Maintaining a Landscape Linkage for Peninsular Bighorn Sheep



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Executive Summary

The Peninsular Ranges extend 1,500 km (900 mi) from Southern California to the southern tip of the Baja California peninsula, forming a granitic spine near the western edge of the North American continent. They comprise an intact and rugged wilderness area connecting two countries and some of the richest montane and desert ecosystems in the world that support wide-ranging, iconic species, including mountain lion, California condor, and bighorn sheep. Connectivity at this continental scale is critical to maintaining ecosystem processes, biodiversity, wildlife movement, and habitat values of existing conservation investments in both countries.

This study was undertaken as part of a larger effort to conserve the integrity of this landscape linkage, in the face of increasing sprawl of development inland from the coast, escalating border security infrastructure, and other competing uses for the land. It focuses on the border region of California and Baja California, where the long-term connectivity between federally endangered bighorn sheep in Peninsular Ranges of Southern California and bighorn sheep in Baja California is threatened. The current level of connectivity and the possibilities for maintaining this connectivity in the future are not well understood. This preliminary study assesses the distribution and habitats of bighorn sheep in the Sierra Juárez in Baja California, just south of the international border, the potential threats to bighorn sheep there, and the threats to this landscape linkage, so as to inform conservation and management strategies for linking protected parklands in both countries.

We researched published and unpublished literature, conducted written and oral interviews, used vegetation communities and topography to develop a preliminary model of suitable habitat, and compiled information on reported observations of bighorn sheep in the Sierra Juárez to evaluate the possibility of maintaining or re-establishing long-term connectivity between bighorn sheep populations in California and Baja California, thus allowing genetic exchange and enhancing long-term viability of the species. Our preliminary habitat model indicates that habitat for bighorn sheep is continuous from north of the border south through the Sierra Juárez, and we received observations of bighorn sheep in the Sierra Juárez within this predicted habitat. Given recent sightings of bighorn sheep in the vicinity of Interstate-8 in California, within 8 km (5 mi) of the international border, these findings suggest that long-term connectivity between bighorn sheep populations in the U.S and Baja California is a realistic long-term management goal.

However, the landscape in this border region is rapidly changing as a result of intensified border security infrastructure, increasing urbanization of rural areas, development of renewable energy projects, and incompatible recreational activities, resulting in habitat loss and fragmentation of the landscape. There is a risk that the protected area network that is integral to ecosystem function and wilderness values in both countries could be severed. Furthermore, disease exposure to the endangered bighorn sheep population in California is a serious concern if bighorn sheep in Baja California have elevated exposure to diseases of domestic livestock.

This document presents the current state of knowledge regarding the distribution of bighorn sheep in the Sierra Juárez and recommends future studies needed to further inform strategies for managing bighorn sheep populations and conserving the wilderness corridor between protected parklands in the U.S. and México.

1. Introduction

The goal of this project is to assess the feasibility of maintaining and/or restoring the linkage between populations of bighorn sheep (*Ovis canadensis*) in the Peninsular Ranges of California and Baja California by conserving habitat between existing conservation areas [or "protected areas"] in California and those in Baja California. Our objectives were to:

- 1. Assess the state of knowledge regarding the historic and current distribution of bighorn sheep in the Sierra Juárez.
- 2. Compile information on and map observations of bighorn sheep in the Sierra Juárez made by biologists and others familiar with the area.
- 3. Develop a preliminary predictive habitat model of bighorn sheep distribution in the Sierra Juárez.
- 4. Conduct a preliminary field reconnaissance of potential habitat to evaluate suitability for bighorn sheep and evaluate access for future surveys.
- 5. Assess the potential threats to bighorn sheep and population connectivity in the Sierra Juárez.
- 6. Recommend future studies to assess and establish/maintain connectivity between sheep populations and to inform linkage conservation strategies.

1.1 Background

Bighorn sheep (*Ovis canadensis*) originated in Asia and moved into North America via the Bering Land Bridge more than 30,000 years ago (Hopkins et al. 1982). Since that time, their distribution has expanded southward into the deserts of the southwestern United States, where they have lived for at least 12,500 years (Harris 1977, cited in Valdez and Krausman 1999). Today, approximately 800 bighorn sheep live in the Peninsular Ranges north of the international border, where they have been federally listed as an endangered population since 1998 (U.S. Fish and Wildlife Service [USFWS] 1998).

Although it is not clear how long bighorn sheep have lived in Baja California, their expansion likely followed the Peninsular Ranges, which extend from the San Jacinto Mountains in Southern California south along the spine of the Baja California peninsula. Although we have no current population estimates of bighorn sheep south of the border, DeForge et al. (1993) estimated that 780-1,170 adult bighorn sheep inhabited Baja California north of Bahía San Luis Gonzaga in 1993, and in 1998 Mexican government officials reported that the population in Baja California was not likely in danger of extirpation (USFWS 1998). Although two subspecies of bighorn sheep occupy the Baja Peninsula (*O. c. nelsoni*, formerly *O. c. cremnobates*, distributed from the international border to approximately the Sierra San Borjas, and *O. c. weemsi*, distributed from these mountains south), this report focuses on *O. c. nelsoni* in the Sierra Juárez.

Bighorn sheep are large, wide-ranging animals that live in a harsh environment where they need room to roam in search of food, water, cover, and mates. Connectivity among groups and

populations is necessary for genetic health and demographic viability, and the ability to move across an open landscape will provide bighorn sheep some resilience to future climate change. One of the long-term goals of the USFWS Recovery Plan for bighorn sheep in the Peninsular Ranges is to re-establish and maintain connectivity with populations south of the border (USFWS 2000).

Although the U.S. population has exhibited some signs of recovery in recent years (Steve Torres, California Department of Fish and Game, unpublished data), and is known to range within 8 km (5 mi) of the international border, there is concern that that the historic link between the two populations is at risk, with a potential geographic gap of unknown extent near the international border (USFWS 2000). Based on limited surveys, bighorn sheep are known to occur in the Sierra Juárez, Sierra Cucapa, and Sierra Las Pintas in Baja California, but we do not know how far north their current range extends or how they are distributed in mountains near the border. We also lack information about the status of bighorn sheep habitat in México, in terms of livestock grazing, disease risk, or land management practices that may threaten future connectivity or population persistence.

1.2 Study Area

In southern San Diego and Imperial counties, the San Ysidro Mountains, Vallecito Mountains, In-Ko-Pah Mountains, and Jacumba Mountains comprise the southern extent of the Peninsular Ranges in the U.S. In northern Baja California, the Sierra Juárez and Sierra San Pedro Mártir, form the backbone of the Peninsular Ranges, extending south for approximately 260 km (160 mi) from the international border (Figure 1). The Peninsular Ranges form the headwaters for several major stream systems in both countries, supporting wetland and wildlife resources. These headwaters also are important municipal and agricultural water sources for large human populations on the Pacific Coast. Coniferous forests at the highest elevations are important carbon sinks, sequestering large amounts of greenhouse gases each year. The north-south orientation of the Peninsular Ranges, as well as the elevational gradients from the Ranges' western foothills, up over the summits of the Ranges, and back down to the floor of the Sonoran Desert at the foot of their eastern escarpment, makes protection of this corridor extremely important in the face of climate change, because it provides species and communities the opportunity to shift their ranges latitudinally or elevationally in response to changing environmental conditions.

The western slopes of the Peninsular Ranges are fairly gentle and gradually extend to the coastal plains near the Pacific Ocean (Peterson 1992). On the east, however, steep, deeply eroded canyons extend east toward the Colorado River and the Sea of Cortez. Vegetation associations on the eastern side include coniferous forest, primarily ponderosa pine (*Pinus ponderosa*) and white fir (*Abies concolor*) at the highest elevations, chaparral and piñon pine (*P. monophy1la*)-juniper (*Juniperus californica*) associations at elevations above approximately 1,200-1,500 m (3,600-4,500 ft), and agave (*Agave deserti*), ocotillo (*Fouquieria splendens*), cholla-palo verde (*Opuntia spp.-Cercidium floridum*), and creosote-palo verde-mesquite (*Larrea tridentate-Cercidium floridum*-Prosopis spp.) associations at lower elevations (Ryan 1968).

Las Californias Binational Conservation Initiative

Park to Parque Linkage



In the U.S. Peninsular Ranges, where there have been significant investments in public lands (e.g., Anza-Borrego Desert State Park, Bureau of Land Management [BLM] wilderness areas) and the population is well-documented, bighorn sheep have been found most frequently at elevations <1,400 m (Jorgensen and Turner 1973), typically below the piñon pine-juniper vegetation association. Therefore, for this study, we focused on the area from the U.S.-México international border to the southern extent of the Sierra Juárez, and extending from the mountain ridgeline to the desert floor (including washes, alluvial fans, and playas).

1.3 Parque-to-Palomar—a Project of Las Californias Binational Conservation Initiative

Las Californias, the border region of California and Baja-California, lies at the center of a global biodiversity hotspot that supports an extraordinary number of plants and animals that occur nowhere else on earth. It is also a landscape of remarkable natural beauty that affords its residents with water supplies, recreational opportunities, and an exceptional quality of life. Major investments have been made in conserving public lands, especially in California north of the border. Unfortunately, many of these investments and the native species that inhabit the landscape are under threat. The rapid pace of growth along the border — from the coast to the Sonoran Desert — threatens to sever the two Californias, fragmenting the rural undeveloped landscape and severely challenging the integrity and functionality of the ecosystems they support.

The Las Californias Binational Conservation Initiative (CBI et al. 2004) identifies the Parque-to Palomar Linkage as a critical transcontinental movement corridor essential to conserving high species diversity, high levels of endemism (Figure 1). This linkage is centered on the Peninsular Ranges that connect protected areas in Southern California, such as Palomar State Park and Anza-Borrego Desert State Park, with protected areas in northern Baja California — Parque Nacional Constitución de 1857 and Parque Nacional Sierra San Pedro Mártir.

2. Findings

2.1 Reported Occurrences

The Conservation Biology Institute (CBI) and Terra Peninsular compiled and reviewed existing information on historic and current distribution of bighorn sheep in the Sierra Juárez, through contacts with biologists at universities, conservation organizations, and Mexican government agencies, as well as an extensive review of published and unpublished literature. Research on bighorn sheep in México has not been extensive (Tarango and Krausman 1997), and bighorn sheep in the Sierra Juárez of Baja California have received especially scant attention. The lack of information likely stems from lack of resources, remote and difficult access, and safety and logistic considerations.

Early explorers, hunters, and missionaries made multiple observations of bighorn sheep in northern Baja California. Spanish Jesuit missionaries reported observations of bighorn sheep in this area in the late 17th century (Buechner 1960). Nelson (1921:132, cited in Buechner 1960) reported that bighorn sheep distribution ranged from sea level at the Gulf of California to elevations of 1,500 m (5,000 ft) along the eastern slopes of Baja California, but that they were found mainly at elevations of 300-900 m (1,000-3,000 ft). According to early owners of Rancho San José, they were also observed at elevations of 2,100-2,700 m (7,000-9,000 ft) and were occasionally observed to wander into pine forests at these higher elevations (Buechner 1960). Townsend (1912, cited in Buechner 1960) noted that during a 1911 expedition, bighorn sheep were observed throughout the desert ranges along the Gulf side of Baja California, from just west of the mouth of the Colorado River southward to near La Paz. Hunter reports from the early 1900s documented bighorn sheep regularly traveling across the flat desert floor between the Sierra Juárez and the Sierra Las Tinajas, a pattern believed to continue in recent times (Toweill and Geist 1999). Buechner (1960) speculated that the Peninsular Ranges of Baja California could potentially support greater numbers of bighorn sheep than the U.S. Peninsular Ranges (assuming that water limits their numbers), due to more abundant water sources in the Mexican mountain ranges.

In 1974, portions of Baja California were surveyed for bighorn sheep by foot during a 2-month period (Cossio 1975, Alvarez 1976). The northernmost part of this survey was conducted during two 8-day foot surveys in the Arroyo Grande area in the San Miguel Sierra, approximately 50 km northeast of San Felipe. Although the area was described as a relatively small (90 km²) portion of the *....extensive mountains that occur from the American border to San Pedro Mártir*, it is not clear if portions of the Sierra Juárez were included (Alvarez 1976). During the surveys, 42 animals (including males, females, and lambs) were observed in the Arroyo Grande area. Using data collected from the overall survey, during which approximately 1,000 bighorn sheep were observed, the overall Baja California population was estimated at 4,500-7,800 animals (Cossio 1975, Alvarez 1976). However, a population estimate for the Sierra Juárez was not presented.

In April of 1992, Deforge et al. (1993) conducted the first helicopter survey of the Sierra Juárez, focusing on eastern slopes of these mountains, as part of a larger survey effort in Baja California.

Four bighorn sheep (1 adult male, 2 adult females, and 1 yearling female) were observed in two groups during the survey of the Sierra Juárez. Based on the overall survey, Deforge et al. (1993) estimated that there were 780-1,170 animals in northern Baja California, suggesting that either the population had declined since the 1970s or that previous surveys had overestimated population size (Alvarez 1976, Monson 1980, Toweill and Geist 1999). No specific population size was generated for the Sierra Juárez; however, the small number of animals observed per square kilometer surveyed suggested low densities relative to neighboring mountain ranges (DeForge et al. 1993).

In September 1995, Lee and Mellink (1996) conducted a second helicopter survey of the Sierra Juárez, also as part of a larger survey of Baja California. The survey also included the Sierra San Pedro Mártir, Las Pinatas, Las Tinajas, San Felipe, Santa Rosa, Santa Isabel, and Cucapa. During 2.8 hours of survey time in the Sierra Juárez, 2 bighorn sheep (1 adult female and one lamb) were observed in one group. The 1995 survey did not generate population estimates; however, the small number of animals observed in the Sierra Juárez per square kilometer surveyed, and per hour of survey time, indicated low densities in these mountains as compared to neighboring mountains, with the exception of the Sierra Cucapa, where no animals were observed (albeit during a short 0.5-hour survey). Therefore, both the 1992 and 1995 survey results suggest that the Sierra Juárez, together with the Sierra Cucapa, supported relatively low densities of bighorn sheep compared to other mountain ranges in Baja California. In October 1999, an aerial survey in Baja California reported an increased observation rate as compared to the 1995 survey (Lee 2000). However, this latter survey focused on areas previously reported to have higher densities and did not include the Sierra Juárez or the Sierra Cucapa (Alaniz-Garcia and Lee 2001).

To our knowledge, no other aerial surveys have been conducted for bighorn sheep in the Sierra Juárez since 1995. In March 2009 the Zoological Society of San Diego (ZSSD) conducted a helicopter survey for golden eagles (*Aquila chrysaetos*) in the Sierra Juárez, during which they observed (opportunistically) four groups of bighorn sheep (Appendix A). They did not comprehensively survey bighorn sheep habitat (M. Wallace and L. Nordstrom, ZSSD, personal communication).

2.2 Habitat Model

We developed a preliminary predictive habitat map for bighorn sheep in northern Baja California using a modification of methods used to map bighorn sheep in the U.S. Peninsular Ranges. The original U.S. map was based primarily on topography (i.e., including areas within 800 m of slopes \geq 20%) and vegetation (i.e., using chaparral vegetation associations as the basis for upper elevational boundaries; USFWS 2000), and provided a good habitat delineation for this population (Rubin et al. 2009). For the México map, we modified methods for delineating the western boundary because bighorn sheep in the Sierra San Pedro Mártir have been observed at elevations above chaparral vegetation, on occasion being observed at elevations of 2,100-2,800 m (7,000–9,000 ft) and in pine forests at these elevations (Buechner 1960, R. Martinez Gallardo, UABC, personal communication). We therefore delineated the western habitat boundary as the crest of the Sierra Juárez and the Sierra San Pedro Mártir, buffered by 800 m (0.5 mi) to the west. At lower elevations (typically facing east), habitat was delineated with the same method as for the U.S. habitat map, with habitat including all slopes $\geq 20\%$, buffered by 800 m. Within these delineated habitat boundaries, we separated vegetation associations into preferred and not preferred vegetation associations, based on observations in the U.S. Peninsular Ranges, as follows (Figure 2):

| Preferred | Not preferred |
|---|--|
| Mixed desert shrub Mixed desert succulent scrub Piñon-juniper Barren | Northern mixed chaparral Jeffrey pine Mixed conifer-pine Perennial and annual grasslands Dunes |

Vegetation Associations Preferred/Not Preferred by Bighorn Sheep

Our preliminary habitat model for bighorn sheep in northern Baja California predicts that (1) bighorn sheep habitat is contiguous from areas of the Peninsular Ranges on the U.S. side of the international border, where bighorn sheep are currently known to exist, south to the furthest extent of our mapping effort, and (2) bighorn sheep may use a range of elevations (Figure 2). This map suggests that it is possible for bighorn sheep to move from the U.S. portion of the Peninsular Ranges south into the Sierra Juárez, and that this connection allows them to access other mountain ranges in Baja California.

2.3 Questionnaires and Interviews

We developed and distributed a questionnaire, in English and in Spanish (Appendix A), to solicit information from biologists and naturalists, Mexican government staff, American and Mexican university staff, and ranchers and ejidatarios from the U.S. and México familiar with the Sierra Juárez or who might otherwise have information about bighorn sheep in these mountains. We sent the questionnaires to 50 people; of the 29 individuals who responded, 8 had seen bighorn sheep in the Sierra Juárez. Collectively, these individuals reported 15 bighorn sheep group sightings and one sighting of sign (tracks and scat) in the Sierra Juárez between 1950 and 2009 (Appendix A). The sightings, reported in the form of latitude-longitude coordinates or as verbal descriptions, were spread across a large portion of the Sierra Juárez (Figure 3), supporting our model predictions that appropriate habitat is continuous across the border and south into the Sierra Juárez.

In addition to observations of bighorn sheep and their sign, observers noted the presence of cattle (at Rancho El Topo near the top of Tajo Canyon; observed by Schwenkmeyer), feral goats (just south of the international border, near Highway 2; observed by Weaver), 1 horse (location not provided; observed by Lee), and 13 cows (location not provided; observed by Lee). The fact that relatively few domestic animals were reported, when far more are known to graze in these mountains, suggests that sightability of animals in this terrain is low and that many more bighorn sheep were likely present than were observed.





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Esther Rubin, CBI & Brian Cohen, TNC, August 3, 2006



Las Californias Binational Conservation Initiative

Potential Bighorn Sheep Habitat in Baja California Norte



In addition to observations south of the international border, one observer reported a number of pellet groups observed just north of the border, in Pinto Wash. Although some of these pellets may be from mule deer, recent observations of bighorn sheep just north of the east-bound lanes of Interstate-8 (including observations in the *island* where the east- and west-bound lanes split; E. Rubin, personal observation) suggest that bighorn sheep likely could be in Pinto Wash. Respondents also indicated that border patrol agents had direct observations of bighorn sheep crossing the east-bound lanes of Interstate-8 near mile post 70.5, providing further evidence that bighorn sheep can access habitat south of the interstate and the nearby international border.

2.4 Field Reconnaissance

In July 2009 Jesús Zatarain of Terra Peninsular conducted a preliminary field reconnaissance to ground-truth areas identified in the questionnaire responses and to evaluate access to bighorn sheep habitats areas, in terms of ownership and road access, for future survey efforts. The reconnaissance was conducted on horseback, guided by property owners, on the eastern escarpment of the Sierra Juárez, within the Cordillera de Molina ejido (Appendix B). The guides confirmed the presence of mountain lions and bighorn sheep throughout this rugged area. Several of the arroyos support small bodies of water. Figure 4 identifies potential access points for future field surveys.





3. Threats and Conservation Challenges

3.1 Domestic Livestock

Livestock represent a potential threat to bighorn sheep because they compete for forage and water sources, and they harbor diseases that can spread to and devastate bighorn sheep populations (USFWS 2000). Araujo (1976) reported that management concerns in Baja California included large numbers of feral goats (*Capra hircus*), noting that these could impact bighorn sheep through competition and transmission of novel diseases and parasites, and feral burros (*Equus asinus*), which compete for food and degrade or destroy scarce natural water sources. During their 1992 survey of Baja California, Deforge et al. (1993) documented extensive vegetation damage from livestock in some mountain ranges and observed more than 200 burros within bighorn sheep habitat. The Sierra Juárez (along with the Sierra Las Tinajas) appeared to have the highest burro numbers among all areas flown (Deforge et al. 1993). Although cattle were reported to be common in the neighboring Sierra San Pedro Mártir, Arroyo Grande, and Sierra Santa Isabel, and goats were reported to be common in the Sierra Juárez (DeForge et al. 1993).

3.2 Unregulated Hunting

Multiple researchers reported uncontrolled hunting of bighorn sheep as a conservation problem (e.g, Buechner 1960, Toweill and Geist 1999, Eaton-González and Martínez-Gallardo 2001). Buechner (1960) reported that bighorn sheep in the Sierra San Pedro Mártir were depleted by hunters in the past, especially in the 1930s when mining operations were underway in the vicinity. The first Mexican law fully protecting bighorn sheep from hunting was established in 1921 (Buechner 1960). However, hunting seasons were re-opened in 1931, then closed again in 1944 (Toweill and Geist 1999). In 1954, the Minister of Agriculture and Livestock signed a decree that bighorn sheep would be permanently protected from hunting. In 1963, the government opened a controlled hunting season. However, Buechner (1960) reported that local residents still killed bighorn sheep frequently, without regard for the law. Cossio (1975) also reported that unregulated hunting was considered the biggest threat to bighorn sheep in México in the 1970s, both for sport (U.S. hunters) and for food (local residents). During a 1975 survey, biologists accompanying hunters in the central portion of the Baja Peninsula found 19 sampled animals with rifle (0.22) bullets in them (from previous hunting efforts) and large stashes of bighorn heads (up to 50 in one location), suggesting that hunting pressure was high (Cossio 1975). Based on large population estimates from a foot survey in 1974 (Cossio 1975), hunting permits were increased, with 625 permits issued during 1980-1989. This was followed by increased concern over the viability of bighorn sheep populations, resulting in a Presidential decree to ban all hunting of bighorn sheep in Baja in 1990 (Toweill and Geist 1999). Much of this fluctuation in hunting regulation likely stemmed from a lack of information on status of Baja's bighorn sheep, including a lack of information on their numbers or abundance trends; this triggered the start of surveys conducted in the early 1990s. Unregulated hunting likely continues to be a problem in Baja California, in large part due to poorly funded law enforcement and the

difficulty in patrolling the rugged and isolated habitat (Toweill and Geist 1999, Eaton-González and Martínez-Gallardo 2001).

There currently is no legal harvest of bighorn sheep in the Sierra Juárez and Sierra San Pedro Mártir. Cossio (1975) suggested that one means of controlling unregulated hunting was to issue permits at an increased price and to give the permit funds to local residents in exchange for their assistance with conservation and management of local bighorn sheep populations. Based on results of surveys in 1992 and 1995, Lee and Mellink (1996) recommended a limited harvest of 9-12 rams annually, representing a conservative harvest compared to hunting permits issued in previous harvest seasons. In 1998, one permit was authorized for Baja California, but it was never issued due to political and social pressures (Lee 1998, Lee 2000).

The policy of Manejo Sostenible del Uso de Vida Silvestre (UMA) under the Ley de Vida Silvestre, or Management and Sustainable Use of Wildlife under the General Law of Wildlife, is an incentive that allows for the development of productive alternatives compatible with protection of natural resources and biodiversity. This tool has been used for management and restricted hunting of bighorn sheep in Baja California Sur and Sonora and for gray whale protection in Laguna San Ignacio, Baja California.

3.3 Emerging Threats

The most serious threat to the functionality of the binational [continental] landscape linkage is habitat loss and fragmentation. While intact habitat spans the Parque-to-Palomar linkage, with large state and federal protected areas in California and two national parks in Baja California, large gaps of unprotected lands remain, primarily in Baja California. Currently, this rugged landscape between the protected areas is mostly intact, with only dirt roads, a few clustered rural homes on ejido lands, and cattle grazing as the primary land use impacts. However, near the border, Interstate-8 and Mexican Highway 2 have impacted the continuity of the landscape and facilitated the gradual development of communities along them. Some of this development and associated uses such as off-road vehicles have been cited as causes of bighorn sheep population declines in Baja California (e.g., Cossio 1975, Araujo 1976, Deforge et al. 1993, Eaton-Gonzáles and Martínez-Gallardo 2001). Nevertheless, compared to habitat loss and fragmentation north of the border and along the Pacific and Gulf Coasts in Baja California, the Sierra Juárez in general has remained a relatively bucolic landscape of coniferous forest, chaparral, piñon pine-juniper, and desert scrub interspersed with granitic outcrops, crags, and boulder heaps, and the eastern escarpment that forms the preferred habitat for bighorn sheep is still a roadless wilderness of steep, palm-lined canyons draining to the Laguna Salada.

However, the integrity and continuity of the binational linkage is threatened by increasing population growth, new border infrastructure, expanded use of wilderness areas for recreation, and new land use policies in México. Intensified border security activities — in the form of fencing, roads, human traffic, and habitat loss and alteration — will likely have major implications to viable habitats and wildlife movement on both sides of the border. Recent legislation in México allows parcelization and sale of ejido lands, resulting in increased potential for development and fragmentation of the landscape. Growing residential developments in

California could also fragment private lands within the linkage, especially around Jacumba. Motorcycles and off-road vehicles are increasingly popular recreational activities in California as well as in the Sierra Juárez and, if not monitored, could result in significant disturbance and habitat loss.

The most imminent threats to the integrity of this wilderness area are the renewable energy projects proposed for wilderness areas in both California and Baja California. The new wind energy project proposed by Sempra—Energia Sierra Juárez—includes up to 1,000 wind turbines, 2,930 ha of *temporary* impacts, 2,190 ha of permanent impacts, 1,230 km of transmission lines, 6 substations, and 900 km of roads. The major areas of impact will be in the Jacume, La Rumorosa, Cordillera Molina, and Sierra de Juárez ejidos. The energy generated by this system will be transported across the border to California as part of the Sunrise Powerlink (SDG&E). If approved, this project will fragment the Sierra Juárez, open it to greater human access, and destroy the wilderness values of this landscape. The potential impacts to wildlife, including bighorn sheep, have not been assessed, and there currently is no program proposed to monitor the effects of the construction and operation on wildlife.

4. Conclusions and Recommendations

4.1 Conclusions from This Study

The findings of this study support our hypothesis that the Peninsular Ranges have the potential to function as a trans-border linkage for bighorn sheep, i.e., that it is possible for bighorn sheep to move between the U.S. and México portions of the Peninsular Ranges. Preferred habitat for bighorn sheep is continuous across the U.S.-México international border and south along the Sierra Juárez. Bighorn sheep have been documented in the island between the east and west-bound lanes of I-8 in southern San Diego County, and bighorn sheep do occupy predicted habitats that are currently unprotected in the Sierra Juárez north of Parque Nacional Constitución de 1857 and south to Parque Nacional Sierra San Pedro Mártir. While systematic surveys were not conducted, and we have not documented actual movement across the border, the number of opportunistic sightings made by a small number of observers who, in some cases were not specifically surveying for bighorn sheep, confirm their presence in the northern Sierra Juárez.

The bighorn sheep population of the Sierra Juárez represents possibly the only link between bighorn sheep populations in the U.S. and those on the Baja peninsula. Establishing the potential for connecting the U.S. and Baja populations is a long-term goal of the USFWS Recovery Plan for bighorn sheep in the Peninsular Ranges (USFWS 2000). Bighorn sheep have been extirpated from many parts of México, including the states of Nuevo Leon, Coahuila, Durango, and Chihuahua and, as of 1997, remaining populations were found only in Sonora, Baja California, and Baja California Sur (Tarango and Krausman 1997). Therefore, viability of bighorn sheep in Baja California and their connection to populations in the U.S. has more than local importance for the Sierra Juárez population.

However, conservation efforts must acknowledge the planning and precautions necessary for establishing and maintaining connectivity between U.S. and México bighorn sheep populations, primarily to prevent transmission of disease. Therefore, it is imperative that U.S. and Mexican scientists and government officials work cooperatively to monitor the populations in México, with a focus on reducing exposure to domestic livestock that may carry diseases to which the U.S. bighorn sheep population likely have had less exposure. Moreover, we should focus on protecting existing and historic habitats for bighorn sheep—on both sides of the border—as this species is slow to re-colonize habitat where it has been extirpated (Geist 1971). Because they live in a harsh environment, bighorn sheep need large blocks of contiguous habitat to find food, water, mates, and safety from predators (Bailey 1980).

Currently, the only nationally-protected desert bighorn sheep habitat in Baja California is within Parque Nacional San Pedro Mártir and in the Reserva de la Biósfera el Vizcaíno (Toweill and Geist 1999). This leaves the vast majority of desert bighorn sheep habitat in Baja California with no governmental protection. Long-term protection of desert bighorn sheep in Baja California will require the collaborative dedicated efforts of non-governmental organizations, local residents and landowner, and sportsmen's groups.

4.2 Recommendations for Future Studies

Eaton-Gonzáles and Martínez-Gallardo (2001) conducted an extensive literature review and concluded that [t]he lack of knowledge that exists about bighorn sheep in México is evident. Tarango and Krausman (1997), in reference to management of Mexican populations, noted that [t]he existence of a >20-year gap of bighorn sheep-related studies is hampering management efforts. Unfortunately, little additional research has occurred since, with a particularly obvious gap of knowledge in the Sierra Juárez. Buechner (1960) suggested that the Baja Peninsula should be carefully studied to determine the abundance and distribution of bighorn sheep, and to determine the magnitude of hunting pressures.

Our own study concurs that further survey and conservation efforts are warranted to inform management and conservation, particularly considering the potential for the U.S. and México populations to close the potential gap between them in the future. Therefore, our recommendations for next steps are for U.S. and Mexican scientists to work collaboratively to:

- 1. Conduct systematic helicopter surveys of the eastern Sierra Juárez, starting at the border and working south, with the following objectives:
 - a. Assess the distribution and species composition of livestock grazing.
 - b. Ground-truth vegetation mapping in the eastern Sierra Juárez.
 - c. Determine bighorn sheep distribution.
 - d. Map potential barriers to movement (roads, fences, railroads, etc.).
 - e. Assess whether a geographic gap exists between the U.S. and Baja populations and, if so, the size of the gap(s) in distribution.
- 2. Work with government agencies in Baja California to educate ranchers on the importance of managing livestock, particularly domestic sheep and goats, to restrict them from grazing in or near bighorn sheep habitat.
- 3. Refine the habitat model, and map observations of bighorn sheep, based on the helicopter surveys.
- 4. Conduct radio-tracking of bighorn sheep in the vicinity of the border.
- 5. Conduct genetic studies to determine whether there is movement and mixing between the populations or whether they are isolated.

Note that the significance of this linkage does not rely on documented observations or tracking of movement of animals between California and Baja California. The ability of even one animal per generation to move between populations (a level of movement that may be difficult to detect) would (1) maintain a significant genetic link, thus contributing to genetic diversity and decreasing the possibility of inbreeding depression, and (2) provide an option for demographic "rescue" and potential recolonization if one of the populations were to be extirpated.

4.3 Goals and Strategies for Linkage Conservation

One goal of the Las Californias Binational Conservation Initiative is to conserve landscape linkages and connectivity for wide-ranging species, like the Peninsular bighorn sheep. This study and future studies on bighorn sheep will help us understand the importance of the linkage for bighorn sheep and other large mammals, how they are using the linkage and in what areas, and how they move within a landscape constrained by ranching, development, roads, and other barriers.

The long-term strategies for conserving the Parque-to-Palomar linkage include:

- Establish a new trans-boundary conservation area linking protected areas in the U.S. (including Anza-Borrego Desert State Park, U.S. Forest Service, and BLM wilderness areas) with Parque Nacional Constitución de 1857 and Parque Nacional Sierra San Pedro Mártir in Baja California.
- Conserve strategic private properties in Southern California, through conservation easements and fee title acquisition, to secure important watershed areas and connectivity between public lands.
- Establish collaborative management efforts on public lands.
- Provide scientific justification to support expanding the protection boundaries of historic Forestry Decrees in the Sierra Juárez and Sierra San Pedro Mártir.
- Work with the Comisión Nacional Forestal (CONAFOR) and local ejidos in the Sierra Juárez and Sierra San Pedro Mártir to conserve lands supporting ecosystem services, such as hydrological processes and high biodiversity.
- Enhance conservation of Parque Nacional Constitución de 1857 and Parque Nacional Sierra San Pedro Mártir through new management activities and partnerships.
- Secure conservation of private lands in Baja California through leases, easements, and purchase of key private inholdings in the expanded Forestry Decree areas around Parque Nacional Constitución de 1857 and Parque Nacional Sierra San Pedro Mártir.
- Work with renewable energy companies to enhance mitigation and conservation opportunities.
- Work with land managers and recreational groups to encourage responsible public use of natural resources.

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Appendix A

Questionnaire about Bighorn Sheep in the Sierra Juaréz







Questionnaire about Bighorn Sheep in the Sierra Juárez

Who we are:

This is a collaborative project being conducted by:

- Conservation Biology Institute (CBI; www.consbio.org),
- The Nature Conservancy (TNC, www.tnc.org), and
- Terra Peninsular (www.terrapeninsular.org).

Purpose of project:

This project is part of the Las Californias Binational Conservation Initiative¹, a shared vision for landscape-scale conservation strategies, sustainable land use planning, and workable long-term management programs in the center of a globally significant hotspot of biodiversity and cultures along the U.S.(California)-México border. Our goal is to conserve large, intact wildlands, working landscapes, and landscape linkages that sustain natural resources and ecological processes on both sides of the border. A long-term goal of this project is creation of a binational park that links Parque Constitución de 1857 in the Sierra Juárez with protected lands in California.

Native bighorn sheep live in desert mountains on both sides of the border, and the population just north of the border (in the U.S. Peninsular Ranges) is listed as Federally endangered. Today, there may be a geographic gap between that population and bighorn sheep in Baja California. One of the long-term goals of conservation scientists is to re-establish and maintain connectivity between these populations, a goal that could benefit from the protection of cross-border lands. We are therefore seeking to learn more about bighorn sheep south of the border, to better understand if a connection to the U.S. population is possible. Although we know that bighorn sheep occurred in the Sierra Juárez, Sierra Cucapá, and Sierra Las Pintas as recently as the mid-1990s, we do not know how far north their current range extends or how they are distributed in mountains near the border. We also do not know the current status of their habitat in terms of livestock grazing (which could represent a disease risk), fences, roads, hunting, and other risks. This questionnaire is our first step in learning more about bighorn sheep south of the border, so we can help protect them and their habitat. We are focusing on the Sierra Juárez because these mountains represent the most northerly documentation of bighorn sheep in Baja in recent years.

How you can help:

Please complete this questionnaire to help us learn more about bighorn sheep in the Sierra Juárez. Return the completed questionnaire to:

Esther Rubin, PhD (CBI, PO Box 369, Borrego Springs, CA 92004, <u>esrubin@consbio.org</u>), or Jesús Zatarain (Terra Peninsular, jesus@terrapeninsular.org).

If you have questions or would like to like to learn more about this project, please contact:

Esther Rubin (CBI, esrubin@consbio.org), Jerre Stallcup (CBI, jastallcup@consbio.org), or Jesús Zatarain (Terra Peninsular, jesus@terrapeninsular.org)

¹ http://www.consbio.org/what-we-do/las-californias-binational-conservation-initiative







Questionnaire about Bighorn Sheep

Thank you for providing the following information! Please use the back of this page if you need more space.

Name: _____

Do you live, work, or recreate in the Sierra Juárez? [please indicate which one(s)]:

Work or home address (optional):

Have you seen bighorn sheep in the Sierra Juárez? Yes____ No____ If yes, please tell us more about your observations:

- Where did you see bighorn sheep? (describe or mark on the attached map.)
- When did you see them? (year or season/year)
- Please tell us about the group size and composition. (See attached photos for reference.)

Have you seen domestic livestock in the Sierra Juárez? Yes____ No____ If yes, please tell us which kind you saw (domestic sheep, goats, cattle), where you saw them (indicate location on map), and the year when you saw them.

Do you know of anyone hunting bighorn sheep in the Sierra Juárez? Yes____ No____ If yes, please tell us the year and general location of where this occurred.

| May we contact you if we have questions about your observations? | Yes | No |
|--|-----|----|
| If yes, what is the best way to reach you? [email, telephone, mail?] | | |

Can you recommend other individuals who might have information about bighorn sheep in the Sierra Juárez?

If so, please provide their contact information_____











Adult Female

Adult Male









Cuestionario acerca del Borrego Cimarrón en la Sierra de Juárez

¿Quiénes somos?

Este es un proyecto de colaboración que se está llevando a cabo por:

- Conservation Biology Institute (CBI; <u>www.consbio.org</u>),
- The Nature Conservancy (TNC; <u>www.tnc.org</u>), y
- Terra Peninsular A C (<u>www.terrapeninsular.org</u>).

Propósito del proyecto:

Este proyecto forma parte de la Iniciativa de Conservación Binacional Las Californias¹, una visión compartida de estrategias de conservación a escala de paisaje, planificación del uso sustentable del suelo, y programas de manejo factibles a largo plazo, dentro de uno de los hotspot de biodiversidad y cultura más significativos a nivel global que ocurren a través de la frontera entre México y los Estados Unidos (California). Nuestra meta es conservar intactas al conjunto de áreas silvestres, así como la funcionalidad y conectividad de los paisajes, para mantener la integridad de los recursos naturales y de los procesos ecológicos en ambos lados de la frontera. Una de las metas a largo plazo de este proyecto es crear conectividad binacional entre el Parque Nacional Constitución de 1857 de Sierra de Juárez y las áreas protegidas de California.

Existe borrego cimarrón nativo que habita en las montañas desérticas de ambos lados de la frontera, y es la población ubicada justo al norte de la frontera (en los alcances peninsulares de Estados Unidos) la que se encuentra incluida en los listados federales de especies en peligro. Actualmente, es probable que existen huecos geográficos entre esa población de borrego cimarrón y la de Baja California. Para los científicos en conservación, una de las metas de largo plazo es reestablecer y mantener la conectividad entre estas poblaciones, lo que podría favorecer a la protección de las áreas de cruce a través de la frontera. Es por ello que estamos buscando conocer más acerca del borrego cimarrón al sur de la frontera, para un mejor entendimiento sobre si la conexión con poblaciones de Estados Unidos es posible. Aunque el conocimiento acerca de la ocurrencia de borrego cimarrón en las Sierra de Juárez, Sierra Cucapa y Sierra Las Pintas, es de mediados de los años 1990's, no sabemos cuán al norte es su rango de extensión actual o cómo se han distribuido en las montañas cercanas a la frontera. Tampoco conocemos el estado actual de su hábitat en relación con el pastoreo de ganado (el cual representa un riesgo de enfermedades). Nos estamos enfocando en la Sierra de Juárez debido a que estas montañas representan el área de distribución más norteña en que se ha documentado borrego cimarrón para Baja California, en años recientes.

¿Cómo puede usted ayudar?:

Por favor complete este cuestionario para ayudarnos a conocer más sobre el borrego cimarrón en la Sierra de Juárez.

Regrese el cuestionario completado a:

Esther Rubin, PhD (CBI, PO Box 369, Borrego Springs, CA 92004, <u>esrubin@consbio.org</u>) Jesús Zatarain (Terra Peninsular, Blvd Bucaneros 35, Playa Ensenada 22880, Ens-BC, <u>jesus@terrapeninsular.org</u>)

Si usted tiene alguna pregunta o le gustaría concer más sobre este proyecto, por favor contacte a: Esther Rubin (CBI, <u>esrubin@consbio.org</u>), Jerre Stallcup (CBI, <u>jastallcup@consbio.org</u>) o Jesús Zatarain (Terra Peninsular, <u>jesus@terrapeninsular.org</u>)

¹ http://www.consbio.org/what-we-do/las-californias-binational-conservation-initiative







Cuestionario sobre Borrego Cimarrón

Gracias por proporcionar la siguiente información! Por favor utilice el reverso de esta página si necesita más espacio

Nombre:

¿Usted vive, trabaja o se recrea en la Sierra de Juárez? (por favor indique cuáles)

Domicilio de su trabajo o casa (opcional):

¿Ha visto borrego cimarrón en la Sierra de Juárez? Si _____ No _____ Si su respuesta es si, por favor háblenos de sus observaciones:

- ¿Dónde vio borrego cimarrón? (describa o marque en el mapa anexo)
- ¿Cuándo los vio? (año o estaciones por año)
- Por favor díganos sobre el tamaño del grupo y su composición (ver fotos de referencia anexas)

(Si algún amigo o familiar ha visto borrego cimarrón en estas montañas, por favor cuéntenos con detalle lo que le han dicho, y si es posible marque la ubicación (es) en el mapa)

¿Ha observado algunos signos (senderos, excretas; ver foto anexa) que indiquen la presencia de borrego cimarrón en la Sierra de Juárez?

Si _____ No _

Si su respuesta es si, por favor háblenos más acerca de sus observaciones:

- ¿Dónde observó esos signos? (describa o marque en el mapa anexo)
- ¿Cuándo los observó? (año o estación del año)

¿Ha visto usted ganado doméstico en la Sierra de Juárez? Si _____ No _____ Si su respuesta es si, por favor díganos de qué tipo eran (borregos domésticos, cabras, vacas), dónde los vio (indicar en el mapa), y en qué año.

¿Conoce usted a alguien que haya cazado borrego cimarrón en la Sierra de Juárez? Si_____ No _____ Si su respuesta es si, por favor díganos el año y la ubicación en general donde esto ha ocurrido.

Los leones de la montaña (puma) son los depredadores naturales del borrego cimarrón. ¿Usted ha visto puma en la Sierra de Juárez? Si _____ No ____

Si su respuesta es si, por favor díganos más sobre lo que ha visto:

- ¿Dónde ha visto león de la montaña? (describa o marque en el mapa anexo)
- ¿Cuándo lo vio? (año o épocas del año)

¿Podemos contactarlo si tenemos alguna pregunta sobre sus observaciones? Si____ No____ Si su respuesta es si, ¿cuál es el mejor medio para buscarlo? (email, teléfono, carta)

¿Podría usted recomendarnos otra persona que pudiera tener información sobre borrego cimarrón en la Sierra de Juárez? Si es así, por favor proporciónenos el dato de contacto:

Gracias!









Macho Adulto



Hembra Adulto



Excretas y huella de una pisada de borrego cimarrón



Table 1. Individuals Interviewed and/or Contacted for Input.

| Name | Organization |
|---------------------------------|--|
| Aguilar, José Luis | SEMARNAT |
| Alaniz, Jorge | UABC |
| Albańes Aarballo, Amado | Comunidad Indígena Santa Catarina |
| Ayala, Sonia | Manejador de UMAs Independiente |
| Avery, Jon | U.S. Fish and Wildlife Service |
| Castellón, José de Jesús | UABC |
| Castro Rubio, Héctor | Ejido Sierra de Juárez |
| Cruz Domínguez, Juan Ramón | CONAFOR-Dpto. Incendios Forestales |
| DeForge, Jim | Bighorn Institute |
| De León Girón, Gonzalo | CONANP-Parque Nacional Constitución de 1857 |
| Delgadillo, José | UABC |
| Delgadillo Villalobos, Jonas A. | CEMEX, El Carmen (Coahuila, México) |
| Detrell, Francisco | Prestador de Servicios Ecoturisticos |
| Díaz, Alain | Prestador de Servicios |
| Díaz, Virginia | Dirección Forestal y Fauna-Gobierno BC |
| Eaton, Ricardo | UABC |
| Escobar, Jonathan | UABC-Grupo Manejo y Conservación de Vida Silvestre |
| Espinosa, Alejandro | CEMEX, El Carmen (Coahuila, México) |
| Flanagan, Pat | Mojave Desert Land Trust |
| Guevara, Aldo | UABC-Grupo Manejo y Conservación de Vida Silvestre |
| Guzmán, Ricardo | CONANP |
| López, Fabiola | UABC-Tesista |
| López, Gerardo | Consultor Independiente |
| Loubet, Héctor | Comisión Federal de Electricidad |
| Krausman, Paul | University of Montana |
| Lee, Ray | Ray Lee LLC |
| Magaña, Reynaldo | Ejidatario del ejido Laguna Hanson |
| Martinez Gallardo, Roberto | UABC |
| McKinney, Billy Pat | CEMEX, El Carmen (Coahuila, México) |
| McKinney, Bonnie | CEMEX, El Carmen (Coahuila, México) |
| Mellink, Eric | CICESE |
| Navarro, Blanca | UABC-Grupo Manejo y Conservación de Vida Silvestre |
| Nordstrom, Lisa | Zoological Society of San Diego |
| Ostermann-Kelm, Stacey | National Park Service |
| Peraza, Iván | Manejador de UMAs Independiente |
| Resendiz Ruiz, María Elenea | Ejido Sierra de Juárez |

| Name | Organization |
|-----------------------|--|
| Quate, Valerie | (no affiliation) |
| Reyes, Claudia | CONAFOR |
| Santos, Aurelio | Prestador de servicios |
| Schwenkmeyer, Dick | (no affiliation) |
| Sorensen, Pete | US Fish and Wildlife Service |
| Uranga, Ramiro | (no affiliation) |
| Valdez, Raul | New Mexico State University |
| Vargas Prieto, Martin | SEMARNAT |
| Vizcarra, Alfredo | Rancho Alamar |
| Wagner, Guy | U.S. Fish and Wildlife Service |
| Wallace, Mike | Zoological Society of San Diego |
| Weaver, Dick | California Department of Fish and Game (retired) |
| Zamora, Enrique | Prestador de servicios |

| East UTM | North UTM | General Location | Date of Observation | Group Size | Group composition | Type of Survey | Observer |
|-------------|--------------|--|------------------------|---------------|---|--|-----------------------|
| 613274 | 3565348 | Near Tajo Canyon, just southeast of Cerro La Milla | Approx. 1950 | 2 | 1 ram, 1 ewe | Opportunistic observation while hiking | Schwenkmeyer |
| 617530 | 3542657 | Cañón el Escondido (canyon just south of La Mora Canyon) | Late 1980s | 2 | 2 ewes | Opportunistic observation while hiking | Schwenkmeyer |
| 618448 | 3559133 | In the foothills east of Guadalupe Canyon, in the last outcrops of granite adjacent to Laguna Salada | Early 1990s | 13 | Ewes and young animals (no mature rams) | Opportunistic observation while hiking | Schwenkmeyer |
| 657896 | 3486502 | Arroyo Grande | Sept. 1991 | 3 | 2 ewes, 1 lamb | Opportunistic observation | Uranga |
| 639166 | 3477261 | | Sept. 19, 1995 | 2 | 1 ewe, 1 lamb | Helicopter survey for BHS | Lee |
| 659609 | 3436382 | | Sept. 19, 1995 | 2 | 1 ewe, 1 lamb | Helicopter survey for BHS | Lee |
| 657466 | 3436091 | | Sept. 19, 1995 | 2 | 1 ram (Class III), 1 ewe | Helicopter survey for BHS | Lee |
| 613315 | 3557577 | At the entrance to Canon de Guadalupe, before crossing the dry arroyo ~1 km before the camp | May 2004 | 2 | Possibly 1 adult male, 1 adult female | Ground survey | Detrell |
| 613315 | 3557577 | At the entrance to Canon de Guadalupe, before crossing the dry arroyo ~1 km before the camp | May 2006 | 2 | Possibly 1 adult male, 1 adult female | Ground survey | Detrell |
| 623901 | 3533646 | Cañón El Palomar | October 2004 | 2 | 2 adult males | Aerial survey | Peraza |
| 610207 | 3553955 | Rancho San Luis above Cañón de Guadalupe | Dec. 2008 | N/A | Tracks and scat | Ground survey | Guevara |
| 616619 | 3526706 | | March 2009 | ~15 | Group included 6 rams | Aerial survey for eagles | Nordstrom/ Wallace |
| 616292 | 3527142 | | March 2009 | 5 | Group included 1 ram | Aerial survey for eagles | Nordstrom/ Wallace |
| 626049 | 3528972 | | March 2009 | 5 | 5 young males | Aerial survey for eagles | Nordstrom/ Wallace |
| 614023 | 3545806 | | March 2009 | 6 | 3 adult females, 3 | Aerial survey | Nordstrom/ |

Table 2. Reported observations of bighorn sheep in the Sierra Juárez¹.

| East UTM | North UTM | General Location | Date of Observation | Group Size | Group composition | Type of Survey | Observer |
|-------------|--------------|---|------------------------|---------------|---|------------------------------|----------|
| | | | | | lambs | for eagles | Wallace |
| N/A | N/A | Sierra Júarez (more specific information not provided) | April 1992 | NA | 1 ram, 2 ewes, 1 yearling ewe (in 2 groups) | Helicopter survey for BHS | DeForge |

¹ When a general location was provided (e.g., a canyon name), a UTM coordinate was assigned to the general area described. In some cases, no general location was provided (only coordinates).

Appendix B

Preliminary Field Reconnaissance July 2009



Inicio del recorrido en Rancho Alamar, con el apoyo el propietario Sr. Alfredo Vizcarra.





Se inicio el recorrido a caballo a través del Rancho Alamar y otros predios que forman para de la Cordillera de Molina





Se observaron diversos ambientes, presentándose en arroyos la transición con matorral desértico y chaparral





A través de esta zona se ha observado puma, de acuerdo con los guías acompañantes del recorrido.





El paisaje de enorcamientos y la transición entre el bosque, el chaparral y el matorral, permite observar a diversidad de hábitat de esta zona.





En algunas partes de los arroyos de la zona se evidencia el nivel de agua que llega a escurrir, principalmente durante el invierno. Esto como zona generadora de recursos hidrológicos.





Dentro de la transición del bosque de Pinus con el matorral desértico, resaltan las formas rosetófilas propias de los géneros *Agave* y *Yucca*.





En algunas zonas el chaparral mantiene su distribución a manera de continuo de vegetación, siguiendo algunas laderas de exposición noroeste





Los diversos estratos topográficos permiten generar condiciones del suelo aptas para la transición en los tipos de vegetación





La forma desarrollada de arbustos como manzanita y chamizo, indican el buen estado de conservación del hábitat en esta zona





Parte del paisaje conservado de la zona recorrida







Elementos xerófilos en la transición con el matorral desértico. Abajo algunas excretas de venado encontradas en este ambiente.





Otra imagen que ilustra la transición altitudinal en la vegetación.





Algunos cuerpos de agua encontradas en las cañadas de la zona, se observaron como sitios de mayor actividad faunística.





Algunos cuerpos de agua encontradas en las cañadas de la zona, se observaron como sitios de mayor actividad faunística.





El paisaje en la cercanía al parteaguas de la vertiente este, permite observar mayor incorporación de elementos del matorral desértico, dejando a tras la influencia del bosque de coníferas.





Imágenes panorámicas tomadas desde la orilla este de la Cordillera Molina, con orientación este hacia la laguna salada





Imágenes panorámicas tomadas desde la orilla este de la Cordillera Molina, con orientación este hacia la laguna salada





Imágenes panorámicas tomadas desde la orilla este de la Cordillera Molina, con orientación este hacia la laguna salada





Imagen ejemplificando la pendiente pronunciada que implica el descenso al este





Imágenes con acercamiento hacia la parte baja de las cañadas que descienden de la cordillera hacia el desierto.





Imágenes de acercamiento a los lomeríos del matorral desértico con los cuales se desvanece orográficamente la sierra hacia el este, en su encuentro con la laguna salada. Esta zona corresponde al hábitat de borrego cimarrón. Es probable que se trate de las últimas zonas al norte donde este hábitat se encuentra aún conservado.

