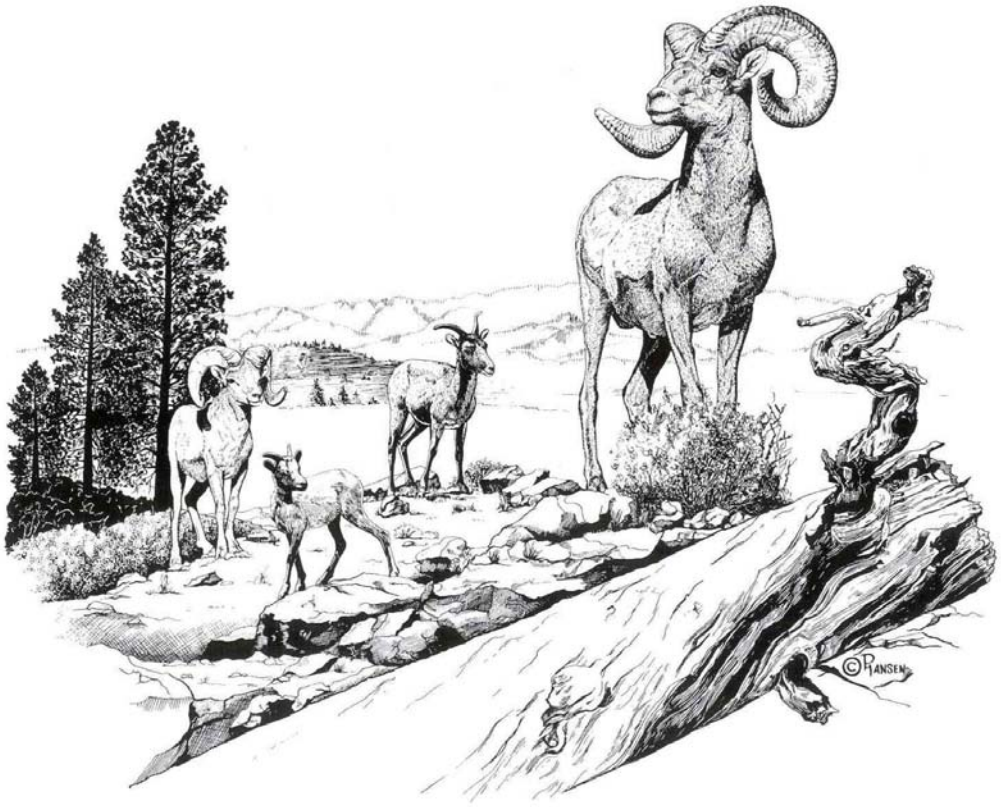
DESERT BIGHORN COUNCIL
2011
51ST MEETING • LAUGHLIN, NV

PROGRAM AND ABSTRACTS



HOSTED BY: ARIZONA GAME AND FISH DEPARTMENT
SPONSORED BY: ARIZONA DESERT BIGHORN SHEEP SOCIETY AND ARIZONA WILDLIFE FEDERATION

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2011 DESERT BIGHORN COUNCIL MEETING HOST

Arizona Game and Fish Department

2011 DESERT BIGHORN COUNCIL MEETING SPONSORS

Arizona Desert Bighorn Sheep Society
Arizona Wildlife Federation

Desert Bighorn Council Meeting
Laughlin, NV • Aquarius Hotel
April 6–8, 2011

Tuesday — April 5, 2011

7:00p Technical Staff Meeting (*Invitational Meeting*)

Wednesday — April 6, 2011

Pisces Room

7:00a Registration, Merchandise, and Silent Auction

Pavilion B

10:00a Welcome and Opening Remarks – Brian Wakeling, Chair

10:15a Panel Discussion: ***How Do We Keep Sheep On The Mountain? Mitigating Habitat Loss, Modification, and Fragmentation***. Vernon Bleich, Ray Schweinsburg, Ben Gonzales, and Kevin Hurley.

11:30a Lunch (On Your Own)

Session 1: State Status Reports – Esther Rubin, Moderator

Pavilion B

1:00p ***Status of bighorn sheep in Arizona, 2010–2011.*** Amber A. Munig.

1:20p ***California.*** Steven Torres.

Colorado – No presentation.

1:40p ***Status of the bighorn sheep restoration programs in northeastern Mexico: states of Coahuila, Chihuahua, and Nuevo Leon.*** Alejandro Espinosa T. and Billy Pat McKinney.

2:00p ***Status report on desert bighorn sheep in various states in Mexico.*** Raymond Lee and Juan Manuel Segundo Galan.

2:20p ***Status of desert bighorn sheep in Nevada, 2009-2010.*** Mike Cox and Pat Cummings.

2:40p	BREAK (Refreshments Provided)

Session 2: State Status Reports – Jon Hanna, Moderator

Pavilion B

3:00p ***New Mexico desert bighorn sheep status report, 2009-2010.*** Elise Goldstein and Eric Rominger.

3:20p ***Status of desert bighorn sheep in Texas, 2009–2010.*** Clay Brewer.

3:40p ***Utah's bighorn sheep in 2011.*** Anis Aoude.

4:00p Open discussion on topics of interest. Brian Wakeling, facilitator.

6:00p	Dinner (On Your Own)
7:00p	Hospitality Room Opens
11:00p	Inhospitality Room Opens (Hospitality Room Closes)

Thursday — April 7, 2011

Pisces Room

7:00a Registration, Merchandise, and Silent Auction

Session 3: Bighorn Sheep Distribution and Movements – Bob Henry, Moderator

Pavilion B

8:00a	POSTER SESSION AND CONTINENTAL BREAKFAST (provided)

8:40a ***Desert bighorn sheep survival rates in Canyonlands National Park, Utah.*** K. S. Sproat, T. S. Smith, W. Sloan, P. Riddle, and G. Wallace.

9:00a ***GIS mapping of North American wild sheep translocations.*** Kevin Hurley and Richard Jones.

9:20a ***Desert bighorn sheep metapopulation dynamics in California: translating analysis of past extinction patterns into conservation planning.*** John D. Wehausen and Clinton W. Epps.

9:40a ***Evaluation of Rocky Mountain bighorn sheep movements along U.S. 191 near Morenci, Arizona.*** Jeff Gagnon, Scott Sprague, Sue Boe, Rick Langley, and Ray Schweinsburg.

10:00a ***Movements and survival of translocated Rocky Mountain bighorn sheep in central Arizona.*** Erin Turnpaugh and Thomas C. McCall.

10:20a BREAK (Refreshments Provided)

Session 4: Management Actions – Tom McCall, Moderator

Pavilion B

10:40a ***An update on management activities and desert bighorn sheep responses on the Kofa National Wildlife Refuge, Arizona.*** Bob Henry and Lindsay A. Smythe.

11:00a ***Culling offending pumas for endangered desert bighorn sheep: is it practical or effective?*** Eric M. Rominger, Elise J. Goldstein, and Darrel L. Weybright.

11:20a ***The realities of establishing a desert bighorn sheep population in Arizona's Mineral Mountains.*** Jon Hanna.

11:40a ***Economic aspects and the "market" for desert bighorn sheep.*** Raymond Lee.

12:00p LUNCH (provided)

Session 5: Genetics and Diseases – Jon Hanna, Moderator

Pavillion B

1:00p ***Genetic variation in captive bighorn sheep in Coahuila.*** Carolina Durán Alvarez, Jaime Gasca Pineda, and Alejandro Espinoza T.

1:20p ***Predicting body fat in bighorn sheep and assessing nutritional status of populations.*** Thomas R. Stephenson, Rachel C. Cook, Kevin L. Monteith, Daniel Walsh, E. Frances Cassirer, Ben J. Gonzales, Vernon C. Bleich, Matthew W. Overstreet, and Donald G. Whittaker.

1:40p	***Genetic analysis of scats reveals minimum number, sex, and diet of mountain lions on Kofa National Wildlife Refuge, Arizona.*** Ashwin Naidu, Lindsay A. Smythe, Ron W. Thompson, and Melanie Culver.
2:00p	***Prevalence of* Mycoplasma ovipneumoniae *in 6 geographically distinct populations of desert bighorn sheep in Arizona.*** Clint J. Luedtke, Matthew Overstreet, James W. Cain III, Tom Stephenson, and Anne Justice-Allen.
2:20p	***Epidemiology of* Mycoplasma ovipneumoniae *and its relationship to respiratory disease in bighorn sheep (*Ovis canadensis *spp.) in California.*** Heidi S. Zurawka, Ben J. Gonzales, and Christine K. Johnson.
2:40p	BREAK AND POSTER SESSION (Refreshments Provided)

Session 6: Management Actions – Rick Langley, Moderator

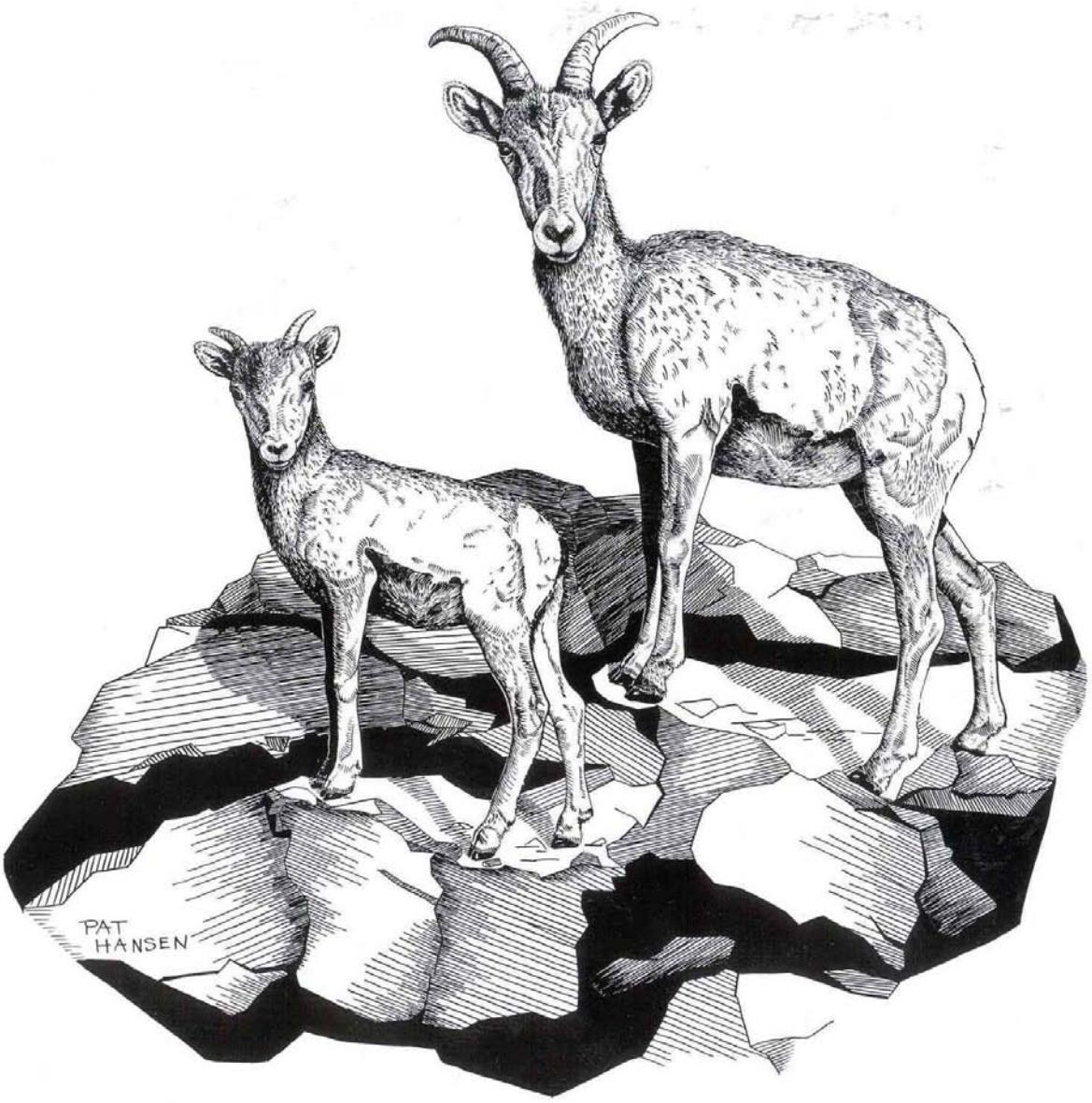
Pavilion B

3:00p	***The Heber-Reno domestic sheep driveway and management of bighorn sheep in Arizona.*** Jon Hanna.
3:20p	***Landscape models of water resource availability for and habitat use by desert bighorn sheep (*Ovis canadensis mexicana*) in southwestern Arizona.*** Cerissa Hoglander, Brett G. Dickson, and Steven S. Rosenstock.
3:40p	***Locating and evaluating desert bighorn sheep overpasses along U.S. Highway 93 in Arizona.*** Jeff Gagnon, Scott Sprague, Chad Loberger, Rob Nelson, Sue Boe, and Ray Schweinsburg.
4:00p	Business Meeting
6:00p	Travel by Boat to Bullhead City, AZ – Meet at river for departure
6:30p	AWARDS DINNER (Provided) - Southwestern Dinner prepared by AZGFD employees - Address by Arizona Game and Fish Department Director Larry Voyles - Presentation of Awards - Ancillary Fun and Festivities
9:00p	Travel by Boat to Laughlin, NV – Meet at river for departure
	Hospitality Room Opens Upon Return From Dinner

11:00p	Inhospitality Room Opens (Hospitality Room Closes)

Friday, April 8, 2011 — Field Tour of Wildlife Crossings on Highways 68 and 93

8:30a	Depart for Field Tour
12:00p	LUNCH (provided)
4:30p	Tour over, hiking on your own, see you in New Mexico in two years.



STATE STATUS REPORT ABSTRACTS (alphabetical by senior author)

UTAH'S BIGHORN SHEEP IN 2011

Anis Aoude, Utah Division Of Wildlife Resources, 1594 West North Temple, Suite 2110, P.O. Box 146301, Salt Lake City, UT 84114, USA

Utah's desert bighorn sheep (*Ovis canadensis nelsoni*) population is relatively stable. About 2,600 animals are estimated to occur within Utah's borders. The overall population of the state is made up of 21 separate populations. Most of these populations are on public land and under the management authority of the State of Utah, except for 4 populations that are within National Parks boundaries and 1 population on Navajo tribal land. Sixteen of the 21 populations are stable, 3 are increasing, and 2 are decreasing.

Utah's Rocky Mountain bighorn sheep (*O. c. canadensis*) population is relatively stable. About 2,350 animals are estimated to occur within Utah's borders, including the California subspecies. The overall population of the state is made up of 18 separate populations. Most of these populations are on public land and under the management authority of the State of Utah, except for 1 population that is within Dinosaur National Monument boundaries, 1 population on Ute tribal land, and 1 population on Antelope Island State Park. Six of the 18 populations are stable, 7 are increasing, 4 are decreasing, and 1 population was depopulated to prevent disease from spreading to a nearby unit.

We have an ongoing study in cooperation with Brigham Young University, National Park Service (NPS), and the Bureau of Land Management (BLM) to look at desert bighorn sheep movement in relation to off-highway vehicles and other recreational uses of public land. We also have a project in conjunction with the Forest Service using 12 GPS collars looking at bighorn sheep movements from the Hoop Lake and Flaming Gorge populations to the Uinta Mountain high country.

In 2008 we moved 30 desert bighorn sheep within the San Juan Unit to improve their distribution. In 2009, we moved 20 desert bighorn sheep from Lake Meade, NV to the Littly Valleya and Croton Canyon area of the Kaiparowits Unit. Rocky Mountain bighorn sheep transplants include the receipt of 60 sheep from Augusta, MT to a new population in the Lake Canyon area of the Wasatch Unit during 2009.

STATUS OF DESERT BIGHORN SHEEP IN TEXAS, 2009–2010

Clay E. Brewer, Texas Parks and Wildlife Department, Wildlife Division Region 2 Director, 114 Center Avenue, Suite 300, Brownwood, TX 76801, USA

Extirpated by the early 1960s, desert bighorn sheep (*Ovis canadensis*) in Texas have been successfully restored to the late 1800 population levels and continue to expand. Based on aerial surveys of 9 primary mountain ranges, desert bighorn population estimates remained relatively stable during the last 2 years. Surveys conducted in 2009 produced 1,144 classifications during 74.3 hours of flight time (15.4 sheep/hour) with ratios of 63 rams:100 ewes: 30 lambs reflected. Survey efforts in 2010 produced 1,115 classifications during 79.7 hours of flight time (14.0 sheep/hour) with results yielding ratios of 64 rams:100 ewes:32 lambs. In December 2010, the largest in-state transplant in the history of the desert bighorn sheep restoration program was conducted with 46 bighorn sheep (12 M and 34 F) captured from Elephant Mountain WMA and released at Big Bend Ranch State Park. Research concerning movements, habitat use, and survival of the reintroduced population is currently being conducted by the Borderlands Research Institute of Sul Ross State University. In 2009, 2 water developments were constructed and 1 refurbished in the Van Horn Mountains, and in 2010, 2 water developments were constructed and 3 refurbished in the Beach Mountains. A record 16 hunting permits were issued for both the 2009–2010 and 2010–2011 hunting seasons.

STATUS OF DESERT BIGHORN SHEEP IN NEVADA, 2009-2010

Mike Cox, Nevada Department of Wildlife, 1100 Valley Road, Reno, NV 89512, USA
Pat Cummings, Nevada Department of Wildlife, 4747 Vegas Drive, Las Vegas, NV 89108, USA

Record numbers of desert bighorn sheep ram tags were issued in 2009 and 2010 at 193 and 216, respectively. A total of 357 rams were harvested the last 2 years, averaging 87% hunter success. The statewide average age of harvested rams rose to 6.5 years in 2010 with an average unofficial B&C score of 153.5. Field biologists in the 2009 statewide aerial desert bighorn sheep survey classified over 3,500 animals. The 2009 lamb ratio was 31 lambs:100 ewes, the lowest lamb ratio since the severe drought in 2002. In 2010, the statewide desert bighorn sheep population estimate was 7,400. Restoration efforts have stalled recently due to unfavorable political climate in Nevada. In 2009, 25 desert bighorn sheep were reintroduced into an unoccupied portion of the Stillwater Range in west central Nevada and 20 desert bighorn sheep from the Muddy Mountains near Lake Mead were furnished to Utah for transplant into the Grand Staircase Escalante National Monument. The following year, 25 Class III and Class IV rams captured from an unhunted population in the River Mountains were translocated to 4 mountain ranges in Lincoln and Clark counties. The translocations were undertaken to address a unique and persistent wildland-urban interface situation marked by excessive numbers of bighorn sheep in Hemenway Park, Boulder City. Nevada Department of Wildlife (NDOW) continues to collaborate since 2007 on bighorn sheep dispersal and population isolation research on herds surrounded by the Las Vegas metropolitan area and Lake Mead. We are collaborating with United States Geological Survey (USGS) and Fish and Wildlife Service (USFWS) on a project to determine bighorn sheep survival and habitat requirements on Desert National Wildlife Refuge, Nevada. In January 2011, 3 desert bighorn sheep herds at risk of domestic sheep association were sampled and real-time GPS collars deployed with plans to work with woolgrowers to monitor temporal and spatial separation. Water development maintenance and inspections of the about 150 desert bighorn sheep water developments (with many being as old as 3 decades) has become an important element in Nevada's bighorn sheep conservation program. Several rebuilds, tank upgrades, and fence improvements were completed the last 2 years. New guzzlers continue to be built at a slower pace than in the past with a very notable 1 in 2009 being constructed for the first time in Nevada wilderness in the Meadow Valley Mountains northeast of Las Vegas. Variable rainfall patterns prompted water hauls in 2009 with about 17,000 gallons airlifted via helicopters to 5 projects situated in 3 mountain ranges. High population and density levels in several herds have prompted discussions to propose desert bighorn sheep ewe hunts for 2012.

STATUS OF THE BIGHORN SHEEP RESTORATION PROGRAMS IN NORTHEASTERN MEXICO: STATES OF COAHUILA, CHIHUAHUA, AND NUEVO LEON

Alejandro Espinosa T., CEMEX-Vice-presidency of Energy and Sustainability, Independencia 901 Ote. Colonia Cementos, C.P. 64520, Monterrey, NL, MX
Billy Pat McKinney, CEMEX-Vice-presidency of Energy and Sustainability, Independencia 901 Ote. Colonia Cementos, C.P. 64520, Monterrey, NL, MX

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 40 bighorn sheep to Sierra Maderas Del Carmen Coahuila during 2009 and 2010; b) The establishment of a cooperative agreement amongst Texas Parks and Wildlife Department, Texas Bighorn Society, and the Wild Sheep Foundation (WSF); c) The collaboration between SEMARNAT Mexico and New Mexico Game and Fish Department for a wildlife exchange; d) 2 successful auctions at WSF's 2010 and 2011 conventions, and the acquisition of the first bighorn sheep permit issued for the State of Coahuila in November 2010; and e) cooperative agreements with La Guarida Ranch in Chihuahua and with Organization Vida Silvestre in Sonora. Other activities in Coahuila and Chihuahua included monitoring the free-ranging bighorn sheep population in Sierra Maderas del Carmen, which resulted in a Master of Science thesis, the completion of ground surveys in the Sierra Pilares and La Guarida bighorn sheep propagation facilities, an aerial survey of the border of Coahuila and Texas, and monitoring of other bighorn sheep reintroduction programs in Coahuila and Nuevo Leon.

NEW MEXICO DESERT BIGHORN SHEEP STATUS REPORT, 2009-2010

Elise J. Goldstein, Wildlife Management Division, New Mexico Department of Game and Fish, Santa Fe, NM, USA
Eric M. Rominger, Wildlife Management Division, New Mexico Department of Game and Fish, Santa Fe, NM, USA

The New Mexico desert bighorn sheep population continues to increase, with a statewide estimate of 530 in 2009 and 565 in 2010. About 90–95 radiocollared bighorn sheep were present each year. In autumn 2009, 18 bighorn sheep were transplanted to the Caballo Mountains to augment a self-starting herd of about 30 bighorn sheep, and an additional 5 rams were sent to each of the Peloncillo and Ladron mountains. No transplants were conducted in 2010. The cougar control program continues to be implemented, with an average removal of 2.8 cougars/mountain range/year. The average annual adult bighorn sheep mortality rate has decreased 52% from 0.23 during years when control was not implemented, to 0.11 during years when cougar control was implemented. The cause-specific mortality rate from cougar predation has declined 71% from 0.17 to 0.05 during the same time period. Desert bighorn sheep were listed as a state endangered species in 1980, downlisted to state threatened in 2008, and are currently proposed to be delisted.

STATUS REPORT ON DESERT BIGHORN SHEEP IN VARIOUS STATES IN MEXICO

Raymond Lee, Ray Lee LLC, 808 Aspen Drive, Cody, WY 82414, USA
Juan Manuel Segundo Galan, Union Ganadera Regional de Sonora, Hermosillo, Sonora, MX

Free-ranging desert bighorn sheep occur in Arizona, California, Colorado, Nevada, New Mexico, Texas, and Utah. They also occur in Mexico in the states of Baja California, Baja California Sur, Coahuila, Chihuahua, and Sonora. The wildlife management agencies in the United States have worked diligently to increase their populations of desert bighorn sheep – and have been hugely successful. Indeed, even in the face of large increases in human populations, desert bighorn sheep populations are at comparatively high levels. The wildlife management programs to augment desert bighorn sheep populations in Mexico mirror those in the United States. Considering just the western states of Baja California, Baja California Sur, and Sonora, enhancement efforts have resulted in considerable success. Recent surveys have led to a better understanding of the number and distribution of desert bighorn sheep in northwestern Mexico.

STATUS OF BIGHORN SHEEP IN ARIZONA, 2010–2011

Amber A. Munig, Arizona Game and Fish Department, Game Branch, 5000 West Carefree Highway, Phoenix, AZ 85086, USA

Bighorn sheep (*Ovis canadensis)* numbers in Arizona have stabilized with some localized increases since the declines documented in the mid-2000s. Desert bighorn sheep (*O. c. mexicana* and *nelsoni*) numbers are similar to our last report of 4,500 statewide. The estimated number of Rocky Mountain bighorn sheep (*O. c. canadensis*) remains around 1,000 statewide. In 2010, desert bighorn sheep ram:100 ewe:lamb ratios were 53:100:25, whereas Rocky Mountain bighorn sheep ratios were 38:100:34. No significant disease outbreak has occurred in Arizona recently; however, contagious echthyma was documented in 2 ewes during a recent capture effort in 1 of our desert bighorn sheep populations. We continue to monitor several populations that have been exposed to domestic sheep or goats or where disease issues have been identified previously. Ongoing research in Arizona focuses on providing input into adaptive predation management plans, reducing fragmentation of bighorn sheep populations, and mitigating ongoing development.

TECHNICAL ABSTRACTS (alphabetical by senior author)

GENETIC VARIATION IN CAPTIVE BIGHORN SHEEP IN COAHUILA

Carolina Durán Alvarez, Instituto de Ecología, Universidad Nacional Autónoma de México
Jaime Gasca Pineda, Instituto de Ecología, Universidad Nacional Autónoma de México
Alejandro Espinoza T., CEMEX-Vice-presidency of Energy and Sustainability, Independencia 901 Ote. Colonia Cementos, C.P. 64520, Monterrey, NL, MX

The bighorn sheep (*Ovis canadensis mexicana*) populations in México have declined due to factors such as illegal hunting, the introduction of livestock, and the loss and fragmentation of their habitat. Hunting of bighorn sheep has been recognized as an important activity in the country, and it is protected by NOM-059 and CITES 2010 (Appendix II) as a priority species for conservation. In México there have been breeding programs to increase bighorn sheep populations. However, some reports have shown that such populations have been founded with a small number of individuals, which could influence genetic variation and potential viability. The purpose of this study is to analyze the genetic variation of a captive population of bighorn sheep in Coahuila. The particular characteristics of these populations are indicative of source captive populations from Hermosillo, Sonora. For these comparisons, we used 10 nuclear microsatellite loci and sequences of the mitochondrial control region. We compare these results with other captive and wild populations previously analyzed. As expected, we found higher genetic variation in the captive population we studied when compared to other captive populations and with variation similar to the wild population previously analyzed.

EVALUATION OF ROCKY MOUNTAIN BIGHORN SHEEP MOVEMENTS ALONG US 191 NEAR MORENCI, ARIZONA

Jeff Gagnon, Arizona Game and Fish Department, Research Branch, 5000 West Carefree Highway, Phoenix AZ 85086, USA
Scott Sprague, Arizona Game and Fish Department, Research Branch, 5000 West Carefree Highway, Phoenix AZ 85086, USA
Sue Boe, Arizona Game and Fish Department, Research Branch, 5000 West Carefree Highway, Phoenix, AZ 85086, USA
Rick Langley, Arizona Game and Fish Department, Region I, 2878 E. White Mountain Boulevard, Pinetop AZ 85935, USA
Ray Schweinsburg, Arizona Game and Fish Department, Research Branch, 5000 West Carefree Highway, Phoenix AZ 85086, USA

In a given year, as high as 10% of the estimated local Rocky Mountain bighorn sheep (*Ovis canadensis candensis*) population in the Morenci, Arizona area is lost to vehicle-related mortality. A majority of these collisions occur within the boundary of the Freeport-McMoRan copper mine where bighorn sheep move across artificial steep rocky areas unique to this area. Collisions with sheep also pose a hazard to motorists travelling U.S. Highway 191. Understanding the movements of this herd in relation to U.S. 191 can help define options to reduce these collisions. Further, studying movements throughout the mine area, including those between the mine and nearby Eagle Creek, allow us to better understand why the mine is used heavily by these normally high-country animals in southeast Arizona. We captured and radiocollared 13 (7 M and 6 F) bighorn sheep in the mine area along U.S. 191 in spring 2009. The radiocollars collected 8 locations/day for about 2 years and have provided about 50,000 GPS locations. To supplement this information, we also evaluated sheep-vehicle collision data from 2001 to present collected by local wildlife managers, including those previously evaluated by Wakeling et al. (2007; DBC Transactions 49:18–22). We provide results from the GPS movement radiocollars and recent sheep-vehicle collision data as well as recommendations to help reduce collisions while maintaining habitat connectivity.

LOCATING AND EVALUATING DESERT BIGHORN SHEEP OVERPASSES ALONG U.S. HIGHWAY 93 IN ARIZONA

Jeff Gagnon, Arizona Game and Fish Department, Research Branch, 5000 W. Carefree Highway, Phoenix, AZ 85086, USA
Scott Sprague, Arizona Game and Fish Department, Research Branch, 5000 W. Carefree Highway, Phoenix, AZ 85086, USA
Chad Loberger, Arizona Game and Fish Department, Research Branch, 5000 W. Carefree Highway, Phoenix, AZ 85086, USA
Rob Nelson, Arizona Game and Fish Department, Research Branch, 5000 W. Carefree Highway, Phoenix, AZ 85086, USA
Sue Boe, Arizona Game and Fish Department, Research Branch, 5000 W. Carefree Highway, Phoenix, AZ 85086, USA
Ray Schweinsburg, Arizona Game and Fish Department, Research Branch, 5000 W. Carefree Highway, Phoenix, AZ 85086, USA

The Black Mountain desert bighorn sheep (*Ovis canadensis nelson*) herd is the largest extant herd remaining in the world. The realigning and widening of U.S. 93 through their habitat and the predicted increases in traffic volumes could prevent sheep from accessing resources (e.g., food, water, mates, and lambing grounds) and restrict genetic interchange, threatening the herd's ultimate existence. Further, the incidence of collisions with sheep by motorists would increase, risking injury to both motorists and sheep. This potential fragmentation of the habitat and increase in collisions would both decrease genetic exchange and increase sheep mortality rates. Following the terrorist attacks on September 11, 2001, commercial truck traffic through the Hoover Dam area was eliminated for safety reasons and the Federal Highway Administration (FHWA) began the Hoover Dam Bypass Project. To mitigate the effects of the project on wildlife, the Arizona Department of Transportation's Transportation Research Center (ADOT-ATRC) worked with the Arizona Game and Fish Department (AGFD) to identify locations for sheep crossing structures and placement of fences to funnel sheep to the crossing structures and keep them off the roadway. In 2004 and 2005, AGFD began evaluating future crossing structure locations by placing 36 GPS collars on sheep along U.S. 93. This data was used to assess where sheep approached or crossed the highway and served as a pre-construction highway permeability measure. We found that sheep approached and/or crossed the highway at 5 main ridge-highway intersections. Funding was sufficient for crossing structures to be constructed at the 3 locations with heaviest use. To mitigate the new highway's effect on sheep, AGFD suggested fencing heights and lengths to funnel sheep to the overpasses. In conjunction with double cattle guards on intersecting roads, the fence would block them from entering the highway corridor and escape ramps would allow sheep to escape if they were caught on the highway side of the fence. AGFD placed additional GPS collars on sheep to evaluate construction effects (2008–2010) on movements and post-construction use of the overpasses: 37 during construction and 35 for post-construction overpass monitoring with funding provided by ADOT-ATRC and the Arizona Desert Bighorn Sheep Society. In addition, AGFD implemented 4-camera video surveillance systems to assess sheep movement and behavior associated with the overpasses and to document other species' use of these overpasses. AGFD will also monitor selected bridges and culverts to assess their ability to allow sheep to safely cross the highway. We provide methods for locating the overpasses as well as preliminary results from the video camera surveillance systems.

THE HEBER-RENO DOMESTIC SHEEP DRIVEWAY AND MANAGEMENT OF BIGHORN SHEEP IN ARIZONA

Jon Hanna, Arizona Game and Fish Department, 7200 East University Avenue, Mesa, AZ 85207, USA

In 1898, Woodrow Wilson created a proclamation allowing for domestic sheep driveways in specifically designated areas, but the proclamation did not give any rights on U. S. Forest Service lands. The actual record of the Heber-Reno Domestic Sheep Driveway establishment in Arizona has not been located but the Tonto and Apache-Sitgreaves National Forests have references to the Forester's marking of the boundaries of the Driveway in 1908. At about the same time an executive order designated other driveways on State Trust Lands and Bureau of Land Management lands. In 1982, the Arizona Game and Fish Department released desert bighorn sheep (*Ovis canadensis mexicana*) in an area that was at that time thought to be far enough east of the driveway to prevent the mixing of domestic sheep and wild sheep. As the bighorn sheep herd expanded to the west they occupied the habitat

that is adjacent to the driveway. There are currently 2 desert bighorn sheep herds that are now adjacent to this driveway. This paper is an overview of the status of those desert bighorn sheep herds and the current decision notice by the Tonto and Apache-Sitgreaves Forest Supervisor's of a Finding of No Significant Impact for the Heber-Reno Sheep Driveway project.

THE REALITIES OF ESTABLISHING A DESERT BIGHORN SHEEP POPULATION IN ARIZONA'S MINERAL MOUNTAINS

Jon Hanna, Arizona Game and Fish Department, 7200 East University Avenue, Mesa, AZ 85207, USA

The Mineral Mountains were identified as a priority area to establish a population of desert bighorn sheep (*Ovis canadensis mexicana*). In 2000, a statewide bighorn sheep habitat analysis rated the Mineral Mountain range as the highest unoccupied bighorn sheep habitat in Arizona. In 2003, 8 rams and 22 ewes were released in the Mineral Mountains and VHF radiocollars were attached to 11 of these sheep. This paper is an overview of biological and administrative realities of trying to establish this bighorn sheep population since that initial release.

AN UPDATE ON MANAGEMENT ACTIVITIES AND DESERT BIGHORN SHEEP RESPONSES ON THE KOFA NATIONAL WILDLIFE REFUGE, ARIZONA

Bob Henry, Arizona Game and Fish Department, Region 4, 9140 East 28 Street, Yuma, AZ 85365, USA
Lindsay A. Smythe, U.S. Fish and Wildlife Service – Kofa National Wildlife Refuge, 9300 East 28 Street, Yuma, AZ 85365, USA

A 50% decline in bighorn sheep numbers on the Kofa National Wildlife Refuge (KNWR) from 2000 to 2006 led to the development of a management plan to address possible causes of the decline and to assist recovery of the population. KNWR has historically been 1 of the most important sources of bighorn sheep for translocation to areas across the southwest. In the 4 years since approval of that plan, Arizona Game and Fish Department and KNWR personnel have placed radiocollars on bighorn sheep and mountain lions, removed "offending" lions, investigated the possible role of disease, and improved supplies of drinking water. To date, bighorn sheep numbers have not increased, but neither have they declined further. A lawsuit was brought against KNWR protesting the placement of drinkers in wilderness and a recent appeals court decision may affect future water management.

LANDSCAPE MODELS OF WATER RESOURCE AVAILABILITY FOR AND HABITAT USE BY DESERT BIGHORN SHEEP (*OVIS CANADENSIS MEXICANA*) IN SOUTHWESTERN ARIZONA

Cerissa Hoglander, Northern Arizona University, Environmental Programs, P.O. Box 5694, Physical Sciences Building 19, Room 119, Flagstaff, AZ 86001, USA
Brett G. Dickson, Northern Arizona University, Environmental Programs, P.O. Box 5694, Physical Sciences Building 19, Room 119, Flagstaff, AZ 86001, USA
Steven S. Rosenstock, Arizona Game and Fish Department, Research Branch, 5000 West Carefree Highway, Phoenix, AZ 85086, USA

The desert bighorn sheep (*Ovis canadensis mexicana*) is 1 of the few ungulate species native to North America that is capable of surviving in harsh desert mountain environments. However, the increased drought cycles and warmer temperatures anticipated with ongoing climate change could adversely affect the species' use of and range of suitable habitat and, consequently, its survival. In this context, an improved understanding of existing habitat and resource needs of desert bighorn sheep subpopulations could help to guide future conservation and management of the species. The desert bighorn sheep herds on the Kofa National Wildlife Refuge (KNWR) and the U.S. Army Yuma Proving Ground (YPG) are subpopulations actively managed by state and federal agencies who work to conserve the subpopulations and re-establish herds across the Southwest. We used location data for individual sheep outfitted with global positioning system collars during 2007-2010 to derive spatially explicit statistical models of space and resource use on the KNWR and YPG. Specifically, we used model selection and an information-theoretic approach to model the intensity of space and resource use as a function of topography, development, artificial water resources, and the presence of green vegetation estimated through the use of satellite imagery and vegetation

indices. We focused our analyses and inference on 2 key seasons in the region: peak lambing and drought. Our results can inform future desert bighorn sheep management and conservation in the Southwest, particularly with respect to maintaining artificial waters as resource supplements during intense drought seasons.

(Following presentation withdrew due to author's inability to attend meetings)
A PRELIMINARY EVALUATION OF A VARIABLE FIRE REGIME AND BIGHORN SHEEP DEMOGRAPHICS

Steve Holl, Steve Holl Consulting, 7049 Pine View Drive, Folsom, CA 95630, USA

In the San Gabriel Mountains wildfires reduce canopy cover, influencing habitat availability and produce an ephemeral plant association which increases nutrient availability. Bighorn sheep (*Ovis canadensis nelsoni*) are attracted to those burned areas and recruitment rates and population abundance are positively associated with fire history. The fire regime in the San Gabriel Mountains consists of frequent small fires during summer and large, wind-driven, high intensity fires during fall; this variable fire regime results in different effects on habitat suitability. In this analysis I present a hypothesis that the variable fire regime results in equally variable demographic responses in bighorn sheep and precipitous population declines following large wildfires that may result in population bottlenecks. I also suggest the current fire regime has been altered by fire suppression.

GIS MAPPING OF NORTH AMERICAN WILD SHEEP TRANSLOCATIONS

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At the Tenth Biennial Symposium of the Northern Wild Sheep and Goat Council (1996 in Silverthorne, CO), a workshop was held to exchange, verify, and update transplant records for wild sheep in 18 central and northern states, provinces, and territories, excluding desert bighorn sheep (*Ovis canadensis*) states. Biologists from state-provincial-territorial wildlife management agencies compared donor and recipient transplant records for wild sheep, as far back as records were available. Tabular summaries were included in the Tenth NWSGC Proceedings. In winter 2005–2006, transplant actions for each state-province were preliminarily entered into a Geographic Information System (GIS), to graphically depict inter- and intra-state-province-territory translocation of wild sheep. The WAFWA Wild Sheep Working Group drafted individual maps for each state, province, and territory, as were composite maps for wild sheep translocations across central-northern U.S. and Canada. An update on this GIS mapping project was presented at the 2009 Desert Bighorn Council meeting in Grand Junction, CO; this presentation reports progress over the past 24 months. Once finalized, these GIS maps-databases should provide a valuable framework and an historic record for future genetic review, population implications, possible disease analysis, and other management strategies relative to wild sheep transplants across the western U.S. and Canada.

ECONOMIC ASPECTS AND THE "MARKET" FOR DESERT BIGHORN SHEEP

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Desert bighorn sheep (*Ovis canadensis*), properly managed, can sustainably provide humans with both aesthetic and economic benefits. The aesthetic value to people to be able to observe wild sheep in their native habitat is considerable; even the knowledge that these animals merely exist in the nearby mountains is of demonstrable value. Opportunities to hunt desert bighorn sheep have been available through wildlife conservation auctions since 1984. These auctions provide wildlife conservationists with an avenue to pursue their philanthropic goals to provide economic support for wildlife conservation programs that enhance wild sheep. Every state with free-ranging desert bighorn sheep (including 4 states in Mexico) offers this opportunity, except for Baja California. These auctions have generated over $50,000,000 for wildlife conservation efforts - with many of these dollars being provided locally. In addition, many local people obtain employment supporting these management programs. This connection provides self respect for the individuals involved, as well as an enhanced appreciation for the wildlife.

In every state where these conservation programs have been in existence, desert bighorn sheep numbers have increased. This increase has led to a larger and more diverse market for desert bighorn sheep.

PREVALENCE OF *MYCOPLASMA OVIPNEUMONIAE* IN 6 GEOGRAPHICALLY DISTINCT POPULATIONS OF DESERT BIGHORN SHEEP IN ARIZONA

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Blood samples and nasal or oropharyngeal swabs were collected from 135 desert bighorn sheep (*Ovis canadensis nelsoni* and *Ovis canadensis mexicana)* from 6 geographically distinct populations in Arizona in 2009 and 2010. *Mycoplasma ovipneumoniae* organisms were detected by PCR in 20% (17 of 85) whereas antibodies to *M. ovipneumoniae* were detected in 46% (59 of 129) of tested bighorn sheep. Mycoplasma titers were not found in 2 of 6 populations indicating some bighorn sheep populations in Arizona are naïve to this bacterium. In contrast, others had seroprevalence rates up to 80%. We were able to compare seroprevalence rates and titers over time in 9 individuals (7 individuals included in the 135 sheep sampled in 2009 and 2010, and 2 individuals originally captured in 2006). Antibody titers persisted for 12 months in individuals from the Kofa National Wildlife Refuge (n = 7) while antibody titers appeared to decline in the Kanab Creek population (n = 2). Based on these results, *M. ovipneumoniae* is present or has been present in multiple populations of bighorn sheep in Arizona. Population declines have been documented in 2 of the bighorn sheep populations studied and we speculate exposure to this organism has contributed to the decline. The results also demonstrate the importance of routine health testing for future translocation efforts to minimize risk to naïve populations.

GENETIC ANALYSIS OF SCATS REVEALS MINIMUM NUMBER, SEX, AND DIET OF MOUNTAIN LIONS ON KOFA NATIONAL WILDLIFE REFUGE, ARIZONA

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Recent records of mountain lions (*Puma concolor*) and concurrent declines in desert bighorn sheep (*Ovis canadensis mexicana*) on Kofa National Wildlife Refuge in Arizona have prompted investigations to estimate the number of mountain lions occurring in the refuge. We performed non-invasive genetic analyses and identified species, individuals, and sex from scat samples collected from the Kofa and Castle Dome Mountains in the refuge. From 105 scats collected, we identified a minimum of 11 individual mountain lions. These individuals consisted of 6 males, 2 females, and 3 of unknown sex. Three of the 11 mountain lion individuals were identified multiple times over the study period. We also identified prey species from bone and connective tissue prey remains inside the scats. A majority of mountain lion diet (52%) was composed of desert mule deer (*Odocoileus hemionus*) and 24% was composed of desert bighorn sheep. These estimates supplement previously recorded information on mountain lions in an area where mountain lions were historically considered only transient. We demonstrate that non-invasive

genetic techniques, when used in conjunction with camera-trap and radiocollaring methods, can provide additional and reliable information to wildlife managers, particularly on secretive species like the mountain lion.

CULLING OFFENDING PUMAS FOR ENDANGERED DESERT BIGHORN SHEEP: IS IT PRACTICAL OR EFFECTIVE?

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After determining that puma (*Puma concolor*) predation was the proximate limiting factor in the recovery of state-endangered desert bighorn sheep (*Ovis canadensis*) in New Mexico, puma control was implemented in 5 bighorn sheep ranges from 2001 to 2009. A decrease in puma predation rate from 0.17 when pumas were not controlled, to 0.05 following puma control, resulted in the statewide desert bighorn sheep population increasing from <170 to >500. Killing only offending pumas, those pumas that have killed a bighorn sheep, is an alternative management tool to protect bighorn sheep. We reviewed the efficacy of culling offending pumas within our larger control effort. During 9 years of primarily range-wide control, 68 puma-killed bighorn sheep were documented. However, only 13 (19.1%) offending pumas were culled. The 2 primary reasons pumas were not culled were 1) bighorn sheep kill was not detected and located prior to the puma departing (58.8% of all kills) and 2) puma was present but missed at the kill site (53.6% of attempts were unsuccessful) (e.g., puma did not step into snare, substrate was not conducive to snare placement, hounds were unable to tree-bay puma). Although sample sizes were substantially reduced, the data set was partitioned between attempts to snare offending pumas and attempts to hound-hunt offending pumas. Use of hounds was successful in 35.7% (5/14) of attempts whereas use of snares was successful in 57.1% (8/14) of attempts. Additionally, we compared success with and without the presence of a daily monitor to radiotrack desert bighorn sheep. Without a daily monitor, only 15.6% (5/32) of offending pumas were culled. However, even with a daily monitor, only 22.2% (8/36) of offending pumas were culled. The low success rate of culling offending pumas makes it unlikely that this technique will provide adequate protection for desert bighorn sheep.

DESERT BIGHORN SHEEP SURVIVAL RATES IN CANYONLANDS NATIONAL PARK, UTAH

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Between 2002 and 2009, 58 desert bighorn sheep (*Ovis canadensis nelsoni*) were captured and fitted with either global positioning system (GPS) or VHF radiocollars in and near Canyonlands National Park in southeastern Utah. We used Program MARK to analyze survival rates for radiocollared sheep. We included age, sex, average spring precipitation, average annual precipitation for the previous year, average maximum temperature in May, and average maximum summer temperature as potential explanatory variables for survival. We also compared survival rates among bighorns from high and low human use areas. We used lamb:ewe ratios to evaluate population growth rates. Preliminary results show annual bighorn sheep survival rates are high (S = 0.95). Monthly survival for ewes (S = 0.99) and rams (S = 0.99) did not differ. Further results and analysis will be discussed.

MOVEMENTS AND SURVIVAL OF TRANSLOCATED ROCKY MOUNTAIN BIGHORN SHEEP IN CENTRAL ARIZONA

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We investigated distances moved and survival by translocated Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) in central Arizona because these movements may result in crossbreeding with native desert bighorn sheep (*O. c. mexicana*). In November of 2005–2007, 78 Rocky Mountain bighorn sheep (24 M, 54F) captured near Morenci in Unit 27 were released into West Clear Creek in Unit 6A. Each bighorn sheep was ear-tagged and 29 were fitted with radiocollars (2 M, 27 F). We determined the average maximum distance moved of male and female bighorn sheep that were ear-tagged and radiocollared. In addition, we determined annual survival and production of bighorn sheep. The mean maximum straight-line distance moved by sheep was 37.6 km (range = 0.8–188.0). There was no difference (P = 0.73) in the mean maximum distance moved among years, and there was no difference (P = 0.18) in the maximum distance moved between males and females. The longest straight-line distance moved was 188.0 km by a 2-year-old female. Movements of Rocky Mountain bighorn sheep in central Arizona following translocation seem sufficient to allow for crossbreeding with native desert bighorn sheep.

PREDICTING BODY FAT IN BIGHORN SHEEP AND ASSESSING NUTRITIONAL STATUS OF POPULATIONS

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We used the carcasses of 24 adult female bighorn sheep (*Ovis canadensis)* to develop equations to predict total body fat from measures of rump fat thickness and body condition scores. Carcasses were acquired opportunistically and included capture mortalities, captive animals, and accidental deaths. Animals were included from the 3 North American subspecies: desert (*O. c. nelsoni*), Sierra Nevada (*O. c. sierrae*), and Rocky Mountain (*O. c. canadensis*; including Rocky Mountain and California ecotypes). Carcasses were dissected and ground samples were analyzed chemically by ether extract to determine the fat content. We used linear regression to determine relationships between total body fat and predictive variables. We developed separate equations based on whether rump fat was depleted. When rump fat was present, body fat was predicted by an equation using rump fat as the predictive variable. When rump fat was absent, body fat was predicted using a body condition score as the predictive variable. The slope and the intercept for the predictive equation for total body fat using ultrasonography for bighorn sheep differs from that of the cervids. Rump fat is depleted in bighorn sheep at a greater level of total body fat than in the cervids. We sampled bighorn sheep populations across subspecies, ecotypes, and states. During field captures (>500), we measured rump fat using ultrasound and determined body condition scores; we used these values to predict total body fat *in vivo*. We also weighed animals. Mean pre-winter body weights of adult female bighorn for each ecotype were variable as follows: Rocky Mountain (69 kg), desert (55–63 kg), California (58 kg), and Sierra Nevada (47–66 kg); ranges represent mean values for different herds. The physiological limit of total body fat in bighorn sheep varies between 0.5 and 24%. In California bighorn sheep in Oregon, mean estimated pre-winter body fat was 10.4 and 13.7% for lactating and non-lactating adult females, respectively. Mean body fat during early winter in Rocky Mountain bighorn sheep lactating females was 14.9%. During autumn, desert bighorn sheep ewe mean body fat ranged from 9.9 to 20%. In the Sierra Nevada, mean pre-winter body fat among herds was 8.2–

15.1% and 14.8–23.7% for lactating and non-lactating females, respectively. On average, non-lactating females were 40% fatter than lactating females. Late winter female mean body fat in Sierra Nevada herds ranged from 10.1–13.6%. When considered relative to population density and recent weather patterns, body fat may be used to indicate proximity of populations to nutritional carrying capacity.

DESERT BIGHORN SHEEP METAPOPULATION DYNAMICS IN CALIFORNIA: TRANSLATING ANALYSIS OF PAST EXTINCTION PATTERNS INTO CONSERVATION PLANNING

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How we formulate conservation strategies for the future is very much a function of how we interpret past population dynamics of desert bighorn sheep relative to causal agents. For desert bighorn sheep in California, metapopulation dynamics are of particular concern because extinction rate greatly exceeded rate of natural colonization during the twentieth century, resulting in considerable vacant habitat. Existing metapopulation fragments in California clearly will not easily persist without considerable intervention if those dynamics were due to a continuing or increasing force driving extinctions. A recent logistic regression analysis of those twentieth century metapopulation dynamics identified 4 variables underlying variation in probability of extinction: past domestic sheep grazing, existence of reliable surface water, average annual rainfall, and maximum elevation. Management actions have the potential to modify only the first 2 of these variables. However, the second 2 variables potentially offer an opportunity to develop a ranking of populations relative to their potential long term contributions to metapopulation processes, and therefore their priority for receiving conservation attention. Because of the potential importance of this statistical model to conservation decisions, we will test its robustness to a variety of data refinements. Second, we will examine the hypothesis that directional climate change played an important role in twentieth century extinctions, and its implications for conservation planning relative to an alternative hypothesis that those metapopulation processes were episodic and lack a directional component.

EPIDEMIOLOGY OF *MYCOPLASMA OVIPNEUMONIAE* AND ITS RELATIONSHIP TO RESPIRATORY DISEASE IN BIGHORN SHEEP (*OVIS CANADENSIS* SPP.) IN CALIFORNIA

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Pneumonia has been reported to be a population-limiting disease in free-ranging bighorn sheep (*Ovis canadensis* spp.) throughout North America. In recent years, desert bighorn sheep from the White Mountains of east central California and those from portions of the Peninsular Ranges of southern California have demonstrated clinical signs of respiratory disease in adults and have suffered high pneumonia-related lamb mortality. Respiratory pathogens have been isolated from diseased tissues in affected animals, but it is now suspected that *Mycoplasma* spp. may play a role in causing pneumonia in desert bighorn sheep. The purpose of this project was to determine if *M. ovipneumoniae* is associated with respiratory disease in free-ranging bighorn sheep in California. Over 700 serum samples were collected between 1999–2009 by the California Department of Fish and Game during routine bighorn sheep capture operations for population management and disease surveillance. Samples were sent to the Washington Animal Disease Diagnostic Laboratory at Washington State University in Pullman, Washington for testing by competitive enzyme-linked immunosorbent assay (cELISA) for *M. ovipneumoniae* antibodies. Overall seroprevalence for *M. ovipneumoniae* among bighorn sheep was calculated and statistical analyses were performed to compare seroprevalence among desert, Sierra, and Peninsular bighorn sheep populations, while evaluating the influence of sex and age classification on *M. ovipneumoniae* seropositivity. Temporal trends in *M. ovipneumoniae* seroprevalence were also evaluated for each population. Advancing our understanding of the role of *Mycoplasma* in respiratory disease in bighorn sheep will inform future interventions which may prove to be instrumental in the stabilization and recovery of bighorn sheep populations in California.

POSTER ABSTRACTS (alphabetical by senior author)

QUANTIFYING STEROID HORMONES IN BIGHORN FECES, *OVIS CANADENSIS* (MAMMALIA: ARTYODACTILA), ON THE SAN FELIPE SIERRA, BAJA CALIFORNIA, MÉXICO.

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The sexual steroid hormones (SSH) quantification can determine sex and reproductive physiology from feces in a systematized way without the need to manipulate or stress the animals. The objectives for our study were: 1) determine the sex in fecal samples from bighorn sheep (*Ovis canadensis mexicana*) based on the SSH concentrations; 2) analyze the temporal relationship with the hormone profiles in males and females; and 3) examine the relationship between feces size and SSH concentration. We quantified androgens (testosterone, T), progestagens (Progesterone, P4), and estrogens (Stradiol, E2) using an enzyme immune assay (EIA). The SSH differential analysis results indicates that 96 of the samples came from males, 65 from females, and 35 from animals whose sex could not be determined. The P4 concentration on females was significantly different ($P < 0.05$) among seasons, with the highest concentration (280 ng/gr) in spring. E2 and T did not differ. P4 and E2 concentrations in females possibly increase gradually as long as the environmental conditions get more favorable from winter to spring; there is a coincidental rise of T in males. Our results are in concordance with the initiation of reproductive activity. We also observed lower concentrations during the dry season (summer to fall), which is probably indicative of a latent state in bighorn sheep from a reproductive perspective.

POPULATION AND HABITAT USE BY DESERT BIGHORN SHEEP (*OVIS CANADENSIS MEXICANA*) TRANSLOCATED INTO SIERRA MADERAS DEL CARMEN, COAHUILA, MÉXICO

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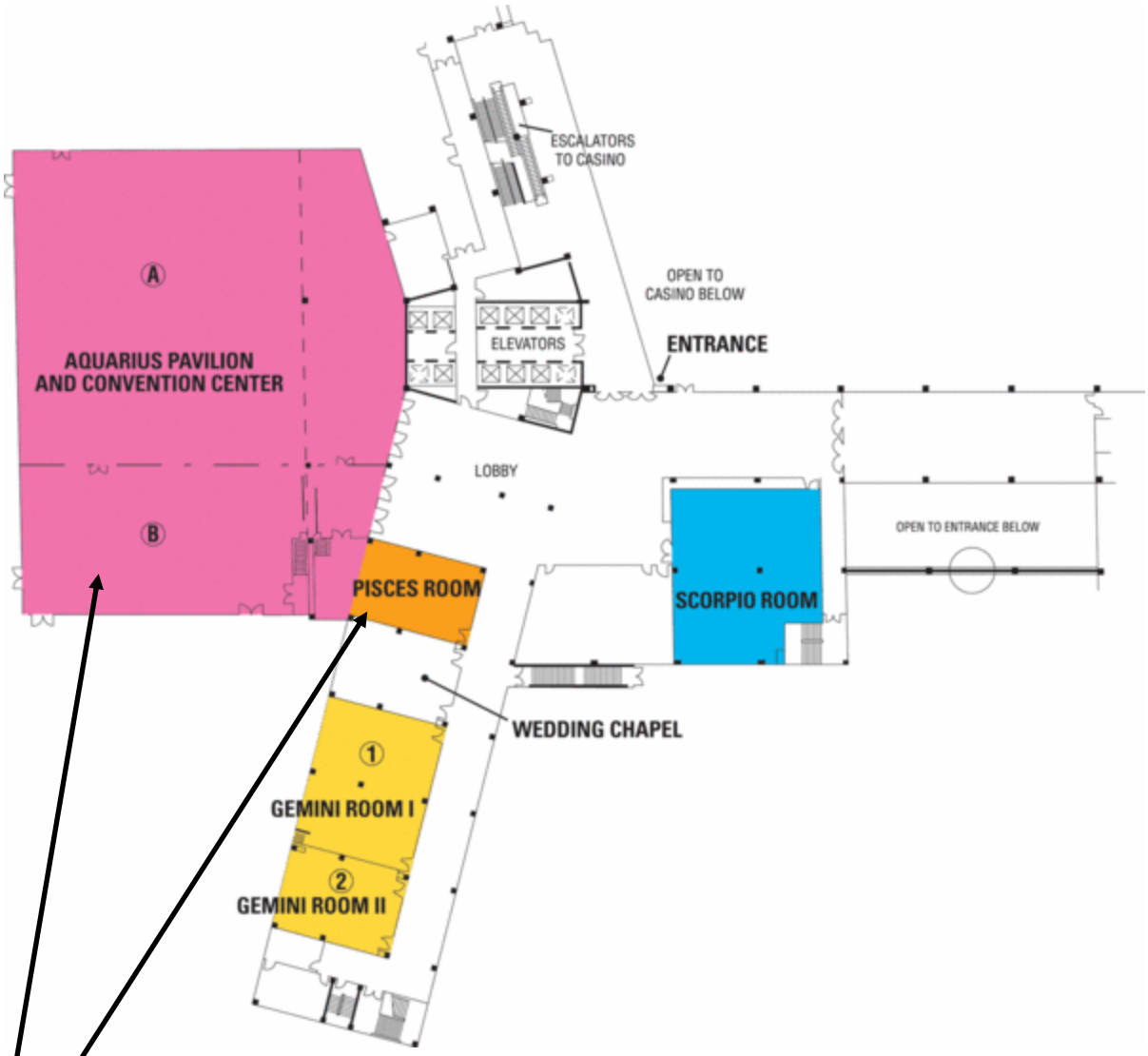
We studied habitat use, home range, and demographic status of a translocated desert bighorn sheep (*Ovis canadensis mexicana*) population in Sierra Maderas del Carmen, located in the northwest portion of Coahuila State, México. During our study, we monitored 20 radiocollared bighorn sheep (1 ram and 19 ewes released in 2004 and 2009, respectively). We also visually monitored other individuals without radiocollars released during the same periods. With the use of Arc View 3.2, we integrated a geographic information system using the geographical coordinates of bighorn sheep sightings, digital vegetation maps, and topographic coverage. We used the "Animal Movement" extension of ArcView to determine the seasonal home range of the entire population. This report includes the first 2 sampling periods (March to August 2010), which included 48 sightings records from the first period and 40 from the second period. We use the adaptive Kernel method to estimate the home range. The results shows a home range of 4,631 ha ($P = 0.05$) and 883 ha ($P = 0.5$) for the first sampling period (March to May) and 6,141 ha ($P = 0.05$) and 743 ha ($P = 0.5$) for the second period (June to August). Of the 20 radiocollared bighorn sheep, we detect 6 ewes mortalities and 2 lost signals. During the same period, 7 lambs were observed.

NOTES



Registration, Merchandise, and Silent Auction will be held in the Pisces Room

Presentations will be made in the Aquarius Pavilion and Convention Center B

DESERT BIGHORN COUNCIL