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Long Range Plan for the Management of Rocky Mountain Bighorn Sheep in New Mexico

2004-2014

Wildlife Management Division
New Mexico Department of Game and Fish
Santa Fe, New Mexico
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Executive Summary

Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) occupy open, mountainous habitat either above timberline or in open canyons and slopes below forests and woodlands. They are characterized by low reproductive rates, long life spans, and populations that can be bottom-up regulated by nutritional constraints or top-down regulated by predation. Two of 3 alpine populations are currently at carrying capacity and require trapping and removal to keep herds below carrying capacity (Hacker et al. 2000). Declines in the 3 low-elevation populations in New Mexico are associated with habitat loss resulting from fire suppression and livestock grazing (Huddleston-Lorton 2000), increased predation from mountain lions (*Puma concolor*) (Ahlm 2001, Huddleston-Lorton 2000, NMDGF files) train-strike kills (NMDGF files), and disease (Ahlm 2001). Other factors influencing bighorn populations include: recreation use, roads, fences, exotic ungulates, poor range conditions, and illegal harvest.

Rocky Mountain bighorn never were widespread in New Mexico, with historical evidence for just 4 populations in Wheeler Peak, Pecos Wilderness, White Rock Canyon, and Manzano/Los Pinos Mountains (Bailey 1931, Leopold 1933). In 2003, there are an estimated 850 Rocky Mountain bighorn in 3 alpine and 3 low-elevation populations (Figure 1). In 2003 all 3 alpine populations are estimated to be > 100 and each of the 3 low-elevation populations are estimated to be < 100. Populations with more than 100 bighorn have an increased probability of long-term persistence (Berger 1990) and New Mexico Department of Game and Fish (The Department) is working to increase all populations above 100.

About the Plan

In this plan, issues and strategies are identified that will guide the Department from 2004 through 2014 in effectively managing Rocky Mountain bighorn and in satisfying the public's interest in this species. A four-fold approach will be used to achieve this.

(1) Involve the public in creating, evaluating, and implementing the plan: A period of public review was included in the development of this plan. The Department will seek further advice from affected publics on implementation of the plan. A biennial review of this plan will be implemented to keep the document current.

(2) Establish and maintain viable populations: The Department will continue to trap bighorn out of populations that reach carrying capacity. These bighorn will be: (a) transplanted within New Mexico to augment extant populations or to fill vacant historical habitats, (b) traded to Arizona for desert bighorn sheep, and (c) traded to other western states if not required in New Mexico. The Department will continue to monitor extant populations annually, enforce laws against illegal harvest, and work with land

management agencies and private landowners to minimize disease outbreaks and the adverse affects of human impacts.

(3) Increase public awareness of and support for bighorn: Wildlife Management Division will continue to work with the Conservation Education Section within The Department to develop educational programs for presentation to schools and other interested groups and work to establish a zoo display.

(4) Increase consumptive and non-consumptive recreational opportunities: The Department will continue to provide quality hunting and provide bighorn viewing opportunities.

Draft Status

This is the second draft of the document, completed on January 30, 2004. This draft is currently posted on the Department Website and is being reviewed by external publics, and agency personnel.

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Natural History and Ecology

Rocky Mountain bighorn (*Ovis canadensis canadensis*) are even-toed ungulates native to North America in the family Bovidae. Northern races or subspecies of bighorn sheep (*O. c. canadensis, O. c. californiana, O. c. auduboni*) were extirpated from Arizona, New Mexico, Nebraska, Nevada, North Dakota, South Dakota, Utah, and Washington (Toweill and Geist 1999). Populations in other western states and provinces of the United States and Canada probably declined to < 10,000 individuals (Toweill and Geist 1999).

Today Rocky Mountain bighorn sheep are found in all western states and provinces with historical records, from New Mexico to British Columbia. Bighorn sheep are characterized by low reproductive rates, long life spans, and populations adapted to live near carrying capacity in relatively stable environments (Geist 1975). Bighorn sheep are a sexually dimorphic species and ewes may weigh 190 pounds (86 kg) and rams may weigh >300 pounds (136 kg). One of the most prominent characteristics of bighorn sheep are the very large horns of adult males. Large-horned, older rams do much of the breeding, though younger rams will breed opportunistically (Hogg and Forbes 1997). Rams may breed several ewes, however they are not territorial nor do they form harems, but rather are serial polygynists (Geist 1971). Ewes generally first breed at 2.5 years and give birth to 1 lamb after a gestation period of 180 days (Lawson and Johnson 1983). Although twinning has been documented in both wild and captive bighorn it occurs infrequently (Eccles and Shackleton 1979). Rocky Mountain bighorn sheep generally breed in December and January with most lambs born in June and July when the climate is relatively mild and forage is becoming abundant (Hass 1993). Bighorn generally have a life span of 10-14 years, although exceptions as old as 18 have been reported (Geist 1975, Goldstein 2001). Mortality tends to be high the first year, low from ages 2-8 and then increases after age 9 (Lawson and Johnson 1983).

Bighorn are social animals that live in groups most of the year. Ewe groups (comprised of adult ewes, yearling ewes, lambs, and young rams) generally are larger than ram groups especially during late spring and early summer when nursery bands may contain 25-100 animals (Lange 1978, NMDGF files). Mature rams generally remain solitary or in bachelor groups except during the pre-rut and rut periods (November-January), when rams and ewes gather on the same range. Bighorn sheep rely on keen vision to detect predators, and on rapid mobility on steep terrain as the principal predator evasion strategy (Geist 1971). Thus, open, steep terrain is the defining component of bighorn habitat (McQuivey 1978, Risenhoover et al. 1988, Krausman and Shackleton 2000).

Bighorn eat a wide variety of plants and their diets vary seasonally and throughout their geographic range (Todd 1975, Cooperrider and Hansen 1982, Johnson 1980, Rominger et al. 1988). Forbs generally dominate the diet, followed by grasses, and lastly browse (Krausman and Shackleton 2000). However, some low-elevation bighorn sheep populations have diets dominated by the leaves of browse species, particularly true mountain-mahogany (*Cercocarpus montanus*) (Rominger et al. 1988). Bighorn also use mineral licks, especially during summer when green, potassium-rich forage may cause an

imbalance in the potassium-sodium ratio of the intracellular fluids (Weeks and Kirkpatrick 1976). A more recent alternate hypothesis is that sodium is a required element in the biochemical pathway used by ruminants to metabolize secondary plant compounds that are often present in forbs and shrubs (Foley et al. 1995).

Unlike other ungulates in which young disperse to new areas, bighorn pass knowledge of home ranges and migration routes from 1 generation to the next (Geist 1971). Therefore bighorn do not typically recolonize ranges where they have been extirpated. Transplants are generally required to establish new populations (Singer and Gudorf 1999). The minimum size for a population to be considered viable and self-sustaining is 100, although several hundred is recommended to maintain a high level of genetic diversity (Soule 1980, Soule and Simberloff 1986, Berger 1990, Goodson 1994, Krausman et al. 1996, Wehausen 1999). Populations with fewer than 100 animals are susceptible to extinction from catastrophic events such as disease outbreaks or density independent effects including weather or predation (Thomas 1990). An additional concern of small population size is the loss of genetic diversity and the relationship to long-term persistence (Franklin 1980).

Some bighorn populations smaller than 100 animals have survived for more than 50 years (Krausman et al. 1993, Goodson 1994, Wehausen 1999). However, most of these populations were: (1) below carrying capacity and had enough habitat to increase to more than 100 bighorn (Krausman et al. 1993, Goodson 1994); (2) had been augmented with additional animals (Goodson 1994); or (3) were part of an interbreeding group of populations, known as a metapopulation (Lande and Barrowclough 1987, Wehausen 1999). The potential for interbreeding among neighboring populations is positively related to population size and proximity to neighboring populations (Gilpin 1987). Intermountain movements of 10 miles by ewes and 15-20 miles by rams have been documented for bighorn (Festa-Bianchet 1986, Dunn 1993, Ramey 1993). Transplanted bighorn sheep have been documented to move between 80-100 miles (NMDGF files, AZGF files, Torres 2000). In this plan, populations are considered viable if they have at least 100 animals, or are within 15 miles of other populations with which they could interbreed and the size of the resulting metapopulation would be more than 100 animals.

Parasites and Diseases

A variety of parasites and diseases can adversely affect bighorn sheep. Many of these diseases have been documented in New Mexico bighorn sheep.

Pneumonia, triggered either by the bacteria *Pasteurella spp.* or the virus Parainfluenza 3, is the major cause of all age die-offs in bighorn populations (Foreyt and Jessup 1982, Goodson 1982, Jessup 1985, Foreyt 1990). In Colorado, about 1 population each year contracts pneumonia resulting in a loss of 25-100% of the individuals (M. Miller, Colorado Div. Wildlife, pers. commun.). It is hypothesized that lungworms (*Protostrongylus spp.*) contribute to the susceptibility of bighorn (particularly juveniles)

to pneumonia (Foreyt et al. 1990a), but no conclusive evidence has been offered to support this hypothesis (Samson et al. 1987, Goldstein 2001). Pneumonia die-offs resulted in failed transplants in the Latir Wilderness (Sandoval 1988), Wheeler Peak Wilderness (Larson 1968, Larson 1970), and are suspected to have caused a substantial population decline in the San Francisco River population (Ahlm 2001).

Lungworms, (*Protostrongylus spp., Muellerius capillaris*) are strongyle parasites that inhabit the lungs of nearly all wild bighorn sheep in northern latitudes (Fougere-Tower and Onderka 1988). Lungworms may block airways, result in dissemination of bacteria, or reduce immunological response of a host (Demartini and Davies 1977). Adult lungworms lay eggs in the lungs, and the hatched first stage larvae are coughed up, swallowed and passed out in the feces. The larvae enter an obligatory secondary host, a land snail, which is incidentally consumed by bighorn while grazing. The larvae travel back to the lungs where they reach maturity (Anderson 1992). Currently, all drugs available to treat lungworms are only effective against the adult stage, not the larvae. Therefore multiple drug treatments will be necessary to eradicate an infection, but it will not be possible to prevent them from reinfecting themselves from the range. Infections are measured by larval load per gram of fecal matter, but it is unknown how this correlates to adult lungworm density in the lungs, what level of infection is hazardous to a bighorn, or how lungworm contributes to mortality risks.

Bluetongue, a viral disease transmitted by gnats (*Culicoides spp*.), produces ulceration of the nasal and oral cavities, tissue death in the mouth and tongue, and may cause abortions (DeForge et al. 1982, Osburn et al. 1983, Singer et al. 1998). The gnat is prevalent when conditions are warm and moist, breeding in shallow water contaminated by fecal material (Osburn et al. 1983). In 1991, the sudden death of 10% of the adults and 5% of the lambs in the captive population of desert bighorn at Red Rock was attributed to bluetongue (NMDGF files).

Contagious ecthyma, a parapox virus that produces lesions on the lips, anus, genitalia, and hooves of bighorn has been reported in Rocky Mountain bighorn sheep (Samuel et al. 1975, Blood 1971, Merwin 2000). While the disease can cause mortality, bighorn generally recover 2 to 4 weeks after the onset of symptoms (Yirrell et al. 1989, L'Heureux et al. 1996). Most mortality occurs in juveniles (Blood 1971, Goldstein 2001).

Psoroptic scabies, caused by the parasitic mite *Psoroptes ovis*, is a contagious skin disease that can effect bighorn populations (Sandoval 1980, Foreyt et al. 1990b). The mite causes pelage to loosen and slough off and extensive lesions to develop in ears and around the head. For bighorn, this results in weight loss, loss of hearing and balance, and potentially death through secondary bacterial infections or environmental stress (Lange et al. 1980, Clark and Jessup 1992).

Chronic sinusitis, a bacterial infection resulting from decaying larval stages of nasal bot flies (*Oestrus ovis*) trapped in sinus cavities, produces deterioration of bone in sinuses and horn cores and may be fatal (Bunch 1980). Chronic sinusitus has contributed to substantial declines in some desert bighorn populations (Jessup 1985). Presence of the nasal bot fly is generally associated with sympatric domestic sheep. The disease is especially prevalent in dry environments.

Elaeophoris, a disease first discovered in New Mexico Rocky Mountain and desert bighorn sheep (Boyce et al. 1998), is caused by the nematode *Elaeophora schneideri*. This disease requires a Tabanid fly vector to feed on blood infected with the microfilaria life-stage. This disease was documented in a Rocky Mountain bighorn ewe that died in the Turkey Creek population near the Gila River and in a desert bighorn ram collected after being observed in debilitated health in the Fra Cristobal population (Boyce et al. 1999). These are the only 2 cases of Elaeophoris of which we are aware. To date there does not appear to be a population level impact of this disease.

Competitors

Bighorn can be adversely affected by poor range conditions where the quality, quantity, and diversity of forage are low (Stoddart et al. 1975, Dodd and Brady 1986, Jorgenson et al. 1993). Poor range conditions in bighorn habitat generally are restricted to foothills where cattle grazing also occurs. These areas can be especially important to low-elevation bighorn because this is where new growth of forage is first available in spring. Livestock grazing can result in direct competition with bighorn sheep and also results in the removal of fine fuels necessary for fires needed to maintain open habitats used by bighorn sheep at lower elevations. During winter, alpine populations of bighorn can overgraze the windswept tundra sites and potentially may damage these sites. Large numbers of elk (*Cervus elaphus*) graze above timberline in all 3 alpine ranges during summer and fall. Cattle also graze above timberline in the 3 alpine bighorn ranges and in portions of the 3 low-elevation bighorn ranges. The effect of this potential competition is unknown.

Deer and elk generally use more gentle and more heavily vegetated habitat than bighorn, but may use the same salt licks and water sources if they are not in very steep areas. Deer and elk occur sympatrically in all New Mexico Rocky Mountain bighorn sheep ranges. Deer are generally the primary prey of mountain lions in North American ecosystems without elk (Logan et al. 1996). However, where elk are present they are generally the most prevalent diet item, particularly calves (Spreadbury 1989, Murphy 1998, D. Freddy, Colorado Division of Wildlife, pers. commun.). Water units installed for bighorn may contribute to range overlap between bighorn and deer (Smith and Krausman 1988). Elk occupy the same alpine habitat as bighorn during summer and autumn. Large groups of elk (>100 individuals) foraging above timberline may potentially overgraze foraging areas important to bighorn during winter.

Barbary sheep also known as aoudads (*Ammotragus lervia*) have been observed with Rocky Mountain bighorn in the Manzano Mountains (NMDGF files). Like bighorn, Barbary sheep occupy open, steep terrain and probably would out compete bighorn because of a higher reproductive rate and a greater ability to subsist on low quality forage (Seegmiller and Simpson 1979). Barbary sheep have been observed tending bighorn ewes during the rut and apparently are able to dominate smaller bighorn sheep rams (NMDGF files). The potential for Barbary sheep to cause an asynchronous rut by defending ewes throughout an estrus cycle is of concern and therefore the removal of Barbary sheep from bighorn range is considered imperative. Barbary sheep euthanized in bighorn ranges have been necropsied at the New Mexico State Veterinary Diagnostic Laboratory and have not been found to carry scabies nor have the 'hot' *Pastuerella* biotypes, known to cause pneumonia, been cultured from tissue samples (NMDGF files).

Predators

In New Mexico Rocky Mountain bighorn are preyed upon by mountain lions, coyotes (*Canis latrans*), bobcats (*Lynx rufus*), and golden eagles (*Aquila chrysaetos*) (Hass 1995, NMDGF files). Lion populations that primarily prey on deer and elk are able to prey-switch to bighorn sheep. If bighorn populations are at carrying capacity, such as in the alpine habitats, predation is thought to be compensatory (the mortality would occur due to some other cause if not predation) rather than additive (the mortality would be additive to base-line mortality) and has not been documented to have an effect on a population level. However, if populations are small and below carrying capacity, as in the 3 low-elevation populations, lion predation can become additive mortality and profoundly influence bighorn population dynamics (Wehausen 1992, Hayes et al. 2000, Rominger and Weisenberger 2000). Although lion predation is the primary cause of mortality for desert bighorn sheep in New Mexico (Rominger et al. 2001), no lion predation has been documented on more than 85 radiocollared bighorn in alpine ranges. In the 3 low-elevation bighorn ranges mountain lions are the primary predator (NMDGF files). Between 1997 and 2002, 15 of 50 radiocollared bighorn were killed by mountain lions in the 3 low-elevation populations.

Human Disturbance

Although considerable research has been conducted on the effect of human disturbance on bighorn sheep, the results have been ambiguous (Leslie and Douglas 1980, Cambell and Remington 1981, Hamilton et al. 1982, Krausman and Hervert 1983, Miller and Smith 1985, Weisenberger et al. 1996, Papouchis et al. 1999). Rocky Mountain bighorn sheep in New Mexico occur in areas with substantial human presence including hikers, dogs, off-road vehicles, trains, military and civilian aircraft, and researchers and managers. Considerable human interaction, driven primarily by a craving for salt (Hass 1992), has been reduced in the Pecos Wilderness population by consistently providing trace element salt blocks to bighorn (NMDGF files).

Historical Perspective

Although no genetic or skeletal materials remain from bighorn sheep extirpated from northern New Mexico, it is assumed that these bighorn sheep, particularly those found in alpine ecosystems up to 13,000 feet, were similar to other Rocky Mountain bighorn sheep. Rocky Mountain bighorn never were widespread in New Mexico, with historical evidence for just 4 populations in Wheeler Peak Wilderness, Pecos Wilderness, White Rock Canyon, and Manzano/Los Pinos Mountains (Buechner 1931, Leopold 1933). Rocky Mountain bighorn sheep were extirpated in New Mexico during the early part of the 20th century (Buechner 1931). The extirpation of Rocky Mountain bighorn sheep has been attributed to several anthropogenic events related to the arrival of Europeans including market hunting, direct competition with introduced livestock, and perhaps most importantly, the introduction of diseases from domestic livestock (Beuchner 1960).

The restoration of Rocky Mountain bighorn sheep in New Mexico began in 1932 with a transplant of 6 bighorn from Canada (Appendix A). This translocation was unsuccessful, and Rocky Mountain bighorn sheep were not established in New Mexico until 1940 in the Sandia Mountains. Additional transplants with bighorn from Canada and the Sandia population resulted in the establishment of herds in the Pecos Wilderness, San Francisco River, and Turkey Creek prior to 1966. The first transplants to the Latir and Wheeler Peak Wildernesses resulted in failures due to contacts with domestic sheep and resulting pneumonia dieoffs. However, both areas currently have viable bighorn populations with persistence for 10 years in the Wheeler Peak Wilderness and 2 years in the Latir Wilderness (Appendix A).

Population trends

Pecos Wilderness

Bighorn were extirpated from the Pecos Wilderness area in the early 1900's (Bailey 1931, Barker 1976). Restoration efforts began with a transplant from Canada in 1932, but no bighorn survived past the mid-1930's (Lange 1978). A second transplant of 24 bighorn in 1965-66 from Banff, Alberta and from the now extinct Sandia population was successful (Appendix A). In 2002 this herd was estimated to have 340 bighorn based on results of a helicopter survey, hunter-guide reports, and mathematical modeling (Table 1).

Smith and Johnson (1979) calculated the carrying capacity of the Pecos Wilderness to be 175-330 based on forage availability during winter. The population increased to ~300 in 1982 and has since fluctuated between 300 and 400 with little between year differences in the number of adults in the population. Annual variation is primarily a function of first winter lamb survival and lamb production. The population becomes more susceptible to mortality with increasing length and severity of winter. This density-dependent relationship is consistent with classic 'bottom-up' regulation, where populations are limited by forage biomass (Rominger 2003). The density on winter range is ~23 bighorn/km^2 when the population is 400 and is ~17 bighorn/ km^2 when the population is 300. The density of this population is perhaps the best metric for estimating carrying capacity of the other 2 alpine populations (Rominger 2000b).

Herds that remain at carrying capacity are not at optimum herd size (Jorgenson et al. 1993). Individuals in populations with stable numbers tend to be physically smaller, presumably from a reduction in the per capita availability of resources, and have lower lamb:ewe ratios due to high lamb mortality (Geist 1971). Populations at carrying capacity produce mature rams with smaller horns, and animals in poor condition are more susceptible to a variety of mortality risks (Owen-Smith 1990, Gulland 1992, Crete and Huot 1993).

The Pecos Wilderness population has been the only New Mexico source of Rocky Mountain bighorn sheep for translocations since the 1966 transplant from the Sandia Mountains (Appendix A). Since the initial transplant from the Pecos herd in 1977, > 191 bighorn have been captured in the Pecos Wilderness. The number of bighorn sheep removed during each trap ranged from 16 to 63 and represented between 3% and 17% of the estimated population (NMDGF files). Since 1993, the 3 traps in the Pecos Wilderness have removed an average of 45 bighorn or 12.4% of the pre-trap population. Average number of ewes removed (mean = 28) has been approximately 21% of the estimated ewe population during the last 3 traps (NMDGF files). Average number of rams removed/trap (mean = 9) has been approximately 6% of the estimated ram population during the last 3 traps (NMDGF files). Since 1996, annual ram harvest (mean = 8.8) has averaged 6 %.

The Pecos population has returned to pretrap numbers within 2 years of each of these traps (NMDGF files). Jorgenson et al. (1993) recommended the removal of 12% of ewes annually, based on conservative estimates of the population. The long-term estimate (1989-2002) of the number of ewes in the Pecos population has been 137. The biennial removal of 24% of the ewe population would require the capture of approximately 33 ewes. A consistent biennial removal of approximately 24% of the ewe population, combined with a similar removal of rams through harvest and trapping will probably be required to keep the population below carrying capacity. An understanding of distinct subpopulations within herds is necessary when implementing captures (Stevens and Goodson 1993).

Wheeler Peak Wilderness

Bighorn sheep occupied Wheeler Peak until the late 1800's (Bailey 1931). Reintroductions have been attempted 3 times (Appendix A). Ten bighorn were released in February 1968. During the following summer, 600 domestic sheep grazed in bighorn habitat and by fall, no bighorn were observed in the area (Larsen 1968). Nineteen bighorn were released in January 1970, but the following summer, 300 domestic sheep grazed in bighorn habitat and few bighorn survived (Larsen 1970). Thirteen observations of bighorn or their sign were made in the Wheeler Peak area between 1978 and 1991 (Dunn 1993), but there was no indication of a viable population. In August 1993, 33 bighorn from the Pecos Wilderness population were released in the Wheeler Peak area (Mabe 1994). At least 4 resident bighorn were observed following the transplant (Mabe 1994). By 2000, the population had grown to an estimated 180 (Rominger et al. 2001).

Recent census data have not improved the estimate, and therefore the 2002 population estimate is 230 (Rominger and Goldstein 2002c).

The Wheeler Peak herd is divided into 2 subpopulations using habitat on the Wheeler Peak complex and Gold Hill. Gold Hill appears to have a carrying capacity of < 60 bighorn. The population of ewes and lambs peaked in 2000, at 59 but has not increased since then (Rominger and Goldstein 2002c). Monitoring radiocollared ewes between 1993 and 1999 never documented movement of ewes between the 2 subherds. However, rams observed during the summer on Vallecitos and Frazer Mountains, have been observed on Goldhill during the rut. We believe that this subpopulation is currently at carrying capacity because it has not grown for several years. As with the Pecos herd, it is important to manage this herd below carrying capacity to have rams with large horns and to lower the risk of a catastrophic die-off from a disease outbreak.

Latir Wilderness

No available historic records document bighorn in Latir Wilderness. However, it is probable that bighorn historically occupied the area because it is only 9 miles north of Wheeler Peak and 12 miles south of the Colorado portion of the Culebra Range, both historic ranges. Based on Festa-Bianchet (1986) and Dunn (1993), rams have the ability to move through the 9 miles of broken timber to the Latir Wilderness.

In 1978, 20 bighorn were transplanted from Pecos Wilderness to Latir Wilderness (Lange 1978). The population grew to 36, but during July 1981, 115 domestic sheep were grazed in bighorn habitat (Saiz 1981). In 1983, only 1 ewe was observed during a population survey. The die-off was caused by pneumonia attributed to association with domestic sheep (Sandoval 1988). The USFS domestic sheep grazing allotment was converted to cattle in 2000. In 2001, 56 bighorn, comprised of 11 lambs, 8 rams, and 37 ewes, were transplanted from the Pecos Wilderness to the Latir Wilderness (Appendix A). High survival (only 1 over-winter mortality) and high recruitment resulted in an increase to ~ 90 bighorn the first year post-transplant.

San Francisco River

Although no specimens exist from the historical population, desert bighorn sheep are assumed to be the subspecies present until the mid-1800's (Buechner 1960). In 1964, 16 Rocky Mountain bighorn were transplanted to Sheridan Ridge in the Mogollon Mountains from the Sandia Mountains (Appendix A). However, these bighorn moved west to the San Francisco River drainage within a year. Although no rams were released in the transplant that occurred before the rut, a mature ram appeared during the rut and all the mature ewes were apparently bred (A. Ford, pers. commun.). This ram is assumed to have come from the Turkey Creek population and therefore the potential for a metapopulation link exists between these herds.

The population grew to an estimated 140-170 (Hayes 1982), but suffered a die-off about 1994 that was likely caused by disease (Ahlm 2001). The herd declined to <40

individuals and experienced low lamb recruitment for several years after, which are characteristic trends of a pneumonia outbreak. The population has increased since 1998 and is currently estimated to 65 individuals in the New Mexico portion of the habitat (Rominger and Goldstein 2002b). The Arizona portion of the San Francisco River population has not increased in recent years and is thought to number <50 (D. Cagle, AZDGF, pers. commun.). Domestic sheep are raised on a ranch that is contiguous with bighorn sheep habitat in the Arizona portion of the San Francisco River. The San Francisco River herd is part of a metapopulation currently comprised of about 750 bighorn which includes populations in Eagle Creek, Bear Canyon, Fotte Creek, Black River, and Nantek Rim in Arizona (D. Cagle, Arizona Department Game and Fish, pers. commun.).

Turkey Creek

The population is divided into 2 distinct subpopulations that are generally found on Watson Mountain along the Gila River and within Hells Half Acre about 7 miles away (Huddleston-Lorton 2000). As in the San Francisco River, the bighorn sheep reported in the Turkey Creek area until the mid-1800's were probably the desert subspecies (Buechner 1960). In 1964, 10 Rocky Mountain bighorn from Banff National Park were transplanted to Turkey Creek (NMDGF files). This population was augmented with 5 bighorn sheep from the Pecos Wilderness in 1998. In 2002 the population was estimated to be 45 (Rominger and Goldstein 2002b).

Movements of Turkey Creek bighorn to Sheridan Ridge (where the San Francisco River population was originally released) in 1964 suggest that interchange between these populations is possible (Hayes 1982). However, none of 22 bighorn radiocollared in 1987, 1997 and 1998 left the Turkey Creek population during 9 years of monitoring (Huddleston-Lorton 2000, NMDGF files).

Manzano/Los Pinos

Bighorn existed in the Manzano and Los Pinos mountains until the 1880's and were observed from Hell's Canyon in the central Manzano Mountains to Yeso Mesa at the southern end of the Los Pinos Mountains (Leopold 1933).

Because of the location of this population it is probable that bighorn typically considered to be the Rocky Mountain subspecies from the Sangre de Cristo Mountains and bighorn that are typically considered to be the desert subspecies from the San Andres Mountains could have interbred. The existence of this 'cline' within bighorn populations is a more accurate reflection of the potential for genetic mixing although it conflicts with the traditional taxonomic concept of subspecies. Because no specimens of the original bighorn exist, any speculation would be just that. A radiocollared ewe and young ram moved from Sand Canyon south to Stallion Gate following their release in 1998 and bighorn were also observed to move north to I-40 in eastern Albuquerque. These locations are approximately 100 miles apart (NMDGF files).

In 1977-78, 32 bighorn were transplanted from the Pecos Wilderness to the Manzano Mountains (Donaldson 1978). The herd was never determined to increase above 30 and by 1998 had declined to fewer than 20 individuals (Rominger 1997). A transplant of 23 bighorn sheep from the Pecos Wilderness temporarily increased the herd above 30, however in 2002 it declined to 20-22 individuals (Rominger and Goldstein 2002b). Bighorn sheep occur almost exclusively in the Sand Canyon and Abo Canyon drainages in the southern portion of the Manzano Mountains. However, rams and ewes are occasionally seen in the Los Pinos Mountains (NMDGF files).

Mountain lion predation and trainstrikes are the primary cause of bighorn mortality in the Manzano population. Between 1998 and 2003, 7 radiocollared bighorn were killed by mountain lions (Rominger and Goldstein 2002b). Between 1998 and 2002, 8 radiocollared bighorn were killed by trainstrike and another 9 uncollared bighorn were killed (NMDGF files). An additional 6 bighorn were reported to have been hit and killed but no carcasses were recovered (BNSF train conductors, pers. commun.). Bighorn are also vulnerable to illegal harvest because of access provided by roads.

Habitat trends

Bighorn sheep habitat in New Mexico, as in most of the west, has been reduced due to encroachment of woody vegetation (Wakelyn 1987, Dick-Peddie 1993, Huddleston-Lorton 2000). Increased woody vegetation decreases visibility within habitats and results in behavioral exclusion of bighorn sheep and increased levels of predation when using habitats with poorer visibility. Exclusion of fire over the past 100 years has allowed shrubs and pinyon and juniper trees to encroach into once open habitat (Wright and Bailey 1982, Wakelyn 1987, Huddleston-Lorton 2000), thereby decreasing the amount of usable bighorn habitat. While fire suppression policies of land management agencies over the past 80 years has contributed to the lack of fires, livestock grazing is the primary factor leading to the absence of fire. Grazing reduces fine fuel loads so that fires cannot carry in these habitats. Increased density, size, and percent canopy cover of pines, junipers, and oaks (*Quercus spp*.) have decreased visibility for bighorn, and provide additional cover for predators (Huddleston-Lorton 2000). Reduced visibility inhibits bighorn's ability to detect predators and reach escape terrain in time to avoid predation. As a result, mountain lions are a primary source of mortality in these habitats. Pinyon-juniper encroachment is a concern primarily in low-elevation habitats (Risenhoover et al. 1988).

Alpine habitat in New Mexico is primarily restricted to sites above 12,000ft (3,658m). Because Rocky Mountain bighorn sheep in alpine habitats are restricted to alpine habitat during winter, the continued presence of this ecosystem will be required to maintain populations. One predicted effect of global warming is the loss of alpine habitat due to the increased elevation of timberline.

Habitat Assessment

Because of the need for open vegetation, bighorn are limited mostly to areas above (i.e., alpine habitat) or below (i.e., low-elevation habitat) forests and woodlands. Rocky slopes greater than 60% are considered steep enough to be escape terrain (Hansen 1980, McCarty and Bailey 1994). Escape terrain is especially important for ewe-lamb groups because of the high vulnerability of lambs to predation (Sandoval 1979, Holl and Bleich 1983, Berger 1991, Bleich 1997). Less steep terrain is generally used for foraging and travel between areas of escape terrain (Berger 1991).

During winter, habitat use of bighorn in alpine ecosystems is restricted by deep snows. Many alpine populations migrate to low elevation winter ranges (Geist 1971, Festa-Bianchet 1986), but in New Mexico, bighorn remain on windswept, snow-free slopes within alpine habitat (Smith and Johnson 1979). Most mortality in alpine populations occurs during winter when weather is severe and forage quality and availability is low (Hass 1993).

Unlike alpine populations, low-elevation populations generally do not have distinct seasonal ranges (McCarty and Bailey 1994). However, these populations may restrict their ranges to areas near water during hot, dry weather when water requirements are high. Ewes with lambs generally remain within 2 miles of water sources that are in open habitat and close to escape terrain (Leslie 1978, Leslie and Douglas 1979, Sandoval 1979, Bleich 1997).

Areas evaluated for their potential as Rocky Mountain bighorn habitat by Dunn (1993) are discussed below in the order of their suitability. Alpine areas such as Touch-Me-Not Mountain, Baldy Mountain, and Little Costilla Peak, and low-elevation areas such as Cimarron Canyon and Rio Chama were not evaluated because they contained little open habitat. Bighorn sheep are occasionally reported in these ranges. Bighorn sheep were observed from the air on Baldy Mountain in 1999 (D. Jones, NMDGF pers. commun.), and a Class II ram was captured near the town of Cimarron in 1999 and transplanted to the Manzano Mountains.

Rocky Mountain bighorn sheep currently occupy 6 ranges in New Mexico (Figure 1). Four additional ranges are currently unoccupied by breeding populations of bighorn sheep (Figure 2).

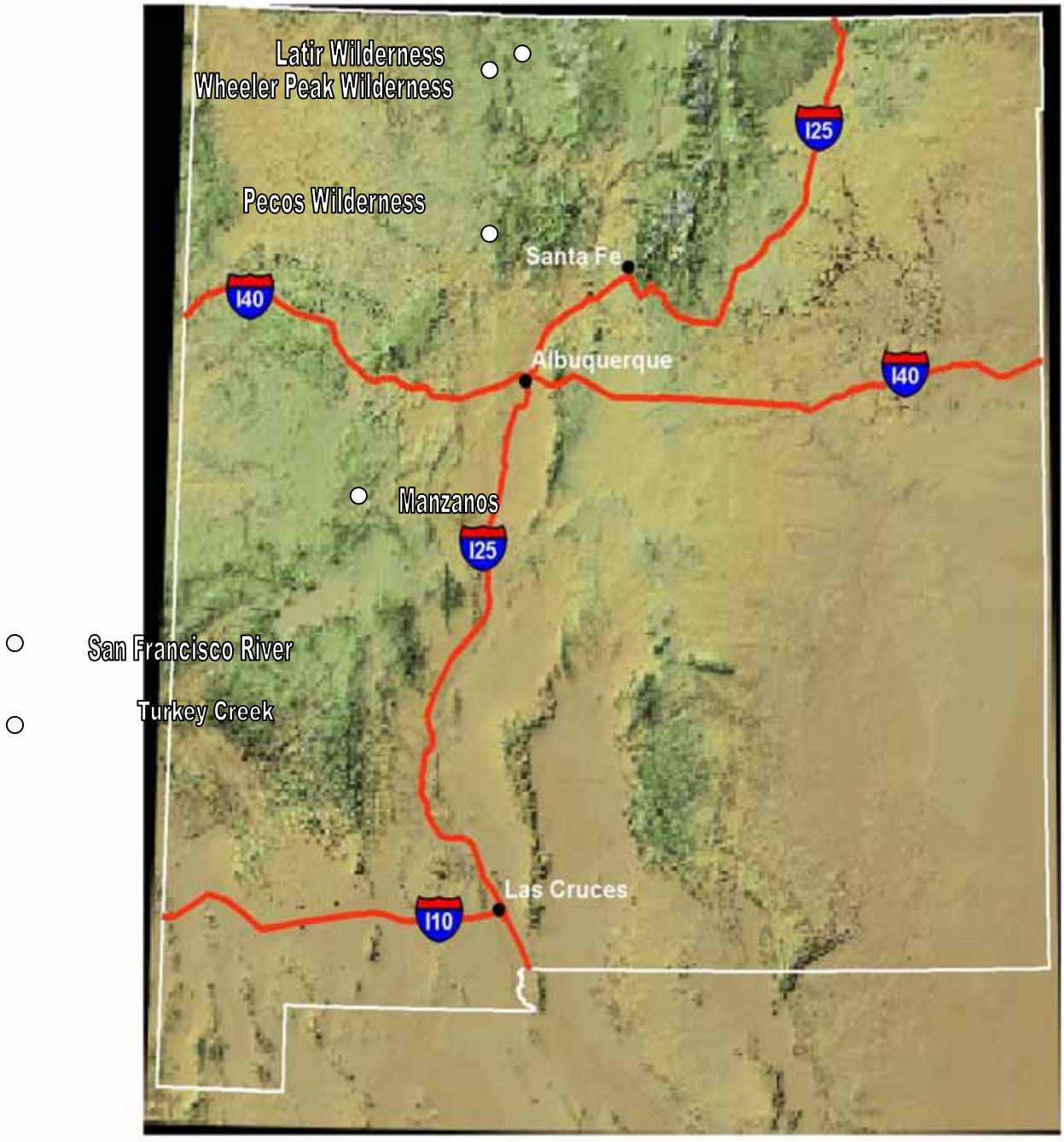

Figure 1. Occupied Rocky Mountain bighorn sheep ranges in New Mexico 2003.

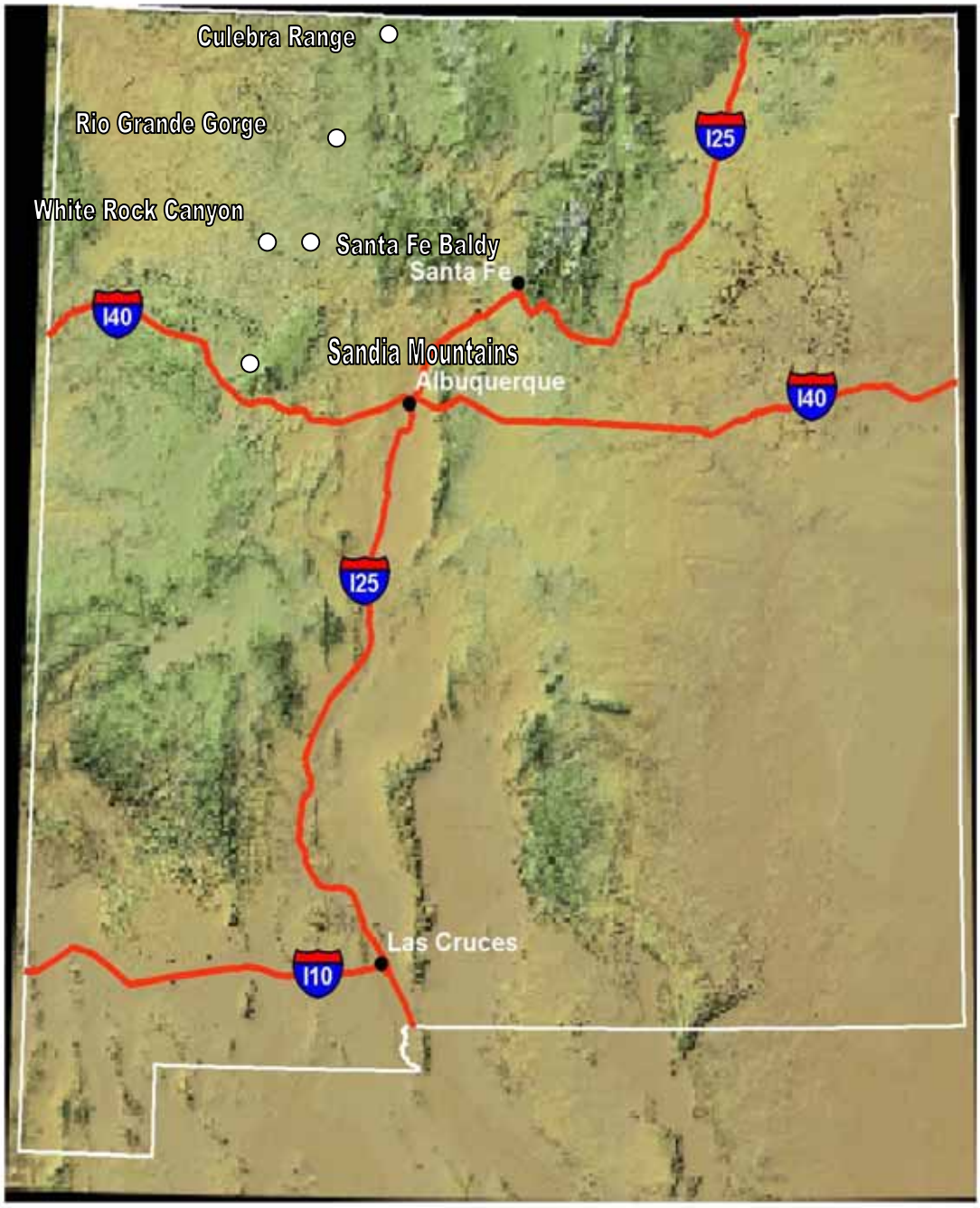

Figure 2. Unoccupied Rocky Mountain bighorn ranges in New Mexico 2003.

Occupied Alpine Habitats

Pecos Wilderness. The Pecos Wilderness is managed by the Santa Fe and Carson National Forests and contains the most bighorn habitat (64.4 km^2) of all alpine areas in New Mexico (Dunn 1993). During summer, most ewe-lamb groups reside in the area of the 2 major lambing sites: Pecos Baldy complex and the Truchas complex. Sexual segregation occurs in this population with most rams using habitat from Chimayosas Peak to Jicarita Peak in the northwest portion of the range. Winter range occurs within 25% of the summer range (17.5 km^2), and is centered on windswept slopes that provide foraging sites (Dunn 1993).

The Pecos receives a high amount of recreation use, but bighorn do not appear to be adversely affected. Most recreational use occurs during a limited period (80% from July through September) and in a limited area (mostly at Pecos Baldy Lake and Truchas Lakes). In the past, Pecos bighorn have exhibited very tame behavior, approaching people for food or salt and consuming charcoal in fire pits. A sodium deficiency in their diet was the suspected cause of this behavior (Hass 1990, Montgomery 1991). Since 1991, salt blocks have been horse-packed to specific sites and bighorn-human interactions have decreased substantially (Hass 1991, 1994, 1995).

Wheeler Peak. The Wheeler Peak area occurs within Carson National Forest and Taos Pueblo lands and has less bighorn habitat (52.2 km^2) than in the Pecos Wilderness, but contains more escape terrain (Dunn 1993). Winter range occurs within 18% of the summer range (10.6 km^2). Using the carrying capacity estimates from the Pecos population (Rominger 2000b) the Wheeler Peak population carrying capacity would be 243 based on the highest density and 180 based on the lower density (Rominger 2000b).

Wheeler Peak is heavily used by recreationists during summer and occasionally used by cross-country skiers and snowshoers during winter (Dunn 1993). Bighorn sheep salt sites have been maintained since 1993 to reduce the interaction with humans. However, there has been considerable interface of bighorn and humans at Goose Lake at the base of Goldhill.

Latir Wilderness. Bighorn sheep habitat in Latir Peaks is managed primarily by Carson National Forest, but 15% is owned by Rio Costilla Cooperative Livestock Association, a 175 member grazing cooperative, and another small portion is managed by Dharma Properties, Inc. Latir bighorn habitat is 28% as large (18.2 km^2) as the Pecos Wilderness (Dunn 1993). Based on the Dunn (1993) analysis, winter range encompasses just 18% of the summer range (3.3 km^2). Using the carrying capacity estimates from the Pecos population (Rominger 2000b) the Latir population carrying capacity would be 76 based on the highest density and just 56 based on the lower density (Rominger 2000b). Dunn (1993) predicted a potential population size of 75-150, using a summer habitat ratio with the Pecos population and adjusting for the quality of the habitat. This herd will need to be monitored closely to minimize the possibility of overshooting carrying capacity.

Currently the recreational impacts in the Latir Wilderness are light compared with Wheeler Peak Wilderness and Pecos Wilderness. There are 2 maintained trails within bighorn habitat and designated campsites at Latir and Heart Lakes (Dunn 1993). This area may be able to support 100-150 bighorn depending on the limitations of winter range (Table 1). This population will become part of a metapopulation potentially totaling more than 800 bighorn that would include the Wheeler Peak and the Culebra (New Mexico/Colorado) populations (Dunn 1993).

Unoccupied Alpine Habitats

Culebra Range. The Culebra Range extends from southern Colorado, at State-line Peak, south to Big Costillo Peak in New Mexico. The alpine portion of this range is 100% privately owned by The Vermejo Ranch (Turner Enterprises), and Rio Costillo Cattle and Livestock Association. No available historic records document bighorn in the New Mexico portion of this range. However, bighorn were found around Culebra Peak in Colorado until the early 1900's (Bailey 1931), so it is probable that they used the New Mexico part of the range occasionally. Bighorn rams have been observed in helicopter surveys in 2000 and 2001 (Rominger 2000a, Rominger and Goldstein 2001). A ewe-lamb group was photographed in 2001 (B. Long, pers. commun.). It is assumed that these bighorn are from Colorado where the population has continued to expand and may be >400 (C. Wagner/B. Holder, Colorado Division of Wildlife, pers. commun.), although they could have been from Wheeler Peak.

Alpine habitat is steep and rugged in the Colorado part of the range. The Culebra Range contains the third largest amount of alpine habitat in New Mexico (30 km^2), but it is a large, rolling, west-facing mesa. Escape terrain is limited mostly to an east-facing escarpment that parallels the mesa. Winter range occurs on 19% of the summer range (5.6 km^2), but in the Dunn (1993) analysis, does not contain escape terrain. Aerial observation of this habitat during winter suggests that winter range adjacent to escape terrain may be limited but the juxtaposition does occur (NMDGF photos). Based on the Pecos Wilderness winter carrying capacity estimate (Rominger 2000b), alpine habitat in the New Mexico portion of the Culebres could support ~95 bighorn. Bighorn sheep transplanted to the Culebra range might move to better habitat in Colorado. However, the Culebra Range in New Mexico will be critically important as a movement corridor for the Wheeler Peak-Latir Wilderness-Culebra Range (Colorado) bighorn metapopulation. Given its location between the Colorado Culebra and the Latir bighorn populations, it is likely that there would eventually be a self-starting herd in the New Mexico Culebras.

Santa Fe Baldy. Santa Fe Baldy is in the Santa Fe National Forest. Barker (1976) reported a ewe killed in this area in 1902, but it probably was a remnant of the Pecos Wilderness population. Bighorn from the current Pecos Wilderness population are observed around Santa Fe Baldy occasionally, but it is unlikely that this area could support a viable population. Santa Fe Baldy has the least amount of habitat of 5 alpine

areas analyzed by Dunn (1993) and is heavily used by recreationists. No bighorn have been observed on Santa Fe Baldy during the 7 most recent helicopter surveys (1996-2002; NMDGF files).

Occupied Low-elevation Habitats

San Francisco River. San Francisco River canyon is mostly within the Gila National Forest and contains the most bighorn habitat of all low-elevation ranges in New Mexico, but only a moderate amount of escape terrain compared with large alpine habitats in New Mexico (Dunn 1993).

Poor range conditions, primitive roads, fences, and high human activity at the hot springs impact about 20% of bighorn habitat in the New Mexico portion of the San Francisco River habitat (Dunn 1993). Recent efforts to enforce laws regulating the number of days individuals may camp on USFS lands may decrease human impacts in this population. Since 1998, the majority of observations of bighorn sheep in the San Francisco River drainage have been from the Alma Box to the Dry Creek tributary (Ahlm 2001, NMDGF files).

Turkey Creek. Most bighorn habitat in the Turkey Creek area is within the Gila National Forest, with some use of private property along Bear Creek. This area has a relatively large amount of habitat, but the least contiguous and smallest amount of escape terrain of all low-elevation ranges in New Mexico (Dunn 1993).

Impacts to bighorn include poor range conditions and off-road vehicle activity. Dunn (1993) found a large amount of range in poor condition, but the Nature Conservancy subsequently purchased a ranch and grazing allotment on Watson Mountain and cattle have been removed from some key bighorn habitat. Reduced habitat in Turkey Creek might not support more than 75 bighorn because of limited escape terrain and woody vegetation encroachment (Dunn 1993, Huddleston-Lorton 2000). A stand replacing wildfire in the upper reaches of Turkey Creek occurred in 2003. The potential for bighorn to use this area may expand the current range of this herd.

Manzano and Los Pinos Mountains. The Manzano and Los Pinos mountains contain the second greatest amount of habitat and escape terrain of all low-elevation ranges in New Mexico (Dunn 1993). This habitat could potentially support 150 bighorn. About 43% of bighorn habitat in the Manzano Mountains is managed by Cibola National Forest and 57% is privately-owned. The Los Pinos Mountains is entirely within the Sevilleta National Wildlife Refuge, a long-term ecological research site not open to the public.

Habitat of the 2 mountain ranges is visually different with the more xeric Los Pinos Mountains having less woody vegetation and a more open mosiac and the more mesic Manzano Mountains having more woody vegetation with forested habitats at higher elevations. Based on historical photos of these habitat types in New Mexico, both

mountain ranges are assumed to be of much lower quality sheep habitat than existed historically because of vegetation encroachment (Huddleston-Lorton 2000). Restoration of a fire regime will be required for bighorn sheep to use much of the potential habitat in the Manzano Mountains.

Unoccupied Low-elevation Habitats

Rio Grande Gorge. Most bighorn habitat in Rio Grande Gorge, between Pilar and the Red River confluence is managed by the Bureau of Land Management (BLM), although a small amount is privately owned. No historic records document bighorn in the Rio Grande Gorge, although the presence of bighorn sheep down-river in White Rock Canyon would suggest that they could have been present. The Rio Grande Gorge has slightly less habitat (77 km^2) than San Francisco River, but substantially more escape terrain. This area potentially could support 150 bighorn (Dunn 1993) (Table 2), but a major effort would have to be undertaken to remove domestic and feral sheep from the area. When bighorn sheep come into contact with domestic sheep, invariably bighorn sheep contract pneumonia and suffer a large-scale die-off (See Disease Section). At least 2 domestic sheep herds graze adjacent to Rio Grande Gorge (including on private land) annually, 1 herd is moved across the gorge in spring and fall, and feral sheep have been observed in the gorge (R. Maggio, BLM, pers. commun.). In addition, primitive roads along the rim of the gorge could provide access for illegal harvest.

White Rock Canyon. Bighorn habitat in White Rock Canyon occurs within Bandelier National Monument, Santa Fe National Forest, Los Alamos National Laboratory, San Ildefonso and Santa Clara Pueblos and on private land. Bighorn occupied White Rock Canyon until the 1880's (Bailey 1931). This area contains a moderate amount of bighorn habitat, but large patches of escape terrain and abundant water. It could potentially support approximately 125 bighorn. This herd could be vulnerable to illegal harvest because of primitive roads at the eastern edge of the canyon (Dunn 1993).

Sandia Mountains. No available historic records document bighorn in the Sandia Mountains despite use of the foothills by Spaniards for grazing as early as the 1600's (Baisan and Swetnam 1995). However, it is possible that bighorn from the Manzano-Los Pinos population occupied the Sandias occasionally. Nine Rocky Mountain bighorn were transplanted to the Sandia Mountains in 1939-41 (Freeman 1959). Intensive pre-release lion control was conducted by 2 hunters prior to the release of these bighorn from Canada (F. Hibbens, pers. commun.). The population was estimated to be greater than 100 in the early 1960's (Freeman 1961) and bighorn were trapped from this population between 1964 and 1966. However, the population began to decline in the mid-1970's (Donaldson 1978) and was considered extinct soon after the last recorded sighting in 1992. The causes of this extinction are unknown.

The Sandias have the smallest amount of habitat and second smallest amount of escape terrain of all low elevation ranges in New Mexico (Dunn 1993). Most of the western

escarpment is covered by vegetation too dense for bighorn. Dense patches of mountain mahogany and associated species occur at lower elevations whereas dense Gambel oak (*Quercus gambelii*) with some patches of ponderosa pine and Douglas fir occur at higher elevations. The absence of fire for more than 200 years may have contributed to an increase in dense vegetation, although Baisan and Swetnam (1994) suggest that fire starts from lightning on the western escarpment may have always been rare and had difficulty spreading across the rugged terrain.

Bighorn habitat in the Sandias is impacted by trails and picnic areas, recreational use of the crest, and houses at the base of the western escarpment. Recreational use in the Sandia Ranger District has increased from about 1 million visitor days per year in the 1960's to 2 million visitor days per year in the 1990's (L. Cosper, Cibola Natl. For., pers. commun.), but this does not reflect the full magnitude of human impacts. Intense year-round recreational use, activity both at the crest and in residential areas at the base of the mountain, and the presence of feral dogs (NMDGF files) leaves little open, steep habitat where bighorn would not be disturbed. A consensus of bighorn sheep biologists feels that the current habitat in the Sandia Mountains would not support a viable population of bighorn sheep.

Management Assessment

Supply and Demand Assessment

Rocky Mountain bighorn sheep have been hunted in New Mexico since 1959 with a total of 320 rams harvested through the 2003 hunting season. This includes 89 permits for the Sandia Mountains population from 1959-74 (25 rams harvested; 28% success), 122 permits for the San Francisco River population from 1970-2000 (114 rams harvested; 93% success), 16 permits for the Turkey Creek population from 1989-1994 and 2001-2003 (11 rams harvested; 73% success), 15 in the Wheeler Peak Wilderness population since 1999 (100% success), and 272 permits for the Pecos Wilderness population since 1970 (145 rams harvested; 53% success; 94% success since 1990).

Prior to 1978, hunt strategies were quite liberal. For example, 60 of the 89 permits for the Sandia Mountains population were granted between 1959-61 and 102 of the 272 permits for the Pecos Wilderness were issued between 1974-1978. The current strategy is much more conservative and designed to ensure a quality hunt (i.e., low hunter pressure, high success rate and good opportunity for harvesting trophy quality rams). The number of permits issued is based on population trend, ram to ewe ratio, total number of rams, and ram age structure. In recent years the ram harvest from the Wheeler Peak herd and the Pecos Wilderness herd have been an estimated 5% and 9% of the estimated ram population respectively.

The demand to hunt Rocky Mountain bighorn in New Mexico is high. For example, 1,441 hunters applied for 11 permits (8 for Pecos Wilderness, 1 for Turkey Creek, 2 for Wheeler

Peak Wilderness) in 2002. These are the highest demand hunting licenses in New Mexico and therefore have the longest draw-odds. To maintain a high quality hunting experience, it is unlikely that the Department will issue permits for more than 20 rams per year even if the Latir Wilderness and San Francisco River populations are hunted. Between 1998 and 2003, hunter success for Rocky Mountain bighorn sheep has been 95% (73 of 74) and 52% (38 of 73) of the harvested rams scored more than 170 Boone and Crockett (B&C) points. These include new state record Rocky Mountain bighorn sheep for both archery (189 4/8 B&C) and rifle (195 2/8 B&C).

Economic Impact Assessment

Currently the 11 public-draw Rocky Mountain bighorn sheep tags generate ~$18,000 in annual license fees and application fees ($99 resident/$3,016 nonresident). In 1989, the New Mexico Legislature authorized the sale of 1 bighorn sheep hunting permit to the highest bidder at the annual Foundation for North American Wild Sheep (FNAWS) convention. Winning bids for a Rocky Mountain bighorn sheep license in New Mexico have been as high as $157,500. Between 1991-2003, $1,086,300 were raised through the sale of this permit and monies have been used exclusively for bighorn sheep restoration and management in New Mexico. In 1999 the New Mexico Legislature authorized the sale of 1 bighorn sheep hunting permit via a public raffle. This raffle has been organized by the New Mexico Chapter of FNAWS and has raised ~$170,000 in the first 3 years. The level of demand is expected to continue to be high, especially because New Mexico has harvested such quality rams in recent years.

Between 1991 and 2003, >$2,365,000 has been spent on bighorn sheep research and management projects in New Mexico using auction and raffle funds. Seventy-five percent of the cost of the majority of restoration and management projects are reimbursed with Federal Aid in Wildlife Restoration monies (funds derived from federal excise taxes on sporting arms and ammunition).

In addition, to monies generated for the New Mexico Department of Game and Fish, many hunters hire guides to assist them when hunting bighorn sheep. Although relatively few hunters are lucky enough to hunt bighorn sheep, the monies spent by these hunters for guides, taxidermists, travel, food, and accommodations in New Mexico is substantial. No data are available on the nonconsumptive user expenditures. Negative economic impacts are minimal with traffic accidents or depredation reported very rarely.

Special Considerations

The susceptibility of bighorn sheep to diseases and parasites transmitted during contacts with domestic sheep and goats and the continuing loss of low elevation habitat constitute circumstances to which this plan must give special consideration.

Summary and Conclusions

The Department has worked since 1932 to restore Rocky Mountain bighorn sheep to historical habitats in New Mexico. Populations have increased from zero to approximately 800. The high value of Rocky Mountain bighorn as hunting trophies, as a highly visible wildlife species, and as integral components of many ecosystems will require continued management effort.

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Long Range Plan

Management Strategy Section

GOAL: To restore Rocky Mountain bighorn sheep into all available habitat in New Mexico to maximize the ecological, economic, recreational, and aesthetic interests of majority of New Mexico residents.

OBJECTIVE: Use strategies developed in the plan to mitigate impediments to the restoration of Rocky Mountain bighorn sheep by 2014 to facilitate the maximum ecological, economic, recreational, and aesthetic goals of the majority of New Mexico residents.

Issues and Strategies

ISSUE 1. The diverse and sometimes conflicting interests of land management agencies, Indian tribes, private landowners, and other affected groups or individuals may complicate attaining increased public satisfaction.

Strategy 1.1 Involve those who may be affected by this plan in evaluating and implementing bighorn sheep management strategies.

ISSUE 2. The current distribution and abundance of Rocky Mountain bighorn sheep are inadequate to satisfy New Mexican's ecological, economic, and recreational interests.

Strategy 2.1 Establish and maintain healthy self-sustaining herds of Rocky Mountain bighorn sheep in 90% of suitable habitats in accordance with the following objective parameters, the attainment of which may be expected to satisfy New Mexican's ecological, economic, and recreational interests.

Strategy 2.2 Monitor population dynamics, distribution, and health of bighorn herds.

Strategy 2.3 Thoroughly census all bighorn populations annually.

Strategy 2.4 Investigate population declines and implement management strategies to reverse them.

Strategy 2.5 Establish transplant rates that ensure protection of the source population.

Strategy 2.6 Establish harvest levels that will not adversely affect population viability or the number of mature rams.

Strategy 2.7 Consider initiation of ewe harvests in populations that are above carrying capacity and surplus individuals are not needed for transplants.

Strategy 2.8 Incorporate management approaches used by other wildlife agencies to maintain alpine populations within carrying capacity.

Strategy 2.9 Cooperate with other western states to trade excess bighorn that are not required in New Mexico.

Strategy 2.10 Mitigate limiting factors to allow populations to increase to a minimum of 100 individuals.

ISSUE 3. Diseases and parasites carried by domestic and feral sheep, and possibly by domestic goats, can cause widespread die-offs of bighorn sheep, thereby impeding restoration of bighorn populations.

Strategy 3.1 Work with land management agencies and private landowners to prevent contact between bighorn and domestic sheep and goats.

Strategy 3.2 Work with land management agencies and private landowners to convert domestic sheep and goat allotments in potential bighorn habitat to allow for the reintroduction of bighorn sheep.

Strategy 3.3 Work with the private sector to retire domestic sheep and goat allotments that are in potential bighorn habitat.

Strategy 3.4 Ensure that all domestic sheep and goats have been removed before transplanting bighorn into former allotments.

Strategy 3.5 Eliminate feral sheep and goats from potential and occupied bighorn range.

Strategy 3.6 Permanently remove and examine any bighorn that has contacted or potentially contacted domestic or feral sheep to reduce the probability of disease transmission to the remainder of the bighorn population.

Strategy 3.7 Continue to prohibit the use of goats as pack animals in alpine bighorn habitats and work to prohibit their use in low-elevation habitats as well.

Strategy 3.8 Review the most recent literature on diseases of other domestic livestock including any ungulates that might come into contact with bighorn sheep.

ISSUE 4. Livestock operators concerns for the potential transmission of diseases and parasites from bighorns to domestic livestock may create opposition to establishing the bighorn populations necessary to meet ecological, economic, and recreational interests.

Strategy 4.1 Sample all captured bighorn for the presence of diseases of mutual concern to the Department and the livestock industry.

Strategy 4.2 Do not release bighorn of questionable health.

Strategy 4.3 Thoroughly investigate and, if feasible, treat disease outbreaks.

Strategy 4.4 Design and place water units and salt stations to reduce overlap of bighorn and cattle.

ISSUE 5. Brush encroachment and lack of water may restrict habitat use by bighorn and preclude the recovery of this species into historical habitat.

Strategy 5.1 Work with land management agencies and private landowners to control tree/brush encroachment by using techniques including control burns, and mechanical and/or chemical treatments to create a more open landscape for bighorn sheep.

Strategy 5.2 Work with land management agencies and private landowners to ensure optimum water distribution. Consider the potential adverse impacts of attracting predators, livestock, and deer with additional water units.

ISSUE 6. Human related disturbances may negatively affect the viability of bighorn populations and preclude the recovery of this species into historical habitat.

Strategy 6.1 Work with land management agencies and private landowners to:

(a) maintain unfragmented habitat (including travel corridors between populations),

(b) limit disturbance during periods critical to the welfare of bighorn populations,

(c) modify fences to ensure safe crossing by bighorn,

(d) establish and maintain salt stations where needed to reduce human-bighorn interactions,

(e) minimize mining and construction activities in bighorn habitat,

(d) mitigate road or railway mortality.

ISSUE 7. Successful implementation of planned strategies is dependent upon public understanding and support.

Strategy 7.1 Develop educational programs about bighorn sheep biology, behavior, and habitat requirements for presentation to schools, wildlife organizations, sportsmen groups, and other interested groups.

Strategy 7.2 Establish viewing sites where they won't be detrimental to bighorn.

Strategy 7.3 Provide quality hunting when monitoring indicates that a population can sustain hunting without adversely affecting population viability.

ISSUE 8. Poor range conditions adversely affect bighorn populations by reducing the quality of bighorn diets and by the elimination of fine fuels required to carry fire.

Strategy 8.1 Work with land management agencies to create basic monitoring program for bighorn sheep ranges to ensure that fine fuels are available for control burn programs.

Strategy 8.2 Encourage grazing management that will maintain high quality forage for both livestock and bighorn**.**

ISSUE 9. Predation can be a significant mortality factor for bighorn populations and may delay or inhibit the restoration of populations.

Strategy 9.1 Transplant a minimum of 30 bighorn to compensate for initial high predation rates and supplement with additional animals if predation is a major cause of mortality and the population has not grown to 50 bighorn within 5 years.

Strategy 9.2 In habitat where substantial lion predation is anticipated, pre-treat these ranges to reduce lion density prior to transplanting bighorn sheep.

Strategy 9.3 Remove offending lions that prey upon bighorn sheep until populations become self-sustaining.

Strategy 9.4 If high mortality rates, documented from radiocollared bighorn, implicate predation as a limiting factor in Rocky Mountain bighorn populations implementation of a predator control strategy similar to that used in endangered desert bighorn herds must be considered.

ISSUE 10. Illegal harvest may adversely affect population viability and recreational opportunities.

Strategy 10.1 Reduce illegal harvest through increased law enforcement and public education.

Strategy 10.2 Continue the ban on private possession of pick-up skulls and the requirement of sealing hunter harvested ram horns and ram horns brought into New Mexico.

Strategy 10.3 Continue to PIT-tag all captured rams to enhance positive identification of these animals.

ISSUE 11. Because of competing management needs, Game Protection funds may be inadequate for achieving the plan goal.

Strategy 11.1 Continue the auction of 1 bighorn sheep permit and the raffle of 1 bighorn sheep permit.

Strategy 11.2 Use additional sources of funding and volunteer assistance available from the Habitat Stamp Fund, private foundations, environmental and sportsmen's groups.

ISSUE 12. Tribal lands are not under the Department jurisdiction, but contain habitat important for bighorn populations.

Strategy 12.1 Develop cooperative agreements with tribal authorities that enhance management of bighorn habitats and populations on adjoining tribal and non-tribal lands.

ISSUE 13. Without future public input, the Department will not know if the goal of this plan is being met.

Strategy 13.1 Develop a plan to assess public satisfaction using public meetings, commission meeting, public polling, or related mechanisms.

Appendix A. History of Rocky Mountain bighorn sheep *(Ovis canadensis canadensis)* transplants in New Mexico.

AREA	EST. 2002	TRANSPLANT HISTORY						
		DATE	SOURCE	RELEASE AREA	RAMS	EWES	LAMBS	TOTAL
Sandia Mountains	0	Feb 1940	Banff NP, Canada	Bear Canyon	1	2		3
		Jan 1941	Banff NP, Canada	Bear Canyon	1	2		3
		Nov 1942	Banff NP, Canada	Bear Canyon	1	2		3
		Jan 1970	Dubois, WY	Top of Tramway	1			1
Turkey Creek	50	Mar 1964	Banff NP, Canada	Turkey Creek	2	8		10
		Aug 1998	Pecos Wilderness, NM	Gila River/Watson	2	3		5
San Francisco River	70	Sep 1964	Sandia Mtns., NM	Sheridan Ridge, Mogollon Mtns.		8	35	16
		Jun 1965	Sandia Mtns., NM	Frisco Hot Springs	2			2
		Aug 1998	Pecos Wilderness, NM	Alma Box		3	1	4
Pecos Wilderness		1932	Banff NP, Canada	?				6 (failed)
	340	Apr 1965	Banff NP, Canada	Pecos Baldy	4	11		15
		Aug 1966	Sandia Mtns., NM	Pecos Baldy	1	8		9
Wheeler Peak Wilderness	250	Feb 1968	Banff NP, Canada	Frazer Mountain	3	7		10 (failed)
		Jan 1970	Dubois, WY	Frazer Mountain	2	8	27	19 (failed)
		Aug 1993	Pecos Wilderness, NM	Frazer Mountain	9	21	3	33
Manzano Mountains	20	Aug 1977	Pecos Wilderness, NM	Canon Monte Largo	1	9	42	16
		Sep 1978	Pecos Wilderness, NM	Canon Monte Largo	2	7	52	16
		Jan 1999	Cimarron Canyon	Canon Monte Largo	1			1
		Aug 1998	Pecos Wilderness, NM	Canon Monte Largo/Sand Canyon	4	12	16	23
Latir Wilderness	0	Sep 1978	Pecos Wilderness, NM	Cabresto Peak	3	14	12	20 (failed)
	90	Aug 2001	Pecos Wilderness, NM	Latir Mesa	7	35	14	56
Ft. Wingate	0	1978	Waterton Lks., Canada	Ft. Wingate-escaped to Zuni Reservation	2	5		7 (failed)
Cimarron Canyon	0	Sep 1978	Pecos Wilderness, NM	Between Clear Creek and Pallisades	1	1	12	5 (failed)

Appendix B. Public involvement in the development of the Long Range Plan.

The first draft of this plan was constructed following consultation regarding shared bighorn populations with Arizona Department of Game and Fish and Colorado Division of Wildlife. The first draft was reviewed from April – November, 2003 by 6 NMDGF employees in the Wildlife Management Division, Conservation Services Division, Administration, Northwest Area, Northeast Area, and Southwest Area offices. Public involvement included asking the agencies, groups, and individuals listed below to provide comments on the second draft.

Federal Agencies

U. S. Forest Service—Regional Office

Carson National Forest
- Questa R.D.
- Penasco R.D.

Cibola National Forest
- Sandia R.D.
- Mountainair R.D.

Gila National Forest
- Glenwood R.D.
- Silver City R.D.

Santa Fe National Forest
- Pecos R.D.
- Espanola R.D.

BLM State Office
Albuquerque District Office, BLM
- Taos Resource Area

National Park Service Regional Office
- Bandelier National Monument

U.S. Fish and Wildlife Service Regional Office
- Sevilleta National Wildlife Refuge

Los Alamos National Laboratory

State Agencies

New Mexico Department of Game and Fish Area Offices
Arizona Game and Fish
Colorado Division of Wildlife

State Game Commissioners

Guy Riordan—Chair
Alfredo Montoya—Vice-Chair
Dave Henderson
Peter Pino
Dr. Tom Arvas
Leo Sims
Jennifer Atchley-Montoya

County Commissions

Bernalillo County
Catron County
Grant County
Santa Fe County
Taos County
Valencia County

Pueblos

Cochiti
Isleta
Picuris
San Ildefonso
Sandia
Taos

Special Interest Groups

National Chapter of The Foundation for North American Wild Sheep
New Mexico Chapter of The Foundation for North American Wild Sheep
New Mexico Chapter of Safari Club International
Southwest Consolidated Sportsmen
United Bowhunters
New Mexico Wildlife Foundation
New Mexico Council of Outfitters and Guides
Rocky Mountain Bighorn Sheep Society
Tierra Grande Improvement Association
The Nature Conservancy

Rio Costillo Livestock Association
Vermejo Park Ranch
Turner Endangered Species Fund
Dharma Properties
Taos Ski Valley
El Salto Livestock Association
Burlington-Northern Santa Fe Railroad

Individuals

Darrel Allred
Mickey Blake
Mick Chapel
Allen/Debbie Eggelston
John Gunlogson
Dave Heft
Al Johnson
Tom Klumker
Huey Ley
Ric Martin
Michael/Becky O'Connor
Buel Pattison
Lanny Rominger
Eric Roybal
Kent Schauer
Terrell Shelly
Dick Weaver
Ortho Woodrow

Appendix C

Approvals

Long Range Plan for the Management of
Rocky Mountain Bighorn Sheep 2004-2014

_____	_____
Division Chief	Date
_____	_____
Ass't Director, NMDGF	Date
_____	_____
Director, NMDGF	Date
_____	_____
Chairman, State Game Commission	Date

Table 1. Current and potential population sizes of alpine Rocky Mountain bighorn sheep herds in New Mexico.

Range	Current Population	Potential Population	Principal Jurisdiction	Issues
Pecos Wilderness	340	300-400	Santa Fe & Carson National Forests	Long-term success will require biennial removal or hunting ewes
Wheeler Peak	250	250-300	Carson Natl. Forest/ Taos Pueblo	Long-term success will require biennial removal or hunting ewes
Latir Wilderness	110	100-150	Carson National Forest/ RCCLA[1]	Long-term success will require biennial removal or hunting ewes
Culebra Range	0	?	RCCLA/Vermejo Park Ranch	Immigration from Colorado herd of > 400 may create this population
Santa Fe Baldy (Pecos Wilderness)	0	?	Santa Fe National Forest	Habitat is too limiting to support year-round population
Totals	700	650-850		

1 RCCLA = Rio Costilla Cooperative Livestock Association

Table 2. Current and potential population sizes of low-elevation Rocky Mountain bighorn sheep herds in New Mexico.

Range	Current Population	Potential Population	Principal Jurisdiction	Issues
San Francisco River	75	150-200	Gila National Forest	Population increasing in NM portion portion of habitat
Turkey Creek	50	75-125	Gila National Forest/ BLM/Private	Small subpopulations to be augmented in 2004
Manzano-Los Pinos	<20	100-150	Cibola National Forest/ Sevilleta NWR/Private	High train-strike mortality and lion predation keeps herd well below carrying capacity
Rio Grande Gorge	0	?	BLM/Private	Presence of domestic sheep precludes transplant
White Rock Canyon	0	100-125	Santa Fe N.F./Los Alamos N.L./Bandelier NM/San Ildefonso Pueblo	Considerable effort on transplant proposal 1997-1999; currently on shelf
Sandia Mountains	0	?	Cibola N.F./Sandia Pueblo	High human impact and loss of most historical habitat to brush encroachment precludes transplant
Totals	145	425-600		