



52nd Meeting of the  
**Desert Bighorn Council**

Las Cruces, New Mexico

April 17–20, 2013

Organized by

Desert Bighorn Council

New Mexico Department of Game and Fish

United States Army, White Sands Missile Range

Cover: Puma/bighorn petroglyph, photo by Casey Anderson.

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# 52nd Meeting of the Desert Bighorn Council

## Organizers



## Sponsors



# Desert Bighorn Council Officers

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Patrick Morrow        U.S. Army, White Sands Missile Range

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Brian Wakeling        Arizona Game and Fish Department

# Schedule: Wednesday, April 17, 2013

3:00–8:00 p.m.    **Registration**

6:00–8:00 p.m.    **Social**

# Schedule: Thursday, April 18, 2013

## MORNING SESSION

7:00–8:00 a.m.    **Registration**

8:00–8:20 a.m.    **Opening Remarks**                      James Lane, Jr., Director  
New Mexico Department of Game and Fish

8:20-10:00 a.m.    **Predation Session**                      Moderator: J. Cain

8:20–8:40                      D. Choate  
ALTERNATIVE PREY AND SPATIO-TEMPORAL PATTERNS OF RISK ON THE  
DESERT NATIONAL WILDLIFE REFUGE: DOES BIGHORN SHEEP USE OF  
WATER SOURCES INCREASE THE RISK OF COUGAR PREDATION?

8:40–9:00                      J. Davis  
PROTECTING SIERRA NEVADA BIGHORN SHEEP FROM MOUNTAIN LION  
PREDATION, 1999-2011

9:00–9:20                      R. Karsch  
DESERT BIGHORN SHEEP LAMB SURVIVAL AND CAUSE-SPECIFIC MORTAL-  
ITY IN THE PELONCILLO MOUNTAINS, NEW MEXICO

9:20–9:40                      J. Villepique  
RESPONSES OF DESERT BIGHORN SHEEP TO EXPERIMENTAL SIMULATION  
OF RISK OF PREDATION BY MOUNTAIN LIONS

9:40–10:00                      E. Rominger  
PUMA: UNGULATE RATIOS IN THE SKY-ISLANDS OF THE CHIHUAHUAN  
DESERT

10:00–10:30 a.m.    **Break**

## **MORNING SESSION — CONTINUED**

**10:30–12:30 p.m. Lion/Desert Bighorn Panel** Moderator: E. Rominger

Panelists:

Elise Goldstein—New Mexico Department of Game and Fish

John Wehausen—White Mountain Research Station, California (retired)

Clay Brewer—Texas Parks and Wildlife Department

Bob Henry—Arizona Game and Fish Department

**12:30–2:00 p.m. Lunch (on your own)**

## **AFTERNOON SESSION**

**2:00–3:30 p.m. General Session** Moderator: S. Liley

2:00–2:20

T. Janke

RESEARCH AND MANAGEMENT IMPLICATIONS FOR BIGHORN SHEEP  
ALONG THE UNITED STATES AND MEXICO BORDER

2:20–2:40

K. Hurley

GIS MAPPING OF WILD SHEEP TRANSLOCATIONS IN U.S. AND CANADA

2:40–3:00

P. Wolff

PHYSIOLOGICAL FINDINGS WITH DIFFERENT CAPTURE METHODS IN DES-  
ERT BIGHORN SHEEP

**3:00–3:30 p.m. Break**

**3:30–4:50 p.m. General Session** Moderator: R. Karsch

3:30–3:50

J. Cain

CLIMATIC VARIABILITY AND NUTRITIONAL CONTENT OF DESERT BIGHORN  
SHEEP FORAGE IN SOUTHWESTERN ARIZONA

3:50–4:10

K. Longshore

DOES FORAGING AT THE WILDLAND–URBAN INTERFACE CAUSE DECOU-  
PLING OF CLIMATE AS A DRIVER OF RECRUITMENT FOR DESERT BIGHORN  
SHEEP?

## **Schedule: Thursday, April 18, 2013 – continued**

- 4:10-4:30 R. Velazquez  
POPULATION AND HABITAT USE BY DESERT BIGHORN SHEEP (*Ovis canadensis mexicana*) TRANSLOCATED INTO SIERRA MADERAS DEL CARMEN, COAHUILA, MEXICO
- 4:30-4:50 K. Garrison  
INFLUENCE OF LIVESTOCK GRAZING ON FORAGE BIOMASS, ACTIVITY BUDGETS AND FORAGING EFFICIENCY OF DESERT BIGHORN SHEEP (*Ovis canadensis mexicana*) IN SOUTHERN NEW MEXICO
- Evening Dinner (on your own)**

## **Schedule: Friday, April 19, 2013**

### **MORNING SESSION**

- 8:30–9:50 a.m. General Session** Moderator: K. Garrison
- 8:30-8:50 S. Sprague  
AN ASSESSMENT OF HIGHWAY CONSTRUCTION DISTURBANCE OF DESERT BIGHORN SHEEP
- 8:50-9:10 T. Janke  
ANALYSIS OF TRANSLOCATED BIGHORN SHEEP MOVEMENTS IN THE BOFECILLOS MOUNTAINS OF THE TRANS PECOS, TEXAS: INITIAL AND SUPPLEMENTAL RELEASES
- 9:10-9:30 J. Escobar  
BIGHORN SHEEP (*Ovis canadensis*) POPULATION SURVEY IN SIERRA SANTA ISABEL, BAJA CALIFORNIA MÉXICO: RECOMMENDATIONS FOR SUSTAINABLE USE
- 9:30-9:50 D. Anderson  
HABITAT SELECTION BY MOUNTAIN SHEEP IN ACTIVE LIMESTONE QUARRIES, SAN BERNARDINO MOUNTAINS, CALIFORNIA, USA
- 9:50–10:30 a.m. Break**



**10:30–12:00 a.m. Genetics Session**

Moderator: E. Goldstein

10:30-11:00

P. Hedrick

NUMBER OF FOUNDERS IN THE ARAVAIPA, ARIZONA AND RED ROCK, NEW MEXICO BIGHORN POPULATIONS

11:00-11:30

A. Naidu

LANDSCAPE GENETICS OF MOUNTAIN LIONS IN THE SONORAN DESERT

11:30-12:00

J. Wehausen

GENETIC POPULATION STRUCTURE AND GENE FLOW PATTERNS IN TWO BIGHORN SHEEP METAPOPOPULATIONS IN THE LAS VEGAS REGION FROM MICROSATELLITE AND MITOCHONDRIAL DNA ANALYSES

**12:00–1:30 p.m. Lunch (on your own)**

**AFTERNOON SESSION**

**1:30-3:00 p.m. State Status Reports**

Moderator: M. Weisenberger

1:30-1:45

Utah—A. Aoude

1:45-2:00

Texas—F. Fernandez

2:00-2:15

Sonora/Baja—R. Lee

2:15-2:30

New Mexico—E. Goldstein

2:30-2:45

Nevada—A. Curtis

2:45-3:00

Coahuila—A. Espinosa

**3:00-3:30 p.m. Break**

**3:30-4:00 p.m. State Status Reports**

Moderator: R. Winslow

3:30-3:45

California—V. Bleich

3:45-4:00

Arizona—B. Henry/B. Wakling

**4:00 p.m. Business Meeting**

## ***Schedule: Friday, April 19, 2013 – continued***

### **5:30-6:30 p.m.      Poster Session**

J. Ochoa

ASSESSMENT OF EQUINE POPULATIONS IN A POTENTIAL HABITAT FOR BIGHORN SHEEP IN NORTHWESTERN COAHUILA, MEXICO

R. Roman

POPULATION DENSITY AND STRUCTURE OF DESERT BIGHORN SHEEP (*Ovis canadensis weemsi*, Goldman, 1937) IN "THE CARMEN" ISLAND, BAJA CALIFORNIA SUR, MEXICO

R. Robinson

DETERMINING THE STATUS AND TREND OF DESERT BIGHORN SHEEP IN THE SAN RAFAEL SWELL

### **6:00 p.m.              Cocktail Social**

### **6:30 p.m.              Awards Banquet**

D. Weaver; Awards Committee Chair

## **Schedule: Saturday, April 20, 2013**

### **7:40 a.m.–5 p.m.    Field Trip to White Sands Missile Range**

MUST BE PRE-APPROVED BY WSMR SECURITY TO ATTEND

# Habitat Selection by Mountain Sheep in Active Limestone Quarries, San Bernardino Mountains, California, USA

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***Abstract:*** We investigated how desert bighorn sheep (*Ovis canadensis nelsoni*) select habitat features in an area modified by past and present mining activity. Active and inactive limestone mining operations overlap approximately 30% of the composite home range for the Cushenbury herd, a group of 12-40 desert bighorn sheep located along the north slope of the San Bernardino Mountains in Southern California. High resolution GPS data were collected for 10 sheep (8 females, 2 males) from 2006 to 2009. A geographic information system (GIS) and remotely sensed imagery were used to (1) characterize and quantify mining-related alterations present during the study period and (2) assess selection by male and female bighorn sheep among anthropogenic habitat features in the immediate vicinity of present and historic mining activity. We characterized five habitat classes: active mine areas, inactive mine areas, mine reclamation areas, water sources, and a 100 m buffer of undisturbed habitat surrounding the mine operations. Preliminary analysis indicates significant selection for revegetation areas, water sources, and inactive mine areas, neutral selection for active mine areas, and avoidance of the buffer of undisturbed habitat surrounding the mine footprint. Further results and analysis will be presented.

***Oral Presentation***

# Climatic Variability and Nutritional Content of Desert Bighorn Sheep Forage in Southwestern Arizona

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**Abstract:** Forage nutritional quality can have a significant influence on the ecology of herbivores, including desert bighorn sheep (*Ovis canadensis mexicana*). Physiological condition, reproduction, and survival are all affected by forage nutritional quality. Both seasonal and annual variation in forage quality is strongly influenced by precipitation. Although studies have been conducted on the nutritional quality of desert bighorn sheep forage, most studies have been of limited duration and have therefore not included time periods with the widely varying environmental conditions (i.e., drought, wet periods) characteristic of the Sonoran Desert. We assessed nutritional content (i.e., nitrogen, ADF, NDF, ADL, and moisture content) of desert bighorn sheep forage collected from 2002 to 2005 on the Cabeza Prieta National Wildlife Refuge, which included periods of severe drought, abnormally high precipitation, and average precipitation. Nutritional content of forage varied among climatic periods and seasons, with significant differences in nutritional quality metrics associated with plant growth form (i.e., trees, shrubs, forbs, grasses, succulents). In general, nutritional quality and moisture content of trees was relative high and consistent across seasons and climatic periods, whereas succulents were consistently low in nutritional content, but high in moisture. Grass, forbs, and shrubs were much more variable, but generally increased in nutritional content with increasing precipitation. However, important differences were observed in specific nutritional metrics, particularly across seasons within climatic periods and in comparisons of the plant growth forms across climatic periods. More detailed results will be discussed in relation to their applicability to the potential influence of forage nutritional quality on the ecology, management and conservation of desert bighorn sheep.

## *Oral Presentation*

# Alternative Prey and Spatio-temporal Patterns of Risk in the Desert National Wildlife Refuge: Does Bighorn Sheep Use of Water Sources Increase the Risk of Cougar Predation?

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**Abstract:** Predation risk from cougars (*Puma concolor*) in desert environments may be enhanced when bighorn sheep (*Ovis canadensis*) increase their use of water sources during summer months. Understanding under what conditions water sources act primarily as ecological traps remains an important issue for wildlife managers. We investigated the spatio-temporal patterns of cougar predation on desert bighorn sheep in relation to water use on the Desert National Wildlife Refuge, NV. The spatial distribution of cougar kills was studied by intensive tracking of 5 GPS-collared cougars, and monitoring of 30 GPS-collared bighorn. Cougar density on the refuge was low ( $<0.2 / 100 \text{ km}^2$ ), and consisted primarily of adult females. Cougar kills comprised ~64.3% mule deer (*Odocoileus hemionus*), 30.3% bighorn sheep, and 5.4% other carnivores, and occurred closer to water sources ( $3.4 \pm 2.4 \text{ km}$ , mean  $\pm$  SD) than random points ( $9.6 \pm 8.0 \text{ km}$ ). However, only 1 kill occurred within 200 m of a water source. Bighorn sheep occurred closest to water sources during summer months. Extensive use of water sources increased during daylight hours, based on 24-h monitoring with camera-traps. Despite increased use of water sources, few bighorn were killed during summer. Conversely, mule deer were killed across all seasons, with a peak during summer months. While proximity to water sources did not appear to influence the difference in mortality between prey species, more frequent nocturnal visits to water sources and differential use of the landscape by mule deer may explain their increased risk of predation by cougar in this desert environment.

**Oral Presentation**

# Protecting Sierra Nevada Bighorn Sheep from Mountain Lion Predation, 1999–2011

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***Abstract:*** In 1999, Sierra Nevada bighorn sheep (SNBS) were listed as endangered under state and federal endangered species acts. Inadequacy of regulatory mechanisms to counter negative effects of mountain lion predation was one of two reasons for endangered listing. Managing predation figured importantly in the recovery plan for these sheep; however, the plan also cautioned that the management of predation should be carried out in a manner that considered the viability of the local mountain lion population. Wildlife Services was contracted during 1999-2011 to monitor/mitigate predation and to monitor lion population dynamics through development of reliable minimum lion counts. Those counts showed the lion population maintained itself in the face of removals to protect SNBS and other human-caused mortality. Lion predation showed large regional variation, as well as variation over time. Management of predation on bighorn sheep also varied over time, and included an experimental period during which lions known to have killed bighorn sheep were not removed, followed by a period in which those lions were removed. Lack of predation control was correlated with a 5-year cessation in the recovery of one bighorn sheep herd; but that recovery resumed after lion removals were reinstated. We found that each geographic area was unique within specific time periods relative to multiple variables that affect predator prey relationships, and that no generalizations could be made across geographic units relative to predation management needs. Consequently, predation management for these sheep needs to be adaptive and based on continued data input.

## ***Oral Presentation.***

# Bighorn Sheep (*Ovis canadensis*) Population Survey in the Sierra Santa Isabel, Baja California Mexico: Recommendations for Sustainable Use

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## RAY LEE. LLC

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**Abstract:** Bighorn sheep is one of the most important hunting species in America, however in Baja California this species is not hunted. Photographic safaris have demonstrated to be a “sustainable” activity because they are not extractive and can be done all year. The objective of this study was to survey the population and characterize its habitat during an annual cycle in two sites: Los Hemes and El Zamora. The results showed spacial-temporal use variations by bighorn sheep. In Los Hemes during the summer and fall, the female count was highest (n= 44), followed by yearlings (n=20), while the male count was lowest (n=36). Observations of adults were consistent in both seasons. In contrast, during winter only five females were observed with three lambs and a young male. In El Zamora, observations of females and yearlings were very common, especially during fall (n=79 and 46, respectively). In conclusion, the population study helped to identify sites that are suitable for photographic safari, and the sex and age classes available for photographing. We propose a rule guide for tourists.

## *Oral Presentation*

# Status of the Bighorn Sheep Restoration Programs in Northeastern Mexico: State of Coahuila

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***Abstract:*** CEMEX has made substantial progress towards the restoration of desert bighorn sheep in historical habitat in northeastern Mexico. Major accomplishments include: a) the release of 18 bighorns to Sierra del Carmen Coahuila during 2012; b) two successful auctions one at WSF convention and Texas Bighorn Society Round Up in 2012; c) the follow up of cooperative agreements with Texas Parks and Wildlife and Texas Bighorn Society, including the support on the monitoring of the free-range bighorn sheep populations in Santa Elena Canyon, Chihuahua; and d) one Master in Science thesis, on desert bighorn sheep habitat use on Sierra del Carmen, was completed.

***Key Words:*** Northeastern Mexico, CEMEX, restoration program, Coahuila, Chihuahua and Nuevo Leon.

## ***Oral Presentation***



# Influence of Livestock Grazing on Forage Biomass, Activity Budgets and Foraging Efficiency of Desert Bighorn Sheep (*Ovis canadensis mexicana*) in Southern New Mexico

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**Abstract:** The desert bighorn sheep (*Ovis canadensis mexicana*) is an iconic species treasured for both aesthetics and sport. Prior to European settlement, desert bighorn numbered in the thousands in New Mexico. By 1980, however, over-hunting, disease, and habitat degradation by livestock reduced desert bighorn to just 69 wild animals. In the following thirty years, desert bighorn populations have recovered to an approximate 750 animals state-wide. Though trends are promising, desert bighorn recovery remains an ongoing challenge. One profound land use which can impact bighorn populations is cattle grazing. By altering the habitat and foraging behavior of desert bighorn, cattle grazing may influence bighorn population growth. Thus, we have begun research investigating the impacts of cattle grazing on desert bighorn sheep in New Mexico. We hypothesize that cattle grazing on desert bighorn habitat reduces the quantity and quality of forage for desert bighorn, thus reducing foraging efficiency. To test this hypothesis we are quantifying forage resources and behavior of desert bighorn in grazed and ungrazed ranges. Specifically, we are measuring the composition and biomass of key forage species at different spatial scales by sampling transects across each habitat and at observed bighorn foraging stations. We are also collecting observational data on desert bighorn activity budgets and foraging bouts to quantify foraging efficiency. Observational data will include time spent feeding, number of steps taken, and time spent in non-feeding activities. We predict that the ungrazed habitat will have higher edible forage biomass, allowing desert bighorn to forage more efficiently than in the grazed habitat.

***Oral Presentation***

# Number of Founders in the Aravaipa, Arizona and Red Rock, New Mexico Bighorn Populations

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***Abstract:*** Many bighorn sheep populations in western North America have had low numbers and consequently lost genetic variation. Here the possible effects of genetic drift and inbreeding are evaluated in two populations of desert bighorn sheep from Aravaipa Canyon, Arizona and Red Rock, New Mexico, both initiated in the 1970s from translocations. From theoretical pedigree analysis, the effective numbers of founders in the Aravaipa population from the 22 sheep released in 1973 was estimated to be only between 5 and 6, depending upon on the reproductive success of the initial ram, Old Granddad. Using these data and estimates of the effective population size in later generations, the current inbreeding coefficient is expected to be between 0.13 and 0.19. From pedigree analysis of the 39 sheep alive in 1976 in the Red Rock population, the effective number of founders was around 17. In this population, about 46% of the ancestry is from Mexican sheep and about 54% from San Andres sheep and the present day estimate of the inbreeding level is 0.10. Estimates of molecular genetic variation in the Red Rock population are low and this analysis suggests that genetic variation in the Aravaipa population is probably even lower. In Aravaipa, the decline in horn size over 30 years and the low survey numbers in 2012 might be related to these high inbreeding levels.

***Oral Presentation***

# GIS Mapping of Wild Sheep Translocations in U.S. and Canada

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***Abstract:*** Beginning with a round-robin session conducted during the 1996 Northern Wild Sheep and Goat Council biennial symposium in Silverthorne, CO, then completed in 2013 through the efforts of the Western Association of Fish and Wildlife Agencies (WAFWA) Wild Sheep Working Group (WSWG), a “master” EXCEL spreadsheet of every known wild sheep translocation documented in the U.S. and Canada has been assembled, including capture-site and release-site decimal degree LatLong coordinates, reflecting the number of wild sheep translocated within and between jurisdictions. In addition to this EXCEL spreadsheet, GIS maps (in .tiff and/or .jpg formats) displaying wild sheep imports and exports (i.e., “inter-jurisdictional”) and translocations within a single state or province (i.e., “intra-jurisdictional”) have also been prepared. Anticipated benefits from this spreadsheet and accompanying GIS maps include evaluation of past (and future) wild sheep translocations, with consideration of genetic factors, disease status, population growth rates, proximity to active domestic sheep and goat public-land grazing allotments, and other public- and private-land management scenarios. Plans are to house this spreadsheet and related translocation data on a moderated WAFWA WSWG website, which would allow password-enabled agency access to data, GIS files, and GIS maps; public, NGO, or other interested party access to GIS files, translocation data, and maps will also be available, on a permission basis. Plans are also in the works for a popular-format glossy publication, to be distributed primarily via the Wild Sheep Foundation and its network of chapters and affiliates. This effort was made in an attempt to discover and document all past wild sheep translocation records, before files/records became lost in agency files, and prior to retirement/departure of many current senior-level wild sheep biologists from career positions.

## ***Oral Presentation***

# Research and Management Implications for Bighorn Sheep Along the United States and Mexico Border

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***Abstract:*** Desert bighorn sheep (*Ovis canadensis* ssp.) are one of countless species that do not recognize borders, whether private, state, or international. In order for many of these species and populations to persist and survive, immigration and emigration are crucial. In 2010 and 2011, 141 bighorn sheep were translocated within Texas to the Bofecillos mountain range of the southern Trans Pecos. Though these relocations are just a small stepping stone in working to restore wild bighorn sheep to their native ranges in the Trans Pecos, they have proven that political boundaries are no obstacle to their movements. Numerous challenges within international cooperation, and even within state and private cooperation, add difficulty in restoring, protecting, and managing such an iconic species. Ruggedness and remote environments add to the challenges of obtaining data to further our knowledge and understanding of the restoration and management of the desert bighorn sheep in Texas. International cooperation has been a blessing thus far, but in order for species such as the desert bighorn sheep to survive and roam freely, more is needed. Implications and obstacles encountered and overcome over the past 2 years will be addressed and discussed.

***Oral Presentation.***

# Analysis of Translocated Bighorn sheep Movements in the Bofecillos Mountains of the Trans Pecos, Texas: Initial and Supplemental Releases

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***Abstract:*** Based on historical estimates in the late 1800s, Texas desert bighorn (*Ovis canadensis mexicana*) numbered 1500 individuals. These sheep roamed across 15 different mountain ranges throughout the Trans Pecos. Despite initial restoration efforts in the 1950s, their numbers continued to decline. It is commonly agreed that overhunting, predation, competition, and disease, had major impacts and eventually led to the extirpation of the species by the early 1960s. Over time, transplanted sheep from other states and Mexico have helped rebuild a viable bighorn population in Texas. Throughout the past 50 years, over 500 sheep (including over 350 from Texas populations) have been transplanted throughout the Trans Pecos mountain ranges. To date, 8 of the historic 15 ranges now have desert bighorn living within them. December of 2010 and 2011 have marked historic translocations for bighorn and restoration efforts in Texas. Not only have these been a part of the most recent translocations since 2000, but they have also been the first efforts to transplant desert bighorn into a Texas State Park. Preliminary analysis of their movements, ecology, and survival will be discussed based on information and data gained by the use of radiotelemetry and GPS collars worn by the translocated sheep.

***Oral Presentation***

# Desert Bighorn Sheep Lamb Survival and Cause-specific Mortality in the Peloncillo Mountains, New Mexico

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***Abstract:*** Lamb survival is one of the most difficult demographic rates to estimate accurately due to the difficulty capturing neonatal lambs and locating lamb carcasses. We are currently studying neonatal lamb survival, recruitment rates, and cause-specific mortality factors in the Peloncillo Mountains, New Mexico. We captured 20 pregnant ewes in November 2011 and 19 pregnant ewes in December 2012 and equipped each with a Vaginal Implant Transmitter to aid locating parturition sites and capturing lambs. Three ewes captured in 2011 died prior to parturition. Of the 17 remaining ewes, all successfully gave birth to live lambs, 12 of which were captured by hand and radio-collared with expandable VHF collars. Lambing began mid-January 2012, with the first lamb captured on 31 January and the last on 22 March. Lambs were monitored daily from capture until 16 weeks of age, every 2–4 days until 6 months of age and weekly thereafter. We documented three mortalities of lambs collared in 2012 before their collars started falling off at approximately four months of age. Based on the condition of the carcasses and evidence at the kill sites, we determined the cause of death to be predation by a gray fox (*Urocyon cinereoargenteus*) in one case and mountain lions (*Puma concolor*) in two cases. Lamb captures from the 2012 ewe capture are ongoing. The overall goal of this study is to provide much needed data on lamb survival, recruitment, and cause-specific mortality, allowing for more informed management efforts to promote population growth.

***Oral Presentation***

# Does Foraging at the Wildland–Urban Interface Cause Decoupling of Climate as a Driver of Recruitment for Desert Bighorn Sheep?

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**Abstract:** A growing number of ungulate populations are living within or near the wildland-urban interface. When resources (e.g., food, water, refuge from predators) at the wildland-urban interface are of higher quality than that of the adjacent natural habitat, wildlife can be attracted to these developed areas. Under natural conditions, recruitment in desert bighorn sheep populations correlates with variation in the timing and amount of rainfall that initiates and enhances growth of annual plant species. However, for populations that forage in developed areas, this relationship may be decoupled. In the River Mountains of southern Nevada, desert bighorn sheep (*Ovis canadensis nelsoni*) have been feeding in a municipal park at the wildland-urban interface since its establishment in 1985. Nearly one third of the population uses the park during summer months when nutritional content of natural forage is low. We hypothesized that use of this municipal area, with its abundant vegetation and water resources, may have altered the previous relationship between precipitation and lamb recruitment. We assessed variables known to affect lamb recruitment before and after establishment of the park using linear regression models and AIC for model selection. Our top candidate model for the pre-park period indicated that total November precipitation was the greatest driver of lamb recruitment in this population. After park establishment, this relationship became decoupled; lamb recruitment is no longer driven by weather variables. These results raise management questions about the impacts of this decoupling on population growth, and the negative impacts of overcrowding in the municipal park, e.g. disease transmission, increased mortality due to vehicle collisions, and property damage at the wildland-urban interface.

*Oral Presentation*

# Landscape Genetics of Mountain Lions in the Sonoran Desert

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**Abstract:** We are investigating the current population genetic status of mountain lions (*Puma concolor*) in the Sonoran Desert with the goal of answering the following questions: 1) what is the probable origin of mountain lions occurring on Kofa National Wildlife Refuge (Kofa NWR) in Arizona; 2) what are the habitat corridors for mountain lion movement in the northern Sonoran Desert; and 3) are there any geographic features (such as interstate highways, Central Arizona Project canal, and the Colorado River) restricting gene flow among mountain lion subpopulations? To answer these questions, we are genotyping ~600 mountain lion DNA samples with 20 well-known *Felis catus* (FCA) microsatellite DNA markers, and with “PumaPlex” – a panel of 26 Single Nucleotide Polymorphism (SNP) markers recently developed for population genetic studies on mountain lions. Using this dataset, we will calculate relatedness between pairs of individual mountain lions and attempt to estimate the likely origin(s) of mountain lions currently occurring on Kofa NWR. We will then test the hypothesis: If population genetic substructure among mountain lions is related to geographic features, then these features are likely specific natural or man-made barriers, or isolation-by-distance. To corroborate genetic data on mountain lion population substructure and connectivity, we are also creating a GIS-based habitat suitability model for mountain lions that will provide us with the most potential corridors for mountain lion movement in the northern Sonoran Desert. Data generated from this study will be useful for wildlife managers, stakeholders, and conservation planners in making regional or statewide management decisions for mountain lions, designating wildlife corridor areas, and facilitating collaborative research between individuals, laboratories and agencies through genetic databases.

## ***Oral Presentation.***



# Assessment of Equine Populations in a Potential Habitat for Bighorn Sheep in Northwestern Coahuila, Mexico

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***Abstract:*** Northwest Coahuila was natural habitat for bighorn sheep populations before they were locally extinguished in the first half of the 20<sup>th</sup> century. Recently, reintroduction projects have been developed in the Big Bend and Maderas del Carmen region in order to recover bighorn sheep populations. Equines (horses and donkeys) are one of the main potential competitors with bighorn sheep for space and food in Mexico. From spring 2011 to January 2013, a population assessment of domestic and feral equines was performed. A survey was conducted of 106 residents of five rural communities in 64,500 hectares of northwestern Coahuila, and by direct animal counting transects. Equine population density was estimated at 1,148 animals (one equine per 56 hectares). Forty-five percent were domestic horses, 30% domestic donkeys, and 25% feral donkeys grazing freely in common land; negative fluctuations in number of equines were because their owners sold them (average 200 animals annually), or death (mainly by predation, and starvation; average 130 animals/year). Equines are an important competitor with bighorn sheep in Coahuila. Therefore a key task is to reduce their populations in order to ensure success of wildlife reintroduction programs.

***Poster Presentation.***

# Determining the Status and Trend for Desert Bighorn Sheep in the North San Rafael Swell

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***Abstract:*** The North San Rafael (NSR) desert bighorn population has been steadily declining for several years. In 2001, the Utah Division of Wildlife Resources counted 326 animals, but only 150 animals in 2008. On average, annual population growth has been  $\lambda = 0.89$  since 2001. In January 2012, 30 ewes and eight rams were captured, tested for disease and fitted with GPS/VHF collars, which will be worn for two years. During that time the sheep will be under constant monitoring. Study objectives are: 1) locate collared females weekly to document survival; 2) locate and necropsy dead bighorns to determine causes of death and limiting factors; 3) quantify production and survival of neonates; and 4) create seasonal range use maps and an associated habitat model. Following the first year of the study, some initial observations can be made. All collared ewes gave birth to lambs. Lambing dates ranged from 4 May to 9 June, with a mean date of 23 May. Lamb to ewe ratios were 45:100 in November 2012. Ten mortalities have been documented. Cougar predation played a role in mortalities. Disease accounted for one mortality. There was one hunter harvest and two mortalities have unknown causes. We estimate the current population to be ~130 animals. Results of disease testing has shown *Mannheimia haemolytica* and *Mycoplasma ovipneumonia* are present in the population.

## ***Poster. Presentation***

# Density and Population Structure of the Desert Bighorn Sheep (*Ovis canadensis weemsi*, Goldman, 1937) in The Carmen Island, Baja California Sur, Mexico

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**Abstract:** El Carmen Island, Baja California Sur, belongs to the National Marine Park of Loreto Bay, decreed published in 1996. Based on geographical location, climatic conditions, shortage of water, vegetation types and topofoms, it is a site of interest. In particular, studies focused on the desert bighorn sheep conservation (*Ovis canadensis*), which is a species that requires specific habitat conditions regarding water, food, cover and space. This species belongs to one of the most popular wildlife groups. Their enormous hunting value, as well as its biological and cultural importance have attracted researchers specializing in wildlife management and conservation. The purpose of this study was to determine the structure and population density of this important hunted species within the island. We used three methods for determining the density and population structure. These are: fringe counting method, direct observation of specimen, and fecal monitoring plots. In addition, sightings of individuals in water holes were used to reinforce observations of the specie's population structure. We determined a density of 0.1725 sheep per hectare through the method of counting fringes. The method of fecal monitoring plots yeilded an estimate of 0.68 groups per hectare stool. The method of direct observation was not useful for estimating population density. Finally, a definitive analysis of population structure found an association of male:female:lamb:yearling of 32:40:23:5 (or 0.8:1.0:0.58:0.13).

## *Poster Presentation*

# Puma: Ungulate Ratios in the Sky-islands of the Chihuahuan Desert

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**Abstract:** Because *minimum* puma (*Puma concolor*) kill rates are independent of ungulate prey density, the ultimate effect of predation is linked to the predator:prey ratio. Maximum ungulate (deer-size) densities in the northern hemisphere, from predator-free enclosures or islands, vary only by a factor of ~3-4 (20-90 ungulates/km<sup>2</sup>). Here, I report ungulate densities varying by a factor of 100-185 between adjacent mountain ranges in the Chihuahuan desert. Mule deer (*Odocoileus hemionus*) density in the San Andres Mountains in New Mexico is reported to be 8-10 deer/100 km<sup>2</sup> compared to 900-1200 deer/100 km<sup>2</sup> in the adjacent Sierra Diablo Mountains in Texas. Desert bighorn (*Ovis canadensis*) density in the occupied portions of the San Andres Mountains is ~40/100 km<sup>2</sup> compared to 200-300/100 km<sup>2</sup> in the Sierra Diablo Mountains. Puma density in the relatively unexploited San Andres Mountains is reported to be ~2 puma/100 km<sup>2</sup>. In Texas, where puma are unprotected, the density is unknown but is assumed to be some fraction of that reported for New Mexico. Assuming a 50-75% reduction in puma density, the puma:prey ratio may be as low as 1:1500 or 1:3000. In New Mexico mule deer ranges without desert bighorn, this ratio may be as high as 1:4 essentially defying the Kleiber Equation, and 1:67 in habitat with sympatric desert bighorn. The effect of this predator:prey imbalance cascades throughout the trophic structure, often resulting in extirpation or near extirpation, of native fauna including desert bighorn sheep, desert mule deer, and porcupines (*Erethizon dorsatum*). High annual mortality rates associated with the Allee Effect will preclude low-density ungulate populations from increasing, regardless of habitat conditions. In the San Andres Mountains, low mule deer numbers has resulted in the elimination of sport-hunting which is the cornerstone of the North American Model. Low mule deer density in other New Mexico ranges has resulted in hunter dissatisfaction which jeopardizes hunter recruitment and retention.

## *Oral Presentation*

# An Assessment of Highway Construction Disturbance of Desert Bighorn Sheep

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***Abstract:*** We investigated the potential disturbance of construction activities on desert bighorn sheep (*Ovis canadensis nelsoni*) along a 17 mile stretch of U.S. Highway 93, which was realigned and widened during the Hoover Dam Bypass Project. GPS collars collected 33,177 locations from 30 desert bighorn sheep leading up to reconstruction (November 2008 – March 2009) and 104,018 locations from 39 desert bighorn sheep during reconstruction (April 2009 – November 2010). The change in highway crossing rate from 0.3 crossings/day prior to reconstruction to 0.2 crossings/day during reconstruction was not significant. There was a shift in the distribution of crossings with a 50% increase between milepost 0.0 and 2.2, where construction was completed prior to this phase of the project, and a 96% decline between mile post 5.0 and 9.0. During the project we populated a matrix of construction intensity with values for each day of construction at each 0.1 mile segment of roadway. When considering desert bighorn sheep locations relative to the no, low-moderate, and high disturbance classes of construction activity, we found no evidence of avoidance. The desert bighorn sheep appeared tolerant of heavy equipment and bridge construction activities. They exhibited a dramatic shift away from sections of the highway under very high disturbance (blasting) conditions. The lambing season distribution of female desert bighorn sheep locations during construction showed a significant shift away from the highway relative to lambing distributions prior to construction. There were 68% fewer during-reconstruction locations within 0.31 miles of the highway and 50% fewer locations within 0.62 miles.

***Oral Presentation.***

# Population and Habitat Use by Desert Bighorn Sheep (*Ovis canadensis Mexicana*) Translocated into Sierra Maderas Sel Carmen, Coahuila, Mexico

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**Abstract:** We studied demographic status, seasonal home range and potential habitat distribution of a translocated desert bighorn sheep (*Ovis canadensis mexicana*) population in Sierra Maderas del Carmen, located in the northwest portion of Coahuila State, México. During our study, we monitored 20 radiocollared bighorn sheep (1 ram and 19 ewes released in 2004 and 2009, respectively). We also visually monitored other individuals without radiocollars released during the same periods. We estimated rates of birth, survival, and mortality, as well as the population growth rate. In addition we analyzed the group size in software R. Home range at finding probabilities of 95% ( $p=0.05$ ), 50% ( $p=0.5$ ) and 10% ( $p=0.9$ ) was estimated using the Animal Movement extension of Arcview 3.2 software based on the Kernel method. The potential habitat distribution model was developed by the maximum entropy algorithm (Maxent) using 23 environmental variables (19 climatic and 4 topographic) with 1 km<sup>2</sup> spatial resolution and processed in the ArcGis 9.3 software. Results showed a population with similar demographic rates to bighorn sheep populations in the Southwest U.S.A. and a low population growth rate of  $r=0.15$ . The average size of mixed groups was statistically different from the other groups ( $p=0.05$ ). The biggest seasonal home range for all the individuals covered 59 km<sup>2</sup> (home range in summer 2010,  $p = 0.05$ ). This indicates that only 4.7% of the potential habitat (land with values of probability  $\geq 0.61$ ) is being used in the Maderas del Carmen Range according to the Maxent habitat distribution model.

## *Oral presentation*

# Responses of Desert Bighorn Sheep to Experimental Simulation of Risk of Predation by Mountain Lions

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**Abstract:** Adaptations that reduce vulnerability to predators can be grouped broadly into indirect mechanisms that affect the likelihood of encountering and detecting predators, and direct mechanisms that involve minimizing the success of a predator upon detection, such as by sight, olfaction, or auditory cues. We investigated responses of desert bighorn sheep (*Ovis canadensis nelsoni*) to olfactory cues conferring a direct risk of predation by experimental delivery of feces from mountain lions (*Puma concolor*), their primary predator. We recorded behavior of randomly selected focal animals assigned to one of three treatments; a control with no manipulation ( $n=13$ ), a control using remote delivery of non-predator feces (horse; *Equus caballus*;  $n=7$ ), and a treatment incorporating remote delivery of feces from mountain lion ( $n=7$ ). We evaluated responses with orthogonal contrasts of manipulation vs. non-manipulation, and treatment with feces from mountain lion vs. feces from horse. No instances of flight response were observed in trials. Vigilance was significantly greater in treatment vs. un-manipulated trials ( $P=0.004$ ) and for treatment with lion feces vs. treatment with horse feces ( $P=0.047$ ). We discuss the adaptive significance of observed responses to risk of predation.

## *Oral Presentation*

# Genetic Population Structure and Gene Flow Patterns in Two Bighorn Sheep Metapopulations in the Las Vegas Region from Microsatellite and Mitochondrial DNA Analyses

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***Abstract:*** Recent rapid expansion of human developments around Las Vegas has raised concerns about impacts on the bighorn sheep metapopulation to the immediate south, and especially potential isolation of the River Mountains. We investigated this by developing genetic data for 13 populations south and west of Las Vegas Valley. We extracted DNA from fecal samples supplemented with blood and tissue samples where available. We developed and analyzed genetic data for 16 nuclear microsatellite loci for 377 individual bighorn sheep and used those data to estimate gene flow between sampling locations, and to evaluate genetic diversity. We also sequenced a 515 bp segment of the mitochondrial DNA control region for 356 individuals identified from the microsatellite data to identify different haplotypes. For microsatellite data we found consistently high genetic diversity in all populations sampled, which in part reflects the close proximity of populations and high male mediated gene flow that has historically characterized bighorn sheep in this region. MtDNA, however, indicated a lack of genetic diversity in some ranges, including the River Mountains, where the population appears to have been initiated in the 1940s by a small number of ewes from the neighboring Eldorado Range. Of the three potential connections that the River Mountains population has with neighboring ranges, only the connection with the Eldorado Mountains showed gene flow estimates from microsatellite data at a level expected for unhindered migration given close proximity of the ranges. The other connections appear to have been affected by anthropogenic barriers.

***Oral Presentation***



# Physiological Findings with Different Capture Methods in Desert Bighorn Sheep

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***Abstract:*** Management programs often involve capture of bighorn sheep in Nevada. We compared three capture scenarios of desert bighorn sheep including ground darting, and helicopter net gun capture with and then without the addition of the sedative drugs midazolam and azaperone. Six ewes were ground darted to evaluate the reversibility of the drug combination butorphanol-azaperone-medetomidine (BAM). A standard dose of 1 ml BAM (27.3 mg B, 9.1 mg A, 10.9 mg M) was used independent of age. Arterial blood samples were collected before and during intranasal oxygen supplementation (6 L/min) and immediately analyzed in the field. For reversal, atipamezole and tolazoline were injected intramuscularly. Recoveries were smooth and calm with sheep walking 2-16 minutes after administration of reversal drugs. All sheep developed marked hypoxemia ( $\text{PaO}_2$  20-54 mmHg) and mild to marked hypercapnia ( $\text{PaCO}_2$  46-65 mmHg). Oxygen therapy was efficient in reversing hypoxemia ( $\text{PaO}_2$  124-167 mmHg). Compared to ground darting, helicopter net gun captured sheep showed physiologic changes attributable to physical exertion. The major effect observed was extreme lactic acidosis with concurrent respiratory alkalosis and hemoconcentration.

***Oral Presentation***

