-growing horns have small horn diameters and "tight" curls, and rams that have large, fast-growing horns have large horn diameters with "big" curls. Thus, a small ram horn with a 10" diameter will reach a full curl at about 31½", and a large ram horn with a diameter of 13" will not reach a full curl until about 41". The most important point here is that, as a rule, rams grow horns to about the same fraction of a curl and arrive at that point about the same time regardless of the horn length. In other words, the curl of a ram horn can be either a miniature, the same, or a large replica of another ram horn of the same year class (slides).

Generally speaking, then, sheep hunters remove large, medium and small horned legal curl rams in direct proportion to their frequency in the population. Trophy hunting does not selectively remove the very largest horned rams, rather the rams of all horn sizes with legally acceptable curls. A case in point is in Alberta where most of the rams harvested are just 5 to 7 years old. The average horn length of all rams harvested has been only 32" (range 26"-42") and less than 15 percent of the annual harvest has been rams with horns exceeding 36" Incidentally, about only half of the available legal rams are harvested annually in Alberta.

There is an interesting record of some ram horn measurements taken over 100 years ago in Alberta by the Earl of Southesk. The rams were taken in the northern part of their range and the horn dimensions were not significantly different from measurements that are recorded in that general area today.

I would like to reemphasize that the impact of trophy hunting on horn development is negligible, particularly when one stops to consider the major environmental influences on horn growth. I have alluded to environmental influences on horn growth in a previous presentation (Wishart 1969). At that time, I recorded abrupt and significant differences in horn sizes between northern Alberta and southern Alberta bighorns due to dramatic differences in winter weather and range quality. In addition, I applied Bergman's rule and Allen's rule to North American wild sheep and compared horn mass/body weight ratios from Alaska to Mexico. The ratios were predictable by the laws of thermoregulation, i.e., by comparing north and south; Dall sheep have light weight horns/heavy weight bodies and desert sheep have heavy weight horns/light weight bodies. The data presented on horn weight and body weight of North American sheep suggested that horn size has a significant role in temperature regulation. Cowan (1940) stated succinctly that the ultimate maximum size of skull and horns in any area is a composite result of genetic and age factors, no doubt conditioned by environmental circumstances.

I would like to make a few comments on the hypothesis that hunting harassment and the harvesting of mature rams causes desertion of traditional ranges that would normally be learned by succeeding generations. First of all, under the present curl laws in North America there is plenty of opportunity for young rams to learn the traditional routes of their elders, even if their elders are only 4 or 5 years old. The chain of tradition is not likely to be broken unless rams are harvested before they reach the age of 2 or 3, i.e., the age when they generally join the older ram bands.

Secondly, I believe that hunter harassment has considerably accelerated the extension of sheep ranges in recent decades. For example, the heavily hunted bighorns of my old study area at Sheep River in Alberta have been shot in every possible tributary leading from their traditional summer range and also tributaries of traditional summer ranges of other herds. In recent years bighorns have been observed on an isolated mountain where there have been no historical records of sheep before. During the past hunting season, rams returned early to their winter range which had been established as a sanctuary for less than two years. In order to avoid hunters the sheep arrived prematurely on a winter range that was primarily set aside for protection from the coal and cattle industries. The reverse occurs on park boundaries where hunters have influenced mature rams to extend their stay on park summer ranges until the hunting season is over. Although some traditional bighorn ranges may have been lost due to hunting, some new ranges have most certainly been gained.

Finally, I am not convinced that under natural conditions older rams are that important in extending bighorn ranges. I have been most impressed with the unusual wanderings of young bighorns. As is the case with most species, the function of surplus young is usually to disperse and apparently search for new range or some extension of the existing range. I think it is rather significant that there are now examples of some remarkable and rapid range extensions of transplanted bighorns without any guidance from older sheep - e.g., Wyoming.

To summarize, I believe the suggested functions of mature rams have been oversold with very little evidence. In view of our present knowledge, I do not consider trophy hunting a detriment to horn development or to range expansion of bighorn sheep.

Finally, where does the Boone and Crockett Club fit into the scheme of things? I believe O'Connor (1973) and Morgan (1973) have done an excellent job of expressing our outrage at what the record book has done to the status of decent mountain sheep hunters. I can imagine the club began to keep records because of man's innate desire to know what is highest, lowest, biggest, smallest, fastest, slowest, etc. This peculiar human phenomenon is best illustrated by the popularity of the Guiness Book of World Records which started circulation less than 20 years ago and now has worldwide distribution and is published in 12 different languages. The need to know upper and lower limits possibly helps us as individuals to know where we fall into the scheme of things. For some who have not found their place in the scheme of things, what better place than to be in possession of something that tells the world you are in the top ten. The unethical practices that hunters have undertaken to make "The Book" (Boone and Crockett), particularly in recent years, has now created an aura of suspicion and lack of credibility for almost anyone listed in the record book. I have had to provide testimony at a number of court cases in recent years that involved mostly guides and outfitters who had obviously sold their souls to their clients and proceeded to cheat by taking rams out of season and out of the parks to meet the demand.

And recently, some of the Indians in Alberta have redirected their hunting rights toward the illegal lucrative sale of ram heads. Nowadays, any hunter with a big ram is immediately suspect.

I was talking to Ian McTaggart Cowan a few years ago at a conference on ungulates in Calgary and I told him the highlight of my trip to New York some years ago was seeing Simpson's ram in the New York Museum of Natural History. Cowan replied that he and Jim Simpson had worked closely together in the national parks during the 1940's and Simpson told him that when he died, Cowan could publish where Simpson actually killed that ram. I understand now that the ram was taken off Aylmer Mountain in Banff National Park. I think it was probably appropriate that the number one bighorn was recently destroyed in a house fire in southern Alberta. That ram was shot in Blind Canyon in 1911. Blind Canyon was a game preserve in 1911 (G. R. Kerr, pers. comm.).

These days I find it very uncomfortable to be associated with outfitters and some of the big sheep killers. I have had that same sensation in associating with falconers (falconry is illegal in Alberta). I have read that a white gyrfalcon will bring up to $30,000 from the right Arab. Just recently I attended a peregrine conference in Connecticut where there was a general concurrence that in order to alleviate illegal trade and the feeling of distrust, all falcons in captivity must be permanently marked. Herein lies a lesson for registering trophy heads. Possibly there should be another book for legally registered, permanently marked ram heads. However, do we really need to know No. 220 when a record of the most massive horns and possibly the longest horn is all that is required, e.g., as Guiness has done with the argali. Do we really need to know who shot the animal? Possibly the location of the head may be of interest, such as in a museum, but hopefully not in Bill Foster's Bighorn Restaurant.

In the final analysis, the state of the bighorn rests in the political process of land use decisions. I would hope that some of those decisions will be influenced by the groups involved at the forthcoming workshop at Missoula on the management biology of North American wild sheep. The sponsors are the Boone and Crockett Club, National Audubon Society, and the Wildlife Management Institute. At the moment, I consider the Boone and Crockett Club a strange bedfellow with this prestigous group because of their less prestigous record book.

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COMMENTS ON HUNTING

By
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I'm out of my element up here with all these learned biologists who can quote all these figures. I'm just a simple, barefoot, unwashed sheep hunter. If I've done some writing about it, it's because a guy's got to make a buck. However, I've possibly been hunting sheep longer than most of you people here. I've been hunting sheep for just 40 years. I started out in Sonora and I've hunted bighorn in Alberta and British Columbia. I've hunted Dalls many times in the Yukon - stones many times in the Yukon. I've shot one barbary sheep and I've shot maybe a dozen urial in Iran, a couple of red sheep and other sheep. Other people have hunted more sheep and gotten bigger heads than I have. I've been very interested and I liked Bill Wishart's talk very much. I always learn something from the biologists, and unlike a great number of sportsmen, I've got great respect for biologists because they are not all inspired by God and they all aren't the wisest guys in the world. They are human beings like everyone else. But on the whole, they're more apt to be right than the ordinary sportsman.

I've been credited with being a gung ho head hunter - actually I haven't been. I've always tried to get mature rams, and I think if you only shoot the relatively large rams that God will be kind to you sooner or later and you'll get an exceptional one.

I'll have to tell you a story - my wife shot a couple of North American sheep and the first sheep she got was 44 and 44-1/4 and almost 15 inches at the base. It was a Dall and she almost froze to death that day and got pretty sour on sheep hunting. With that ram she won second place in Boone and Crockett that year. The second sheep - the last North American sheep she got was a stone. It was 37-1/2. She had killed one sheep, so when she got up to her stone she looked at it with vast disgust. She turned to me and said, "For heavens sake, why didn't you tell me it was just a little one?"

Bill mentioned the bighorn in the exhibit at the habitat group in the American Museum of Natural History. The story I heard about that was that it was shot in Jasper Park. Is that correct? It was shot in Jasper Park by a guy named James Simpson and he told the park officials there was a very exceptional ram and it should be shot and preserved - he didn't want it to go out and die. He was an outfitter. So he kept bugging those people, but they wouldn't let him shoot the ram and they wouldn't take it themselves, so finally the ram disappeared and they suspected Simpson. I understand that for 3 years they searched his car every time he came into the park and left. He had ditched the sheep with its head in a spruce tree. He brought the horns and skull out and sold it to a head collector who was not a hunter called Dr. Beck from Philadelphia. Dr. Beck put another scalp on it and when he died he left it to the American Museum of Natural History and they put a third scalp on it, and it's on exhibition.

I have been terribly disgusted by the crookedness and the lying and the cheating that has gone on in this record head business. Jim Morgan, in an article he wrote, blamed me for that. I'm not the boy because I haven't encouraged that sort of thing at all - in fact, it disgusts me.

One friend of mine, a well known sheep hunter and very rich man has a couple of big stone sheep heads in the record book. He told me a very circumstantial account of how he got each of them. I'm a natural born patsy - you know a 5-year old child can con me and everything else. So I believed the guy. I happened to hunt up there with the same outfitter, so I said to my guide, who was also the guide for this guy, "Where was it that so-and-so got these big stones?" He was sitting on a pack with a drink in his hand and he fell off backwards, screaming with laughter. He had bought one from an Indian who had found it in a rock or snow slide and the other he bought from an outfitter up there. I know another record head that was taken off the wall at a beer joint on the Alaska highway. This is not new.

I was going through an old copy of Outdoor Life some years ago and in it I saw a guy named Sheard who lived in Portland, Oregon, and he had a claim in there for the world's record bighorn ram. Anybody who knew anything could tell that his world record bighorn ram was some kind of an argali with a bighorn scalp on it. Their horns are entirely different.

And some of these head hunters! I know one guy who was what I call an instant sheep hunter - a man who made a lot of scratch after the war and decided he was going to be one of the world's great hunters. He was a little guy, he couldn't hit golf balls and he couldn't play tennis and he was so homely that even with all his dough the women didn't dig him. He was looking for appreciation, so he became the world's greatest sheep hunter and he is alleged to have taken all varieties of North American sheep in 30 days. I heard he was in Alaska and he jumped the season and shot 7 Dall rams before he got one which would go in the record book. But I get weary with all this stuff. I say that any mature ram is a good trophy, and particularly with bighorn or desert sheep, any mature ram is a good trophy whether it goes 34 or 44. I refuse to go back east and help them measure heads.

I'm doubtful, but I think Jim Morgan is kind of lining up with the little old ladies in tennis shoes, and I'm sorry to see this, but I've got great respect for Jim as a biologist. However, I think Jim is researching some of his conclusions with his heart.

I was talking to a very dedicated clambake over in Memphis. They had spent a lot of time and a lot of money trying to do something about the California bighorns. They told me there were about 3,000 desert bighorns in California, and of course they haven't had a season on desert bighorns there for at least 70 years and also the little old ladies who protected them are also protecting the burros and the wild burros are taking over the water and the feed.

Years ago, I grew up in Arizona, and the season on desert sheep there was closed about the time I was born. I batted around in the hills and I knew that along in the 30's the sheep were being heavily poached by the prospectors. They all had 30-30's and they had the romantic idea they would live off the country, so they were shooting hell out of the sheep. I went down to the Game Commission one time and I said, "They're poaching the sheep, the sportsmen of the state are not getting the recreation, they're not getting any trophies, the game department isn't getting revenue, the sheep are declining, so why not institute a study first to find out how many sheep are there and second to study the feasibility of an open season, as I think it's far better to take some of these old rams than to just let them be poached or die of old age." There was a reporter there and the next day you would have thought I had recommended ravishing a Red Cross nurse on the main street in Phoenix - by that time the sheep had become sacred.

I'll have to tell you something funny that happened after that - one of the first guys they hired was a very interesting guy named Felipe Wells - he is still alive - he was a cousin of Sumner Wells the Secretary of State. He had grown up in Mexico, he spoke perfect Spanish, he had gone to an exclusive school in the east and his family had quite a bit of money. He was hired to study sheep so he had a little camp way back up in the Catalinas. His supervisor decided to go up and see how he was doing, as he hadn't heard from him in some time. He got on a mule and went on down the trail and up there was Felipe with a nice fat ram hung up in a tree and he was toasting sheep ribs over the fire.

The first man who made a study that amounted to anything on desert sheep in Arizona was a friend of mine named Nichols - he's dead - and then I know Johnny Russo who studied bighorns. Since then there's been a lot of fine bighorn rams taken in Arizona and the sheep they say are slowly declining, but it's because of the invasion of the habitat and not because some of the rams have been taken out.

I think, in the first place, that the sheep is a trophy animal. I think when you've got the meat hunter, the casual meat hunter, that this is the end and I think that some of that has happened up in Alaska.

I hunted up around the Big Smoky in 1943. The greatest game country I ever saw in my life. I saw about 75 mature rams, about 300 ewes, lambs and small rams, I saw 33 grizzlies in 30 days, we saw hundreds of caribou, we saw maybe 20 bull moose and then I went there 18-19 years later, took my wife and daughter up there, and boy that country had had it as you well know. There were outfits all over. There were still a few rams, but the caribou were shot off. I heard a rumor of a big grizzly that had been killed by some outfit and I saw the big grizzly hide - it was about 4 foot long.

There were thousands of goats when I was up there in '43 - literally thousands of them - one camp we had we could look out from and there would be goats all over the hillside - 30-100 goats, and when I was up there the second time there weren't any goats. I mean instead of thousands we might have seen a hundred - I'd like to ask - just what happened to the goats?

But anyway, there were a lot of very casual hunters coming in there. They would go to Grand Cache, I think it was, and rent some Indian horses and then ride in there and shoot all kinds of things. I was visiting an Alberta rancher one time and I saw some horns nailed up on his barn. I didn't know what they were, so I said, "What the hell are those things?" He said, "They're bighorn heads." There wasn't one over 3 years old and most about 2 and those guys went in there hunting every year. I don't think it should be allowed. I think sheep should be kept as a trophy animal.

I have just finished a book on sheep hunting and I borrowed very heavily from various biologists. I haven't finished the last chapter, but I'm going to call it "The Future of Sheep Hunting" and I frankly don't know what it is. I think it sounds pretty good in Alaska, I'm scared about northern British Columbia, I think there is too much development going on there. I think I'm very gloomy about the situation in the U. S. In Oregon I think it was, I think they gave 14 sheep licenses and they had about 5,000 applicants for them. Well, that becomes simply ridiculous and the same thing in Washington. I'll tell you there are so many people hunting sheep just so they can say they shot a ram or just because they want some kind of a head to hang on a wall. They have a few California bighorns in Washington, not far from where I live in Idaho, and people apply for and sometimes get a permit to hunt them.

This guy called me up from right across the river in Washington, and said, "Mr. O'Connor, I drew a sheep permit for a California bighorn for the Blue Mountains." He asked me how to hunt sheep, and I said, "Well, you get a fairly flat shooting rifle, a good pair of binoculars, spend your time scouting the country if you can and spend more time looking and walking than anything. When you see a sheep, wait till he's settled down and will stay put for a while and then get as close as you can to him. Take a good, firm rest and then a carefully placed shot, kill him with the first shot."

About 6 weeks later he called me up and said, "Mr. O'Connor, do you remember I called you and told you I got a sheep permit?" I said, "Yes, did you get anything?" He said, "Yes, I got one." "Well, did you take my advice?" "Well, not exactly. I went out and I saw this ram and I got excited, he was about 300 yards away, and I started shooting at him off-hand. He acted as if he were hit so I went over there and I finally found some blood, but I never found the ram. I hunted for him 2-3 days and then I went on and shot at a couple more but I never did hit those. Then I went out to hunt again about 10 days later and some trout fishermen told me there was a wounded ram down by the creek, and by God it was the first one I shot. The poor thing was lying there by the creek and by Jesus did he stink, but he was still alive so I shot him. It was a pretty nice ram."

Well, I'll let you go now. Thanks again for the opportunity to talk to you.

THE IMPORTANCE OF MINERAL LICKS TO DALL SHEEP IN INTERIOR ALASKA AND ITS SIGNIFICANCE TO SHEEP MANAGEMENT

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The importance of mineral licks to Dall sheep populations was studied using marked individual Dall sheep at the main mineral lick in Dry Creek, Alaska Range. Sheep were captured by drop net, marked and released. Observations of marked sheep locations were made from aircraft and on foot. It was found that at least three populations of sheep utilize the main lick on Dry Creek. The populations of sheep inhabiting the study area overlap only at the mineral lick. The time of lick use corresponds with the time of movement to summer range, and sheep travel out of their way to use the lick at this time. The use of the lick by sheep is dictated by immediate and long-term weather conditions. Lactating sheep visit the lick more times throughout the course of the season, spend 1.6 times as much total time involved with the lick, and spend more time licking than others. Data on utilization with respect to time of year, weather conditions and daily licking activity pattern are presented. The probability of resighting sheep in successive years is calculated.

The predictable nature of utilization by sheep demonstrates the critical nature of mineral licks to Dall sheep in interior Alaska, and provides a unique situation for survey and inventory work. Mineral licks are foci of sheep activity and movement immediately following lambing. Consequently, a technique is presented for determining production, survival to yearling age and population composition by making observations at mineral licks.

INTRODUCTION

Investigations of general group movements and seasonal distribution of Dall sheep *(Ovis dalli)* have been conducted previously in various areas in Alaska (Viereck 1963, Palmer 1941, Scott 1951, Murie 1944, Gross 1963). These studies indicated that sheep were seasonally present in certain habitats, but failed to establish whether they were wandering animals which were attracted to a given area or residents that were there each year. In order to determine whether or not these are resident sheep, it was necessary to mark individuals so they could be identified year after year.

Mineral licks are known to exist and have apparent importance in most Dall sheep habitat in Alaska. It has been proposed that they have primary and profound effects on sheep distribution and movements (Pitzman 1970, Palmer 1941, Viereck 1963a and b, Erickson 1970). However, few specific data are available to support this seemingly reasonable idea.

In order to provide information on and to show the relationship between these two important aspects of Dall sheep biology, the Alaska Department of Fish and Game instituted an intensive study of the sheep influenced by the main mineral lick in Dry Creek, Alaska.

MATERIALS AND METHODS

Study area and general method: The Dall sheep study area is centered on the Dry Creek drainage in the Alaska Range south of Fairbanks and includes adjacent drainages (Figure 1). Animals for use in the study were captured and marked during June and July of 1968-71 at the main mineral lick on Dry Creek using the drop net method described by Erickson (1970a). In 1969 and 1970 large, safety-orange plastic collars with canvas backing and black numerals were used (Figure 2). In 1971 collars consisting of polypropylene rope strung through a numbered pendant and secured around the sheep's necks using hog rings were used. All collared animals were also marked with ear tags (Jumbo Rototag by Dalton Henley of England).

The large collars are visible at great distances; numbers on the pendants are discernible at distances of up to 250 or 300 meters using a 60x spotting scope in good light.

Sheep were identified on home ranges throughout the year, and locations were plotted on topographical maps. Most observations were made on foot surveys, but some aircraft surveillance was utilized. Success of aerial survey techniques was limited to occasional sightings of collars which were used in 1969 and 1970. The smaller pendant collars used in 1971 were impossible to identify from aircraft.

Observations of mineral lick utilization at the main mineral lick on Dry Creek were begun in 1969. In 1969 observations were made from June 16 through June 25 from 0300 to 1800 hours. In 1970 observations were made continuously from June 3 through June 12 and from June 29 through July 3. In 1971 no organized observations were conducted, but collared sheep were noted as they entered the lick. In 1972 continuous 24-hour per day observations of lick utilization were made from May 19 through July 5. During the eight hour observation shifts, observers were stationed in a plywood blind about 200 meters from the lick. In 1973 observations were made from 0400 to 1600 hours from May 26 through June 30.

In 1972 and 1973 all sheep coming into the lick were classified with respect to age and sex. Sheep within the lick were also classified and counted every 30 minutes. At these times weather conditions were also recorded. Returns of collared sheep to the lick allowed calculations of fidelity constants (Geist 1971) for sheep in different age and sex classes.

RESULTS

Collaring: The large collars used in 1969 and 1970 were the most effective means of identifying sheep. These collars appeared to cause no problem to the sheep, and were retained fairly well by the sheep. Considerable problems did result from lack of rigidity in the canvas backing on the collars. Insufficient stiffness resulted in the collars folding and rolling to the point that the numbers could not be read. During 1969 and 1970, 100 animals were marked with this type of collar. Forty of these animals were identified by collars and ear tags in the summer of 1973. Of these, the collar was still useful for identification of 35 animals (87.5 percent). This means that a high percentage of the collars had functioned well for four years. Those collars are, however, in very poor condition now and their usefulness will probably not exceed five years.

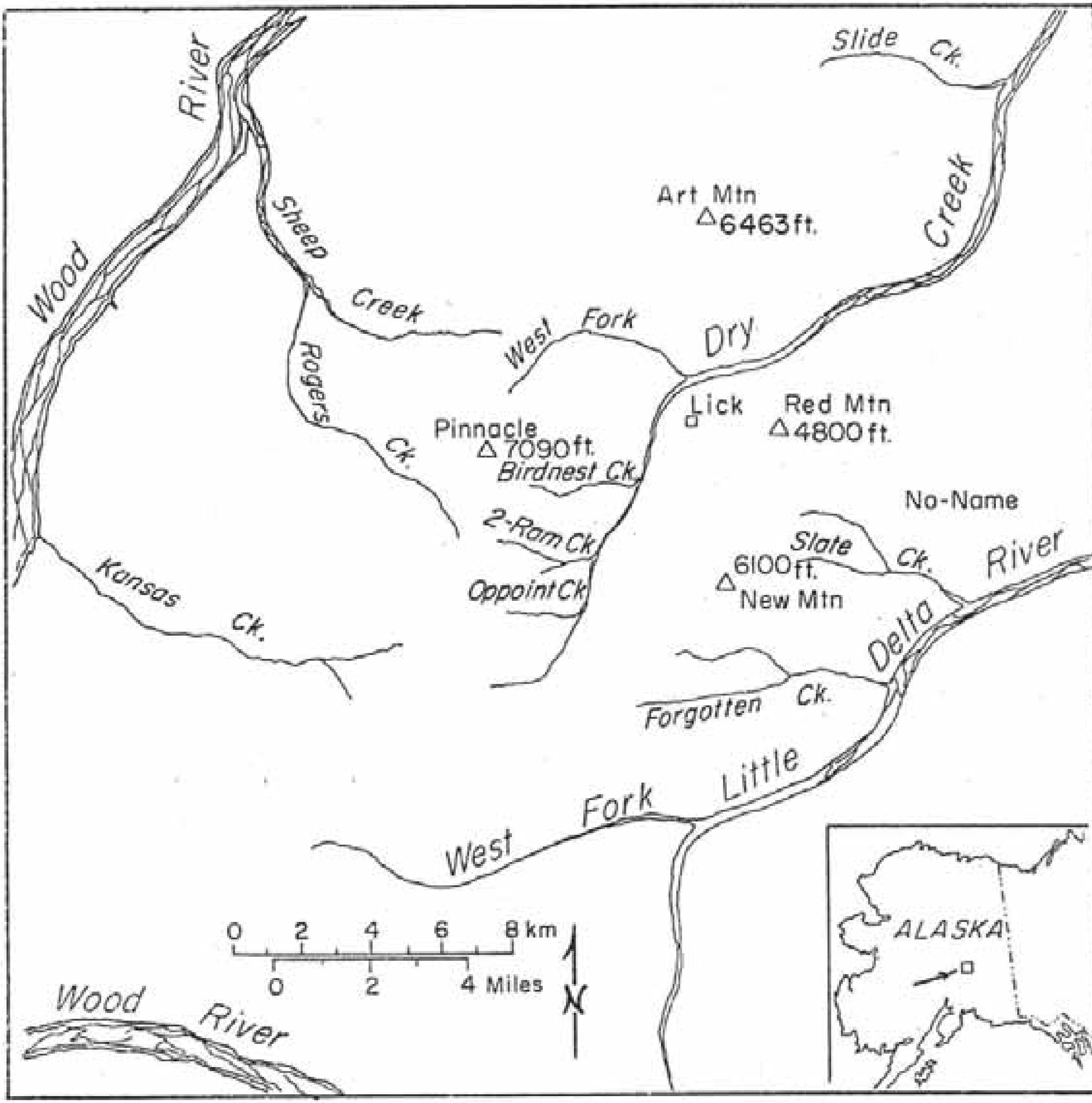

Fig. 1. Sheep study area in Dry Creek and adjacent drainages, about 70 miles south of Fairbanks, Alaska.

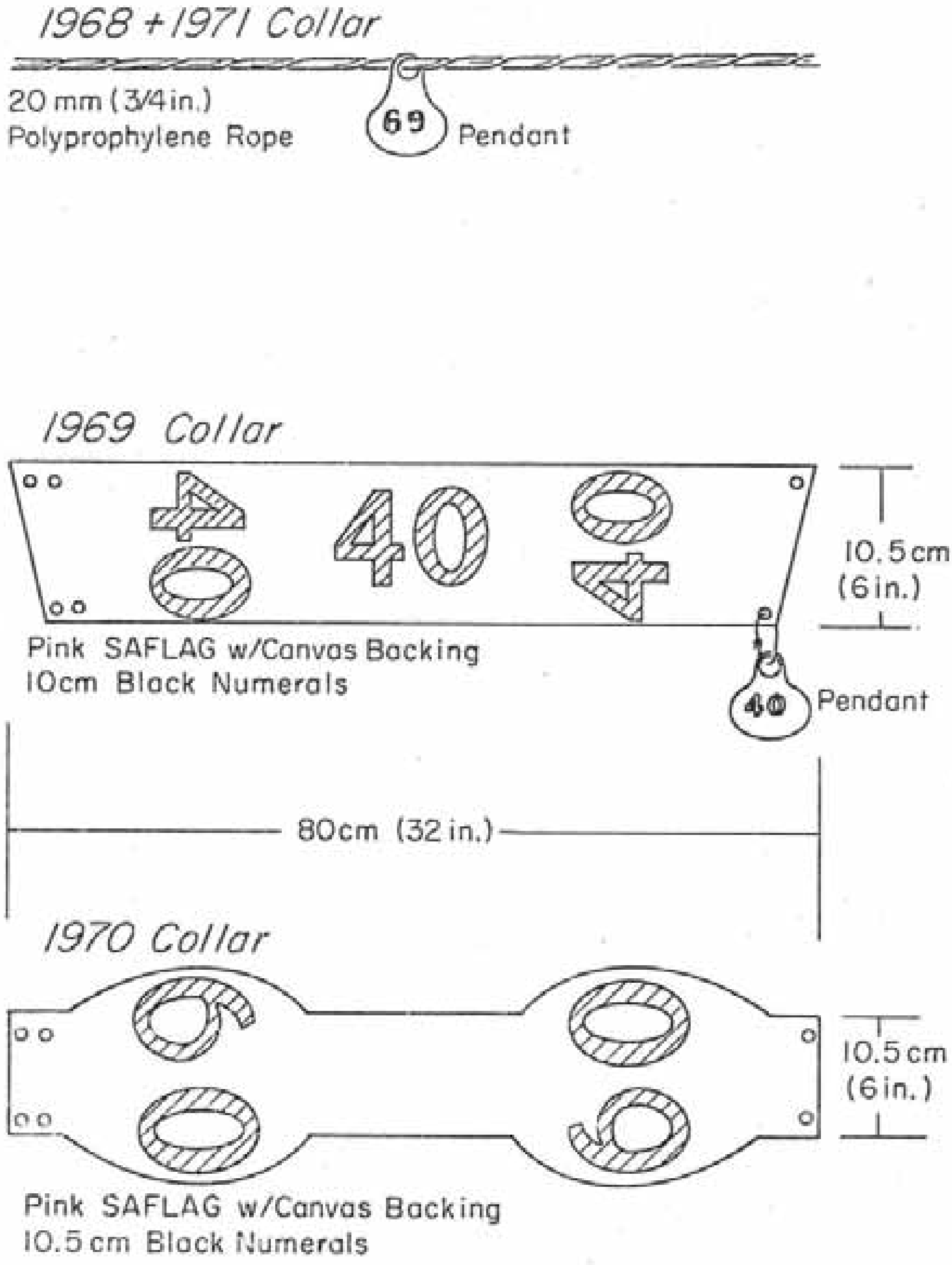

Figure 2. Collars used on Dall sheep captured during 1968, 1969, 1970 and 1971 at Dry Creek, Alaska Range.

In 1971, 95 animals were marked with the pendant and rope collars. During the summer of 1973, 53 of these animals were identified. Of these identified animals, only 26 (49 percent) still retained the collars. This type of collar does not appear to be as successful as the canvasbacked plastic. The most certain identification markers have been the ear tags. No animals are known to have lost ear tags, and damage to the tags has been minimal. This type of marker has the disadvantage of not being readily apparent and requiring close inspection of the sheep in good light with good optical equipment to make a positive identification.

Effect of mineral lick use on seasonal movement: The period of maximum lick use has been found to correspond to the movement of sheep from winter to summer ranges. During 1972 this period was observed to be from about the 16th to the 23rd of June. Other data indicate that movement may occur as early as the first week in June or as late as the last week in June. In any event, the time of maximal mineral lick use follows shortly after lambing and corresponds to the time of general movement from winter to summer range.

The traditional use of the main mineral lick on Dry Creek by the animals of all populations in the study area causes movement from winter range to be over much greater distance than the physical distance involved. For example, ewes wintering in Birdnest Creek and Two Ram Creek move to the lick and then to upper Dry and Kansas Creeks (Figure 3); consequently the distance traveled is increased from approximately 2 miles (3.2 km) to about 10 miles (16 km). Ewes wintering on the Slide-Exclosure-Bigfoot area on the other hand, pass through the vicinity of the lick on their way to summer range. Ewes wintering on the west side of Dry Creek may be considered to have the lick on the periphery of their ranges. Journeys of 4 miles (6.2 km) to summer range are extended to approximately 8 miles (12.8 km) for those on the Red Mountain - No-Name complex, while animals which winter on Slate Ridge increase their distance traveled from about 2 miles (3.2 km) to nearly 12 miles or 20 km (Figure 3).

It appears that several populations of sheep inhabiting the study area overlap or mingle only at the main mineral lick on Dry Creek. The time of lick use corresponds with the time of movement to summer range, and it appears that animals travel out of their way to spend time at the lick during this time.

Peak lick use: Peak use of the main mineral lick at Dry Creek has been observed to be in early summer. In 1970 the day of highest use was June 6, in 1972 the day of highest use was June 19 (Figure 4), and the day of highest use in 1973 was June 27 (Figure 5). These dates represent the times of migration from winter to summer range. The extent of use during the maximum period is apparently dependent on the manner in which winter snows disappear, the conditions of warming in the spring and the immediate weather conditions. In 1972 snow accumulation was great and melt-off was not complete until mid-June. Peak use that year was about mid-June, and corresponded quite closely with mean ambient temperatures which rose to averages of above 60 F at that time. In 1973 snow accumulation was light and melt-off was essentially complete by June 6. However, local ambient temperatures did not reach daily means of 50 F until the last week in June. Under these conditions, lick use was spread over a greater interval and the intensity was less than in 1972.

In 1972 barometric pressure correlated strikingly with lick use. In 1973 there was no apparent correlation between lick use and barometric pressure.

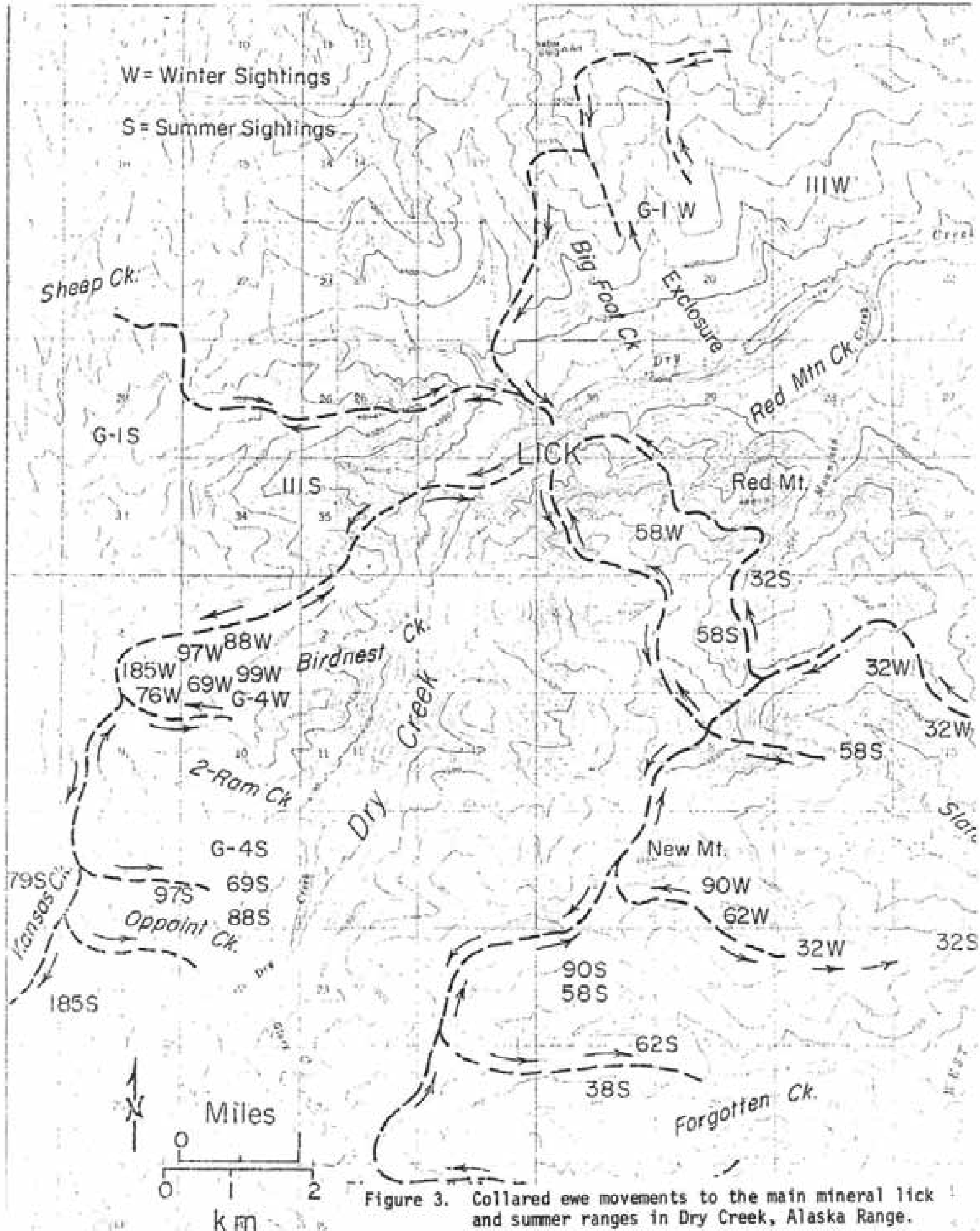

Figure 3. Collared ewe movements to the main mineral lick and summer ranges in Dry Creek, Alaska Range.

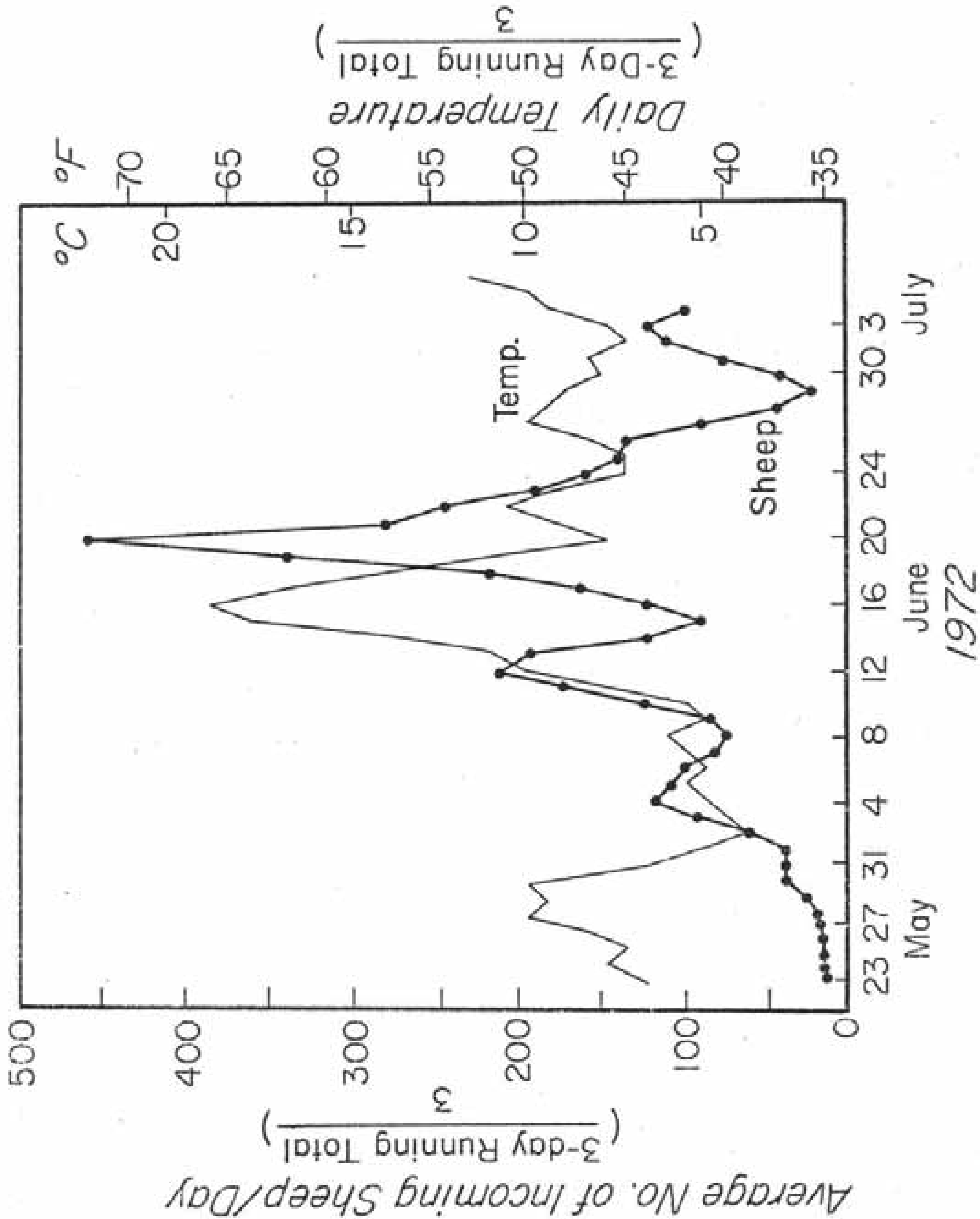

Figure 4. Temperature and lick use at Dry Creek 1972.

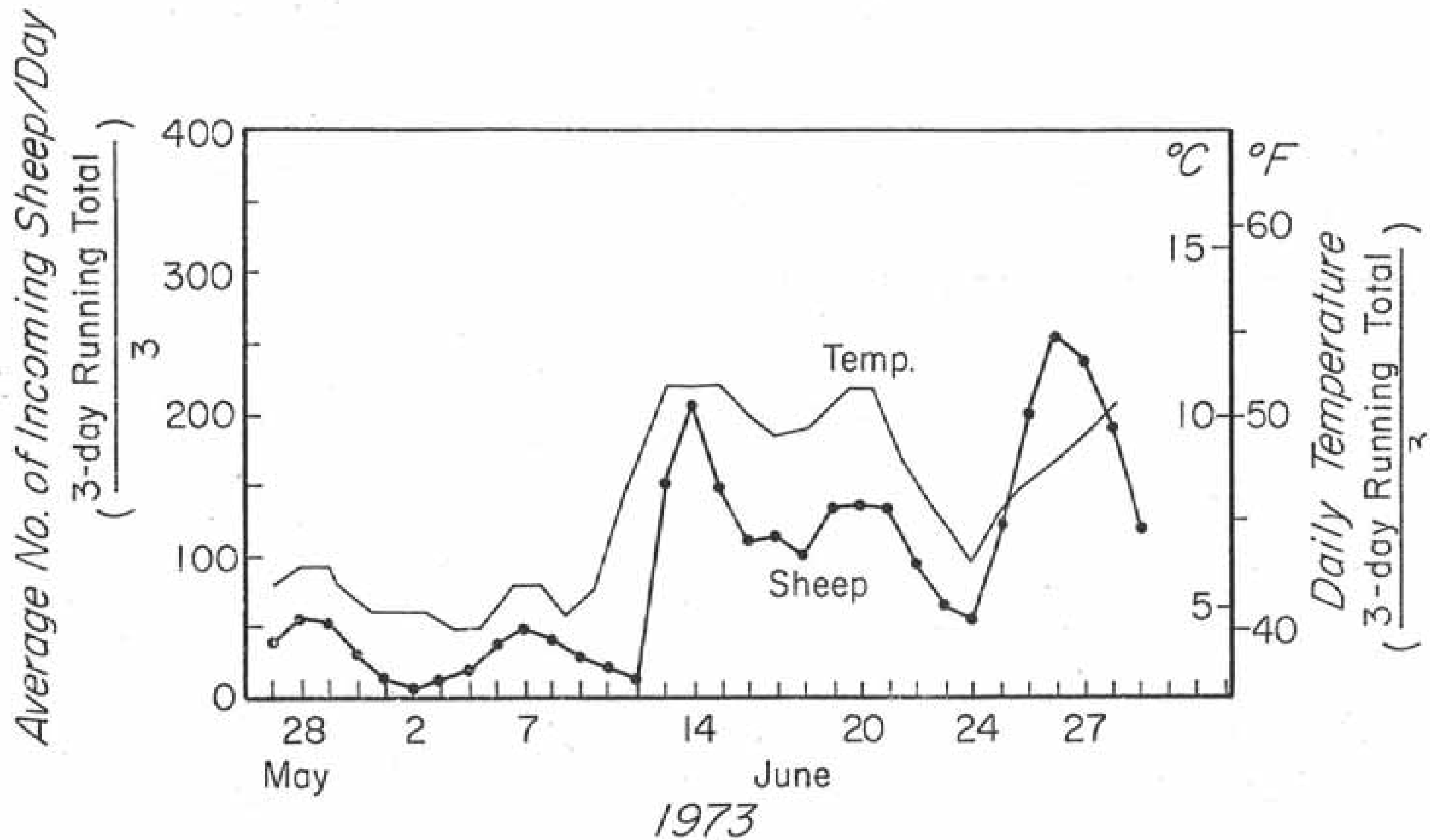

Fig. 5. Temperature and lick use at Dry Creek: 1973.

Intensity of lick use in 1972 was reflected by the entry of 580 sheep in one 24-hour period on June 19. In 1973 about 350 sheep entered the lick on June 27.

Time spent per visit and frequency of visitation: The length of time a sheep spends in the lick is a function of how many times it has been at the lick during the yearly cycle of lick utilization as well as the sex and reproductive status of the animal. Ewes that are nursing lambs appear to spend more time licking and visit the lick more than any other class of animals. Sheep spend virtually all of their time present in the lick eating soil or licking. In 1972 sheep spent 93 percent of their time in the lick licking (first visit of the year). On the second visit they spent 95 percent of the time licking, and all subsequent visits averaged 93 percent of the time in the lick spent consuming soil.

In 1972 a total of 70 collared sheep made 293 visits to the lick; an average of four visits per collared animal. Of these animals, 29 were rams; they accounted for 122 visits for an average of four visits per ram during the season. Thirty animals were ewes that were never seen to nurse a lamb. These ewes made 124 visits to the lick for an average of four visits per animal. The remaining animals were ewes that were seen to nurse lambs; they were 11 in number and made 57 visits for an average of five visits per sheep. Consequently, it appears that there is no difference in lick use between ewes which are not lactating and rams.

The collared rams which utilized the lick made 122 visits in 71 sheep days for an average of 1.7 or 2 visits per day. The average length of time which elapsed between visits for those rams visiting the lick on separate days was two days. The average number of visits per ram was four. This means that the average ram spent at least four days involved with the lick.

Ewes without lambs made a total of 124 visits in 79 days for an average of 1.6 or 2 visits per day. The average length of time which elapsed between visits of those sheep which revisited the lick was 198 days between 118 visits or 1.7 days between visits. The average number of visits by this group of ewes was four. Hence, the average ewe with no lamb spent four days involved with the lick as did the average ram.

By way of comparison, ewes with lambs made 57 visits in 36 days for an average of two visits per day. The average length of time which elapsed between visits of those sheep which revisited the lick was 69 days between 36 visits or 2 days between visits. The average number of visits made by the sheep in this group was five. Hence, these animals must spend six and one-half to seven days involved with the lick. This is approximately 1.6 times more than animals without lambs.

Ewes with lambs (lactating ewes) spent 25 to 50 percent more time than rams and ewes without lambs on their first visit of the year; ewes with lambs 93 minutes, ewes without lambs 75 minutes, and rams 63 minutes. During the second visit the situation was less well defined, with ewes with lambs spending 64 minutes, ewes without lambs 71 minutes, and rams 59 minutes. However, all other visits combined show that ewes with lambs had an average time of 76 minutes, ewes without lambs an average of 62 minutes and rams an average of 47 minutes.

Lactating ewes visited the lick more times throughout the course of the season, spent about 1.6 times as much total time involved with the lick, and spent more time licking on most visits than other ewes and rams.

Daily activity patterns: Figure 6 reveals that in 1972 cumulative lick use for the period of observation was at its lowest ebb from 2000 hours to 0200. From 0200 to 0600 there was an 11-fold increase to the time of maximal daily utilization. Then a decline occurred through the next three hours and another small peak occurred at 1000 hours. Use then declined to about half its maximal (0600 hours) use and remained at about that level until 1900 hours when it declined again to the low level described for 2000 to 0200.

Cumulative activity from 1972 is summarized in Table 1.

Table 1. Cumulative activity at the Dry Creek mineral lick 1972.

Hours Necessary to Observe	Percent of Daily Activity
0300-1400	67
0300-1430	69
0300-2100	90
0300-1000	50
0300-1600	75
Total sheep counted = 13,451 in 44 days	

These data represent cumulative daily activity patterns and may be subject to some variance from those seen early or late in the cycle.

Fidelity to the mineral lick: Table 2 lists resightings and observed fidelities since 1969.

Table 4. Resightings and observed fidelity to the Dry Creek mineral lick.

	Ewes	Rams
Seen in 1969	28	26
Resighted in 1970	26	13
Observed fidelity	93 percent	50 percent
Seen in 1970	61	28
Resighted in 1971	44	17
Observed fidelity	72 percent	61 percent
Seen in 1971	100	55
Identified in 1972	78	37
Seen but not identified in 1972	6	4
Total resightings	84	41
Observed fidelity	84 percent	75 percent
Seen in 1972	84	41
Identified in 1973	77	27
Seen but not identified	-	2
Total resightings	77	29
Observed fidelity	92 percent	71 percent

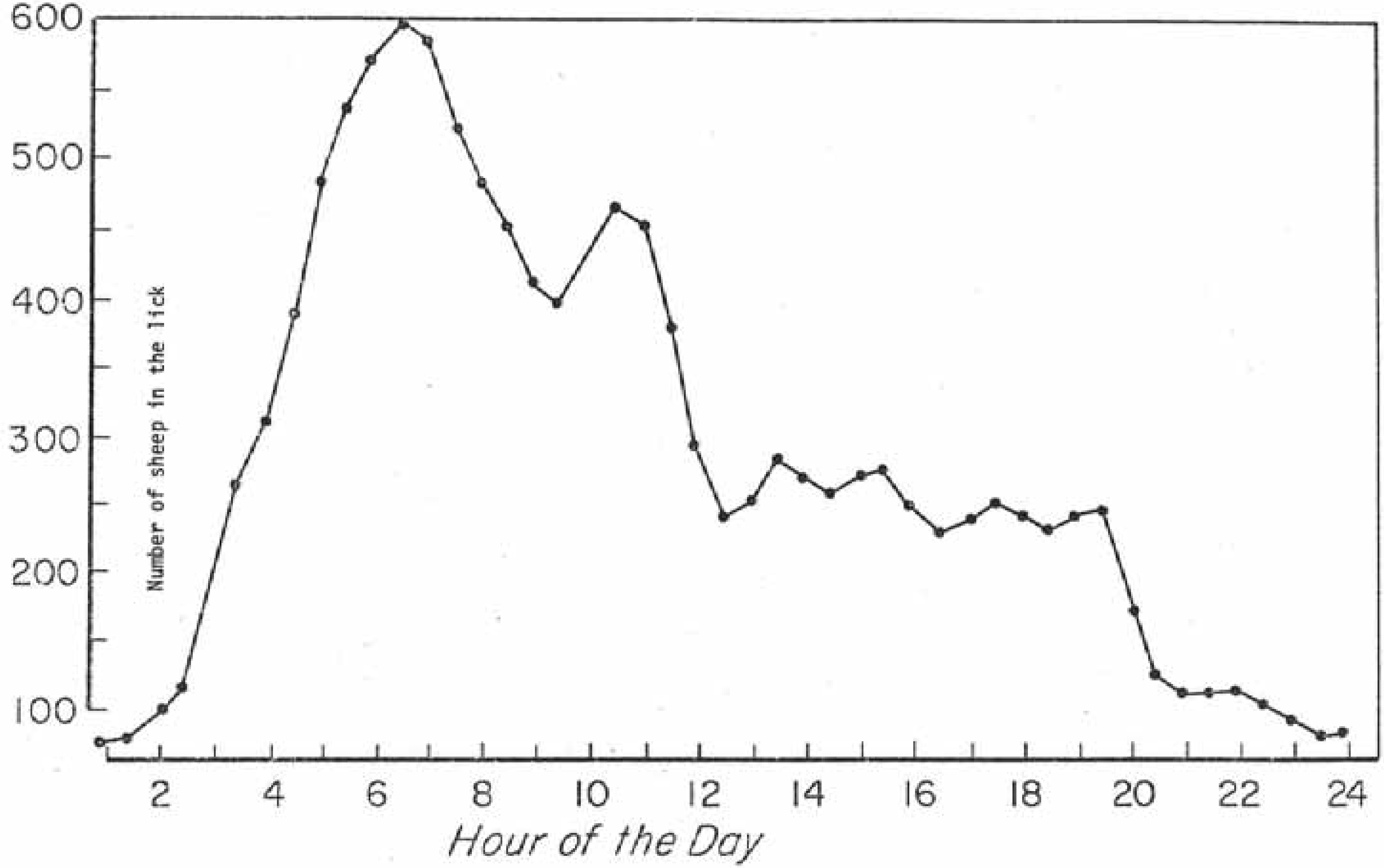

Fig. 6. Cumulative hourly mineral lick use at main mineral lick on Dry Creek, 1972.

The observation of 100 marked ewes in 1971 and 78 marked ewes in 1972 means that 22 individuals which visited the lick in 1971 did not visit the lick in 1972. All the marked animals which were not seen in 1972 are listed below:

142 age 3 years	6 animals were seen which had lost collars and whose ear tags could not be read. (Because of their young ages these animals are arbitrarily assumed to be the 6 ewes seen whose ear tags could not be read.)
162 age 3 years	
191 age 3 years	
164 age 4 years	
51 age 5 years	
147 age 5 years	
14 age 9 years	found dead
26 age 6 years	
33 age 12 years	collar found - no remains
43 age 7 years	
53 age 10 years	
63 age 8 years	last seen May 1972 with broken leg
64 age 9 years	
74 age 10 years	
86 age 8 years	
G-1 age 9 years	
111 age 13 years	
114 age 9 years	
121 age 10 years	
137 age 10 years	
180 age 10 years	
181 age 8 years	

The average age of these missing animals is 8.7 years.

Throughout the study 17 animals which would have been in this age class (9 years) were marked. Of these 17 animals, 11 were seen at the lick in 1972, and the average age of the six that were not seen was 10.5 or 11 years. Only one of these six animals can be demonstrated to be dead, but it is assumed that the others are dead because of their absence and advanced age. This means that the calculated, cumulative mortality in 1971 for ewes of the age class 9 years and above was 6/17 or 35 percent.

If it is assumed that animals 33 and 63 are dead and that the mortality of the remainder of the unaccounted-for animals listed above was 35 percent, then 0.35 x 13 = 4.6 or 5 of the animals were likely victims of mortality. This reduces the number of ewes which were not accounted for to 8 and brings corrected fidelity to 78 animals identified, plus 6 animals seen but not identified, plus 3 known dead, plus 5 presumed dead to 92 animals accounted for of the 100 seen in 1971. The result was a fidelity of 92 percent for 1972.

Because the winter of 1971-72 was harsh, and because the cumulative mortality calculated was averaged over the last 4 years, I think it is probable that 1971-72 winter mortality was higher than 35 percent in the 9 year and older class for ewes. Because fidelity is so high for ewes and could reasonably be higher, I think it is very reasonable to state that ewe fidelity to the Dry Creek lick is essentially 100 percent.

During 1973 seven ewes were not seen which were observed in 1972. These animals were considered to be no longer in the population.

In summary it appears that ewe fidelity is 100 percent. Animals which do not visit the lick in subsequent years may be considered dead.

Ram fidelity: Table 2 shows that 55 rams were seen at the lick in 1971. Thirty-seven identifiable rams were seen in 1972 as well as four unidentifiable tagged individuals. This brings the number of observed, tagged rams seen to 41. The apparent fidelity then becomes 41/55 or 75 percent.

The rams not accounted for are listed below:

34 age 5 years	108 age 3 years
40 age 9 years	118 age 3 years
45 age 9 years	152 age 3 years
55 age 10 years	157 age 3 years
65 age 5 years	161 age 5 years
81 age 4 years	184 age 3 years
101 age 4 years	195 age 3 years

When the heavy hunting pressure in the study area is considered, it is reasonable to predict that rams 40, 45 and 55 had been killed by hunters and not reported. This leaves eight, 3- and 4-year old rams which may have changed ranges. Young bighorn *(Ovis canadensis)* rams (2 year olds) are the most likely sheep to change traditional ranges (Geist 1971). This is thought to occur when they join the ram bands. Young males will follow any larger-horned male when they leave the juvenile and ewe groups. Because Dry Creek sheep grow slowly (Heimer and Smith 1973 unpubl. data), the possibility that this could occur among 3- and 4-year old Dall rams is most attractive. In any case, it must be noted that the fidelity of rams in the younger age classes is less than that of rams which have established home ranges, and that the fidelity of 2-, 3- and 4-year old rams at Dry Creek lick is low.

If it is accepted that the three old rams not seen in 1972 were probably dead, fidelity could be adjusted to 44/55 or 80 percent for rams. Here it should be noted that the average age of rams resighted in 1972 was less than 5 years. These animals usually occurred in ram bands, but were not yet legal to hunt. Also, fidelity may change as the animals mature.

DISCUSSION

The predictability of Dall sheep return to and utilization of the main mineral lick on Dry Creek as demonstrated by the fidelity constants of 1.00 for adult ewes and 0.80 for rams, coupled with the appearance of all populations of sheep which occupy the study area has several important consequences. First, it demonstrates that the mineral lick is of major importance to the population. It is not known whether the drive to utilize the lick is one born of tradition or physiological necessity. The more intensive use by lactating females seems to support the idea that the mineral lick is nutritionally beneficial.

The coincidental use of the lick by all segments of the study populations indicates that one important function served by the lick is maintenance of genetic homogeneity among the several populations of the study area. When the loyalty of sheep to their traditional ranges is considered, it appears that the lick could serve as a sort of "clearing house" for the placement of young rams in the ram populations of the study area. Geist (1971) has shown that when a young bighorn ram is ready to enter ram society he will follow a group of larger-horned males. At the lick young rams are exposed by chance, it appears, to the opportunity to join any of the ram bands in the area depending on the coincidence of their arrival at the lick. This may work to prevent genetic drift among the otherwise isolated populations of ewes and the rams which traditionally rut with them and result in the preservation of genetic stability. For these reasons mineral licks should be considered critical habitat and protected from human encroachment and development.

Secondly, the predictable nature of Dall sheep movements to the mineral lick and their concentration at mineral licks immediately following lambing presents a unique opportunity for efficient survey and inventory work. Dall sheep production has been traditionally monitored from aircraft. This is both expensive and more dangerous than observation from the ground. The discovery that it is possible to yearly view large numbers of Dall sheep from the same populations at low risk and low cost may reduce the need for aircraft surveillance. The data presented indicate that in major licks such as the main lick on Dry Creek the build-up of activity can be followed, perhaps by aircraft, and when it is advantageous, an observer could be placed near the lick to gather information on production, yearling survival, and population composition. If marked individuals are present in the population it is also possible to estimate the total number of animals using the lick. Here it should be stressed that production can only be assessed by observations toward the end of the licking cycle.

The meteorological correlates of lick use appear to be important in the scheduling of mineral lick observations. Of these it appears that temperature has the most important role. Dall sheep use of mineral licks appears to correspond closely to ambient temperature with activity being greater when the weather is favorable. Consequently, observations should be scheduled for periods of fair weather and generally warm temperatures.

The data from 1972 also indicate that about 75 percent of daily activity can be seen in a 12 hour observation day. This procedure was followed in 1973 at the Dry Creek lick and worked rather well with two observers working six hour shifts. In a typical survey and inventory situation this would not be necessary, but it was called for in 1973. Total numbers of animals using the lick in 1973 were calculated using this approach and agreed well with the 1972 figures.

It was found that there is a preferential use of the lick by lactating Dall sheep ewes. This preferential use is reflected in more visits but not in more frequent visits. This could lead to an excessively high estimate of production if observations were prolonged. However, in a survey and inventory situation the observations should be made for less than 7 days. This should preclude excessive recounting of lactating ewes. Data gathered during these observations would probably accurately reflect the productivity of sheep populations in the surrounding area.

Even if this set of circumstances did not exist, the relative numbers gathered in this manner should be comparable from year to year, and as a relative index of production and survival, should provide better data than aerial surveys. Furthermore, the danger and expense involved in mineral lick observations are far less than those in aircraft surveys, and the influences of weather on data gathering are much less.

Finally, because of the apparent importance of the Dry Creek lick to the sheep it influences, it is recommended that mineral licks be considered and designated critical habitat areas for all Dall sheep populations in interior Alaska.

ACKNOWLEDGMENTS

James A. Erickson was responsible for conception of, and the early performance of the Dry Creek study. His untimely death in 1970 left this major biological investigation without a leader. Tony Smith capably took charge of the study and guided it throughout the major portions of the trapping and preliminary data gathering phases. Numerous temporary assistants performed much of the routine data gathering at the Dry Creek lick, and without their contribution the utilization portion of the study could never have been completed.

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BIGHORN SHEEP IN THE MISSOURI RIVER BREAKS OF MONTANA

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In 1805, Lewis and Clark observed bighorn sheep in the Missouri River breaks near the mouth of the Judith River in central Montana. In his journal, Clark noted, "...I saw great numbers of the bighorned animals, one of which I killed..." However, in less than 75 years, man reduced the native bighorn, *Ovis canadensis auduboni*, to near extinction. The last known native bighorn disappeared in the Billy Creek area by 1916.

In the early 1940's, biologists began to talk of introducing Rocky Mountain bighorns, *Ovis canadensis canadensis*, to range once occupied by the native (also called Audubon or badlands) bighorn. In 1947, Colorado provided 16 Rocky Mountain bighorns for release within a 328-acre, fenced area on Billy Creek in the Missouri River breaks.

In 1951, the herd had grown to 54 and bighorns roamed on both sides of the fenced area. Following removal of the fence in 1952, the bighorns scattered over a wide area. Permit hunting seasons for 3/4-curl rams opened for 2 years. Hunters bagged two in 1955 and none in 1956. A population decline became evident, and the bighorn disappeared by 1963. The decline apparently began with the removal of the fence, but specific reasons for this population's failure are unknown. Undoubtedly, habitat deficiencies played an important role in the disappearance. Competition for forage, disease, cross-breeding with domestic sheep and social intolerance of domestic sheep may have complicated the transplant bighorn's life and hurried along its demise.

In 1957, the Montana Fish and Game Department began a second reestablishment transplant in the Two Calf Creek area in northern Fergus County. Department personnel constructed a 7-foot fence around 1400 acres on the Missouri River. Between 1958 and 1961, they released 43 Rocky Mountain bighorns of Montana origin, within this enclosure.

Although inventory records before 1969 are incomplete, the bighorn population apparently increased slowly from the original 43 transplants. Lamb production was good in 1969 and the population increased to at least 51. During the fall of 1969, hunters harvested 5 legal (3/4 curl minimum) rams. The following year productivity was even better and a ratio of 79 lambs per 100 ewes survived the winter, increasing the population to at least 63 (Table 1). This is probably the highest production and lamb survival rate on record for Rocky Mountain bighorns. Hunters took three more legal rams in 1970. Productivity remained good in 1971 and the population increased to at least 90 bighorns during the fall of 1971. Hunters bagged three legal rams in 1971.

The Two Calf bighorn population experienced high mortality before the spring of 1972. Femur marrow from 18 of the 19 bighorn carcasses we examined indicated starvation. The near elimination of this population (Table 1) focused attention to severe winter range problems. Domestic livestock, primarily cattle, grazed the Two Calf area (except for the range inside the enclosure) from April through November. Cattle did not make uniform use of the entire range because of rough terrain and the distribution of water. Throughout the summer bighorn herds grazed areas missed or lightly grazed by livestock. However, late summer cattle grazing has contributed to overuse on drainage bottoms and the adjacent lower slopes, sources of potential winter range for bighorns.

Table 1. Two Calf Bighorn Sheep Classification

Date	Male Full	Male 3/4	Male 1/2	Male 1/4	Female	Young	Total
Winter 1969-70	4	1	5	6	24	11	51 1/
Winter 1970-71	2	2	5	2	29	23	63 1/
Winter 1971-72			3		18	2	23
Winter 1972-73		2		1 2/	18	0	21
Winter 1973-74	2		1		15	0	18

1/ Minimum counts

2/ Two year old ram in spring of 1973

Most bighorns must therefore return to the enclosure for winter forage. Bighorns returning to the fenced enclosure must compete for forage with an underharvested deer herd. Continual overuse (Table 2) of desirable browse plants by deer has led to the "hi-lining" (eating all the foliage from lower branches) of even such poor quality forage as Rocky Mountain juniper and Douglas fir. The "hi-lined" condition indicates an overall depleted range. Bighorns also must depend upon browse plants for winter survival, when grasses they normally prefer have inadequate nutrition or are gone or buried by winter snows.

The Bureau of Land Management initiated a rest-rotation grazing system in 1973 to improve winter range conditions for bighorns in the Two Calf Creek area. We are now monitoring this grazing system. Additional fencing and livestock watering facilities will distribute livestock to some areas not previously grazed. This may reduce summer range for bighorns, but bighorn winter range conditions should improve. The winter range within the rest-rotation system implemented in 1973 showed 3 percent canopy coverage of residual vegetation in June 1972, after the bighorn sheep die-off and with season-long livestock grazing. This winter range was rested from all livestock use in 1973. In March 1974, there was 55 percent canopy coverage of residual vegetation. The bighorns did use this winter range within the rested pasture during the winter of 1973-74. If wildlife objectives are not met with the rest-rotation grazing system, other alternatives will be reviewed and recommended.

Table 2. Percent Use on Browse Transects Within Two Calf Enclosure.

	Percent Use			
Date	4-30-71	3-23-72	5-4-73	3-13-74
Transect #53				
Chryothamnus nauseosus	100	96	87	93
Rhus trilobata	57		11	69
Transect #54				
Atriplex nuttallii		51	0	2
Transect #56				
Atriplex nuttallii		35	0	0
Artemesia tridentata		65	0	3
Transect #57				
Artemesia cana		100	49	95
Artemesia tridentata		84	0	3

A 1972 change in deer hunting district boundaries should direct more hunter pressure into this portion of the Missouri River breaks and hopefully attain better balance between the deer and their food supply. Deer hunting is still not allowed within the 1,400 acre enclosure, but if competition for winter forage continues at unacceptable levels, hunting changes will be recommended.

RANGE ECOLOGY OF BIGHORN SHEEP IN RELATION TO SELF-REGULATION THEORIES

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INTRODUCTION

In the Canadian National Parks, the Rocky Mountain bighorn sheep *(Ovis c. canadensis* Shaw) occurs in Jasper, Banff, Waterton Lakes and Kootenay in southwestern Alberta and southeastern British Columbia. These parks comprise 7,511 square miles and have existed at their present size since just prior to 1915. Since their establishment, sheep numbers have fluctuated between 1,000 and 5,000 and there have been five major "die-offs." Each die-off resulted in the loss of at least 75 percent of infected herds within a 2-year period, with the majority dying sithin 6 months. In Japser and Kootenay, numbers increased following the die-offs to return to previous peak populations within 20-25 years. A second die-off has not occurred in the parks except for Kootenay where die-offs occurred in 1941 and 1966. A second die-off appears imminent in Jasper. These die-offs have been attributed to "pneumonia-lungworm" or "verminous broncho-pneumonia" disease, inclement winter weather and deteriorated ranges.

The government and public alike are concerned about the long-term effects which these die-offs will have on future sheep populations. Since 1940 there has also been concern over the effects of increasing elk numbers, and encroaching forests onto grasslands, on the welfare of bighorn sheep.

STUDY

In the fall of 1966, a cooperative study between the Canadian Wildlife Service and the National Park Service began in these four parks and continued through 1973. Major emphasis was placed on range ecology, population dynamics, disease-parasitism, and interspecific competition. The basic objectives were three-fold, namely:

1. To determine the causes of population fluctuations, in particular, die-offs.
2. To determine the effect and interrelationship of various intrinsic and extrinsic factors in limiting sheep numbers. The intrinsic factors included animal condition, reproduction-recruitment rates, and disease-parasitism. Extrinsic factors included range condition and trend, weather, interspecific competition and predation.
3. To determine if any population-regulating mechanisms (intrinsic and/or extrinsic) exist which will prevent native ungulate populations from increasing to a level deleterious to the long-term welfare of both the sheep and their ranges. Of particular interest was the possible existence of self-regulating mechanisms which could limit native ungulate populations before densities surpassed range carrying capacities and before food supplies became depleted. A recent philosophy believes that there exists an effective density-dependent, self-regulating mechanism which functions to limit animal numbers before food supplies become depleted. If this mechanism exists,

then the need to consider "man-made" controls of high native ungulate populations within parks would be unnecessary and unjustified. The presence of short-term ungulate surpluses and range forage depletions, if they existed, could be viewed as unimportant to the long-term well-being of both the ungulates and their ranges.

SELF-REGULATION PHILOSOPHIES

Malthus in his 1824 essay stated that human populations tend to grow in a geometric progression at a rate that would double numbers every 25 years. Food supplies could increase in arithmetic progression. The superior power of population growth required that population growth must inevitably be checked, if not by preventive measures, then by starvation, disease, wars, etc. (Malthus 1960).

Darwin and Wallace modified the Malthusian Principle to include predation as a limiting factor (Eiseley 1961). The four limiting factors which they believed limited animal numbers were:

1. Amount of available food.
2. Predation.
3. Physical factors such as climate.
4. Disease.

From 1920 to the early 1940's, several ecologists such as Chapman (1928), Andrewartha and Birth (1954), and Darling (1937) presented views on animal rates of increase and population regulation. They explained that animal numbers were limited by the species "biotic potential" or "innate capacity for increase," within the limits imposed by food, weather, space and competition. By the early 1940's it became apparent that previous philosophies did not explain some of the observed declines in populations or cases of relatively static populations. It was suggested that factors intrinsic to the population were involved in its regulation (Leslie and Ransom 1940).

Since 1949, there have been many studies on density-dependent changes that occur within the animal when subjected to various combinations of food, competition, weather, predation, etc. (Chitty 1952, Davis 1953, Errington 1956, Christian 1963, Edwards 1956). In addition, the theories of Lack (1954) and Andrewartha and Birch (1954), which leaned heavily on food and weather to explain population control, remained popular.

From the mid-1950's, there has been an effort to integrate social actions and habitat factors into a scheme to explain population changes. A theory originated which states that within the broad limits set by the environment, density-dependent mechanisms have evolved within the animals themselves to regulate population growth and curtail it short of environmental destruction (Nicholson 1958, Wynne-Edwards 1956, Chitty 1960, Milne 1962, Christian 1963). Many believed this mechanism functioned through a "feed-back" control via the endocrine system, operating as a behavioral-physiological mechanism. As population density increased, reproduction was inhibited by stimulation of pituitary-adrenocortical activity. This increased activity resulted in greater mortality indirectly from lowered resistance to disease, parasitism, environmental stress, or more directly through "shock diseases" (Christian and Davis 1964).

Ardrey (1961, 1966) illustrated this mechanism in primates, while Hornocker (1970), Mech (1970), Cowan (1947) and others showed that large North American carnivores such as wolves and cougars self-regulated their numbers before their food supply became depleted.

Concerning the large native ungulates, densities of the Uganda kob and the roe deer in natural unfenced and unhunted areas were shown to be limited by territorial behavior which prevented overcrowding and which served to expel surplus animals into inferior habitat where they were controlled by increased mortality (Buechner 1963, Anderson 1961, Kurt 1968). In North America, it was reported that an elk population in part of Yellowstone National Park was self-regulated by density-influenced mortality from intraspecific competition for food, and by compensating natality (Cole 1969). Similarly, moose in Grand Teton National Park, bison along the Pelican Valley of Yellowstone National Park, and elk and mule deer along the Middle Fork of the Flathead River drainage in Glacier National Park were reported to show population stability primarily due to heavy winter mortality and low recruitment rates plus emigration of sub-adults (Houston 1968, 1971, Martinka 1969).

The general conclusions from Yellowstone, Grand Teton and Glacier National Parks appears to be that "Realized annual recruitment is low; range conditions fluctuate, and some areas appear periodically 'overgrazed.' Ungulates participate in plant successional processes and may be capable of reducing or eliminating remnant vegetation types that are no longer a number-limiting food source. Large predators represent only one of a complex of regulatory factors on ungulates and may have been overrated as a major control in harsh environments." (Houston 1971).

Geist (1971) has suggested that native ungulates associated with climax vegetation associations, such as wild sheep and goats may be self-regulated. In opposition to the above views on self-regulation in wild ungulates, there are numerous reports suggesting that nonterritorial ungulates normally "outstrip" their predators in population growth and denude their food supply before their numbers are finally limited by the quantitative and qualitative limits of their food supply (Klein 1970, Cowan 1950, Flook 1964, Riney 1964, Rasmussen 1941, Pengelly 1963, Cauley 1970, Eddleman and McLean 1969, Morris 1956, Moss and Watson 1970, Lowdermilk 1953, Cottam 1961).

RESULTS

1. Historical. Bighorn sheep numbers in the region which is now the Canadian National Parks described above, had been reduced to low levels in the late 1800's and the early 1900's by excessive, indiscriminate hunting plus the effects of a few catastrophic winters (1886-88, 1906-07). When these lands became National Parks just prior to 1915, sheep numbers increased from 1500 up to 4500 by 1936. In the late 1930's and early 1940's, winter range conditions in all four parks were reported in a poor, overgrazed condition (Clarke 1941, Green 1949, Cowan 1950, Pfeiffer 1948, Flook 1964). A series of die-offs in all four parks, and adjacent provincial lands, reduced park numbers from 4500 to 1000. Die-offs resulted from poor range conditions due to overgrazing by bighorn sheep, elk, deer and to some extent from livestock. The terminal factor was a "pneumonia-lungworm" disease. For example, in Waterton Lakes National Park (204 square miles), park files indicate an estimated 1000 bighorn sheep, 1500 mule deer plus elk, and 2211 livestock, or 5000 ungulates grazed the park in 1936. As only about 50 square miles of this park are suitable winter range,

the stocking rate must have been close to 100 ungulates per square mile. In the spring of 1937 a major die-off occurred in the bighorn sheep herds. The die-off was attributed to "verminous broncho-pneumonia," but undoubtedly depleted winter forage supplies was a major factor. The unfavorable range/ungulate situation in the parks in the 1940's was aptly described by Cowan (1950) who remarked, "...National Parks of Canada between 1943 and 1946 supported over-capacity populations of big game in which moose, elk, mule deer and bighorn were in competition for a declining food supply on the winter ranges."

By 1966, sheep populations climbed to 4400 prior to the fifth die-off which occurred in Kootenay in 1966-67. This die-off was again attributed to "pneumonia-lungworm" disease precipitated by constricted and overgrazed winter ranges (Stelfox 1971). In 1969, sheep populations in Jasper were similar to those in 1946 just prior to an 85 percent die-off. Although a second die-off has not occurred in Jasper, high ungulate densities on the winter ranges and high endoparasite loads indicate that another die-off is imminent.

Historically, die-offs occurred concurrently on both park lands and on adjacent provincial lands subjected to hunting. This indicates that past hunting pressures on Alberta and British Columbia bighorn sheep herds were not effective in preventing major population fluctuations similar to those occurring in the national parks.

2. Range Ecology. Tables 1 and 2 compare forage production and utilization, range stocking rates, endoparasite burdens and overwinter sheep weight losses in Jasper, Banff and Waterton. On the overgrazed Jasper ranges, forage production was only 36 percent as great as that on the productive and moderately-grazed Waterton ranges. Forage utilization was 64 percent in Jasper, 46 percent in Banff and 34 percent in Waterton. There was a strong correlation between forage:ungulate ratios and overwinter weight losses. The Waterton ranges supported 38.6 wild ungulate days-use/acre and the adult ewes only lost 13.2 percent of their fall weight during the winter. Conversely, the Jasper ranges supported 138.1 wild ungulate days-use/acre and the adult ewes lost 20.1 percent of their fall weight overwinter. Corresponding lungworm burdens were 594 larvae/gm. feces in Waterton compared to 2375 larvae/gm. feces in Jasper. On the heavily grazed Jasper ranges, forage production was 168 percent and 104 percent higher within the exclosures, 2 and 5 years after protection from grazing than on adjacent grazed ranges that were only protected from grazing during the preceding growing season. On the moderately grazed Waterton ranges, forage production was only 80 percent and 6 percent higher within the exclosures 2 and 5 years after protection compared to adjacent grazed ranges. Thus the Jasper winter ranges were significantly affected by the heavy grazing pressure.

Reproductive rates were not significantly lower in sheep herds on heavily grazed ranges (Jasper) than in herds on moderately grazed ranges (Waterton) as revealed in Table 1. However, recruitment rates (yearlings:100 ewes) were significantly different with the lower recruitment rates occurring in herds on overgrazed ranges. The sheep evidently continued to reproduce at, or close to, their innate capacity regardless of range conditions, overwinter weight losses, or endoparasite loads. Those lambs produced on overgrazed ranges were apparently weaker neonates at birth or else, because of poorer post-natal nutrition, were unable to make satisfactory growth rates to prevent heavy winter mortality.

WATERTON			BANFF			JASPER			AVERAGES
Galwey	Ruby		Palliser	Bourgeau		Sulfur	Disaster		
Forage Production (lbs/Acre Dry Wt.)									
756	345	551	551	294	422	244	155	200	391
Percent Forage Utilization									
43.6	24.9	34.2	39.7	52.4	46.0	66.6	61.4	64.0	48.1
Ungulate Use As Sheep Days Per Acre									
295	138	216	426	375	400	941	606	774	464
Lungworms Per Gram of Feces									
		594			626			2375	1198
- % Winter Weight Loss of Adult Ewes									
		13			11			20	14
Production of Lambs (Fall) Per 100 Ewes									
		32.8			44.1			35.7	37.5
Recruitment of Yearlings (Fall) Per 100 Ewes									
		21.0			21.5			16.8	19.8

Table 2. Coefficient of determination r^2, and correlation coefficient r (Pearson's) between percent forage utilization (independent variable) and forage production, lungworm burdens, winter weight loss of ewes, sheep production (lambs:100 ewes), and recruitment rates (yearlings:100 ewes).

Correlation Symbol	Correlations of Forage Utilization (x) with Five Dependent Variables				
	Forage Production	Lungworms/ Gram Feces	% Winter Wt. Loss (Ewes)	Lambs:100 Ewes	Yearlings 100 Ewes
r^2	0.23	0.86	0.66	0.02	0.77
r	-0.48	+0.93	+0.81	+0.13	-0.88

However, the decreased recruitment rate in Jasper was insufficient to prevent sheep populations from exceeding range carrying capacities.

CONCLUSIONS

Bighorn sheep in the Canadian National Parks did not exhibit any density-dependent self-regulating mechanism to control their numbers when range conditions declined and disease-endoparasite loads climbed. Reproduction (6-8 month old lambs:100 ewes) remained normal, but lamb mortality increased in proportion to range deterioration as revealed in the ratio of yearlings (18-20 month old yearlings):100 ewes. This increased lamb mortality on overgrazed ranges was ineffective in reducing sheep numbers to within range carrying-capacity limits.

The major extrinsic factors operating to limit sheep numbers after range forage utilization exceeded 50 percent were:

1. Endoparasites - in particular lungworms and gastrointestinal helminths which stressed the animal and increased lamb mortality.
2. Pneumonia-Lungworm Disease - which culminated the physiological stress initiated by malnutrition and which caused a 75 percent plus decline in sheep numbers.
3. Range Condition and Trend - the primary extrinsic factor. It takes about one decade of overgrazing 50 percent plus) to weaken the animals to a level of advanced malnutriiton (high endoparasite loads, high winter weight loss, high lamb mortality), and to seriously deplete the forage resource. At this stage, pneumonia-lungworm lesions become prevalent in the lungs and the stage is set for a major die-off, once these conditions are combined with abnormally severe winter weather conditions. Such a combination produces the lethal "pneumonia-lungworm" disease.
4. Winter Weather - which combines with poor range and malnutrition to produce the "pneumonia-lungworm" disease which causes the major die-off. Occasionally catastrophic winters such as 1886-88, 1906-07 and 1947-49 act in a density independent manner causing major die-offs regardless of range conditions.

The major extrinsic factors limiting numbers of elk and mule deer were:

1. Range Condition and Trend - which acted in a density-dependent manner to increase juvenile mortality thus reducing population growth. However, range did not provide a sufficient influence on elk and deer numbers to prevent them from exceeding range carrying capacities and inducing a downward trend in the range.
2. Weather - elk and mule deer appear less hardy than bighorn sheep. Severe winters depress populations giving short-term relief to overgrazed ranges with greater mortality evident on overgrazed than on healthy ranges. Occasional catastrophic winters occurred about once every 50 years and temporarily annihilated elk and deer from extensive areas.

The national park ungulates, in particular elk, deer and bighorn sheep, are evidently not self-regulated. They increase in number until severe range deterioration occurs which induces a lethal pneumonia-lungworm disease in bighorn sheep but not in elk or deer. For this reason, elk and deer have the ability to maintain high numbers in the face of deteriorating range conditions at the expense of bighorn sheep. The only natural limiting factor which may occasionally cause greater mortalities in elk and deer than in bighorn sheep is severe winter weather. Because severe winters occur more or less randomly, they cannot be counted on to suppress elk and deer numbers before both the winter ranges and the sheep populations have been seriously depleted.

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RANGE USE AND FOOD HABITS OF BIGHORN SHEEP
IN THE SUN RIVER AREA, MONTANA

By
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The 800 square mile study area lies within the Sawtooth Mountain range approximately 65 miles west of Great Falls, Montana. Seven major vegetation types and five subtypes have been recognized. The most commonly occurring vegetation types were bunchgrass, Douglas fir *(Pseudotsuga menziesii)* and rocky reef, while quaking aspen *(Populus tremuloides)*, lodgepole pine *(Pinus contorta)*, lodgepole-aspen and beargrass *(Xerophyllum tenax)* were less commonly found.

During summer the percent distribution of bighorn sheep was 55, 24, and 17 for the rocky reef, bunchgrass and old burn habitat types, respectively.

During fall 64 percent of the bighorn sheep observations were made on the rocky reef type and 34 percent were on the bunchgrass type.

In winter, the percent distribution of bighorn sheep was 44, 26 and 29 for the bunchgrass, rocky reef and old burn habitat types, respectively.

During spring, 59 percent of the bighorn sheep observations were made on the bunchgrass types.

During both fall and spring those subtypes related to past fires received greatest use by bighorns. Grasses, and grasslike plants, forbs and browse made up 92, 5 and 1 percent of the diet during fall and 94, 3 and 2 percent of the diet during spring, respectively.

These data were combined with those of earlier studies to summarize the year-round food habits of bighorn sheep in the Sun River area.

COMMENTS ON BEHAVIOR

By
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The purpose of this talk is to give some insight into the work of two of my students on bighorn sheep. They are Dr. D. M. Schackleton and Mr. B. L. Horejsi, the former having completed a Ph.D.; the latter in the process of completing requirements for the same degree.

Dr. Shackleton's thesis deals extensively with the question of population quality which he investigated between populations and placed into a wider theoretical framework; Mr. Horejsi's deals with population quality within a population on the basis of year-to-year variations, but its main aims are to describe in a quantitative fashion the mother-young relations in bighorns.

We can safely conclude that the concept of population quality as first elaborated in my earlier studies does hold. The ecology, morphology and behavior of sheep forms a consistent syndrome permitting us to evaluate whether the population deviates from an ecological optimum. Thus small body size and horn size together with greater adult longevity, low reproductive rates, low suckling frequencies of lambs, low growth rates of lambs, delayed sexual maturation, poor mothering, low frequency of play, early feeding on vegetation by lambs, relatively low social activity by adult rams and a short vegetative season. It is thus possible in the context of the above criteria to read the state of a bighorn sheep population using behavioral data, as well as data from skeletal remains found in the field, without killing animals or handling them. I do not claim that these tools are perfected and reliable, but a start has been made on developing criteria of use to wildlife managers since the criteria mentioned are sensitive indeed.

MOVEMENTS OF BIGHORN SHEEP IN WESTCENTRAL MONTANA[1/]

By
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A study was conducted in the Sun River area of westcentral Montana during summer and winter to obtain quantatative data on the daily and seasonal movements and range use habits of bighorn sheep. This paper also presents data collected during the fall of 1972 and spring of 1973 by Mike Frisina (M.S. Thesis Montana State University, Bozeman).

Vegetation was classified as to seven major habitat types, of which five were extensively studied.

Sex and age composition of the herd was determined from 5,165 observations. Numbers per 100 ewes for rams, lambs and yearlings were 45, 55 and 37 in summer and 27, 40 and 23 in winter, respectively. Group constancy, as determined from the analyses of 326 associations of marked bighorn sheep, indicated there was no great attraction between any two individuals.

The winter home range for each of 41 marked bighorn sheep was determined by using the center of activity and standard diameter. Pooled standard diameters in each of the three wintering areas were 1.48, 1.56 and 1.37 miles.

The summer distribution from the three wintering areas was described from relocations of 31 marked animals. Distances between consecutive relocations averaged .67 and 1.78 miles in winter and summer, respectively. Throughout the spring period bighorn sheep confined their movements within the winter concentration areas. Distances between consecutive relocations on the fall range were much larger than any of the other seasons, ranging from 0-12.50 airline miles and averaging 2.00 airline miles.

1/ A joint contribution from Montana State University, Master's thesis and the Game Management Division, Federal Aid Projects W-12--2 through 3, Montana Department of Fish and Game.

THE EFFECT OF AMBIENT TEMPERATURE ON THE
WINTER FEED INTAKE OF BIGHORN SHEEP

By
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INTRODUCTION

The concept of winter range has preoccupied the thinking of biologists for many years. Intrinsic in this concept are data describing population size, sex ratios, age classes, carry-over, distribution, vegetative types and yield.

However, little or no data have been collected regarding feed intake, proportion of feed types ingested, apparent digestibility, the relation of feed quality to intake, the effect of snowfall on nutritional status, the efficiency of the feed habits of individual animals and the influence of ambient temperature and topography on feed intake.

The study of the winter nutrition of any wild ungulate must involve at least three factors:

(a) the quality of the feed
(b) the quantity which is ingested
(c) the influence of environmental variables.

RESULTS

Many authors have substantiated the progressive decline of nutrients (crude protein, gross energy, phosphorus) in winter range forage, with seasons (Figure 1). Summer range forage contains a greater quantity of nutrients than does winter range forage, but nutrient decline proceeds in a similar manner (Figure 2), correlating with the phenological stage.

During the period October through March most ungulates subsist on winter range forage of a relatively poor quality (low crude protein, high crude fibre). At this time modifications in temperature, snowfall and range availability are extremely critical.

Feeding trial measurements during the winter months indicate that a decline in quality produces dramatic changes in digestibility and nutrient intake (Table 1). Conventional trials generally utilize large changes in nutrient content over short time intervals. This tends to separate the balance between nutrient content and digestibility.

Conversely, in the natural state, qualitative changes occurring throughout the winter appear to be minor. Of singular importance is the length of time spent on each low quality diet.

Therefore, minor changes in nutrient content of overwintering feed, over longer time intervals correlate well with degrading rumen condition and resultant digestibility.

Description of Diet	Quality of Diet Crude Protein	Feed Intake gm/day/group	Apparent Digestibility %	Digestible Protein gm/day/group	Age Status of Animal
Mainly Agropyron	5.87	998.18	50.6	20.53	Adult
Mainly Agropyron	4.78	910.83	38.16	-2.72	Adult
Mainly Agropyron	3.44	850.92	58.99	10.06	Yearling
Mainly Agropyron	3.22	681.54	55.94	5.48	Yearling

Table 1: The change in digestibility for the adult and yearling animals as a unit, in relation to level of feeding and quality of the diet.

Subsequently, a comparison of the adult ewe group as a unit while on diets differing in quality (CP content) indicates that feed intake declines throughout the year in response to declining dietary quality, without improvements in digestibility or nutrient intake (Table 1). In this instance digestibility and DCP paralleled declines in feed intake and dietary quality in contrast to the following experiment where digestibility increased as feed intake declined. Results were similar when tested with the yearling animals (Table 1).

Examination of the seasonal feed intake for a migratory and nonmigratory group of sheep (with body weight standardized-Feed Intake/Kg. B.W.) indicates that it also correlates with the natural decline in forage quality (Figure 3).

Within each group (adult and yearling sheep) it was noted that certain individuals ingested higher quantities of feed which in turn lowered the apparent digestibility of that feed. The following data test the idea that this combination of feeding and digestibility is nutritionally superior and will promote greater survivorship among individuals of this type. Blaxter and Wilson (1962) show that the apparent digestibility of hay of a given nutritional quality fell with increasing intake.

In my study, feed intake for the individual adult ewes on the standard ration 36-57 (Table 2) ranged from 767.61 to 1209.84 grams per day. This increase was accompanied by a decline in digestibility from 86.1 to 78.9 percent respectively. However, the animal with the higher feed intake, despite the lowered digestibility, acquired 197.29 grams of DCP/day while the one with the lower feed intake acquired 134.77 grams of DCP/day.

This relationship was similar when the ewe group was maintained on alpine forage. Again the greatest DCP intake (107.03 gm./day) was associated with the highest feed intake (1321 gm./day). The relationship was confirmed with the yearling group (Table 2).

Body weight differences were minimal during the comparison of individuals on any of the described rations, and should not produce significant differences in feed intake among individuals of a group.

These data indicate that individuals which ingest high quantities of summer or winter range feed, while sacrificing efficiency of digestion, still benefit in terms of nutrient intake.

A comparison of the two different experiments suggests that, although dietary quality determines the change in feed intake, apparent digestibility, DCP, etc., individuals which have a higher feed intake on any particular quality diet will benefit by receiving a greater nutrient intake.

Feed Intake and Ambient Temperature. The influence of minimum ambient temperature on air dry (10 percent moisture) feed intake during the critical winter period of 1969-70 was examined using low quality forage (3.3 percent CP) available to the animals during that season. The test was standardized by holding forage quality constant and expressing feed intake on a body weight basis.

Description of Diet	Feed Intake gm/day/animal	Apparent Digestibility %	Digestible Protein Intake gm/day/animal	Age Status of Animal
Ration 36-57	767.61	86.1	134.77	
	1198.48	83.2	190.20	Adult
	1209.84	78.9	197.29	
Alpine Forage	579.76	68.1	48.19	
	1034.98	65.1	88.77	Adult
	1321.00	61.6	107.03	
Alpine Forage Early Cut	1104.03	77.29	142.65	Yearling
	1422.96	70.46	170.85	
Alpine Forage Later Cut	1249.23	75.28	111.49	Yearling
	1343.60	71.45	118.06	

Table 2: The change in digestibility for individuals of the adult and yearling groups, as affected by level of feeding.

As shown in Figure 4, feed intake/kilogram body weight increased sharply with declining ambient temperature and declined gradually with increasing ambient temperature. Thus, feed intake increased 30 percent for the control group while ambient temperature declined from 19 F to -11 F (30 F).

An inverse relationship between feed intake/Kg BW and ambient temperature for both groups of sheep is evident in Figures 5 and 6 as ambient temperature increased. Consequently, feed intake/kilogram body weight can be predicted from ambient temperature during the critical winter period for the control group according to the equation $Y = 18.95 - .2728\ x \pm 12.97$. The relationship is significant at the .01 level ($p = .007$). Similarly, this relationship is described by the equation $Y = 24.42 - .1868\ x \pm 11.14$ for the experimental group. It is significant at the .05 level ($p = .0317$). The slope of the lines does not appear to be significantly different ($F = .949$, $p = .352$) as both groups responded similarly. Within the described range of ambient temperature, feed intake changes .27 gm/Kg BW for each $1^{o}F$ change in temperature for the control group and .18 gm/Kg BW for the experimental group.

Feed intake began to respond to minimum ambient temperature at 32 F (Figure 7). During the period November 18-22 when ambient temperature was 27-38 F, feed intake was 1187.83 grams/day; 118.16 grams/day or 9.1 percent less than when the average temperature was 25 F during November 23-28. This change in feed intake was reflected also in crude protein intake which was 6.94 grams/day less and gross energy intake 509.27 Kcal/day less. Forage quality remained constant during this period and body weight was approximately stable.

Extremes in temperature were experienced in late December 1968 (-50 F) and January 1969 (Figure 8). Feed intake increased markedly from 750 grams/day prior to the cold spell to 1148 gm/day during the period of extreme cold. This is an increase of 397.58 grams/day or 34.6 percent. Crude protein and gross energy intakes showed a similar percentage increase.

During the two-month period of feed intake and ambient temperature measurement shown in Figure 8, forage quality declined slightly. It has previously been shown that the resulting effect would be a decline in feed intake and body weight. The data in this figure indicate that the sharp increase in feed intake is a response to ambient temperature.

Feed intake is significantly related ($p = .0002$) to ambient temperature for the adult ewe group (Figure 9) according to the equation $Y = 854.7 - 17.05\ x \pm 10.77$. Within the temperature range - 20 F to 10 F each $1^{o}F$ change results in a change in feed intake of 17.1 gm/day.

The relationship between ambient temperature and feed intake/day is excellent prior to and during the cold spell for the control and adult ewe groups, respectively. In Figure 5 (designated as 0) and Figure 9 (compensatory points are 1026.5 and 1131.5 gm feed/day at 15 and 17 F, respectively) two points are out of phase with the described relationship and have not been included in the calculation of the equation. These occurred during the rise in temperature after the cold spell when there was a lag of about two weeks before nutrient and feed intake returned to the level it had been at the same ambient temperature before the cold period. This lag was not noticed with the experimental group (Figure 6) which had been on higher quality feed during the summer and was in better condition throughout the winter months than the control group.

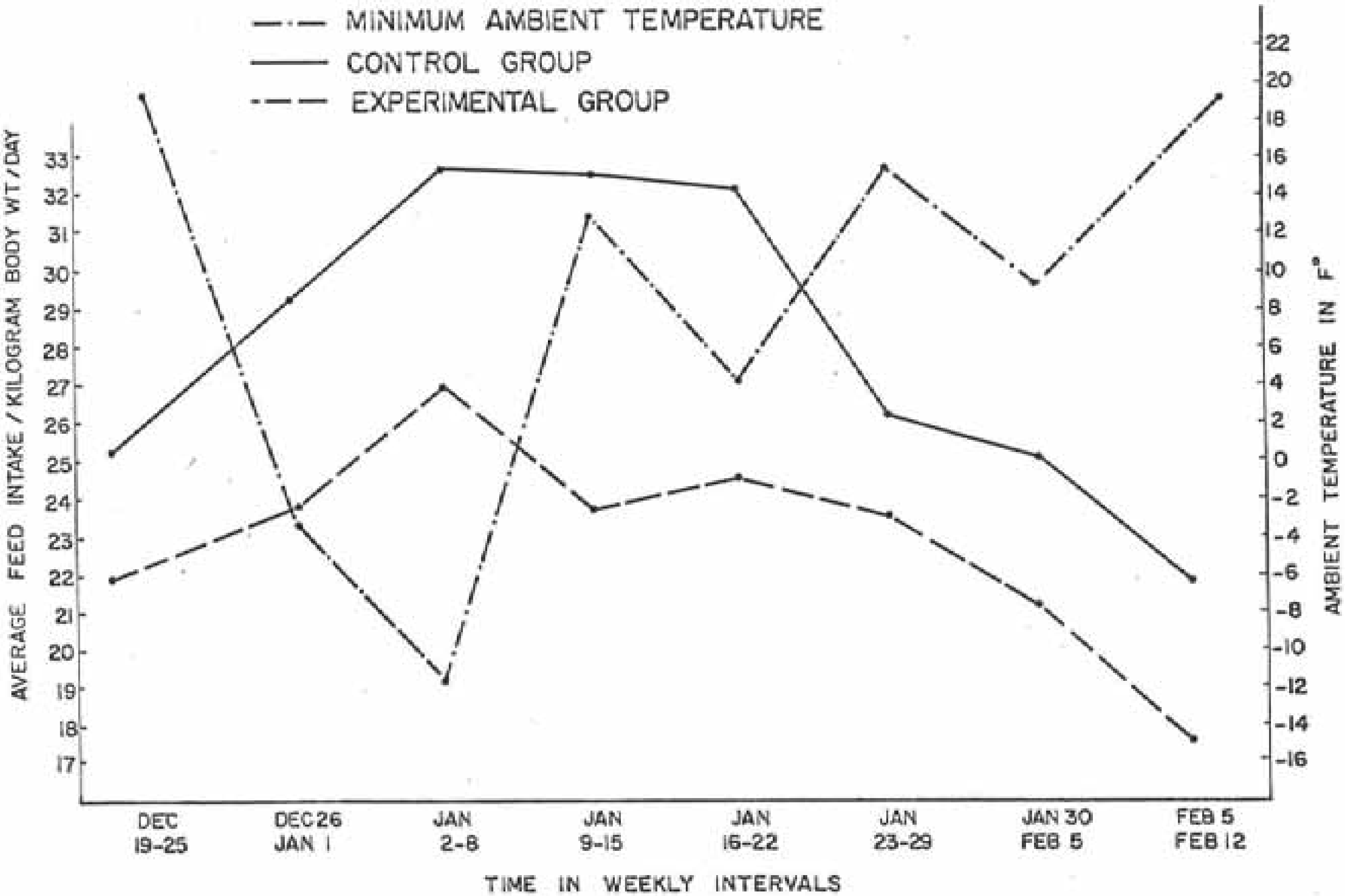


FIGURE 4 Average daily feed intake/kilogram body weight for the control and experimental groups of sheep in relation to changes in ambient temperature during the critical winter period.

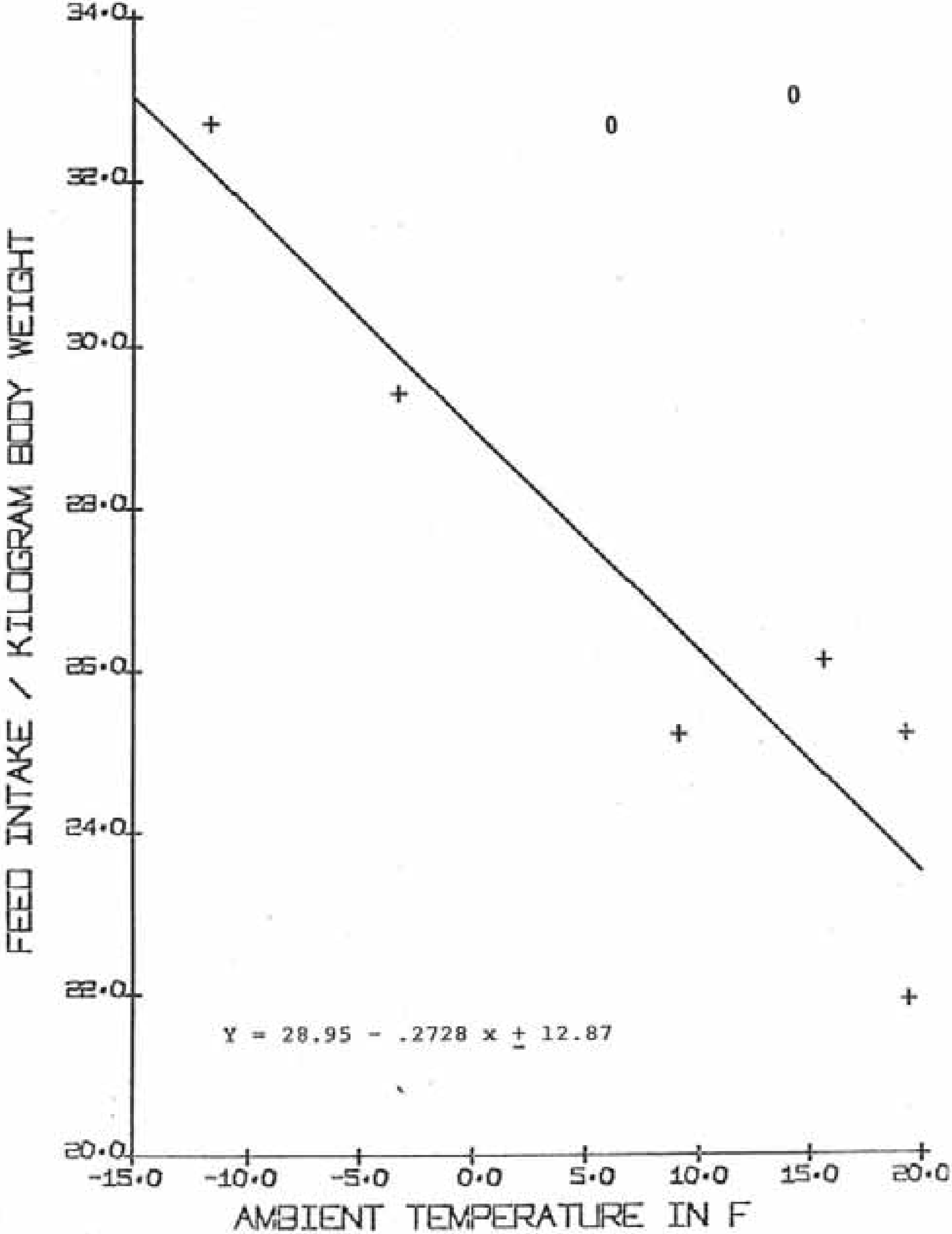


FIGURE 5. The relationship between minimum ambient temperature and feed intake/kilogram body weight for the control group.

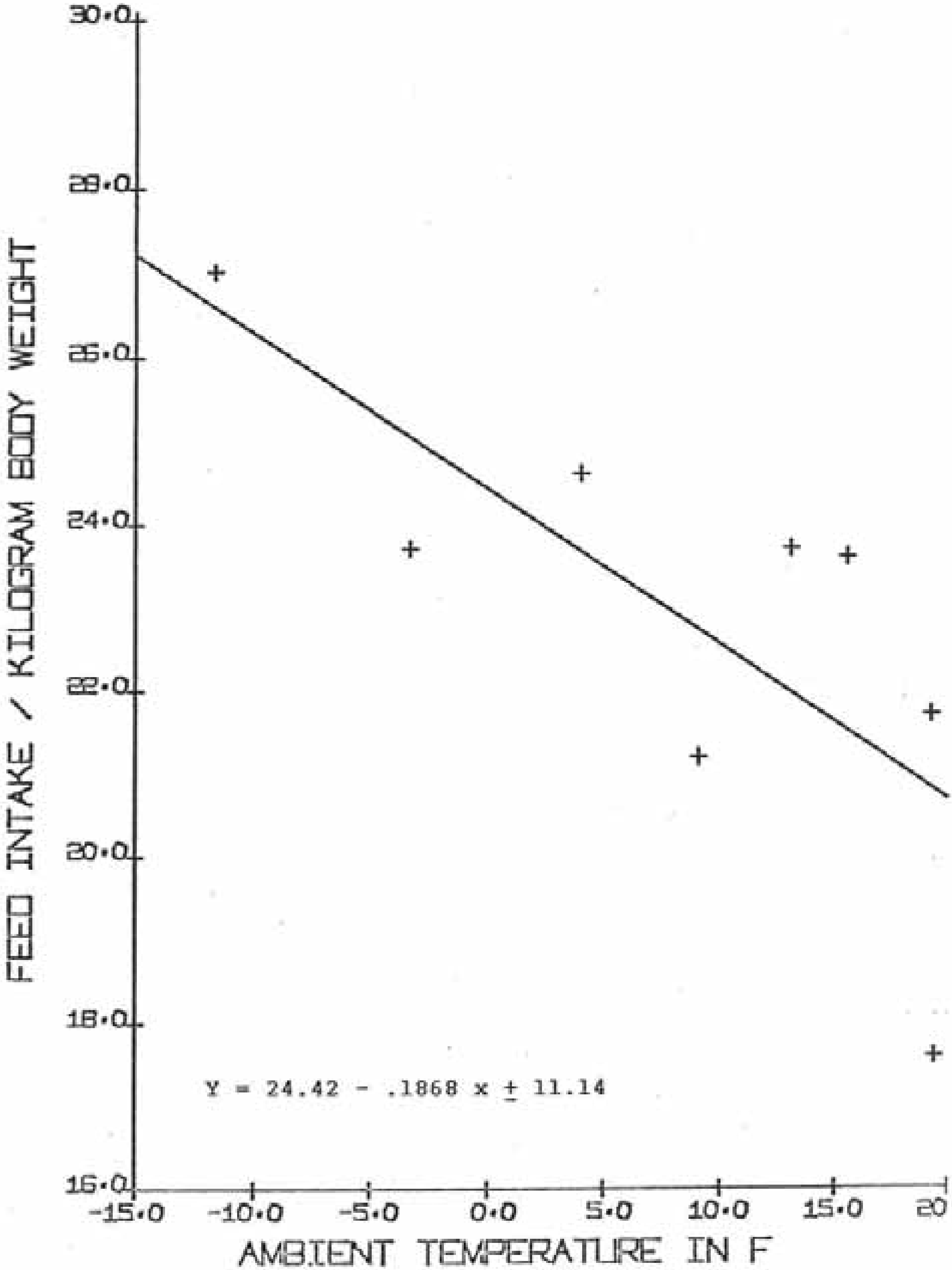
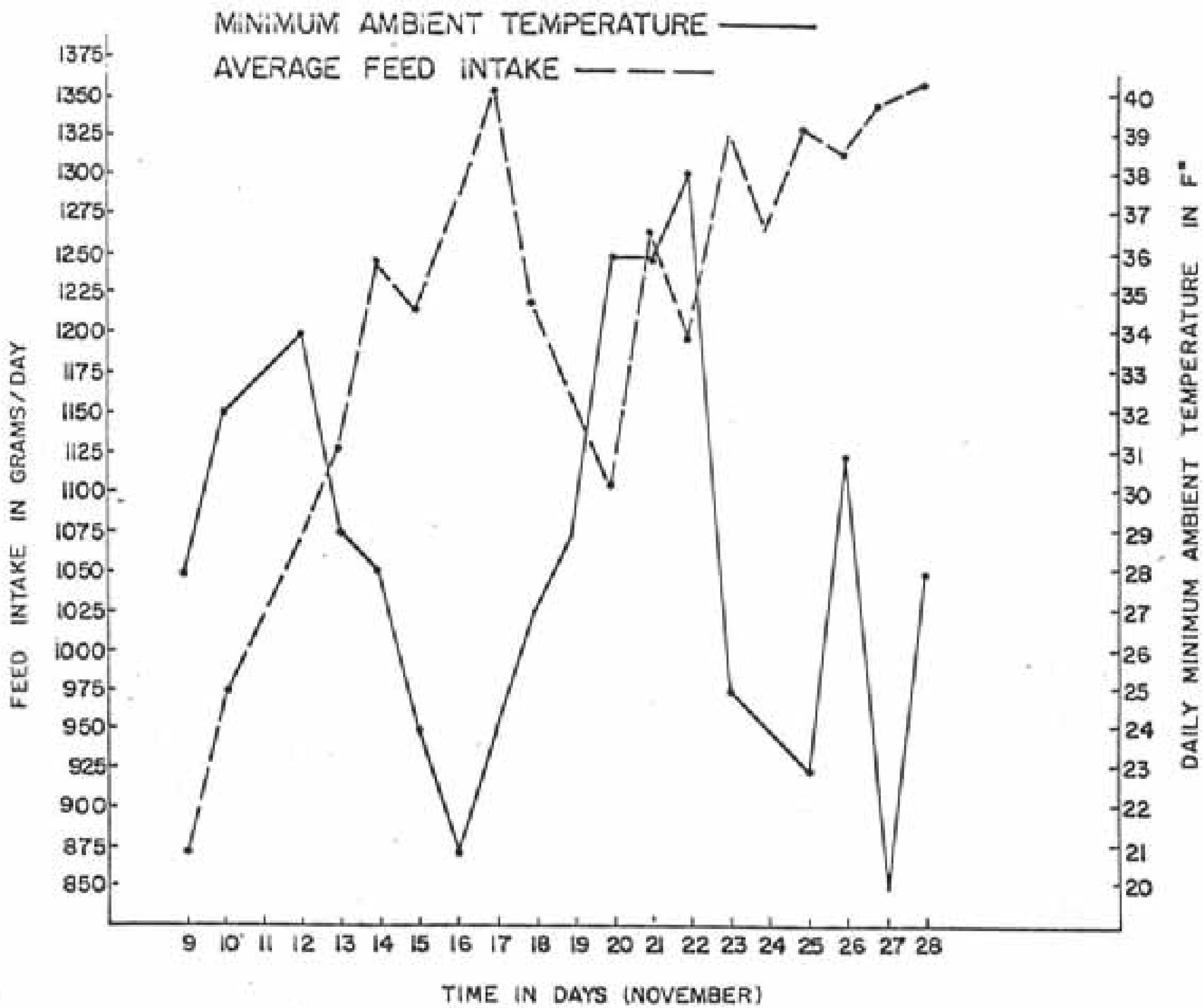


FIGURE 6. The relationship between minimum ambient temperature and feed intake/kilogram body weight for the experimental group.

Figure 7. Changes in minimum ambient temperature and feed intake for the adult ewe group during November 1969.



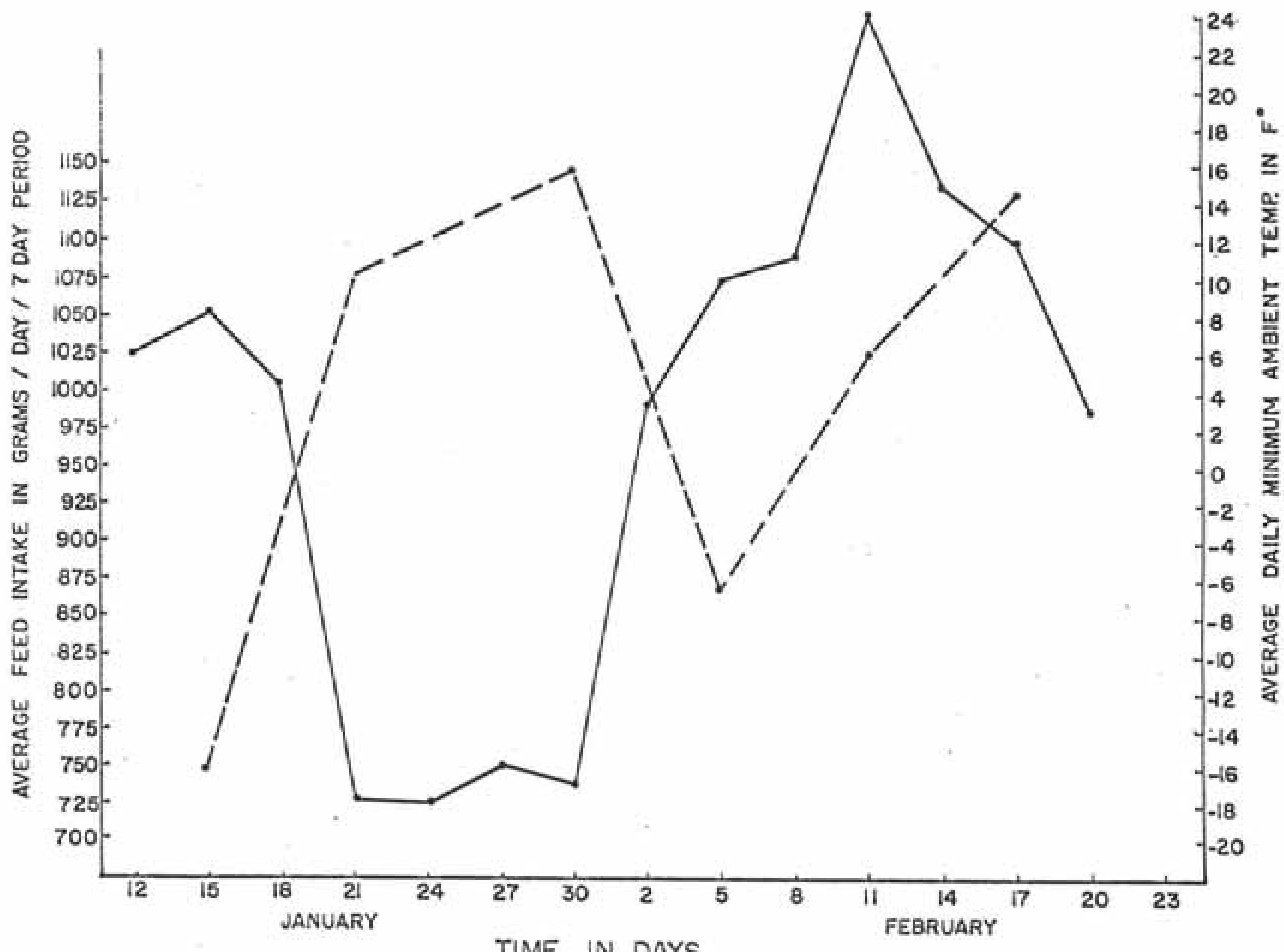


FIGURE 8. Changes in minimum ambient temperature and feed intake

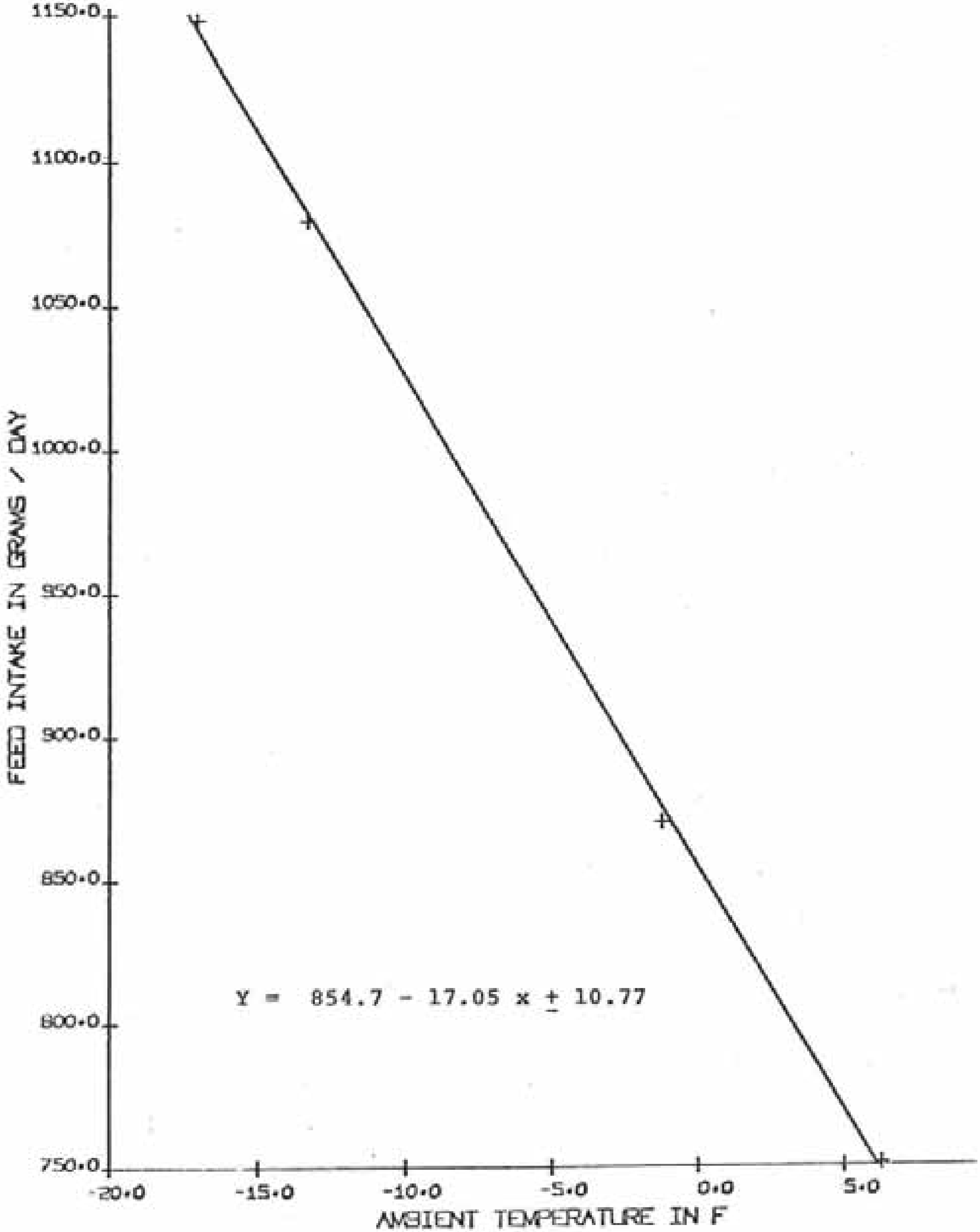


FIGURE 9. The relationship between minimum ambient temperature and daily feed intake for the adult ewe group.

THE LAVA BEDS BIGHORN TRANSPLANT

By
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Abstract: The 1971 transplant of California bighorn *(Ovis canadensis californiana)* from British Columbia to Lava Beds National Monument, California, has been a successful and popular program, setbacks not withstanding. Increases have been steady, losses few. From a beginning of eight ewes and two rams, after two lambing seasons the total stands at 17, with a potential of seven more this spring.

Administration: The signing of a five-agency cooperative agreement in 1969 was the official beginning of the program, although the Leopold Committee on Wildlife Management in the National Parks presented the recommendation in 1963. The five agencies involved are the National Park Service, U. S. Forest Service, Bureau of Sport Fisheries and Wildlife, Bureau of Land Management and California Department of Fish and Game. Each had responsibilities for funds, construction, manpower, planning or obtaining the animals. Some agencies assisted in several of these fields. The same five agencies remain cooperatively "in charge" of the herd, and I, as a National Park Service biologist, have as one of my projects the responsibility to the Interagency Committee to watch after and report upon the new herd.

Location: Lava Beds National Monument is located in northeastern California, immediately south of Tulelake National Wildlife Refuge. The bighorn enclosure encompasses about three miles of the high escarpment and adjacent flats in the northwestern portion of the monument. The area enclosed is comprised of 1,100 acres of excellent bighorn habitat (700 acres in the monument and 400 acres on the Modoc National Forest). Within the eight-foot fence are three artificial watering devices, one built by the Park Service and two by the Forest Service. Small exclosures and forage transects are included for future range trend determinations.

Transplant: On October 22, 1971, National Park Service Research Biologist Charles Hansen (killed in May 1973 during aerial bighorn counts at Canyonlands National Park) and California Department of Fish and Game Biologist Richard Weaver arrived at Williams Lake, British Columbia, to assist the Canadian Wildlife Service with the bighorn capture. The trapping was completed that day, and the two men drove nonstop to Lava Beds in 24 hours, releasing the animals in the pen on October 23. The eight ewes and two rams arrived in good condition and seemed to feel at home in about ten days.

Reproduction and Loss: In May 1972, four of the eight ewes lambed. Low success was attributed to disturbance during the move just prior to the rut, although loss of lambs at birth was a distinct possibility. One lamb disappeared in July and another in August with no trace of either being found. At that time the lambs were quite large and difficult to catch, but large predators such as cougars, coyotes, bobcats and golden and bald eagles are present. There is always the chance they fell or were otherwise injured.

Two lambs survived, one of each sex. Going into 1973, we had 12 bighorn. This was increased by eight in May when all eight adult ewes produced one lamb each. In July, one of the original ewes was observed to be lame in the left hip; no wound was seen, although observation was made from eight feet away. She was found dead a week later. Her lamb was adopted by the remainder of the herd. Early September brought the loss of one lamb, again without a trace. Whether or not it was the orphaned lamb is not known. Seven lambs survived the winter.

The real tragedy, the one which so much enraged the people of California, Oregon and other western states, occurred on October 20, 1973 when one and probably both of the adult rams were shot by unknown riflemen. The younger ram was killed outright. The older died five weeks later. He left the herd after four or five days and never rejoined them. To date, over $4,000 has been put up by sportsmen's groups, conservationists and clubs for the capture and conviction of the slayers.

In early December, with an eye toward possible late breeding, a two-year old ram was captured at the Charles Sheldon National Antelope Range and brought back to become a member of our herd. This gave us two rams, the other being one of our original lambs, now a long yearling. If we are to have lambs in May or June 1974, which ram will be the sire? The yearling was observed actively breeding in November.

Was either of the now dead rams with the ewes enough to sire lambs? This has now become a very large question, because just last Friday, April 19, the first 1974 lamb was born! This is 13 days earlier than we've observed one since their return to the Lava Beds area. And it is 181 days after the first ram was killed and the second may have been shot and so severely sickened that he would not breed. It may indicate breeding by the yearling ram, as has been the case in some penned bighorn.

Conclusion: So this is where we stand now. We have a total of 18 bighorn, with a potential of 24. It may just be that within a few years we will be prepared to begin repopulating other historical bighorn areas in northeastern California. Our Interagency Cooperative Agreement calls for this. The target in the enclosure is 25 breeding ewes, and five breeding rams. Then they move on to do their increasing in other needed areas.

WYOMING'S BIGHORN SHEEP TRANSPLANTS

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Wyoming's bighorn sheep trapping program was initiated in 1934, but did not operate consistently until 1956. A total of 722 bighorns have been transplanted since 1956. The grand total since 1934 is 762 head. Several areas within the state have received sheep from the Whiskey Mountain area, as well as the states of South Dakota, New Mexico and Utah. Some of these areas in Wyoming now have or will have hunting seasons as a result of the transplanting program. A few recent plants cannot be fully evaluated as to their success or failure at this time. Some of the plants made did not expand as desired, but token populations still exist in these areas.

Wyoming's bighorn sheep trapping program was initiated in 1934 in Flat Creek Canyon out of Jackson, Wyoming. Twenty sheep were caught and taken to the Big Horn Mountains. No further trapping was recorded until 1949. The trapping in the Whiskey Mountain area at Dubois, Wyoming was started in December of 1949. However, this was not on a continual basis until 1956. At this time, the trapping program was carried out to provide animals for our Sybille Research Station located southwest of Wheatland, Wyoming. The main objectives were to furnish bighorns for research studies and use the surplus from the herd increase for transplanting to other areas. However, the sheep taken to Sybille never increased fast enough to provide any stock for transplanting. The idea of having "brood stock" to furnish animals for transplanting from Sybille was abandoned. It was determined that any sheep for other sites would have to come from the regular trapping program in the Whiskey Mountain area.

Since 1934 we have transplanted 762 bighorns. Since there was little trapping done between 1934 and 1956, the majority (722) of the sheep have been captured between 1956 and 1973. Our yearly catch has ranged from 0 to 136. The best season we have experienced was during the winter of '72-'73 when we caught the 136 head. We have furnished bighorn sheep to South Dakota, New Mexico and Utah.

We try to take one ram for every seven ewes, but the selection of a good ratio of ewes and rams in trapping is not always feasible. Early in the trapping period there are usually sufficient numbers of rams available to capture with the ewes and lambs. Toward the end of the season many of the rams are not available because they have gone to higher elevations. The rams we transplant are the yearlings, two-year olds, and three-year olds. Rams are not usually placed in the trucks until all the ewes and lambs are loaded. They are put in the box with the adult ewes when there are too few to be taken in a separate truck.

The sheep we capture are given an injection of Bicillin before they are put into the pickup box used for transporting them. All sheep are eartagged in both ears. The date of capture, sex and age of each animal is recorded for the corresponding numbers. Normally, the adult ewes are fitted with plastic neckbands to aid in identification of the transplanted animals. However, we have found that some of these neckbands have been tightened (probably by other sheep pulling on the stubs sticking out of the buckle). There have been several instances where this has resulted in death to the sheep. This problem can easily be remedied.

The sheep are transported in specially constructed boxes that cover the backs of the four-wheel drive pickups we use. The boxes are designed to provide good ventilation and are high enough to allow the adult sheep to stand. Adequate ventilation is a must for the sheep, especially for the time immediately after loading. The bed of the pickup is covered with a layer of sawdust. This gives the sheep adequate footing and comfortable bedding.

The technique we try to employ at the release site is to park the pickups side-by-side with the back of the trucks facing uphill toward the area the animals are supposed to go. All boxes are opened at the same time to allow the sheep to escape at once. This has proven to be satisfactory on most of our releases, but we still get a few animals that "run blind" and go in any direction they please - including back into the truck. The sheep are released in, or as close as possible to the area we want them to become established in. Attempts to hold bighorns within fenced pastures at the transplant sites have met with both success and failure. The successful attempt was on a plant made to a pasture of about 40 acres that was fenced with 5-1/2 foot net wire. Only one ewe jumped the fence during the holding period from February to July, but she would jump in and out at will. The unsuccessful attempt was due to the snow that drifted over the fence. This allowed the sheep to simply walk out over the drifts.

Most of the early transplants made were relatively small, numbering about 20 animals. In the mid-sixties, attempts to introduce more animals into an area were initiated. This has been accomplished in varying degrees. Most areas have received more sheep, but some of these have required successive plants that have spanned two or even three years. The success of trapping sheep in our state is extremely unpredictable. This is the reason for some of the plants being strung out over two or three years. Even with the extended period of transplanting, we appear to be getting positive results in most instances. The important criteria seems to be the introduction of a sufficient number of animals into the area before ceasing the transplanting.

Transplanting bighorn sheep in Wyoming has resulted in varying degrees of success. It has been instrumental in establishing populations in several areas. A few plants have not developed as we had hoped they would, but they have established small populations. These small herds may only need to be augmented with additional plants to reach the threshold population required to produce significant increases. The initial plants of approximately 20 animals are not felt to have been adequate. Our present attitude is that a minimum of 40 sheep is necessary to establish a new herd.

The trapping and transplanting of bighorn sheep in Wyoming has been a major factor in contributing to the establishment of hunting seasons in at least three areas. An additional area will be opened for hunting in the near future if the herd continues its present rate of increase.

Two other areas have received bighorns recently, but it is too early to prognosticate the results of these plants. We have two areas with small herds. Although these herds may only need additional animals brought in to give the necessary stimulus for expansion, they are faced with problems of greater magnitude that could neutralize all transplanting efforts. These particular problems are: (1) competition with livestock and other big game species, (2) poaching and accidental killing by deer hunters, and (3) relatively small habitat areas.

BIGHORN SHEEP TRANSPLANTING IN MONTANA

By
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Montana Department of Fish and Game
Missoula, Montana

Bighorn sheep were at a low ebb in Montana in 1941 when wildlife restoration funds became available for research and management.

One of the first projects of the Wildlife Restoration Division was trapping game animals in areas of abundance, and transplanting them to suitable habitat in areas where the species was scarce or absent. In the case of bighorn sheep, many of the transplants were reintroductions into areas where bighorns formerly occurred.

The first bighorn transplant under this program was made in 1942 when 11 were trapped in the Sun River Canyon and released at the Gates of the Mountains north of Helena. Including this transplant, 643 bighorns in 39 different groups have been transplanted in Montana (Table 1). The distribution of these releases is shown in Figure 1.

Sources for the transplanted sheep were the Sun River Canyon, the Tarryall Mountains in Colorado, Wildhorse Island in Flathead Lake, and the National Bison Range. By far the greatest number was taken from the Sun River Canyon.

A transplant of 16 Colorado sheep was released in 1947 at Billy Creek in the Missouri River breaks. This is the former range of the extinct Audubon sheep. The sheep were released in a large fenced enclosure and held until 1952, when they were released and the fence removed. The sheep scattered and eventually disappeared. A similar procedure was followed with the Two Calf Creek transplant (also in the Missouri River breaks). These sheep came from the Sun River area. This herd built up to more than 100, both inside and outside the enclosure, and some limited hunting was permitted. About three-quarters of the herd died off during the severe 1971-72 winter. The remaining animals are still in the vicinity and are reported to be increasing.

There are several bighorn herds, established or augmented by transplants, that are currently supporting limited hunting and thus are considered successful. These are the Kootenai Falls, Thompson Falls, Highland Mountains, Anaconda (Olson-Foster), and Blue Hills populations. Approximately half of Montana's huntable populations have been established or augmented by transplants.

In addition, the Two Calf herd in the Missouri Breaks is recovering from a die-off, and the East Fork Bitterroot transplant appears to be increasing. These may provide hunting in the near future. The Wildhorse Island (Flathead Lake) herd is also a successful transplant. No hunting has been permitted by the landowner, but sheep have been trapped and transplanted from the island.

Approximately eight transplants apparently failed to become established. Several failures were in the Wolf Creek-Cascade area, where transplants totaling 121 bighorns have been made. The latest of these was made on the department's Beartooth Game Range in 1971 and 1973. Sheep from these plants are surviving in the area, so their success is still undetermined. Several dead or dying sheep, apparently from verminous pneumonia, were found or reported from the earlier transplants in this area.

The success of some other releases is still undetermined. These are in the Petty Creek area near Missoula, the Pryor Mountains and the Little Rockies.

The procedure for making bighorn transplants is similar to that for other big game species. The area is inspected by Department of Fish and Game and land managing agency personnel (chiefly the U. S. Forest Service and BLM). Then an inspection report describing the area and its suitability for the transplanted species is written. This, together with proof of concurrence of private landowners in the area, and a cooperative agreement with the land agency, is signed by the Forest Supervisor or BLM District Manager, Forest Service Regional Office and the Fish and Game Commission, before the transplant can be made.

Table 1. History and status of transplanted bighorn sheep herds in Montana

Location of Release	No.	Year	Present Status
Gates of the Mountains (Lewis & Clark Co.)	14	1942	Not successful
C.M. Russell Game Range (Garfield Co.)	42	1947	Failed after 1952
C.M. Russell Game Range (Fergus Co.)	31	1965	Sheep surviving in area
Sixteen Mile Creek (Gallatin Co.)	16	1954	Not successful
Wildhorse Island (Lake Co.)	2	1939	Increased to 137 in 1957,
Wildhorse Island (Lake Co.)	6	1947	range base
Kootenai Falls (Lincoln Co.)	13	1955	Huntable population
Bull Mountain (Jefferson Co.)	23	1955-57	Not successful
Blue Hills (Custer Co.)	13	1958	Limited hunting
Thompson Falls (Sanders Co.)	19	1959	Limited hunting
Doris Mountain, Lake Blaine (Flathead Co.)	14	1963	Not successful
Sheep Creek (Meagher Co.)	18	1962	Not successful
Sheep Creek (Cascade Co.)	21	1956-60	Not successful
Tobacco Root Mountains (Madison Co.)	25	1965	Not successful
Highland Mountains (Madison Co.)	21	1967	Limited hunting
Olson-Foster Gulch (Deer Lodge Co.)	25	1967	Limited hunting
Sieben (Lewis and Clark Co.)	34	1968	Not determined
Petty Creek (Missoula Co.)	16	1968	Surviving - 11 in 1974
Teakettle Mtn. (Flathead Co.)	15	1968	Not successful
Bull River (Lincoln Co.)	33	1969	Surviving
Highland Mountains (Madison Co.)	30	1969	Limited hunting
Pryor Mountains (Carbon Co.)	78	1971-74	Not determined
Beartooth Game Range (Lewis & Clark Co.)	55	1971-73	Surviving
East Fork-Bitterroot (Ravalli Co.)	35	1972	Increasing
Little Rockies (Phillips Co.)	42	1972-74	Surviving & reproducing
Stillwater Canyon (Stillwater Co.)	6	1968-74	To augment native pop.
Total	643		

No. 1050 — County Outline Map (100 to pad)
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MONTANA

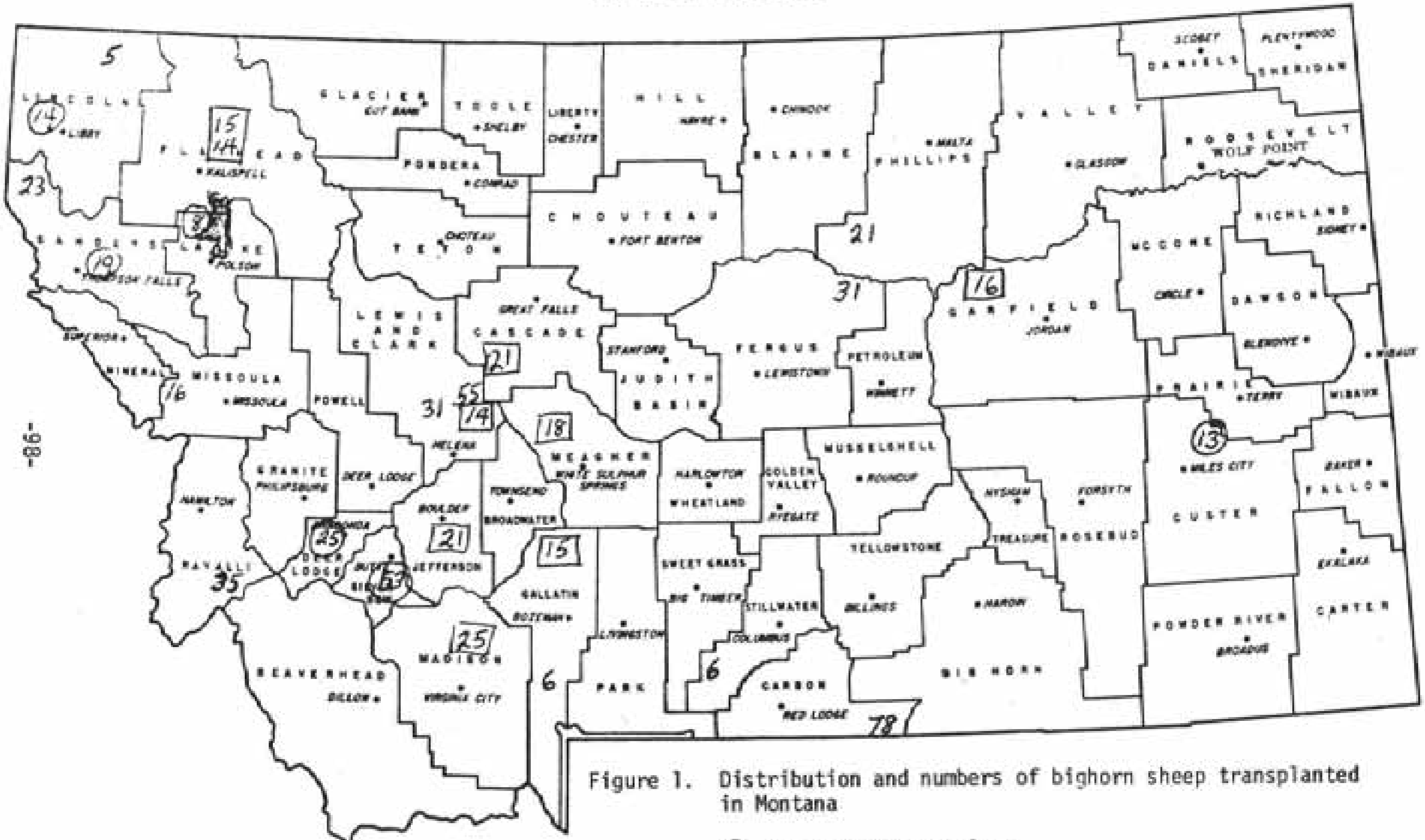

Figure 1. Distribution and numbers of bighorn sheep transplanted in Montana

○ Successful Transplant
□ Unsuccessful transplant
Others - undetermined

COMMENTS ON TRANSPLANTING

By
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I have found these last presentations on bighorns quite fascinating to say the very least. A number of years ago I wrote a number of states and provinces trying to decipher the results and deficiencies of mountain sheep introductions.

At this time I started corresponding and looking into European literature on introductions of animals which biologically are rather similar to mountain sheep, namely the ibex. However, I also had some experience with the movement patterns and the manner in which domestic goats in the feral state had taken over the landscape. This stimulated me toward thinking along somewhat unusual lines as far as the introduction of animals are concerned, animals which are quite different in their biology from such animals as have been successfully managed on this continent. The successfully managed species are white-tailed deer, moose, pheasants, rabbits and also waterfowl. These are characterized by an ability to produce a surplus of young, a surplus of young which is scattered to go and establish home ranges and new populations. This makes a lot of sense in the biology of moose. You find that when habitat conditions are bad, and therefore restricted, moose are confined to alluvial bottoms or other refuge habitat. You may also find them confined to subalpine areas where they can winter. It is from these refuge areas that they can disperse into new habitat created by forest fires so that forest fire is, in a sense, a very important part of the habitat of moose. Moose have the adaptability to scatter their young and occupy the newly created terrain. It is quite different with mountain sheep. Mountain sheep belong to a group of animals that does not appear to disperse youngsters. They conserve youngsters. Everything I know in the biology of these animals is consistent with the view that when dispersal does take place it takes place in different ways. I have noticed a few examples that were mentioned here - for instance, you mentioned that just prior to the die-off you found your sheep were dying off due to the introduction of domestic sheep into the area, and behold, a number of miles away you discovered a little band of sheep.

The literature suggests that dispersal is correlated with ecological hardships or catastrophies and is undertaken by groups, not by individuals. For instance in the ibex introduction in Switzerland - and Switzerland has done a lot to introduce the ibex - they found that the species dispersed along mountain ranges, not across mountain ranges, and that they would disperse in correlation with relatively hot, dry summers that produced a decline in the forage production. In other words, when conditions got tight you found that groups of ibex - not individuals - moved out and began colonizing the areas of the land that previously had not been colonized.

I have been further fascinated by the figures that you have produced from Montana. They corroborate and expand considerably on what previously was sent to me from Montana. The ratio of successful to unsuccessful transplants was rather fascinating, too, because not all of the transplants have been successful. There are some theoretical reasons why some transplants will not be successful. If you have a continuous piece of habitat, uninterrupted by bands of timber or timbered valleys, then one expects a gradual dispersal of sheep throughout that habitat. If, however, the habitat is broken up into small patches, such as is normally found in the Canadian Rockies, then one cannot expect to find sheep reoccupying these patches - without some help from us. Introduce them in the conventional manner and you can rest assured that they will colonize the immediate vicinity of the release site, as long as the habitat is continuous. (It could happen, of course, that under some circumstances the introduced population overshoots carrying capacity and groups of sheep wander off in search of forage. However, this has certainly not been the rule, although it may have happened.) Under natural conditions small patches of habitat are held together by very precise migratory movements, and home range knowledge appears to be maintained traditionally. Young following old accept the home range patterns of the old. This has to be somehow duplicated during reintroductions of sheep into mountains with patchy sheep habitat.

A number of years ago I thought that the best way to do this would be to take young sheep and literally imprint them on human beings and lead them around through this countryside. However, first you have to know your area very well, you have to plot the range, you have to get a pretty good idea of where they will be able to survive in winter and summer and fall, and so on. Then lead them through this area, so that they can develop knowledge of this country. I thought at that time I had hit upon something original, very outlandish, ridiculous according to conventional business. I am aware of that, but in fact I had been upstaged by a good number of years by a gentleman you may know; his name is Dr. Tom Bergerud. Tom was faced with a problem of reintroducing caribou in Newfoundland. At first they would dump caribou in one place that looked like caribou country, and the animals would take off and you would never see them again. This is what you would expect when you have a very open piece of countryside that does not confine them naturally. They take off.

What Tom did was just what I have indicated, but he made another elaboration which is worthwhile noting. He and his helpers took the caribou calves, imprinted them, and led them around the area where they wanted the population to be. Then they put in (and this is an important point) wild calves they had caught, so that now you had the imprinted ones as well as a group of wild ones that did not have too much experience with human beings. The wild ones adopted the same route that was now used by the animals that were familiar with the country.

True to expectations, because if you raise young ungulates you tend to imprint them, the males tend to mistake you for a rival when they become sexually mature. It can be quite embarrassing - very embarrassing, as a matter of fact - and it can also be very troublesome as was found out. The caribou bulls in the group that were more than 2-1/2 or 3-1/2 years old were found wandering around lumber camps in Newfoundland with rather unpleasant results, as one logger was rescued from underneath antlers, a number of bulls were shot, and a number of them had their heads caved in by axes. So what can you predict after someone has shot all the marked animals and the populations have been permanently ticking on and are being hunted at the present time? What I am saying, therefore, is that leading young sheep is not nearly as ridiculous as it sounds, because something similar has in fact been done and does work. So this is one of the techniques that could be used.

I note that there is a tone of sadness involved in bighorn management. The tone of sadness is, "Look, we have been trying to look after these animals for so many years, and they have not dispersed to occupy their original state or increased to their original population densities." I do not see any reason why we should not be able to reintroduce and establish new sheep populations. I think it is possible to do this, provided the land is available and provided we are willing to experiment with some rather ridiculous techniques at the same time. There is no reason whatsoever why our children and grandchildren should not look at multifold populations of the bighorn populations that are available today. I think that we have a great job ahead of us. I do know that reintroductions with various methods have been partially successful, and I believe you can get better results. I am an optimist as far as bighorn sheep and their future are concerned. Thank you.

LAMB MORTALITY

By
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Fort Collins, Colorado

Fortunately all of us have one common interest, and that's for the preservation and maintenance of healthy and expanding bighorn sheep herds. The material that Bob Lange and I will present is a problem on Pike's Peak, Colorado. This problem may or may not apply to your area.

Some bighorn sheep herds experience all-age die-offs; others have a low lamb survival, and some have both - other areas have other problems. In Colorado we have both lamb mortality and have had all-age die-offs. We, that is, several personnel of the Colorado Division of Wildlife and personnel of Colorado State University including parasitology, virology, bacterial and pathology, are all working together on this problem of lamb mortality.

The main study area is Pike's Peak. Pike's Peak ranges in altitude from 7,000 to 14,000 feet. Pike's Peak is a range west of Colorado Springs and probably is 250 to 300 square miles in area. Sheep on this range winter and summer on the same area, they do not - or cannot - migrate from the high summer ranges to lower winter ranges.

The history of this herd is rather fuzzy. The population was estimated in 1950 to be about 300+ sheep. Population census, as you know, are at best horrible. But let's use these estimated populations as trends instead of exact numbers. They said there was an all-age die-off in the Pike's Peak, Kenosha and Tarryall herds in 1952-53.

It was said to have started in September 1952 on Pike's Peak. The sheep that were necropsied were said to be in good body flesh, not in a state of malnutrition and the lungs were characterized by a verminous pneumonia. Unfortunately, I do not know any more about the dead animals. An estimated 12 or so animals survived the winter.

Following the die-off, the population steadily increased to an estimated population, by the same biologist, of 300 sheep in 1970. Again I emphasize the difficulty of accurate population census, but the herd did boom following the die-off.

Game biologists noticed a 98 to 99 percent lamb mortality occurring in the summer of 1971. The few lambs seen had a dull yellow, rough hair coat, coughed and lagged behind in the herd.

In the winter of 1972-73, Bob Schmidt captured 75 bighorn sheep on Pike's Peak. The regional biologist told us there were 28 legal rams on the peak; well that winter (trapping for 3 months), we captured 33 legal rams. Again, that is 33 rams, all of which were legal, out of 75 sheep. This winter we trapped 89 sheep and only 4 of the 89 were rams. What happened to the rams, I do not know.

Out of the 75 sheep that we captured in 1972-73, we aged them. Notice we captured only 1 lamb, 0 yearlings, 0 two-year olds and 5 3-year olds.

I realize it is difficult to age ewes over 4 years old, but it is relatively easy to age lambs, yearlings, 2-year olds and rams. So it appears that this lamb mortality has been going on for the past 3 to 4 years. It is also important to notice that this lamb mortality had been going on for 2-1/2 years before it was even observed.

Before we start into the suspected pathogenesis of this lamb mortality, let me tell you some of the habits of the sheep on Pike's Peak. First, the range is in excellent shape; second, several of the ewes in late March of this year, weighed between 165 to 185 pounds and were fat and in extremely good condition. The population now is estimated to be about 100 animals, and about 75 percent of the population is collared.

The sheep have what we call preferred areas. These preferred areas have lots of escape cover and grass. There is a fairly constant number of sheep on these preferred areas, but there is a mixing of these sheep. That is, in a preferred area you find 10 to 15 sheep, but, for example, 4 new sheep will come into this area but 3 will leave, or 6 will come in and 4 will leave, so there is a continual turnover of sheep in these specific preferred areas, although there is a fairly constant number of sheep on each preferred area.

Before we get into the pathogenesis of this lamb mortality, allow me to review with you the life cycle of lungworm of sheep. Adult *Protostrongylus stilesi* live in the parenchyma of the lungs, especially in the posterior dorsal aspect of the diaphragmatic lobes. They deposit eggs, these eggs hatch to stage 1 larvae. These first stage larvae then migrate up the horizontal bronchi, up the trachae, are coughed up and swallowed, then pass through the alimentary canal and are dropped as feces onto the ground. The first stage larvae on the ground are then ingested by snails and inside the snail develop for 3 to 4 weeks to mature third stage larvae, or infective larvae. Then to complete the life cycle, sheep must eat these snails containing these larvae.

After the snail is eaten, the third stage larvae penetrates the intestinal wall and probably enters the blood stream to go to the lungs. And here they develop to adults and shed eggs again in 30 to 60 days. The main sticker of this life cycle is that some of the third stage larvae do not develop in the lungs but instead stay in a dormant state in somatic tissue of the ewe until pregnancy. During the last half of pregnancy these stored larvae leave these somatic tissue, cross the uterus and infect the fetus. Ok, with a background of these two types of life cycles of *Protostrongylus stilesi*, let's talk about the pathogenesis of this lamb mortality.

An important fact is this lamb mortality could, and possibly does, occur in several of our declining herds in Colorado at a percent of mortality that is from very low - 5 to 10 percent to the extreme on Pike's Peak of 98 to 100 percent mortality. And another important fact is as the population of sheep decreases, and here on Pike's Peak the usable range is the same size, the sheep continually pull themselves into the more highly preferred areas. So you see the sheep remain concentrated on these small areas, thus maintaining a high concentration of lungworms on the range being used. And these preferred areas are not overgrazed.

CAUSE AND NATURE OF MORTALITY IN BIGHORN SHEEP

By
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CSU Department of Pathology
Fort Collins, Colorado

Terry has discussed the pathology as we see it in these lambs on the range we have in Colorado - specifically Pike's Peak. The question is how does this build up on the range - what has happened on the range that gets us involved in this pathogenic situation - a cycle. Many aspects of the study have been in relation to that. I have studied those portions of the life cycle of this parasite that occur on the range.

Usually when I start this talk, I like to give my definition of wildlife management and how I fit into it, because I am, as we have discussed earlier, a diseasologist or parasitologist. My definition of wildlife management is "the application through knowledge and collection of facts or principles which will manipulate an animal population or several of them and the environment toward achieving the desired end, be it beneficial or detrimental to the animal or the environment."

Now where does the diseasologist come in? In my opinion the diseasologist is a tool to be used when the application of historic management regimes in obtaining desired goals has proven unsuccessful and not indiscriminantly in all situations. That is in my opinion where we would use what we call a diseasologist or parasitologist.

Well, let's start out with the slides.

First I'll review the life cycle that Terry introduced to you. This is the *Protostrongylus rushii* here. It is one of the two species of lungworms found in bighorn sheep. This one is found in the air passageways and the other one, *Protostrongylus stilesi*, is found, like Terry said, in the parenchyma of the lung. This is the adult parasite. Those are centimeters above.

Terry talked about the first stage larvae. This is the first stage. There are a number of lungworms in bighorn sheep - this lungworm, *Protostrongylus*, is characterized by this distinct tail. It has an inflexion here on the tail where, as some of the others that you may see, have other characteristics that allow us to distinguish them. As Terry said, snails are the intermediate hosts in this life cycle and they have been found naturally infected on bighorn sheep ranges.

To show you what they look like, these are the snails themselves. Here are four genera of snails and this is the tip of a pencil. They are so small that unless you look very carefully you will never find them unless you happen to hit one of these spots where they are very plentiful.

This is *Velonia* - very common in Colorado. This is *Vertigo* - another common species in Colorado. This is *Pupilla blondii* which, in Colorado at least, is the most important species of all of these snails in continuing this life cycle. This particular snail, one that we examined last summer, contained 63 of these third stage lungworm larvae in it. That's in one snail, so we're talking about a larvae that is quite small and with a lot of snails concentrated in an area, it has a hell of a potential of continuing or seeding the range with this parasite.

This is *Valonia cyclotrilla*. Not important, just to give you an idea of what it looks like. These are drawings. This snail is recognized by vertical ribbing on the shell. This is the other member of this genus - *Velonia pulchrilla*. Snail introduced from the eastern United States and a drawing to show you it's a smoother shelled snail.

OK, sagebrush, surprisingly enough, you can find these in sagebrush areas. Underneath these bushes are mossy areas providing small foci of concentration of these snails. If you pull apart these beds of moss you will be able to locate snails usually in them.

This is the Trickle Mountain area in southern Colorado. You can find them right here on what looks like a windblown area. Pike's Peak is the subject of this, though, so where do we find them on Pike's Peak? Where are they concentrated on that area? This is typical Pike's Peak range. Another view. We started by wondering what we could do to locate what we theorized was there. These foci of infection, and by that I mean an area utilized by the sheep where snails could be found and which is also suitable for high numbers of infected snails, these are the components you would expect foci of infection to have.

To start out, then, Bob Schmidt and others and ourselves spent a lot of time on Pike's Peak with a topo map and marked in the areas that were possibilities - areas which were heavily utilized by the sheep. After that we backpacked into these areas and began collecting snails in the areas we suspected. We would bring these snails back to the lab and look at them under a microscope to get an idea of the level of infection in them. The next step was to get back to these areas. We found very few snails in some areas and in other areas we found lots of snails. Some of these areas, then, after we had been back to the lab and examined them, we were able to cross off as unlikely sources of this cycle because we found either few snails or those that we found were uninfected.

This is *Pupilla blondii* and because you can't see the characteristics on it we have these drawings. It has a characteristic toothing pattern inside the shell. This is one that I mentioned was most important in Pike's Peak range.

This is the other one I mentioned, *Vertigo*, and this is *Vcanulus fulvus* another snail that's not quite as important in Colorado.

This is the snail after it's infected. First stage larvae when it enters the snail cannot infect a sheep. The first stage larvae is found on the ground, defecated in fecal pellets. That larvae also is incapable of infecting a sheep. It will die on the range in time if it does not enter a suitable intermediate host and I mentioned the ones that can serve. After it enters a suitable intermediate host it must develop to be infective. The third stage of this parasite develops a black cuticle and you can look at these under a dissecting microscope just as you can there. There are two of them.

Dissected out, this is what this parasite looks like - still having the characteristic tail. This is a finer magnification of the same tail.

Ok, where do you find these snails? If you're looking at a range you want to know where to look. Well, you can find them in some numbers almost anywhere. This is a slide of western Colorado in pinon pine/juniper type country, very dry country, and I can find snails here. This is mountain mahogany and if you will look in the little bit of duff and leaf material underneath these plants you can find them, and this is an area that is considered a desert in western Colorado. You won't find them underneath these pinon pines for some reason.

So we approach the last part of this study, the quantification of these areas - that is the degree of utilization, what's in them, what's their exposure and that sort of information.

These areas were bedding grounds, feeding grounds and lambing grounds. The lambing grounds did not prove to be foci of infection; the summer bedding and feeding grounds were.

This is a typical summer bedding ground, and here's a group of rams on Pike's Peak. We found, in those areas where we had large numbers of snails that we had dense mats of vegetation, an absence of evergreens, damp soil or a good deal of organic material, protection from wind/cold dessication, and south to southeast exposures. This is what proved to be one of the foci of infection and this is a better look at what a foci of infection is.

In this kind of area, if you peel back the grass at the edge of these rocks you can find large numbers of snails. This is another sort of area. We looked over 13 areas. Two of them qualify, in my opinion for foci of infection. The point is that we have concentrations of sheep in different areas on a range. Only a few of these areas are going to be sources of this infection, sources of the continuing of this life cycle. In this case two of them, areas 9 and 10, were selected. One of these had 49 out of 173 snails infected and the other one 7 out of 36.

In quantifying these areas we wanted to know their density of snails and parasites and snails themselves. For sheep utilization, we wanted to be able to characterize this in some way - to be able to say that the sheep were using this area more than another area and show that portion of foci of infection that we were interested in. We did that, an imperfect way, but the best we could come up with, by collecting at random from standard sized plots, the feces in the area we thought were foci and then going 200 yards away and again collecting at random from plots of a standard size, feces from that area. In that way we were getting a relative usage of these two areas.

We did the same with snails. We collected snails in that area and outside of it and compared the levels of infection in the snails in that area and outside of it. We did that in the two areas that looked like potential foci of infection.

In area 9 this shows the relative usage by the sheep and this shows the number of snails we found per meter squared. Now I'm talking about live snails here and the levels of infection in those snails. This is the second of those two areas - shows the level of infection and the number of snails. We also found up to 1600 shells per square meter in these areas. By multiplying that out over a foci you can see the potential of this thing in a very, very small area, and if the sheep are using that area a lot, then there is a potential for completing this life cycle.

The size of these areas I'm talking about is surprisingly small. The first area was perhaps 40 yards by 10 yards, very small, and the second area was about 50 by 100 yards. And so it is, in some cases, like looking for a needle in a haystack. These are the species of snails we found infected on that range, and as you can see, 5 out of 6 possibilities were found there.

EFFECTS OF LATE PREHISTORIC AND EARLY HISTORIC ESKIMO HUNTING OF DALL SHEEP IN NORTH ALASKA: EXAMPLES OF ABORIGINAL OVERKILL1/

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

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

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

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

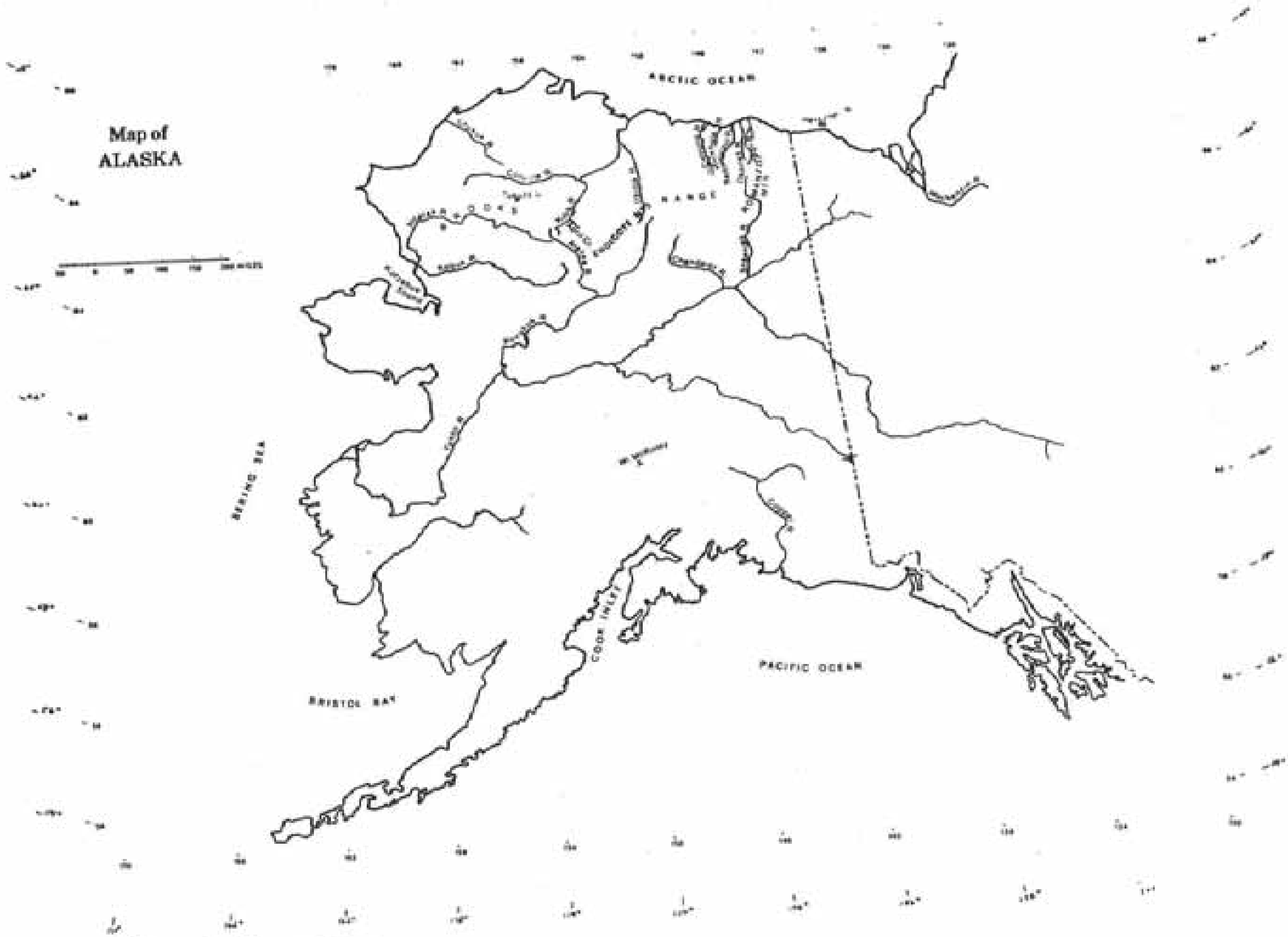

Figure 1 - Map of Alaska.

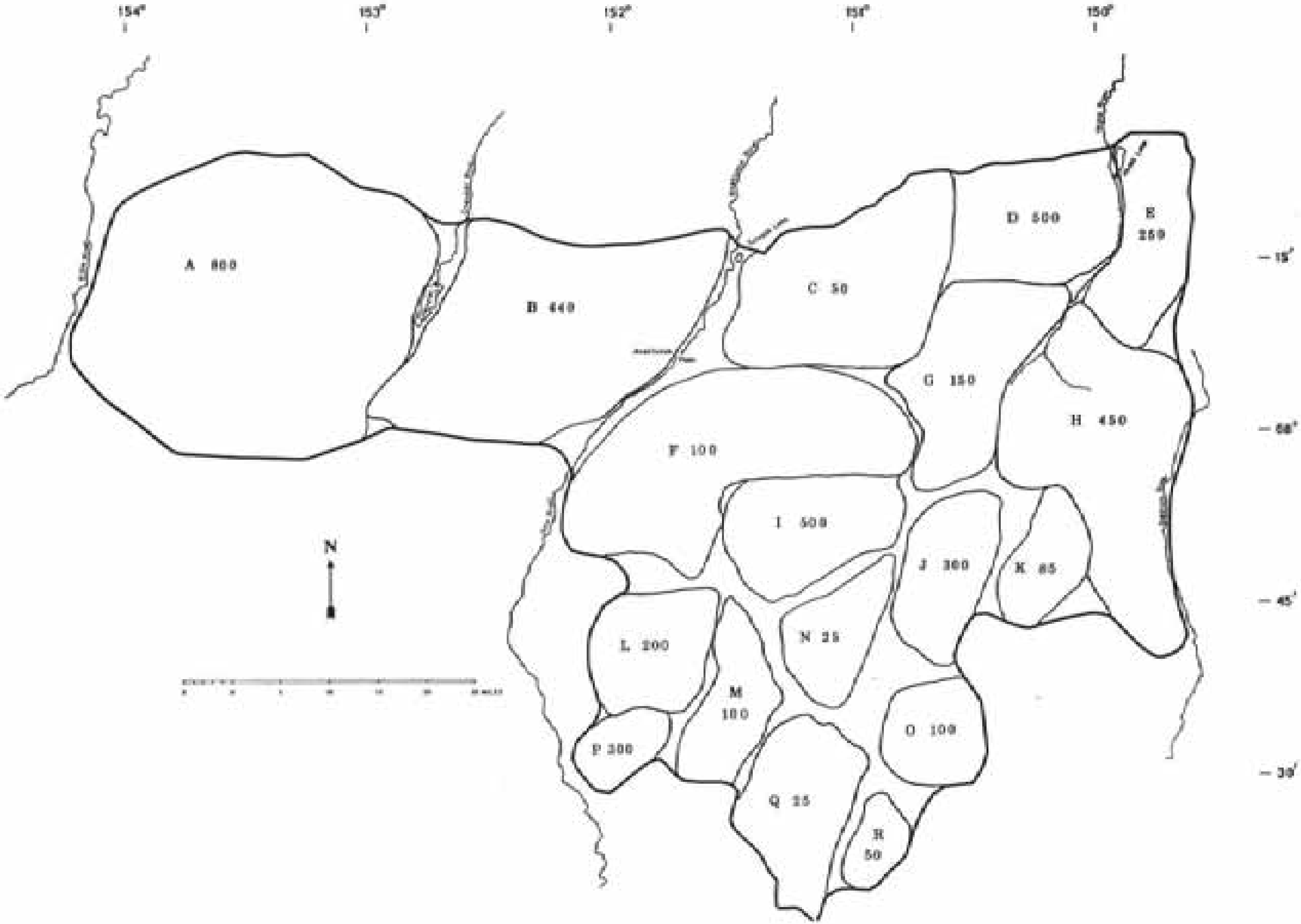

Figure 2. Modern day populations of Dall sheep in the central Brooks Range, Alaska.

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

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

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

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

The above references, while not exhaustive, are typical of the historical literature which testifies to the relative abundance of Brooks Range Dall sheep during approximately the past six decades. By contrast, both ethnographic and historical accounts establish that from sometime before 1885 until about 1910 sheep were generally very scarce in the Brooks Range. Nunamiut Eskimo informants say that sheep were nearly absent from the central region (Figure 2) during the period of about 1900 to 1910, and as noted below they recall that sheep could hardly be found during the starvation winter of 1906-1907, nor again during the famine of 1910-1911.

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

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

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

And further that..."Until recently the Jago and Okpilak Rivers (Figure 1) were taboo (to the Nunamiut Eskimos, as also noted by Ingstad (1954)), and the sheep were undisturbed. The writer's party was the first to go far within the mountains on the Okpilak. Sheep were constantly seen, as many as 40 or 50 in a day. The high Romanzofs will always be a refuge, so that these sheep will not be entirely exterminated"(Leffingwell 1919, 63).

Anderson, who in 1908 and 1909 reconnoitered parts of the eastern Brooks Range and Arctic Slope, as far west as the mouth of the Itkillik River (Figure 1), reports in even greater detail, as follows: "Sheep were formerly quite numerous on the heads of nearly all the rivers on the Arctic side of the (Brooks Range) divide, at least as far west as the Colville (River). It is probable that until comparatively recent times, before whaling ships began to winter at Herschel Island (Figure 1) in 1889, the sheep were not much hunted in this region. The population was sparse, and the caribou were larger, more abundant, and more easily taken. The gradual extermination of the caribou in northwestern Alaska, combined with other causes, has for many years induced Eskimo from the rivers at the head of Kotzebue Sound (Figure 1) to move across to the Colville, at the same time that many Colville (Nunamiut) Eskimo have gradually moved eastward, occupying one mountain valley after another until the sheep became too scarce to support them...(in) the Endicott Mountains (Figure 1) sheep (are) much more common on the north side of the divide than on the south side, although the south side is an uninhabited wilderness...On the Hulahula River...we found two families of (Nunamiut) Eskimo sheep hunters. One of these Eskimos had in this small river valley killed 30 or 35 sheep from June to August 1908, and 37 from September 1908 to May 1909, subsisting with his whole family almost entirely on sheep meat. This man's clothing from head to foot was made of sheepskins, his tent of sheepskins, and even his snowshoes strung with sheepskin thongs...Although the numbers of sheep have been greatly reduced, I believe that a few are still found near the head of every mountain river from the Colville to the MacKenzie (River, Figure 1). The natives (Nunamiut Eskimos and presumably others) hunt strictly for meat and skins, and the habitat of the sheep prevents the hunters in this particular region from picking up sheep as a sideline to other game hunting and trapping. When a local influx of hunters cuts down the number of sheep beyond a certain limit in some mountain valley, pressure of hunger soon causes the people to move out. Word is passed along that the said river is starvation country, and an automatic closed season affords the sheep a chance to recuperate" (Anderson 1813, 508-10).

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

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

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

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

In the high valleys of the central region the positions of the largest as well as many of the smaller Nunamiut settlements were mainly predicated upon ease of access to migrating caribou - the animal which was by far the single most critical mainstay of Nunamiut economy (Solecki 1951, Ingstad 1954, Spencer 1959, Campbell 1962a, Gubser 1965), and the interception of which, during the spring and fall migrations, was facilitated by the enclosing mountain walls of the valleys (Campbell 1970). Because of their scarcity, food plants were very little used, and birds comprised only two or three percent of the annual diet. The major secondary Nunamiut food resource was fish of several species, which most importantly included the lake trout *(Salvelinus namaycush)*. The Nunamiut therefore placed their largest settlements beside the scattered bodies of water which contained this and other fishes (Campbell 1968b), and which also lay in the paths of migrating caribou. Hence, for example, there were more or less permanent Nunamiut encampments at Chandler, Tuluak (Tulugak) and Ulu (Itkillik) Lakes (Figure 2). At these and similar lakes, herds of caribou were driven into the water, where the animals were lanced from kayaks. In the nearby terrain the herds were also impounded and snared (Stoney 1899, Rausch 1951, 1953, Gubser 1965).

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

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

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

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

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

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

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

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

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

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

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

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

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

These were major reasons for the human depopulation of the Arctic Slope and northern Brooks Range, which by 1920 was literally complete. From about 1920 to 1938 it appears that not a single Nunamiut Eskimo remained anywhere in the interior north of the Brooks Range divide (Gubser 1965). Another decisive factor, however, was the virtual disappearance of the caribou from much of Nunamiut territory in the early years of the present century. Explanations for this decline include statements that they were nearly exterminated by overhunting on their summering grounds near the Arctic Coast (Stefansson 1913) and that they emigrated eastward into Canada (Ingstad 1954). (See Skoog 1968 for a detailed historical review of movements and relative populations of north Alaska caribou herds during the period of roughly 1937 to 1957). In any case, between about 1900, or slightly earlier, and about 1912 or 1915, caribou were repeatedly either scarce or absent from their customary migration paths in the central Brooks Range and on the central Arctic Slope. As a direct consequence, 6 to 10 percent of the total number of Nunamiut who still resided in the central region starved to death in the winter of 1906-7 (C.W. Amsden pers. comm.). It is appropriate to the aims of this paper that when I asked an older Nunamiut informant why, during that winter, the Eskimos did not survive by hunting sheep, he expressed a shared opinion by saying, "There weren't any."

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

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

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

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

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

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

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

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

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

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

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

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

Perhaps, therefore, the model is not sufficiently conservative. Nevertheless, it contains other imperfections which tend to balance the score. They include the following: first, while in all probability there were no more sheep in the central region 200 years ago than at present, they may have been considerably smaller. As described, the present total population seems to reflect approximate carrying capacity. However, because the southern Brooks Range Eskimos and Indians were probably established in the region well before the Nunamiut colonizations (Anderson 1970, Cook 1970, 1971, Giddings 1951, Morlan 1973), it is quite possible that sheep in parts of the area shown in Figure 2 had been more or less intensively exploited for centuries. Second, in former times the several "discrete" sheep populations in the central region (Figure 2) were certainly not equally hunted. As noted, major regional Nunamiut settlements were situated close by or just within the northern edge of the mountains, while those of the Indians lay along their southern flanks (McFadyen 1966, McKennan 1965, Osgood 1936). Thus, as examples, most of the sheep in areas G and I (Figure 2) were less accessible to the Nunamiut than those in areas A, B and C, and similarly, most of the sheep in areas G and I were less accessible to the Indians than were those of areas M, N and Q. This situation implies that some groups of sheep within the total region would survive these Eskimo and Indian predations far longer than would others, and it would seem that this is what happened.

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

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

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

One may assume that a number of factors prevented the total extermination of Dall sheep in the central region as well as elsewhere in the Brooks Range. For example, these factors probably include: that even the major Eskimo and Indian settlements were intermittently shifted (Campbell 1968b), with the result that small, local sheep populations were permitted to lie fallow for several years at a time; that once the sheep in a given area were reduced to a certain level, it became no longer worthwhile to pursue them, with the result that the population of that area was enabled more or less to recuperate; that because of distances and rough terrain some local sheep populations were practically inaccessible to the Eskimos and Indians; and most importantly, that beginning about 1880, the total northern Brooks Range and Arctic Slope Nunamiut population itself entered into a decline and eventually reached zero in about 1920. Nevertheless, it would appear that over a span of less than two centuries the Nunamiut, aided by other Eskimos and by Indians, gradually reduced Brooks Range Dall sheep to very low levels.

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

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

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FOOTNOTES

1/ This essay is primarily based on the author's work in the central Brooks Range during the years 1956 to 1969, inclusive, 1961, 1963 and 1967-1972, inclusive. For their assistance in the field or in subsequent consultations I am especially indebted to the following Nunamiut Eskimo hunters: Noah Ahgook, the late Jonas Ahgook, Daniel Hugo, David Mekiana, Raymond Paneak, Simon Paneak and Johnny Rulland; to the following Alaskan licensed guides and outfitters: C. R. Loesche, P. Merry and B. Pinnell; to the following anthropologists: H. L. Alexander, Jr., C. W. Amsden, L. R. Binford, W. J. Chasko, Jr., A. M. Clark, L. S. Cordell, E. S. Hall, Jr., R. A. McKennan and P. L. Nietfeld; and to the following biologists in Alaska, Alberta, Arizona and the Rocky Mountain states: W. I. Crump, W. G. Freeman, V. Geist, W. E. Heimer, W. S. Huey, L. J. Johnson, C. W. McIlroy, P. D. Olson, J. P. Russo, W. S. Sandfort and N. Steen. My field studies were supported by the American Museum of Natural History, the Arctic Institute of North America, the Explorers Club, The George Washington University, the National Science Foundation, the Office of Naval Research, U. S. Navy, the University of New Mexico and Yale University. The United States government may reproduce this paper in whole or in part.

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

FIGURE CAPTIONS

1. The state of Alaska, showing the central Brooks Range region (hatchured area) described in the text.

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

PHYSICAL CONDITION, PRODUCTIVITY AND QUALITY OF NUTRITION OF BIGHORN SHEEP IN THE SUN RIVER AREA, MONTANA

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Crude fiber and protein content of rumen samples, crude fiber in fecal samples and percent light transmittancy of rumen liquor samples for each of 10 adult ewes collected in spring were determined.

A kidney fat index was determined for each of the animals. Kidney fat indices indicated all bighorn sheep with the exception of one were in good condition.

The values for protein and crude fiber may represent at least minimal and maximal values respectively for bighorn sheep on adequate ranges.

A negative correlation between percent light transmittancy for rumen liquor and nutritive quality was found.

Each pair of ovaries of 10 adult ewes collected during spring contained one corpus luteum which, together with embryo counts, indicated a frequency of fertilization of 100 percent. No evidence of twinning was found.

A PRELIMINARY LOOK AT DALL RAM HORN GROWTH
IN ALASKA AND ITS IMPLICATIONS

By
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Dall sheep in Alaska are highly prized by the hunting public, and the primary interest in these animals results from the trophy value of the horns carried by mature rams. The oral tradition of Dall sheep trophy hunters has established that there are variations in horn conformation and growth among the mountain ranges which support Dall sheep in Alaska. This impression is also prevalent among mountain sheep researchers. Valerius Geist (1971) has stated in his "Quality Hypothesis," that quality differences exist between sheep populations and that high quality populations are characterized by more rapid horn growth and more massive horns at any given age than are low quality populations.

Data concerning the size of Dall sheep horns in Alaska have been collected by Scott (1951), Hemming (1967), Boone and Crockett Club (1964), and Erickson (1969, 1970). Scott (1951:76) measured the "Average number of inches by which the length of horn exceeded spread in each area," and stated that "In Kenai rams, length exceeded spread by about 4 inches more than the average of all other areas. Between the other areas there is apparently little significant difference." Scott also stated (1951:80) that "The annual rate of growth increases to a maximum in the third (segment) and then decreased each year throughout the life of the animal" and "An average ram will never grow horns as large as 40 inches in length." Taylor (1962), Wishart (1969), and others have written about horn growth in the Bighorn sheep. Both in Bighorn sheep (Taylor 1962) and Dall sheep (Hemming 1967) maximum growth in horn length was reported to have occurred during the second "summer" of the sheep's life. Taylor (1962) found that horn segment lengths and segment diameters were significantly larger (statistically) for Bighorn rams from the Bison Range in Montana than from rams inhabiting Wildhorse Island. Wishart (1969) found statistically larger horn segment lengths and segment diameters in Bighorn sheep south of the Bow River in Alberta than in Bighorn sheep north of the Bow River.

Measurements of Dall sheep horns compiled by the Boone and Crockett Club indicate that the majority of exceptionally large Dall sheep rams are taken in the Wrangell and Chugach Mountains of Alaska, but rare individuals in all Dall sheep ranges may reach the unusually large size necessary to be recorded. The records maintained by Boone and Crockett Club are of limited interest to the serious student of Dall sheep horn growth because they do not contain information on age, increment length or other parameters which describe conformation. Furthermore, the rams recorded by the Boone and Crockett Club in Records of North American Big Game (1964) represent unusual individuals which are far different than the average.

Hunting of mature Dall sheep rams is the predominant use of these animals in Alaska. Harvest statistics compiled by the Alaska Department of Fish and Game indicate that increased sheep hunting pressure in recent years has resulted in decreasing horn size among sheep harvested in some areas (Smith 1973). The regulations defining harvestable sheep as rams of more than 3/4 curl have been in effect for approximately 25 years. During most of this time, weather and a fairly small hunting public, as well as limited means of transportation, combined to keep Dall sheep populations in a rather stable situation in spite of the limited harvest. However, in recent years, increased pressure and more efficient transportation methods have resulted in localized shortages of trophy rams, increased hunter-hunter interactions and a generally deteriorating sheep hunting experience. For these reasons the days of essentially non-regulated harvest of Dall sheep in Alaska have probably come to an end.

The management policy of the Department of Fish and Game (adopted in 1972) states that, "Consistent with its responsibility to manage game species in the best interests of the species and the people, the Department will manage the resource on the basis of a) maximum overall recreational opportunity, b) maximum aesthetic appeal to the user, and occasionally c) maximum sustained yield of animals." In order to realize all management objectives set forth in the policy in light of the predominance of recreational trophy hunting it becomes obvious that at least some portions of Alaska must be managed for trophy production. Reason dictates that these areas be those where the inherent characteristics of the sheep present are compatible with the desired objective. For example, it would be folly to attempt management for trophy production where the Dall sheep present have small, slow-growing horns. In order to make reasoned decisions in planning Dall sheep management, data on rates of horn growth and expected cumulative growth for sheep from different areas of the mountain ranges of Alaska are essential. One purpose of this study was to provide data for making these planning decisions.

Materials and Methods

Alaska's Dall sheep inhabit 7 different mountain ranges throughout the state: Alaska Range (ARE east of Mt. McKinley and ARW west of Mt. McKinley), Brooks Range (BRR), Chugach Mountains, (CMR), Kenai Mountains (KMR), Talkeetna Mountains (TCW), Tanana Hills-White Mountains (THW), and the Wrangell Mountains (WMR). Sport hunting takes place in all of these mountain ranges, and hunters frequently take Dall sheep horns to taxidermy shops to have them prepared for display as trophies. These taxidermy shops were visited and horns from each of the seven mountain ranges were identified and measured. Approximately seven hundred sets of Dall ram horns were obtained for measurement by this means from 1968 through 1970. Additional specimens from areas where interest was high and hunter effort was low during those periods were obtained through cooperation with hunters known to have taken sheep from the areas of interest during other years. Some specimens from the eastern Brooks Range were obtained from Renewable Resources Ltd. which had picked up the remains of natural deaths in the course of their survey of the Canning River in 1973. These specimens were not hunter kills, but it is assumed that growth rates were the same as hunter killed animals from the same area.

The age of each set of horns was determined by counting the annual growth segments according to the procedure of Geist (1966). A flexible steel measuring tape was then fastened to the horn on the frontal (Severtzoff 1873 cited by Brooke and Brooke 1875) surface with masking tape, and the lengths of all growth segments measured. The greatest diameter at the annuli of each segment was then measured using a vernier caliper spanning the distance from the frontal surface to the nunchal edge (in the groove) as defined by Severtzoff (cited by Brooke and Brooke 1875).

After linear measurements were made the extent of curl was determined using an apparatus similar to that described by Taylor (1962) (Fig. 1). The apparatus consisted of a c-clamp mounted in a swivel base. Horns were fastened securely in the apparatus by clamping the skull (a portion of which always accompanies horns prepared for display as trophies) in the c-clamp. The horns were then tilted and swiveled until an observer about 4 meters away could sight along the axis around which the longer horn was coiling (Fig. 2). When viewed along this axis the outer surface of the horn nearly describes a circle. A plexiglass plate with a series of engraved, concentric circles from 20 to 36 cm in diameter was placed about 50 cm from the horns opposite the observer. The outermost circle on this plate was divided into one degree graduations. As the observer sighted along the axis of coiling an assistant moved the horns and the plexiglass "target" until the axis of coiling passed through the center of the concentric circles. The circle described by the horn was then matched with one of the concentric circles on the plate and degrees of curl were read from the graduations (Fig. 2). Finally, the diameter of the circle described by the horn was measured on the 90-270 degree plane at right angles to the axis of coiling with forestry-type calipers.

All measurements were recorded in millimeters, and computer analysis of the linear measurements (horn lengths, segment lengths, and diameters of annuli) was begun. It then became apparent that linear measurements did not give a comprehensive understanding of the actual size or trophy value of a set of Dall sheep horns. Consequently, the volume of each horn was calculated from the linear measurements available. For purposes of calculation it was assumed that the horn was a regular cone which had been bent into a spiral with no deformation, and that each annular segment was a frustum of the cone. The volumes of each frustum were then calculated using the formula, $v = \frac{h}{3}(r_1^2 + r_1 r_2 + r_2^2)$, where r_1 and r_2 are the radii at the annuli describing the upper and lower limits of each frustum. The frustal volumes were then summed to determine the total volume of the horn. Of course, these calculated volumes are but an approximation of the true volume, but they could be used if necessary as indices of true volume.

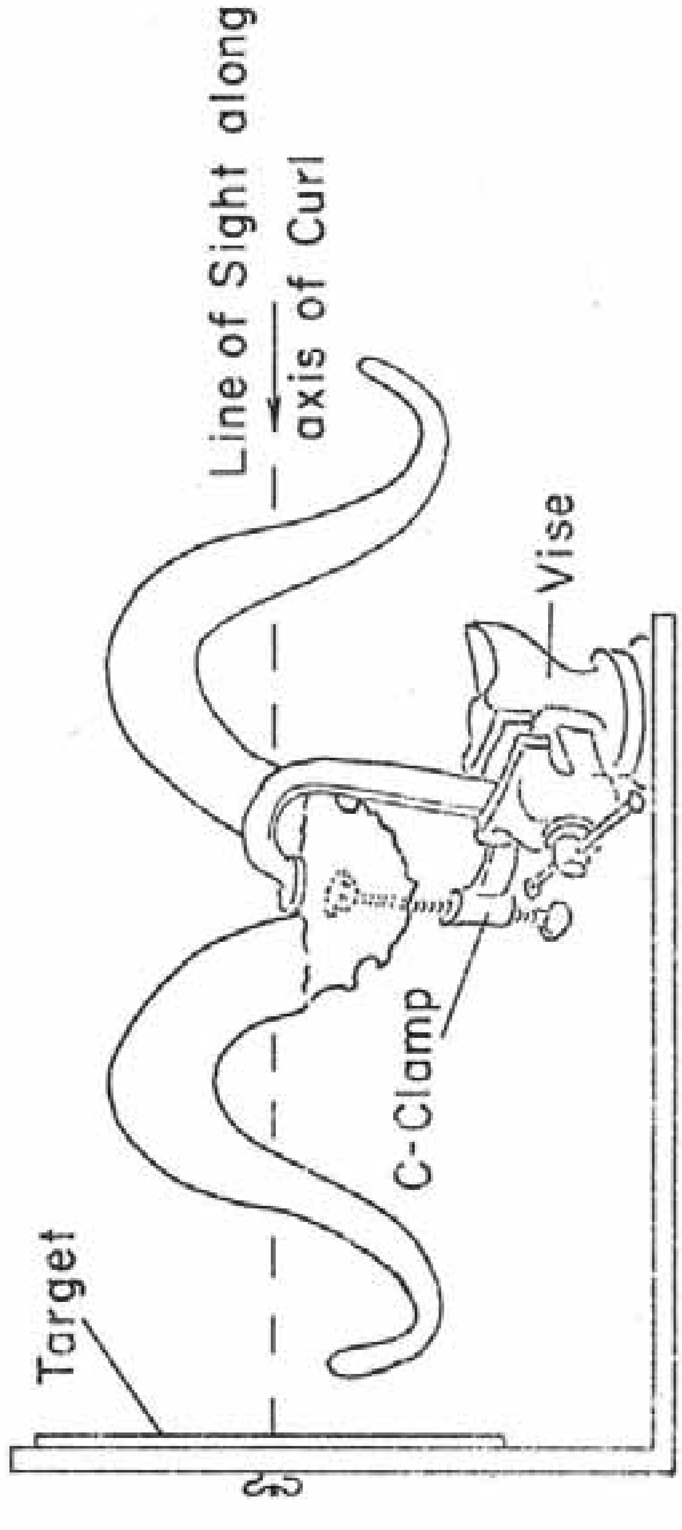


Figure 1. Horn measuring apparatus.

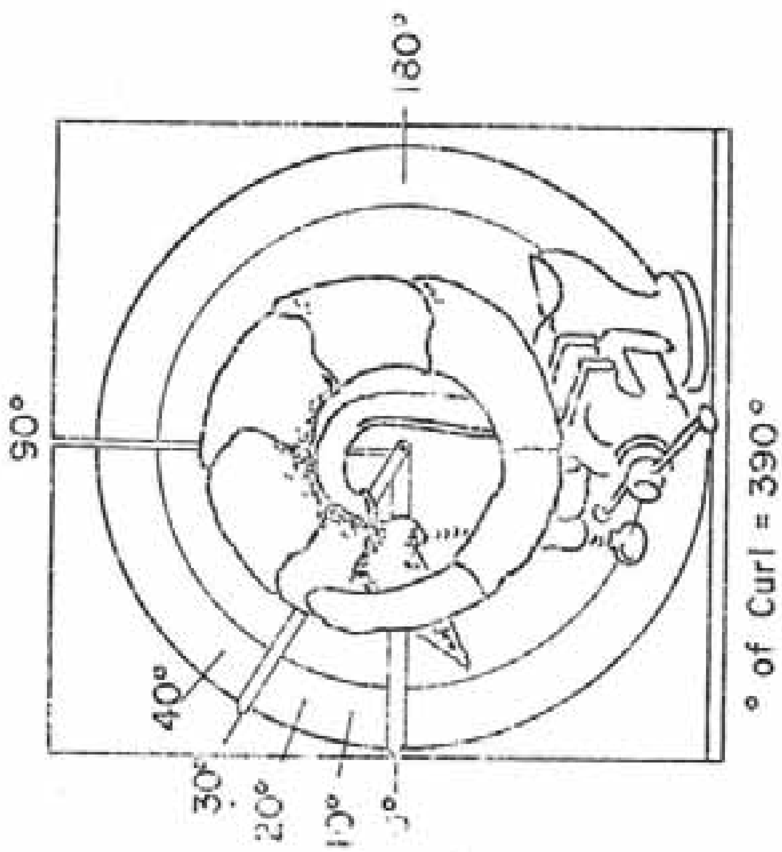


Figure 2. Axial view of Dall ram horn in measuring apparatus.

Approximation of true volume was accomplished by calculating the volumes of 29 sets of horns and then measuring their actual volume by displacement. The mean percentage difference between calculated volume and actual volume for the 29 sets was 54.4 percent. That is, the actual volume was only 54.4 percent of the calculated volume (standard deviation = 3.3 percent). All calculated frustal volumes were then multiplied by 0.456 to give an estimate of true volume.

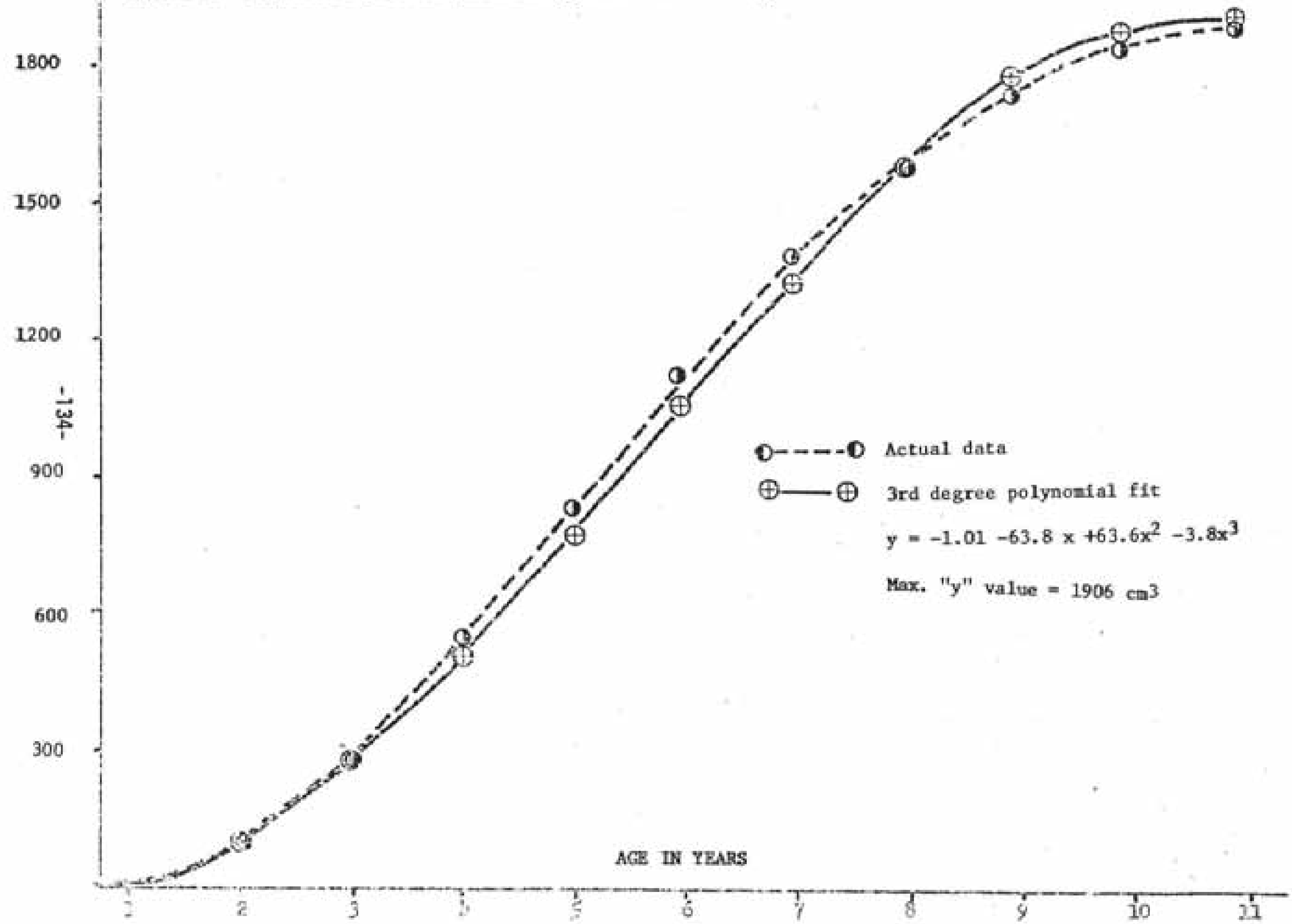
Initial statistical comparisons were made between entire mountain ranges. Further inquiry revealed, however, that there is sufficient variation within a given mountain range that each mountain range was separated into geographical areas on the basis of physiography and these subunits within ranges compared. Growth rates were then determined by plotting cumulative segment volumes against year of growth. This produced a classical "s-shaped" curve, a slow beginning followed by a rapid, nearly linear, period in mid-life and a slowing in rate as the animal reached old age. The computer was then used to "fit" the data to an equation. First and second degree equations were tried but a third degree polynomial of the general form $y = ax^3 + bx^2 + cx + d$ generated the proper "s-shaped" curve. Fit of the data to the curve appeared to be satisfactory.

When the growth patterns of horns from a given area are described by a mathematical expression it opens the possibility of comparison of absolute and relative growth rates between differing groups of sheep. The absolute growth rate can be determined for any given year by evaluating the first derivative of the equation at the year desired. Relative growth rates as percentages of the maximum attainable volume (average) for each area also become calculable if the average maximum attainable volume is known. This term can be obtained by evaluating the first derivative at $x = o$ and determining the sign of the second derivative at $x = o$.

When each of the seven mountain ranges was partitioned according to its physiography the variation of the sample groups decreased. This allowed for more meaningful comparisons within mountain ranges. The different geographical areas were ranked according to average cumulative volume at seven years of age. Seven years was chosen because it represented the upper age which could be used and retain adequate sample sizes for all areas. This age is somewhat below the average age of sheep taken in most ranges but allows a good basis for comparison.

Maximum average growth rate was determined graphically for purposes of early comparison by measuring the slope of the cumulative growth curve in its linear portion. All geographic areas were then ranked according to maximum average growth rate from greatest to least. Both numerical positions for each area were then summed. The sums of the numerical positions on both lists were then ranked in descending order and termed a "Quality Index." This third list according to quality index score was used to evaluate the quality of sheep in different regions of Alaska's mountains. It should be noted that a low quality index score represents high quality.

Figure 3. Comparison plot of predicted growth and actual growth of horns in ARE I.



Results

The geographic areas into which Alaska's mountain ranges were divided are shown in Figure 4. Table 1 shows the ranking according to maximum average horn growth rate and cumulative volume at 7 years as well as the quality index score.

Table 1. Dall ram horn growth in Alaska.

Cumulative volume at 7 years (average)	Average Maximum Growth Rate in cc/year	Quality Index Rank		Score
1. WMR II-2110cc	1. WMR II-445	1	WMR II	2
2. CMR II-1998cc	2. CMR II-406	2	CMR II	4
3. ARE III-1975cc	3. TCW I-406	3	TCW I	7
4. TCW I-1882cc	4. KMR II-403	4	ARE III	9
5. KMR II-1805cc	5. THW I-390	5	KMR II	9
6. THW II-1794cc	6. ARE III-386	6	THW I	14
7. ARE II-1726cc	7. ARE II-365	7	THW II	14
8. WMR I-1726cc	8. THW II-364	8	ARE II	14
9. THW I-1648cc	9. WMR I-344	9	WMR I	17
10. CMR I-1607cc	10. CMR I-325	10	CMR I	20
11. ARE IV-1591cc	11. KMR I-323	11	KMR I	23
12. KMR I-1587cc	12. ARE IV-321	12	ARE IV	23
13. ARW II-1476cc	13. ARW I-310	13	ARW I	26
14. TCW II-1425cc	14. TCW II-296	14	TCW II	28
15. ARW I-1392cc	15. ARW II-290	15	ARW II	28
16. ARE I-1384cc	16. ARE I-284	16	ARE I	32

Data on conformational parameters are not yet analyzed and will be published elsewhere.

Discussion

The immediate question which must be dealt with in the face of the data presented on quality difference is ... why? This is not an unreported phenomenon and Geist (1971) has proposed mechanisms which may explain such differences.

Several trends of interest are shown by the data. The first of these to be dealt with here is that of a general increase in quality (decrease in quality index score) as one samples along mountain ranges toward the east. Sheep are of generally higher quality further to the east in the Alaska Range, Wrangell Mountains, and the Chugach Mountains. The Brooks Range will not be considered here because the sample sizes for the areas involved are not sufficient for valid comparison. Also, not included were the extreme eastern Chugach (CMR III) and the northern Talkeetna Mountains (TCW III) because of insufficient data. However, indications are that CMR III is the area of highest quality in the Chugach Mountains and TCW III is the area of lowest quality in the Talkeetna Mountains.

Fig. 4. Arbitrarily designated portions of Alaska used in determination of "Quality Index."

In the Alaska Range, the Wrangell Mountains and the Chugach Mountains the increase in quality toward the east parallels an increase in existing glaciation as postulated by Geist (1971). In the Talkeetna Mountains the increase in quality appears to run from TCW III in the north to TCW II in the southeast, and TCW I in the southwest Talkeetnas is the area of highest quality. This pattern also fits the general situation of increasing quality with increased presence of glaciers. In the Kenai Mountains the sheep of higher quality are found on the sheltered side of the peninsula. It appears that there may be more glaciers in the sheep habitat of the western Kenai Mountains (KMR II) than in the eastern area (KMR 1). The Alaska Range west of Mt. McKinley also presents a situation where the sheep of higher quality come from the more glaciated areas.

The notable exception to this trend exists in the Tanana Hills-White Mountains. Sheep from this area rank surprisingly high in the list of overall quality (Table 1), and the area which they occupy has never been extensively glaciated. Currently no glaciers exist in this area of Alaska.

Increases in quality correlate well with lower densities of sheep per unit of available area. Density figures are approximate and the square miles used are the total available mountainous terrain in areas in which sheep are known to exist. Area ARE I, just east of Mt. McKinley Park in the Alaska Range, is clearly the lowest quality area in Alaska (Table 1). This area is known to have a density of 9 sheep per square mile. Further to the east (ARE II) the density is about 3 sheep per square mile. Still further to the east (ARE III) the density is approximately 1 sheep per square mile. East of ARE III, in area ARE IV, quality is lower and the density of animals on the range has increased to 4 sheep per square mile.

In the Wrangell Mountains quality also correlates with sheep density. The eastern Wrangell Mountains (WMR II) has a density of 1 sheep per square mile and ranks higher on the quality list than does the western Wrangell Mountains (WMR I) which have a density of 2 sheep per square mile.

In the Chugach Mountains the generalization again holds with the eastern, less densely populated area, CMR III, ranking higher on the quality list than the more westerly areas, CMR II and CMR I (Table 1).

At the present time there is no known exception to the generalization that higher quality is associated with lower sheep population densities. This may account for the high quality of sheep in the Tanana Hills-White Mountains, an exception to the "Glaciation Hypothesis."

Correspondence between high quality and low density is more consistent than that between high quality and the presence (present or past) of glaciers. Geist's (1971) hypothesis predicts that higher quality should be correlated with glaciation, but also postulates that population numbers should be lower in these areas. The data are generally supportive of the hypothesis, but the questions raised by the exceptions are yet to be answered. Further work utilizing the technique of fitting horn growth data to a third degree polynomial for analysis of growth patterns, particularly as an aid in determining relative growth rates, may be useful. Analysis of the data by this technique should indicate whether Dall sheep follow the pattern described by Wishart (1969) for Bighorns. Wishart found that Bighorns have similar relative growth rates and concluded that overall size was a function of habitat. The answers to these questions may shed some light on the question of whether differences in quality are of genetic or environmental origin.

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BUSINESS MEETING

The business meeting opened with a discussion about the Boone and Crockett Club's record book. Delegates voiced opinions that bighorn sheep, and maybe all sheep, should be removed from the book. Others disagreed, stating that if that happened somebody else would immediately start a book of records of sheep.

The discussion continued with the following points being made: Alberta's Indians are killing many rams and selling the heads. Poaching is a problem in many states and provinces. Is the loss of these rams actually biologically detrimental to the sheep populations? Sheep heads are worth a lot of money. Remove the hunter's name from the Boone and Crockett record book.

The discussion ended with (1) a suggestion that, since several of the delegates present would attend the Boone and Crockett sheep meeting in Missoula in June 1974, they could voice their opinions; (2) the following resolution, proposed by John Stelfox, and approved by the delegates:

> WHEREAS, uncontrolled hunting can seriously deplete sheep populations, be it resolved that the Northern Wild Sheep Council supports the principle that native ethnic populations enter into cooperative agreement with state, provincial and federal agencies in the management of wild sheep.

The resolution was mailed to individuals listed by John Stelfox.

Wayne Heimer presented the following two resolutions which were approved by the delegates:

(1) WHEREAS, the wild sheep of North America occur in many different habitats, and

WHEREAS, the numbers and status of wild sheep in North America are extremely variable from population to population, and

WHEREAS, the overall status and well-being of the wild sheep of North America rest ultimately on the status and well-being of individual populations,

BE IT HEREBY RESOLVED that the Northern Wild Sheep Council recommends that management of wild sheep in North America be effected at the population level for the best interests of each population. Furthermore, the Northern Wild Sheep Council recommends that general species management over large areas be carefully defined and given a lower priority than that of the individual population.

(2) WHEREAS, the Alaska Land Claims Settlement Act of 1968 provides for selection of 80,000,000 acres in Alaska as national interest land, and

WHEREAS, the Interior Secretary's tentative selections include a substantial portion of the world's Dall sheep, and

WHEREAS, the proposed management agencies will have the option of regulating hunting on the national interest lands, BE IT HEREBY RESOLVED that the Northern Wild Sheep Council recommends to the Bureau of Land Management, the United States Forest Service, the National Park Service and the U. S. Fish and Wildlife Service that hunting be retained as a viable management option for most Dall sheep populations residing on these public lands.

Wayne Heimer provided a list of people to whom the second resolution should be sent.

The following Statement of Concern was passed by the delegates:

Statement of Concern to be Brought Forward at the Missoula Sheep Meeting, June 18-20, 1974:

WHEREAS, the Boone and Crockett Club was originally formed to promote both quality, sportsmanlike trophy hunting and the concept of wise conservation of big game species, and

WHEREAS, wild sheep populations in North America have been subjected to undesirable hunting and cropping ethics, the Northern Wild Sheep Council recommends that the Boone and Crockett Club either remove wild sheep species from Boone and Crockett listings or else delete those entries which are listed as "pick-ups" or are judged as not taken in fair chase.

The Wyoming delegation volunteered to host the 1976 meeting in Wyoming.

Danny Wilson invited delegates to attend their Desert Sheep Council meetings.

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