Proceedings of the

10th Mountain Lion Workshop

Cougars: Conservation, Connectivity and Population Management

MOUNTAIN LION WORKSHOP 2011
BOZEMAN, MONTANA

Sanctioned by:
Western Association of Fish and Wildlife Agencies (WAFWA)

WAFWA Agency Host:
Montana Fish, Wildlife & Parks
Workshop Co-Host:
Wild Felid Research and Management Association (WFA)

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Linda Sweanor, WFA

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SUGGESTED CITATION

Complete volume:

Williams, J., H. Robinson, and L. Sweanor, editors. 2011. Proceedings of the 10th Mountain Lion Workshop. May 2-5, 2011. Bozeman, Montana, USA.

Individual article:

Author's name(s). 2011. Title of article or abstract. Pages 00-00 in Williams, J., H. Robinson, and L. Sweanor, editors. Proceedings of the 10th Mountain Lion Workshop. May 2-5, 2011. Bozeman, Montana, USA.

The complete proceedings are available at the Montana Fish, Wildlife & Parks website:

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Distinguished Service Awards

Howard Quigley – Panthera, Craighead Beriniga South
Kerry Murphy – United States Forest Service
Toni Ruth – The Selway Institute

(L - R) Award Recipients Kerry Murphy, Toni Ruth and Howard Quigley - Photo by Steven Winters

The original Yellowstone National Park mountain lion research pioneers were celebrated at the 10th Mountain Lion Workshop in Bozeman, Montana. All three esteemed scientists were originally hired and supervised by mountain lion pioneer Dr. Maurice Hornocker. Kerry Murphy initiated the mountain lion research effort before wolves were reintroduced into Yellowstone National Park. Kerry shed light on fascinating life history secrets ranging from population demographics to predation rates for Yellowstone cougars. Following wolf reintroduction, Toni Ruth was the first to explore the relationship between wolves and cougars in the Park. Toni identified interesting cougar habitat use changes and cougar/wolf/bear behavior following wolf restoration. Howard Quigley is currently tackling cougar ecology and behavior in the south end of the greater Yellowstone ecosystem near Grand Teton National Park. Howard and his team are using new GPS technology to tease out intricate relationships betwetween cougars and their environment. Howard has also been involved with Maurice and his cougar programs from the beginning. All combined, these three researchers pioneered in scientific cougar research in the greater Yellowstone ecosystem.

Preface

Chronology of Mountain Lion Workshops:

1st Mountain Lion Workshop - Sparks, Nevada
2nd Mountain Lion Workshop - St. George, Utah
3rd Mountain Lion Workshop - Prescott, Arizona
4th Mountain Lion Workshop - Denver, Colorado
5th Mountain Lion Workshop - San Diego, California
6th Mountain Lion Workshop - San Antonio, Texas
7th Mountain Lion Workshop - Jackson Hole, Wyoming
8th Mountain Lion Workshop - Leavenworth, Washington
9th Mountain Lion Workshop - Sun Valley, Idaho
10th Mountain Lion Workshop - Bozeman, Montana

The 10th Mountain Lion Workshop was held in Bozeman, Montana, from May 2-5, 2011. The theme for the workshop was Cougars: Conservation, Connectivity and Population Management. The global conservation organization, Panthera, sponsored Dr. Luke Hunter, the workshop keynote speaker. Dr. Hunter inspired all in attendance with his presentation and discussion on leopard conservation in Africa and how that relates to science, hunting, and policy development.

Keynote Speaker Dr. Luke Hunter - Photo by Steven Winters

Workshop hosts, led by Jim Williams and Hugh Robinson, provided sessions for state and province status reports that were moderated by Steve Nadeau of Idaho Fish and Game. Engaging plenary sessions included topics addressing species interactions/predation, corridors and habitat use, human dimensions, and population harvest. Workshop co-host, the Wild Felid and Research and Management Association led by Linda Sweanor, provided an engaging international session that addressed issues such as population segments of concern and population monitoring.

Steve Nadeau moderating the WAFWA agency panel discussion

There were 161 registered workshop participants and many unregistered local students. We received $32,766.99 in registration fees (many of them late registrations), contributions, sponsorships, and vendor fees. We expended $30,614.58, which left us with $5,115.90 that was applied to the conference wrap-up and the balance sent to WAFWA. We provided each conference registrant with a Patagonia torrentshell rain jacket with the conference logo, and a tablet and pen with cougar artwork donated by Zara McDonald and her team at the Felidae Fund. Thanks to Caryn Amacher of Montana Fish, Wildlife & Parks, the workshop registration, organization, accommodations, and food were excellent.

The next state to host the WAFWA mountain lion workshop will be Utah. Justin Shannon, the Wildlife Program Manager for southeast Utah, was on hand to accept. Moab was suggested as a possible location. This will be determined by the Utah Department of Natural Resources at a later date. The WAFWA workshop schedule is now every three years so that the black bear and mountain lion workshops will not occur in the same year. Thanks to all for attending, participating, and making this a truly enjoyable and relevant mountain lion workshop! We will see you in Utah!

Jim Williams and Hugh Robinson
Workshop Co-Chairs
10th Mountain Lion Workshop
Bozeman, Montana

THE 10TH MOUNTAIN LION WORKSHOP

Agenda

Tuesday, May 3

8:30 **Welcome –** Jim Williams (Montana Fish Wildlife & Parks) and Don Clark (Houndsman and Libby Rod and Gun Club)

9:00 **Keynote –** Dr. Luke Hunter (Panthera)

10:00 **Break**

Plenary Session 1 – State and Provincial Presentations
Session Chair: **Jim Williams** (Montana Fish, Wildlife & Parks)

Only presenting author listed; see abstract for full authorship**.**

10:15 ***Montana – Montana mountain lion status report***
Quentin Kujala (Montana Fish Wildlife & Parks)

10:30 ***Utah – Utah mountain lion status report***
Kevin Bunnel (Utah Division of Wildlife Resources)

10:45 ***New Mexico – New Mexico mountain lion status report***
Frederic S. Winslow (New Mexico Department of Game and Fish)

11:00 ***Nevada – Nevada mountain lion status report***
Carl Lackey (Nevada Department of Wildlife)

11:15 ***Idaho – Idaho mountain lion status report***
Craig White (Idaho Department of Fish and Game)

11:30 ***Alberta – Managing an expanding cougar population in Alberta***
Nathan Webb (Alberta Sustainable Resource Development)

11:45 **Lunch**

1:00 ***Arizona – Arizona mountain lion status report***
Ronald L. Day Jr. (Arizona Game and Fish Department)

1:15 ***Washington – Washington mountain lion status report***
Richard A. Beausoleil (Washington Department of Fish and Wildlife)

1:30 ***Florida – Managing Florida panther depredations: implications for continued recovery***
Mark A. Lotz (Florida Fish and Wildlife Conservation Commission)

1:45 *Wyoming – Discussions on source/sink/stable population management of cougars in Wyoming*
Daniel J. Thompson (Wyoming Game and Fish Department)

2:00 **State Panel Discussion –** ***Predator control and other management issues***
Moderator: Steve Nadeau (Idaho Fish and Game)

2:50 **Break**

Plenary Session 2 – Species Interactions/Predation
Session Chair: **Dr. Mike Mitchell** (Montana Cooperative Wildlife Research Unit)

Only presenting author listed; see abstract for full authorship**.**

3:10 ***Cougar presence influences diet optimization in ungulate prey***
David M. Choate (School of Life Sciences, University of Nevada, Las Vegas)

3:30 ***Inter- and intraspecific competition in a large carnivore guild***
Nathan F. Webb (Alberta Sustainable Resource Development**)**

3:50 ***Cougar prey composition and predation rates in a multi-prey community in northeast Oregon – preliminary results***
Darren A. Clark (Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University)

4:10 ***Cougar prey composition and predation rates in Central Utah***
Dustin L. Mitchell (Department of Wildland Resources, Utah State University)

4:30 ***Sex matters: dietary strategies of male and female cougars on the southern Colorado Plateau***
Brandon Holton (U.S. National Park Service, Grand Canyon National Park, Science and Resource Management)

4:50 ***Prey switching, specialization, and multi-species functional response in cougars: implications for small populations of alternate prey***
Kyle H. Knopff (Golder Associates Ltd., Calgary, Alberta)

Plenary Session 3 – Social/Poster Session

Posters to be posted the entire conference. This evening's presenters in attendance 6:00-7:00.

Wednesday, May 4

Plenary Session 4 – WFA Population Segments of Concern
Session Chair: **Melanie Culver** (Arizona Cooperative Fish & Wildlife Research Unit)

Only presenting author listed; see abstract for full authorship**.**

8:15 ***Jaguars in peril: the next 100 years***

Rodrigo A. Medellin (Arizona-Sonora Desert Museum and Instituto de Ecología, Universidad Nacional Autónoma de México)

8:30 ***Vulnerability of the ocelot populations in the United States***
Michael E. Tewes (Caesar Kleberg Wildlife Research Institute, Texas A&M University)

8:45 ***Don't eat the shrimp***
Jim Sanderson (Small Cat Conservation Alliance, and University of Arizona Wild Cat Center, School of Natural Resources and the Environment)

9:00 ***Collateral impacts of increasing Florida panther numbers: dealing with unintended consequences***
Darrell Land (Florida Fish and Wildlife Conservation Commission)

9:15 ***Demographic history of mountain lion in Texas: a genetic evaluation***
Joseph D. Holbrook (Caesar Kleberg Wildlife Research Institute, Texas A&M University)

9:30 **Panel Q&A**

10:05 **Break**

Plenary Session 5 – WFA Population Monitoring
Session Chair: **Linda Sweanor** (WFA President)

Only presenting author listed; see abstract for full authorship**.**

10:25 ***The Puma as an Umbrella Species for Conserving Western Hemisphere Carnivores***
Christopher L. Burdett (Colorado State University, Department of Fish, Wildlife, and Conservation Biology)

10:40 ***Pilot study on scat detection dogs for cougar population estimation***
Gregory A. Davidson (Oregon Department of Fish & Wildlife)

10:55 ***Noninvasive tracking of jaguars (Panthera onca) and co-occurring feline species in Belize by genotyping feces and remote camera trapping***
Claudia Wultsch (Department of Fisheries and Wildlife Sciences, Virginia Tech)

11:10 ***Estimating detection probability for Canada lynx using snow-track surveys in the Northern Rocky Mountains***
John R. Squires (U.S. Forest Service, Rocky Mountain Research Station)

11:25 ***Estimating mountain lion density with motion-activated cameras using mark-resight***
Jesse Lewis (Department of Fish, Wildlife, and Conservation Biology, Colorado State University)

11:40 **Panel Q&A**

12:10 **Lunch**

Plenary Session 6 – Corridors, Habitat Use, and the Urban Interface
Session Chair: **Justin Gude (**Montana Fish, Wildlife & Parks**)**

Only presenting author listed; see abstract for full authorship.

1:10 ***Functional connectivity for pumas (Puma concolor) in central Mexico***
Zaira Y. González-Saucedo (Universidad Autónoma de Querétaro, Facultad de Ciencias Naturales, Posgrado en Ciencias de los Recursos Bióticos)

1:30 ***Mountain lion (Puma concolor) population status, and biological corridors in Sierra San Luis, Sonora México***
Alejandro González-Bernal (Naturalia A.C. Av. 32 entre calle 3 y 4 Agua Prieta, Sonora, México)

1:50 ***Habitat use of pumas during dispersal in the central rocky mountains***
Jesse R. Newby (*Teton Cougar Project*, P.O. Box 34 Kelly, WY, 83011, USA)

2:10 ***Panther habitat characteristics and distribution in Southern Florida***
Robert A. Frakes (U.S. Fish and Wildlife Service, South Florida Ecological Services Office)

2:30 ***Modeling Cougar Resource Selection Over Multiple Scales and Behaviors***
Wendy R. Rieth (Department of Wildland Resources, Utah State University)

2:50 **Break**

Plenary Session 7 – Corridors, Habitat Use, and the Urban Interface (cont.)
Session Chair: **Rich DeSimone (**Montana Fish Wildlife & Parks, retired**)**

Only presenting author listed; see abstract for full authorship.

3:10 ***Linking resource selection and mortality modeling for population estimation of mountain lions in Montana***
Hugh S. Robinson (Montana Cooperative Wildlife Research Unit, University of Montana)

3:30 ***Direct and indirect effects of predators on an endangered species: testing predictions of the apparent competition hypothesis***
Mark Hebblewhite (Wildlife Biology Program, College of Forestry and Conservation, University of Montana)

3:50 ***Understanding the conservation needs of mountain lions in an urban southern California landscape***
Jeff A. Sikich (Santa Monica Mountains National Recreation Area)

4:10 ***Effects of residential development on cougar spatial ecology in Washington***
Brian N. Kertson (School of Forest Resources, University of Washington)

4:30 ***Cougars in the backyard: large carnivore conservation in developing landscapes***
Aliah Adams Knopff (Talus Environmental Consulting, 127 Silver Valley Rise NW, Calgary, AB, Canada)

4:50 ***Cougar behavioral response to anthropogenic activities and landscapes: evidence of ambivalence?***
David C. Stoner (Utah State University, Department of Wildland Resources)

5:10 ***Conservation Conflicts and Management Decisions: the Puma and the Huemul Deer in Patagonia Park, Chile***
Cristian Saucedo (Conservacion Patagonica, Patagonia Park, Cochrane, Chile)

6:00 **Social**

7:00 **Banquet**
Presentation: A Yellowstone Mountain Lion Research Celebration
Toni Ruth
Kerry Murphy
Howard Quigley

Thursday, May 5

Plenary Session 8 – Human Dimensions
Session Chair: **Rod Bullis** (Bitterroot Houndsman Association)

Only presenting author listed; see abstract for full authorship.

8:30 ***Florida Gulf Coast University promotes Florida panther conservation through a unique environmental education program***
Ricky Pires (Director/FGCU "*Wings of Hope*" Environmental Education Program)

8:50 ***The feasibility of the Northeastern U.S. supporting the return of cougars (Puma concolor)***
John W. Laundré (Department of Biological Sciences, SUNY Oswego)

9:10 ***An explanation of cougar-related behaviors and behavioral intentions among northern Arizona residents***
David J. Mattson (U.S. Geological Survey (USGS) Southwest Biological Science Center, Northern Arizona University)

9:30 ***Mountain lion policy process in three states – an advocate's viewpoint***
Wendy Keefover (WildEarth Guardians, P.O. Box 1471, Broomfield, CO)

9:50 ***The discourses of incidents: cougars on Mt. Elden and in Sabino Canyon, Arizona***
David J. Mattson (U.S. Geological Survey (USGS) Southwest Biological Science Center, Northern Arizona University)

10:10 **Break**

Plenary Session 9 – Harvest
Session Chair: **Hugh Robinson** (Montana Cooperative Wildlife Research Unit)

Only presenting author listed; see abstract for full authorship.

10:30 ***Assessing selectivity and harvest composition of cougar hunters in Wyoming***
Daniel J. Thompson (Wyoming Game and Fish Department)

10:50 ***Landscape context influences spatial population dynamics: pumas under varying levels of human-induced mortality***
Jesse R. Newby (*Teton Cougar Project*, P.O. Box 34 Kelly, WY)

11:10 ***Mountain lions of the Great Basin: identification of source-sink dynamics using Bayesian genetic techniques***
Alyson M. Andreasen (Program in Ecology, Evolution and Conservation Biology, University of Nevada)

11:30 ***Beyond cougar source-sink management: distributing hunt effort to preserve social stability***
Richard A. Beausoleil (Washington Department of Fish and Wildlife)

11:50 ***Comparison of cougar survival and mortality patterns in exploited and quasi-protected population***
Michael L. Wolfe (Department of Wildland Resources, Utah State University)

12:10 ***Effects of sport hunting on cougar population, community, and landscape ecology***
Robert B. Wielgus (Large Carnivore Conservation Lab, Department of Natural Resource Sciences, Washington State University)

12:30 **Closing Remarks – Jim Williams, Linda Sweanor, and Hugh Robinson**

Session 1:

State and Provincial Presentations

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10th Mountain Lion Workshop

Cougars: Conservation, Connectivity and Population Management

Montana Mountain Lion Status Report

Quentin Kujala, Montana Fish, Wildlife & Parks, 1420 East Sixth Avenue, Helena, Montana 59620-0701 (presenter)

Abstract: Montana has a goal of maintaining a reasoned diversity of mountain lion objectives across Montana's different habitats and associated tolerance levels for mountain lions. Fundamentally, different mountain lion objectives are primarily achieved through adjusted female harvest. A spectrum of lion habitat and human tolerance for mountain lions runs in a "decreasing" continuum from west to east. Northwest Montana as functionally represented by Region 1 and portions of Region 2 has significant public landownership, traditional lion habitat/prey densities and a long-established history/public advocacy for lions and lion hunting. Far eastern Montana has less public land, more open environments with typically lower prey densities and a generally smaller (but present and growing) advocacy for lions and lion hunting. These circumstances describe parts or all of Regions 5, 6 and 7. Between these two ends lie Regions 3 and 4 where the variables of landownership, habitat, prey, and public advocacy mix and transition from one "extreme" to the other. While management objectives often vary across these physical and human landscapes, fundamental management strategies relative to female harvest do not. That is, higher or lower mountain lion objectives are commonly achieved through higher or lower female lion harvest.

In addition to the varying objectives influenced by diverse habitats and other landscape features, population status also influences female lion harvest. Perhaps not surprisingly, Montana exhibits a spectrum of population status levels. Generally speaking, the preponderance of evidence from Region 1 and 2 suggests robust mountain lion populations from both the human tolerance and historical perspectives. Recognizing that special licenses to date suggest a harvest focus on male lions, the region is maintaining (and adjusting with this permit setting process where necessary) female subquotas equal to approximately 20% of the total number of limited licenses. Region 3 in southwest Montana is in part responding from recent history that included higher lion harvest influenced by higher lion populations and public interest in additional lion harvest beyond traditional houndsmen inputs in the late 1990's. Management questions of prey amounts and wolf interactions are also present in some cases. Regional management actions currently include conservative female harvest intended to rebound some population levels to a point higher than present but yet below previous highs. Not surprisingly, Regions 4, 5, 6 and 7 exhibit a higher tolerance/prescription for female harvest reflecting relatively lower lion objectives. Like Region 1, these regions generally exhibit stability with respect to recent harvest and quota levels—albeit with lower objectives.

Utah Mountain Lion Status Report

Justin M. Shannon, Utah Division of Wildlife Resources, 319 North Carbonville Road, Suite A, Price, UT 84501 (presenter)

Kevin D. Bunnell, Utah Division of Wildlife Resources, 1594 W. North Temple, Salt Lake City, UT 84114, USA.

***Abstract*:** Mountain lions have been managed as a protected game species in Utah since 1967. In 2009 the Division of Wildlife Resources completed the Utah Cougar Management Plan v2, developed with the assistance of a public-based Cougar Advisory Group which will guide management of cougars through 2021. Cougar harvest is managed under harvest objective (quota), limited entry and hybrid "split" strategies. The Division manages to sustain cougar densities on all management units except those that have approved predator management plans, where cougar harvests are increased to reduce cougar numbers and predation on big game. Under the revised management plan cougar permits / quotas are determined at an eco-region scale, based primarily on the proportion of adult females ($\geq$ 3 years old) in the harvest over a 3-year period. Permits / quotas are then distributed to individual hunting units. Cougar harvest has ranged from 287 to 448 annually since the 2000-2001 season. Both hunting and pursuit seasons run from mid-November through June 1, although some units have extended seasons. Harvest management continues to improve with better understanding of cougar movements, dispersal, harvest impacts and population recovery time, particularly between lightly hunted and heavily harvested cougar populations, based on research being conducted in cooperation with Utah State University. All cougar complaints are handled under the guidance of a Nuisance Cougar Complaints policy. Most cougar conflicts are handled through lethal control.

New Mexico Mountain Lion Status Report

Frederic S. Winslow, New Mexico Department of Game and Fish, P.O. Box 25112, Santa Fe, NM 87504 (presenter)

Abstract: Cougar (*Puma concolor*) management in New Mexico has changed from non-protection through the early 1970's to Zone Management since the late '90's. The current harvest strategy is to manage for stable or reduced cougar populations in areas with important ungulate resources, primarily desert bighorn sheep, and in areas with high or potentially high human conflict. The balance of the state is managed for increasing populations. Cougar harvest limits have historically been met in the northern cougar zones in New Mexico and rarely met in the south. Harvest limits in most of New Mexico are based upon sustainable levels of harvest to the population as a whole and protection of the breeding segment of the population. The maximum zone harvest limits are not quotas to be met.

Nevada Mountain Lion Status Report

Carl W. Lackey, Western Region Predator and Furbearer Biologist, Nevada Department of Wildlife, P.O. Box 277, Genoa, NV 89411, USA, clackey@ndow.org (presenter)

Russell Woolstenhulme, Furbearer and Waterfowl Staff Specialist, Nevada Department of Wildlife, 1100 Valley Road, Reno, NV 89512, USA

Abstract: Mountain lion management in Nevada and throughout the West is not without its controversy. Predator control, as it relates to cougars is a common topic at most public meeting's when discussions include ungulate population declines and cougar biology. Wildlife managers, tasked with keeping up with constantly changing attitudes and policies regarding predator management have faced many challenges in the last several years. In Nevada the process has resulted in regulations that have often evolved based on input from non-wildlife professionals. Most of these regulatory changes have been made with the goal of reducing statewide cougar abundance and density by increasing harvest. Overall these changes have not had a significant effect on statewide lion harvest. Additionally, predator management projects that focus solely on predator removal have also been implemented. This report will summarize these topics as well as developments in cougar research that have taken place in Nevada since the 9th Mountain Lion Workshop in 2008.

HARVEST & REGULATION HISTORY

Cougars have been a protected game mammal in Nevada since 1965. Since that time changes to the season structure and harvest regulations have been frequent, including; modification to season lengths, changes in harvest objectives, requirement of tags, and altering of hunt unit boundaries to affect hunter distribution. In 1997 particularly, several regulatory changes were made with the intent of substantially increasing statewide cougar harvest. These changes included over-the-counter tag sales, an increase in available tags per hunter from one to two, a decrease in resident tag fees from $50 to $25 and a change in hunt unit groups. The result was a record high statewide cougar harvest of 210 animals that year but by the following year the harvest had dropped to 140 animals, below the 10 year average (Figure 1). In 1998 the southern third of the state went to a year-around season and in 2001, the Nevada Wildlife Commission increased the statewide season length from seven months to year-around for the rest of the state.

In 2008 lion tags were made available on-line. Despite these major changes in regulation and season structure, cougar harvest rates in Nevada have remained mostly unchanged and even slightly declined over the last 15 years on the average. For example, between 1992 and 2001 sport hunters took an average of 156 cougars annually but the average for the period 2002-2011 has decreased to 138 (Figure 1). The only noticeable effect of these regulatory changes has been the number of tags sold annually (Figure 2).

Once referred to as "quotas" the term was changed to "harvest objectives" in the late 1990's even though the numbers established were not objectives based on biological goals or indices. Recently NDOW has been using the term "harvest limits" thereby representing a more biological rather than political ceiling. Cougar harvest limits are set on an annual or biennial basis along with other big game quotas. Historically harvest limits were calculated by biologists and those recommendations were reviewed and sometimes altered during the public meeting process. Since 2003 harvest limit recommendations were not formulated in this manner, but rather have been indiscriminately chosen with little input from Department biologists by the Wildlife Commission. This change in the process was implemented in an endeavor to increase lion harvest, but these changes and the subsequent increase in harvest limits have had no tangible effect on the number of cougars killed statewide (Figure 3). For 2011 the harvest limit set by the Nevada Wildlife Commission was 500 cougars statewide (238% higher than the highest recorded harvest of 210 animals in 1998). The increases in the harvest limit seem to be in vain given the fact that for the last 20 years actual sport harvest has averaged approximately 50% of the published harvest limit quotas (Figure 3). There is a strong correlation however between cougar harvest and deer harvest implying that the only way to kill more cougars is if there are more cougars in the population, a thought process contrary to current political trends (Figure 4).

HARVEST PROGRAM

Per regulation all legally killed cougars, whether taken under the authority of a sport tag or killed for depredation or public safety reasons, must be inspected and validated. Each cougar validated receives a metal seal permanently attached to the pelt, and pertinent data are recorded including: sex, age, weight, location, body condition, reproductive status, stomach contents and physical anomalies. Additionally, NDOW documents all other known mortalities such as road kills, natural mortalities, etc. Premolars are pulled for exact aging purposes and tissue samples are collected and deposited in a DNA bank.

NDOW maintains the practice of adaptive management for most of its big game species and manages for sustainable populations. Cougar harvest trends are evaluated to determine population status. Because of Nevada's basin and range topography and the obstacles this presents to the public there are many areas that act as natural refugia where cougars are pursued little if at all. NDOW models the lion population by estimating a minimum population size needed to maintain known mortality rates. Population structure and trend estimates are based on harvest data and reports from guides, hunters, and Wildlife Services personnel who remove depredating lions, lions that are a threat to the public and lions removed for management purposes related to other big game enhancement programs. Prey abundance and cougar recruitment, survival and fecundity rates are all parameters used in a deterministic reconstructive spreadsheet model. Estimates place Nevada's cougar population at between 1100 – 1500 adults (data through 2010). Major shifts in sex ratios or age cohorts are absent suggesting the lion population in Nevada is stable.

NEVADA PREDATOR MANAGEMENT PROGRAM

Nevada's predator management philosophy as stated in the *Nevada Predation Management Plan-2011(NPMP)* was, "*The goal of the Nevada Predation Management Program is to initiate projects that have the greatest potential to produce the intended results based on the best available information and carried out in the most appropriate manner. NDOW maintains the philosophy that predation management is a valuable management tool. It is a tool to be applied by itself, or ideally in conjunction with other management techniques. The sole intention is to lessen the impacts of predation on identified populations that are being additively impacted by specific predators. As with any management strategy, predation management should be applied on a location specific, case-by-case basis, with clear goals, and based on the best available information. It should be applied in the proper intensity and at a focused scale. Equally important, after management is initiated, projects should be monitored to determine whether the desired results are achieved. The analysis of these projects will lead to better applications on future projects.*" The plan may be accessed on the Nevada Department of Wildlife web site at http://www.ndow.org/about/pubs/brochure/2011_Predator.pdf

There are two different funding sources for predator management projects in Nevada and both originate from sportsmen's dollars. Legislative actions in 2001 resulted in Nevada Revised Statute (NRS) 502.253 which is summarized as follows:

AB291 Introduced at the 71st session of the Nevada State Legislature on March 6, 2001 sought to establish a fee for all Nevada hunt permit applications to be used for predator management.

- **NRS 502.253 was signed into law May 31, 2001. This legislation created an additional application processing fee ($3) for all game tags to be used for the predator management program as described in subsection 1. as follows:**

1. In addition to any fee charged and collected pursuant to NRS 502.250, a fee of $3 must be charged for processing each application for a game tag, the revenue from which must be accounted for separately, deposited with the State Treasurer for credit to the Wildlife Account in the State General Fund and used by the Department for costs related to:

    (a) Programs for the management and control of injurious predatory wildlife;

    (b) Wildlife management activities relating to the protection of non-predatory game animals, sensitive wildlife species and related wildlife habitat;

    (c) Conducting research, as needed, to determine successful techniques for managing and controlling predatory wildlife, including studies necessary to ensure effective programs for the management and control of injurious predatory wildlife; and

    (d) Programs for the education of the general public concerning the management and control of predatory wildlife.

2. The Department of Wildlife is hereby authorized to expend a portion of the money collected pursuant to subsection 1 to enable the State Department of Agriculture to develop and carry out the programs described in subsection 1.

3. Any program developed or wildlife management activity or research conducted pursuant to this section must be developed or conducted under the guidance of the Commission pursuant to subsection 2 of NRS 501.181.4. The money in the Wildlife Account remains in the Account and does not revert to the State General Fund at the end of any fiscal year. (Added to NRS by 2001, 1213; A 2003, 1541; 2009, 464).

Important provisions that guard and regulate the use of these funds include:

- Revenue to be held in a separate wildlife account and only ~~be~~ used for the predator program.Revenue rolls over each year and cannot be reverted to other state funds.

The following is a summary of revenue and expenditures since the program's inception:

- ✓ *Average annual amount since inception ≈ $390,000*
- ✓ *Total revenues generated since inception ≈ $3.5 million*
- ✓ *Total expenditures ≈ $2,950,598*

Additional funds are available though the Heritage Program where projects are submitted for approval by the Nevada Wildlife Commission. The Department administers the Heritage Program by assembling project proposals, ranking them, providing copies to the Commission, implementing contracts to conduct projects, and collating project reports.

SUMMARY OF PROJECTS CONDUCTED UNDER NRS 502.253

To date 23 projects have been or are being implemented with funds generated under NRS 502.253.

- Projects have focused on protecting various species including: Mule Deer, Pronghorn, Bighorn sheep, Sage Grouse, Turkey, Waterfowl and Pheasant.
- Predator species targeted for removal were Mountain lions, Coyote, Badger and Corvids (Raven, Crow and Magpie).
- No monies have been spent on projects related to sensitive species, habitat or education and very little has been spent on research.

There are two notable projects pertaining to cougars – Projects 18 and 22.

Project 18

The primary objective of this project was to provide a benefit to mule deer through decreased predation by cougars and coyotes. This project was implemented in 2004 when NDOW fitted 24 mule deer (8 juveniles and 16 adults) in the project area with ear tag transmitters. The battery life of the transmitters did not exceed two years and none of the 24 deer were recorded as mortalities during the two year monitoring period. Predator removal was also initiated in 2004. Since that time a total of 34 cougars and 812+ coyotes have been removed at a project cost of $386,567. Average age of the lions taken was 3.6 years (males and females combined). An additional $102,193 has been proposed for FY2011 bringing the total project costs through July 2011 to $488,760 (Tables 1 and 2). The project will run another five years.

Table 1 - Project 18, Predator Removal by Year

	2004	2005	2006	2007	2008	2009	2010	2011	**Total**
Lions	0	4	0	10	5	5	7	4	**34**
Coyotes	66	119	230	149	84	105	59	na	**812+**

Table 2 - Project 18, Expenditures by Year

FY05	FY06	FY07	FY08	FY09	FY10	Total Expended Thru FY 2010	FY11	**Total**
20, 511	25,966	31,946	95,525	103,945	108,674	386,567	102,193	**$488,760**

Mule deer abundance and production are two of the many parameters being measured to determine success of this project. As summarized in the *Nevada Predator Management Plan – 2011*, measured success cannot be attributed solely to the project thus far since most of the mule deer increase occurred prior to any appreciable cougar removal – "*Population increases in 011-013* (37%) and 014* (53%) could be attributable to a number of factors including; predator control, wild horse gathers, mild winters, wet springs, and late summer moisture. Predator control has publicly received credit for much of the 53% increase in Unit 014 (850 deer to 1300) and may well have facilitated at least some of the growth. It should be noted that well over half of that population increase (850-1100) occurred by the spring of 2007 before any appreciable lion removal occurred. Only 4 of the 31 lions were removed before preparation of the 2007 deer population estimate. Additionally, since the same pattern of deer population increases occurred in 011-013 and 033* from 2004 to 2008 in the absence of predator control, it strongly suggests deer population increases in northwest Nevada were likely the result of a larger landscape scale phenomenon such as weather. Spring Fawn/Adult ratios have varied widely. In only one of 6 years since the inception of the project, was the spring fawn/adult ratio noticeably higher in 014 than the other units. This occurred after only 4 lions and 185 coyotes had been removed and has not occurred since with significantly more predator removal having occurred subsequent to that time… the variation between years is much greater for all units than variation between units within years. This suggests that production and recruitment are most often driven by landscape scale phenomenon such as climate.*"

*(reference to hunt unit boundaries in north western Nevada)

<u>Project 22</u>

The funding amount for this project proposal for 2011 is $145,187. It is referred to in the NPMP-2011 as "*Statewide deer and multi-species enhancement project*". It allows for removal of predators in areas where:

- Mule deer herds below carrying capacity or exhibiting long-term below average fawn/doe ratios (post-season) and/or long-term below average recruitment (spring surveys).
- Areas where more than one species of big game animals exist.
- Areas where long-term habitat improvements are under way.
- Areas where recent augmentations or reintroductions are planned.
- Areas where other big game species are below carrying capacity or exhibiting long-term below average young/adult female ratios and/or long-term below average recruitment.

Monitoring methods of the project is not identified in the NPMP-2011.

SUMMARY OF HERITAGE FUND PROJECTS

The Heritage Fund is funded through *Governors Tag* auctions. Recently approved proposals have had an emphasis on predator removal with little or no post-project monitoring. Heritage Fund Projects approved by the Wildlife Commission for 2011 include the *Jersey Valley Cattle* contract which allow a local rancher (the contractor) and his family to take up to 10 cougars in identified mountain ranges to "maintain a balance between mountain lions and their prey". The contractor and his family can harvest lions under authority of NDOW issued mountain lion tags (sport harvest) but then are paid $1,800 for each cougar killed. As stated in the original proposal the project areas were identified with empirical and anecdotal information which was supplied to the Commission. The project goal is to reduce the number of mountain lions in order to increase the number of mule deer and bighorn sheep. Monitoring of the results will be completed by the contractor - "*as I guide clients for hunts and run my ranch in the area*" [sic] for a period of three years following lion removal.

COUGAR RESEARCH IN NEVADA

There are currently three research projects underway:

- An Assessment of Desert Bighorn Sheep on Desert National Wildlife Refuge, Nevada
- Nevada Test Site Mountain Lion Study
- Characterizing Mountain Lion Distribution, Abundance, and Interactions with Prey Populations in Nevada

An Assessment of Desert Bighorn Sheep on Desert National Wildlife Refuge, Nevada

The projects main goal is to assess habitat use, diet, distribution and overall health of the bighorn sheep population in the Sheep Range. Cause specific mortality will also be investigated. The cougar researcher is David Choate (post doc) and he will be collaring cougars in the study area for the predator component of the project. Methods of capture include cage traps, foot snares and houndsmen. They are also using trail cameras to locate lions. As of mid-April 2011 they have captured four lions and deployed three collars. The project is expected to run through 2014. Cooperators include the U.S. Fish & Wildlife Service, U.S. Geological Survey, Nevada Department of Wildlife, University of Nevada, Las Vegas, and the White Mountain Research Center at the University of California.

Nevada Test Site Mountain Lion Study

In the Draft Study Plan submitted to NDOW authors David Mattson, Brandon Holton and Derek Hall outlined several goals for the project which takes place in 2010-2011. Specifically they are investigating: 1) the correlation of human exposure to mountain lions and the associated risks to workers on the Nevada Test Site; 2) prey composition and the effects of mountain lion predation on prey distribution; 3) seasonal activity patterns and population demographics of the NTS lion population which is un-hunted due to access restrictions on the property. Capture methods are limited to foot snares due to NTS restrictions regarding dogs off-leash. They have captured and collared three lions as of mid-April 2011, one of which has died. Cooperators include the U.S. Geological Survey, the National Park Service and the Nevada Test Site.

Characterizing Mountain Lion Distribution, Abundance, and Interactions with Prey Populations in Nevada

This project is in northwestern Nevada and is being conducted by Alyson Andreason, a PhD candidate at the University of Nevada, Reno. Goals include determining predation rates, prey selection, habitat use and connectivity. There is also a statewide genetic analysis component. As of mid-April 2011 they have captured and collared 25 cougars since January 2009 utilizing houndsmen and cage traps. There have been a few mortalities for various reasons. They anticipate two more years of field work. Cooperators include the University of Nevada, Reno, the Wildlife Conservation Society and the Nevada Department of Wildlife.

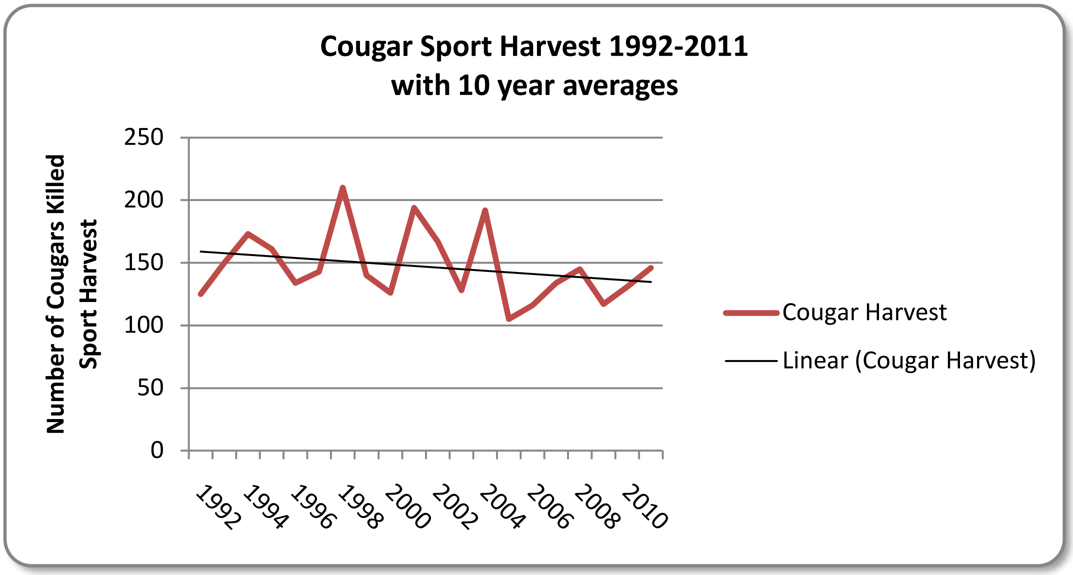

Figure 1 – Nevada statewide Cougar Harvest, 1992-2011

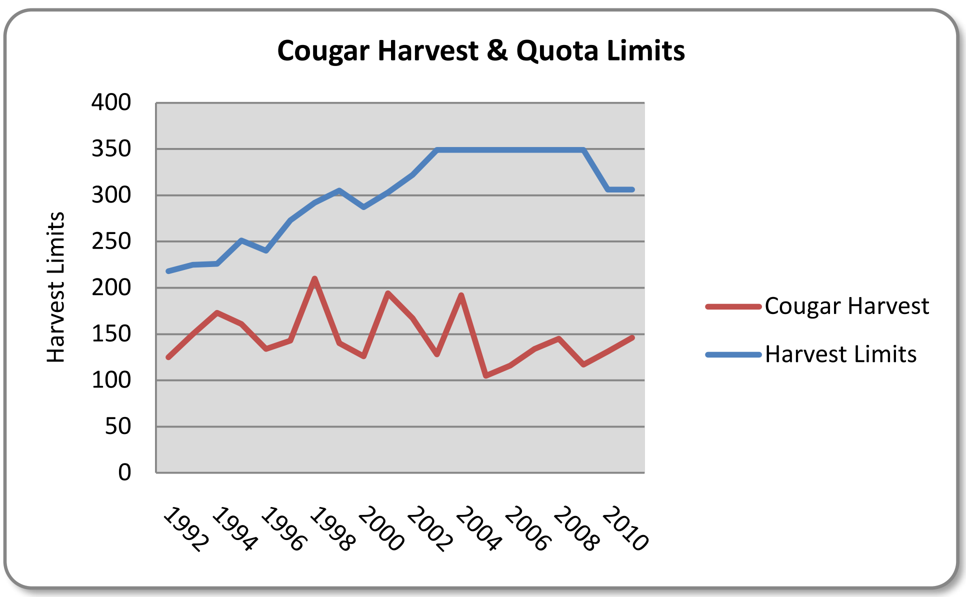

Figure 2 – Nevada statewide Cougar Harvest & tag sales, 1992-2011

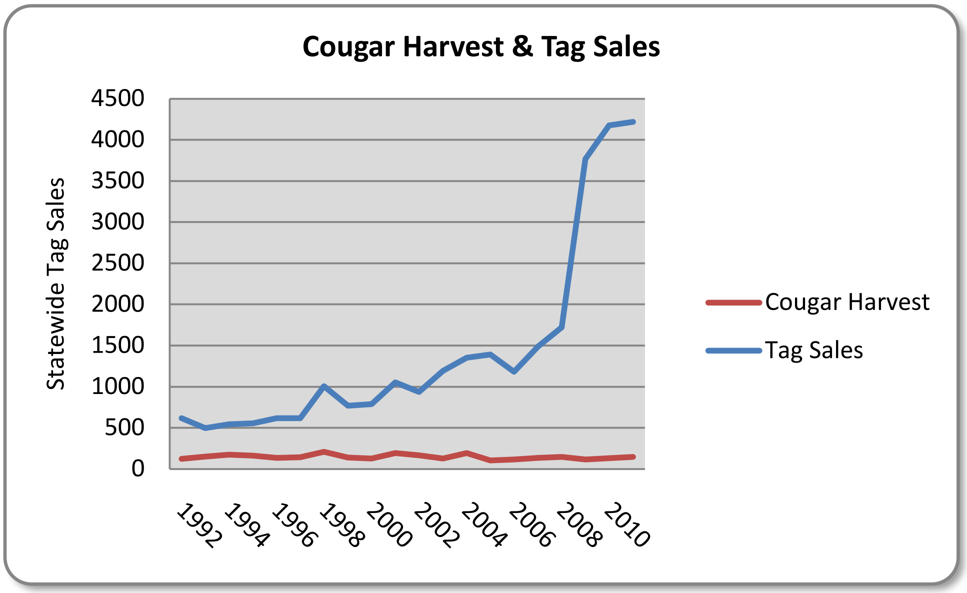

Figure 3 – Nevada statewide Cougar Harvest & Harvest Limits (quotas), 1992-2011.

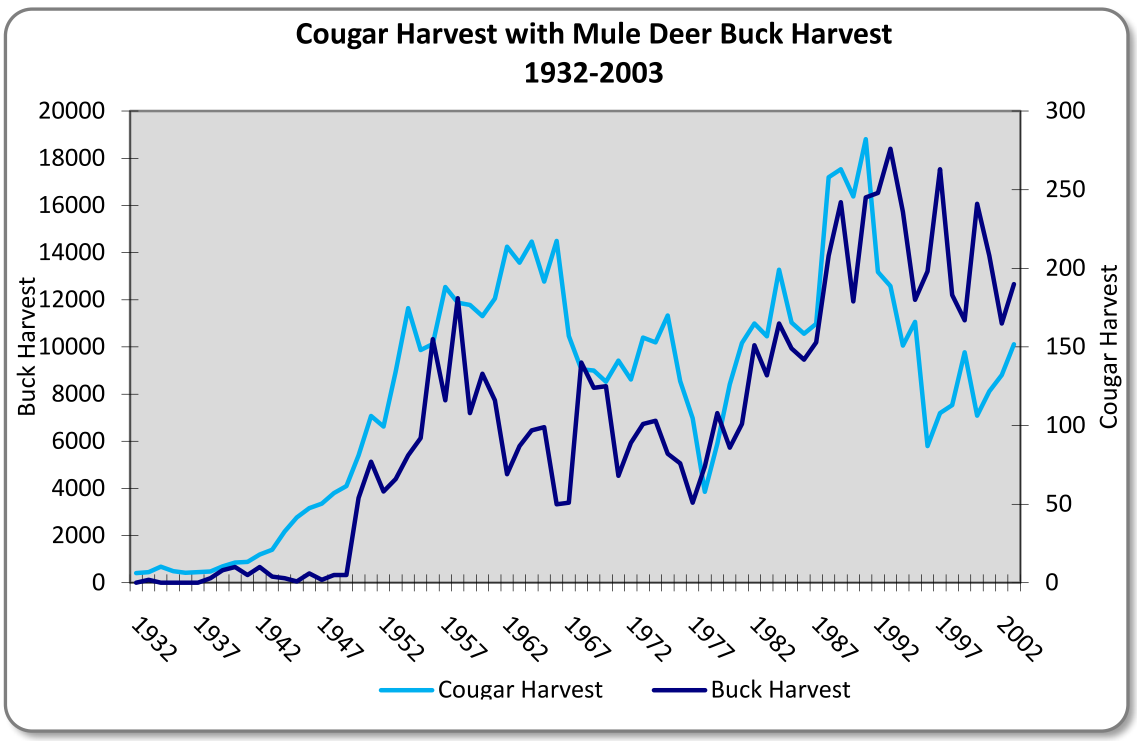

Figure 4 – Nevada statewide Cougar Harvest & Mule Deer Buck Harvest 1932-2003. Correlation exists when deer herds are increasing. 3 year lag in cougar population.

Idaho Mountain Lion Status Report

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Abstract: Since 1972 mountain lions (*Puma concolor*), or cougars, have legally been classified as a big game animal in Idaho. However, the public perception of mountain lions has fluctuated with the times. In Idaho, one of those perceptions is that mountain lions have an unacceptable impact on several different ungulate species. Accordingly, between the mid-1990s and mid-2000s, Idaho conducted several studies to evaluate the impact that mountain lions may be having on elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and bighorn sheep (*Ovis canadensis*) populations. This status report will give a brief background of the studies, brief overview of the studies' findings, and the impact the findings may or may not have had on wildlife management in Idaho. During these studies the statewide harvest of cougars peaked in 1997 when 800 mountain lions where harvested. Since then, harvest of mountain lions have declined and recently leveled off with harvest from 430-480. During these studies, mountain lion seasons across the state were made more lenient. In some game management units two-lion bag limits were initiated, non-resident hound hunting was expanded, and female quotas were modified or removed.

INTRODUCTION/BACKGROUND

The legal status and public perception of mountain lion in Idaho has changed over the last 100 years. During 1915-1941 state, federal and livestock employees removed 251 lions. It is unknown how many were removed by individuals acting on their own. During 1945-1958 bounties were implemented and the annual average removed was 80 lions. The highest removal during these years was 144 cougars in the 1953-1954 winter period.

During 1959-1971 hunting cougars for sport started to grow in popularity. During this period there were no restrictions or regulations and an estimated annual average of 142 cougars were removed. At the end of this unregulated sport harvest period it was estimated that 300 cougars were removed in the 1971-1972 season. Research on mountain lions in the Big Creek drainage of the Frank Church River of No Return Wilderness from 1964-1973 and concern over mountain lion populations resulted in legislation, implemented July 1, 1972, reclassifying the mountain lion as a big game species. This legislation allowed the Idaho Department of Fish and Game (IDFG) to regulate mountain lion harvest for the first time. Starting in 1973, IDFG required that all harvested mountain lions be checked and tags have been required since 1975. The research in the Big Creek drainage and associated efforts also started changing and enlightening many public perceptions and attitudes regarding mountain lions (Idaho Department of Fish and Game 2002).

With protection and restrictions during the 1970s-1990s and likely in response to increasing deer and elk populations, it is believed that mountain lion populations were stabilized or flourishing. Subsequently, with increased interest in sport harvest and likely higher populations, IDFG responded by extending seasons to allow more hunting and recreational opportunity. During the late-1990s to early 2000s because of concern among deer and elk hunters that high cougar populations were impacting declining deer and elk populations, IDFG further responded by increasing harvest opportunity in game management units (GMU) that were most likely affected by lions. Concurrent with these last changes, mountain lion harvest peaked in 1997 when 800 lions were harvested. Since then mountain lion harvest has declined and over the last 6 seasons has leveled off with harvest from 430-480 lions (Figure 1).

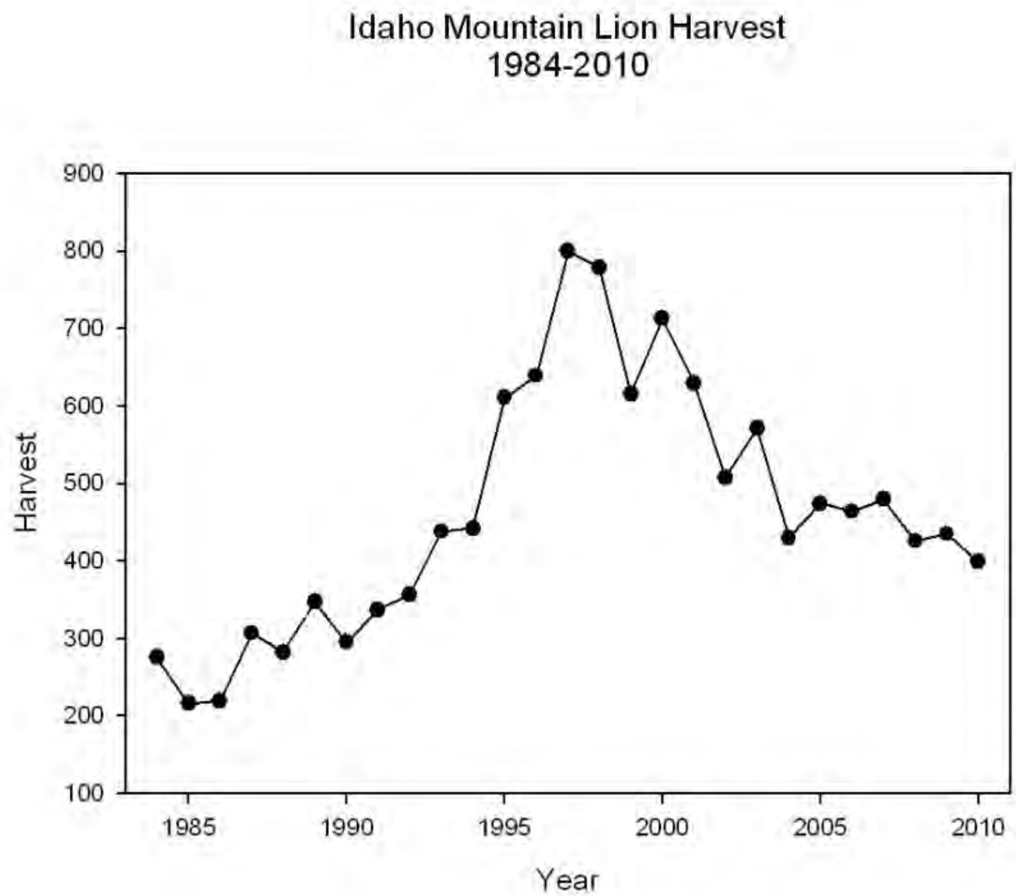

Figure 1. Mountain lion harvest in Idaho 1984-2010.

RECENT INVESTIGATIONS

During the mid-1990s, IDFG initiated 2 studies to investigate the potential impacts that mountain lions may be having on deer and elk populations. By the early-2000s, IDFG also initiated a study to evaluate why a California bighorn sheep population was declining. Since these studies have been published elsewhere our intent in this article is to provide a brief review of the finding from each of these studies. The deer and elk study were designed to increase harvest of mountain lions and other predators in a manipulative framework, thus allowing managers in Idaho to quantify the impact of lion harvest on deer and elk survival. The bighorn sheep study evaluated bighorn sheep habit use and mortality factors, thus providing insight into the how habitat and predators may interact to impact bighorn.

Elk Calf Survival in North-Central Idaho

Elk recruitment rates began declining in some north-central Idaho GMUs in the early 1990s. It was believed that mountain lions were one of the major causes for the decline in elk calf survival and subsequently, IDFG experimentally manipulated predator populations of black bears (*Ursus americanus*) and mountain lions. White et al. (2010) predicted that calf survival would improve with increasing predator harvest and decline with reductions in predator harvest.

It was determined that mountain lions were responsible for 18-68% of the annual elk calf mortality during the 8 year study (Zager et al. 2007). White et al. (2010) further determined that manipulation of black bear harvest had immediate impacts to calf survival. However, it was difficult to evaluate the results of manipulating mountain lion harvest on calf survival because harvest declined in almost all of the treatment and control areas. As an obligate predator, it appeared that the cougar population had a numerical response to declining prey (i.e., elk) populations. Since mountain lion populations apparently declined because of lower prey availability, it was difficult to implement an increase in lion harvest. Subsequently, White et al. (2010) could not statistically detect that manipulation of mountain lion harvest resulted in a functional response to calf survival. In addition, even though calf survival responded to predator manipulation, particularly to black bear harvest, White et al. (2010) also demonstrated that calf birth mass and habitat structure influenced calf survival. In an interesting twist, calf survival and subsequently the elk population responded to removal of black bear and mountain lions, however further potential population growth was negated by increased predation on older elk calves when wolves (*Canis lupus*) became well established in this study area (IDFG, unpublished data).

California Bighorn Sheep in Southwest Idaho

The purpose of this study was to monitor ewe survival, and lamb production and survival with the goal of identifying factors contributing to a downward trend in the bighorn sheep population. The population of bighorn sheep in southwest Idaho grew from a reintroduction of 12 sheep in the mid-1960s to a few hundred sheep by the early 1990s. However, the bighorn sheep population started to decline in the 1990s. Mountain lions were a leading cause of bighorn ewe and lamb mortality during a study spanning 2002-2005 (Berkley 2005).

Berkley (2005) evaluated habitat structure and lamb survival of 3 bighorn sheep herds jointly, recognizing that predation risk can have important repercussions for prey behavior and habitat selection, this may in turn affect nutrition, reproductive success, adult health, and an individual's ability to escape predation. Berkley (2005) concluded that the herd which had the highest lamb survival used feeding sites with moderate amounts of grass which were close to steep terrain resulted in the best tradeoff between security and nutrition. The herd that had relatively low lamb survival used feeding sites dominated by cliffs but relatively less grass and was favoring escape security over nutrition. Finally, the herd with the lowest lamb survival used feeding sites dominated by grass but few cliffs, thus favoring forage over security cover. Berkley's (2005) conclusion is that while predators may be a proximate cause of a population decline, predation may be exacerbated or mitigated by habitat structure.

Mule Deer Survival in Southern Idaho

Mule deer populations exhibit volatile population cycles, with low troughs often viewed by the public and wildlife professionals as a crisis. In areas of southern Idaho, deer herds underwent a widespread decline in the 1990s. During this decline it was perceived that predation may be a reason for population decline since fawn ratios and population growth suggested that habitat and deer density may not be limiting deer populations. In southern Idaho, predation by mountain lions and coyotes (*Canis latrans*) is the major proximate cause of mule deer mortality during winter (Unsworth et al. 1999, Bishop et al. 2005, Hurley et al. 2011). Subsequently IDFG tested the effects of removing mountain lions and coyotes on mule deer populations in 11 GMUs in southeastern Idaho from 1996 to 2006.

Hurley et al. (2011) determined that mountain lion removal did increase survival of individual adult does in the winter and marginally in the summer, and fawn ratios did increase with mountain lion removal. However, the overall population changes were variable because weather had the greatest impact on deer survival and population change, whereas deer population response exhibited a weak relationship to mountain lion removal.

IMPLICATIONS AND SUMMARY

Mountain lions in Idaho are currently managed to provide continued recreational opportunity for hunting and non-hunting resources. IDFG has responded with increased harvest or removal of mountain lions in GMUs when information suggests that lions are impacting ungulate population(s). Recent investigations in Idaho involving lion removal or proposed lion removal to benefit ungulate species have had unclear or mixed results; despite solid experimental designs. The mule deer study and to a very limited degree the elk study did indicate that under certain situations increased harvest of mountain lions through sport harvest may benefit ungulate species but it is not a “one size fits all approach” nor does lion removal guarantee a deer or elk population response. Further, the long-term effectiveness (i.e., cost, consistency, and interest) of mountain lion removal programs is questionable. The elk and mule deer studies had a difficult time manipulated cougar populations because interest in mountain lion hunting faded with declining lion populations or poor hunter success. Further, it appears that the benefits of mountain lion removal can be short term unless increased pressure is applied to a declining mountain lion population, which may only increase cost and expectations without actual population benefit.

Important knowledge has been gained to improved strategies for the management of predator/prey dynamics in Idaho, and the role that harvest of mountain lions have in these dynamics. Much of the initial momentum to conserve and promote mountain lions is due to the research work started in the Big Creek Drainage of the Frank Church River of No Return Wilderness. Perspectives and attitudes towards mountain lions have changed in Idaho. Recent investigations in Idaho have focused more on the impact that mountain lions may have on ungulate species, rather than the demographics and behavioral response of mountain lions. The tenor of these studies may be the best gauge of current perspective toward mountain lions in Idaho.

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Managing an Expanding Cougar Population in Alberta

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Abstract: In Alberta, number of cougar mortalities caused by humans has increased rapidly over the past two decades. Management agencies sometimes use human-caused mortalities as an index of cougar population trend, but mortalities may be decoupled from cougar numbers. Recent work even suggests that higher human-caused cougar mortalities (primarily due to sport hunting) are causing cougar populations in North America to decline. We used a combination of radiotelemetry based cougar density estimates and the distribution of human-caused cougar mortalities in Alberta to evaluate change in cougar populations during 1991-2009, a period over which human-caused cougar mortality increased rapidly. We provide evidence that cougar densities have increased by at least 250% in west-central Alberta during the past two decades, and that cougars have expanded their range in northern and eastern Alberta. Importantly, both cougar mortalities and cougar sightings have increased markedly in Alberta's 'White Zone', which consists of prairie-parkland habitats and is dominated by private land. Despite increasing cougar populations, hunters have been reluctant to harvest cougars in these areas, likely due to the difficulty of using hounds on small holdings of private land. We discuss recent changes in cougar hunting regulations that are intended to refine management where cougar densities have increased and to address concerns by the rural public who are faced with increasing interactions with cougars.

Arizona Mountain Lion Status Report

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***Abstract**:* Mountain lions are an important part of Arizona's wildlife resource. They are distributed statewide and have in recent times become established in the harsh habitat found in the southwestern desert. Statewide hunter harvest has been relatively stable averaging 238 during the last five years. Current issues in Arizona lion management include monitoring the adult female portion of the annual harvest, examining potential barriers preventing lion movement, identifying important travel corridors, recognizing and dealing with the increasing potential of human/mountain lion conflicts, and implementing management strategies designed to reduce mountain lion predation on important prey species such as bighorn sheep.

Washington Mountain Lion Status Report

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***Abstract*:** This status report will be an update of cougar research, management, and legislative activities since the last mountain lion workshop in 2008. Several cougar research projects have been completed involving personnel from WDFW, Washington State University, and University of Washington. Collectively, these projects investigated population size, survival, movement patterns, habitat use, changes in predation events, testing apparent competition and prey-switching hypotheses, and how cougars existed along the urban-wild land interface. We will also present a full description of 3 bills that have been introduced in the January 2011 legislative session and explain how they will affect cougar management in Washington. Engrossed Substitute House Bill 2438 (HB 2438), which in 2008 authorized a 3-year extension of a cougar pursuit and kill season with the aid of dogs (for a total of 7 years) in 6 Washington counties, expired in 2011. A new bill, HB 2011, attempts to extend this hunt season for 5 additional years. Another bill, Senate Bill 5385 (SB 5385) was introduced to increase hunting license fees, including that for cougar. Lastly, SB 5201 was introduced and would allow wildlife officers to fine residents that are negligently feeding, attempting to feed, or attracting predatory wildlife. Finally, WDFW and Insight Wildlife Management completed a public opinion survey regarding cougars in Washington. The objective of the survey was to better understand the public's perceptions of cougar management, identify information gaps, and define effective outreach methodologies for development of a cougar education and outreach plan. We will present results of that project and discuss our cougar education plans.

Managing Florida Panther Depredations: Implications for Continued Recovery

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Abstract: An increased Florida panther (*Puma concolor coryi*) population, currently estimated between 100-160 adults, has resulted in new management challenges. Depredation complaints from hobby livestock owners and commercial cattle ranchers occur more frequently. Most conflicts in exurban areas involve panthers preying on pets or hobby livestock, such as goats. The Interagency Florida Panther Response Plan was drafted to deal with human-panther interactions and depredations. However, the Response Plan was not intended to address depredations on large-scale commercial cattle operations. Hobby animals can usually be safeguarded by their owners securing them in predator-proof enclosures at night, but this is not practicable on commercial ranches with herds ranging across hundreds of hectares. Cattle ranches make up a significant portion of the panthers' current breeding range and frequently offer more favorable habitat conditions than some areas of public lands. Fostering relationships with these private landowners is vital to Florida panther recovery efforts. Recently, the Florida Fish and Wildlife Conservation Commission (FWC) learned that cattle ranchers are experiencing the loss of a portion of their calf crop to panther depredations. Loss of income from panthers, whether real or perceived, has the potential to generate resentment towards panthers within the ranching community, creating reluctance to embrace recovery efforts and accept the presence of panthers on their lands. Ranchers have expressed a desire for FWC to develop a solution. Understanding panther-calf depredation dynamics on private ranchlands is important to develop cooperative solutions to this issue. The FWC will quantify panther prey selection near ranching operations and characterize panther-calf depredation variables. Ideally, this will help to identify management actions that can be taken to reduce calf losses by panthers while at the same time fostering a relationship with the ranching community that will generate additional support for recovery of the Florida panther.

Discussions on Source/Sink/Stable Population Management of Cougars in Wyoming

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Abstract: Wyoming recently adopted an adaptive harvest management scenario based on research conducted in Wyoming assessing impacts of harvest on cougar populations; where cougar populations were perturbed in order to quantify what level of harvest resulted in population reduction or increase. Cougar mortality was quantified as the number of mortalities/1,000 km^2, as well as quantifying the sex/age relationship of harvest; primarily assessing the female segment of harvest. Generally speaking, as harvest increased (> 8.0 mortalities/1,000 km^2), the proportion of adult females taken increased (> 20%). If high harvest levels were maintained, the average age of adult females decreased. Cougar habitat was quantified statewide and used as a template to derive mortality limits for hunt areas based on an objective of source, stable, or sink population status for a 3 year period. Mortality data on mountain lions were gathered annually among 31 hunt areas grouped into five mountain lion management units (MLMUs). Management objectives for MLMUs and hunt areas were determined by balancing public demands and biological requirements for sustainable lion populations throughout the landscape. Three primary monitoring criteria were used to assess population status of hunt areas: 1) Density of human-caused lion mortalities/1,000 km^2; 2) Percentage of adult females in the harvest; and 3) average age of adult females in the harvest. Managing for a combination of source, stable, and sink mountain lion subpopulations within MLMUs (i.e., at the hunt area level) provided flexibility to address local management concerns while maintaining overall population viability on a landscape level and provide for long term harvest and recreation opportunities. Maintaining static mortality limits for 3 years allowed us to better assess trend and perhaps more importantly helped prevent unwarranted "knee-jerk" reactions to annual fluctuations in harvest, weather conditions, conflicts, or ungulate recruitment.

INTRODUCTION AND BACKGROUND

The following report contains data for mountain lion harvest and mortality in Wyoming for harvest years (HY) 2007-2009. HY 2009 represents the final harvest period within the 3-year cycle used for mountain lion harvest management based on the plan adopted by the WGFD Commission prior to HY 2007. Therefore, this report represents our initial analyses of management strategies and classification of Hunt Area's (HA's) based on monitoring protocol. Mortality limits and management objectives generally remained static during the 3-year period, however the mortality limit for HA 15 was increased by 10 for HY 2008 and 2009. Reported ages and age classifications for HY 2009 are based on field assessment of animal age (based on tooth wear and pelage) and future reports may alter some of these values as the annuli ages were not available as this report was finalized.

Mortality data on mountain lions are gathered annually among 31 hunt areas (Figure 1) that are grouped into five MLMUs. The number of hunt areas increased from 29 to 31 in HY 2007. The additional hunt areas came as a result of splitting two existing hunt areas in order to better address regional concerns. The boundaries of MLMUs encompass large areas with contiguous habitat and topographic features and are believed to surround population centers. Each hunt area has an annual mortality limit that varies from 2-35 animals, with 3 areas also having a maximum female harvest limit. If the mortality limit is filled (total or female), the hunt area automatically closes, otherwise hunt area closure occurs at the end of the harvest season. During mandatory inspections of harvested animals, many variables are recorded, including: harvest date, location, sex, lactation status, estimated age, number of days spent hunting, use of dogs, other lions observed, as well as several other parameters. Skulls and pelts must be presented in unfrozen condition so teeth can be removed as well as providing evidence of sex and lactation status. The information gathered during inspection is used to assess sex/age structure of harvested animals. Beginning in HY 2007 all known human-caused mortality events counted toward the mortality limit; prior to this, only legal and illegal mortalities counted toward the mortality limit.

The WGFD does not estimate lion population numbers. Rather, population trends are assessed through sex and age composition of mortality data (Anderson and Lindzey 2005). Management objectives for MLMUs and hunt areas are determined by balancing public demands (i.e., human/lion interactions, livestock depredation, adequate hunting/viewing opportunity) and biological requirements for sustainable lion populations throughout the landscape. The sex and age composition of harvested lions is compiled and analyzed statewide, for each MLMU and for each hunt area. Analyzing data by management units allows managers to evaluate harvest within specific hunt areas and therefore assess the effect harvest has on the regional population. If observed trends are consistent with objectives set forth for each hunt area, changes in mortality limits are not recommended. However, if trends deviate from hunt area objectives, mortality limit increases or decreases may be recommended for the next cycle of management.

WGFD fosters a regional scheme based on source/sink/stable population dynamics (CMWG 2005) for managing mountain lions. Managing for a combination of source, stable, and sink mountain lion subpopulations within MLMUs (i.e., at the hunt area level) will provide flexibility to address local management concerns (e.g., livestock depredation) while maintaining overall population viability on a landscape level and provide for long term harvest and recreation opportunities.

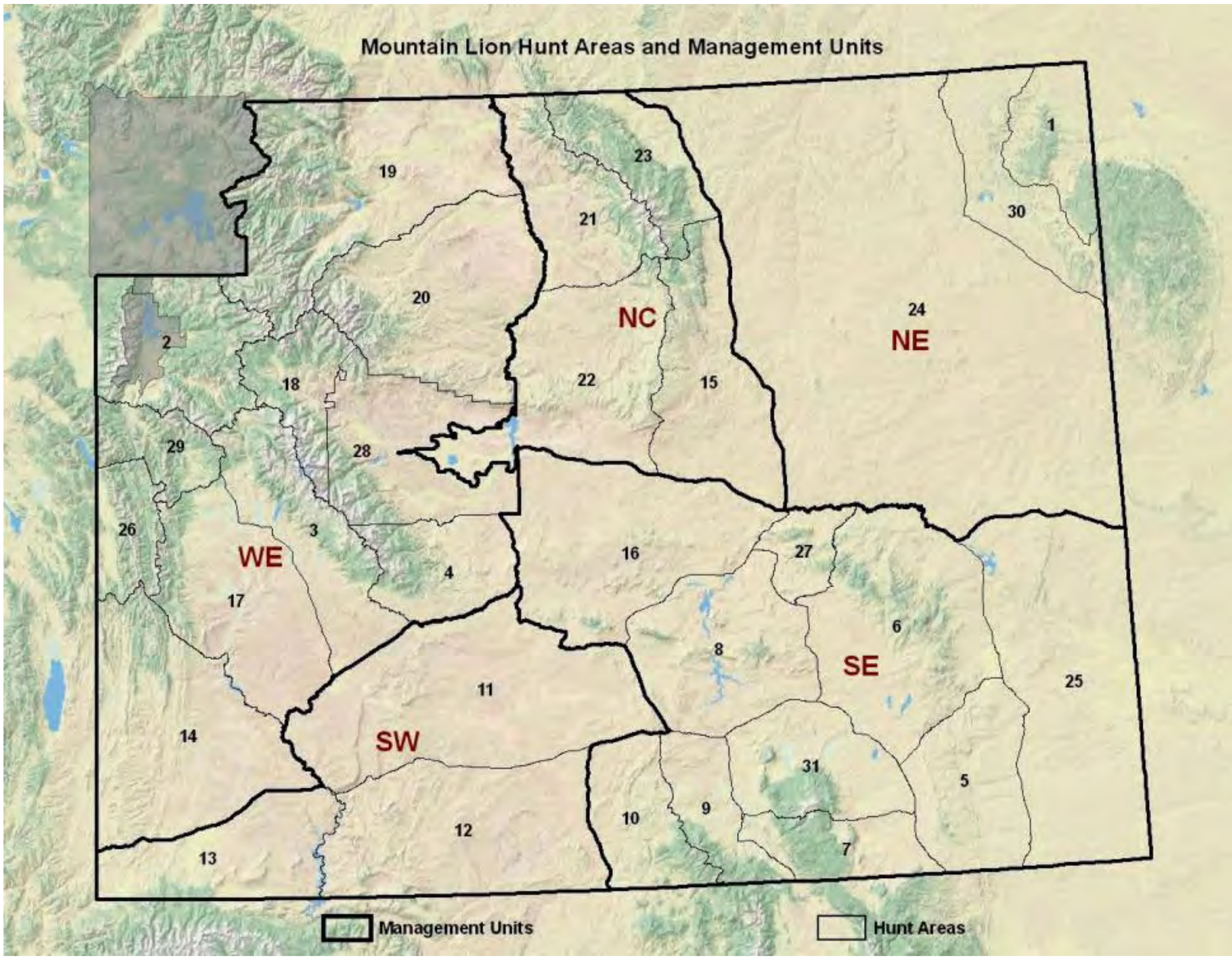

Figure 1. Map of Hunt Areas and Management Units for mountain lions in Wyoming, harvest years 2007-2009. (NE – Northeastern MLMU; NC – Northcentral MLMU; SE – Southeastern MLMU; SW – Southwestern MLMU; WE – Western MLMU. The Western MLMU is further dichotomized into 3 Data Analysis Units (DAU's): Absaroka DAU (Hunt Areas 19 and 20); Wind River DAU (Hunt Areas 3, 4, 18, and 28) and the Wyoming Range DAU (Hunt Areas 2, 14, 17, 26, and 29).

Hunt area management objectives include:

1. Sink management: reduce mountain lion densities
    a) Maintain density of human-caused mortality >8 mountain lions/1,000 km^2 (386 mi^2).
    b) Achieve adult female harvest >25% of total harvest for 2 seasons.
    c) Progression in mean age of harvested adult females should decline to <5 years old.
2. Source management: maintain human-caused mortality levels that allow mountain lion population growth or maintain relatively high mountain lion densities that provide a source to other populations.

a) Maintain density of human-caused mortality <5 mountain lions/1,000 km^2 (386 mi^2)
b) Maintain adult female harvest <20% of total harvest.
c) Maintain older-age adult females in the population (>5 years old). This will be difficult to identify without additional sampling due to low sample size from harvest, but would be expected for lightly hunted populations.

3. Stable management: maximize long-term hunting opportunity and population viability.
   a) Maintain human-caused mortality density between 5-8 mountain lions/1,000 km^2 (386 mi^2)
   b) Adult female harvest should not exceed 25% of total harvest for more than 1 season.
   c) Maintain intermediate aged adult females (mean ≅ 4-6 years old) in the harvest. Adequate age evaluation may require averaging age data over time to achieve meaningful sample sizes.

MLMU management objectives:

- The MLMU management objective should attempt to achieve the criteria above for source, stable, or sink mountain lion management at the MLMU level. The objectives chosen by managers will be based on the adjacent management priorities, size of the MLMU, maintaining recreational opportunity, maintaining source mountain lion populations, as well as depredations and other factors to achieve the overall management goal of sustaining mountain lion populations throughout core habitat at varying densities depending on management objectives.

- Coordinating management efforts with adjacent states would be most desirable for the smaller MLMUs (i.e., Northeast and Southwest MLMUs) where the majority of connected mountain lion habitat extends beyond Wyoming. Source or stable management could be maintained with interagency coordination, but sink management could also be implemented when sufficient source habitat has been identified in adjacent areas.

It is important to note that the monitoring criteria (mortality density, proportion of adult females in harvest, average age of adult females annually harvested) for mountain lion harvest are not used independently to assess the status of a HA. Density of human-caused mountain lion mortality is the more powerful tool of assessment and when coupled with percentage of adult females harvest and their subsequent average age, can be helpful in assessing over a 3-year period if in fact a Hunt Area is moving in the management direction stated prior to season setting processes relative to objectives. The quantification of Hunt Area status will be derived from an assessment of the 3 monitoring criteria together as well as nuances related to immigration/emigration from other lion populations. When the mountain lion management plan was adopted by the commission in 2006, there was a paucity of habitat data in the Northeastern and Southwestern portions of the state relative to mountain lions. During the winter of 2009-2010, the trophy game section quantified mountain lion habitat in both the Northeastern and Southwestern MLMU's based on forested habitat, terrain, historic harvest, regional/expert input, and telemetry data from marked mountain lions (D. Thompson/SDSU, unpublished data). These efforts will greatly help to monitor Hunt Areas regionally and help determine future mortality limits and management strategies.

Acknowledging that managers rarely have precise information to measure success of management objectives, that mountain lion densities may vary regionally, and that the criteria proposed here are general guidelines; these criteria should be compared to one another and applied adaptively to assess success of management prescriptions. Applying management objectives in an adaptive management framework, where density of human-caused mortality, harvest composition, and age of harvested adult females are monitored relative to expectations (criteria above) allows assessment of whether or not management objectives are being achieved and if management strategies may need modification to produce desired outcomes.

STATEWIDE MOUNTAIN LION HARVEST

During the 2007 – 2009 harvest cycle, we documented record harvest and mortality of mountain lions in Wyoming since the inception of state management of the species (Figure 2). Due to the way that management directions (source/stable/sink) are spread across hunt areas and management units, the record numbers of mortality are not indicative of overall population reduction or long-term negative effects of harvest. Rather the higher harvests are more a derivative of higher mortality limits allocated to hunt areas on a statewide level. Relative to effort, mountain lion hunters successfully harvested a mountain lion for every 3.59 days of hunting (3.47 – 3.62 days/kill annually; with outliers as high as 50 days per an individual hunter), the majority of mountain lion hunters harvested a lion during one day of hunting. Approximately 85% of successful hunters used hounds in order to harvest a lion. Other methods of harvest included incidental/opportunistic take, spot/stalk, tracking, and predator calling. In addition to harvest mortalities, 21 mountain lions mortalities were attributed to removal for depredation/human safety reasons, 16 incidental snare/trap mortalities, 12 vehicle mortalities and 7 self defense mortalities, with agency removal and incidental take accounting for the majority of non-harvest mountain lion mortality (Figure 3).

A total of 16 illegal mountain lion harvests were documented by agency personnel, which are included in the harvest analysis. Male cougars made up the highest proportion of mountain lions taken by hunters, and adult female lions made up less than 20% of the total harvest on an annual basis (Figure 4). Total take of females never exceeded 50% annually during the 3-year cycle.

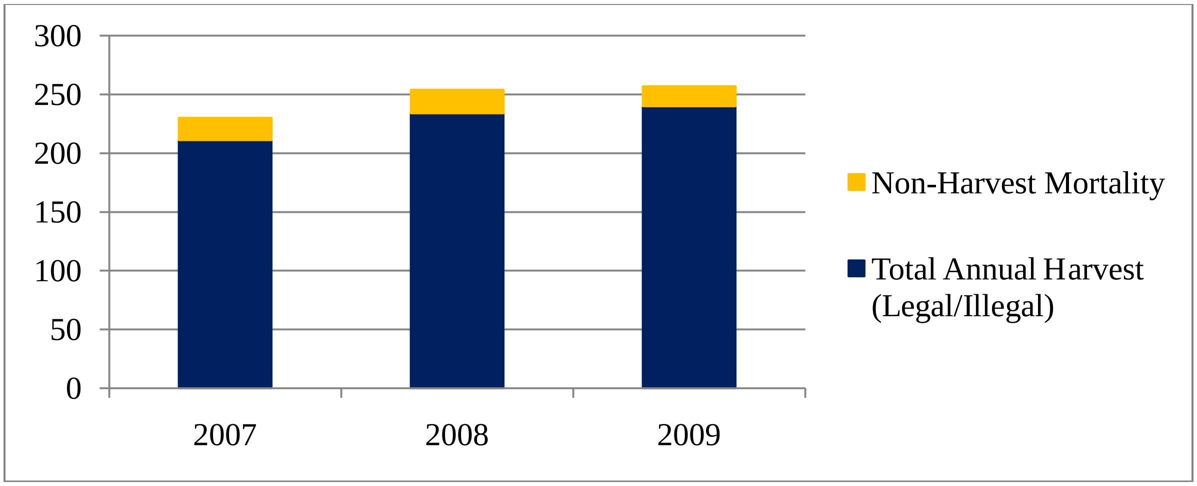

Figure 2. Annual mountain lion harvest and human caused mortality in Wyoming.

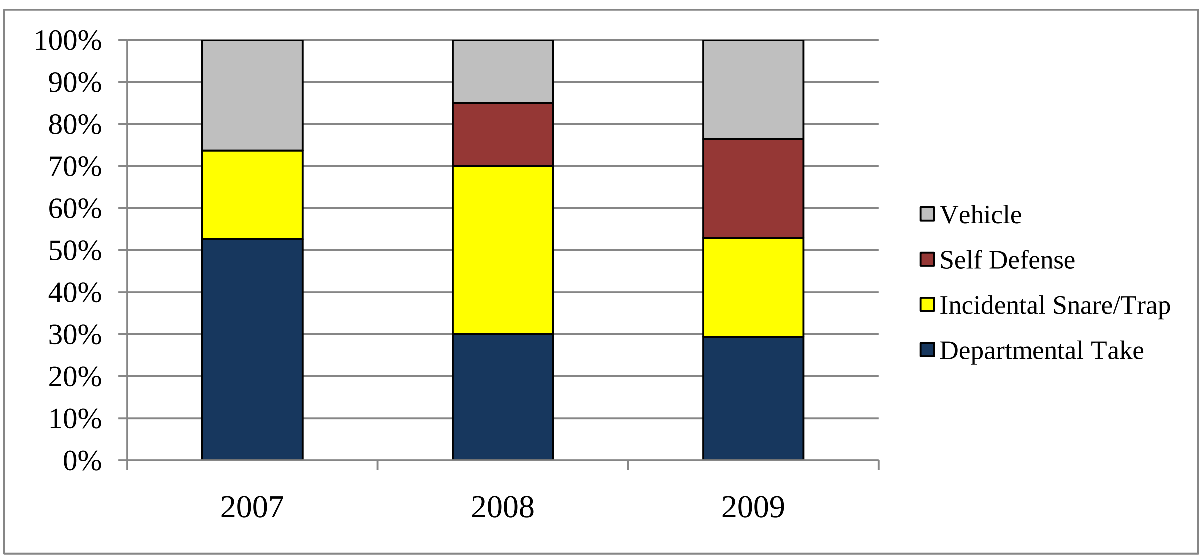

Figure 3. Proportion of non-harvest human-caused mountain lion mortality documented in Wyoming, 2007-2009.

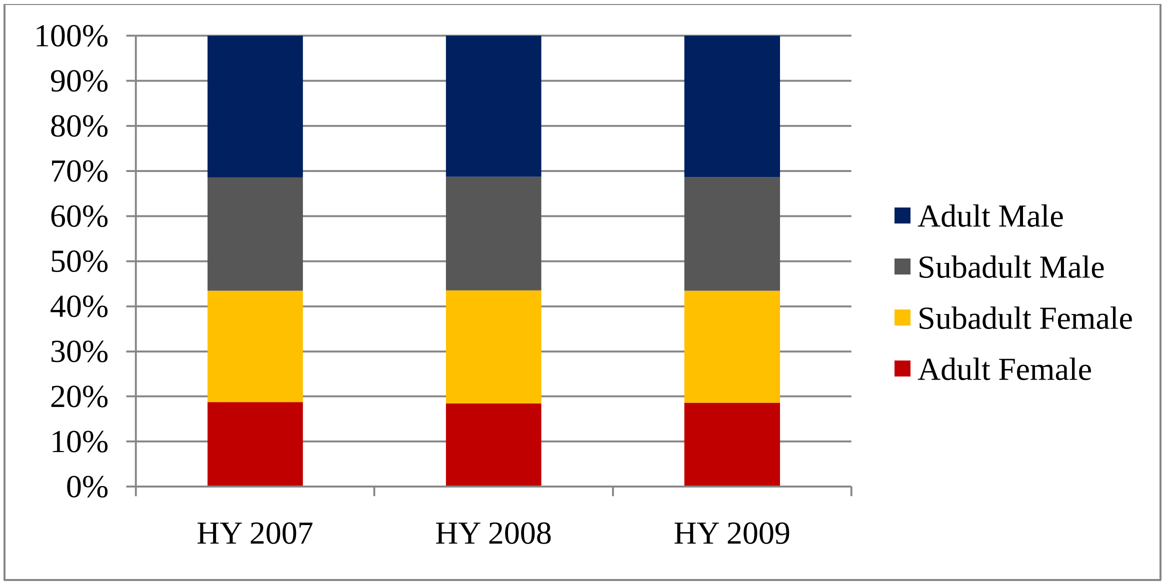

Figure 4. Annual breakdown of sex and age of mountain lions harvested in Wyoming, 2007-2009. (Proportions are derived only from harvested animals, not all forms of human-caused lion mortalities.)

The proportion of adult females harvested statewide annually is an optimum level toward maintaining a stable population across the landscape while allowing for source and sink management on a finer scale/regional level. Table 1 provides a further breakdown of sex/age classifications as well as other human caused mortalities, broken down by Management Unit and annually across Wyoming.

Table 1. Mountain lion annual mortality data for the state of Wyoming separated by Mountain Lion Management Unit annually, 2007-2009.

Hunt Area/ Harvest year	Adult Females	Subadult Females	Subadult Males	Adult Males	Total Harvest	Non Harvest	Total Mortality
NE LMU 2007	7	5	9	6	27	6	33
NE LMU 2008	4	9	8	3	24	2	26
NE LMU 2009	7	8	4	6	25	4	29
NE TOTALS	18	22	21	15	76	12	88
NC LMU 2007	18	20	12	16	66	3	69
NC LMU 2008	17	19	20	21	77	6	83
NC LMU 2009	12	18	24	23	77	3	80
NC TOTALS	47	57	56	60	220	12	232
SE LMU 2007	11	9	7	24	51	3	54
SE LMU 2008	10	13	6	21	50	4	54
SE LMU 2009	8	14	14	20	56	4	60
SE TOTALS	29	36	27	65	157	11	168
SW LMU 2007	0	2	2	1	5	0	5
SW LMU 2008	1	2	2	1	6	0	6
SW LMU 2009	1	2	2	3	8	0	8
SW TOTALS	2	6	6	5	19	0	19
ABS DAU 2007	2	4	2	4	12	1	13
ABS DAU 2008	0	3	2	7	12	1	13
ABS DAU 2009	3	5	2	6	16	1	17
ABS TOTALS	5	12	6	17	40	3	43
WY RANGE ‘07	8	6	4	11	29	2	31
WY RANGE ‘08	6	13	7	9	35	2	37
WY RANGE ‘09	7	9	9	8	33	2	35
WRANGE TOT.	21	28	20	28	97	6	103
W RIVER ‘07	2	6	3	10	21	1	22
W RIVER ‘08	4	5	6	9	24	4	28
W RIVER ‘09	6	5	6	9	26	1	27
W RIVER TOTAL	12	16	15	28	71	6	77

HUNTER SELECTIVITY AND SATISFACTION

When evaluating harvested lions during mandatory checks, the hunter is asked whether he/she was selective while hunting, as well as days hunted, use of dogs/outfitter, number of tracks pursued/lions seen, and these results can be compared with the harvested quarry to better assess selectivity. We quantified the sex/age ratios of harvested lions based on whether a person stated they were being selective (Figure 5) or not as well as comparing with our definition of selectivity (based on tracks pursued, lion seen, and harvestable lions passed) and found no significant difference between sex/age ratios of females, however more adult male lions were harvested by people who stated they were selective. Successful hunters who were selective harvested a much higher proportion of adult males, which is generally what is sought after by trophy lion hunting expeditions. When comparing sex/age ratios between resident and non-residents as well as outfitted and non-outfitted hunts we found no significant differences.

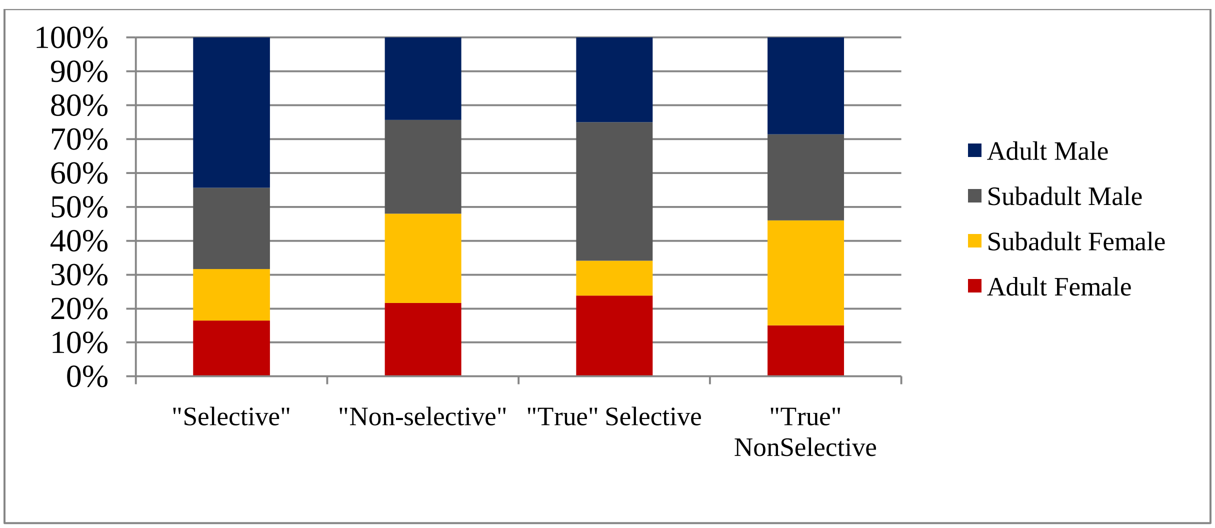

Figure 5. Sex/age composition of harvested mountain lions based on hunter selectivity in Wyoming, 2007-2009. “Selective/Non-selective” was based on what the hunter stated during mandatory check of the animal; “True” Selective/”True” NonSelective was based on WGFD’s interpretation of selectivity.

Regardless of how selectivity is "deciphered" hunters have the ability to be selective when harvesting mountain lions in Wyoming, whether a person chooses to be may be more a function of hunting conditions, and mortality limits of the hunt area where the individual is hunting at the time. For example due to a high number of roads and hunters in Northeastern Wyoming, mortality limits are generally reached after the first snowfall event when tracking conditions are optimal. While hunters have the ability to be selective, most legal mountain lions encountered are harvested because the hunt areas historically close quickly.

Beginning in 2008, WGFD surveyed all mountain lion hunters to assess satisfaction with their hunt and allow for comments relative to mountain lion harvest and management in Wyoming. Results from the 2008/2009 indicated overall satisfaction with mountain lion hunt quality in Wyoming; 62.1 % of residents who responded were satisfied (43.2%) or very satisfied (18.9%) with the quality of their hunt. Nonresident respondents showed even higher satisfaction with 55.7% stating they were very satisfied and 27.3% satisfied (83% overall satisfaction). A total of 162 written comments were received from mountain lion hunter surveys. Of the written comments, 16.7% (n = 27) were related to hunt area mortality limits/closure/opportunity, with 16% (n = 26) of written comments positive in nature to Wyoming mountain lion management. (As an aside; 13.6% (n = 22) of the comments were specific to ungulate management unrelated to any form of trophy game management, and an additional 10.5% (n = 17) were specific to wolves and state management.)

HUNT AREA STATUS

Perhaps the most sought after information within this document is the status and classification of Hunt Areas based on the monitoring protocol used by the WGFD Trophy Game Section. In order to quantitatively determine the status of a hunt area, the monitoring protocol (mountain lion mortality density/1,000 km^2, percentage of adult females in harvest, average age of adult females annually) are used in combination and assessed over a three year period. Evaluation of harvest and mortality over 3 harvest years helps to negate anomalous incidents related to harvest/conditions and provide the minimum amount of data points (3) to assess trend relative to harvest and how it relates to management objectives. The appendices of this document will have a more in-depth discussion of how each hunt area was classified related to status, as well as figures to illustrate determination of hunt area status. Figure 6 provides Hunt Area classifications for Harvest years 2007-2009 in Wyoming. In general, hunt areas met objective status, or were at least moving in the direction of the status objectives. Twenty-four of 31 Hunt Areas met objective or were considered to be moving toward the objective status (Table 2). The SW LMU had three hunt areas that did not meet "objectives" however at the time mortality limits were developed, there was not a great deal of historical harvest or habitat data relative to developing harvest numbers for those hunt areas (11, 12, and 13). Hunt Areas 26 and 27 both appear to be moving toward sink status, but may need additional harvest years at the same level of harvest to proceed to the point of full sink classification.

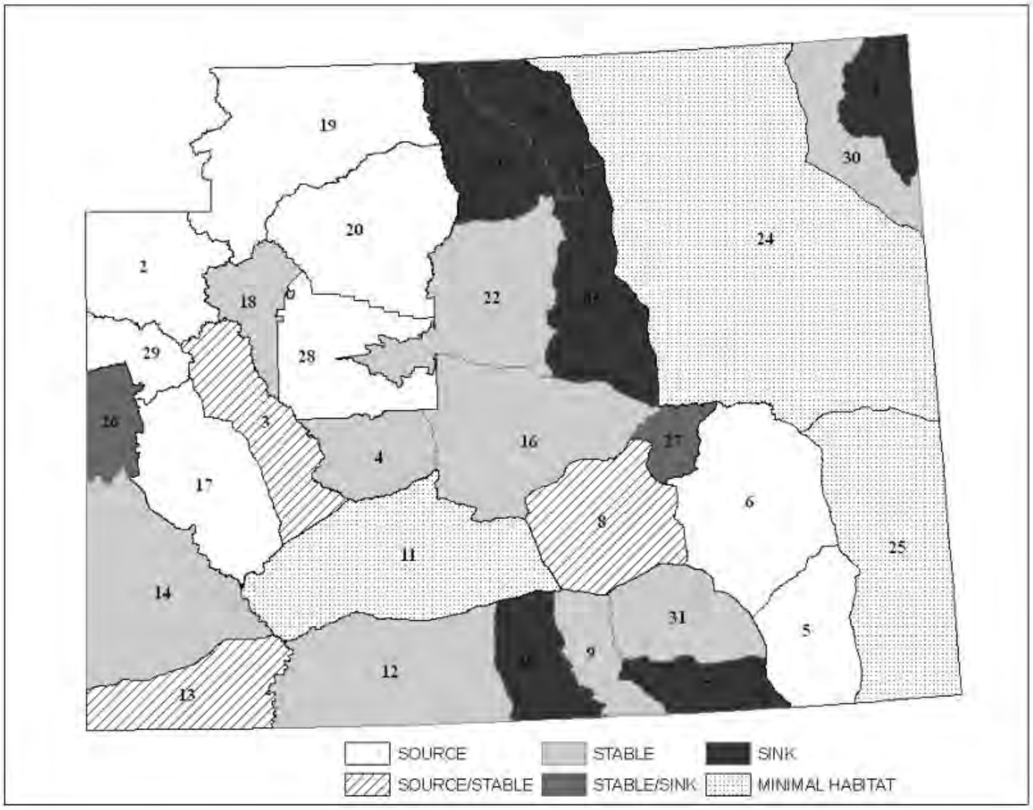

Figure 6. Wyoming Mountain Lion Hunt Area Status, Harvest Years 2007-2009.

Table 2. Mountain Lion Hunt Area objectives and classifications, harvest years 2007-2009.

HUNTAREA	MGMTUNIT	Objective	Status
15	North Central	Sink	Sink
21	North Central	Stable	Sink
22	North Central	Stable/sink	Stable
23	North Central	Stable	Sink
1	Northeast	Sink	Sink
24	Northeast	Stable	N/A
30	Northeast	Stable	Stable
5	Southeast	Source/stable	Source
6	Southeast	Stable	Source
7	Southeast	Stable/sink	Sink
8	Southeast	Stable	Source/Stable
9	Southeast	Stable/sink	Stable
10	Southeast	Stable/sink	Sink
16	Southeast	Stable	Stable
25	Southeast	Source/stable	N/A
27	Southeast	Sink	Stable/Sink
31	Southeast	Stable/sink	Stable
11	Southwest	Source	N/A
12	Southwest	Source	Stable
13	Southwest	Source	Source/Stable
2	West	Source	Source
3	West	Stable	Source/Stable
4	West	Stable	Stable
14	West	Stable	Stable
17	West	Stable	Source
18	West	Stable	Stable
19	West	Source	Source
20	West	Source/stable	Source
26	West	Sink	Stable/Sink
28	West	Source	Source
29	West	Source	Source

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Session 2:

Species Interactions and Predation

Proceedings of the

10th Mountain Lion Workshop

Cougars: Conservation, Connectivity and Population Management

Cougar Presence Influences Diet Optimization in Ungulate Prey

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Abstract: Risk-induced changes in prey behavior appear in many predator-prey communities, often triggering cascades to additional trophic levels when prey alter intake rates or diet selection; however, the fitness consequences of predation risk remain unclear. Natural colonization by cougars (*Puma concolor*) on the National Bison Range (Montana, USA) enabled the testing of predictions from foraging theory that assess the fitness consequences of predation-sensitive foraging decisions by ungulate prey. Diets of herbivores prior to colonization by cougars matched expectations based on an energy maximization foraging goal predicted by a linear programming model. Here, behavioral observations and new field data were used to re-parameterize the foraging models to predict diets for three prey species that differ in body size and anti-predator behavior: mule deer (*Odocoileus hemionus*) white-tailed deer (*O. virginianus*) and elk (*Cervus elaphus*). The models were solved for two goals - energy maximization or time minimization. The latter would be expected if prey reduce their feeding to minimum requirements in order to devote more time to anti-predator behaviors. In response to the increase in predation risk, none of the prey switched to a time-minimization foraging strategy. The largest and least vulnerable prey selected a diet that fit a new energy-maximization strategy but incurred an energetic cost for reduced feeding time. Diets selected by the smaller, more vulnerable prey appeared to be intermediate, suggesting a trade-off between energy maximization and time minimization. With the observed changes in feeding time when faced with predation risk, all three ungulates incurred a 5-38% reduction in daily surplus energy intake – a substantial effect of risk on summer foraging that could impact subsequent winter survival and reproduction. This study represents the first attempt to employ a mechanistic linear programming foraging model to evaluate alternate strategies and energetic costs of large ungulates foraging in the presence of predators.

Inter- and Intraspecific Competition in a Large Carnivore Guild

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Abstract: Historically, cougars and wolves were sympatric across much of North America, but range overlap was reduced to include only portions of Alberta, British Columbia and Montana during the 20th century. Wolf reintroduction in northwestern USA has sparked increased interest in understanding wolf-cougar niche partitioning, the effects of reintroduced wolves on cougar populations, and their combined effects of both predators on ungulate prey. However, most studies of wolf-cougar interactions have focused on recently reintroduced wolf populations and little is known about long-term dynamics of wolf-cougar systems. In west-central Alberta, cougars and wolves have persisted together throughout modern times, and both species currently exist at relatively high densities. We compared winter movement rates, habitat use, and ungulate predation patterns between wolves and cougars during 2003-2008 to investigate niche separation. Wolves were most active at dawn and dusk and moved nearly 3X as fast as cougars, while cougar movement rates and killing frequency both peaked during the evening. Cougars and wolves exhibited slightly different patterns of fine-scale habitat selection, with cougars tending to use areas with higher terrain ruggedness while avoiding forest openings. Male cougars used areas with more rugged terrain than either female cougars or wolves. Overall, wolves tended to kill more large-bodied prey species and fewer YOY prey than cougars, but male cougars were more similar to wolves than to female cougars in their predation patterns. We found that differences in hunting styles, habitat use, and body size altered prey selection between wolves and cougars, resulting in niche separation and reducing direct competition. Predator facilitation, where attempts by prey to avoid one predator put them at increased risk from the other, may also occur where wolves and cougars are sympatric.

Cougar Prey Composition and Predation Rates in a Multi-Prey Community in Northeast Oregon – Preliminary Results

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Abstract: To better understand the impact of cougars (*Puma concolor*) on elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*) populations in northeast Oregon, we are placing GPS collars on cougars to estimate prey composition and predation rates of cougars. Between January 2009 and October 2010, we monitored 16 GPS collared cougars for 4,910 days ($\bar{x}$ = 307 days, range = 42-638 days). During this time, we investigated 1,913 potential predation sites and found prey remains at 675 (35%) of these sites. The remains of deer were located at approximately 65% of kill sites and remains of elk were located at approximately 30% of kill sites. Non-ungulate prey was present at the remaining kill sites. We located remains of 201 elk killed by cougars. Most of the elk killed were calves (79%) followed by adult (11%) and yearling (10%) elk. The remains of 455 individual deer were located at 440 predation sites. Mule deer were the most common deer species preyed upon (55%), followed by unknown deer species (25%), and white-tailed deer (*Odocoileus virginianus*; 20%). Out of all deer killed by cougars, 49% were fawns, 36% were adults, 9% were yearlings, and 6% were of unknown age. Seasonal patterns in deer predation were evident, with a higher percentage of fawns being killed in the summer than in the winter. On average, cougars in our study area killed one ungulate every 6.71 days. Strong patterns in seasonal predation rates are evident, with predation rates in June being the highest (4.41 days per kill) and lowest in March (13.62 days per kill). Our research is ongoing and results will be updated.

Cougar Prey Composition and Predation Rates in Central Utah

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Abstract: We studied cougar (*Puma concolor*) prey use in a multi-prey system consisting of mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*) and livestock, on three mountain ranges in central Utah. Our goal was to determine: (1) cougar prey composition; (2) age and sex classes of prey; and (3) predation rates. Between May 2003 and October 2010, we investigated potential kill sites of 23 adult cougars (18 females, 5 males) equipped with global positioning system (GPS) collars. We ground truthed potential kill sites based on GPS cluster locations, accessing the sites with the aid of hand held GPS units. The sites were systematically searched within a 100 m radius from the mean of the cluster location for 30 minutes or until evidence of a kill was found. Demographic and habitat information (species, sex, age, vegetation) were recorded for all prey remains located. We identified 910 potential kill sites and ground truthed 773 sites. Of these, we found 518 prey remains. Prey composition consisted of 11 species, of which mule deer comprised 88%, with elk and livestock accounting for 5% and 2%, respectively. The age composition of the deer remains encountered was: juveniles 16%, yearlings 13% and adults 63%). Elk were taken more frequently by males than females (78% vs. 22%). Mesocarnivores and porcupines (*Erethizon dorsatum*) were more commonly associated with subadult and senescent individuals. We also documented 3 scavenging and multiple surplus killing events. Of all the predation events documented 47% occurred in gambel oak (*Quercus gambelii*) vegetation. These data have utility in a management context, including: (1) parameterization of cougar predation-impact models, (2) identification of predation refugia for mule deer, and (3) construction of a framework for using prescribed burning to improve forage while minimizing predation risk to mule deer.

Sex Matters: Dietary Strategies of Male and Female Cougars on the Southern Colorado Plateau

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***Abstract*:** Sexual dimorphism can result in males and females of the same species occupying different niches, with implications for management. We report preliminary results of a long-term study of cougars (*Puma concolor*) on the southern Colorado Plateau that reveal different sex-specific dietary strategies. To date, our sample of cougar kills is >630, of which 225 were investigated within 9 days of when the kill happened, and 433 within 32 days. By design, the 60 cougars studied to date were tracked in 3 study areas that encompassed a wide range of biophysical conditions and prey availability. Sex had a stronger effect on size of kills than did either cougar size, as such, or study area, with male kills averaging nearly twice the size of female kills. Much of this difference was attributable to the much greater proportion of elk among male kills, compared to mule deer (*Odocoileus heminous*) among female kills, controlling for intervening effects. Compared to males, females consistently more often drug (60%) and buried (75%) their kills (versus 40-75% and 30-70%, respectively, for males), and also more thoroughly consumed their kills (87% of estimated edibles), at a more leisurely rate (typically *c*. 1.5 kg/hr). Males consumed 40-75% of edibles from kills, at a rate of approximately 2.0-3.2 kg/hr. The longer kill intervals of females (7.5 dys) and smaller mass of their kills (50-60 kg) during most of the year yielded low average ingestion rates (8.5 kg/dy). However, during winter, ingestion rates increased to 15 kg/dy. With the exception of spring, males killed prey 60-125 kg in size at average 3.5-7 day intervals, which yielded ingestion rates of around 19.5 kg/dy. These results regarding predatory behavior suggest that female cougars in our study areas were employing an energy maximizing foraging strategy whereas males were employing a time minimizing strategy.

Prey Switching, Specialization, and Multi-Species Functional Response in Cougars: Implications for Small Populations of Alternate Prey

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Abstract: Predation by generalist predators (e.g., cougars) in multi-prey systems has the potential to limit small populations of alternate prey and even contribute to extinction through apparent competition. Accurate prediction of species-specific predation rates may depend on understanding of multi-species functional response (MSFR). Our primary objectives were to investigate prevalence of prey switching and individual specialization and to distinguish the primary drivers of cougar MSFR. We studied the MSFR of cougars preying on 6 species of wild ungulates in west-central Alberta, Canada. Data were derived from continuous monitoring of predation by 37 cougars over an average of 241 consecutive days (SD = 125 days), yielding a total of 1,093 ungulate predation events. Prey switching by cougars was weakly supported by the data, and there was substantial evidence for specialization. Specialist predators occasionally contravened the switching pattern by focusing on less-abundant prey within the home range. Male cougars specialized most often on large prey (e.g., moose, elk, feral horses), while females focused exclusively on smaller prey (e.g., deer, bighorn sheep). Contrary to expectation, cougar MSFR was not driven by prey density or habitat variables, but rather by cougar demography and relative abundance of alternative prey. Our results indicate that cougars are efficient predators, capable of maintaining high kill rates even as prey density declines. A weak relationship between prey density and predation rate means that cougar predation is more likely limiting than regulating. The risk posed by cougars to small populations of endangered prey is ameliorated by a tendency towards prey switching (stabilizing), but can be exacerbated by the presence of individual specialists (destabilizing). Targeted removal of individual specialists might be an effective strategy for managing the effects of cougar-mediated apparent competition.

Session 3:

Poster Presentations

MOUNTAIN LION
WORKSHOP 2011
BOZEMAN, MONTANA

Characterizing Cougar Predatory Behaviour from Fine Scale Movement Data

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Abstract: It is generally accepted that cougar (*Puma concolor*) hunt and kill prey by stalking; using stealth to reduce the distance between themselves and prey before initiating a final attack. However, support for this is limited to a few anecdotal observations and descriptions of snow-tracking. Few studies have described this predatory behaviour based on fine scale movement data. Using GPS location data from 6 collared cougars with a between-fix-interval of 15 minutes, we examined movement metrics (i.e. step length and turning angle) created by cougars just prior to making a kill. We combined these metrics with data from GPS clusters visited in the field (i.e. kill/no-kill). We assumed that prior to making a kill; a cougar is "hunting" and in a state of predatory behaviour. Using cluster analysis we plan to sub-divide movement metrics made prior to kills into distinct groups. Ultimately, we will describe cougar predatory behaviour by categorizing it into unique movement states such as search, stalk and travel between consecutive searches. By breaking cougar predatory behaviour into quantifiable components we then hope to develop a measure of predation success from the ratio of stalk attempts/stalks resulting in a kill. It should be noted that this study is currently in the latter stages of field data collection and the final results are not expected until Jan 2012. As such, the methods, preliminary results and plans for future analysis will be presented.

Cougar Ecology, Predation, and Caribou in the Columbia Mountains of British Columbia

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Abstract**:** Much of the recent decline of mountain caribou (*Rangifer tarandus*) populations in British Columbia has been attributed to an increase of other large ungulates and their predators following broad-scale habitat modification. In response to the decline of caribou in the Columbia Mountains (CM), the Fish and Wildlife Compensation Program began a cougar (*Puma concolor*) project in 2006 to: 1) determine their distribution, 2) quantify their overlap with mountain caribou, and 3) determine their prey selection and kill rates. Between 2006 and 2009, we monitored 3 GPS-collared cougars (1 adult male, 1 adult female, and 1 sub-adult male) as well as 1 VHF-collared cougar (adult female). We used GPS data to investigate 200 of a total 634 multiple-point cluster locations and found prey remains at 101 of those clusters. Although our cougar sample was small, we found that caribou comprised of a small proportion (3 of 101 total kills) of the cougar diet and that alternate prey such as deer, moose, elk, and beaver were the predominant prey species selected. However, this amount of predation can still be sufficient to negatively affect a small caribou population that lives in the study area. In quantifying cougar overlap with caribou habitat, we found that cougars spent the largest proportion of time in lower quality caribou habitat for all seasons but that there was overlap with higher quality habitat during the spring, summer, and early winter suggesting a relatively higher predation risk to caribou during those seasons. A similar pattern was seen in the overlap of non-caribou cougar kills, where non-caribou prey were killed in higher quality caribou habitat during the spring, summer, and early winter. Although our sample size was small, it represented a significant proportion of the cougars in the study area (3 of 6-7cougars). In this context, our dataset suggests that alternate prey make up the predominant prey species for cougars in this area which suggest at least partial credence to the apparent competition hypothesis.

Conservation Implications of Tiger Predation Dynamics in the Russian Far East: New Insights from GPS Collars

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Abstract**:** Prey depletion is one of the primary short-term threats to Amur tigers (*Panthera tigris altaica*). Therefore, improved ungulate management is essential for the survival of this northernmost tiger subspecies, particularly as the vast majority of Amur tiger habitat in the Russian Far East (RFE) is comprised of unprotected, multiple-use forest lands where both tigers and hunters rely on the same prey base. Russian wildlife management agencies currently adjust legal ungulate harvests to account for the estimated number of ungulates needed to sustain tigers. Rigorous data on tiger kill rates are lacking, but are needed to inform this approach. Unfortunately, information on kill rates of Amur tigers outside the winter season has been difficult to obtain, and existing winter estimates vary greatly. Recent advances in Global Positioning System (GPS) collar technology have enabled researchers to gain insights into year-round predator-prey dynamics for many carnivores, but until recently, no one had applied this approach to tigers. Our project is the first to use GPS technology to expand existing scientific knowledge of year-round tiger-prey dynamics in the RFE, improve methods to estimate kill rates and contribute practically to sustainable wildlife management. We will also develop a tiger energetics model using information from the literature to estimate the energy budget of tigers, and test the model using GPS-based, empirically derived movement rates and kill/consumption rates. This model will provide estimates of tiger food requirements and facilitate understanding of which suite of prey sizes are likely to ensure successful reproduction. Quantifying the energetic requirements of tigers will allow conservationists and wildlife managers to estimate adequate prey population sizes, better identify critical prey species and promote science-based recommendations for ungulate management. An improved understanding of tiger energetics has implications for conservation efforts across all tiger range countries.

Cougar Response to a Seasonal Flux of Human Use in Insular Cougar Habitat

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Abstract: The Cypress Hills, located in southeastern Alberta and southwestern Saskatchewan, is characterized by an isolated foothill eco-zone surrounded by a vast expanse of native grasslands, ranchlands, agricultural and rural development. Cougars (*Puma concolor*) have recently re-colonized this island-like portion of their former range and exist in very high density (6.5-8.25 cougars/ 100km^2). The hills also form the basis for Cypress Hills Interprovincial Park which attracts approximately 500 000 visitors seasonally. The high density of cougars and humans using the same area raises questions about how to manage this shared environment. Large carnivores can alter the distribution and abundance of herbivores ultimately influencing the communities and ecosystems in which they exist. However, large carnivores can evoke heated social, political and legal conflicts which can influence the management, and ultimately the ecological function, of these species. Our research will examine the ecological implications associated with the return of cougars to the Cypress Hills including 1) seasonal variation in habitat selection and movement in an isolated and fragmented landscape and 2) seasonal changes in potential human-cougar interactions and conflict. GPS radiocollared cougars, traffic counters and remote cameras will be used to monitor the spatial and temporal patterns of human and cougar use. We hypothesize that the Cypress Hills cougar population is structured into three resident subpopulations occurring in distinct patches of forested habitat with travel between habitat patches limited to dispersing juvenile cougars. At a finer scale we expect that cougars will shift their seasonal distribution avoiding areas with a seasonal pulse in human use and that the extent of this spatial shift will be constrained by the spatial and temporal availability of suitable habitat.

Effects of Trophy Hunting on Female Cougar Population Growth and Persistence

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Abstract :Carnivore populations are managed based on the density dependent, compensatory mortality model, which suggests that trophy hunting of males causes an increase in female reproductive success, survival, and population growth. Previous research on cougars showed that increased mortality of males resulted in no net reduction in males due to increased immigration. Female reproduction and survival did not increase with male mortality. That research suggested that female demographics are additive to male mortality and might even be depensatory (inversely compensatory), whereby increased male immigration and infanticide may be associated with decreased female reproductive success, survival, and population growth. In this paper we test the compensatory, additive, and depensatory hypotheses by censoring incidental female hunting deaths and plausible kitten infanticides from two independent cougar populations. The previously observed lack of compensatory demographics allowed us to censor deaths in this manner. The lightly hunted population (male hunting mortality = 0.16) had a female population growth rate of 1.05. With incidental female mortality from hunting removed the growth rate increased to 1.14. The heavily hunted population (male hunting mortality = 0.35) had a female population growth rate of 0.78. With plausible infanticide removed the growth rate increased to 0.89. With hunting mortality of females removed, the growth rate increased to 0.98. With both female mortalities and infanticide removed, the growth rate increased to 1.14. Light hunting of males (no net male immigration) decreased female population growth in an additive manner and heavy hunting of males (increased net male immigration) decreased female population growth in a depensatory manner. We reject the compensatory mortality hypothesis, and suggest that hunting of males has a negative additive or depensatory effect on female population growth depending on the intensity of male mortality.

Exclusive Use of Riparian Habitat by a Population of Puma in Central New Mexico

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Abstract: Understanding metapopulation dynamics of puma (*Puma concolor*) is critical for their successful long-term management and conservation. Riparian areas have been recognized as potentially critical dispersal corridors for puma, particularly in the Southwest and Midwest where there may be large areas of inhospitable matrix dividing suitable habitat patches. We describe the movement, home range, and prey selection characteristics of a resident puma population (3 males, 2 females), that confine their movements almost exclusively to the relatively narrow middle Rio Grande flood plain of New Mexico. Implications of resident puma populations in narrow strips of riparian habitat for puma conservation, dispersal, and recolonization of the Midwest are discussed.

Mule Deer and Elk Adhere to Puma Induced Landscape of Fear in Southwestern New Mexico

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Abstract: Large carnivores may alter the distribution of prey species as the prey select habitat based on predation risk, or evaluate the 'landscape of fear'. We hypothesized that mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) would both exhibit different spatial distribution patterns than puma (*Puma concolor)* based on this 'landscape of fear' assumption. Using GPS collar data from 3 male and 3 female puma along with data from 175, 200m sq, ungulate pellet plots, we found that habitat use of both mule deer and elk differed significantly from that of puma at the landscape (~500Km sq) scale. Further, using data from 14,240 camera nights of data collected from 25 remote cameras distributed in a 100Km sq grid a Poisson regression revealed significant negative associations between puma and both mule deer and elk, consistent with our hypothesis. However, at this time we cannot rule out the possibility that simple differences in habitat preference are responsible for this pattern.

Developing a Management Tool to Estimate Unmarked Puma Populations with a Remote Camera Array

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Abstract: Remote camera traps placed in an array present a promising new tool for surveying cryptic mammals. Techniques for estimating population levels of unmarked animals or species that do not have individual markings are needed. Our goal was to develop a technique using a remote camera array (1) to determine the camera effort needed to detect resident pumas (*Puma concolor*) with 95% certainty and (2) to estimate the puma density of an unmarked puma population. An array of 25 cameras spread 2km apart in a square grid covering an area of 100km^2 was used to monitor the detection of 5 individually marked pumas. Photographic captures and GPS collar data for one male and one female puma were used to estimate the mean number of camera nights required to reach a detection probability of 95% for a single puma within the camera array for any number of cameras (1-25). These estimates were used to develop a technique to calculate puma density based on the number of cameras in the array, camera nights included in the survey, and puma photos captured. Population estimates were calculated from 71 days of camera data, including 1,220 camera nights. A mark-resight population estimate yielded a puma density of 2.1 (1.7-4.4) pumas/100km^2. Our population estimate based on photo capture rate yielded 1.8 (1.4-2.2) pumas/100km^2 and fell within the 95% confidence interval of the mark-resight estimate. These results suggest that a remote camera array can be used to accurately estimate puma population density based only on unmarked pumas.

Assessing Spatial Dynamics of Cougars in North-central Montana: Distribution, Resource Selection, Population Dynamics, and Conservation Design

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Abstract: Cougars use large scale landscapes and require cooperative management and conservation at multi-jurisdictional scales. Montana manages cougars based on regional habitat capabilities, however, little is known about capabilities of landscapes in the island mountain ranges of northeastern Montana or the Missouri River Breaks, nor of current population levels or viability. We began a study in 2006 with objectives including: 1. Obtaining a minimum count estimate; 2. Obtaining estimated rate of mortality, density, distribution, and reproduction; 3. Obtaining estimates of landscape composition of home ranges; 4. Estimating connectivity between island mountain ranges and the Missouri River Breaks; and 5. Obtaining estimates of conflicts between cougars and livestock. We placed GPS collars on 6 females and 8 males in the Bears Paw and Little Rocky Mountain ranges. Hunters harvested 9 and 2 died of natural causes. From December 2006 - May 2010, overall survival rate was 0.01. Hunter harvest mortality rate for that period was 0.81. Mean number of months alive post capture for cougars was 8 (range = 1-12). One cougar dispersed from the Bears Paws to the Little Rockies. We estimate the core habitat for cougars in the Bears Paws is about 260 km^2 yielding a density of 1.5 adult cougars/100 km^2 during periods of known high population and a density of 0.7/100 km^2 during periods of lowest known population. Three female home ranges ranged from 95-326 km^2. Five male home ranges ranged from 160-472 km^2. The composite home range for 8 cougars was 931 km^2. Most cougar locations were within habitats we predicted and defined as cougar habitat based on ruggedness and forest cover models. Investigations are continuing with attempts to collar additional cougars in the Bears Paw and Little Rocky Mountains, and 5 cougars were collared in the Missouri River Breaks during January-March, 2011.

Differential Prey Use by Male and Female Cougars in Washington

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Abstract**:** Male and female predators are usually assumed to have the same effects on prey. However, because of differences in body size and behavior, male and female predators may use different species, sexes, and ages of prey. This could have important implications for wildlife conservation and management. We tested for differential prey use by male and female cougars (*Puma concolor*) from 2003-2008 in Washington State. We predicted that male cougars would kill a greater proportion of larger and older prey (adult elk, *Cervus elaphus*), while solitary females and females with dependent offspring would kill smaller and younger prey (elk calves, mule deer, *Odocoileus hemionus*). We marked cougars with Global Positioning System (GPS) radio collars and investigated 436 predation sites. We located prey remains at 345 sites from 9 male and 9 female cougars. We found prey remains at 127 sites for solitary females, 111 sites for females with dependent offspring, and 107 sites for males. We detected 184 mule deer, 142 elk, and 17 remains from 4 other species. We used log-linear modeling to detect differences in species and age of prey killed among cougar reproductive classes. Solitary females and females with dependent offspring killed more mule deer than elk (143 vs. 83, $P < 0.01$), while males killed more elk than mule deer (59 vs. 41, $P < 0.01$). Proportionately, males killed 4 times as many adult elk than females (24% vs. 6% of kills) and females killed twice as many adult mule deer than males (26% vs. 15% of kills). Managers should consider the effects of sex of predator in conservation and management of ungulates, particularly when managing for sensitive, threatened or endangered species.

Session 4:
Felid Population Segments of Concern

Wild Felid Research and Management Association (WFA)

Jaguars in Peril: The Next 100 Years

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Abstract: Jaguars are deeply intertwined with humans wherever they exist. They have been incorporated into the culture of innumerable pre-Columbian indigenous groups, and also are currently considered modern symbols of power, strength, and superiority. At the same time, unfortunately, jaguar numbers continue to dwindle. At a recent continent-wide conference, we identified that the single most important factor determining jaguar mortality is not deforestation or hunting of prey, but direct jaguar killing. Hundreds of jaguars are killed every year across Latin America for any number of unfounded reasons. Today, Mexico has become the first country to have a nation-wide estimate of the jaguar population. The National Jaguar Census is a multisectoral effort to survey jaguars across the Mexican territory. Mexico has also produced a National Jaguar Conservation Strategy and with the aid of a protocol to aid livestock operations in cases of jaguar predation, the country is on the road to secure the future of its jaguar populations, although time is running out. The continent-wide experts who met to evaluate the status of jaguars signed an open letter to all federal governments of Latin America demanding attention to the severe problem of jaguar killing. To continue along those lines and given the similarities in ecology and differences in conservation status, Mexico has signed an agreement with the Kenya Wildlife Service to carry out a workshop to compare the ecology, natural history, and conservation needs of jaguars and leopards. The coin is in the air; much more needs to be done in the next 20 years if we are to secure the future of the jaguar. With a strong, diverse group working in many areas, exchanging and comparing data, and collaborating, this challenge is feasible.

Vulnerability of the Ocelot Populations in the United States

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Abstract: The only known resident populations of ocelot (*Leopardus pardalis*) in the United States occur in southern Texas. Our research and monitoring for the past 30 years has yielded valuable information and insight into the vulnerability of this endangered felid. The two populations in Texas are isolated, occupy a constellation of small, fragmented habitat tracts, and experience high mortality on roads. Each population is likely less than 40 individuals with no documented exchange. Genetic erosion in the ocelot populations of Texas has occurred over the past 25 years, while heterozygosity and allelic richness maintain higher levels in northeast Mexico. Population viability analyses suggest vulnerability of the two populations in the United States. Catastrophic events further threaten these populations, including extreme and frequent drought, disease epidemics and uncontrolled wildfire under certain burning conditions. For long-term benefits, habitat restoration near the core populations is being actively undertaken for both populations and will ultimately facilitate population stability. Additionally, conservation strategies are being implemented that will mitigate road mortality, including placement of culvert passages with appropriate fencing. Immediate benefits could be derived from demographic and genetic augmentation of the ocelot population from vital, healthy sources. Finally, the establishment of one or more new populations within the former range would lessen the vulnerability of the ocelot in the United States.

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Don’t Eat the Shrimp

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Abstract: Currently six felids are ranked Endangered by the IUCN Cat Specialist Group. Two are big cats, the tiger and snow leopard, and four are small cats: Andean cat, Bay cat, Fishing cat and Flat-headed cat. While tiger and snow leopard conservation programs are well-funded, money flowing into conservation efforts of small cats is a mere trickle. Best estimates of the total Andean cat population are 2200 individuals, only 2/3 that of the estimated wild tiger population. While there are many tigers and snow leopards in zoos throughout the world, no Andean cats are found in captivity. Conservation actions that reduce threats to all species, especially small cats, are urgently needed. A few conservationists’ actions are necessary but not sufficient. Broad public support is needed. But how can the public help to reduce threats to species living far beyond their home country’s borders? Understanding the threats and informing the public of specific actions they can take that will make a difference is one way to harness the broad public support that is vital to saving these species from extinction. Biodiversity loss is widely recognized to be the most serious global threat to the well-being of humans. Many argue that the sixth mass extinction is well underway with losses of species exceeding 10 to 100 times historical rates. Though many people might reject the existence of global warming and ocean acidification, there is widespread recognition that species and habitats are disappearing. With this recognition, however, comes frustration about how the average person can help stem these losses. For instance, what positive steps can a person in Arkansas take to help save a wild cat that exists on the other side of the planet? One course of action is to stop eating shrimp.

The IUCN Cat Specialist Group considers six members of the Felidae to be globally endangered. While many millions of dollars are invested annually in snow leopard and tiger conservation efforts, far fewer dollars are spent on conservation efforts aimed reducing threats to Andean cat, bay cat, fishing cat, and flat-headed cat. Certainly much of this lack on investment in small cat conservation is due to a severe lack of awareness of the plight of these four small cats. Moreover, the threats to these cats have not been articulated clearly. Surely conservation efforts cannot be mobilized if the threats to these cats are not clearly understood. In fact, the many threats faced by these small wild cats are well known and courses of action to reduce and mitigate these threats are being taken. In some cases reducing global demand created by a largely ignorant public for certain products marketed by some of the world's largest companies is a formidable task.

THE TALES OF THREE WILD CATS

For at least three small cats, Andean cat, fishing cat, and flat-headed cat, threats are well known. Dealing with these threats is a different matter altogether. This is because each cat faces unique threats so that solutions designed to deal with threats to one cat do not apply to other cats. Because these cats are small, they do not pose a direct threat to humans. No records of attacks on humans has ever been recorded.

Populations of Andean cat have been reduced by direct killing, loss of prey due to competition from humans, loss of fresh water due to industrial scale mining, competition from a competitor those populations have increased due to an introduced prey species, and global warming that threatens the long-term existence of Andean glaciers and the fresh water they supply to the prey of Andean cats.

Humans and their poultry pose a direct threat to fishing cats. A fishing cat that is tempted by free-ranging chickens eventually becomes a dead cat. Fed by a growing global consumer demand, the widespread conversion of coastal wetlands to support industrial-scale shrimp and fish ponds is the direct cause of massive losses of prime fishing cat habitat. Moreover, because ponds become polluted in less than ten years and are simply abandoned and never restored more wetland must be converted.

The flat-headed cat is very poorly known and does not pose a threat to humans. Like the fishing cat, a flat-headed cat that attempts to prey upon poultry does not live long. Like the fishing cat the main prey of the flat-headed cat is fish, frogs, and other creatures inhabiting wetlands in Southeast Asia. The cancerous replacement of tropical hardwood forest and the immense biodiversity contained within it by oil palm plantations across peninsular Malaysia and Indonesia including Sumatra and Borneo (the entirely of the flat-headed cat's geographic range) has caused a dramatic decline in flat-headed cat populations. Palm oil is found in many consumer products used daily by humans. Both Malaysia and Indonesia have state goals of becoming the world's largest producers of palm oil. Indeed the demand by global consumers for such products has recently led to an agreement between Malaysia and Brazil to establish oil palm plantations in the Amazon Basin. Once again global companies market these products to ignorant consumes who become unwitting accomplices supporting the Sixth Mass Extinction.

Conservation strategies for Andean cat, fishing cat, and flat-headed cat

In the case of the fishing cat and flat-headed cat the cause of their endangerment is widespread habitat destruction caused by global consumer demand for products whose origin and destructive nature they have absolutely no understanding of. Thus, the task of conservationists is to increase awareness among consumers that shrimp and fish pond such as those in Thailand, and products that contain palm oil are causing widespread habitat loss. Such products must be avoided. Indeed, conservationists are educating consumers that they are in fact partly responsible for the decline in populations of fishing cats, flat-headed cats, orangutans, and other creatures inhabiting what little remains of natural forests and wetland in Southeast Asia.

For the Andean cat, other conservation actions are necessary. Few people live in the high Andes of Argentina, Bolivia, Chile, and Peru. The inhospitable climate and lack of rainfall make agriculture impossible. Unfortunately those people that do live in the Andes believe that cats are sacred and hold supernatural powers that can be harnessed only when the cats are killed, dried, and elaborately decorated. Unless consumers can halt global warming by their actions, there is little than can do but support the work of conservationists in educating school children about the plight of the Andean cat, the most threatened cat in the Americas.

Collateral Impacts of Increasing Florida Panther Numbers: Dealing With Unintended Consequences

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Abstract: Since a breeding population of Florida panthers (*Puma concolor coryi*) was officially verified in 1978 south of Lake Okeechobee, intense panther conservation efforts were directed towards ensuring the survival of this small population. These efforts included habitat preservation, installation of wildlife crossings in highways, improved habitat management practices that benefited both panthers and their prey, and thorough biomedical assessments of individual panthers. These health assessments revealed that the remnant population was suffering from inbreeding and subsequent demographic modeling suggested the population was spiraling towards extinction. Therefore, in 1995, we initiated panther genetic restoration to mimic natural gene flow into this isolated and small population. We documented higher kitten and adult survival for genetically-admixed panthers versus canonical panthers and survival increased with increased genetic heterozygosity. Additionally, we found that kitten survival was negatively density dependent with a panther abundance index. The panther population has grown over the past 30 years from as few as 20-30 animals to 100-160 adult (>1 year of age) cats today. This population growth is a desirable outcome based on the third revision of the Florida Panther Recovery Plan (FWS 2008) that established recovery criteria of 2 or 3 populations of at least 240 adults and subadults, coupled with sufficient habitat security, for reclassification to threatened or delisting, respectively. However, population growth has led to unintended consequences that could undermine support for panther conservation. Increased human-panther interactions, hobby livestock depredations, depredations on commercial livestock and perceptions that game species have been declining are some collateral impacts of increasing panther numbers. Managing both conservation needs and social acceptance will be critical not only for maintaining the current population but also for fostering population expansion that is an essential component of panther recovery.

INTRODUCTION

The Florida panther (*Puma concolor coryi*) is a State and Federal endangered subspecies of the puma that at one time occurred throughout the southeastern U.S. (Young and Goldman 1946). Unregulated harvest of panthers through the mid-1900s and, more recently, habitat loss and fragmentation due to the human population growth reduced panther numbers and isolated them from other puma populations. When the Florida Fish and Wildlife Conservation Commission (FWC) began investigations into the status and distribution of panthers in the early 1970s, there were an estimated 20-30 panthers still living in southern Florida.

Intensive panther research and management actions began in 1981 and were focused primarily on ensuring that this small population did not disappear. Highways were made safer with wildlife crossings and barrier fencing and thousands of acres of panther habitat were purchased or preserved through easements. Gene flow into this isolated population was also restored to levels that would have occurred historically prior to its isolation. These measures have been successful resulting in a rise in panther numbers and increased population viability.

Social acceptance of Florida panthers has not kept pace with the increase in panther numbers as evidenced by increasing reports of conflicts between humans and panthers. These conflicts include hobby livestock depredations in residential areas, depredations on cow-calf operations and perceptions that white-tailed deer herds are declining. Additionally, people are encountering panthers and their sign more frequently to the point where questions are raised about whether the species should still be considered endangered. Resolving these complex social acceptance issues may be the biggest challenge for managing the existing population and more so for establishing new populations within the historic range.

RECOVERY GOALS

The US Fish and Wildlife Service (FWS) completed the third revision of the Florida panther recovery plan in 2008 (FWS 2008). The recovery objectives from this plan calls for: 1) the maintenance, restoration, and expansion of the panther population and its habitat in south Florida and expanding this population into south-central Florida; 2) identifying, securing, restoring and maintaining habitat in potential reintroduction areas and the establishment of additional viable populations within the historic range outside of south and south-central Florida; and 3) to facilitate panther recovery through public awareness and education.

A viable panther population for purposes of recovery is defined as one in which there is a 95% probability of persistence for 100 years. Population viability analyses indicated that to be viable, a population would consist of at least 240 individuals. Reclassification from endangered to threatened will be considered when two viable populations have been established and maintained for a minimum of 12 years. Additionally, habitat protection measures need to be in place to protect the quality, quantity and connectivity of panther habitat within each population re-establishment area. Similarly, delisting will be considered when three viable populations have been established for a minimum of 12 years and the habitat base for these populations is secured for the long-term.

GENETIC RESTORATION

In the early 1990s, the panther population reached a critical juncture. The combined effects of habitat loss and isolation over the previous century led to an inbred and declining population that suffered from low levels of genetic variation and various health problems. In 1994, FWC met with population genetics experts and other cooperating agencies (the National Park Service and the FWS) to develop "A Plan for Genetic Restoration and Management of the Florida Panther" (Seal 1994). The resultant objectives included the following:

- reducing inbreeding in the Florida panther,
- restoring genetic variability and vitality of panther offspring, and
- restoring the population's genetic diversity to levels comparable to those in populations of western puma subspecies.

The group determined that introducing 6 to 10 individuals from a genetically healthy population of North American pumas would reverse the effects of inbreeding in resulting offspring and achieve the desired genetic restoration of the Florida subspecies. FWS approved the plan following an Environmental Assessment and FWC began the process to release eight female Texas pumas (*Puma concolor stanleyana*) into the wilds of southern Florida. This tactic mimicked historic gene flow between the two subspecies and gave the remaining 30 to 50 Florida panthers the best chance of avoiding extinction. The intent of this management initiative was not to replace the Florida panther's gene pool, but to create a healthier, more resilient population that is similar to the historic population that roamed the southeastern United States prior to becoming isolated in southern Florida. A population with higher levels of genetic variation is more apt to recover from its endangered status.

Following the release of the eight Texas pumas in 1995, researchers assessed the level of genetic variation in the population using three methods:

- a pedigree analysis, similar to a family tree, to assist in determining family lineages and associated health issues that may be passed along family lines;
- a genetic analysis to identify unique characteristics of Florida panthers and Texas pumas and define levels of genetic variation; and

- an analysis of physical characteristics associated with inbreeding (e.g., tail kinks, cowlicks, undescended testicles, sperm quality, and heart defects).

Pedigree analyses verified successful pairings between canonical panthers and the Texas females, as well as between subsequent generations of the offspring of these pairings (admixed panthers)(Johnson et al. 2010). Inbreeding continued to occur to some extent, although not at pre-1995 levels. Pedigree analyses also documented associations between specific family lines and occurrences of undescended testicles and heart defects. Genetic markers showed greater genetic variation than existed before restoration, with obvious impacts on the frequency of physical defects associated with inbreeding: fewer undescended testicles, a higher percentage of normal sperm, and fewer instances of heart defects, kinked tails, and cowlicks. Today's population has increased heterozygosity and is comprised of younger individuals than the pre-restoration panther population.

Panther survival rates improved as heterozygosity increased both for adults and kittens and adult females had higher survival than adult males (Hostetler et al. 2010, Benson et al. 2011). The female Texas puma offspring had the highest survival rates both as kittens and as adults (Hostetler et al. 2010, Benson et al. 2011). Kitten survivorship irrespective of genetic diversity was correlated negatively with a panther abundance index (negatively density dependent) (Hostetler et al. 2010).

While genetic restoration of the Florida panther was successful with regard to some of its initial objectives, Florida panthers remain isolated and will therefore suffer from inbreeding and loss of genetic variation over time. As the plan acknowledges, this eventuality may require the release of additional pumas in Florida to assure the long-term survival of the panther population.

PANTHER POPULATION GROWTH

References to panther numbers have appeared in scientific literature, agency outreach materials, and popular media for years. Historically, most statements regarding Florida panther numbers have resulted from expert opinion, informed by field observations of those most closely engaged in panther research. Various figures have been used throughout the years, including 20-30 throughout the 1970s and early 1980s; 30-50 in the late 1980s through the mid-1990s; 50-70 for a few years following genetic restoration in 1995; and from 2000-10, 90-120 panthers (McBride et al. 2008).

FWC recently completed a new population "guesstimate" suggesting that the number of adult (> 1 year of age) panthers is between 100-160 individuals (http://myfwc.com/news/resources/fact-sheets/panther-population/). The upper bound of 160 is based on an idealized and unlikely premise that the high panther density found in the core range would be found across all areas within the breeding range. Nevertheless, this provides reasonable boundaries of a minimum and maximum population to provide some insight into the possible magnitude of the adult population size in this area of Florida. Dispersal of male panthers has been documented throughout peninsular Florida and in one case as far north as Georgia. Female panthers have not been documented north of Lake Okeechobee and therefore breeding range is restricted to southern Florida.

COLLATERAL IMPACTS OF PANTHER POPULATION GROWTH

The intent of genetic restoration was to create a healthier, more resilient panther population with improved long-term viability. A larger population size was an anticipated result. What was not foreseen were impacts that were products of the law of unintended consequences, namely "that actions of people and especially of government always have effects that are unanticipated or unintended" (Norton 2008). In our case, an increase in the number of panthers has placed more panthers in proximity to people resulting in increases in residential animal depredations, calf depredations on ranchlands and perceptions that white-tailed deer herds are in decline. Another unintended consequence of more panthers is the expectation that agencies should be able to count panthers and measure our progress towards achieving recovery plan criteria.

Residential Animal Depredations

FWC, in partnership with the National Park Service and FWS, developed a Florida Panther Response Plan in 2008 to provide guidance in dealing with human-panther interactions including depredations. Depredation complaints from hobby livestock and pet owners have been increasing as the number of panthers increased. Most conflicts in exurban areas involve panthers preying on goats or sheep. The vulnerability of pets and residential livestock can be lessened significantly by proper animal husbandry practices such as keeping pets indoors and confining livestock to secure enclosures at night. Some residents are willing to take steps to secure their animals and others are very resistant. If panther numbers remain at current levels, we can expect to have perennial panther issues between people that live in rural areas and panthers. These human-panther interactions are an emerging human dimensions issue that must be handled appropriately in order to maintain or improve upon the social acceptance of panthers by people living in rural areas.

Calf Depredations on Ranchlands

Publicly owned lands in south Florida, such as Fakahatchee Strand State Preserve, Big Cypress National Preserve and the Florida Panther National Wildlife Refuge, provide large tracts of protected panther habitat. Quality panther habitat also exists on privately-owned lands and many of these lands are managed as cattle ranches. Cattle ranching has a long and rich history in

Florida and these operations rank among the top 15 of calf-producing states (National Agricultural Statistics Service [NASS] 2011). Panther numbers have risen over the past decade on both public and private lands. Co-existence of cattle ranching and panthers will be critical to maintain the existing population and perhaps more so to establish new populations within the historic range.

Surveys conducted by the NASS found that in Florida, calf losses to predators statewide were around 18% and 67% of these predators were reported to be either coyotes (59%) or dogs (8%). No losses were attributed to either panthers or bobcats. It should be noted, however, that this survey was conducted either via telephone or through a questionnaire not through direct hands-on studies. Typically, panthers feed on deer and other wildlife, but in the past, FWC has documented the occasional calf depredation by panthers. These depredations were considered to be rare events.

Recent reports, however, indicate an increase in the number of calves lost to panther predation. Calf depredation causes an economic loss to ranchers. These losses are viewed as an economic penalty against the very individuals who manage their land in ways that benefit wildlife and panthers. A long term approach is warranted to assist private ranch owners so that they do not bear the financial burden of providing panther habitat and to provide incentives to them to accommodate panthers as the species expands their range and continues on the road toward recovery.

The problem of calf depredation by panthers is complex and there are no easy answers. As a federally protected endangered species, there are many legal requirements that must be adhered to by local, state, and federal agencies when dealing with these conflicts. Lethal removal of an offending panther would not be permitted in most cases. Relocation risks moving a problem to a different area or could put the panther in unfamiliar, occupied territory causing disruptions of the social structure. The state and federal agencies recognize that without the cooperation of private land owners, it is doubtful that the panther will ever be removed from the endangered species list. The long term best interest of both panther conservation and ranching may be the development of financial incentives for private land owners to manage their land in ways that are conducive to providing habitat for wildlife, including panthers. For example, there are programs in the U.S. Department of Agriculture that are designed to provide incentives for land owners to encourage sound ecological land management. Potential modification of existing programs should be explored to see if they can be applied to recognize the public value these private ranch lands provide for panther conservation.

While this is the long term vision, more information is needed to adequately design such programs. It will be important to determine with some certainty the impacts panthers may be having on ranch production in order to develop land incentive programs that will offset these economic losses. FWC, FWS and the University of Florida will be working with some private ranches in areas occupied by panthers to 1) conduct panther prey studies; 2) conduct calf survival studies; and 3) analyze existing data on past calf production. There is a need to conduct research to provide factual and science based information regarding the panther impacts. We need to better understand how panthers adapt to living in these landscapes to better understand the biological and ecological aspects of this issue. By learning more about panther depredations we may discover steps that can be taken that would reduce the likelihood of depredations.

Some form of immediate relief is needed now because it will take several years to collect reliable data to better inform long-term solutions. A working group comprised of landowners, ranchers and agency representatives recommended that a fund be created to provide financial compensation to ranchers in southwestern Florida with verified calf losses caused by panther depredations. FWC and FWS have agreed to provide the funding to the Department of Agriculture and Consumer Services (DACS), who has agreed to administer the fund. The three agencies will develop an intergovernmental agreement on how the fund will be managed and distributed. The agreement will specify the roles and responsibilities of each agency. This fund should be available by mid-2011 well before next year's calving season.

Decline in White-tailed Deer, Southern Big Cypress National Preserve

Some members of the hunting public have expressed concerns regarding panther impacts on deer numbers with a particular focus on the southernmost unit of Big Cypress National Preserve (BCNP; Fig. 1). BCNP is one of the largest areas open to public hunting (720,566 total acres, 565,848 open to hunting) and this area also supports many panthers. Within BCNP south of I-75 and north of US 41, Jansen (2000) reported sign of 2 panthers circa 1995. Documented panther numbers within this same area have risen to 21 in 2009 (McBride 2009). The entire BCNP is supporting more panthers today than were thought to exist when the species was listed as endangered in 1967. Deer numbers also appear to have increased in BCNP since the 1980's (Jansen 2000). Factors that may have contributed to this increase of a panther prey item include better prescribed fire management, the removal of unapproved backcountry camps, cessation of deer hunting with dogs, and changes in hunting regulations. Panthers have been shown to spend more time in areas that have been burned within the previous year and this response was thought to be associated with the presence of more deer (Dees et al. 2001). An average of 220 deer was harvested in BCNP between 1988 and 2009; 245 deer were harvested in 2009.

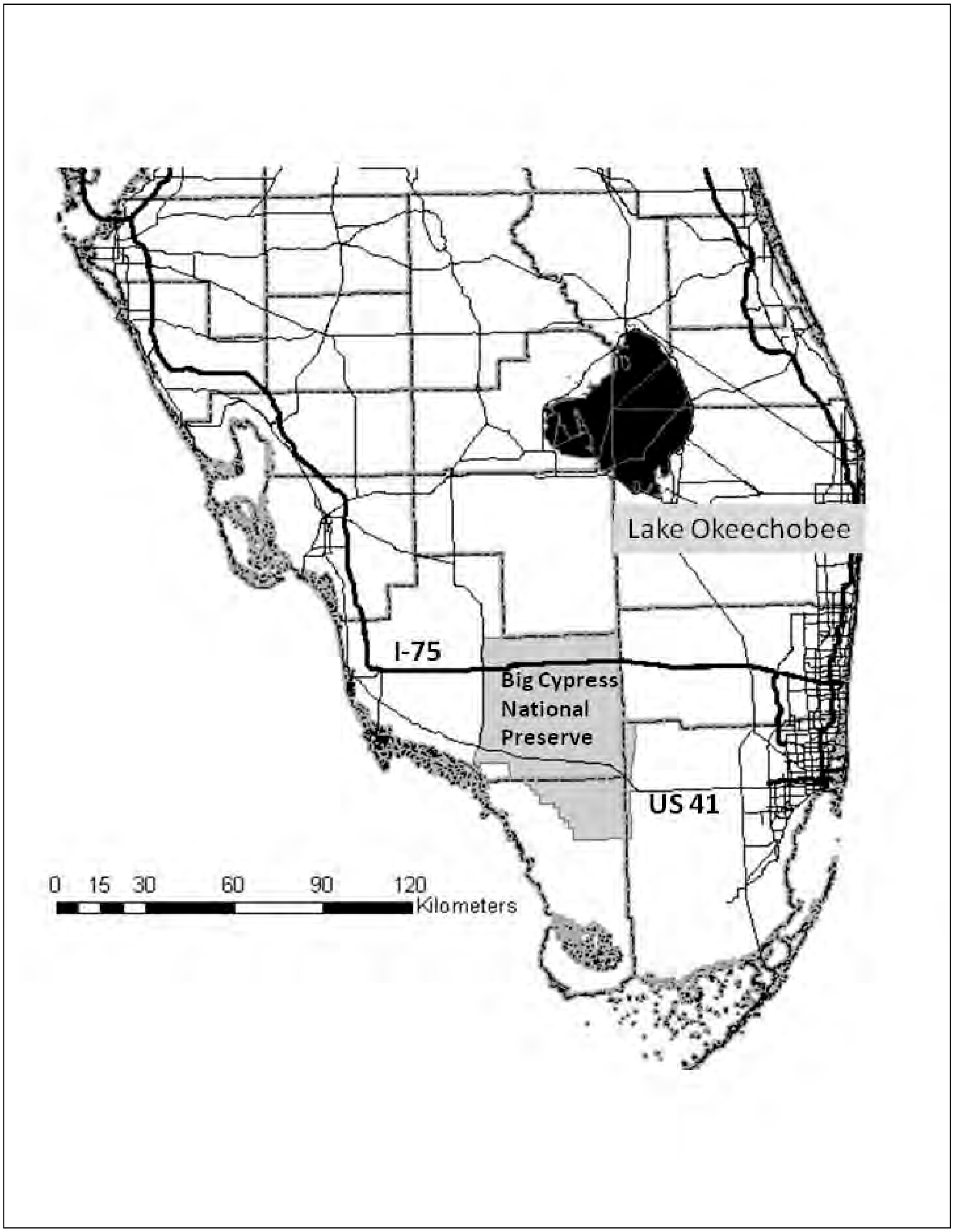

Figure 1. Location of Big Cypress National Preserve, southern Florida, USA.

The Stairsteps Unit of BCNP experienced an increase in deer numbers between 1996 and 2001 (393 deer counted in summer aerial surveys) then declined to a low of 7 deer counted in 2010. Hunter harvest declined from a high of 113 deer harvested in 1998 down to 22 harvested in 2009. This is the southernmost unit of BCNP and is 147,312 acres in size. Habitats within the Stairsteps Unit are predominantly open marshes and wet prairies with some tree islands, cypress forests, and scattered pinelands (Duever et al.1986). Yearly hydrological fluctuations determine the plant communities of south Florida ecosystems and are influenced not only by yearly rainfall amounts but also by the extensive system of canals, levees and pump stations that have been built to move water. The Stairsteps unit is considered to be rather poor deer habitat in comparison to the rest of BCNP and has not historically been utilized by as many panthers.

Annual panther surveys conducted between 2003 and 2009 documented a range of 1-5 panthers in this area of BCNP. Most radiocollared panthers that used this area also included other units of BCNP in their home ranges. FWC and BCNP are working together to analyze factors associated with the declining deer numbers. Preliminary results suggest that increases in the frequency of high water events since the mid-1990's may have caused the deer declines due to lower deer productivity, reduced recruitment and higher mortality. There is evidence that habitats have changed from wet prairies to freshwater marshes, most likely a reflection of the changing hydrology, and this transition would reduce deer habitat quality. Predation certainly contributed somewhat to the decline but does not appear to be the driving force behind the reduction in deer numbers.

Other units of BCNP have not experienced similar declines in deer numbers, as evidenced by consistent harvest levels, even though they support more panthers. Also, FWC manages hunts on other State lands occupied by panthers that total over 160,000 acres; no declines in deer numbers are evident on these wildlife management areas. However, there still is a perception that the documented increase in panther numbers is diminishing deer populations throughout south Florida. Whether these conflicts are real or perceived, acceptance of Florida panthers by outdoor sporting groups will be critical for further population expansion and achieving recovery.

Measuring Population Size Relative to Recovery Goals

The 2008 Florida Panther Recovery Plan established recovery criteria that utilized discrete numbers of panthers without also identifying a way to count panthers. The question of "how many are there?" is a natural one when discussing the status of an endangered species. Currently, our measures of population trends rely on an annual count of panthers based on documented physical evidence (McBride et al. 2008) as well as a summation of the minimum number of panthers alive during a given year. Neither of these methods provides a population estimate with associated confidence intervals.

Rigorous capture-mark-recapture methods (CMR) used to develop population estimates, including DNA hair snares and trail cameras, have been effective for bears or felids with uniquely identifiable fur coloration patterns, respectively. Unfortunately, preliminary testing has shown that panthers are not consistently attracted to hair snares to make this a dependable method to obtain a robust population estimate, and it is not possible to reliably identify individual panthers via their fur (they are not spotted or striped). In addition, CMR sampling techniques are labor intensive and expensive when implemented for carnivore populations that occupy large areas. This includes panthers, which occupy a breeding range of 2.2 million acres.

The need to develop a statistically robust panther population estimate has now become a political concern with a proviso attached to FWC's panther budget allocation that reads "*the Commission will develop improved methods to generate statistically sound estimates of the* *panther population size using best available science*." FWC is planning on assembling a small team of people with expertise in population estimation techniques to provide guidance and recommendations for appropriate estimators for Florida panthers.

SUMMARY

Intensive Florida panther research and management actions began in the early 1980's and the main focus of these actions was to prevent extinction of the small remnant population of 20-30 animals. These actions concentrated on improving the health of the population through genetic restoration, protecting habitat and reducing panther deaths along highways through wildlife crossings, fencing and speed zones. The panther population responded well to these measures and now numbers between 100 to 160 adult cats. However, these management actions had unintended consequences that may prove to be even greater conservation challenges. Florida's human population has grown considerably since the early 1980's and panthers have expanded their range to include rural residential areas resulting in depredations on pets and hobby livestock. Panthers have also been documented taking calves on commercial ranchlands and these private lands are important as panther habitat. Outdoor sporting groups have expressed concerns that the rise in panther numbers is reducing deer herds. Finally, with the well-documented panther population increase, FWC and FWS are being challenged to provide statistically-valid population estimates so that progress towards achieving recovery criteria can be measured. Advancing Florida panther recovery will depend upon habitat protection and direct population management as well as developing strategies for resolving recently emerging social acceptance issues. Resolving these complex social acceptance issues may be the biggest challenge for managing the existing population and more so for establishing new populations within the historic range.

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Demographic History of Mountain Lion in Texas: A Genetic Evaluation

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Abstract**:** Mountain lions (*Puma concolor*) in Texas have been exposed to liberal harvest, with no season, bag limits, or reporting of harvest. Thus, little information is available to guide management decisions and the current status of populations is poorly known. We used a relatively novel genetic approach to examine the demographic history of mountain lions in western and southern Texas, where breeding populations presently occur. We sampled museum specimens taken during the early–mid 1900s and received tissue samples from contemporary populations during 1990–2010. We used genetic data from 10 DNA microsatellite loci to characterize temporal changes in genetic diversity, genetic differentiation, and effective population size between the historical and contemporary populations. Preliminary results suggest that populations in southern Texas have experienced genetic drift, as evidenced by lower genetic diversity and effective population size in contemporary populations. In contrast, genetic diversity and effective size have remained relatively stable in western Texas. The genetic structure between western and southern Texas has also increased >2-fold in contemporary populations. We are currently examining these trends further, but management concern seems warranted in southern Texas given the substantial temporal changes we observed. Our findings highlight the importance of museum collections for wildlife species with poorly documented demographic histories.

KEY WORDS mountain lion, *Puma concolor*, microsatellite loci, museum collections, Texas.

Intensive research and harvest regulations are used by many states to inform mountain lion management in the United States (U.S.). For example, researchers throughout the western U.S. (e.g., Hornocker 1970, Seidensticker et al. 1973; Logan and Sweanor 2001; Anderson and Lindzey 2005; Stoner et al. 2006; Cooley et al. 2009) have used long-term studies of radio-marked mountain lions to assess the effects of harvest on populations and inform management goals. Most states set region-specific goals for harvest, which are regulated by length of hunting seasons, bag limits, and mandatory inspection (Anderson et al. 2010). Reporting of harvest facilitates the collection of demographic data that can be used to inform future mountain lion harvest (e.g., Anderson and Lindzey 2005).

In Texas, the harvest of mountain lions is not regulated by season or bag limits, and mandatory inspection is not required (Harveson et al. 1996). Breeding populations primarily occur in western and southern Texas (Schmidly 2004), though mountain lions have been sighted throughout the state (Figure 1). Previous research has indicated that mountain lions in western (Pittman et al. 2000; Young et al. 2010) and southern (Harveson 1997) Texas exhibit high mortality due to harvest. Furthermore, a recent study revealed low levels of genetic diversity in southern Texas, and substantial genetic structure between the 2 breeding populations (Walker et al. 2000). Collectively, the little information available suggests that high mortality and reproductive isolation may be a concern for southern Texas mountain lions. However, southern Texas populations occur on the periphery of the North American range. Peripheral populations may display lower genetic diversity due to small populations, less opportunity for gene flow, or large changes in census size due to range shifts (Schwartz et al. 2003). Thus, it is difficult to determine if the genetic data are the result of historical or recent processes.

The lack of historical data on population trends and absence of harvest reporting leaves few options to evaluate the current population status of Texas mountain lions. Retrospective genetic analysis is a relatively new approach that has not been widely used for populations of large mammals (Schwartz et al. 2006, Wandeler et al. 2007). For example, researchers can investigate temporal changes in populations by comparing genetic data from museum specimens to samples from contemporary populations. Retrospective analyses are appearing in the recent literature and have revealed useful data to guide conservation and management. For instance, a temporal decline in genetic diversity was documented in grey wolves (*Canis lupus*; Leonard et al. 2005), Florida panthers (*P. c. coryi*; Culver et al. 2008), and Arctic foxes (*Alopex lagopus*; Nyström et al. 2006), which substantiated hypotheses of long-term population declines. In contrast, genetic data indicated that populations of grizzly bears (*Ursus arctos*; Miller and Waits 2003) and Eurasian badgers (Pertoldi et al. 2005) had remained stable over time despite predictions of genetic bottlenecks. We are applying retrospective genetic analyses to examine temporal changes in population characteristics of mountain lions in Texas.

The ultimate goal of our study is to characterize the demographic history of mountain lions in western and southern Texas. Our specific objectives are to examine long-term changes in genetic diversity, genetic structure, and effective population size. Currently, we have sampled >60 mountain lion skulls from museum collections including the National Museum of Natural History (Smithsonian) and Texas Tech University Museum; these samples span the early–mid 1900s. We also have acquired >200 tissue samples from trappers between 1990–2010. Preliminary results suggest mountain lions within southern Texas have experienced declines in genetic diversity and effective population size, and that genetic drift has occurred over time. However, mountain lions within western Texas appear to have remained stable given that we documented no declines in diversity or effective size. Furthermore, the genetic structure between southern and western Texas has apparently increased >2-fold over time. Our results indicate that the low genetic diversity in southern Texas and the pronounced genetic structure between western and southern Texas are the result of recent events. The temporal changes and declines we observed, along with the high mortality previously documented (Harveson 1997), suggest population concerns are likely warranted in southern Texas. Additional data on reproduction and survival are needed to determine the viability of mountain lions in this region. In western Texas, mountain lion populations seem to have remained relatively stable over time.

Our study highlights the importance of natural history collections for conservation and management. Retrospective genetic analyses are not commonly employed, but can be highly useful when historical data are lacking or where populations are difficult to survey. Retrospective genetic approaches should be considered more frequently as a tool to inform the conservation and management of wildlife species.

ACKNOWLEDGMENTS

We thank the National Museum of Natural History, Texas Tech University, Sul Ross State University, Field Museum of Natural History, Texas Cooperative Wildlife Collection, University of Michigan Museum of Zoology, Texas Memorial Museum, American Museum of Natural History, Baylor University's Mayborn Museum Complex, Midwestern State University, Louisiana State University Museum of Natural Science, Angelo State University, Illinois Natural History Survey, and Carnegie Museum of Natural History for allowing access to museum collections. Bill Applegate, Louis Harveson, Jan Janecka, Jimmy Rutledge, and personnel from USDA APHIS Texas Wildlife Services assisted with contemporary tissue collection. Texas Parks and Wildlife Department provided financial support for this project. This represents contribution 2011-124 of the Caesar Kleberg Wildlife Research Institute.

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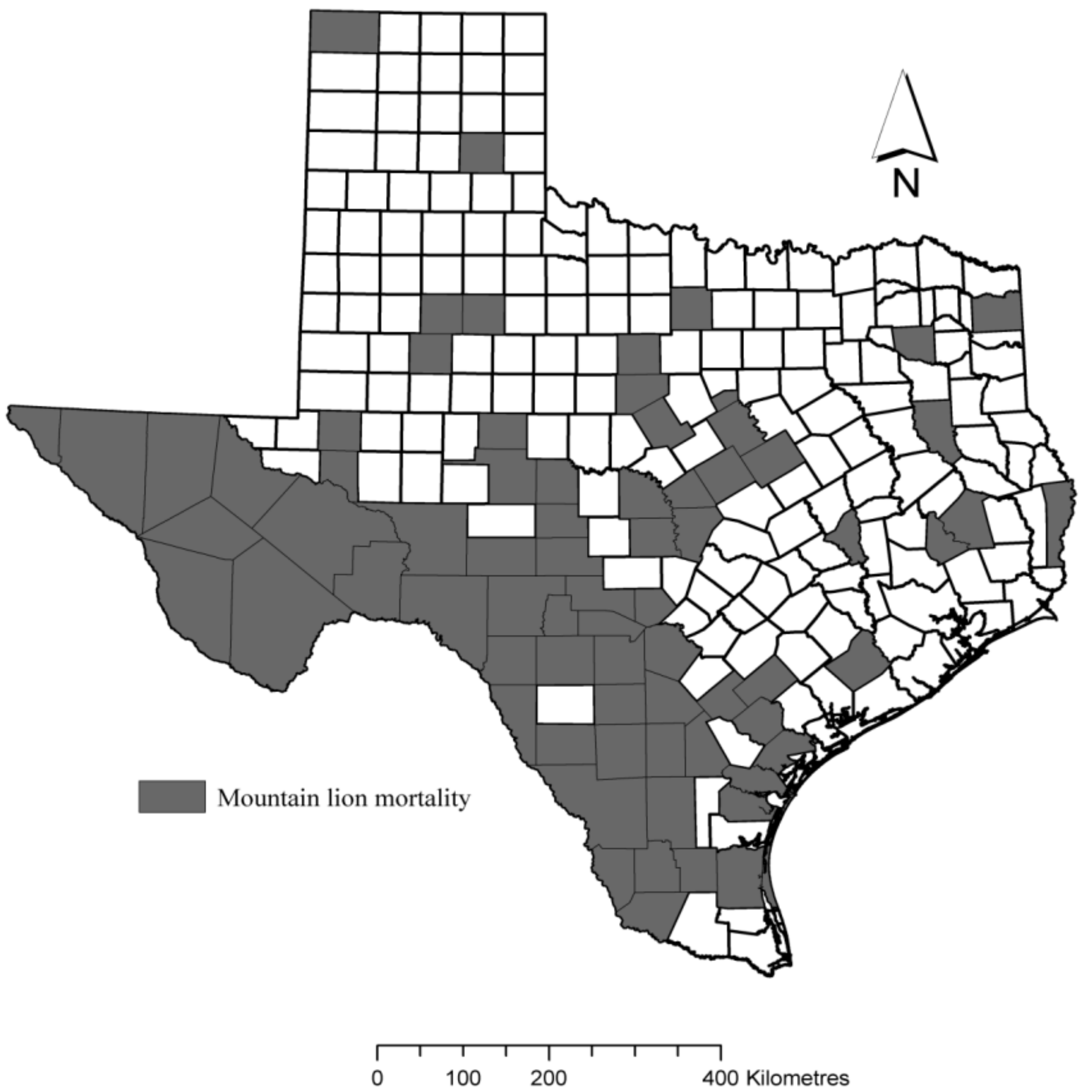

Figure 1. The distribution of mountain lion mortalities reported in Texas, USA, during 1983–2005. Reports were documented by the Texas Parks and Wildlife Department.

Felid Population Segments of Concern, Panel Q & A

Participants and Presentations:

Joe Holbrook (**JH**) - Demographic history of mountain lions in Texas: a genetic evaluation.

Darrell Land (**DL**) – Collateral impacts of increasing Florida panther numbers: dealing with unintended consequences.

Rodrigo Medellin (**RM**) – Jaguars in peril: the next 100 years.

Jim Sanderson (**JS**) – Don't eat the shrimp.

Mike Tewes (**MT**) – Vulnerability of the ocelot populations in the United States.

Mediator: Dr. Melanie Culver, Assistant Professor University of Arizona, and Assistant Leader Arizona Cooperative Fish and Wildlife Research Unit.

(Recorded and transcribed by L. Sweanor)

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1. **Q: What are the impacts of the US-Mexico border fence on the movement of ocelots, pumas and jaguars?**

   RM – I will reiterate some of the findings from our recent Jaguar Recovery Team meeting in Arizona. Yes, the wall has had significant impacts on wildlife, overall. However, because most of it is built along the flat areas of the border and not really in the mountains, it is not affecting the jaguar. The Department of Homeland Security has provided some mitigation for jaguars; however, it is only applied on the U.S. side of the border where there are no jaguars.

2. **Q: What is status of pumas in Mexico? Are they increasing and if so, is there competition with jaguars?**

   RM – We do not have specific data on pumas in most places. However, pumas are in really good shape throughout most of Mexico except around Mexico City. There is a record of a puma going from the northern to the western part of Mexico City on the outskirts. We have found puma sign in all places where we do jaguar surveys. As to linkages, we are still not sure. We may work with Melanie (Culver) on that? Pumas are not experiencing significant threats except in specific locations. Double and single cameras we've been using have allowed us to individually identify 95% of jaguars.

3. **Q: In your educational program for people in Thailand, what are your recommendations for alternate forms of economic development?**
   JS - Prior to industrial shrimp farming, human population densities in small villages were not nearly as high. People were self-sufficient, providing products to local markets. Industrial shrimp farming increased the human population density. It is not our job to provide alternate forms of employment. Our job is one of conservation in dealing with the issues caused by large companies, industrialization and global markets. People had other jobs before they moved into these areas. For example – a few Germans came in and started shrimp farms because it was so lucrative. I don't think we should be providing other jobs (than shrimping). What we'd rather do is shut down the market. I don't understand why don't we have shrimp farms in Louisiana. There (Thailand) we're driving species to extinction; here in the U.S., we can monitor and ensure against that. In Thailand they are creating shrimp farms in former mangrove swamps. It is a profit motive for them to be in Thailand (vs. U.S.); they can make more money there than anywhere else.

4. Q**: Is there still suitable ocelot habitat in other areas of Texas?**
   MT – Yes. But think stabilizing the existing population is the first priority. We formed a subcommittee within the recovery plan to identify possible locations for new ocelot populations. The problems in East Texas included a much higher human density and amount of development. Using South Texas optimal habitat as a baseline, there is not much habitat in East Texas. Historically ocelots were found in most riparian systems but these were the first places to be colonized by pioneers and thus caused the early loss of ocelot populations. We may be able to use areas in Southern Texas as a possible platform for a new population, but this may require putting together a few smaller subpopulations to make an effective metapopulation. In South Texas there are more options.

Follow-up Q: Any GIS analyses been done?

MT – Yes. John Young did 1 modeling effort using genetic algorithms, and the Fish and Wildlife Service has done some mapping.

5. **Q: Can the present Florida panther population reach the 240 recommended for a viable population?**

DL – If you had asked me before we started the genetic restoration if we could have 100-160 panthers in the same area where we had 30-50 beforehand, I would have thought there was no way you could pack them in so densely. Given what's happened, I have to rethink it a little. However, I don't really think we can get to 240. Kitten survivorship is an indication. I think the box has gotten full. The average age of the population has gone down (high turnover) and kitten survivorship is down to 25-30%. I think we can use these accomplishments to help guide us in determining how many panthers other areas will support in a reintroduction effort.

MT – Ocelots – We think the two populations we're aware of are near saturation. There is variation depending on conditions (e.g., drought). The population has declined because of drought. Private lands likely have other ocelots; how many we can only speculate for now. With the formation of a coalition I think we'll have a better answer for that. We are attempting to have natural movements between subpopulations with infrequent intervention to mimic dispersal.

RM – Jaguars –There is very little known about jaguars in comparison to other species. We can't use data at face value and must rely on modeling. But we can use models as indicators to help us determine where we want to focus our efforts. In VORTEX for example, the estimated MVP was 600. But there are hardly any 600 populations of jaguars left in world. There are key variables in model – for example kitten survival. We have no idea what it is. Same for female survivorship and fecundity. But this helps point the way where we need to go in research. Other MVP estimates go as low as 200. We are using this benchmark of 200 animals and not the 600 and feel it is acceptable based on similar estimates for the Florida panther.

6. **Q: Are there regions where we know extremely little about jaguars, considering they have such a large range?**
   RM – In our 2002 book we did a gap analysis. We examined where we know we have jaguars and where we don't. We've made a significant effort to fill the gap over the past 10 years to go look in those areas. The dry scrub habitat in northern Mexico is still a big mystery. How do jaguars survive there? Historically there have been good populations there.

7. **Q: What about using trophy hunting of jaguars as a conservation tool?**
   RM – First I must make a disclaimer. I am an advocate for trophy hunting for purposes of conservation and have done this very significantly with bighorn sheep in northern Mexico for a very long time. Trophy hunting may be a very strong conservation tool. But, in the case with jaguars, there are so few left and such a strong image of the animals everywhere you go. Consequently, trying to put trophy hunting on the table as a conservation tool probably would not work. However, there are some problem jaguars that we have tried to relocate, to get them away from the places where they are causing trouble, and 2-3 weeks later they are back. We need to come to grips with this problem. (To reiterate), the situation presently is not ripe enough to have a decent discussion about trophy hunting because of 2 things: 1) too few jaguars; and 2) strong public image.

8. **Q: Have there been any recent discussions among sports groups to change the status of the puma in Texas to a game animal?**
   JH – There have been 2 panel discussions. One included various interest groups: sportsmen, cattle ranchers, advocacy groups. The consensus there was that individual land owners liked the flexibility of being able to do what they wanted on their land but also didn't want to see pumas wiped out. That was the agreement everyone came to but there was still a lot of conflict. Texas has a lot of privately owned land. Right now those landowners want the flexibility to take care of what they feel is necessary. In a recent panel that took place on campus in South Texas, groups talked about alternatives and future directions. They agreed there was the potential for alternatives, but mainly in South Texas. They agreed they needed to evaluate what was happening in South Texas,

with the possibility there would be changes in just that region, such as reporting harvest or that sort of thing.

MT- It is a very complex, difficult issue. JH was (first) referring to the 1992 Del Rio roundtable. It included a very interesting collection of groups, including every kind of advocate. The only consensus from the 2-day meeting was no one wanted pumas to disappear. I would like to see the development of a management plan with goals and objectives. If we can get to that point, it will dictate what happens after that - whether there needs to be seasons, bag limits, etc. Research is showing that the West Texas population is pretty resilient, probably because of the surrounding populations in New Mexico and Mexico. The South Texas population was probably historically not a large population. The area was mostly grassland 200 yrs ago, and recent modeling by John Young (PhD) shows there is not a lot of good habitat. The puma population there is sensitive/vulnerable. The problem is when you don't collect information on mortalities, which I think we should be doing in South Texas as a minimum, is that you don't have a baseline to use to compare with over time. Landowners do like flexibility and are one of the dominant forces in Texas. However, they can't collectively see the bigger picture about what's going on in the puma population over large regions. That's where the state agency can step up and provide the big picture.

9. Q: Another question on the effects of the border fence, this time for ocelots and pumas along the Texas-Mexico border.

MT – The border fence in Texas is not continuous; it is interrupted in places. In terms of possible effects on ocelots – the impact on ocelots had already been done in terms of creating a disconnect between Mexico and Texas. I don't think much more harm can be done by the fence. In the past 30 years there has been only one instance of an ocelot showing it may have come from Mexico. The exception may be upstream from McAllen. We don't know much about that area. Concerning pumas, I am unsure how contiguous the population is. I'm sure there's ongoing exchange around the Yule Pass(?) and Laredo area. The fence could be a factor for pumas. MT asks JH to discuss the problem in terms of genetics. JH – I definitely think it's a factor and a huge unknown. We need to follow up on this. Development along the Rio Grande to the south of South Texas and the location of South Texas pumas shows they are on the periphery, and from landscape perspective this seems to be creating a pinch from Mexico in. We don't know the frequency of animals moving in but also all the samples we collect are from harvested cats. So they may be moving in but don't know if they are reproducing.

10. **Q: Now that the small population problem (for Florida panthers) is solved (i.e., the "box is full"), are there other reintroduction locations identified? And are you obtaining acceptance?**

DL – Our focus now is north of Lake Okeechobee. Panther breeding is only occurring south of Lake Okeechobee. The Caloosahafchee River drains west out of the lake to Ft. Meyers. South of there is where we documented the presence of female panthers. We know dispersing males will make it north of this point, but not females. We had a male shot southwest of Atlanta along the Alabama border, so the males have great dispersal capability. We consistently see male sign in a fairly large area south of Orlando down to Lake Okeechobee. We are looking at potential habitat there. The Fish and Wildlife Service is looking at projects to secure as much land base as we can. But if asked – "When are we taking females across the river?" We are not there yet. We are doing outreach opportunities now, getting the public ready for having resident panthers. This is a lot different than having dispersing panthers. The magnitude of the problem is much greater, considering the amount of panther food on the properties (domestic, hobby animals) and the larger numbers of people. This is a big challenge and will be a long term project. We are not at a critical point right now; the population won't go extinct in the next 10 years.

Follow-up Q: What about building a bridge across river?

DL – We're not considering it right now. We would need one that's high enough (or a drawbridge) to allow boat traffic. It would be extremely expensive.

Follow-up Q: Back to acceptance – is that your biggest problem?

DL – Twenty years ago we ran a surrogate test, bringing Texas cats into the Okefenokee Swamp - Osceola National Forest area. Chris (Belden's) study showed cats finding food and cover, but also coming into contact with lots of people. The presence of people was the determining factor. The panthers were not accepted! The agency is not anxious to repeat this experiment. Q: Are there identifiable release sites outside Florida? Yes, the recovery team has identified possible release sites outside Florida. But I believe every state that is in historic panther range has said “no thank you” to having panthers. The situation is pretty bleak right now...

End of panel discussion.

Session 5:
Felid Population Monitoring
Wild Felid Research and Management Association (WFA)

Proceedings of the

10th Mountain Lion Workshop

Cougars: Conservation, Connectivity and Population Management

The Puma as an Umbrella Species for Conserving Western Hemisphere Carnivores

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***Abstract*:** A challenge for macroecological studies is collecting sufficient empirical data to study large-scale patterns of distribution or abundance. Comprehensive surveys for presence cannot be conducted at such large scales for most carnivores, including the puma. However, habitat-suitability models were recently developed to estimate the area of occupancy (i.e., presence), rather than just the extent of occurrence, within the geographic ranges of all terrestrial mammals. We used these models to measure the distribution of high-quality habitat within the geographic range of the puma, and evaluate the potential for the puma to serve as an umbrella species for carnivore conservation in the Western Hemisphere. The extent of the puma's geographic range covered a total area of over 22 million km^2, and 75% of that area was high-quality habitat. However, only 6% of this high-quality habitat occurred in protected areas. The puma has considerable potential to serve as an umbrella species. The puma's high-quality habitat overlaps 75 ± 8% (mean ± SE) of the high-quality habitat of 11 sympatric felid species. Puma habitat supports more than double the mean species richness of mammalian carnivores (9.34) than unsuitable puma habitat (4.37). In addition to providing valuable life-history data for macroecological analyses, these models allow species co-occurrence patterns to be quickly estimated at a fine spatial resolution, which has historically been an impediment to evaluating the utility of umbrella species.

KEYWORDS: carnivore, connectivity, cougar, fragmentation, habitat modeling, mountain lion, puma, *Puma concolor*, umbrella species

INTRODUCTION

Macroecology is the study of factors influencing the distribution and abundance of species at large spatial or temporal scales (Brown 1995). One overriding challenge for any macroecological study is obtaining sufficient large-scale data on species' distributions. Although some species, notably birds, can be surveyed at national or continental scales, these data are unavailable for secretive, low-density carnivores like the puma (*Puma concolor*). Consequently, most macroecological analyses of carnivores have been conducted using only coarse information about the distribution of these animals. One distribution metric that is widely used in macroecological studies is the area of the geographic range.

The current extents of all mammalian geographic ranges, including the puma (Figure 1), were recently reassessed and digitized as part of the International Union for the Conservation of Nature's (IUCN) Global Mammal Assessment (Schipper et al. 2008). This map of the puma's geographic range depicts what is known as the extent of occurrence, or the entire area in which the species has been known to occur (Gaston 1991). For the puma, the extent of occurrence is undoubtedly an optimistic estimate of the actual species distribution, primarily because it does not account for the differences in habitat suitability that determine whether an area contains sufficient resources to support a puma population. To better depict the distributions of all mammals, the geographic-range maps produced as part of the IUCN's Global Mammal Assessment were recently merged with expert-based habitat-suitability models (Rondinini et al. 2011). Instead of the extent of occurrence, these habitat-suitability models estimate what is known as the area of occupancy, or the area within the geographic range where the species is likely to be present (Gaston 1991). These new habitat-suitability models are therefore designed to better depict the actual distributions of mammals.

We recently used these habitat-suitability models to measure fragmentation and connectivity within the geographic ranges of all terrestrial carnivores (Crooks et al. 2011). Here we review ongoing work that expands on that study and present some basic but novel information about the distribution of pumas and other sympatric carnivore species (Burdett et al. unpublished data). Our first objective was to measure the proportion of the puma's geographic range that contains high-quality habitat, and determine how much of that habitat occurs within protected areas. Second, we use similar habitat-suitability models from sympatric carnivores to explore the puma's utility as an umbrella species for the carnivore conservation throughout the Western Hemisphere. One of the key impediments to the effective use of umbrella species, which are widely distributed species whose protection is assumed to also protect a large number of additional species, is simply measuring the extent of habitat overlap, or co-occurrence among species (Andelman and Fagan 2000).

Figure 1. The geographic range of the puma (Schipper et al. 2008). This representation of the puma's distribution is an estimate of the species' extent of occurrence.

METHODS

Habitat-suitability models

Rondinini et al. (2011) recently developed expert-based habitat-suitability models for all extant terrestrial and semi-aquatic mammals (*n* = 5315 species). These models assessed habitat suitability at a 300m resolution and were restricted to the area within the updated geographic ranges of mammals (Schipper et al. 2008). Habitat suitability was assessed for four environmental variables (elevation, land cover, human impact, and hydrological features) using the expert opinions (i.e., both numerical and textual data) collected as part of the IUCN's Global Mammal Assessment. The models define three levels of habitat suitability: 1) high, which represents the primary habitat of a species that contains sufficient resources for persistence, 2) medium, which represents the secondary habitat of a species, where presence is possible but persistence is unlikely without nearby high-quality habitat, and 3) unsuitable, which represents places where the species is not expected to be found. The models also depict the area of habitat that occurs within protected areas. Additional methodological details are available in Rondinini et al. (2011).

We used the puma habitat-suitability model to measure the puma's extent of occurrence (i.e., the total area within the boundaries of its geographic range) and estimated area of occupancy (i.e., the proportion of the puma's geographic range that is high-quality habitat). We also measured the proportion of high-quality habitat that occurs within protected areas.

The puma as an umbrella species for felid and carnivore conservation

We also used the habitat-suitability models of Rondinini et al. (2011) to quantify the overlap among high-quality habitat for the puma and other Western Hemisphere carnivores. First, we measured the percentage of overlap between the puma's high-quality habitat and the high-quality habitat of the 11 other Western Hemisphere felids, which are the Andean cat (*Leopardus jacobita*), bobcat (*Lynx rufus*), Canada lynx (*Lynx canadensis*), Geoffroy's cat (*Leopardus geoffroyi*), guigña (*Leopardus guigna*), jaguar (*Panthera onca*), jaguarundi (*Puma yagouaroundi*), margay (*Leopardus wiedii*), ocelot (*Leopardus pardalis*), oncilla (*Leopardus tigrinus*), and Pampas cat (*Leopardus colocolo*). The geographic ranges of all 11 Western Hemisphere felids at least partly overlap with the geographic range of the puma. Second, to assess overlap between the puma's high-quality habitat and other sympatric carnivores, we created a species richness map for all 79 terrestrial carnivore species of the Western Hemisphere and measured the mean ± SD carnivore species richness that occurred in high-quality puma habitat. For comparison, we also measured the mean ± SD carnivore species richness of the unsuitable habitat within the geographic range of the puma.

RESULTS

The area of the puma's geographic range was 22,284,237 km^2, of which 75% (16, 756, 875 km^2) was high-quality habitat (Figure 2). These are the largest values among all carnivores whose distribution occurs only within the Western Hemisphere. Nonetheless, only 6% of the puma's high-quality habitat (1,391,261 km^2) occurred within protected areas.

Between 22 - 97% (mean ± SE = 75 ± 8%) of the high-quality habitat of other Western Hemisphere felids occurred within high-quality puma habitat (Fig. 3). The high-quality habitat of three felid species classified by the IUCN as vulnerable (guigña and oncilla) or endangered (Andean cat) all overlapped the puma's high-quality habitat by over 90%. Adjusting for spatially-explicit patterns of co-occurrence, we found 19 carnivore species was the maximum species richness value among the 79 terrestrial carnivores of the Western Hemisphere. The mean (± SD) species richness of terrestrial carnivores occurring in high-quality puma habitat was 9.46 ± 3.51, whereas the species richness in unsuitable puma habitat was 4.37 ± 4.25.

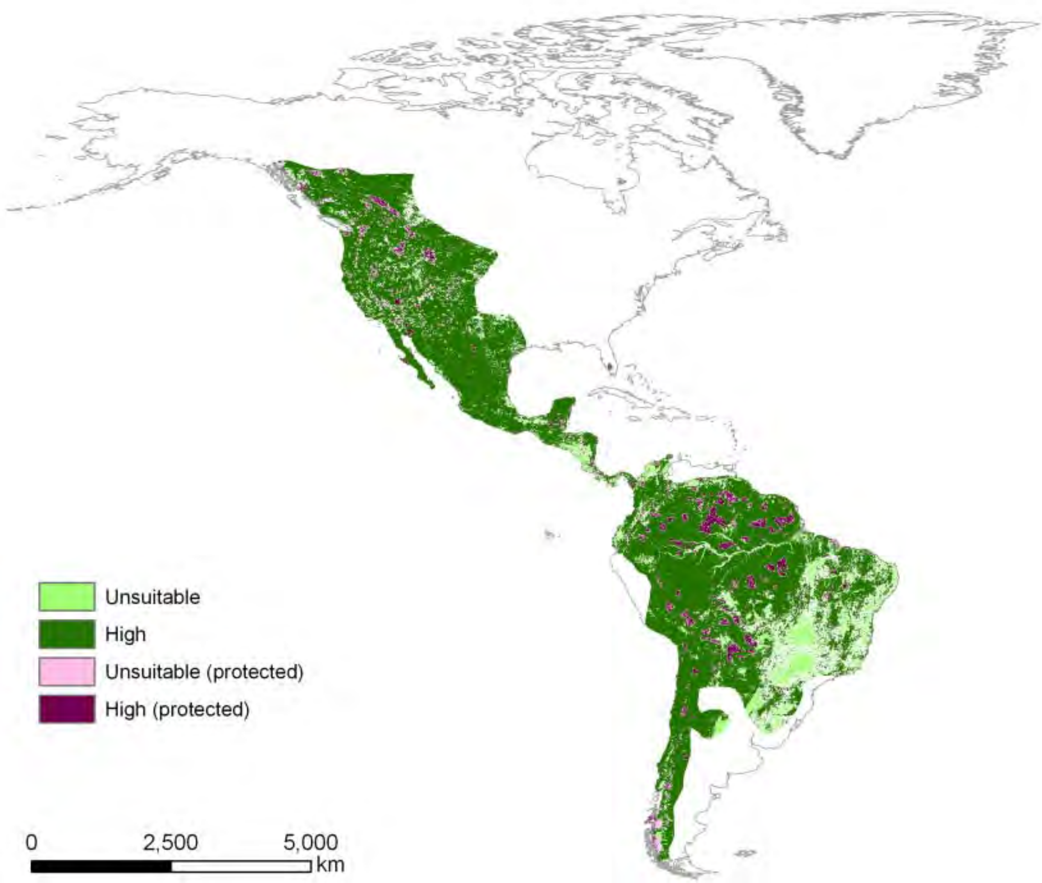

Figure 2. An expert-based habitat-suitability model depicting habitat quality within the geographic range of the puma (Rondinini et al. 2011). This representation of the puma's distribution is an estimate of the species' area of occupancy (Burdett et al. unpublished data).

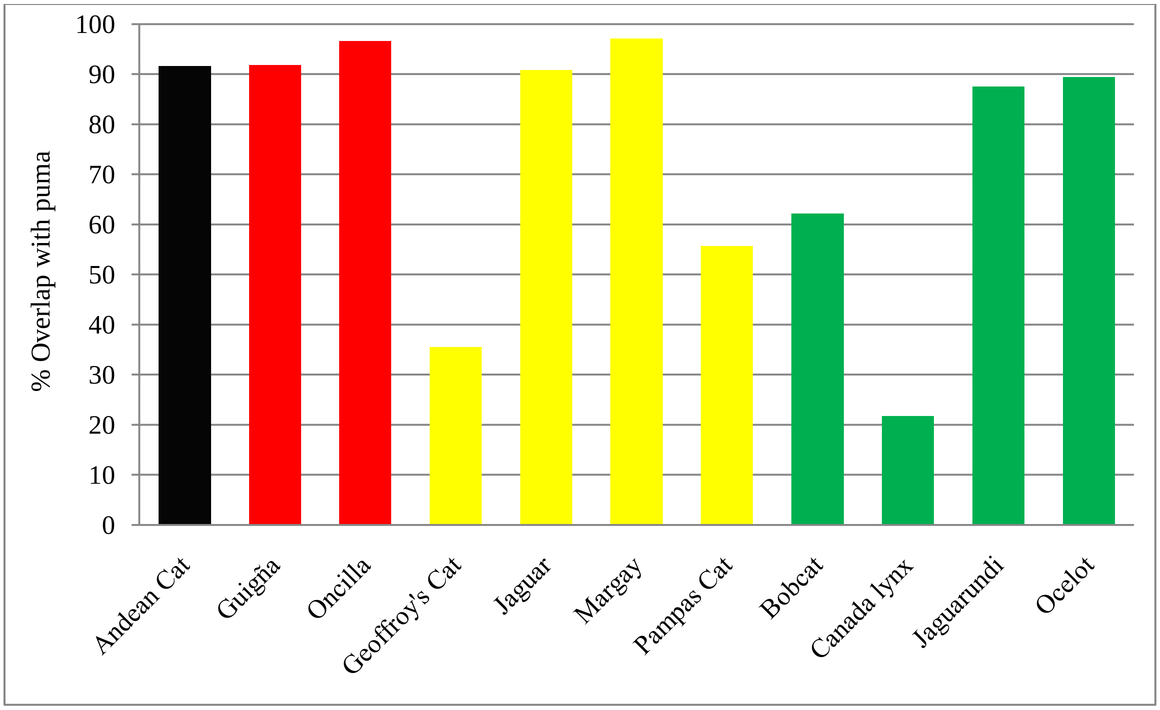

Figure 3. The extent of overlap between high-quality puma habitat and the high-quality habitat of 11 other Western Hemisphere felids (Burdett et al. unpublished data). The color of the bars reflects IUCN Red List Status (black = endangered, red = vulnerable, yellow = near threatened, and green = least concern).

DISCUSSION

The new habitat-suitability models developed by Rondinini et al. (2011) are valuable new tools for depicting the distribution of difficult to survey mammals like the puma (Crooks et al. 2011). Our initial results from this ongoing study show how these models can be used to not only measure the distribution of puma habitat, but also answer basic questions about the co-occurrence of pumas and other carnivores.

The life-history characteristics of the puma meet several of the criteria for effective umbrella species, such as a wide distribution, large home-range size, and high probability of persistence (Andelman and Fagan 2000, Seddon and Leetch 2008). However, a critical impediment to evaluating the potential for umbrella species has been the lack of adequate distribution data to assess species co-occurrence (Andelman and Fagan 2000). The habitat-suitability models of Rondinini et al. (2011) help overcome this problem by providing a better estimate of the area that pumas actually occupy within their geographic range.

The puma has been previously promoted as a flagship or umbrella species for regional habitat-connectivity planning (Beier et al. 2006, Morrison and Boyce 2009). Our results suggest the puma also has value for habitat conservation at larger scales. Specifically, we found that puma habitat overlapped extensively with the habitat other sympatric carnivores. The extensive overlap between the puma's habitat and that of other, more threatened, felid species suggests the puma could have particular value as an umbrella species for the conservation of Western Hemisphere felids. Additional studies will be necessary to corroborate whether the conservation and management needs of pumas actually benefit co-occurring felids or other carnivore species, especially those classified by the IUCN as vulnerable and endangered. Nonetheless, our preliminary analyses suggest that the puma could be an effective umbrella species for conservation planning in the Western Hemisphere.

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Pilot Study on Scat Detection Dogs for Cougar Population Estimation

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Abstract. Estimating cougar (*Puma concolor*) populations is fraught with difficulties because of the cougar's solitary and elusive habits as well as their low densities. Currently, the most accurate estimates for cougar populations involve intensive capturing of cougars to approximate a census. Noninvasive sampling methods are increasingly being used to monitor carnivore populations and offer a less intrusive and more economical alternative over traditional mark-recapture techniques. We are exploring utilizing scat detecting dogs (*Canis familiaris*) to collect scat and estimate the cougar population across a 2000 km^2 study area in northeast Oregon. Beginning this spring, we will take 2 dog teams in the field to determine how many scats can be located per dog team per sampling session. Our study design will then be developed that will accomplish the goals of covering a large area, collect a sufficient amount of scat for unbiased and precise estimates, account for heterogeneity, satisfy closed model assumptions, and be economically feasible. We will explore increasing precision of estimates by using a stratified random sample in which the study area is divided up into high, medium, and low areas of expected cougar densities based on current research in the area. We will explore single and multiple survey sessions in order to meet model requirements. We will test 2 methods of incorporating heterogeneity into capture probability estimates – CAPWIRE, and a generalization of the closed population capture-recapture models. As a result of this presentation, we hope to generate discussion and promote collaboration from other researchers who have dealt with some of the issues addressed above.

Noninvasive Tracking of Jaguars (*Panthera onca*) and Co-Occurring Felids by Combining Molecular Scatology, Remote Camera Trapping and GIS in Belize, Central America

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Abstract: Jaguars (*Panthera onca*), mountain lions (*Puma concolor*) and other elusive felids are extremely difficult to study due to their wide ranging behavior, crepuscular activity peaks, and their occurrence at low population densities. We demonstrate the feasibility of noninvasive research approaches such as scat detector dogs, molecular scatology and remote cameras to study these species and other co-occurring wild felids (ocelot, jaguarondi, margay) across fragmented tropical forest habitats in Belize, Central America. We used the survey techniques simultaneously across 5 study sites from 2007-2010 to gain valuable information on population densities, genetic variation and connectivity of wild felid populations which will ultimately help to assess their conservation status within the country. An initial pilot study helped us to identify the most efficient scat collection and storage techniques for our target species. Furthermore we optimized laboratory methods to amplify 14 highly polymorphic microsatellite loci which are used to determine species and individual ID for all felid scats collected. We also provide several recommendations for scat detector dog work conducted in hot and humid climates. The preliminary results presented here intend to provide an overview of our findings and demonstrate that the techniques used enable large-scale and multiple species monitoring of elusive felids occurring in tropical environments.

The elusive jaguar (*Panthera onca*) is extremely difficult to study due to its wide ranging movements, crepuscular activity peaks and its occurrence in low population densities in often dense forest habitats. It is the least studied of all large cats and as a result, little is known about its ecology. Listed as near threatened (IUCN 2011), some jaguar populations face local extirpation due to habitat loss, fragmentation and direct persecution (Ruiz-Garcia et al. 2006). Due to increased human presence, forest areas have disappeared and/or have been reduced to small, isolated patches. Severe habitat loss and fragmentation has resulted in a more than fifty percent decrease in the jaguar's historic range, and jaguars now exist often in highly fragmented populations spread across Central and South America. Loss of large carnivores has ramifications for biodiversity conservation because these species can have broad impacts on ecosystems. Ecosystems where top predators have been removed have been shown to suffer trophic cascades whereby smaller predators (or prey) increase dramatically in number and, in-turn, decimate their prey which can then result in altering vegetation structure (Terborgh et al. 2001). Additionally, protecting carnivores often requires establishing large reserves that protect substantial biodiversity allowing such animals to function as umbrella species. Jaguars are a species of concern, but our ability to provide for their survival is hampered by our inability to obtain reliable information on the status of their wild populations, which is crucial for successful wildlife management and conservation in the future.

Studying tropical felids often requires physical capture, handling and extensive subsequent monitoring, an approach which is intrusive, expensive, time-consuming, often dangerous, and considering its low sample sizes, not efficient enough to gather information relevant to conservation. Noninvasive monitoring techniques such as remote camera trapping have been developed in response to these inadequacies. Camera-trapping, where wild felids are captured on film and identified by their distinct coat patterns, has provided the first repeatable estimates of densities and sex-ratios for jaguars (Silver et al. 2004). Yet this technique has limitations. It tends to photograph a disproportionate number of males which might result in inaccurate population estimates. Furthermore, due to severe loss and fragmentation of jaguar habitat, there is a great need to study the effects these two major threats may have on wild felid populations and examine whether they suffer from reduced genetic variation or an alteration in population structure, often caused by low levels of gene flow between populations. Severe isolation of entire populations may decrease the genetic variation within the population resulting in lower fitness (e.g. lower survival and/or reproduction) and the loss of adaptive potential (i.e. ability of animals to adapt to a changing environment) (Frankham and Ralls 1998).

Molecular scatology is a relatively recent advancement in non-invasive genetic monitoring, where individuals are genotyped from intestinal epithelial cells found in their feces (scat) (Kohn et al. 1999). This technique is especially suitable for elusive and hard to detect species such as jaguars since scat is a prominent sign the animals leave behind for intra-specific communication and territorial marking. Without ever capturing wild felids and by simply collecting and analyzing their scat samples, molecular scatology is a powerful approach applicable for identification of species, gender and individuals. It can be also used for population size estimation and monitoring (Ernest et al. 2001). Furthermore, molecular scatology also provides the means to analyze genetic variation and population structure of wild felid populations giving insight into genetic health and the degree of population connectivity across the landscape. Molecular population genetics approaches on jaguars are rare (Ruiz-Garcia et al. 2006; Eizirik et al. 2001), and noninvasive fecal genotyping of wild jaguars has only been conducted on a small scale. This project is the first large-scale genetic study which genotypes jaguars across the country of Belize, Central America. A set of 14 highly variable microsatellite primers is used to estimate population size and density, and to determine sex ratio, genetic structure and variability of felid populations on a country-wide scale. Co-occurring cat species such as mountain lion (*Puma concolor*), ocelot (*Leopardus pardalis*), margay (*Felis wiedii*), and jaguarundi (*Herpailurus yaguarondi*) are also genotyped for the same purpose. This study will provide crucial information on the coexistence of these elusive carnivore species. The felids are simultaneously monitored by remote camera traps which allows for a pioneering comparison of density estimates obtained from these two non-invasive techniques in tropical environments.

Finding scat of wide-ranging carnivores can be difficult, particularly in thick tropical vegetation and in a hot and humid climate where feces decompose much faster and the scat DNA has a high potential to show genotyping error caused by allelic dropout, PCR failure, or contamination. Because of these concerns and also due to a lack of an established protocol for locating, collecting, storing and analyzing scat samples of elusive felid species in the tropics, the feasibility of the molecular scatology approach was evaluated during a pilot study conducted in two initial study sites in Belize: the Mountain Pine Ridge Forest Reserve and the Rio Bravo Conservation and Management Area. A scat detector dog (originally bomb/drug detector dog) was used to increase the detection rate of scat samples in the field since professionally trained dogs detect target scats much faster and more successfully than an experienced person searching for scat visually (Long et al. 2007). The scat dog survey was conducted based on an opportunistic search design and simultaneously with the camera trap study within an effective survey area of ~216 km^2. The study areas were superimposed with a grid consisting of 10-13 (4 x 4 km) cells and each cell was searched 4-5 times to create 4-5 encounter occasions for subsequent mark-recapture population density analysis. During the pilot study 375 scat samples were collected. DNA samples can be collected from different locations on the scat which may vary in DNA quality and quantity due to factors such as mold, UV-light, contamination with prey DNA, etc. Thus, DNA amplification success rates from samples collected from four different scat locations (top, bottom, side, and inside) were tested. Also, two different storage techniques, 95% ethanol and DET buffer at 1:4 ratio by volume, which can be both stored under room temperature, were further investigated. The four scat locations differ significantly with highest success rates for DNA samples collected from the often more dry and less moldy top (74.38%) and side (74.88%) locations of scat samples. The comparison of the two storage techniques resulted in significantly higher amplification success rates for DET buffer (68.80%) versus 95% ETOH (49.98%). Based on a large sample size and high DNA amplification success rates (> 70%), we conclude that scat detector dogs and the molecular scatology approach can be successfully applied to survey multiple elusive carnivore species simultaneously in tropical environments.

Belize currently is experiencing widespread land conversion and development, as well as privatization of public lands. The large number of reserves with various degrees of fragmentation and human impacts makes Belize an excellent location to examine the impact of fragmentation on felid distribution, abundance, connectivity and gene flow countrywide. Since dispersal is dependent on geographical and environmental landscape features (Manel et al. 2003), a landscape genetic study will be conducted examining various factors facilitating genetic connectivity. We hypothesize that jaguars living in most northern and southern sites of Belize exist in lower population densities and experience lower levels of genetic connectivity due to the highly isolated protected areas in these parts of the country and a higher degree of human disturbance. We will determine if natural or anthropogenic barriers in the landscape, geographic distance or the degree a heterogeneous landscape facilitates movement drive gene flow in the landscape and cause population structure by testing several hypotheses of landscape resistance (Cushman et al. 2006). Noninvasive genetic sampling combined with landscape genetics techniques will help to identify and map the strongest relationship between the landscape and population structure of felids. This approach provides more insight for conservation and management by identifying potential movement corridors (if needed) for multiple felids across the fragmented landscape of Belize counteracting genetic isolation.

Noninvasive survey techniques such as molecular scatology and remote camera trapping made it possible to study multiple felids noninvasively across Belize and to explore and compare new techniques and types of analysis used for capture-mark recapture (photographic and genetic data), conservation and landscape genetics studies with the main goal to combine results from spatial, genetic and demographic analyses to examine the conservation status of wild felids countrywide. To date, a total of 1190 felid scat samples have been collected in the wild and 160 individual felids (68 jaguars, 56 mountain lions, 29 ocelots and 7 margays) have been genetically identified so far. Compared to previous studies which used only small sample sizes mainly collected from zoos or museums, this project allows us to conduct a population genetic study on multiple wild cat species on a country-wide scale. This information is crucial for future conservation and management actions such as increasing understanding of landscape effects on genetic connectivity of felid populations, identifying local felid populations under threat and establishing corridors between more isolated populations to ensure their survival also in a fragmented landscape. Besides developing and optimizing protocols for molecular scatology and scat detector dog studies in the tropics, the techniques and analysis developed will serve as model system, widely applicable and relevant for the conservation of endangered carnivore species existing in fragmented and changing landscapes worldwide.

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Estimating Detection Probability for Canada Lynx Using Snow-Track Surveys in the Northern Rocky Mountains

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Abstract: During winter of 2006 and 2007, we used snow-tracking surveys to determine the probability of detecting Canada lynx (*Lynx canadensis*) in areas where lynx were known to be present in the northern Rocky Mountains, Montana, USA. We used this information to determine the minimum number of survey replicates necessary to confidently infer the presence and absence of lynx in areas of similar lynx density. In the Purcell Mountains, we sampled a total of 50 survey routes (24 in 2006 and 26 in 2007) for a total of 504 km surveyed over all grid cells. We detected lynx tracks 424 times during the 2 years of sampling. Average survey distance per lynx detection was 0.9 km (SD = 1.2 km, range = 0.02 – 9.1 km, n = 424). In the Seeley Lake area, we sampled 35 survey routes (18 in 2006 and 17 in 2007) and surveyed 371 km total. We detected lynx 130 times during the 2 years of sampling. Average survey distance per lynx detection was 1.8 km (SD = 2.1 km, range = 0.08 – 9.8 km, n = 130). Our track encounter rate averaged 2.9 lynx detections / 10 km of survey distance. The probability of detecting lynx in mountainous habitats that support resident populations was 0.8 – 0.99 when surveys were conducted on an 8 x 8 km^2 grid with 10 km of search effort per cell. Snow-track surveys were highly successful at detecting the presence of Canada lynx over large landscapes. Two survey replicates were needed to establish Canada lynx absence with 95% certainty. The high probability of detection associated with snow-track surveys makes this method useful for documenting populations of Canada lynx in areas where their presence is uncertain.

Conceptual Framework for Estimating Mountain Lion Density with Motion-activated Cameras

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Abstract: Reliable population estimates of wildlife are critical for management and conservation. It is particularly challenging to obtain population estimates of mountain lions due to their secretive nature, inherently low population densities, and wide-ranging movements. Estimates of population characteristics for mountain lions would be especially useful to wildlife agencies in western states that manage hunting seasons on these populations. The goal of this ongoing pilot study was to evaluate whether reasonable estimates of mountain lion density could be obtained with motion-activated cameras to inform future efforts to estimate mountain lion densities across an appropriately broader spatial scale. Our study site consisted of 40 motion-activated camera sites spaces approximately 2-km apart within two 80 km^2 grids, constructed on the Uncompahgre Plateau, CO, for the primary purposes of estimating occupancy of sympatric mountain lions and bobcats and to estimate bobcat density. Using mark-resight techniques in program MARK, we estimated the super population size of mountain lions using our camera grids and then used telemetry data to determine the amount of time that animals spent on camera grids to estimate population density for our grid areas. This mountain lion population has been the subject of an intensive radio-collaring and demographic study since 2004. Over a 3.5 month period during summer and fall 2009, we obtained 80 photographs of lions (51 marked, 29 unmarked) and detected 9 marked mountain lions using our sampling grids. The amount of time spent on grids was calculated for 8 mountain lions wearing functioning telemetry collars and ranged between 8 – 64%. We discuss how these results could inform camera grid designs scaled specifically to mountain lions to obtain better population estimates. These considerations might also be useful for designing camera and mark-resight methods for other species of large solitary-living felids.

KEYWORDS: cougar, density, mark-resight, motion-activated cameras, mountain lion, population estimation, *Puma concolor*

INTRODUCTION

Estimates of population size, density, and trend for mountain lions (*Puma concolor*) have been obtained through intensive telemetry studies (Logan and Sweanor 2001), track surveys (Smallwood and Fitzhugh 1995), and identifying unique individuals based on natural markings using motion-activated cameras (Kelly et al. 2008; Negroes et al. 2010). If a proportion of a mountain lion population consists of marked individuals (e.g., through telemetry collars and/or eartags), motion-activated cameras can also be used to estimate population size using mark-resight techniques (McClintock et al. 2009). Estimates of population size can then be used in conjunction with the amount of time that animals spent on the sampling grid to estimate the density of animals within the grid (White and Shenk 2001).

Our objective is to outline a conceptual framework that can be used to estimate the super population size and density of mountain lions, which is part of an ongoing pilot effort that we conducted on the Uncompahgre Plateau, CO in 2009. The ultimate goal of our work is to demonstrate how reliable population estimates can be obtained through a mark-resight framework to inform future efforts that would conduct similar techniques across a broader spatial extent appropriate for mountain lions. Such information would be invaluable for managing and conserving mountain lion populations, especially those that experience harvest by sportsmen.

STUDY AREA

Our work was conducted in southwest Colorado on the Uncompahgre Plateau to the west of Montrose, CO (Figure 1). The area was characterized by mesas, canyons, and ravines, which supported forests of pinyon pine (*Pinus edulis*) / juniper spp. (western juniper, *Juniperus occidentalis*; Utah juniper, *Juniperus osteosperma*; Oneseed juniper, *Juniperus monsperma*) and ponderosa pine (*Pinus ponderosa*), gambel oak (*Quercus gambelii*) thickets, and big sagebrush (*Artemesia tridentata*) flats. Cottonwoods (*Populus spp.*) occur in riparian areas and aspen (*Populus tremuloides*) stands were found at higher elevations.

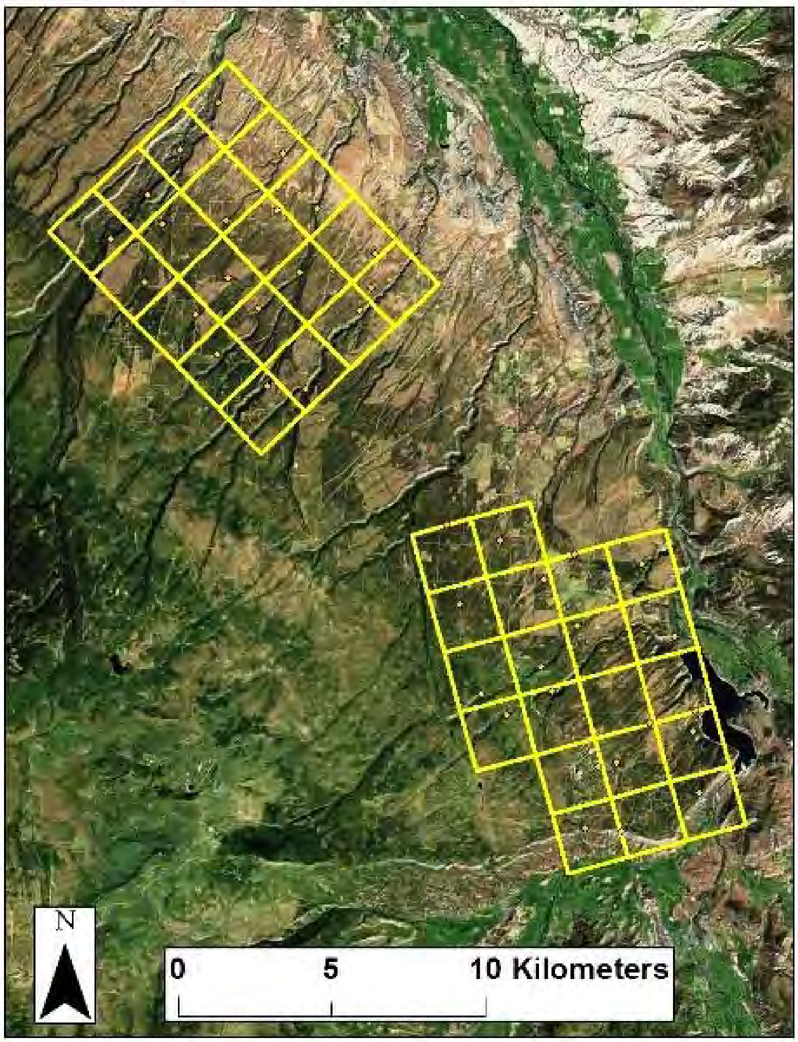

Figure 1. Study area where 40 motion-activated cameras across 2 sampling grids were maintained from 21 August to 13 December, 2009 on the Uncompahgre Plateau of southwest Colorado, USA.

METHODS

Camera Placement

Our study site consisted of 2 grids of motion-activated cameras (Figure 1; area 1 = southern grid, area 2 = northern grid). Each grid was comprised of 20 sampling cells that measured 2 x 2 km. Our grid layout was designed to evaluate the occupancy of mountain lions and bobcats (*Lynx rufus*) and estimate density of bobcats. Within each cell, we placed 1 Cuddeback Capture white-flash motion-activated camera at a site that we believed maximized the opportunity to photograph both mountain lions and bobcats. Cameras were placed along game trails, people trails, and secondary dirt roads where felid sign was observed or in areas that appeared to be likely travel routes for felids. Our sampling was passive in that we did not use attractants (i.e., sight, sound, scent) to lure animals in front of the camera. Cameras were operational from August 21 to December 13, 2009. We visited each camera approximately every 2 weeks to replace memory cards and batteries if necessary.

Marked Mountain Lions

As part of an ongoing research project through the Colorado Division of Wildlife, mountain lions were captured with the use of hounds and cage traps for 5 years leading up to the camera study. Animals were fit with either GPS or VHF collars as well as eartags – we used these marks to assist in identifying individuals. GPS collars attempted a location every 6 hours and animals wearing VHF collars were located via aerial telemetry approximately every 2 weeks.

Estimating Super Population Size and Density of Mountain Lions

To estimate the super population size (number of individuals that used the sampling grids during the period of our camera surveys) we used mark-resight techniques and the Poisson log-normal mixed effects model (PNE; McClintock et al. 2009) in Program MARK (White and Burnham

1999). Assumptions of the PNE model included marking does not affect sightability, unmarked animals are counted as efficiently as marked animals, sampling with replacement, the number of marked animals was known, marked individuals were identified without error, and demographic and geographic closure during the primary interval. These recent mark-resight techniques extend Program NOREMARK (White 1996), where sighting information from marked and unmarked individuals is used to estimate the super population size. To estimate density of mountain lions on our camera grids, we used the amount of time that animals with telemetry collars spent on our grids (White and Shenk 2001). Therefore, our estimates of density are specific to the grid areas and we did not extrapolate our results out to a larger area.

RESULTS

We obtained a photo of a mountain lion at 23 out of 40 camera sites (area 1 = 11 out of 20 sites; area 2 = 12 out of 20 sites). Overall, we documented 80 photographs of mountain lions (area 1 = 39 photos; area 2 = 41 photos), with 50 photographs of marked individuals (area 1 = 17 marked individuals; area 2 = 33 marked individuals).

Nine marked mountain lions were captured with our motion-activated cameras across our 40 camera sites. Four marked mountain lions used area 1 (3 GPS, 1 VHF) and 5 marked lions used area 2 (2 GPS, 3 VHF). Another marked female mountain lion used grid 2, but her GPS collar was not functioning during the camera survey. One male wearing a GPS used both areas 1 and 2. For the amount of time spent on grid, on average, mountain lions spent 12% of their time in area 1 and 30% of their time in area 2. The amount of time spent on grid ranged from 8% to 64% for individual mountain lions.

Analyses for our pilot effort are currently ongoing and being modified; therefore, herein we do not present estimates of the super population size or density of mountain lions in our study. However, when finalized, this information will be presented in a future scientific publication (Lewis et al. in prep).

DISCUSSION

Motion-activated cameras appeared to be an effective method to obtain an appropriate data set to use with mark-resight and time spent on grid techniques to estimate population parameters of mountain lion populations. Although we do not report specific values of our preliminary estimates of super population size or density because our analyses are on-going, our initial results appear reasonable and fall within estimates as reported by previous research (Lewis et al. in prep). For example, Logan and Sweanor (2001) summarized estimates of mountain lion density across several studies and reported that density can range from 1 – 4 individuals per 100 km^2, which is consistent with our preliminary estimates.

While our pilot effort is encouraging in that we were able to demonstrate that both mark-resight and time spent on grid techniques could be effectively applied to our data set to obtain reasonable population and density estimates of mountain lions, our results should only be considered for demonstrative purposes and not used for management of mountain lions. To obtain reliable population estimates for mountain lions we suggest several considerations for future work. First, more cameras should be maintained over a broader spatial extent to better sample the landscape used by mountain lions. Our sampling occurred over 160^2 km and a larger study area is necessary to better sample mountain lions due to their relatively large home range sizes. As a result of sampling over a broader area, more photos of mountain lions would be obtained, thus increasing the sample size for analyses. Second, a greater number of marked mountain lions should be incorporated into the analyses. Nine mountain lions used portions of our 2 sampling grids during our survey; there are between 20-30 individuals with telemetry collars, however, that occur within the larger Uncompahgre Plateau study area throughout the year. Thus, by expanding the grid to a broader extent more animals with telemetry collars would be sampled, which would produce a better estimate for the amount of time that animals spend on the sampling grids. Lastly, the cameras could be run for a longer time period. Our cameras operated for 3.5 months; if cameras were maintained for a longer time period, population size and density could be estimated for different times of the year.

ACKNOWLEDGEMENTS

Funding and support were provided by the Colorado Division of Wildlife, Colorado State University, and the National Science Foundation (NSF EF-0723676).

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Felid Population Monitoring, Panel Q & A

Participants and Presentations:

Chris Burdett (**CB**) – Novel tools for the range-wide conservation and management of pumas.

Greg Davidson (**GD**) – Pilot study on scat detection dogs for cougar population estimation.

Jesse Lewis (**JL**) – Estimating mountain lion density with motion-activated cameras using mark-resight.

John Squires (**JS**) – Estimating detection probability for Canada lynx using snow-track surveys in the Northern Rocky Mountains.

Claudia Wultsch (**CW**) – Noninvasive tracking of jaguars and co-occurring feline species in Belize by genotyping feces and remote camera trapping.

Mediator: Linda Sweanor, President, Wild Felid Research and Management Association

(Recorded and transcribed by L. Sweanor)

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1. **Q: Will you compare your puma mark-resight densities using time-spent-on-grid with other methods to define the survey area, like mean maximum distance moved (MMDM)?**

   JL – We just started doing the analyses. This summer we will compare the estimates to MMDM.

2. **Q: Did you identify individuals based on just ear-tags; did you have dual camera sets?**

   JL – Ear-tags were put in primarily in conjunction with GPS collars. Ear-tags were put in both ears, but sometimes males would rip out one of them. Also, we only had 1 camera.

2b. **Follow-up Q**: How did you consider ear-tagged cats in your data set?

   We looked at different ways of formatting the input file and what we classified as a marked individual. Marked animals either had been or were wearing a radiocollar and had ear-tags.

When Ken (Logan) visited nurseries and marked kittens, he would put an ear-tag in 1 ear (and often an expandable radiocollar that fell off prior to independence). We got at least 1 photo of a subadult with an ear-tag. We classed this as an unmarked individual. An assumption of these models is that you know the number of marked individuals on the camera grid. There could be a number of subadults with or without ear-tags running around; we wouldn't know how many. We do know the number of radiocollared individuals.

3. **Q: Many of these non-invasive surveys are done on a relatively small area and likely individuals roam well beyond the area surveyed. Is this a problem?**

   CW – I haven't started my analyses yet. I will be using a couple of different mark-recapture analyses types. We have done some preliminary capture /mark analysis. Especially for scat analysis I didn't feel the MMDM way to estimate the study area was the best way to do it. Plus, I believe some of the new Spatial Explicit (SE) models would account for temporal animals coming in and out. So that's what I'm hoping to do. With scat and cameras we've seen cats come in once and we never detect them again. Many of these may be males. I hope the SE model will account for this. Haven't started; ask me again in a couple of months.

4. **Q:** (by Jim Sanderson) **–** [Mentions that he had a camera trap study in Surinam over a 3.5-year period with 35 paired cameras running 365 days per year. There were 5 cat species, but jaguars could be identified to individual. The individual jaguars we identified were in the high 40s with over 1700 total jaguar pictures.] We observed so many because there were no people in the area. We found a constant flow of floaters. So, over any 2-month period we had about the same number of pictures of floaters and residents. But by running the cameras year

after year we could identify the residents. **If you run the cameras for only a 2- to 3-month period how do you know who is a floater and who's a resident? And what's the population density?** You use all the pictures in the mark-recapture program and it spits out a number.

JL – For unmarked individuals, that's a great question. By incorporating the information for the amount of time spent on grid for the marked pumas, we are assuming that is a representative sample for the population. Potentially we would group all adults (marked, unmarked) and subadults. We didn't include kittens. If you have an expert you can probably identify adults versus subadults in the camera data. This is one way to have more confidence that you are identifying residents. Subaduuts (versus adults) are most likely the ones that are passing through.

4b. **Follow up Q by JS**: I noticed that residents can shift their home ranges over years.

JL - Sure. That was something we struggled with: time spent on grid. Jake Ivan, who finished his PhD on snowshoe hares at CSU, tagged and released hares, then used telemetry locations to determine time spent on grid. For this effort we decided to use only the 3.5-month period that cameras were operational.

4c. **Follow up Q**: Did you think the spatial extent of the grid was appropriate for pumas? Also, would it have been more appropriate to run the grid during winter when puma home range sizes would be smaller?

JL – We were focusing on bobcat and puma. We found it appropriate for bobcats (we also put GPS collars on the bobcats). In some cases the bobcat's entire home range fell within the grid. For puma – it was not appropriate; it wasn't large enough. We're just providing this information for future studies. It should have a broader extent. The numbers we obtained for pumas should also not be used for management purposes. We just wanted to put the technique out there. We think there is a lot of potential for mark-resight models to be used with puma camera data, but there's a lot of work to be done. Definitely need a larger scale. As to your second question about winter… I don't have good answer. I think it would be good for future studies to consider a more robust design where you look across seasons. There are also constraints in winter, for example cameras operating properly and batteries lasting in the cold.

5. **Q: Have you evaluated multiple techniques for determining density?**

   CW – We did genetics (from scats) and the cameras, and have started some comparisons. We want to compare density estimates. We used CAPTURE to analyze our data. So far we have gotten slightly less cats (lower density) with genetics but it hasn't been significantly different. But the effective survey area was calculated using the ½ MMDM which may not work well with the genetics (cat-dog work). Effective area is hard to calculate based on scat work. I am hoping to do the comparison with the Spatial Explicit models. We actually should have comparisons ready in a couple of months.

6. **Q: (by Darrell Land). Can work conducted at broad regional and global scales utilize the population estimation techniques that people are using in local-scale study areas?**

   CB – I think it certainly could. When you compile home range estimates you run into all the different techniques that have been used to calculate them. This is certainly the case with density estimates. However, on a regional scale it doesn't really matter. It is more accepting of error in the data. We can put it in and use that instead of presence-absence or ask how density might vary relative to habitat suitability - plugging those in would be very interesting to do. I'm not sure how much that's been done. It's a very simple thing to do.

Later (after the Q&A), **CB** stressed that a complied list of density estimates would be more useful for model validation rather than prediction. He thought that we will likely never have enough abundance/density estimates with which to build a broad-scale model. In hind sight, he said a better answer might have been to turn the answer around and explain that broad-scale models can help camera trappers find key places to conduct new studies. Specifically, working in areas where connectivity is poor, low to medium density populations, etc. Camera traps are almost always done in areas where populations are relatively high and secure. While it is certainly hard to justify funding work likely to find few cats, it is important to know more about such areas of conservation concern.

7. Q: Can you get distribution and density information from snow-tracking?

JS – I can't give a formalized p value associated with that. I'm basing this on my experience both in Colorado and Wyoming where we were able to detect single individuals really effectively. In Colorado we did a real survey trying to detect the number of lynx in the Vail Pass area; we knew what was there because of telemetry. In the Wyoming Range in Wyoming we had a single marked individual and we think that was it. I think lynx are extremely visible, like wolverines. They are highly mobile. And a formalized grid based track surveys is a powerful way to delineate local distributions and densities.

7b. **Follow-up Q**: how useful are snow-track surveys in population estimation?

JS – They can certainly be used in a mark-recapture framework. We did this with wolverines; we used a mark-recapture estimate in the Southern Island Ranges of Montana that was a truly genetic-based snow-tracking effort where we had marked individuals for research. Our recapture was based on snow tracks and taking DNA off of snow tracks. In that context it was a true population estimator.

We've been using it mainly to delineate distributions just as a presence on-off.

Session 6:
Corridors, Habitat Use and the Urban Interface

Proceedings of the

10th Mountain Lion Workshop

Cougars: Conservation, Connectivity and Population Management

FUNCTIONAL CONNECTIVITY FOR PUMAS IN CENTRAL MEXICO

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Abstract: The transformation of natural habitat through human pressures results in the reduction and isolation of natural areas making them not suitable for maintaining viable populations of large carnivores, such as pumas, because dispersal is affected by the loss of connectivity between habitat patches. Consequently, the identification of corridors through a least-cost path analysis (LCPA) is an important tool to understand landscape permeability and dispersal for this felid. Sierra Fria, located in the State of Aguascalientes, is a natural protected area surrounded by a highly human-impacted landscape, conditions favorable for studying the effect of isolation and test models of LCPA for puma populations in Mexico. Our objective was to identify least- cost paths between protected natural areas and verify their use by cougars. Through the creation of a Geographic Information System (ArcGIS 9.3 and Corridor Design), a model for puma habitat was created to connect Sierra Fria-Sierra de Laurel and Sierra Fria-Sierra Morones. Currently, validation in the field used semi-structured interviews with the local inhabitants within and around corridors, to identify sites where the puma has been documented. Habitat characteristics in the study area indicate 35% is suitable habitat for puma. On this basis, we identified three potential corridors for the movements of pumas in the Sierra Fría and surrounding mountains, which are not entirely protected. Corridors are located south, southwest and northwest of ANP Sierra Fría, with a length of 3.60, 35 and 44 km, respectively. Of the 86 interviews conducted, 25 verified cougar presence in the first corridor, 29 in the second, and 12 in the third, while the remaining (*n*=20) failed to detect it in places with high human impact. It requires the protection of natural areas with high habitat quality and connectivity to promote stability and long-term survival of populations of cougars in central Mexico and the rest of its distribution.

KEYWORDS: *Puma concolor*, Central México, Connectivity, Fragmented habitat

The transformation of natural habitat through human pressures results in the reduction and isolation of natural areas, making them unsuitable for maintaining viable populations of large carnivores with a wide distribution, such as pumas (Sepúlveda, et al. 1997; Crooks and Sanjayan, 2006). Large carnivores are directly affected because the movement of any species between patches may restrict the access to unevenly distributed resources, consequently increasing their home range size, which can in turn increase the energy cost for individuals (Jones, 2004). As distance between patches increases, movement between patches becomes hazardous, increasing mortality risk or express different patterns of movement as small quality patches are hard to find (Kindlmann and Burel, 2008). As a consequence, species such as carnivores only survive within a network of habitat patches that remain connected and local extinctions become common (Beier and Noss, 1998, Collinge, 2009).

The puma (*Puma concolor*, Linnaeus) had one of the widest distributions for any mammal in the Americas; currently the re-colonization of former areas where it occurred has been limited because of the loss of connectivity between patches of habitat. Connectivity is defined as the degree to which the landscape facilitates or impedes movement of organisms between habitat patches (Ferreras, 2001; Rothley, 2005; Kindlmann and Burel, 2008), and is not only dependent on the characteristics of the landscape (structural connectivity), but also on the mobility of organisms (functional connectivity) (Crooks and Sanjayan, 2006).

Habitat loss and fragmentation hinders puma dispersal. As distance between patches increases and landscape connectivity is reduced, gene flow also decreases (Broquet, et al. 2006). Consequently the identification of travel corridors will help us to understand the landscape connectivity for pumas, as they facilitate long-distance movements (LaRue, 2007).

One way to determine dispersal corridors is through a least-cost path analysis. This tool has been used to explain landscape permeability and dispersal for several species. This analysis measures the effective distance between patches of habitat to determine the connectivity of landscapes or reserves (Rothley, 2005). This is important because protected areas should be able to maintain populations of species with large home ranges and allow connectivity to support genetically viable populations (Crooks and Sanjayan, 2006; Sepulveda, et al. 1997).

Least Cost Path Analysis (LCPA) models the relative cost for an animal to move between two areas of available habitat. This technique uses landscape features (such as land use, human population density, roads) and how those features affect the movement path of an animal (LaRue and Nielsen, 2008). This model is developed through a Geographic Information System (GIS), where each cell is assigned a cost value based on various environmental factors that impede or facilitate movement (Crooks and Sanjayan, 2006). The model creates the most likely travel route with the least resistance and shortest distance between two areas of available habitat (LaRue, 2007).

Central Mexico provides a good opportunity to develop and test such models, as the landscape is highly fragmented with isolated populations of pumas subject to anthropological pressure. To test the LCPA model we selected an area encompassing portions of the Mexican States of Aguascalientes and Zacatecas. This area includes three natural protected areas with reduced to no connectivity due to habitat loss. Our aim was to identify least-cost paths between protected natural areas and verify their use by pumas.

STUDY AREA

This study was carried out in central Mexico, on sites adjacent to Sierra Fría and two other protected natural areas (PNA), including portions of the states of Aguascalientes and Zacatecas. The evaluation was carried out on intermediate sites to the northwest, between Sierra Fría and Sierra Morones PNA, and south, between Sierra Fría and Sierra del Laurel PNA (Figure 1). The study area has a temperate arid climate with summer rains. Precipitation ranges from 500 -800 mm with temperatures of 14-22 ° C, The site consists of a system of intermountain valleys surrounded by mountain ranges, deep canyons and mesas (INEGI, 2005).

The vegetation types include oak forest, pine-oak forest, tropical deciduous forest, grasslands and agricultural. Oak species *Quercus eduardii*, *Q. laeta* and *Q. potosina*, occur with juniper (*Juniperus flaccida*) or pinyon pines (*Pinus cembroides*). There are also tropical species such as *Ipomoea intrapilosa*, *I. murucoides, Bursera bipinnata, Heliocarpus terebinthinaceus, Acacia pennatula, Acacia farnesiana, Tecoma stans, Eysenhardtia polystachya, Opuntia fuliginosa* and *Mimosa monancistra*. Shrubs include *Arctostaphylos pungens*, *A. polifolia*, *Arbutus glandulosa* and *A. arizonica*). Mammalian species include white-tailed deer (*Odocoileus virginianus*), bobcat (*Lynx rufus*), gray fox (*Urocyon cinereoargenteus*), coyote (*Canis latrans*), white-nosed coati (*Nasua narica*), raccoon (*Procyon lotor*), ringtail (*Bassariscus astutus*) and collared peccary (*Tayassu tajacu*) (Biodiversidad del Estado de Aguascalientes, 2008).

Human activities have changed the landscape in the study area to satisfy the demand for food, timber, and combustibles; of added importance are rain-fed or irrigated agriculture and livestock grazing. The tropical deciduous forest is subject to deforestation from logging and agave plantations for tequila (Biodiversidad del Estado de Aguascalientes, 2008). Several two-lane highways occur between mountain ranges and protected areas both in Aguascalientes and Zacatecas (INEGI, 2005).

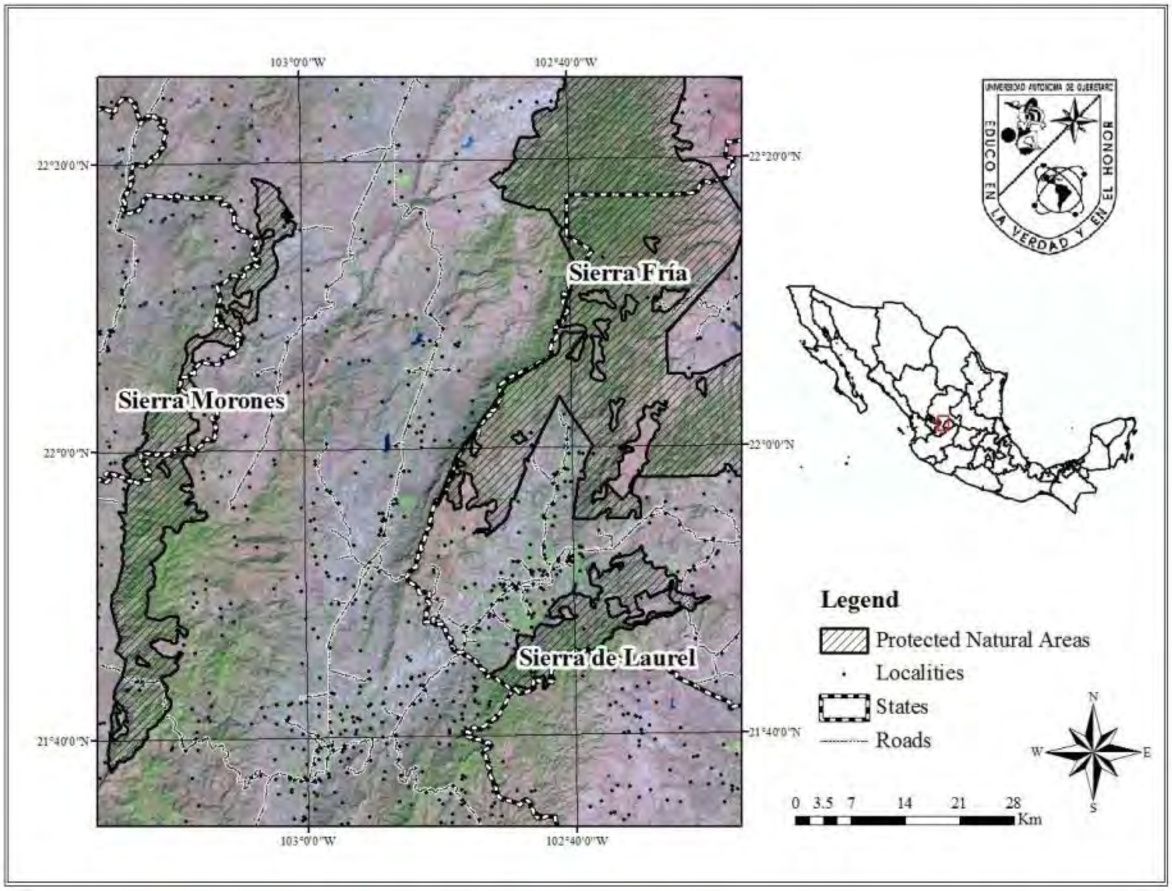

Figure 1. Protected Natural Habitat in Central Mexico, separated by the high human impact on the intermediate valleys.

METHODS

This research was developed in three phases. The first was to make a suitable habitat model for pumas in the study area, followed by a least cost path analysis model, (Beier, et al. 2007 y Majka, et al. 2007) using ArcGis 9.3 and toolbox Corridor Design. Ground truth in the field of the model was performed after.

Habitat Suitability Model

The habitat variables used for the model were topographic position, elevation, land use and vegetation, distance to roads and human population density (Riley and Malecki, 2001; Dickson and Beier, 2002; Meegan and Maehr, 2002; Dickson, et al., 2005; Dickson and Beier, 2007; Schwab, 2006; Monroy-Vilchis, et al., 2007; Moye, 2007; LauRe and Nielse, 2008). We classified each variable in sub variables based on the characteristics of the landscape in the study area (Table 1). For the sub variables of topographic position was used a digital elevation model (INEGI, 2010), where pixels were classified as follow: *Bottom of the Canyon:* If the pixel has an elevation of at least 12 m lower than the average of neighboring pixels. *Top of the Ridge:* If the pixel has an elevation at least 12 m higher than the average of neighboring pixels. *Gentle Slope:* If the pixel has a slope less than 6 °*Steep Slope:* If the pixel has a slope greater than 6 ° (Dickson and Beier, 2007).

Table 1. Classification of habitat variables with their respective value of permeability (cost) and score importance of each variable to potential cougar habitat suitability (weight) in central Mexico.

Topography (25%)	Cost	Elevation (15%)	Cost	Distance to Roads (m) (5%)	Cost	Population Density (per/Km^2) (5%)	Cost	Land Use and Vegetation (50%)
Bottom of the Canyon	80	1300-1800	70	0-500	40	0-20	80	
Gentle Slope	50	1800-2100	80	500-1000	60	20-50	60	
Steep Slope	70	2100-2500	90	1000-3000	70	50-100	40	Table 2
Top of the Ridge	100	2500-3100	100	3000-6000	90	100-300	30	
				6000-25000	100	300-700	20	
						700- >1000	10	

The classification of the sub variables of distance to roads was done using Euclidean distance, while the human population density was obtained through Kernel Density tools. The sub variables of land use and vegetation were obtained from the layer series III generated by the National Institute of Statistics and Geography (INEGI, 2005), where a numerical value was assigned to polygons with the same type of vegetation (Table 2).

Table 2. Sub variables of land use and vegetation present in the study area.

No.	Land Use and Vegetation (50%)	Cost
1	Primary Vegetation of Pine Forest	80
2	Primary Vegetation of Pine-Oak Forest	90
3	Primary Vegetation of Oak Forest	100
4	Primary Vegetation of Oak-Pine Forest	100
5	Primary Vegetation of Crasicaule Scrub	60
6	Primary Vegetation of de Mezquite Desert	10
7	Primary Vegetation of Natural Grassland	50
8	Secondary Vegetation Arborea of Oak Forest	90
9	Secondary Vegetation Shrub of Oak Forest	100
10	Secondary Vegetation Shrub of Crasicaule Scrub	50
11	Secondary Vegetation Shrub of Mezquite Forest	10
12	Secondary Vegetation Arborea of Mezquite Forest	10
13	Secondary Vegetation Shrub of Mezquite Desert	10
14	Secondary Vegetation Shrub of Natural Grassland	40
15	Secondary Vegetation Shrub of tropical deciduous forest	70
16	Induced Grassland	10
17	Temporary Agriculture	30
18	Irrigated Agriculture	20
19	Water Bodies	20
20	Human Settlements	10
21	Urban Area	10
22	Secondary Vegetation Shrub of Tascate Forest	10
23	Secondary Vegetation Shrub of Pine-Oak Forest	10
24	Secondary Vegetation Shrub of Oak-Pine Forest	10

Once classified, each sub variable was assigned a value of habitat availability which was determined from a literature review of puma habitat requirements where: Suitable habitat (80 to 100), suboptimal habitat (60 to 79), occasional use (40 to 59) and unsuitable habitat (< 39). Likewise, we assigned a weight to each variable, with a greater preference for high representing the puma. The weights must equal 100% (Beier, et al. 2007).

To create the model we used the tool HSM 1-*Create habitat suitability model* in the toolbox Corridor Design, which combines and reclassifies two to six different habitat factors based on their availability. This was done using the geometric mean algorithm, to obtain a single availability value for each pixel.

$$\text{Permeability} = \Pi\ (Sn^{Wn})$$

Where each Sn is the cost score for variable n, Wn is the weight for that variable and Π mean "multiply the n terms". Once generated, the model calculates the percentage of suitable and unsuitable habitat for the puma in the area of study.

Least – Cost Path Model

This model was generated in two phases. The first was between Sierra Fría PNA and Sierra del Laurel PNA, while the second was to the Sierra Morones PNA. For this, we used the tool *Create corridor model* of the toolbox Corridor Design. We established as the connecting habitat block the polygons designed by the National Commission of Protected Natural Areas (CONANP). Also for each interaction, was used as a base model suitable habitat (map of permeability), which was created a cost raster (map of resistance), which associates the favorable habitat with lower pixel values and thus, lower cost of movement across the landscape. The model generates a corridor with 11 bands of different permeability percent (0.1, 10 to 100%), where permeability ranges from high (0.1 %) to low (100 %). The bands with higher permeability were characterized to obtain length, area, percentage of suitable and unsuitable habitat, road length and narrow points of the corridor, taking into account a threshold of 500 meters (Beier, 1995).

Field Validation

For corroboration of the model, semi-structured interviews were conducted with the inhabitants of towns located within and outside the corridors, considering only those with more than 50 residents and people over 25 years, preferably peasants, because they are more in contact with the environment. We were particularly interested in determining those areas involving puma sightings, and spoor (tracks, scats and scrapes). As a test to assess the reliability of the sighting a plate that included several species of Mexican and African felids was shown to any interviewed person. Of the information gathered, analyzed the frequency, distance to the towns, and season in which they have been observed. For different puma records were considered records obtained in both interviews and collected by biologists from the University of the State of Aguascalientes.

RESULTS

Habitat Suitability Model and Least-Cost Model

The model developed included 35% of good quality habitat for the puma, concentrating mainly on protected areas, while 65% was not adequate (Figure 2). We generated a cost raster for each interaction (Figure 3A, 3B) and detected three least-cost paths for the puma. One was south of the Sierra Fría NPA and two were north-west of this location. The first two corridors were detected at the minimum permeability percent (0.1%), while the third was at 60%; this is because it has a greater distance (Figure 4). Of the three corridors, the least distance and best quality habitat was between Sierra Fría-Sierra de Laurel PNAs (Table 3). The second corridor, Sierra Fría-Sierra Morones, had greater distance and reduced quality of habitat, as almost half of it was very narrow and comprised of unsuitable habitat. Because of this, we considered an adjacent strip of permeability (10%) as part of the corridor, resulting in a wider corridor with more area and higher habitat quality. The third corridor was longer but had better quality of habitat. It was also very narrow, so we again considered a second strip of permeability (70%) as part of the corridor (Table 4). The amount of unsuitable habitat in this corridor increased and was distributed along the corridor as small patches within a matrix of suitable habitat.

Table 3. Habitat characteristics of each corridor. LCP = Least – Cost Path, C1= corridor 1, C2= corridor 2, C3= corridor 3.

LCP	Permeability (%)	Length (Km)	Area (Km^2)	Suitable Habitat (%)	Unsuitable Habitat (%)
C1	0.1	3.60	12	86	14
C2	0.1	35	13	59	41
	10	31	123	86	14
C3	60	44	38	91	9
	70	43	77	88	12

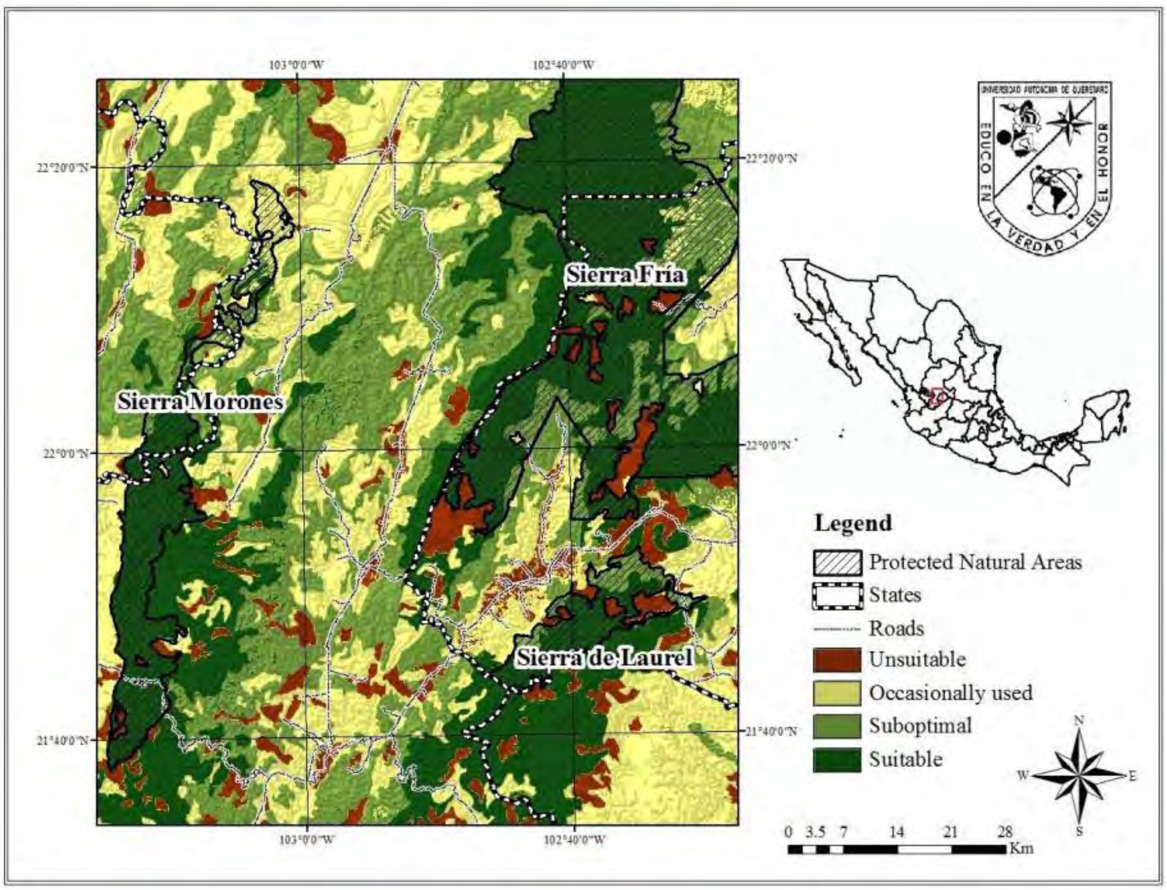

Figure 2. Habitat Suitable Model. The green areas are high quality habitat for cougar and brown are areas of high human impact.

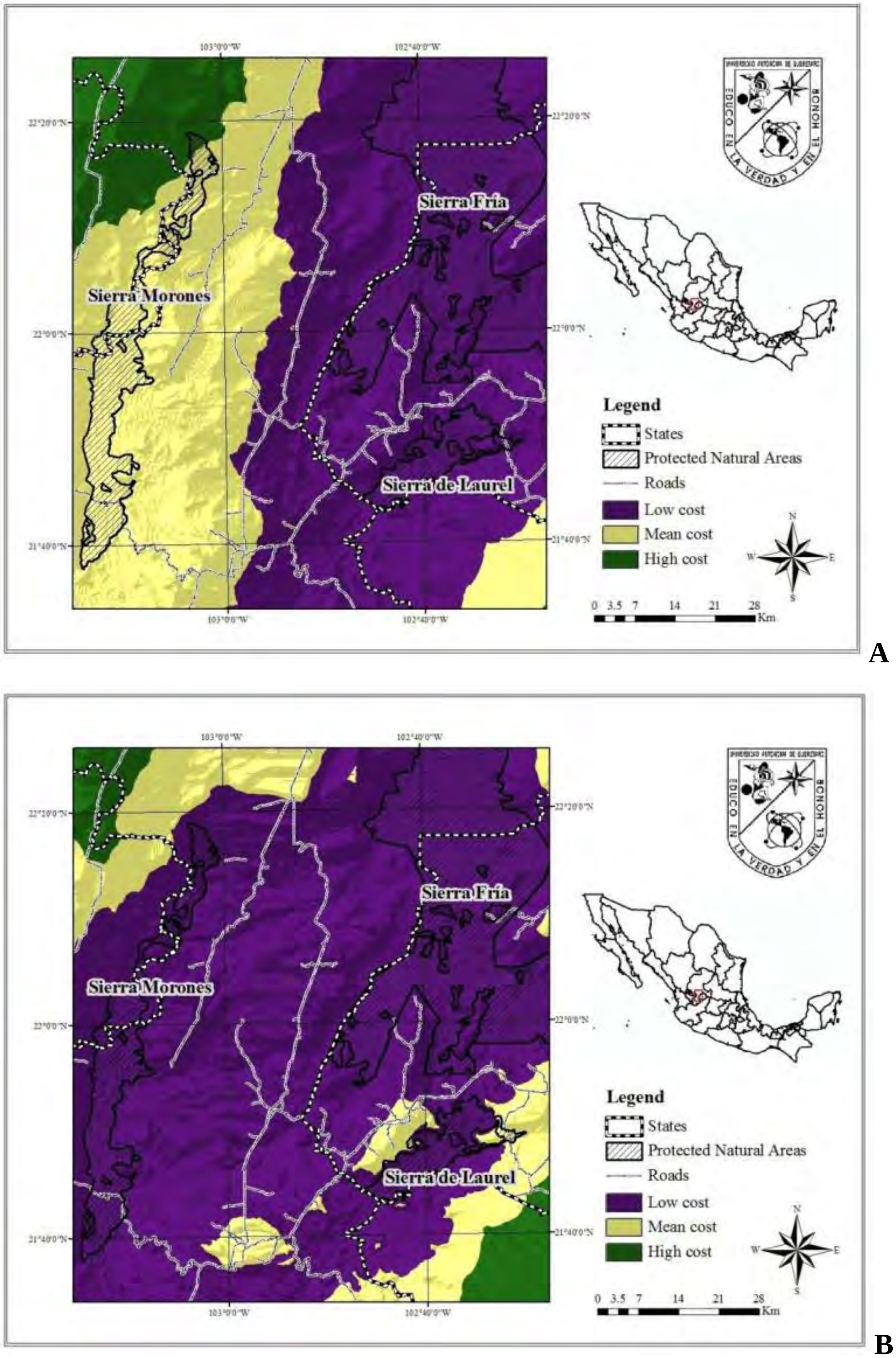

Figure 3. Cost Raster. A) Interaction between Sierra Fría PNA to Sierra del Laurel PNA. B) Interaction to Sierra Morones PNA.

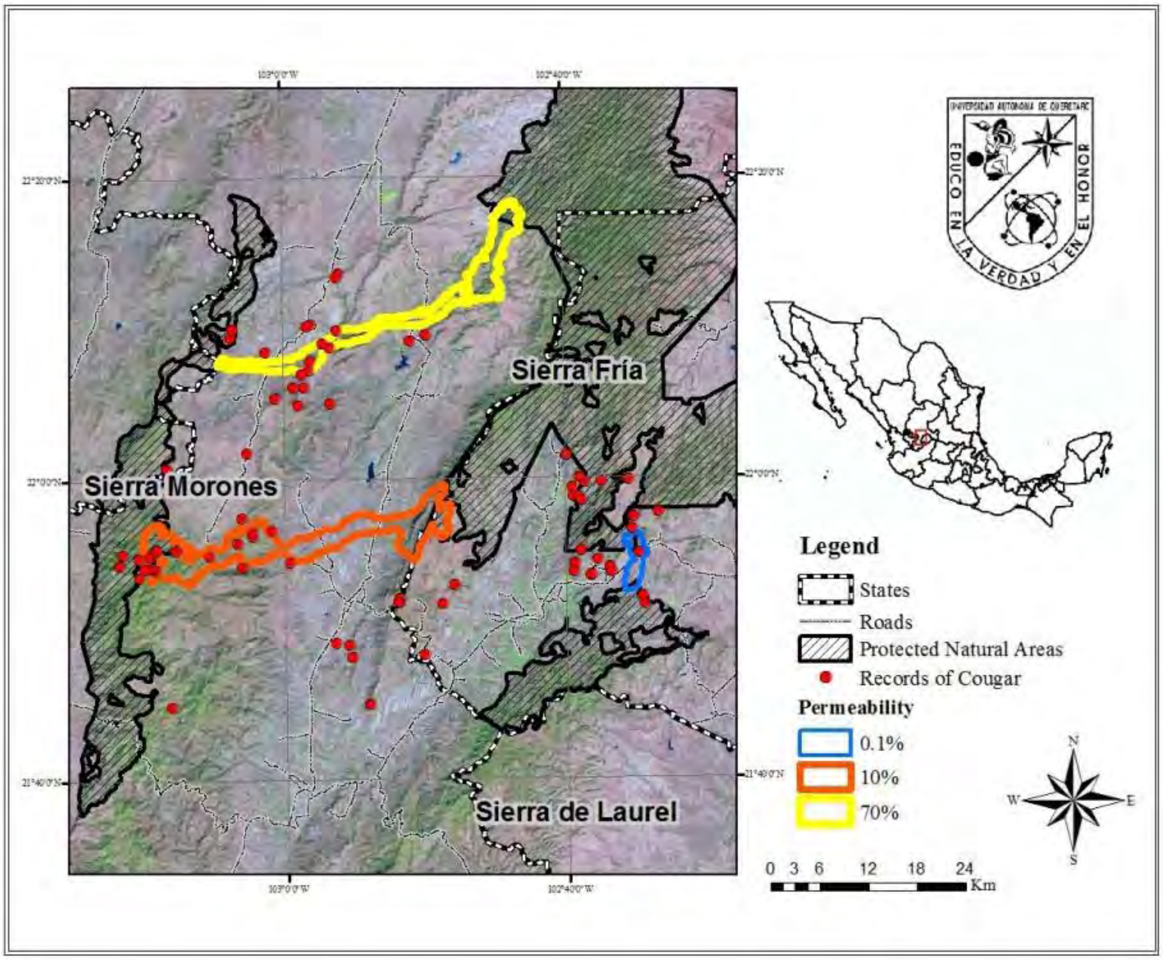

Figure 4. Least- Cost Paths with different permeability percentage between protected areas where puma presence was detected from records obtained by biologists and through interviews.

Table 4. Statistics narrow points of each corridor with different permeability percentages. NSA and NSB = Narrow Spot Above and Below the threshold (500 m).

Statistic	C1	C2		C3	
Permeability (%)	0.1	0.1	10	60	70
NSA (%)	100	13	100	73	100
NSB (%)	-	87	-	27	-
Minimum Width*	1.02	0.07	0.67	0.11	0.49
Maximum Width*	1.87	0.77	3.96	1.51	3.36
Mean Width*	1.53	0.33	2.02	0.67	1.23
Standard Deviation of Width*	0.26	0.14	0.59	0.27	0.57

*Km

The three corridors are traversed by a two-lane federal highway, where the highest traffic flow occurs during the day. However, the corridors linking the Sierra Fría PNA with Sierra Morones PNA are also crossed by a municipal road (second corridor) and two state roads (third corridor), which have low traffic flows (Table 5).

Table 5. Length of roads crossing least-cost paths for pumas between natural protected areas.

LCP	Permeability (%)	Roads	Length (Km)
C1	0.1	Libre Federal Ags. - Jalpa	1.89
C2	0.1	Libre Federal Gdl. – Zac.	0.39
		Libre Municipal Ramal-Cosalima	0.32
	10	Libre Federal Gdl. – Zac.	1.95
		Libre Municipal Ramal-Cosalima	2.77
C3	60	Libre Federal Gdl. – Zac.	0.84
		Estatal Ramal-Joaquín Amaro	0.69
	70	Libre Federal Gdl. – Zac.	1.72
		Estatal Ramal-Joaquín Amaro	1.48
		Estatal Libre Ramal-Col A. López Mateos	0.40

Field Validation

We surveyed a total of 50 localities and obtained a total of 86 interviews, where 76.9% verified puma presence. Of the total interviewed, 25 verified puma presence in the first corridor, 29 in the second, and 12 in the third, while the remaining (*n*=20) failed to detect it (Figure 4). We were unable to carry out any interviews in the state of Zacatecas due to drug cartel activity. Puma records included sightings, claws, scats, and meat from a cougar, deer caches and puma carcass. The data obtained in the interviews documented the presence of pumas in the area between one to three years ago or older than three years. Pumas were mostly observed less than one kilometer away from the locality where people were interviewed, followed by one to five kilometers. Additionally we found no significant difference between the wet and dry season (Figure 5).

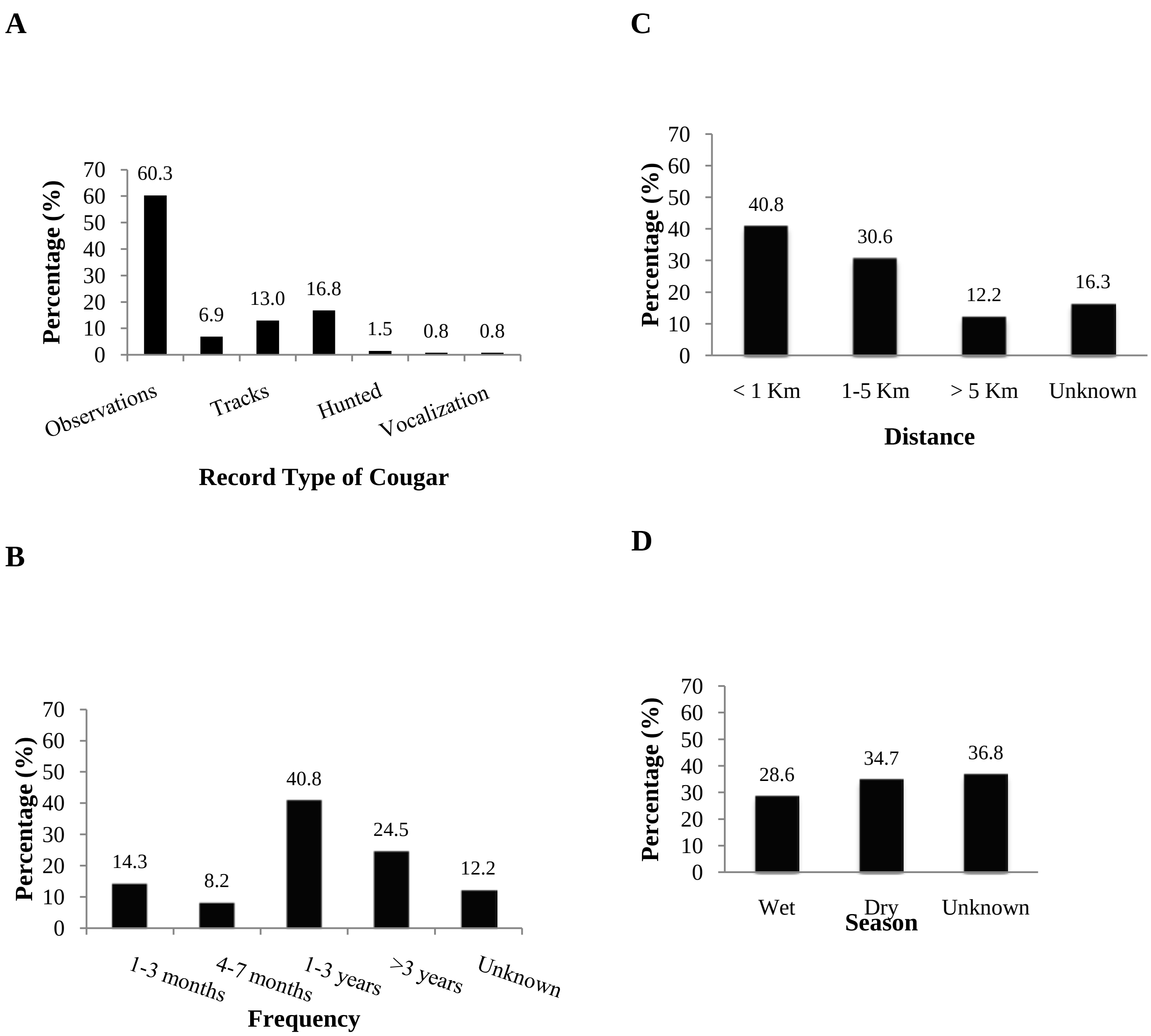

Figure 5. A) Record Types for the presence of cougar obtained by biologist and interviews. B) Frequency of records. C) Distance to towns. D) Season records.

DISCUSSION

The puma has a broad geographical distribution throughout most of the Americas, from central Canada to southern Chile and Argentina (López-González & González-Romero, 1998; Hemes 2004; Caso, et al., 2008), where most of the information on their ecology, behavior, and habitat use is concentrated in the United States and Canada (Hornocker and Negri, 2010). In Mexico there are very few studies that consider puma habitat use (Monroy-Vilchis, et al. 2007; Rodriguez-Soto, 2007) but little is known about the interaction between the landscape structure and movements of pumas, so this work is the first in Mexico to determine the functional connectivity of the landscape through the identification and description of dispersal corridors for pumas.

Understanding in detail the habitat of the puma is necessary to predict patterns of dispersal across the landscape (Shrader-Frechette, 2004). It also is an indirect way of conserving this species, by identifying the habitat characteristics required (Cougar Management Guidelines Working Group, 2005) in order to generate information on the areas and resources that influence physical activity (fitness) of individuals and population viability (Land, et al. 2007). This is reflected in the results of the habitat model showing that the study area still has good habitat (35%) that is able to support viable populations of pumas, focusing on protected areas, which, over time are more separated, due to loss of habitat to its surroundings.

More than half of the study area (65%) is highly impacted by human activities such as agriculture or urbanization. These activities are deteriorating and fragmenting large areas of habitat in the intermountain valleys and and gentle hills found between PNAs, creating a mosaic of patches of different sizes (Chapa- Bezanilla, et al. 2008). The identification of small patches of habitat between habitat block is of utmost important as these may serve as sinks (Sweanor et al., 2000; Laundré and Clark, 2003; Hornocker and Negri, 2010). Such is the case for the only potential breeding patch identified in this study, because areas <100 km^2 are too small to be biologically self-sufficient and are considered sinks because of the small number of residents (Laundré and Clark, 2003) as a breeding pair in courtship or to pumas young age of dispersal (Majka, et al. 2007; Beier, et al. 2010).

Dispersal movements are usually made through suitable habitat (Hornocker and Negri, 2010), that is not always continuous, so pumas are forced to cross unsuitable areas quickly, using very small patches as stepping stones (Beier et al. 2007; Hornocker and Negri, 2010). This may facilitate the movement of pumas through a fragmented landscape, as identified in the model. Such patches were not identified within the corridors, However, small patches of unsuitable habitat were detected within a matrix of suitable habitat. This is no great problem for the puma, as they have been found using corridors located in areas with high human impact (Beier, 1993).

Landscape connectivity and robustness of a source population are essential for maintaining population stability and a metapopulation structure in the puma (*Cougar Management Guidelines Working Group*, 2005; Hornocker and Negri, 2010). Consequently, the identification and protection of natural areas with high quality habitat where land use is regulated and safe for a source population of cougars is necessary to ensure the persistence of puma populations. There are protected areas as Sierra Fria where both natural and anthropogenic disturbance has led to fragmentation of forest in areas with gentle slopes and surrounding areas (Chapa-Bezanilla, et al. 2008). These regions are apparently becoming isolated, threatening the stability of puma populations, that by occupying small areas or large isolated regions, have a high risk of being removed. As a result, both pumas and their prey require corridors to allow dispersal among areas (Cougar Management Guidelines Working Group, 2005)

The results of the LCP show that functional connectivity exists between the Sierra Fría PNA to adjacent protected areas (Sierra de Laurel and Sierra Morones). We identified three dispersal corridors that are used by pumas to move between patches of habitat. This agrees with Crooks and Sanjayan (2006) and Sepulveda, et al. (1997), who mentioned that protected areas should have high connectivity to maintain genetically viable populations of animals with a wide distribution as the puma. For a network of patches, can combine landscape patterns with species metapopulation dynamics to better understand the influence of fragmentation on the persistence of populations such as the puma (Baggion et al., 2011)

To understand the movement in networks of patches, it is necessary to identify potential dispersal corridors, which connect to two or more blocks of habitat, facilitating the movement of species across the landscape (Beier and Noss, 1998; Collinge, 2009). However, due to increasingly greater distances between patches because of habitat loss, as among the protected areas of central Mexico, the puma will find it more difficult to cross from one patch to another, and face a high risk death of being caught or hit by a vehicle. The identification of least cost paths will help us understand landscape permeability for large carnivores such as pumas and acknowledge the effort that an individual has to exert to move between patches of habitat (Adriaensen, et al. 2003, LaRue and Nielsen, 2008).

These movements are usually performed by young pumas from their natal areas in order to establish territories or by adults to reproduce or go in search of food (Logan and Sweanor, 2001; Hornocker and Negri, 2010).The mean dispersal distance for males estimated by Beier (1995) is 63 km, while the rank of the analysis of eight studies in the western United States and Canada is 49 to 483 km (Hornocker and Negri, 2010). As the length of the three corridors (3.60, 31 and 43 km) designed among protected areas of central Mexico is short in relation to dispersal distances of male pumas, which typically disperse greater distances than females, we can infer that they do not represent large energy costs for mobility, provided the profile to be the least cost paths.

Of the three corridors, the smallest connects Sierra Fría with Sierra de Laurel (12 Km^2). This represents a good corridor because it has high quality habitat (86%) and its narrowest point is 1.02 km, conditions favoring the movement of pumas between sierras. Beier (1995) suggests that the corridors used by pumas with distances from 1 to 7 km must be over 400 m wide. In contrast to this corridor, the first strip of the second and third corridor (southeast and northeast of Sierra Fria) have more than half of the habitat in good condition (59 and 91%) but are not very favorable for puma movement because 87% and 73%, respectively, of these are very narrow (<500 m). This agrees with Collinge (2009), who mentions that some animal species like the puma actively avoid corridors that are not wide enough. So it was necessary to consider as part of the corridors, a second strip of permeability (10 and 70%) by increasing its width to exceed the threshold, making them suitable corridors for puma movement. It can be inferred that corridors 31-44 km in length must be more than one kilometer wide.

An additional impact on the landscape is the presence of roads between patches of habitat, which directly increases the mortality of animals that move from one patch to another due to their large spatial requirements for survival (Gloyne & Clevenger, 2001; Hornocker and Negri, 2010). Which, was not reflected in this work, for any two-lane roads that cross through the corridors, it is highly transited by night, so it can be said to pose no threat to pumas, because to date there has been no incidents collisions with vehicles..

The design of corridors through geographic information systems is a way to infer puma movements across the landscape (Rabinowitz and Zeller, 2010; Cougar Management Guidelines

Working Group, 2005) so its validation in the field helps us better understand the importance of these corridors. There are different ways to validate a model, from the most effective but more expensive methods of using GPS collars or camera traps to the most economical as searching for sign or conducting interviews with local residents about the presence of puma (Land et al. 2007; Collinge, 2009). Validation of corridors is not only recommended within the corridors, but also in disturbed areas, in order to ensure that the puma is not displaced by these sites (Naranjo - Piñera, Pers. Com.). Based on this, our findings through interviews we conducted within the corridors confirm that pumas use the least cost paths to move between protected areas and indicates pumas are not using areas highly impacted by humans, at least in the state of Aguascalientes. This could not be verified for the state of Zacatecas because of the current threats from drug trafficking.

The application of interviews reflected not only puma presence (Rabinowitz and Zeller, 2010), but also provided information on puma biology and behavior around anthropological activities. This was demonstrated in scores of interviews, where pumas are seen or detected one to three or more years in the corridors, possibly due to young pumas leaving their natal areas to disperse to other areas (Logan and Sweanor, 2001).During dispersal moves, is likely that pumas face barriers such as roads or urban areas, with the risk of being killed (Logan and Sweanor, 2001; Hornocker and Negri, 2010). However, the interview data show that the pumas did not avoid areas where the total population was > 50 inhabitants. This does not mean they are not at risk, as there are people who, due to lack of economic resources, hunt pumas for fat, meat, or skins to survive (Don Santos, Pers. Com.).

Protected areas are considered source populations if they are large enough and experience low human pressure (Laundré and Clark, 2003). As this work is an initiative to begin to assess puma metapopulation dynamics by identifying dispersal corridors between protected natural areas because they are less likely to be altered and are able to provide dispersal links to sink areas (Laundré and Clark, 2003). Also, this work contributes to and complements the scarce information on cougar populations in Latin America (Hornocker and Negri, 2010).

On the other hand, this work shows a way to identify areas with high habitat quality that are not under any protected status and used by umbrella species like the puma. Such was the case, to identify records in a small mountainous region located between protected areas Sierra Fría and Sierra Morones, which may disappear if you do not have a control over human activities in the area. As the study of cougars may generate information for conservation strategies that benefit the most species, they help to establish limits on human activities that degrade key areas as corridors (Hornocker and Negri, 2010). In addition, it can be an important tool to make proposals to extend protected areas, not only ensuring the conservation of cougar populations but from many species and the same landscape.

ACKNOWLEDGMENTS

I want to thank Dr. Eduardo Naranjo Piñera and Dr. Robert W. Jones that enriched with their knowledge this work. To Universidad Autónoma de Querétaro and Universidad Autónoma de Aguascalientes. To Instituto Nacional de Estadística y Geografía (INEGI) and Instituto Mexicano del Transporte (IMT) by facilitation of geographic information. Likewise, to Biodiversity Conservation for Central Mexico, A.C. and Comisión Nacional de Areas Naturales Protegidas (CONANP), for their support during field trips and Environmental Management Unit “Sierra Morones” for providing information and hospitality.

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Mountain Lion (*Puma Concolor*) Population Status, and Biological Corridors in Sierra San Luis, Sonora México.

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Abstract: The sky islands are mountainous complex surrounded by grasslands, deserts and valleys between the United States and Mexico, characterized by a high biodiversity. However, in this region the main economic activity is livestock, where carnivores represent a problem due to predation, which result in predator control measures. This, coupled with the construction of the border fence between the two countries and the increment in traffic due to mining reactivation in the region make a necessity to evaluate the current status and conservation of predators and population connectivity in the region. One of the carnivore that is markedly affected by predator control is the mountain lion(*Puma concolor*). Our objective was to determine the population status and distribution of mountain lion in the Sky Islands and to identify biological corridors in this region. We used records from camera-trap surveys to estimate the abundance and density using capture-recapture models with the program Mark. To assess the distribution and probability of occupation we use the program PRESENCE. Corridor were determined taking into account the probability distribution of this species and the type of management and land tenure. The average density obtained (2.2 individuals/100km^2) indicates that mountain lions present no immediate problems in conservation, but there is a gradient of less than 1 to 4 individuals/100km^{2,} which shows that there are significant differences in mountain lion densities depending in the type of management (conservation, livestock), which potentially can affect the population due to unregulated predator control measures. According to our results Sierra de San Luis seems to work as a source population of individuals to the rest of the Sky islands. The occupation probability model shows a major biological corridor for both Mexico and the U.S. located in Sierra San Luis, therefore, the development plans for the future should take into account the connectivity between wild areas to ensure the population viability of mountain lions and also the rest of mammal community.

INTRODUCTION

The diversity and richness of species in the Northeast region of the State of Sonora is given according to its topographical and environmental characteristics given by its mountain ranges, which are known as Sky Island or Archipelago Madrean (Coblentz, 2005; Coblentz and Riitters, 2005). The Sky Islands are a mountainous complex composed of more than 40 mountains located from the southwestern United States in the Colorado Plateau and the Rocky Mountains to the north of the Sierra Madre Occidental in Mexico.

Within this region converge various different climates, which give a high ecological importance, since different habitats provide with a high diversity of flora and fauna species (Coblentz and Riiters, 2005). In Mexico, this richness and diversity has been affected by the type of land management (Ceballos and Navarro, 1991), which has threatened the wildlife populations reducing significantly their abundance, even to the point of disappearing some of them. Such is the case of some mammals such as the grizzly bear (*Ursus arctos*) and the Mexican wolf (*Canis lupus baileyi*, Brown, 1983). In this region, you can find different types of management such as private conservation areas, protected natural areas and areas with economic activities. The Sierra San Luis is located within the Sky Islands and the dominant land tenure is private ranches where the main economic activity is extensive livestock farming. Predators are considered a serious problem due to the alleged excessive predation on livestock, resulting in measures of control over them.

Of the predators present in this region, the cougar or mountain lion (*Puma concolor*) is the one that probably is receiving more of this predator control measures, because of its strict carnivorism diet and its abundance and widely distribution throughout the region. Added to this, the construction of the border wall between Mexico and the United States, the expanding of border highway no. 2 from two to four lanes and the imminent increase in vehicular traffic due to the re-activation of the mining area in the region, makes a necessity to evaluate the current status of cougar populations and connectivity of their populations in this region. Therefore, the objectives were to determine the population status of cougar population in four Sky Islands and to identify areas most likely to be occupied by the species to determine potential biological corridors in the region.

STUDY AREA

The study was conducted in four Sky Islands located in the northeast of the state of Sonora, Mexico. The area is under the influence of the Sierra Madre Occidental, the Rocky Mountains and the Chihuahuan and Sonoran deserts (Coblentz and Riiters, 2005). This landscape is characterized by mountains range surrounded by grasslands, deserts and valleys between them (TheWildlands Project 2000). The sampling areas included the Sierra San Luis (SSL), Ajos, Buenos Aires and El Tigre, the last three in the National Forest Reserve and Wildlife Refuge Ajos Bavispe (RFN and RFS Ajos Bavispe).

The SSL is constituted by a mosaic of ranches with different types of management strategies. The San Bernardino, El Pinito and Los Ojos ranches are focus, since more than 10 years on conservation of flora and fauna where the hunting and cattlement are not allowed. San Bernardino Ranch is bordered is located in the foothills of the SSL while El Pinito and Los Ojos ranches are set in the mountains. The properties Potrero de la Sierra, El Tápila and Oaxaca, are dedicated to cattlement and apply regular predator control measures.

The elevation of the localities goes from 1.500 to 1.800 meters. The hydrography is characterized by a permanent river called Cajon Bonito and several intermittent and artificial water bodies (Rodríguez-Martínez et al. 2008). The climate is dry temperate with summer rainfall, the average summer temperature is 18 º C , and in winter from 7 º C (INEGI, 1973). Average annual rainfall is 450 mm (Iniguez et al. 2005). The vegetation is mainly composed of grassland and scrub. Also, there are forested areas dominated by aspen (*Populus* sp.) and in some parts can be found juniper-oak and huizachal-oak associations (Rodríguez-Martínez et al. 2008).

Sierras within the RFN and RFS Ajos Bavispe have varying degrees of livestock management. Sierras Madera and Buenos Aires are those with the highest number of cattle ranches, followed by the Sierra del Tigre. Finally, in Sierra Ajos the cattle is rare, appearing only in the lowlands, due to the steep topography.

Altitudinal gradient range from 1.100 to 2.646 meters (CONANP, 2003). The RFN and RFS Ajos Bavispe covers an important area of the watersheds in the region, including the Sonora, San Pedro, Bavispe and Yaqui rivers and the Mariano, Borregas and Mavavi streams (CONANP, 2003). Precipitation in this Sierras ranges between 500 mm to 600(CONANP, 2003).

The vegetation within the reserve are forested areas, dominated mostly by oak, juniper, pine-oak and pine forests, grasslands, desert vegetation, mezquite areas and subtropical scrub. (CONANP, 2003).

METHODS

Trap Cameras

We place an average of 28 camera traps (WildView ®) by locality, for a total of 248 sampling stations in nine locations. The camera traps were placed along fauna trails, during the years 2009 and 2010. The camera traps were active for an average of 28 days for each sampling point were recorded geographic coordinates and altitude using GPS.

The cameras had a north-south orientation in order to avoid being activated by sunlight. Were placed in trees at a height between 50 and 100 cm, depending on the topography of the terrain and the type of vegetation. We program the cameras to record the time and date for each event photography, as well as taking three shots every time the camera was activated for maximize the chance of getting elusive species.

Abundance and Density

To calculate the abundance and density of cougars, photographic records obtained were classified and separated and trough a 5 researchers comparative analysis (Kelly et al, 2008) the cougars were identified at an individual level taking on account the independent events. Each observer determined the number of individuals who were photographed and their recapture, based on the following characteristics: body complexion, blemishes, scars and natural markings. To calculate the abundance, we generate a capture-recapture history of cougars in each sampling site, which was introduced to the program MARK (using CAPTURE extension). Subsequently, we calculated the effective sample area (ESA) for each sampling location using ArcMap 10 (ESRI, 2011), to do this, we generated a buffer around each camera trap, trying to dissolve the overlapping areas to avoid overlap on the circles, and therefore overestimation of the ESA. This buffer corresponded to the species home range (293 km2; Currier, 1983). Finally, the density was calculated by dividing the abundance between the ESA, and reported as number of individuals per 100 km2.

Occupancy models and potential wildlife linkages

To estimate the probability of occupation of the cougar and identify potential wildlife linkages, photographic records were associated with the environmental and topographical covariables through the program PRESENCE (Hines, 2006), under the assumptions of a single species, one sampling season and covariates associated with each site (Donovan and Hines, 2007).

The study area was divided into sampling units of 1 km2, representing a grid of 32.761 km2. Each obtained record of cougar was related to its corresponding sampling unit. Also, it was determined as sampling units visited (SUV) those where the cameras were placed. With the SUV we proceeded to build a matrix of presence (1) – pseudo absences (0), sample units not visited were cataloged with a dash (-) which the program recognizes as an unknown category (whether the species is present or absent).

The environmental and topographical variables that were chosen for the analysis were altitude, orientation, slope and normalized vegetation index (NDVI). Geographical layers of the covariates were associated with the grid of sampling units, using the program ArcView 3.2 (ESRI, 1999), through the Spatial Analyst extension (version 1.1). In this way we obtained a matrix where each sample was associated with a specific value of each of the covariates. The obtained values of the covariates in all sampling units were normalized (Mackenzie et al., 2003). Based on the array of records and the matrix of covariates, we proceeded to generate generalized linear probability models within the PRESENCE program. Each model considered the probability of occupancy and detection probability associated with one or more covariates, considering also a constant covariate (.) and a covariate with time (*t*; Donovan and Hines, 2007). Thus, given all the possible combinations of covariables, we generated a total of 1,024 models. The best model to explain the occurrence and probability of detection was selected by the lowest AIC (King et al., 2007).

Once we got the best model, we generate a space map, given the probabilities of occurrence per sampling unit. This map served us to identify areas of highest probability of occurrence of the species, and to determine potential corridors for cougar.

RESULTS

With a sampling effort of 9,847 days-camera we obtained 456 photographic records of cougars (Table 1). Most photos were taken in Sierra Ajos, followed by Rancho Los Ojos, El Pinito and El Tapila.

Abundance and Density

The abundance obtained was variable according to the sampling localities. In some areas could not be determined because the cougar records were insufficient or we did not get recaptures. For example, in San Bernardino ranch we did not detect presence of cougar, and in the Sierra El Tigre, and the ranches Potrero de la Sierra and Oaxaca, we were only able to identify a single individual with no recaptures (Table 2).

Table 1. Cougar records (independent events) and localities sampled in the Sky Islands of northeastern Sonora, Mexico.

Locality	Camera traps	Independent Events	Survey Effort (camera days)
Sierra Ajos	29	11	1148
Sierra El Tigre	29	1	805
Pinito Ranch	28	6	1007
Tápila Ranch	25	7	864
Ojos Ranch	31	10	938
San Bernardino Ranch	21	0	349
Sierra Buenos Aires	29	8	1933
Oaxaca Ranch	29	1	1150
Potrero de la Sierra Ranch	27	1	1653
Total	**248**	**45**	**9847**

Table 2. Abundance and density of Mountain lion (*Puma concolor*)

	Abundance	e.e.	Ind./100km^2	e.e
Ajos	7	2.11	1.289	0.09
El Pinito Ranch	18	14.86	3.709	0.67
San Bernardino Ranch	0	-	-	-
Los Ojos Ranch	23	23.76	3.711	0.95
El Tigre	1*		-	
El Tapila Ranch	9	2.12	1.670	0.09
Potrero de la Sierra Ranch	1*	-	-	-
Oaxaca Ranch	1*	-	-	-
Buenos Aires	5	2.59	0.750	0.10

*Registros únicos

The average density of mountain lions that were obtained throughout the sampling area was of 2.22 individuos/100km2. Higher values of densities are in areas dedicated to conservation, compared with other areas with different management (Figure 1). By comparing the densities of puma with white-tailed deer, which is its main prey in the region, we can observe that the densities of deer do not seem to fluctuate as much as the densities of cougars.

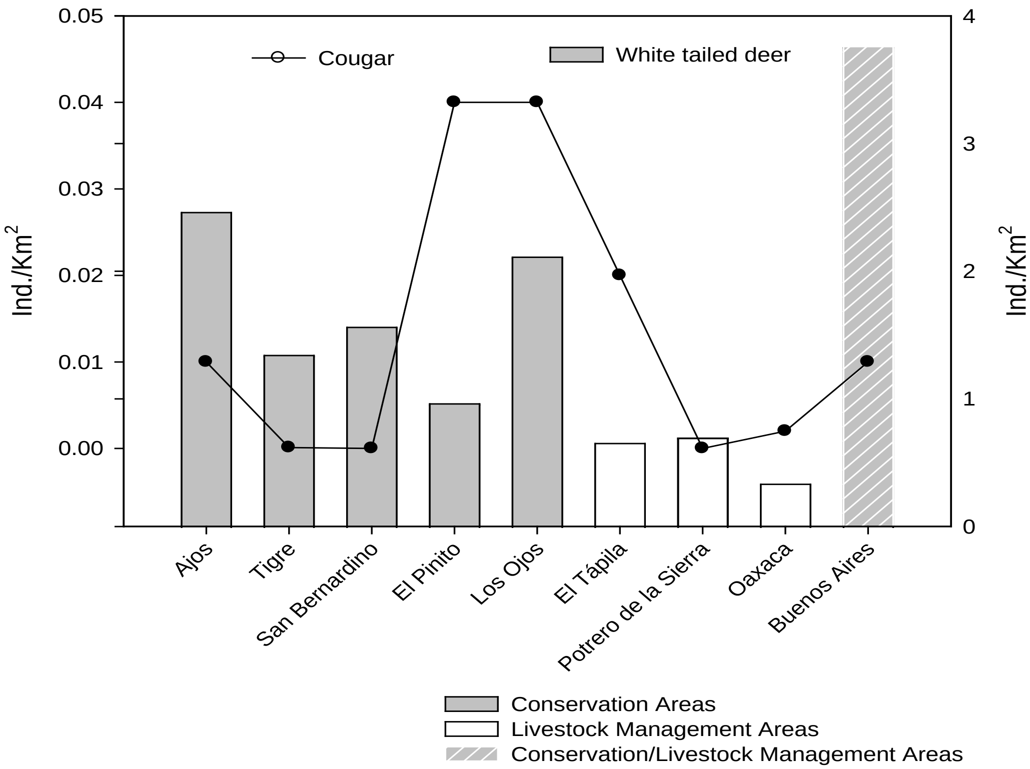

Figure 1. Cougar densities (Lines) and white-tailed deer (columns) in the locations sampled. The locations are grouped based on their type of management: Grey-Conservation Areas; Hollow-Areas with livestock management; Striped-Areas with livestock management and conservation.

Occurrence Model

The best model for determining the probability of occurrence of cougar (AIC = 200.95) considered the covariables elevation and NDVI for the probability of occupation, and the altitude, NDVI and *time,* for the probability of detection: *psi* (altitude, NDVI), *p* (elevation, NDVI, time). The relationship between the presence of cougars with the covariables was positive. This means that at higher altitudes and greater vegetation cover, increases the likelihood of a given area to be occupied by cougars.

The average probability of occupancy for the entire study area was 0.2198, with a minimum of 0.03 in 175 sampling units and a maximum of 0.47 with 111 sampling units (Figure 2). In general, we obtained a low probability of occupation for the area. This low probability may be due to the number of records of cougar in the areas sampled, with very few in relation to the sampling units visited and in relation to the total area, which could cause the model found a low correlation with variables selected.

Once the model is exported to a space map it shows areas where the probability of occurrence is relatively higher both the U.S. and Mexico (Figure 3). One of these areas located in the U.S. are the Huachuca Mountains, a protected area that can benefit the presence of pumas, for it is a protected area and hunting and human activities are forbidden. In the county of Bisbee (Arizona), its another area with high probability of occupation as well as in Mexico in the county of Cananea. These areas, however, are isolated and fragmented by roads, towns and cities. The occupation model define that the most likely areas for cougar presence are to be found in the tops of the mountains, showing a large continuous area located in the Sierra San Luis, which goes along to the north into the United States.

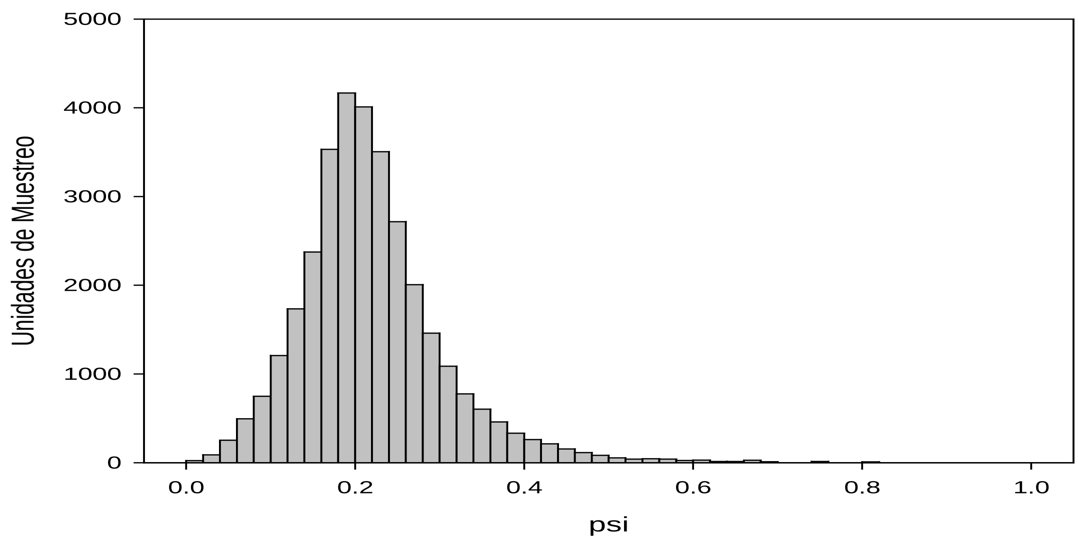

Figure 2. Distribution frequency of occurrence probabilities of cougar in the area of study.

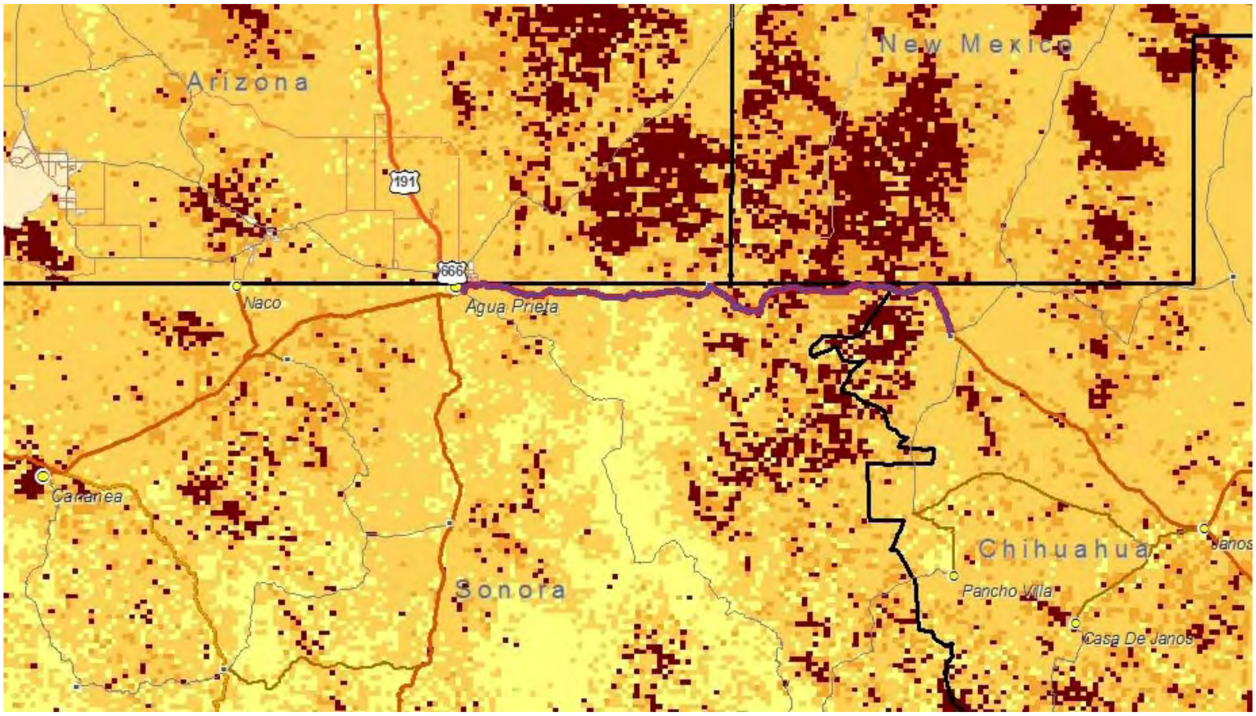

Figure 3. Best model considering altitude and NDVI (AIC 200.9537). The darker areas represent a higher probability of occupation of cougar.

DISCUSSION

Puma densities in the study area varied apparently as a result of the characteristics of each site and management strategies applied on them. Apparently, livestock management has a negative influence on the density of puma, especially when comparing the monitored plots in Sierra de San Luis (Figure 1), with ranches like Oaxaca Ranch which have cougar densities much lower than ranches of Los Ojos and El Pinito.

El Tápila Ranch sowed no such low density of cougars despite having livestock management. However, it is geographically close to Los Ojos and El Pinito Ranch (13 and 3 km respectively) Therefore, it seems that the areas dedicated to conservation are providing with cougars individual for the nearby ranches. In areas with extensive livestock management are carried out predator control measures as well as poaching of different species, including white-tailed deer (pers. obs). The combination of this two things (not directed predator control using poisons and poaching) may be contributing to the reduction of the availability of wild prey, in turn increasing the probability of predation by cougars over livestock (Polisar *et al*, 2003). Although consumption of livestock by the puma may represent less than 10% of the biomass consumed (Rosas-Rosas *et al*, 2008), and that the main prey for cougars are white tailed deer (Luna-Soria y Lopez-Gonzalez, 2005) social perception may aggravate the situation, encouraging measures to increase in predator control techniques in those areas.

Predator control, particularly related to pumas, has shown that if done in areas less than 1,000 km^2 (Robinson et al 2008), the animals removed are substituted by immigrant individuals (typically young individuals searching for a territory) from neighboring areas, causing a change in the population structure toward mostly younger individuals (Cooley *et al* 2009). This scenario could be causing an increase in predation on livestock (calves and female) due to lack of experience of younger immigrants in hunt techniques. Therefore predator control measures could be feeding a vicious cycle in which it promote predation on livestock instead of preventing form it.

The model showed a low probability of occupation of puma in the entire study area. This may be due because we used only the photographic records obtained with the trap cameras to build the model. The number of records obtained was low, mainly because the puma is an elusive species and the probability of detection is low. Therefore, we recommend using the probability of detection in the estimation procedure (MacKenzie *et al*, 2004) in a future analysis and to include other records of the species presence (tracks, scats, sightings) to increase the number of SUV, especially when working on such a large area.

The model showed that the zones to the west of the study area are isolated from each other by large non-cougar habitat areas. To the east (Figure 3), there is one large and continuous patch, indicating that this area should be treated as one. Because in this area we obtained the highest cougar densities reported in this study, we consider that this area might be functioning as source populations for the Mexican Sky Islands, and possibly as a biological corridor for the U.S.

These wildlife corridors and linkages should be considered in management and conservation plans for the cougar, especially in the presence of natural and anthropogenic barriers that may hinder the dispersion of cougar populations. In this sense, the two immediate threats to these predator populations are the border wall and the expansion of a federal highway in Mexico. Although, in the area of highest probability of occupancy and potential biological corridor for the puma, the border wall has mostly Normandy type barriers, which can be permeable for this species, it can potentially affect the dispersion of its prey. Likewise, the expansion of Highway # 2, from 2 to 4 lanes, will bring an increase in vehicular traffic and people, which could affect the distribution and dispersal of individuals, not only of pumas, but also for black bears, deer and jaguars among other species. Therefore it is necessary to identify biological corridors at a fine scale for species through tools like the one posed in this study, to establish measures in management plans to reduce negative impacts (*e.g.* wildlife passes, Dickson and Beier, 2007).

The occupation model shows a potential isolation of cougar populations in the region, thus we recommend considering it as a metapopulation having special emphasis on dispersal behavior of individuals, to assess the connectivity between populations by migration patterns.

Management Implications

This study shows that cougar populations, in terms of densities, present no immediate problems in conservation. However, there is a gradient of less than 1 to 4 ind/100km^2, which may be associated with the type of land management. Livestock management, linked to the control of predators could be the factor that exerts a greater negative influence on populations of cougars, both in density and in their places of employment. It is necessary to promote livestock management practices that reduce the chances of predation and decrease the removal of predators. Such practices could include the induction of simultaneous parturition, keeping livestock away from the hunting areas, the increase of wild prey, among others.

The occurrence model shows a potential biological corridor between Mexico and the U.S., located in Sierra San Luis, therefore human activities in this region must take on account in their development plans the wildlife connectivity, not only for this carnivore species, but for the rest of the mammal community.

Cougar populations in the region appear to be functioning as a metapopulation in which Sierra de San Luis could be a source population for the rest of the Sky Islands in Mexico, so it is recommended that the cougar management proposals are made in a regional basis.

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Habitat Use of Pumas during Dispersal in the Central Rocky Mountains

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Abstract: Dispersal movements through heterogeneous landscapes form the foundation for species' evolution, ecology and conservation. Habitat use during dispersal is expected to be especially significant for populations strongly influenced by inter-population processes. We examined habitat use of dispersing pumas (*Puma concolor*) in three separate study populations in the Central Rocky Mountains using location data from GPS (n = 11) and VHF (n = 123) radio-collared individuals, providing two independent datasets from all three study areas. Hypotheses for landscape features preferred during dispersal were tested with *a priori* models centered on forest cover, topographic cover, hunting habitat, and anthropogenic disturbance. The best-supported hypotheses for GPS collared dispersers included landscape characteristics associated with successful hunting of ungulate prey and avoidance of anthropogenic development. Among VHF collared individuals the hunting of ungulate prey model performed best, with the combined prey and anthropogenic disturbance model ranked second. For both GPS and VHF datasets no significant effects on habitat use were found for dispersers' sex, study populations, or day versus night locations. No difference in habitat use was evident between winter and summer for VHF collared individuals; however, seasonal effects were significant in the GPS dataset. A resource selection function (RSF) was developed using results obtained from the best performing GPS model and validated with an independent dataset (VHF locations). Overall, the RSF was found to be highly predictive of disperser space use with an independent dataset. This RSF could help identify areas important to dispersal in the Central Rockies. More generally, tests of competing *a priori* models indicate dispersing pumas prefer habitats with ample access to ungulate prey, similar to resident adult pumas, and that dispersers may avoid development. Identifying landscape linkages of suitable hunting habitat and minimizing anthropogenic development in these areas could assist conservation of puma populations and inter-population connectivity.

Panther Habitat Characteristics and Distribution in Southern Florida

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Abstract: The Florida panther is the last subspecies of *Puma* still surviving in the eastern United States. Historically occurring throughout the southeastern United States, today the panther is restricted to less than 5 percent of its historic range in one breeding population of approximately 100 animals, located in southern Florida. Using radio-telemetry data from 84 prime-aged adult panthers (31 males and 53 females) during the period 1999 to 2009 (30,247 radio-locations), we analyzed the characteristics of the occupied area and used those attributes in a generalized linear model and a random forest model to develop a predictive distribution map for resident breeding panthers in southern Florida. Using 10-fold cross validation, the model was 90 percent accurate in predicting presence or absence of panthers in the 17,000 km^2 study area. Analysis of variable importance indicated that the amount of wetland forests and forest edge, hydrology, and human population density were the most important factors determining presence or absence of panthers in southern Florida. Marshes, shrub swamps, and grassland/prairies were also important components of panther habitat. As expected, saltwater wetlands and urbanized areas were strong negative predictors of panther presence. On a scale of 0-1, all panther home ranges had an average model-predicted probability between 0.48 and 0.98, with a median probability of 0.87. The models indicate that 6,345 km^2 of suitable breeding habitat remain in southern Florida and that 1,548 km^2 (25%) of this habitat is in non-protected private ownership. These models should be useful for evaluating the impacts of future development projects, in prioritizing areas for panther conservation (*e.g.*, mitigation areas, panther conservation banks, conservation easements, and fee title purchases), and evaluating the potential impacts of sea-level rise and changes in hydrology associated with climate change.

Modeling Cougar Resource Selection over Multiple Scales and Behaviors

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Abstract: Nocturnal predators, such as the cougar (*Puma concolor*), may utilize resources differently depending on time of day, particularly if resource use is optimized for a specific behavior. We used conditional logistic regression models and GPS collar data from 12 cougars in the Oquirrh Mountains, Utah, to determine whether cougar resource selection varied over three behaviors (prey caching, daybed selection, and nocturnal activities) and two scales of availability. Results indicated that cougars used resources differently depending on their behavior. The cache site models suggested that cougars attempt to reduce losses to scavengers and decomposition when caching prey. Cougars cached prey in canyons; southern and eastern aspects; lower elevations; areas with a high diversity of vegetation types; wooded and forested land cover types; and away from edges. Cougar selection of daybeds appeared to be a function of security and thermoregulation variables. Daybed models indicated a negative association with western aspects, edges, and roads, but a positive association with streams; moderate to high elevations; moderate to steep slopes; southern aspects; and rocky, deciduous woodland, and riparian cover types. Cougars used a wider range of resources during nocturnal activities than for caching or daybed activities, but cougars used resources that reduced the energetic costs of hunting and facilitate stalking of prey. Models describing cougar nocturnal activities indicated a negative association with northern aspects, valley landforms, grasslands, agriculture, and disturbance, and a positive association with streams; roads; edges; canyon landforms; gentle to moderate slopes; and rock and deciduous woodland cover types. Models differed depending on the scale at which resource availability was defined. Cross-validation procedures confirmed that the models were reliable. We conclude that using only diurnal telemetry data to model cougar habitat, or using data pooled over all behaviors and times of day could result in a misleading or incomplete understanding of cougar habitat.

Session 7: Corridors, Habitat Use and the Urban Interface *(cont.)*

Linking Resource Selection and Mortality Modeling for Population Estimation of Mountain Lions in Montana

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Abstract: In Montana a combination of limited entry and quotas are used by the Department of Fish Wildlife and Parks (MTFWP) to allow recreational opportunities for the public, while maintaining viable mountain lion populations, thus creating a need for accurate and defensible population estimates. Advances in generalized linear modeling and geographical information systems (GIS) have made available new techniques to quantify and spatially represent resource selection, mortality risk, and population dynamics. Using data collected by our collaboration of scientists, I propose to produce spatially explicit models of mountain lion resource selection, survival, densities, and population dynamics. This research will be directed towards aiding MTFWP personnel in developing local harvest strategies and a statewide mountain lion management plan.

Direct and Indirect Effects of Predators on an Endangered Species: Testing Predictions of the Apparent Competition Hypothesis

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Abstract: Predation can disproportionately affect endangered prey populations when generalist predators are numerically linked to more abundant primary prey. Apparent competition, the term for this phenomenon, has been increasingly implicated in the declines of endangered prey populations. We examined the potential for apparent competition to limit the recovery of Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*) an endangered subspecies under the U.S. Endangered Species Act. Using a combination of spatial, demographic, and habitat data we assessed whether cougars were having direct and indirect effects on bighorn sheep as a consequence of winter range overlap with abundant mule deer. Consistent with the apparent competition hypothesis, bighorn sheep populations with high spatial overlap with deer exhibited higher rates of cougar predation and cougar-kills occurred within areas of overlap of bighorn sheep and deer. Of those bighorn sheep populations that experienced cougar predation, antipredator behavior was correlated to the area of overlap with deer, such that populations with greater spatial overlap with deer selected steeper, more rugged terrain. The effects of predation were spatially variable among bighorn populations and temporally variable within them. Spatial variation was likely driven by landscape-scale differences in the availability of low elevation habitat, and temporal variation by changes in forage availability. Evidence suggests that apparent competition is limiting some bighorn sheep populations, but is not the primary factor limiting all populations. Management plans for endangered species should consider the spatial distributions of key competitors and predators to reduce the potential for apparent competition to hijack conservation success.

Understanding the Conservation Needs of Mountain Lions in an Urban Southern California Landscape

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***Abstract*:** Habitat loss and fragmentation are serious threats to mountain lion conservation, especially in southern California, where human development encroaches upon and subdivides remaining natural areas. In 2002, the National Park Service began studying the ecology, behavior, and conservation of mountain lions in and around Santa Monica Mountains National Recreation Area using GPS radio-collars. Based on home range sizes and the small population, it is clear that remaining natural areas are too small to support a sustainable mountain lion population; therefore habitat connectivity across freeways is critical for local mountain lion persistence. Only 1 of 20 radio-collared lions has crossed Highway 101, which separates the Santa Monica Mountains from other natural areas to the north. Based on microsatellite genotypes, the lions in our study area are less genetically diverse than those in other areas throughout California. The lion that crossed Highway 101 successfully mated with a female that produced three kittens, bringing new genetic material to the region. We have documented successful reproduction and monitored 7 kittens (2 litters) with implantable VHF transmitters. However, the leading cause of death in our study is intraspecific strife, and we have found that roads and development can restrict lion movements, especially for young males attempting to disperse, which may increase the likelihood of fights with adult males. The exposure of lions to anticoagulant rodenticides may also be greater in urban areas. Two lions died from anticoagulant toxicity, and 8 of 9 lions showed exposure to multiple compounds, with the youngest being 3.5 months old. Fortunately, conflict with humans and livestock has been minimal. We identified 389 kills, and although 94% were mule deer, 2 lions also killed sheep and goats on a local ranch. After working with the landowner to modify their husbandry practices, depredations were eliminated. Mountain lion persistence in the park may be possible as long as sufficient habitat with connectivity is available, human-caused mortality sources are reduced, and lion-human conflict remains minimal.

Effects of Residential Development on Cougar Spatial Ecology in Washington

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Abstract: Residential development creates significant challenges for managing and conserving large carnivores. Cougar (*Puma concolor*) use of residential areas and proximity to people is a growing management concern, but little is known of how residential levels and patterns effect cougar spatial ecology. We used utilization distributions (UD), county tax parcel data, and multiple comparison techniques to quantify and compare cougar (n = 101) use of residential areas across 4 study areas in Washington. We used Weibull functions and a lacunarity analysis to examine how different levels and patterns of residential development influence space use and reports of cougar-human interaction. Cougar UDs encompassed predominantly undeveloped parcels at both the hectare ($\overline{x}$ = 98.09%, SD = 3.12, n = 101) and km^2 ($\overline{x}$ = 81.59%, SD = 15.60, n = 101) scales as cougars decreased use as residential densities increased. Lower use of residential areas at the hectare scale demonstrated use of undeveloped, suitable habitat within the matrix of residential development. Use in eastern Washington study areas occurred in areas with residential densities ≤ 55.2 residences/km^2 whereas use in western Washington occurred in areas with ≤ 846.0 residences/km^2. Dense forest vegetation and clustered residential development allowed western Washington cougars to exploit landscapes with higher residential densities. Increasing amounts of forested habitat and human population size increased the number of cougar reports, but both factors explained < 50% of observed variability in annual report levels (Forest: R^2 = 30.5%, Population: R^2 = 44.3%). Diffuse, low density development (i.e., exurban) can increase cougar proximity to residences and may increase report levels. Wildlife managers looking to reduce use of residential areas and interactions should account for cougar spatial ecology and human distribution while exploring collaborations with development and landscape planners to cluster residential development at urban densities (> 10 residences/ha) in lower quality habitat.

Cougars in the Backyard: Large Carnivore Conservation in Developing Landscapes

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***Abstract**:* Maintaining large carnivores in human-dominated landscapes poses a significant conservation challenge. In such landscapes, large carnivores are often extirpated by anthropogenic habitat modification or direct persecution by people. Persecution is especially likely when carnivores threaten human lives or property. Habitat loss and conflict with people have been identified as top threats to conservation of cougars in North America. We studied cougar habitat selection and human perception of cougars in west-central Alberta, Canada. Cougars varied in the degree of avoidance they exhibited to human development. Individuals exposed to higher levels of anthropogenic development within their home range exhibited less avoidance of anthropogenic features than cougars with limited exposure to development. Additionally, cougars altered habitat use temporally to accommodate diel variation in human activity. Survey results indicated that nearly 40% of west-central Albertans would shoot a cougar on sight if it was seen near their home and respondents substantially overestimated the risk cougars pose to human safety. Nevertheless, respondents valued the persistence of cougars in Alberta, provided cougars did not occur in their "backyard" and remained in wilderness areas. Tolerance for cougar-human coexistence in rural areas was lowest amongst older members of the community, hunters, and ranchers and was positively correlated with education. Our results suggest that persistence of cougars in moderately developed rural and exurban landscapes hinges more on the tolerance of local residents than on habitat constraints resulting from development. Addressing conflicts in conjunction with education programs designed to promote value for cougars will be critical for cougar conservation on increasingly human-dominated rural and exurban landscapes.

Cougar Behavioral Response to Anthropogenic Activities and Landscapes: Evidence of Ambivalence?

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Abstract. Recent developments in theoretical and applied research have elucidated the tenuous balance between predation risk and resource acquisition in habitat selection behavior of carnivores. Cougars (*Puma concolor*) are obligate carnivores distributed over much of the West and several investigators have hypothesized that cougars avoid landscapes associated with human activities. In addition to survival costs, anthropogenic landscapes present cougars with highly predictable foraging opportunities. Therefore, our goal was to evaluate the hypothesis that cougars are wilderness obligates by addressing three constituent questions: 1) how do cougars respond to human altered landscapes, 2) do cougars make trade-offs in habitat selection based on anthropogenic inputs, and 3) do peri-urban cougar populations act as *de facto* sinks? We employed GPS collars to study cougar movement and predation behavior in the Oquirrh Mountains near Salt Lake City, Utah. From 2002-2009 we instrumented 21 individuals and measured their response to four human land-use types comprising the urban-wildland interface (UWI) at two scales. At the macro scale response was generally defined by avoidance, as all individuals used to anthropogenic landscapes less than available. At the micro-scale however, cougar response varied by demographic class and land-use type. Contrary to our predictions, maternal females did not make habitat selection trade-offs, but used risky habitats within the UWI at greater frequencies than their non-maternal counterparts. Human-caused mortality on the UWI disproportionately affected dispersing males and senescent females. Animals capitalizing on anthropogenic food resources tended to be inefficient hunters, best exemplified by the very young and the very old, lending little support to the *de facto* sink hypothesis. We argue that cougar response to anthropogenic landscapes is best described as one of ambivalence; they appear sufficiently flexible to exploit opportunities provided by human activity, but their nocturnal, reclusive, and non-gregarious behavior partially ameliorate potential conflicts. Rather than viewed as either a wilderness obligate or synanthropic, cougars are best characterized as a behaviorally plastic, disturbance-adapted species.

Session 8:
Human Dimensions

Proceedings of the

10th Mountain Lion Workshop

Cougars: Conservation, Connectivity and Population Management

Florida Gulf Coast University Promotes Florida Panther Conservation through a Unique Environmental Education Program

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Abstract: Elementary students are bused in their yellow limo (school bus) to the FGCU campus, and participate in a science based Florida Panther Posse program, in a classroom transformed into a learning center focused on the Florida panther. The FGCU "*Wings of Hope*" program is an integral part of the Environmental Humanities curriculum and service learning at Florida Gulf Coast University (FGCU). University students from diverse majors are introduced to native South Florida wildlife species, with a focus on the Florida panther. The elementary students become a Panther Posse and rotate through five challenges, where FGCU students teach them about Florida panther natural history and panther signs (becoming a "panther tracker"), Florida panther kittens, wildlife that lives with the Florida panther, water conservation, and the Florida panther research. The program involves hands-on activities, note-taking in a specially designed science journal, and examination of scientific instruments used for research. The challenges build confidence and help all participants to understand, protect, and save the Florida panther and the natural world. Back at their individual elementary schools, the young students in each Posse collect "Pennies for Panthers" in their classroom, used to purchase infrared motion cameras. The Posses cameras are mounted around South Florida panther habitat. These images provide all students a better appreciation of the Florida panther. The FGCU "*Wings of Hope"* program focuses on bringing back a sense of place within our family, community and the environment. Each elementary school and college student takes the information they learn and educates at least two other people about the Florida panther and the natural world. Over 8,000 additional people are educated each year about this endangered species. For the past 10 years the FGCU Florida Panther Posse program has built bridges of hope for the endangered Florida panther and its habitat with environmental education and awareness to thousands of individuals in South Florida.

The Feasibility of The Northeastern U.S. Supporting The Return Of Cougars (*Puma Concolor*)

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Abstract: Cougars (Puma concolor) were part of the pre-European fauna of northeastern United States. They were extirpated in the late 1800's and since the late 1900's there has been discussions concerning their reintroduction into the region. One site mentioned is Adirondack State Park in upstate New York. In 1981, an assessment of the feasibility of returning cougars concluded the Park could biologically support a small population of cougars. However conflicts with humans would cause the demise of this population in 10 years. Thus, reintroduction at that time was not advised. Since that time, knowledge of cougar ecology and cougars' relationship with humans has increased substantially. Based on information compiled since the 1980's, I conducted a GIS analysis to assess if cougars could live in the Park. Results indicate that cougars could occupy approximately 13,700 to 19, 500 km2 (57-79%) of the Park with minimal contact with human habitation. Based on common cougar densities, the Park could support 190-390 cougars. These cougars would consume < 10% of the adult deer population annually and that fawn production is sufficient to replace these loses. Politically, the Park has similar human and road densities of the Black Hills, South Dakota region and the Big Cypress Swamp region of Southern Florida, both of which have viable populations of cougars. I concluded that the Adirondack Park could both biologically and politically support a population of cougars. What remains to be seen is if there is human will to bring them back.

The Discourses of Incidents: Cougars on Mt. Elden and in Sabino Canyon, Arizona

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***Abstract*:** Incidents are relatively short periods of intensified discourse arising from public responses to symbolically important actions by public officials. We applied a framework for the analysis of international incidents to events during 2001-2004 in Arizona precipitated by the removal or intended removal of cougars (*Puma concolor*) by state and federal agencies in response to public safety concerns. Our objectives were to elucidate elements of key narratives, alliances of participants, and differences in narrative focus between incident and background periods. Cougars were mentioned in newspaper articles 13 to 33 times more often during incidents compared to background periods. During incidents, discourses focused on describing problematic human behaviors and advocating related solutions. State wildlife agency commissioners and hunters consistently shared a narrative that featured killing cougars to solve problems, making cougars and those who promoted the intrinsic value of cougars culpable, and retaining power to define and solve cougar-related problems. Personnel from affected state and federal agencies shared a similar narrative. Most other participants shared a narrative that defined “the problem” primarily in terms of peoples’ behaviors, whether when around cougars or, relative to agency personnel, when formulating and implementing policies. This narrative also advocated decentralization of power over cougar management. We concluded that differences in perspectives were organized around differences in allocations of responsibility and preferences for lethal versus non-lethal methods, which aligned with whether participants were enfranchised or disenfranchised by current state-level management power arrangements. Common ground was evident in shared concerns about habitat and a preference for solutions that featured education.

Mountain Lion Policy Process in Three States: an Advocate's Viewpoint

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When a wildlife-management agency and stakeholders with divergent points of view can find common cause, decision-making becomes better informed by science and acrimony dissipates. WildEarth Guardians has advocated in three states for maintaining ecologically functional populations of mountain lions. Results have varied. In Colorado, mountain lions benefited from substantial policy reforms as a result of a decision-making process that became more inclusive over time—but only after divergent stakeholders came to agreement among themselves first. In comparison, New Mexico and Montana have held less inclusive stakeholder forums. As a result, the policy outcomes in those states reflect a disregard for the best available science, which has resulted in increasing lion-hunting quotas, which we believe are neither justified nor sustainable.

Below we summarize some of the greatest obstacles to achieving policy reforms for mountain lions and then give a brief description of our campaign work in three states for mountain lions.

The problem:

As politicized institutions, wildlife agencies often adopt policies that are uninformed by the best available science, especially regarding the principles of conservation biology. Because hunters, the key stakeholder group of the wildlife agencies, have held historical relationships with, and provide benefits to, wildlife agencies through the user-pay model, unsustainable and scientifically unjustified mountain lion hunting-permit levels have been instituted—despite the fact that wildlife belong to no one and are held in a public trust for all (see e.g., Horner 2000, Jacobson et al. 2010). Additionally, wildlife agencies in the West have catered to concerns held by those in agribusiness but not the entire public, which also results in detrimental outcomes for wildlife.

In 1982, hunters in 10 Western states killed a total of 931 mountain lions. By the mid-1990s, however, lion hunting increased three-fold, peaking at 3,454 in 2001. Since that time, hunter kill of lions has declined by about 1,000 in those states—perhaps because of overkill.

Native carnivores such as mountain lions are largely killed because of misperceptions that they compete with humans for food or make humans and livestock safer (Baker et al. 2008). Arguably, a high level of lion hunting appeases both hunters and the state wildlife agencies. The former because of concerns about resource competition over big game prey, but also because this group can profit from guiding others, who do not own lion-hunting dogs.

A high level of lion hunting benefits state wildlife agencies because states derive license revenues from both lion and ungulate hunters. State agencies' key constituents are appeased because it appears the state has allowed greater hunting opportunities for both lion and ungulate hunters. Furthermore, by keeping lion quotas high, states can claim they are helping to prevent future conflicts between lions and humans, livestock, and pets. We dispute each of these notions in turn.

Mountain lions and other native carnivores kill few livestock. The National Agricultural Statistics Service (NASS), an arm of the US Department of Agriculture (USDA), issues bi-decadal reports on livestock losses. It released the newest cattle inventory and loss report in May 2011, and the sheep figures the year before. In 2010, the cattle inventory numbered 94 million head (NASS 2011). Of that figure, 219,900 cattle, or 0.23% of the total US cattle inventory, were killed by native carnivores and domestic dogs. Felids (pumas, bobcats, and lynx) preyed on 18,900 cattle, or 0.02% of the 2010 cattle inventory (NASS 2011).

In comparison, weather, health, and theft losses totaled nearly four million cattle, or 4% of the cattle inventory (NASS 2011). The top five killers of cattle came from respiratory problems (over one million); digestive problems (505,000); complications while calving (494,000); weather (489,000); and “unknown” causes (435,000).

In 2009, sheep producers raised 5.7 million animals (NASS 2010b). Of that figure, native carnivores and domestic dogs killed 4% of the total production (NASS 2010a). In comparison, 7% of sheep died from poor health, weather events, or other causes (NASS 2010a).

As the data prove, a miniscule number of cattle and sheep are lost to predation. Livestock growers face threats from disease, calving, and weather, but numerically few from native carnivores and dogs.

Mountain lions and other native carnivores are also implicated by some for eating native prey such as deer, elk, or bighorn sheep. Yet, the largest threat to ungulates (and indeed, all mammals) is human hunters (Collins and Kays 2011). Nevertheless, wildlife agencies jealously guard against ungulate consumption by native carnivores, because they see carnivores as a potential threat to their revenue streams, which is largely derived from the sale of elk and deer licenses. In recent years, the Department of Interior has found that the number of hunters has declined; yet, states have yet not broadened their economic portfolios to capture monies from other stakeholders, because to do so would encourage a more participatory process, and, in our experience, states have been resistant to engage in democratic decision making processes.

Furthermore, few people have been attacked or killed by mountain lions. Eighteen people have died in the U.S. from lion attacks in the period between 1890 and May 2011 (Beier

1991, 1992, Fitzhugh 2003). Some parties routinely use exaggerated human-safety fears to invoke large carnivore extermination campaigns (Schwartz et al. 2003). Decision makers have persisted in calls for elevated lion killing in the assumption that it will make people safer. Yet, there is “no scientific evidence” that sport hunting reduces the risk of lion attacks on humans (Cougar Management Guidelines 2005). And as we learned at this conference, high-hunting pressures on lion populations change their social structure—releasing more sub-adult males, which can create both social and ecological chaos.

Conservationists, not the paying clientele of wildlife agencies, are marginalized, even when conservation biology decisions should prevail—decisions based on the best available science not only benefit the public trust but also ecological systems. WildEarth Guardians' success in obtaining mountain lion management reform, that is, getting states to adopt science into policy-making, has been uneven in the face of states' institutionalized barriers as follows.

The Colorado Case:

In 2001, WildEarth Guardians (then known as “Sinapu”) raised concerns about Colorado's mountain lion population when we saw that the quota and hunter kill of lions had jumped by 219% and 442%, respectively, over a period of two decades. Beginning that year, and until 2008, we annually petitioned the Colorado Wildlife Commission seeking redress, such as calling for the establishment of hunt-free refugia (a robust conservation biology concept), protections for breeding females and their dependent young (hunter education and sub-quotas), and reductions in the lion-hunting quota.

We also used both public and private spheres to call for reforms. Public sphere forums included providing public testimony at commission hearings, using the media—both earned and paid—and presenting our mountain lion slide shows to public audiences around the state. The result was that we were able to generate thousands of letters over time to the agency and gain a public that was more engaged and educated about the wildlife-management policy process.

In the private sphere, we interacted individually with wildlife commissioners, most often at commission hearings. Additionally, at those forums, we talked to houndsmen and outfitters. We also interacted frequently with Colorado Division of Wildlife (DOW) officials – both at hearing spaces, at meetings at their offices, or by individual communication (i.e., phone and Internet).

WildEarth Guardians met with considerable resistance from the agency, the Wildlife Commission, and most other stakeholders. Nevertheless, early on, we convinced commissioners that the DOW had no credible population data for mountain lions and that it could not show that a 400% increase in the level of lion hunting was sustainable—despite the DOW's public assurances to the contrary.

In 2002, while our petition was ignored, the Wildlife Commission called for the hire of a new carnivore biologist to study Colorado's lion population and to document the effects of hunting. In 2003, Ken Logan, PhD and co-author of *Desert Puma* (2001), was hired to commence a 10-year study of the effects of lion hunting on a population.

In 2004, because we had effectively been shut out of public policy process by the DOW and the commission for three years, WildEarth Guardians brought our message to the public. That year and for several years after, we began giving a multitude of mountain lion talks about the natural history, co-existence, and management of mountain lions around Colorado, often in less urbanized areas. In 2004, the houndsmen responded by sponsoring Dr. Logan, who gave five lion talks to stakeholders around the state.

Inspired by the Logan-houndsmen tour, our 2004 petition to the Wildlife Commission solely requested that protections for females and kittens be instituted through a formalized hunter education program—so that hunters could reliably distinguish between the sexes, thus sparing breeding females and their dependent young. In addition to our statewide public forums, we earned a good deal of statewide media. At the Commission's hearing, we presented 2,000 letters to the Commission.

Also, that year, the DOW produced a greatly improved mountain lion management plan, which had used GIS mapping and modeling. After seeing their own results, the DOW revised its earlier estimate of the lion population, from 3,000 to 7,000, to a more substantiated number, 4,500 to 5,500 mountain lions. The new population estimate caused the DOW to recommend that the Wildlife Commission reduce the quota from 791 to 567, and in 2004, the Commission voted to reduce the quota by a dramatic 30%.

Todd Malmsbury, the DOW spokesman, stated to the *Rocky Mountain News*: "The Wildlife Commission agreed to change [the quota] because both the lion hunters and Sinapu came to an agreement on the number," (Gary Gerhardt, "Wildlife panel lowers cougar hunting quota" 11/18/04). Sinapu and the houndsmen agreed to the quota number developed by the DOW. That number, for the first time, had a scientific basis. This marked a turning point for the policy process. At this moment, the DOW had begun to "listen" to all stakeholders.

In 2005, we again conducted a public campaign and gave talks in 22 venues. To elevate our profile in some of the towns where we gave talks, we bought newspaper ads depicting a female lion with a kitten captioned, "Pumas don't have orphanages." Our petition that year again called for a mandatory hunter education program, so that hunters could distinguish between the sexes in order to protect breeding females and kittens. To our surprise, ten days later the Colorado Outfitters Association made the same request.

At the 2005 Colorado Wildlife Commission hearing, the houndsmen, agriculturalists, and the DOW itself testified in opposition to the hunter education program. However, as a result of the outfitters and our common wish, the Wildlife Commission ordered that the DOW develop an online hunter education program with an emphasis on distinguishing between males and females and promoting the conservation of breeding females and their dependent kittens.

Despite its initial public opposition, the DOW, to its enormous credit, devised a program that was then vetted through a public stakeholder process and informed by the best available science. The program has since become a model for other states—thus, we were able to bring it to both New Mexico and Montana, where it has been adopted.

In Colorado, the lion hunter education program has caused a decline in the number of females in the hunter kill. From 1991 to 2004, the average percent of females in the hunter kill was 43%. From 2005 to 2011, the average percent of females in the hunter kill equals 36%.

In short, the Colorado process resulted in a win-win-win outcome for lion hunters, conservationists, the DOW, and arguably, most important for lion conservation. While the agency was initially adverse to robust input from all stakeholders, eventually, it came to appreciate participatory mechanisms during the mountain lion policy process; it has been open to hearing input from diverse stakeholders on mountain lion issues over the last few years; the agency has engaged in this process—generally through informal communications. As a result, the quota has remained roughly static, and the number of females in the hunter kill has declined. The debate in the public sphere has also subsided.

New Mexico Case:

WildEarth Guardians along with our colleagues, Sierra Club and Animal Protection of New Mexico, has worked on a multi-year campaign to better mountain lion conservation in New Mexico. We gained some achievements in 2006 and 2008 such as the establishment of female subquotas in some units and the adoption of the mandatory hunter education program.

In July 2010, the New Mexico Department of Game & Fish (NMDGF) reversed that progress when it proposed a 140% increase (490 to 1,190) in the annual cougar mortality for the years 2011-15. At the same time it called for an enormous quota increase, it shuttered the public rulemaking process for mountain lions from a two-year to a four-year cycle. The agency claimed that it needed to see trends in the lion mortality before the public could again be entrusted with weighing in on lion quotas.

To justify its new quota system, the NMDGF threw out the 10-year Logan and Sweanor study (2001), and instead adopted an unpublished, one-year masters student’s study. That study was conducted in an unusually biologically rich area of New Mexico. NMDGF then took the highest density estimate produced by that study and applied it statewide.

Our groups lead a vociferous public campaign over a few short months in the summer of 2010. As a result, thousands of people sent correspondence to the Game Commission, and we earned a steady drumbeat of statewide media. At the hearing, one NMDGF official dismissed our letters and emails as “robo” mail during public testimony.

Yet, as a result of the public outcry, NMDGF at the eleventh hour reduced its proposed July quota of 1,190 to 745 in October 2010. The new quota for the next four years represents a 52% increase from 2008-10 figure of 490. The New Mexico Game Commission also instituted the agency's recommendation of a 137% increase in the female subquota from 126 to 299. These increases have no credible biological basis.

In sum, the NMDGF advanced an extremist agenda, which resulted in detrimental outcomes for everyone, including itself. The agency has damaged its own credibility with the public.

Montana Case:

In 2009 in Montana, WildEarth Guardians worked with individual houndsmen on its campaign to maintain ecologically functional populations of mountain lions. We also immediately invited Montana Fish, Wildlife & Parks (FWP) officials to attend and speak at all of our public forums which we held across the state in 2009. The outcome of our 2009 campaign: We developed a strong trust with some houndsmen, and potentially a few agents within FWP. Houndsmen and state officials presented at a few of the public forums.

While Montana immediately adopted the online hunter education program as a result of our collective work, we have been dismayed to see quotas—and particularly female subquotas—increase. In 2008, the statewide quota equaled 411 with a female subquota of 136. By 2010, the statewide quotas increased to 562 and female subquota to 174, a 37% and 28% increase, respectively. Like New Mexico, these jumps in the quota are neither gradual nor biologically justifiable.

In many parts of Montana, the most current understanding of science fails to drive the decision making process, including mountain lions' effects on prey and exaggerated anxieties over human safety. As a result, even a lion researcher who had called for conservation measures was ignored and even ridiculed at a commission hearing by one commissioner. In Montana, an open arena for all stakeholders to mountain lion management has not yet been instituted, which will have detrimental outcomes for large carnivore conservation.

In conclusion, because of our campaign, and because the DOW was willing to adopt a more robust stakeholder process, several positive steps for mountain lions have been achieved in Colorado. In 2004, the DOW produced a defensible mountain lion management plan that was informed by GIS technology and population modeling. The estimated lion population was deduced, which lead to a 30% reduction in the lion-hunting quota. The reduction in the quota, in turn, has lead to a reduction in the hunter kill of lions. In the last two years, however, the lion kill has climbed, which concerns us. Second, the DOW has hired two carnivore biologists to study mountain lions. Dr. Logan studies the effects of hunting on a lion population on the Uncompahgre Plateau of western Colorado, while Dr. Mat Alldredge studies human-lion interactions in the urban-rural interface on the Front Range (Denver-Boulder corridor). Next, the hunter education program, which found its genesis in the Logan-houndsmen talks of 2004, went online in 2005. In 2007 the program became mandatory. The result has been a decline of females in the hunter kill. The program has since been exported to other states. A less tangible measurement has been increasing public awareness about mountain lions –both on co-existence issues and on management. Moreover, the media had been engaged throughout the policy process. The final result in Colorado over time has been a developing trust between the DOW, hunters, outfitters, and conservationists.

The similar level of trust and communication has not been developed in either New Mexico or Montana. We urge that state agencies, in the absence of scientific evidence, use the precautionary principle when setting hunting quotas. Not to do so can damage lion subpopulations. We also urge all state agencies to begin to broaden their economic portfolio—so that science, not politics, informs decision-making. Not only is this good policy, it is expedient given that the numbers of hunters is in decline. The public interest in large carnivore conservation is increasing and those resources should be tapped to maintain ecologically functional populations of mountain lions.

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An Explanation of Cougar-Related Behaviors and Behavioral Intentions among Northern Arizona Residents

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Abstract: Management of cougars (Puma concolor) in the American West is typified by conflict among stakeholders that is plausibly rooted in life experiences and worldviews. We used a self-administered mail questionnaire to assess demographics, views of nature, life experiences, cougar-related behaviors, and support for cougar-related policies among 693 permanent residents of forested regions in northern Arizona. Questionnaire responses were the basis for models explaining behaviors and support for policies. We employed a modified version of Kellert's (1996) schematic of values to assess respondents' natureviews. Natureviews and life experiences performed far better than demographics alone in explaining behaviors and support for policies. The Utilitarian/Dominionistic natureview had the strongest effect of any variable in six of seven models, and was associated with behaviors involving firearms and opposition to policies that would limit killing cougars. The Humanistic/Moralistic natureview had thematically opposite effects in five models. Sex had the strongest effect of any demographic variable in our best models. Controlling for natureviews, male sex was positively associated with behaviors involving firearms. The degree to which people orientated toward dominance of nature and related lethal behaviors offered a robust explanation for their support of cougar-related policies.

Session 9:
Harvest

Proceedings of the

10th Mountain Lion Workshop

Cougars: Conservation, Connectivity and Population Management

Assessing Selectivity and Harvest Composition of Cougar Hunters in Wyoming

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Abstract: Assessing hunter selectivity and how it relates to sex/age composition of harvested cougars (*Puma concolor*) is beneficial for evaluating efficacy of management scenarios for statewide management programs. We examined Wyoming cougar harvest data from September 2000 through March 2009 (9 harvest years) to assess potential differences between hunters who reported being selective while hunting and those who reported no selectivity. We also separated harvest by method (i.e., use of dogs, opportunistic, outfitted hunts) to evaluate differences between sex/age structure of harvest depending on method of take and whether hunts were outfitted. The strong majority of successful hunters (89.2 %; $n = 1{,}741$) used dogs to harvest cougars versus other methods ($n = 175$). Hunters using dogs harvested a lower proportion of females (42.7%), than those using other methods (56.0 % female harvest). To further assess selectivity, we analyzed data from hunters using dogs only. Hunters who stated they were selective harvested fewer (31.1 %) and older (mean age = 4.2 yrs) females ($P < 0.05$) than those who were not selective (51.0% female harvest, mean age = 3.7 yrs) and spent more time hunting (1.9 days annually; $P < 0.01$) to successfully harvest a cougar. Whether hunts were outfitted or not had no effect on sex/age composition of harvest. Hunting with trained dogs allowed for the most selectivity; however, results suggest that other factors such as harvest vulnerability, weather conditions, and quota status may be as important as hunters' perspective of selectivity when evaluating composition of cougar harvests. Hunter selectivity, method of take, relative harvest vulnerability, and the impact of differing management regimes (i.e., liberal vs. conservative mortality limits) should be considered when assessing sex/age composition of cougar harvest, and the methods which may be best suited to achieve specific management objectives.

Landscape Context Influences Spatial Population Dynamics: Pumas under Varying Levels of Human-Induced Mortality

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Abstract: Appreciation of both population spatial structuring and landscape effects on within-population vital rates are well established. However, the effects of landscape context on inter-population vital rates and the consequences for multi-population dynamics are less well known. An understanding of how stressors affect both individual disperser attributes and the contribution of single populations to metapopulation dynamics are of immediate value to basic and applied ecology. Pumas (*Puma concolor*) provide an example of a carnivore with population characteristics largely driven by inter-population movements, and are susceptible to human-induced source-sink dynamics. Using long-term, detailed data from a high mortality landscape in the Garnet Mountains of western Montana and a relatively secure landscape in the Northern Greater Yellowstone Ecosystem (NGYE), we quantified the contributive roles of the populations. The NGYE puma population depended on inter-population movements for its own growth as well as its ability to make a net contribution to the metapopulation. The Garnet area under heavy hunting pressure was a sink with a declining population until hunting was partially restricted, at which point it became a source with positive intrinsic growth and a 16x increase in emigration. In both systems we examined the spatial and temporal landscape effects on individual dispersal attributes (emigration, dispersal distance, establishment success) of subadult pumas (N=126). Human-induced mortality regimes modulated all three dispersal components, reducing inter-population vital rate for males and females in different ways. Male inter-population exchange was reduced directly through elevated pre- and post-emigration mortality. Indirect effects were more evident for females, which displayed reduced emigration propensity and dispersal distance in high risk landscapes. Human-induced mortality and other landscape effects, acting on inter-population vital rates, will determine the ability of local populations to contribute to other subpopulations. In spatially structured populations these effects will have important consequences for population ecology and management.

Mountain Lions of the Great Basin: Identification of Source-Sink Dynamics using Bayesian Genetic Techniques

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***Abstract**:* An increasing number of demographic studies suggest that mountain lion populations operate as source-sink systems. Failure to understand such population dynamics, especially in hunted populations, could lead to detrimental management decisions if a constant level of harvest is assumed to be sustainable across the entire landscape without considering the role of immigration sustaining populations in different areas. However, in many systems it is not logistically feasible to examine mountain lion movement rates in the field at the scale at which source-sink dynamics operate. Nonetheless, recent advances in multilocus Bayesian genetic techniques allow the estimation of population genetic structure and movement rates necessary to model source-sink systems at large scales. Thirteen microsatellite loci were analyzed for 776 mountain lions using muscle tissue samples from individuals in the Great Basin and the eastern Sierra Nevada mountain range. We used a combination of spatial (TESS software) and non-spatial (STRUCTURE software) model-based Bayesian clustering methods to first identify genetically distinct populations. We then used a recently developed Bayesian multilocus genotyping method (BIMr software) to estimate asymmetrical rates of movement between those sub-populations and identify source and sink populations. We identified two populations at the highest level of genetic structuring with a total of 5 subpopulations in the Great Basin of Nevada and the eastern Sierra Nevada Mountains. Our results indicate that source populations are those under relatively less hunting pressure and comprised of refugia for mountain lions. Results from these types of analyses could be used by managers to create biologically meaningful management boundaries and harvest quotas that take into consideration the amount of immigration sustaining populations in different areas.

Beyond Cougar Source-Sink Management: Distributing Hunt Effort to Preserve Social Stability

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Abstract: Wildlife agencies use a variety of techniques to regulate cougar (*Puma concolor*) harvest and achieve management objectives; these include general hunt seasons, limited entry hunts, harvest quotas, and bag limits. These techniques are often executed using a zone management (Logan and Sweanor 2001) and/or source-sink metapopulation approach (Laundré and Clark 2003). Zones incorporate large-scale geographic areas typically made up of multiple game management units (GMU's) and are designated as cougar population sources (low harvest) or sinks (high harvest). However, we believe it is important to maintain the natural, self-regulating mechanism of territoriality that cougars have evolved through eons of evolution and management should strive to mimic this natural dynamic when implementing hunts. The role of evolution is recognized in ungulate management and helps guide trophy management and quality hunt programs. However, a similar philosophy has not yet been considered for managing carnivores. Just as maintaining mature individuals is important for managing ungulates, maintaining resident adult cougars, which influences reproduction, rates of immigration and emigration, and density, mandates management attention. To avoid altering the natural regulating function of cougar social organization, we advocate a hunt system that preserves social stability. To accomplish this, our philosophy is to equitably distribute harvest across the jurisdiction using a limited entry draw hunt, reducing the hunt zone size to the individual GMU level, and limiting removals to 10% of the GMU's cougar population. This would avoid excessive removals in selected GMU's where human access is high and cats are most vulnerable. We also propose an increased license fee, comparable to that of other big game species. Benefits to this system may include a stable age structure, maintained or increased agency revenue, more efficient wildlife enforcement, less human conflict, and because older animals would be more plentiful, a quality hunt experience for the hunter.

Comparison of Cougar Survival and Mortality Patterns in Exploited and Quasi-Protected Population

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Abstract*:* Using information from a 14-year (1996-2009) study of radio-collared animals (n = 139) within a BACI framework, we analyzed cause-specific mortality and survival rates for two Utah cougar (*Puma concolor*) populations subject to differing levels of exploitation. The Monroe (exploited) and Oquirrh Mountain (semi-protected) populations were located in wildland and peri-urban (population >1 million) settings, respectively. We investigated whether: (1) survival was independent of hunting regime; (2) survival changed either annually or periodically (hunting and non-hunting seasons),; or both; and (3) harvest-specific survival differed by sex. We used known-fate survival analysis to estimate location-, sex-, time-, and harvest-specific survival rates, and Cox Proportional Hazard models to compare the impact of anthropogenic and other causes of mortality (intra-specific strife, malnutrition and injury). Males and females from both locations experienced enhanced survival following relaxation of hunting pressure on the exploited population in 2002. Survival probabilities did not differ seasonally, but males sustained greater declines in survival during the hunting season (January to June) compared to females. Female survival rates between populations were comparable ($S = 0.892 \pm 0.03$ and $S = 0.877 \pm 0.034$, respectively), whereas male survival was lower in both the Oquirrh ($S = 0.760 \pm 0.085$), and Monroe ($S = 0.640 \pm 0.093$) populations. Anthropogenic agency (hunting, poaching, highway mortality and depredation control) accounted for 72.9% and 33.3% of the overall mortality in the Monroe and Oquirrh populations, respectively, but the latter showed a relatively high incidence (30.7% of human-caused losses) of highway mortality. Overall Disease and intra-specific strife were the main drivers of cougar mortality in the Oquirrh population (28.2% and 23.1% respectively), especially among females. These data suggest that human exploitation and other causes of mortality might be additive, but confirmation of this assumption will require formal testing.

Effects of Sport Hunting on Cougar Population, Community, and Landscape Ecology

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Abstract: Cougars (*puma concolor*) are managed on the traditional density dependent, compensatory mortality, game management model (same as deer and elk). In population ecology, hunting is believed to result in reduced numbers of cougars and increased female reproductive success, population growth, and sustained yield. In community and landscape ecology, hunting is believed to result in reduced predation on game animals, a decreased "footprint" of cougars, and reduced conflicts with humans. We conducted a series of field experiments from 1998 to 2011 (13 years, 16 papers) in 6 areas of WA to test the traditional game management model for cougars. Increased complaints, livestock depredations, and high predation on mule deer did not correspond with increasing numbers of cougars. Cougars were declining or stable where complaints and livestock depredations were high and were increasing where complaints and depredations were low. High hunting mortality of males resulted in compensatory immigration by males, decreased kitten survival (increased infanticide?), female decline, and male increase – resulting in no net change in total cougars and non-sustainable females. Low hunting mortality of males resulted in compensatory emigration by males, high kitten survival, female increase, and male stability – resulting in no net change and sustainable females. Heavy hunting reduced female population growth by 34%. Females with kittens were the main cause of mule deer declines in heavily hunted areas - because high hunting of males resulted in increased predation on mule deer by females. Females switched from numerous white-tailed deer at low elevations to sparse mule deer at high elevations to avoid potentially infanticidal immigrant males in heavily hunted areas. Only high harvest of females reversed high predation on mule deer. High hunting mortality resulted in a doubling of home range size and overlap (footprint size) for immigrant males. Large home ranges and movements outside a defined study boundary also resulted in a 2-3 X overestimate in population size. Younger animals used human-occupied areas more than older animals. Increased hunting of cougars did not reduce cougar complaints and livestock depredations. Our results suggest that the traditional game management model does not apply to solitary territorial predators such as cougars.

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