POPULATION CHARACTERISTICS OF TRANSPLANTED CALIFORNIA BIGHORN SHEEP IN WESTERN NORTH DAKOTA

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ABSTRACT: North Dakota's present day bighorn sheep herd was established in 1956 when 18 California bighorns (Ovis canadensis californiana) from British Columbia were transplanted into an enclosure on Magpie Creek in McKenzie County. Progeny from those bighorns were subsequently transplanted at Theodore Roosevelt National Park - South Unit, Dutchman's Barn, Devils Slide, and Moody Plateau. Characteristics of transplants in the first 4 areas differed substantially from those of Moody Plateau. The first 4 herds exhibited some or all of the following characteristics: (1) bighorns were placed in 200-acre enclosures for several years before release, (2) transplants were conducted from 1956-1962, (3) size of home ranges for rams was 13-57 km^2 and for ewes 5-18 km^2, (4) densities of rams ranged from 0.2 to 2.5/km^2 and ewes between 0.4 and 2.4/km^2, (5) home ranges of bachelor groups and ewe bands overlapped, (6) annual reproduction rates were between 10% and 40%, and (7) the lamb survival rates were 0-5%. In contrast, the Moody Plateau herd exhibited the following characteristics: (1) bighorns were released without an enclosure in 1966, (2) the home range of rams was 8 km^2 and that of ewes was 28 km^2, (3) density was 0.4 rams/km^2 and 0.5 ewes/km^2, (4) home ranges of bachelor groups differed from those of ewe bands, (5)

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the reproductive rate was 100%, and (6) lamb survival was 50%. The following characteristics were common to all 5 herds: (1) lack of seasonal migration, (2) equal sex ratios prior to hunting season, (3) diets composed of 90% browse and 10% grass, (4) home ranges composed of chains of large plateaus, (5) approximately 95% of daily activities were spent on or near these plateaus, and (6) the major cause of lamb mortality was coyote predation. Data indicate bighorns in the first 4 herds were subjected to stress from overcrowding resulting in low productivity, an age structure dominated by older animals, and low population quality. The major causal factor in the overcrowding and resulting stress were: (1) method of transplant, which resulted in constricted home ranges, (2) high densities, and (3) ram-ewe interactions. The Moody Plateau herd did not show signs of overcrowding and exhibited increased reproduction, an age structure dominated by young animals, and higher population quality.

Bighorn sheep (O. c. auduboni) were once common in south western North Dakota where large herds were found along the Missouri and Little Missouri rivers (Bolt et al. 1973). Few sheep remained on the Great Plains following settlement of the area in the late 1800's and the last known native bighorn in North Dakota was killed in 1905 (Murdy 1957). In 1956, the North Dakota Game and Fish Department, after consulting with the British Columbia Game Commission, decided the area could still support a bighorn population.

Eighteen California bighorns (O. c. californiana) were trapped in south central British Columbia in November 1956 and transported to a 81 ha (200 acre) enclosure on Magpie Creek in North Dakota (Murdy 1957). In subsequent years, progeny from those 18 bighorns were transplanted into 4 additional areas (Samuelson 1972). Between 1960 and 1962, 17 bighorns were transplanted

to an enclosure erected in the South Unit of Theodore Roosevelt National Park near Medora, hereafter referred to as the Park. During the summer of 1962, 7 bighorns were transplanted to an enclosure in the Dutchman's Barn area, 8 km south of Medora. The Devils Slide herd, 32 km south of Medora, began in 1962 with the release of 12 bighorns directly into the wild, and the same technique was used to establish the Moody Plateau herd, 19 km south of Medora, when 3 ewes were released there in 1966. An unsuccessful transplant occurred in 1962 when 2 rams were released in the North Unit of Theodore Roosevelt National Park. One ram was later recaptured inside the Magpie Creek enclosure, but the other one was never seen again (Samuelson 1972). By 1967 all of the captive bighorns had been released from the transplant enclosures.

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STUDY AREA

The state's bighorn sheep range presently lies in central Billings and Southern McKenzie Counties of western North Dakota. This area, 19 to 32 km wide, is known locally as "the badlands" and is comprised of a series of

breaks extending east and west of the Little Missouri River. The elevation ranges from 716 m to 915 m. The climate is semiarid and is characterized by long, cold winters and short, warm summers. Temperature extremes of 43°C and -44°C have been recorded; monthly averages range from -11°C in January to 22°C in July. Precipitation averages about 38 cm per year with 50% falling in May-July. Snowfall averages about 75 cm per year, but winds usually prevent uniform accumulations (Edwards and Ableiter 1944).

METHODS AND MATERIALS

Ground surveys were conducted in 29 months during the period from May 1975 through April 1979 in 5 study areas to determine population size, herd structure, and productivity. The Magpie Creek, Park, Dutchman's Barn, Moody Plateau, and Devils Slide study areas were systematically surveyed from ½ hour before to 1 hour after sunrise and from 1 hour before to ½ hour after sunset. Observations were made with 7 x 35 binoculars and a 20 x 45 spotting scope. Numbers, location, and sex of bighorns observed were recorded. Bighorn bands were classified by their sex and age ratios, and band size. Occasionally, individual sheep were recognized by a distinguishing physical characteristic, such as a cracked horn.

In 1978, radio telemetry studies were conducted in an attempt to overcome observation problems. Three ewes, 1 each in the Magpie Creek, Park, and Moody Plateau herds, were captured from a helicopter by use of a dart gun loaded with 4½ mg of M-99 and 5 mg of Acepromazine. Radio collars were attached to those animals, and also to 4 lambs, 3 in the Moody Plateau herd and 1 in the Dutchman's Barn herd, captured by hand during April 1979. The radio-equipped ewes were located from January 1978 through April 1979. Locations of rams were recorded from field observations collected during the same period.

Radio telemetry locations and field observations were used to construct home range polygons by the minimum area method (Mohr 1947). Densities, herd interactions, seasonal migration, and daily movements were obtained from radio telemetry data and field observations.

Data from ground surveys and home range studies were used to calculate herd densities. Densities were calculated for each herd by dividing numbers of individuals by the area of their respective home ranges.

Food habits were determined through field observations, by analysis of rumen samples taken from 15 rams harvested in 1975 and 1976, and by analysis of 10 pellet groups collected during the 4 seasons of 1976 from study areas 8 km south of Medora. Rumen and fecal samples were sent to the Composition Analysis Laboratory, Colorado State University to determine diet preference. Plant communities were defined by importance value measurements and used to demonstrate the relationship between community utilization and food habits (Fairaizl 1978).

RESULTS

Intensive ground surveys compiled after 1,100 hours of observation revealed a statewide herd of approximately 170 animals (Table 1). Herd structure observations revealed a sex ratio approaching 100:100 in all herds except Moody Plateau (Table 1). Productivity data indicated that reproductive rates of Magpie Creek, Park, Dutchman's Barn, and Devils Slide herds were 10-40% and lamb survival was 0-5%. The Moody Plateau herd, however, had 100% reproduction and 50% lamb survival. Of the 4 lambs radioed, 1 disappeared shortly after capture, 2 were killed by coyotes (Canis latrans) and 1 survived. One additional lamb, from the Moody Plateau herd, was found dead; the cause of death was not determined. However, at least one of the lambs killed by

Table 1. Individual bighorns observed during ground surveys conducted in 1975-76 in 5 western North Dakota study areas.

Study Area	Rams	Ewes	Lambs	Total
Magpie Creek	18	12	3	33
Park	14	11	3	28
Dutchman's Barn	32	26	2	60
Moody Plateau	3	13	13	29
Devils Slide	11	8	1	20
	78	70	22	170

coyotes and the lamb found dead may have been abandoned due to excessive harassment by the capture crew.

Home ranges of rams, determined from 55-65 hourly visual locations per month, ranged from 8-57 km^2; home ranges of ewes, determined from an average of 150-160 hourly radio telemetry locations per month, ranged from 5-28 km^2 (Table 2). Radio telemetry data and field observations revealed that bighorns did not move at night, therefore home ranges were based on daytime locations. Rams in the Devils Slide herd had the largest home range and those in the Moody Plateau herd the smallest. Ewes in the Moody Plateau herd had the largest home range and those in the Magpie Creek and Park herds the smallest. Home ranges of rams were consistently larger than and completely overlapped those of ewes in all herds except Moody Plateau (Fig. 1); that herd did not have a resident population of rams but shared bachelor groups with the Devils Slide herd.

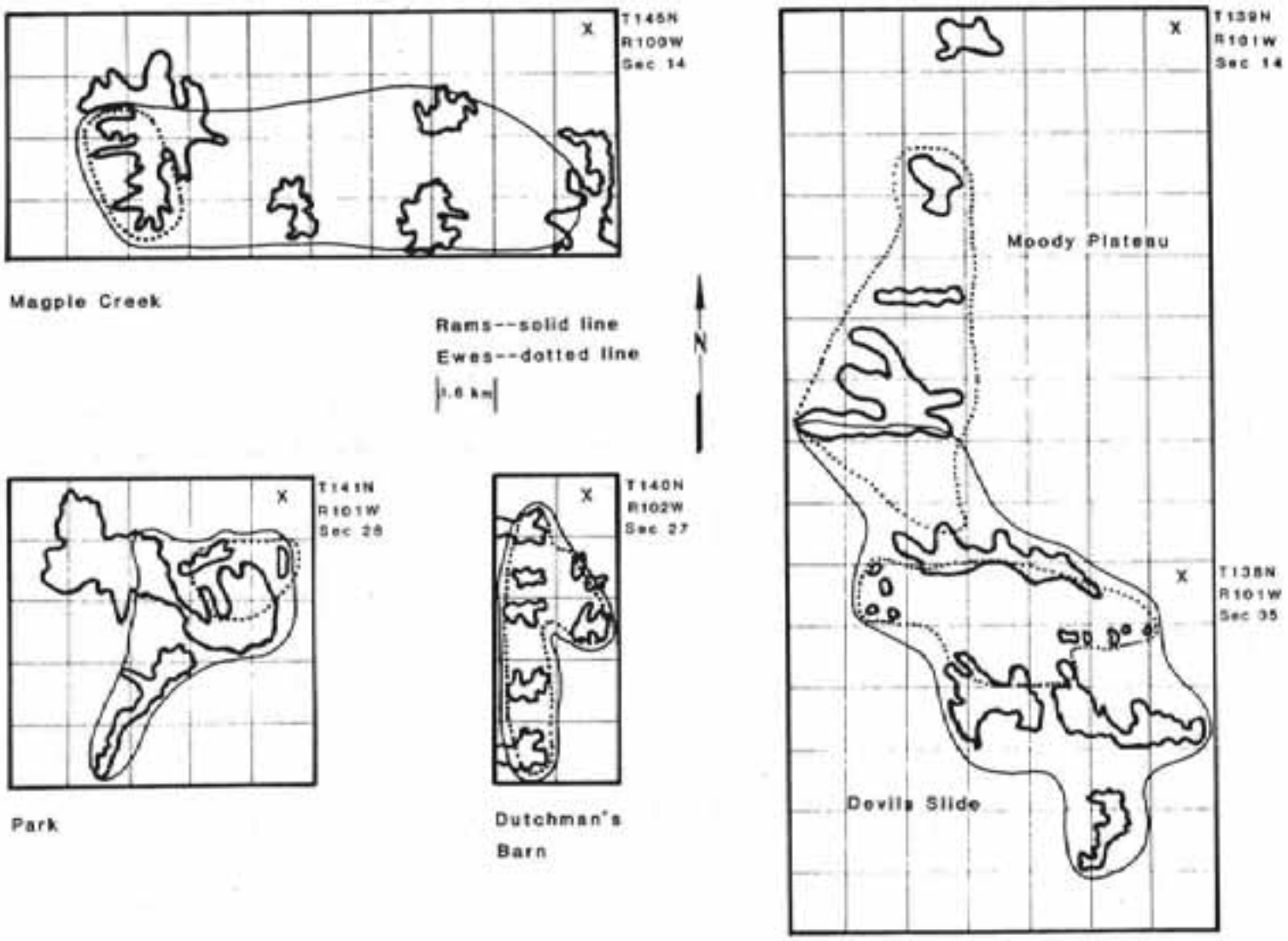

Fig. 1. Home ranges of North Dakota bighorn sheep herds.

Table 2. Ram and ewe home ranges for the 5 North Dakota bighorn sheep herds.

Herd	Rams km^2 (mi^2)	Ewes km^2 (mi^2)
Magpie Creek	52 (20)	5 (2)
Park	21 (8)	5 (2)
Dutchman's Barn	13 (5)	13 (5)
Moody Plateau	8 (3)	28 (11)
Devils Slide	57 (22)	18 (7)

Based on ground surveys and radio telemetry data, densities of rams in the 5 herds ranged from 0.2 to 2.5/km^2 and were lowest in the Devils Slide and highest in the Dutchman's Barn herds. Ewe densities in the 5 herds ranged from 0.4 to 2.4/km^2 and were lowest in the Moody Plateau herd and highest in the Magpie Creek herd (Table 3).

Table 3. North Dakota bighorn sheep herd densities.

Herd	Rams/km^2 (Rams/mi^2)	Ewes/km^2 (Ewes/km^2)
Magpie Creek	.4 (.9)	2.4 (6.0)
Park	.7 (1.8)	2.2 (5.5)
Dutchman's Barn	2.5 (6.5)	2.0 (5.0)
Moody Plateau	.4 (1.0)	.5 (1.2)
Devils Slide	.2 (.5)	.4 (1.2)

Analysis of rumen and fecal samples revealed that the diet was composed of approximately 90% browse during summer, fall, and winter but only 60% in spring. Grasses comprised approximately 10% of the diet during summer, fall, and winter and 40% in spring. Forbs comprised less than 1% of the diet during all seasons. The dominant browse species was winter fat (Ceratoides lanata) except in summer when buffaloberry (Shepherdia argentea) was dominant. Western wheatgrass (Agropyron smithii) was the dominant grass in all seasons except spring when thread leaf sedge (Carex filifolia) was dominant. Of all species utilized during summer, fall, and winter, winter fat accounted for approximately 60% of the diet (Fairaizl 1978).

Additional food habit data based on 90 hours of field observations, revealed that bighorns spent approximately 70% of the time feeding in sage communities, 20% in wheatgrass communities, and 10% in sedge communities. Observations indicated dominant species in the diet were dwarf sage (Artemisia cana), western wheatgrass, and thread leaf sedge (Fairaizl 1978).

Daily movements were assessed based on 267 hours of observation in 1976. Nearly all daily activities were associated with the large plateaus. Plateaus were characterized by precipitous cliffs on all sides and flat tops encompassing approximately 2.5 km^2. Tops were covered with a dense growth of wheatgrasses and sage, and dense juniper (Juniperus scopulorum) stands extended up the sides. Other areas utilized by bighorns were flat-topped ridges, sidehills, and creek bottoms. Sidehills were used almost exclusively as bedding cover and were associated with both plateaus and flat-topped ridges. Creek bottoms were utilized as feeding habitat along with plateaus and flat-topped ridges. Approximately 70% of the feeding occurred in creek bottoms within 200 m of the plateau base, 15% on plateau tops, 10% on flat-

topped ridges, and 5% on sidehills. Approximately 85% of bedding occurred on sidehills, 10% in juniper stands, 2% on plateau tops, 2% on flat-topped ridges, and 1% in creek bottoms. Juniper stands were used as escape cover approximately 80% of the time and sidehills 20%. Plateaus and a 200 m area surrounding the base were designated primary areas of activity. Approximately 95% of total daily activities occurred within these areas. When normal daily activities took the herd outside the 200 m boundary, bighorns generally moved to another plateau. The remaining 5% of activities occurred in the area between plateaus. This pattern of daily movements occurred during all seasons of the year indicating seasonal migration did not exist.

DISCUSSION

Data from ground surveys, along with miscellaneous observations and aerial surveys (Samuelson 1975), suggested additional bighorn bands existed and were not recorded in my census. Based on these miscellaneous observations and opinions of North Dakota Game and Fish biologists, I proposed that the total statewide population was approximately 25% greater than the figure recorded in ground surveys. Furthermore, herd structure observations collected during 1975-76 indicated a sex ratio approaching 100:100. Buechner (1960) presented data indicating a ram:ewe ratio of 25:100 would contribute to a higher rate of population growth than would an equal sex ratio. This study implies that herds with a sex ratio of 100:100 would have a ram surplus resulting in excessive ewe harassment and non-breeding. With the equal sex ratio observed in North Dakota herds indicating a surplus of rams, excessive ewe harassment could have occurred resulting in lower reproductive rates.

Manifestations of the ram surplus were observed in the Dutchman's Barn herd where numerous cases of ewe harassment were recorded and rams were observed chasing, butting, and mounting ewes during all 12 months of the year. In one exceptional case, a 6 year old 3/4 curl ram collected and maintained a harem from May 1975 until November 1976, during all 18 months breeding behavior was exhibited by the ram. Data indicate lowered reproductive rates in the Dutchman's Barn herd were probably caused by intense ram-ewe interaction. For example, this herd had an equal sex ratio, prior to 1975, and produced only 2 lambs. During the 1975, 76, and 77 hunting seasons, 20 rams were harvested from this herd and 6, 9, and 10 lambs were produced during the 1976, 77, and 78 lambing seasons respectively. These data suggest reductions in numbers of rams improved the reproductive output of this herd.

The concept of an equal sex ratio indicating a surplus of rams, which causes excess ewe harassment, was also suggested by Deming (1963). In his paper discussing aspects of bighorn breeding, overbreeding resulting from intense ram-ewe interaction was proposed as a ramification of ram surpluses. Deming goes on to describe a situation in which an equal sex ratio would not be desirable. For example, fewer rams would be needed for breeding when home ranges of rams and ewes overlapped or where rams had to travel only short distances and had a high probability of finding a ewe in estrus. In this situation, an equal sex ratio would result in intense competition, by many rams, for the estrus ewe and excess harassment. Furthermore, because wild sheep are polygamous, the author proposes that some rams may never engage in breeding, creating a biological surplus. The low reproductive rates, observed in 4 of the 5 North Dakota bighorn herds, could be explained by the factors of intense ram-ewe interaction, overlap of ram and ewe home ranges, and poly-

gamy working either singly or in combination. Hunting season successfully eliminated the ram surplus.

The reduced home ranges and restricted movements observed in 3 North Dakota herds may be a product of the method of transplant, badlands topography, and the lack of migration in the original herd for the following reasons. First, because of confinement in enclosures for several years bighorns became imprinted to the habitat and remained in that area after release. Furthermore, transplanting progeny which had never migrated precluded development of seasonal migration patterns. Second, topographic features of the former range recognized by bighorns were lost in the transplant. In addition, badlands topography does not allow an altitudinal migration from summer to winter ranges. Third, bighorns from the British Columbia herd did not exhibit a seasonal migration (Sugden 1957) therefore, the traditional behavior patterns and migration routes did not exist and could not be transmitted to the progeny. Because the area within the enclosure was all the bighorns recognized, badlands topography did not allow seasonal migrations, and the ancestors of these bighorns did not migrate, the herds never left the release sites. As a result of these 3 factors, the Magpie Creek Park, and Dutchman's Barn herds exhibited restricted home ranges. The last 2 factors also applied to the Moody Plateau and Devils Slide herds, however, these sheep were released directly into the badlands without detention in an enclosure and as a result exhibited considerably larger home ranges.

Furthermore, Geist (1967) proposed 5 theories which explain restricted home ranges in transplanted herds. First, when sheep were transplanted they lacked familiarity with the new habitat and tended to cling to the immediate vicinity. Second, home ranges passed on from generation to generation and traditions of habitat retention were desirable. Third, social structure of

bighorn bands and concepts of habitat retention did not provide for juvenile dispersal. Fourth, females but not males acquired the home range of the female band into which they were born. Fifth, males in a natural population move off to their own areas, whereas rams of a transplanted herd share home ranges with ewes. These observations help explain the following: (1) association of bighorn herds with release sites, (2) bighorn densities, (3) extremely small home ranges of ewes, (4) somewhat larger home ranges of rams, and (5) overlap of ram and ewe home ranges.

Ewe densities were considerably higher in the 3 transplants which employed enclosures than in the other 2 herds. Furthermore, densities remained stable throughout the year except in the fall when an increase occurred due to rams concentrating for the rut in the small ewe home ranges. Behavioral patterns which produced these high densities by preventing bighorn dispersal and the association with release sites which resulted in restricted home ranges, increased ram-ewe interactions. These data suggest that densities in these 3 herds intensified ram-ewe interactions which could have affected reproduction.

Data from North Dakota indicate bighorns were predominantly browsers with winter fat being the major food item. Food habit observations and vegetation analysis, however, did not indicate the substantial proportion of winter fat revealed by microtechnique analysis. The importance value of this plant was relatively low indicating scarcity. Furthermore, winter fat occurred only in dwarf sage and dwarf sage-green rabbitbrush (Chrysothamnus graveolens) communities which were generally associated with plateaus. The low frequency of occurrence in the environment plus the high percent utilization indicate bighorns were actively selecting for winter fat.

Observations indicate bighorns were also selecting large plateaus. For example, the Dutchman's Barn herd, upon release, migrated approximately 3 km east to an area containing a chain of these large plateaus. The preponderance of daily activities associated with these large plateaus coupled with habitat and food item selection may have further concentrated bighorns.

Data indicate 1 or a combination of 5 factors (herd interaction, home range, densities, food habits, habitat selection) were working to create an overcrowded condition in 4 of the 5 North Dakota bighorn herds. Furthermore, the overcrowded conditions were generating stress which was affecting reproduction.

Similar population characteristics have been observed in other areas, and researchers have proposed 4 theories which describe: (1) conditions leading to overcrowding, (2) how stress was manifest, and/or (3) ramifications of stress. First, loss of habitat would create constricted home ranges resulting in overcrowding. This overcrowding placed excessive stress on the herds, which was manifest by lower productivity and population quality (Hansen 1971). Second, numerous contacts and conflicts with other members of the herd would generate excessive stress, which stimulates the endocrine system. Excessive stimulation of the endocrine system results in inhibition of reproductive functions, increased mortality, and behavioral disturbances (DeForge 1976). Third, stress may trigger the self regulatory mechanism of population density and dispersion (Banko 1963). Fourth, concepts of habitat retention and group association, which in the past were highly desirable for the survival of the species (Geist 1967), may induce stress which would result in degeneration of an overcrowded population. These theories imply that overcrowding and the resulting stress may lead to a catastrophe which would decimate the population.

Geist (1971) proposed that in the absence of a catastrophe, however, bighorn populations would stabilize at high densities with low reproductive and mortality rates.

CONCLUSION

The theories of home range reduction, habitat retention, group association, and juvenile dispersal help explain the restricted home ranges and high densities of some North Dakota bighorn herds. Furthermore, the theories of ram surpluses and social interactions help explain the intense ram-ewe interaction. The 3 factors of restricted home ranges, high densities, and intense ram-ewe interaction created a stressful overcrowded condition. In addition, the theories of stress manifestation and self-regulation help explain the low reproductive and recruitment rates. The low recruitment rate resulted in a population age structure dominated by older animals. Based on herd age structure, recruitment rate, and overcrowded conditions population quality was assessed.

Four North Dakota bighorn sheep herds (Magpie Creek, Park, Dutchman's Barn, Devils Slide) were characterized by some combination of constricted home ranges, high densities, or intense ram-ewe interactions. These herd characteristics produced a stressful overcrowded condition which resulted in low recruitment, a population age structure dominated by older animals, and low population quality. These data indicate the 4 herds were in a static state, however, these herds were doing exactly what was expected. In addition, if a catastrophe such as habitat loss or home range reduction occurred these herds would decline.

The 5th herd, Moody Plateau, differed substantially in these characteristics. The home range was larger, density was lower, and ram-ewe interactions were negligible, which resulted in increased population recruitment, an age structure dominated by young animals, and higher population quality. The Moody Plateau herd appeared to be a vigorous, productive band with a good future.

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QUESTION - RESPONSES

Anonymous: You mentioned just at the end there, that the population quality is low; so are you referring to some physiological condition of the animals, do you have any data on that at all?

Steve Fairaizl: No we don't. We based our population quality estimates on the older age structure, the lower recruitment rate and the fact that they are leaning to over crowding. And assuming these sheep are over crowded that it leads to a lower population quality.

Lanny Wilson: Did all these sheep come from the original 19?

Steve Fairaizl: Right.

Wayne Heimer: When you decided to deal with all this harassment by shooting the rams, did you leave any place where you; any control areas where you didn't shoot the rams?

Steve Fairaizl: Yes. It was in the south unit of the national park, there was no hunting in there and reproduction remained quite low in those areas, or in that one particular area I should say.

Wayne Heimer: A comparable area adjacent to it has responded?

Steve Fairaizl: Right.

Wayne Heimer: How much?

Steve Fairaizl: It has just about tripled as I recall. I mentioned that when I first went in there in the spring of "75" this one particular herd only had 2 lambs and I think 3 years later it had 10 lambs.

Manfred Hoefs: You mentioned the overlap of home ranges year round. Do the sheep, the two sexes, run together as well?

Steve Fairaizl: Yes, they do. We're seeing them right now with rams intermixed with the ewes. We don't really have an exclusive lambing ground out there, but usually these ewes will try and break off away from the rams to have their lambs. But, even right now the rams are still harassing and chasing them around.

Anonymous: How long is the lambing season?

Steve Fairaizl: It usually starts about the middle of April and runs until about the middle of May.

Walt Bodie: You mentioned that these rams were having harems. Were they showing any sign of territorality, on the home ranges?

Steve Fairaizl: Some, yes. It's just kind of a wild idea, we don't have any data on it at all, but it is a good possibility. Especially within rams that have collected a harem or even with ewe bands. There is very little interaction or mixture between bands of sheep out there, and absolutely no interaction between herds. So there is a possibility of it.

Walt Bodie: Do ewes behave like this?

Steve Fairaizl: What is normal behavior? North Dakota is such an unusual situation out there and so unique in many respects. The seasonal migration for example, we don't have any seasonal migrations at all. Mostly because they don't have any altitude to migrate down. But, that is again, one of the very unique characteristics of North Dakota. So I'm not sure what normal sheep behavior is or should be for that area.

Anonymous: There has been some recent work put out regarding African ungulates dealing with the inbreeding and some of the characteristics that you're referring to were reflected in these studies, very high infant mortality and possibly poor conception. Are you looking into that at all?

Steve Fairaizl: We're beginning to. We think that is probably our biggest problem, some type of a self regulatory problem; some type of inbreeding, and we're beginning to start studies along those lines now. During hunting seasons we collected some lungs from the sheep and it looked as though they had as high a lungworm infestation as any place, but doesn't appear as though they are causing any trouble out there. So it must be some type of a population characteristic that is causing the problems out there.

Anonymous: You mentioned overcrowding. Did you see any affects of over use of forage in the area?

Steve Fairaizl: No. We haven't done an awful lot of food habit studies or nutrition studies, but there appears to be pretty good growth out there, we haven't seen any competition with cattle or any over usage of the range at all.

Anonymous: Steve, would you comment on how much impact oil and gas leases is having on those areas?

Steve Fairaizl: I've been waiting for that question. North Dakota is really expanding their oil developments right now. In one area, the Magpie Creek herd, there is 2 oil wells right up in the top of the north end of that plateau that the sheep use. Unfortunately, we can't document that sheep were ever on the north end of that plateau. I don't think there is any question, but we don't have any black and white numbers. And, since the oil wells have gone in, the sheep never go anywhere near the north end of that plateau. So, we're anticipating some real problems. Especially if the oil wells go in on the tops of those plateaus.

Anonymous: Is 175 sheep the current estimate, the total estimate of California bighorns in North Dakota?

Steve Fairaizl: That estimate was made during 1975 and "76" prior to the hunting season, and we've shot about 45 rams out there and it's quite doubtful that we've replaced that many from latest production. So that estimate is probably a little bit high.