Proceedings of the

11th Mountain Lion Workshop

Integrating Scientific Findings into Management

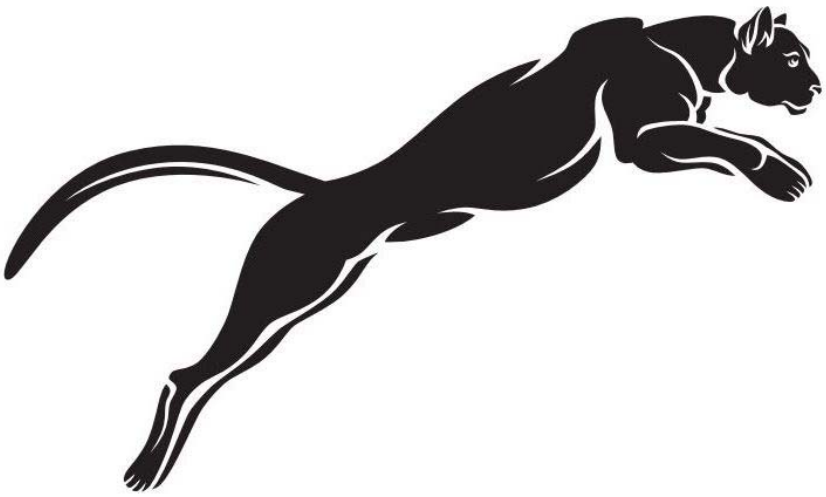
Hunter Conference Center, Southern Utah University
Cedar City, Utah

May 12-15, 2014

Sanctioned by:
Western Association of Fish and Wildlife Agencies

WAFWA Agency Host:
Utah Department of Wildlife Resources

Workshop Co-Host:
Wild Felid Research and Management Association (WFA)



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The complete proceedings are available at the WFA websites:
www.wildlife.utah.gov
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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
11th Mountain Lion Workshop – Cedar City, Utah

The 11th Mountain Lion Workshop was held at Southern Utah University in Cedar City, Utah from May 12 to 15, 2014. The theme of the workshop was "Integrating Scientific Findings into Management." Dr. John Linnell, Norwegian Institute for Nature Research, Trondheim, Norway, gave the Keynote Address. Dr. Linnell's inspiring presentation on the ecology and status of Eurasian lynx provided many comparable insights to mountain lions, another widespread species with a highly variable status. At the Wednesday night banquet Dr. Mike Wolfe, Emeritus Professor at Utah State University, gave another excellent presentation with a talk entitled "Predation: the road from myth to reason."

Session topics included: state and province reports; felid ecology, conservation and populations; predators and prey; felids and humans; non-invasive techniques; and management strategies. All of the presentations were professional, timely, and well-attended. Presentations focused on puma research and management in the western U.S. (including 3 on recently recolonized populations in the Dakotas) and Canada, with two additional talks on the Florida Panther. To provide insights into puma management and conservation concerns outside of North America, WFA sponsored Dr. Mauro Lucherini, Universidad Nacional del Sur in Argentina, whose talk examined puma-livestock conflicts in the Espinal of Central Argentina.

Along with over 50 presentations, fifteen posters were displayed, with topics covering diseases, feeding ecology and diet, orphans, GPS location cluster analysis, range expansion, effects of ambient light, comparisons of noninvasive and invasive methods of population monitoring, compensatory and additive mortality, and puma-human conflicts. Two sessions included follow-up panel discussions. During a 2-hour, WFA-sponsored session Wednesday morning, David Stoner moderated a predator-prey session that included 5 invited speakers (Becky Pierce, David Choate, Alyson Andreasen, Jeff Villepique, and Mark Hurley) with intimate knowledge about specific predator-prey systems. Presenters discussed top-down versus bottom-up

forces on a puma-deer system, the potential of water sources to function as ecological traps for mule deer and bighorn sheep, puma specialization on novel prey (feral horses), range abandonment by bighorn sheep, and the demographic response of deer to experimental reductions of coyotes and pumas. Later that same day, John Shivik moderated a session on puma-human conflict that included short presentations and a panel discussion by individuals from 6 different interest groups: sport-hunters, houndsmen, livestock ranchers, animal damage management (Wildlife Services), puma advocacy – philosophical aspects, and puma advocacy – science aspects. The topic question was "How should we balance puma conservation with predator population reduction?" This session was well-received and many attendees thought that similar panel discussions should be offered at future workshops.

John Shivik moderating the Felids and Humans panel discussion.

There were 188 registered workshop participants. We received $29,651.61 in registration fees, contributions, sponsorships, and vendor fees. We expended $24,227.78 which left us with $5,423.83 which was sent to WAFWA and will be available for the next workshop. Each workshop registrant was provided with a satchel and beanie with the conference logo. Thanks to all of the participants, attendees, organizers, moderators, and volunteers for making this a successful workshop! A special thanks to Division staff who acted above and beyond their normal duties by assisting with registration, refreshments, and running the conference. They include Natalie Brewster-Wilson, Mindi Cox, Troy Davis, Darren Debloois, Stephanie Rainy, and Heather Talley.

Ken Logan, Carnivore Researcher with Colorado Parks and Wildlife, requested that Colorado host the next (12th) workshop in 2017; all agreed. The exact workshop location will be determined at a later date.

THE 11th MOUNTAIN LION WORKSHOP
Agenda

Monday, 12 May

Evening Social, Registration
4:00 – 8:00 p.m. Iron Gate Inn, 100 N 200 W St, Cedar City, UT 84720

Tuesday, 13 May

8:15 **Welcome –** John Shivik (Utah Department of Wildlife Resources)

Plenary Session 1 – State & Provincial Reports
Moderator: John Shivik

8:30 *Utah mountain lion status report*, John Shivik (UDWR)

8:45 *Wyoming mountain lion status report*, Justin Clapp (WDG&F)

9:00 *Idaho mountain lion status report*, Jim Hayden (IDF&G)

9:15 *Florida panther status report*, Marc Criffield (FFWCC)

9:30 *Nevada mountain lion status report*, Carl Lackey (NDW)

9:45 *Washington mountain lion status report*, Rich Beausoleil (WDF&W)

10:00 *California mountain lion status report*, Marc Kenyon

10:15 **Break**

10:30 *Alberta mountain lion status report*, Jay Honeyman

10:45 *Nebraska mountain lion status report*, Sam Wilson

11:00 *New Mexico mountain lion status report*, Elise Goldstein (NMDG&F)

11:15 *Montana mountain lion status report*, Jim Williams (MFW&P)

11:30 *Arizona mountain lion status report,* April Howard (ADG&F)

11:45 *North Dakota mountain lion status report*, Stephanie Tucker

12:00 **Lunch**

Plenary Session 2: Keynote

Introduction: David Stoner, Utah State University

1:00 *A big cat in a small body: Do Eurasian lynx have what it takes to survive the Anthropocene?*
Dr. John Linnell, Norwegian Institute for Nature Research

Plenary Session 3: Felid Ecology, Conservation, & Populations, Part 1

Moderator: Teresa Griffin

2:00 *Potential barriers restricting gene flow among mountain lions in Arizona.*
Ashwin Naidu.

2:20 *The importance of scale and behavioral state in puma resource selection functions.*
Kathy Zeller.

2:40 *California's cougar connectivity: genetics informing conservation and management*.
Holly Ernest.

3:00 *Population genetics of a small, isolated population of mountain lions: Barriers, inbreeding, and genetic rescue.*
Seth Riley.

3:20 **Break**

Plenary Session 4: Felid Ecology Conservation, & Populations, Part 2

Moderator: Teresa Griffin

3:40 *Home range characteristics of a subordinate predator: selection for refugia or prey availability?*
Patrick Lendrum.

4:00 *Genetic structure of cougars in the Black Hills, South Dakota.*
Rebeca Juarez.

4:20 *Integrating Resource Selection and Harvest into Spatial Capture-Recapture Models for estimating mountain lion abundance*.
Kelly Proffitt.

4:40 *Evaluation of harvest indices currently used for cougar management in Utah: Oquirrh-Stansbury and Monroe units as case studies*.
Mike Wolfe.

5:00 *Survival rates of cougars in Oregon from 1989 – 2011: a retrospective analysis*.
Darren Clark.

5:20 *Using DNA to evaluate field identification of cougar gender by agency staff and hunters using trained dogs.*
Rich Beausoleil.

Plenary Session 5: Posters

Posters to be displayed during entire conference in the Yankee Meadows and Vermillion Cliffs Rooms. Presenters in attendance from 5:40-6:40.

- Peter Alexander. *Camera trapping vs radio-telemetry: a comparison of noninvasive and invasive methods for monitoring cougar populations.*
- Rich Beausoleil. *Orphaned kittens in Washington result in a decade of nationwide cougar education.*
- Linsey Blake. *Foraging patterns of cougars in the Pryor Mountains of Wyoming and Montana.*
- Kevin Blecha. *Improvements on GPS location cluster analysis techniques for predicting feeding activities.*
- Marc Criffield. *Trichinella in two disjunct populations of puma.*
- Aaron Ghaemi. *Confirmed mountain lions in Oklahoma.*
- Benjamin Maltetzke. *Cougar response to residential development*.
- Rick Minter. *Wild pumas in Britain – exploring evidence and gauging people's attitudes*.
- John Odden. *The ecology of a conflict: Eurasian lynx depredation on domestic sheep and semi-domestic reindeer in Norway.*
- Omar Ohrens. *The relationship of rural depopulation to puma-human conflict in the Altiplano region of Tarapacá, Chile.*
- Sadie Perrin. *Effects of puma sex, season, and habitat type on diet.*
- Scarlett Sellers. *Effects of ambient light on puma, deer, and elk activity*.
- Jeff Sikich. *P22: Will this mountain lion make it in Hollywood?*
- Alex Viere. *Puma activity and mesocarnivores.*
- Mike Wolfe. *Compensation and additivity in cougar mortality: learning from heavily and lightly harvested populations.*

Wednesday, 14 May

Plenary Session 6: Predators and Prey, Part 1

Moderator: David Stoner

8:20 *Program Cluster: identifying predation events through clustered GPS data.*
Peter Mahoney.

8:40 *Cougar strategies of feeding site selection: energy maximization, classical optimal foraging, or fear driven human aversion?*
Kevin Blecha.

9:00 *Estimating mountain lion (Puma concolor) predation rates in the recently recolonized region of the Little Missouri Badlands, North Dakota, USA.*
David T. Wilckens.

9:20 *Estimating cougar (Puma concolor) consumption rates and prey composition in the Black Hills, South Dakota.*
Joshua Smith.

9:40 *Nowhere to hide: pumas, black bears and competition refuges.*
Mark Elbroch.

10:00 **Break**

Plenary Session 7: Predators and Prey, Part 2

Moderator: David Stoner

10:20 *Top-down versus bottom-up forcing: evidence from mountain lions and mule deer.*
Becky Pierce.

10:35 *Cougar predation in the Mojave Desert: seasonal spatio-temporal overlap influences prey selection more than water use.*
David Choate.

10:50 Variation in prey selection and incidence of individual specialization on novel prey in the Great Basin.
Alyson M. Andreasen.

11:05 *Range abandonment by ungulates: Predator avoidance or response to habitat changes induced by drought?*
Jeffrey Villepique.

11:20 *Demographic response of mule deer to experimental reduction of coyotes and mountain lions.*
Mark Hurley.

11:35 Panel Discussion

12:05 **Lunch**

Plenary Session 8: Felids and Humans, Part 1

Moderator: Linda Sweanor

1:20 *Cougar space use on a landscape with high levels of anthropogenic disturbance in south-central Utah.*
Julie Young.

1:40 *Correlates of puma-livestock conflicts in the Espinal of Central Argentina*. (Sponsored by WFA)
Mauro Lucherini.

2:00 *Road impacts on mountain lions in Orange County, California: using multiple data types to prioritize management actions.*
Patrick Huber.

2:20 *An overview of puma depredation trends in California, 1972-2013.*
Anne Orlando.

2:40 *Florida panther recovery: Livestock depredation, predation risk maps, and new approaches to compensation programs.*
Caitlin Jacobs.

3:00 **Break**

Plenary Session 9: Felids and Humans, Part 2

Moderator: John Shivik

3:20 *An integrated regional outreach and research model for wildlife conservation across the San Francisco Bay Area*.
Anne Orlando

3:40 Byron Bateman, representing sportsmen (deer hunters)

4:00 Dan Cocayne, representing houndsmen

4:10 Kirk Robinson, Cougar Advocate, representing philosophical aspects

4:20 Brett Selman, representing livestock interests

4:30 Bob McCoy, Cougar Advocate, representing science aspects

4:40 Mike Bodenchuk, Wildlife Services, representing animal damage management

4:50 Panel Discussion: "*How should we balance cougar conservation with predator population reduction?*"

6:30 **Social and Banquet**
Heritage Center, 105 North, 100 East
Presentation – *Predation: the Road from Myth to Reason*
Mike Wolfe

Thursday, May 15

Plenary Session 10: Non-invasive Techniques
Moderator: Ken Logan

8:20 *Estimating Cougar Densities in northeast Oregon Using Conservation Detection Dogs.*
Gregory Davidson.

8:40 *DNA-based diet identification of mountain lions in southwestern Arizona.*
John Clemons.

9:00 *PumaPlex: A rapid and high-throughput method to genotype single nucleotide polymorphisms in mountain lion tissues and scats.*
Alex Irwin.

9:20 *Lynx monitoring in Scandanavia.*
John Odden.

9:40 *Use of camera traps to assess prey availability and distribution relative to mountain lion predation in the Davis Mountains, Texas.*
Catherine C. Dennison.

10:00 **Break**

Plenary Session 11: Management Strategies
Moderator: Ken Logan

10:20 *Conservation of pumas (Puma concolor) in a rapidly urbanizing landscape; research informing the need for more action.*
T. Winston Vickers.

10:40 *Predation-specific resource selection by cougars in the Pryor Mountains of Wyoming and Montana.*
Linsey Blake.

11:00 *Techniques used to raise orphaned Florida panthers for release to the wild.*
Mark Lotz.

11:20 *Effects of Remedial Sport Hunting on Cougar Complaints and Livestock Depredations.*
Robert B. Wielgus.

11:40 *Research to regulation: cougar social behavior as a guide for management.*
Rich Beausoleil.

12:00 **Closing comments, final business.**

John Linnell and Mike Wolfe outside the Hunter Conference Center.

Session 1:

State and Provincial Reports

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11th Mountain Lion Workshop

Integrating Scientific Findings into Management

Events in Utah's Cougar Management, 2011-2014

John A. Shivik, Utah Division of Wildlife Resources*; johnshivik@utah.gov*

***Abstract*:** Utah's current cougar management plan was approved by the Wildlife Board in 2009. The plan incorporated a regional management approach where hunting units were grouped in ecosystem-sized management areas, and ideas of source-sink dynamics were implemented. Some units were assigned as limited entry units and others as harvest objective units, with others being a hybrid of the two, split units, which opened as limited entry units and then transitioned into harvest objective units for the second part of the season. The plan was designed to be followed until 2021, with management recommendations only being made on 3-year cycles. However, continued controversy and discussions led to frequent revisions by the Wildlife Board during the 2011-2014 timeframe. Some units were put onto predator management plans, and some were assigned minimum harvests. A complex flow-chart and series of rules that dictated allocation of permits was devised. Another unit was closed by emergency action. Most recently, the Division has been given direction by the Wildlife Board to simplify the plan, which we hope to do by returning to a unit based management system that incorporates data collection at an ecosystem scale.

Assessment of Population Trends and Management Strategies for Mountain Lions in Wyoming

Justin G. Clapp, Wyoming Game and Fish Department, 260 Buena Vista Dr., Lander, WY 82520, USA*; Justin.Clapp@wyo.gov* (presenter)

Daniel J. Thompson, Wyoming Game and Fish Department, 260 Buena Vista Dr., Lander, WY 82520, USA

Abstract: In 2007 Wyoming began managing mountain lion populations under an adaptive management plan, with harvest limits set to achieve stable, source, or sink population objectives within 5 mountain lion management units (MLMUs) across the state. The annual monitoring criteria used to assess population status primarily quantifies the density of human-caused mortality/1,000 km^2 of suitable winter mountain lion habitat, proportion of adult females in the harvest, and the mean age of adult females harvested. Mountain lion management strategies and harvest limits are proposed on a 3-year cycle to assess population trend and efficacy of management strategies. Harvest year 2012 marked the end of the second 3-year cycle under this management plan, and we provide an update on the effectiveness of the strategy to sustain mountain lion populations throughout suitable habitat at varying densities for each MLMU in Wyoming.

INTRODUCTION

In 2007, Wyoming began managing mountain lion populations under an adaptive management plan, with harvest limits set to achieve stable, source, or sink population objectives within five mountain lion management units (MLMUs) across the state.

Primary monitoring criteria were established via empirically tested research (Anderson and Lindzey 2005), which provided insight to general trends in mountain lion populations under various conditions and hunting pressures. Telemetry data were collected from a sample of various cohorts of mountain lions throughout test and reference areas within the state, and population estimates were established through mark-recapture techniques. Location data from these samples were also used in a resource selection function analysis to estimate and map suitable mountain lion habitat. Hunting pressure was applied to test areas to increase mountain lion mortality and to estimate a mortality density that resulted in decreasing population estimates. When hunting pressure was restricted, mortality densities were again estimated to determine the level at which population estimates rebounded. Age and sex composition of mortality data were also gathered throughout this process. Generally, as relative mortality increased (number of mortalities/unit area of suitable habitat), a higher proportion of adult females were

harvested, and the average age of those females decreased. The opposite was true of these trends as relative mountain lion mortality decreased across the landscape.

These findings were used as a framework for the adaptive state management plan (WGFD 2006), where primary monitoring criteria can be derived through mountain lion mortality data including: **(a) human-caused mountain lion mortality density/1,000km² suitable winter habitat, (b) proportion of adult females harvested, (c) mean age of adult females harvested.** (Female status is determined by lactation.) These criteria are assessed at the hunt area level to determine a status of source, stable, or sink trends.

Primary hunt area management objective criteria include:

1. Sink management: reduce mountain lion densities

    a) Maintain density of human-caused mortality >8 mountain lions/1,000 km² (386 mi²).
    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 km² (386 mi²)
    b) Maintain adult female harvest <20% of total harvest.
    c) Maintain older-age adult females in the population (>5 years old).

3. Stable management: maximize long-term hunting opportunity and population viability.

    a) Maintain human-caused mortality density between 5-8 mountain lions/1,000 km² (386 mi²)
    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.

In addition to the hunt area criteria, other factors (e.g., total age/sex composition trends, hunter effort, and hunter selectivity) are also evaluated when assessing hunt area and/or MLMU population trends.

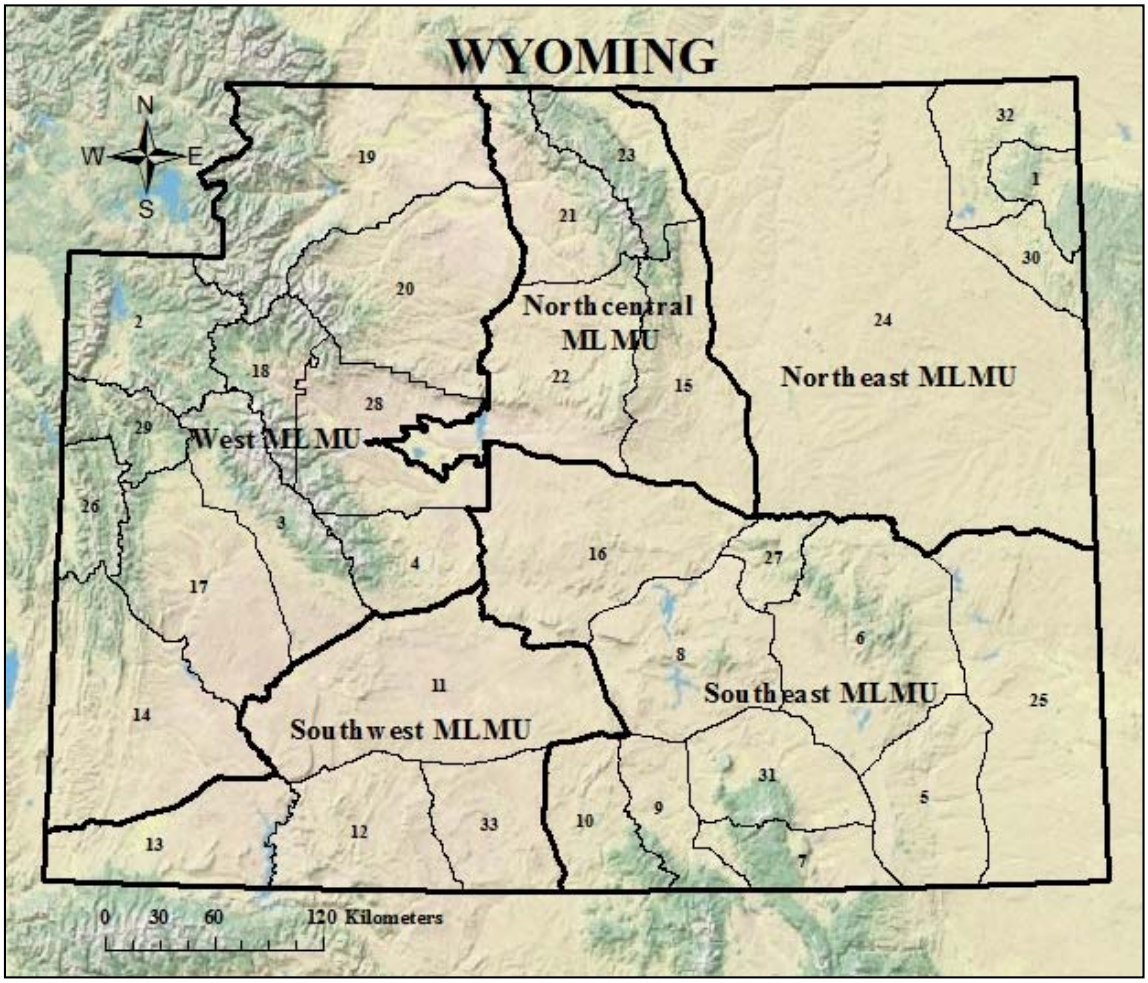


Figure 1. Mountain lion Hunt Area and Management Unit boundaries for Wyoming, USA in 2013.

Figure 1 shows current mountain lion hunt areas and MLMUs across Wyoming. Additionally, the west MLMU is partitioned into Data Analysis Units (DAUs) due to the expanse of contiguous suitable habitat identified throughout the western portion of the state. These DAUs include Absaroka (hunt areas 19 and 20), Wind River (hunt areas 3, 4, 18, and 28) and Wyoming Range (hunt areas 2, 14, 17, 26, and 29).

Mountain lion management in Wyoming uses the described criteria to assess trends on a 3-year management cycle, where alterations to objectives, harvest limits, seasons, and boundaries are minimized during a management cycle to provide necessary data to delineate trend and avoid reactionary management decisions based on variation within any given harvest year. The 3-year management cycle also bolsters the evaluation and classification of sink, stable, or source for hunt areas given previous direction in trends. Managing for a

combination of source, stable, and sink mountain lion subpopulations within MLMUs (i.e., at the hunt area level) provides flexibility to address local management concerns (e.g. livestock depredation, proximity to residential areas) while maintaining overall population viability on a landscape level as well as long-term harvest and recreational opportunities (WGFD 2006).

Harvest year 2012 (1 Sept. 2012 – 31 Aug. 2013) marked the end of the second 3-year cycle under the management plan, which provided complete harvest data in Wyoming necessary to assess the effectiveness of the mountain lion management strategy across two complete management cycles. Therefore, harvest data collected after 31 Aug. 2013 are not included. These data also include annuli ages for the majority of mountain lion mortalities in Wyoming, providing more accurate age estimation and classifications than field personnel estimations alone.

WYOMING MANAGEMENT OBJECTIVES AND POPULATION TRENDS

We quantified hunt area objectives based on mortality density criteria **(a)** that would classify source, stable, or sink management for each mountain lion hunt area throughout Wyoming at the beginning of each 3-year management cycle. Mortality limits set for each hunt area reflect recommendations including WGFD biologist perspectives, public/landowner/ sportsmen comments, and the potential for livestock depredation, human safety, and potential impacts to sympatric prey populations. The status for each hunt area was estimated using all WGFD monitoring criteria, and was compared to the objectives set for each management cycle (Table 1). Since the implementation of the management plan in 2007, most hunt area status matched objectives set in the management strategy, with approximately 82% matching or trending toward objectives. All hunt areas that deviated from objectives resulted from a status that was higher than the potential objective, a direct reflection of approximately 25% of hunt areas closing annually due to reaching or exceeding set mortality limits prior to seasonal closure dates. Six hunt areas (~21% total) adapted management at the end of the first cycle to increase allowable mortality limits, resulting in a change in classification (i.e. HAs 1, 3, 6, 13, 22, and 30), one area changed objective classification by reducing mortality limits (HA 29).

We used the proportion of matching hunt area objectives as a rough estimate to quantify the effectiveness of the management plan at a hunt area level, but it is important to consider how the culmination of mountain lion management at local scales impact the population. When considering the habitat that supports interconnected mountain lion populations statewide, mortality limits revealed an overall objective to slightly reduce mountain lion populations across the state, and the monitoring criteria we used show a statewide population status that is trending toward stability in the mountain lion population in Wyoming (Table 1).

Table 1. Mountain lion hunt area objectives vs status for first and second management cycles in Wyoming. Objectives are based only on potential mortality densities. Status are based on all WGFD monitoring criteria for each management cycle.

		First Cycle (HY2007 - HY2009)		Second Cycle (HY2010 - HY2012)	
MLMU	**Hunt Area**	**Objective**	**Status**	**Objective**	**Status**
Northeast	HA 1	Stable/Sink	Sink	Sink	Sink
	HA 30	Source	Source	Sink	Sink
	HA 32	---	---	Sink	Sink
	HA 24	Minimal Habitat	NA	Minimal Habitat	NA
Northcentral	HA 15	Sink	Sink	Sink	Sink
	HA 21	Sink	Sink	Sink	Sink
	HA 22	Stable	Stable	Sink	Stable
	HA 23	Sink	Sink	Sink	Sink
Southeast	HA 5	Source	Source	Source	Source
	HA 6	Source	Source	Stable	Stable
	HA 7	Sink	Stable→Sink	Sink	Stable→Sink
	HA 8	Stable	Source	Stable	Source
	HA 9	Sink	Stable/Sink	Sink	Stable/Sink
	HA 10	Sink	Stable→Sink	Sink	Stable/Sink
	HA 16	Stable	Stable	Stable	Source
	HA 25	Minimal Habitat	NA	Minimal Habitat	NA
	HA 27	Sink	Stable→Sink	Sink	Source
	HA 31	Stable	Stable	Stable	Stable
Southwest	HA 11	Minimal Habitat	NA	Minimal Habitat	NA
	HA 12	Stable	Stable	Stable	Stable/Sink
	HA 13	Source	Source	Stable	Stable
Absoroka DAU	HA 19	Stable/Source	Source	Source/Stable	Source→Stable
	HA 20	Source	Source	Source	Source
Wind River DAU	HA 3	Stable/Source	Stable/Source	Stable	Source
	HA 4	Stable	Stable	Stable	Stable/Sink
	HA 18	Stable/Sink	Source	Stable/Sink	Stable/Source
	HA 28	Source	Source	Source	Source
Wyoming Range DAU	HA 2	Source	Source	Source	Source
	HA 14	Stable	Stable	Stable	Stable
	HA 17	Stable/Source	Source	Stable/Source	Source
	HA 26	Stable/Sink	Stable/Sink	Stable/Sink	Source
	HA 29	Stable	Source	Source/Stable	Source/Stable
STATEWIDE		Stable	Stable/Source	Stable/Sink	Stable

*Arrows indicate data trending toward objectives.
**Hunt Area 32 did not exist prior to HY2012, and only includes one year of data.

DISCUSSION – SUCCESSFUL APPLICATIONS AND CHALLENGES WITH SOURCE/STABLE/SINK MANAGEMENT STRATEGIES

We provide the southeast MLMU as an example of a well-balanced mountain lion management unit, located in southeastern Wyoming. Figure 2 depicts classifications of hunt area status based on monitoring criteria throughout the first two cycles of the state management plan (2007–2012). Individual hunt area status within the MLMU have the potential to be influenced by alterations in management objectives, as well as by natural variation in population dynamics or environmental conditions influencing tracking conditions that drive harvest success. However, the overall status of this MLMU indicated a sustainable and well-functioning system where source areas provide opportunity for recruitment and juvenile dispersal to adjacent areas, stable hunt areas maintain balanced subpopulations, and sink areas allow increased mortality without jeopardizing the integrity of the population.

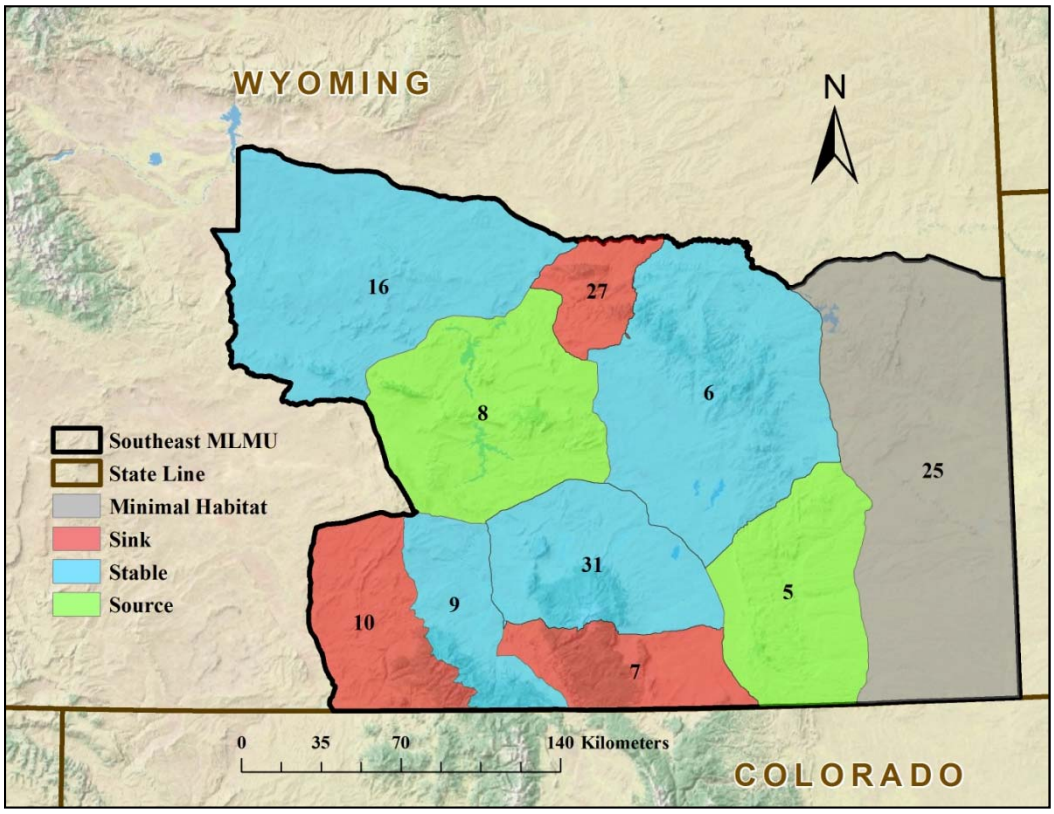
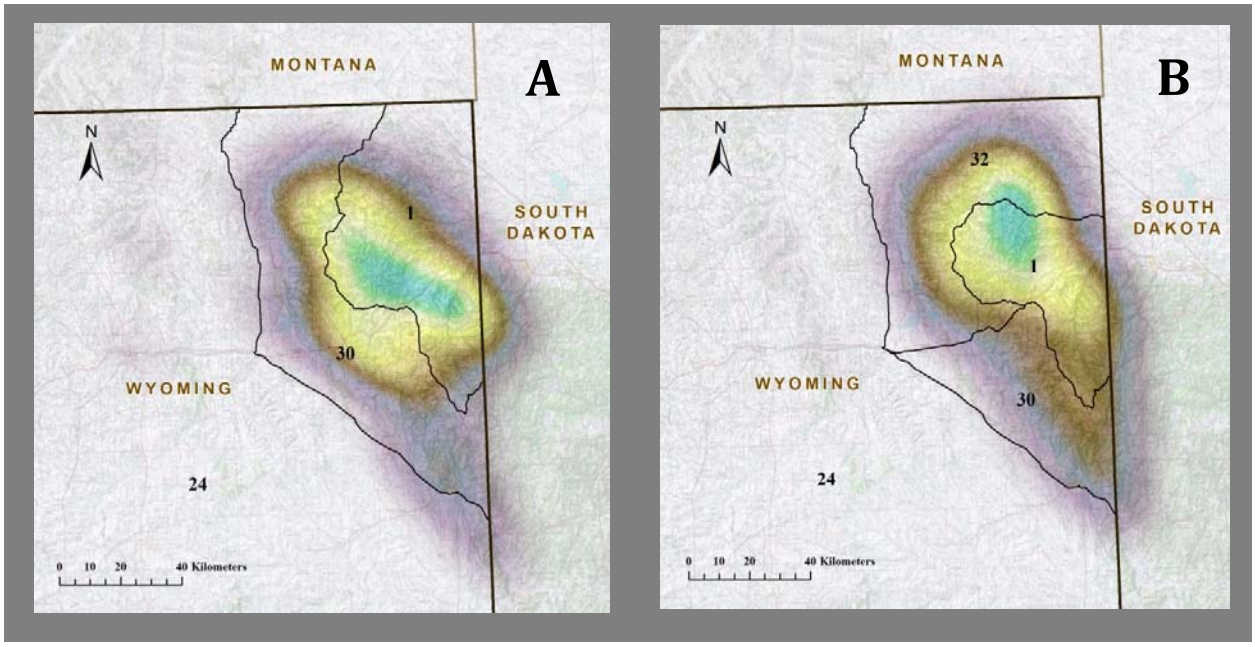


Figure 2. Average Hunt Area status classification within the southeast MLMU in Wyoming from HY 2007–HY 2012. Monitoring criteria indicate this MLMU functioned at a stable/source level ([a]human-caused mortality density = 5.0/1000km² suitable winter habitat, [b] % adult female harvest = 15.5, [c] average age of adult females in harvest = 5.5 years)

We also provide an example of the benefits derived from the ability to adapt management strategies. In 2011, the WGFD responded to public perception regarding regional mountain lion management as well as potential conflict,

primarily in the form of domestic sheep depredation in northeast Wyoming. This resulted in hunt area boundary and mortality limit changes implemented in the northeast prior to HY 2012 to direct mountain lion harvest onto private lands surrounding the Bear Lodge Mountains (Hunt Area 32). We used a kernel density estimator as a visual aid to compare harvest densities relative to the northeast MLMU before and after management strategies were implemented. Figure 3A shows general areas where the the highest densities of mountain lion harvest had occurred previous to the hunt area boundary alterations (HYs 2010–2011). When compared to Figure 3B (HYs 2012–2013), the restructure of the hunt areas resulted in a shift in harvest densities toward the desired area, driven by directing harvest to the newly established hunt area 32 and accompanied by an increase in overall harvest limits for the northeast MLMU.

Figure 3. Spatial comparison of relative harvest densities before (A) and after directing mountain lion harvest (B) by incorporating a new Hunt Area 32 in HY 2012 within the Northeast MLMU.



As with any implementation of wildlife management strategies intended to address complex ecological processes and social commentary, challenges and complications are inevitable. As we look at harvest data acquired over two complete management cycles, we identify some of these challenges, give examples of where they occur, and discuss potential ramifications for limitations within current state monitoring criteria and mountain lion management across Wyoming.

Interpretation of monitoring criteria to determine trends in hunt area status can be challenging. Low sample sizes in hunt area harvest often result in sporadic and highly variable results, where the proportion of adult females harvested (criteria **(b)**) can be increasingly difficult to determine. For example, hunt area 13 consistently reported low overall harvest numbers, and therefore was increasingly

difficult to determine a reliable trend in the proportion of adult females harvested (Figure 4).

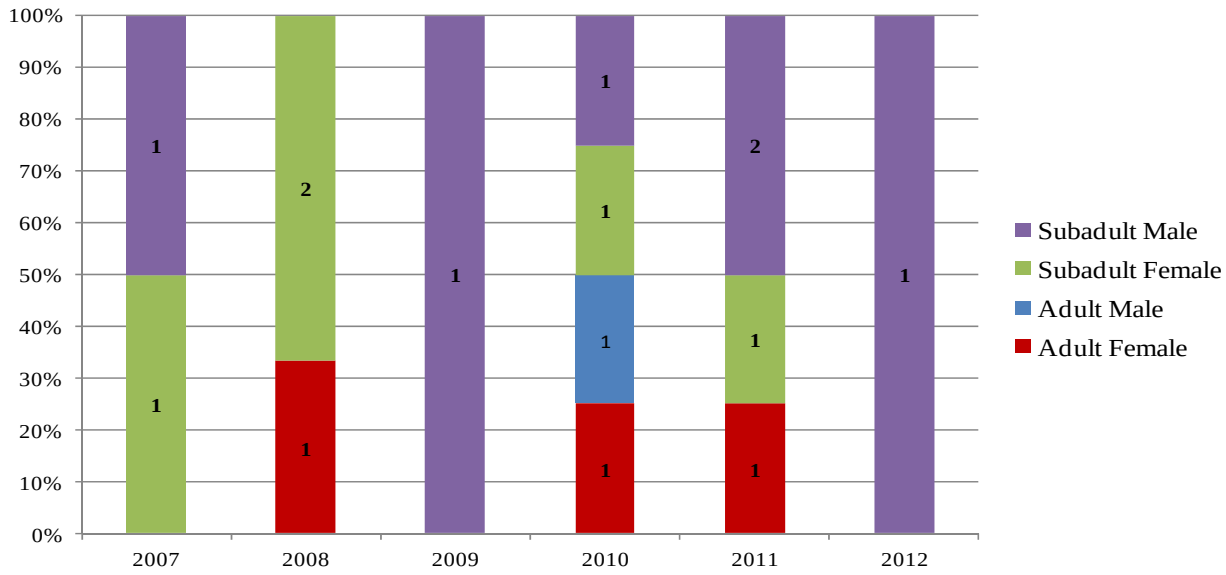


Figure 4. Age/sex composition of mountain lion hunt area 13 in Wyoming from 2007–2012. Bold numbers indicate reported sample sizes for each cohort.

Collecting adequate harvest data can be accomplished either by spatially expanding the area under analysis to incorporate more potential harvest, or by temporally extending the given timeframe to allow more harvest to occur and be assessed under various methods (e.g., 3-year average, running averages, smoothing methods). Explained within the management plan, refraining from making management changes within the 3-year cycle provides valuable temporal buffers to alleviate these sample size concerns. However, further complicating sample size adequacy within these scenarios is the application of criteria **(c)**, where the average age of adult females harvested is further used to assess population trend. At a hunt area level, with suppressed overall harvest already influencing the accuracy of the proportion of adult females taken, this issue is exacerbated when the sample size is further restricted to the amount of adult females harvested within a hunt area, and often results in a sample size of 1 or 2 adult female mountain lions in determining the average age (e.g. Figure 4).

To maximize accuracy in trend analyses, the current management plan also emphasizes the importance of using multiple metrics to determine population status, such as the density of human-caused mountain lion mortality/1000km^2 **(a)**. Although mortality density is typically one of the strongest metrics used to determine hunt area status, this too has limitations. Human-caused mortality density is calculated based on the amount of high quality winter habitat identified for mountain lions, and was derived in part through resource selection models developed in select areas in Wyoming and extrapolated via predictive maps across the state. These empirically tested mortality densities and associated habitat models

are essentially the foundation for this portion of the state management plan monitoring criteria in Wyoming. An assumption necessary for the application of statewide suitable habitat model include that mountain lions have indeed colonized all areas where habitat has been identified, which is generally supported. However, with variability in key habitat characteristics (e.g. large or small connected areas of suitable habitat, various prey densities, etc.) across the state, we understand that mountain lion densities are unlikely to be uniform across the landscape. Specific hunt areas where little to no suitable habitat is apparent renders mortality densities inapplicable to evaluate. And while the management plan supports the ability to restructure hunt area boundaries as necessary, hunt areas are more often split to create new areas than merged together. While these changes are often implemented to target harvest to specific areas, these actions often tie back to the importance of conservation of spatial area that support the sample sizes necessary for previously mentioned metrics of hunt area trends. Although sample size adequacy was given much consideration during the development of the state management plan, it never-the-less persists as a primary challenge when analysing mountain lion mortality data.

Another challenge that merits discussion is the verbiage of objectives within the mountain lion management plan. The very term "objective" ironically may be subjective under various circumstances, as well as at various scales. At population levels (MLMU or statewide), the general mission of mountain lion management in Wyoming is apparent: to sustain mountain lion populations in core habitat at varying densities depending on management objectives (WGFD 2006). However, hunt area level "objectives" for stable/source/sink are less clear. In 2010, mountain lion regulation nomenclature was changed from the use of "harvest quotas" to the term "mortality limits." This was done to support the concept that given the self-regulating tendency of mountain lion populations, the level of allowable mortality are meant to provide limits that may be reached through hunting opportunity, but are not necessarily a failure if not met or exceeded. So although source/stable/sink may be used to classify an objective for each hunt area, it is the combined result that provides sustainability in mountain lion populations. However, specific hunt areas within the state do set objectives likened to a specific management goal (e.g., to reduce local mountain lion densities). Although we cannot force hunters to increase harvest of mountain lions within hunt areas where harvest limits are not reached, the state does attempt to increase harvest levels by providing additional and reduced price licenses in some hunt areas, or by altering hunt area boundaries to further direct harvest. This seems contradictory to the previous argument, and renders objectives difficult to interpret depending on desired outcomes. For example, when quantifying hunt area objectives based on mortality limits, the state has shown an increase in the proportion of hunt areas that would classify as a sink if all mortality limits were reached. While a portion of these hunt area mortality limits are set with the intention to reduce local population densities, others are set simply to maximize hunter opportunity. Regardless of intent, the flexibility in the management strategy designed to regulate mortality limits to meet objectives of source, stable, or sink hunt areas therefore have the potential to become skewed.

Managing multiple adjacent hunt areas at relatively high mortality densities can cause a reduction the proportion of resident mountain lions, which may complicate interpretation of monitoring criteria used to assess population trends. For example, Hunt Area 1 located in the Black Hills is one of four hunt areas under management for local reductions in the resident mountain lion population within the northeast MLMU. From 2007–2009, this hunt area exhibited higher proportions of females harvested in response to increased mortality limits. However, recent data (HY 2010–HY 2012) have shifted this metric to a relatively low proportion, due to assumed suppression in overall abundance of mature individuals under increasing mortality densities (Figure 5). Under consistently high mortality densities, the elevated proportion of adult females harvested cannot be sustained for prolonged periods, and scenarios such as these convey the importance of assessing harvest data through time to identify trends in the data, as well gathering a spectrum of data to best determine the status of the population. In this situation, the challenge therein lies not solely in the management plan itself, but in the adherence to maintain a balance of source/stable/sink through mortality limits set within each MLMU.

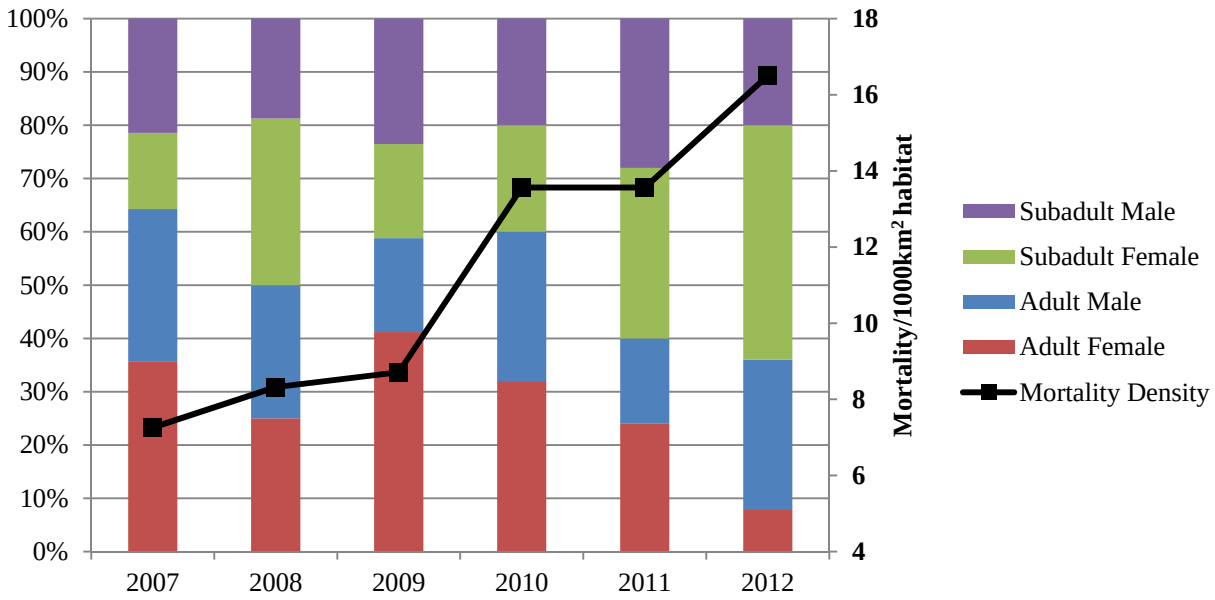


Figure 5. Hunt Area 1 trend in mortality density (black line) and age/sex composition of harvested mountain lions from 2007–2012. Mortality density values from 5–8 generally indicate stability in the population. Note the inverse relationship between the proportion of adult females harvested (red) and mortality density trend.

In conclusion, Wyoming's mountain lion management plan has thus far provided an effective framework to accomplish the statewide objective to provide viable and sustainable mountain lion populations at varying densities within suitable habitat. Wyoming has reported record harvest levels over the past several years, but monitoring criteria data indicate stabilization in the assumed increase in mountain lion distribution and abundance over the past few decades (Jenks 2011).

The flexibility of the plan has provided the ability to be proactive in the prevention of mountain lion depredation events, to address public safety concerns, and work in concert with management strategies aimed to support other wildlife species throughout the state.

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Recent Management Approaches for Cougar in Idaho

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***Abstract*:** Idaho currently operates under a Cougar Management Plan drafted during 2002 and originally slated to be re-written by 2011. Cougar hunting seasons are set on a Game Management Unit (GMU) scale, but analysis of harvest data occurs across 18 Data Analysis Units comprised of 2 to 14 GMUs. Seasons are set annually. At the start of the planning period, harvest in 35 GMUs was managed using a female quota. Of the remaining 64 GMUs without a quota, 9 were managed under a 2 cougar bag limit. Currently, management of 35 GMUs remains under a female quota, and 13 of the remaining units are managed under a 2 cougar bag limit. Predation management plans have been approved for two areas of Idaho (the Lolo/Selway and the Middle Fork Salmon River) to address substantial declines in these elk herds. However, no control actions have been included to date for cougar within these areas. While there are no firm plans for a Cougar Management Plan re-write, this need is being discussed.

Florida Panther Status Report

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***Abstract*:** Florida panthers (*Puma concolor coryi*) are federally classified as endangered by the Endangered Species Act and protected in Florida. As such, panthers are managed under the Florida Panther Recovery Plan with the overall goal of achieving long-term viability and delisting. The Florida Fish and Wildlife Conservation Commission (FWC) initiated research on Florida panthers in 1981. Over the last 33 years, with assistance from our Federal partners, we have radiocollared 229 panthers, and handled 405 neonate kittens at dens. The FWC continues to assess progress towards panther recovery via long-term monitoring, research initiatives aimed at assessing population parameters, and working to resolve human-panther conflicts coinciding with a growing panther population in shrinking habitat. The FWC and our partners are currently focused on several research studies including: 1) assessing multiple techniques to derive a statistically defensible panther population estimate; 2) continued assessment of the impacts of genetic restoration; and 3) monitoring the potential impacts of wildlife diseases on panther recovery. The FWC and the University of Florida are collaborating on research aimed at garnering a better understanding of human dimension issues associated with an expanding panther population. These include an assessment of the causes of calf mortality on ranching operations in Southwestern Florida and determining economically feasible methods of providing incentive programs to private landowners to conserve and manage their land in ways that benefit both

traditional land uses and habitat for panthers. Florida panther recovery relies on long-term monitoring data to guide public land habitat management, minimize loss of habitat from new developments and to support cooperative programs with private landowners to help conserve remaining panther habitat in Florida.

Nevada Cougar Management Topics

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***Abstract*:** Nevada's Mountain Lion Management Plan was last updated in 1995. Since that time there have been several regulatory changes to cougar management in the state, most of which were implemented with the goal of increasing annual harvest. This was the product of a politically charged system under which cougar management in the state was operating. These revisions included reduced tag costs, over-the-counter tag sales, increased bag limits and changes to a year-around season. These changes have had only moderate effects on total harvest. Current harvest levels represent roughly 11% of the adult cougar population and are below the 5-year and 10-year harvest averages. Statewide cougar harvest probably has been more dependent on yearly climatic fluctuations than it has on the imposed regulatory changes mentioned. Cougar research continues in western Nevada with a contribution to the journal *Molecular Ecology* (2012) by Alyson Andreasen, University of Nevada, Reno. Additional publications from that PhD dissertation are forthcoming. We continue to investigate research opportunities and are anticipating that a cougar and black bear interaction study will begin in fall of 2014.

Washington Mountain Lion Status Report – 2014

Richard A. Beausoleil, Washington Department of Fish and Wildlife; *richard.beausoleil@dfw.wa.gov*

***Abstract*:** This status report will be an update of cougar research, management, and legislative activities in Washington since the 2011 mountain lion workshop. After 13 years of continuous research on 6 study areas in Washington, many cougar research projects have been completed involving personnel from WDFW, Washington State University, and University of Washington. Much of this research has been published since the last workshop and several more manuscripts are in production and press; those will be highlighted in this presentation. Activity during the last 3 legislative sessions since the Montana workshop will also be summarized; they include Substitute Senate Bill 1885 regarding feeding of wildlife and fines and Senate Bills 5356 and 6287 concerning the use of dogs to hunt cougar. Finally, in

2012-13, WDFW adopted a new harvest guideline structure incorporating the social structure of cougars into management. The state was divided into 49 population management units (PMUs) and a 12-16% harvest guideline was applied to each. This process, as well as results from the past 2 years, will be discussed.

Events in California's Mountain Lion Management, 2011-2014

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***Abstract*:** Mountain lions are designated as a "specially protected mammal" for which hunting is prohibited and no funds are allocated for monitoring, research or depredation and public safety response. As a result, California's mountain lion management has been guided by state law that is limited to responding to human-mountain lion conflicts, and conflicts associated with sensitive bighorn sheep populations. Although responding to mountain lion conflicts represents an unfunded mandate, the public expects a well-coordinated response to such calls for service where individuals perceive a threat to public safety. However, due to recent reductions in force, high personnel turnover, and reductions in resources available to responding personnel, this expectation has not been consistently met throughout the state. To ameliorate this situation, CDFW began revising the state's mountain lion policy. This was prompted by a series of unfortunate circumstances including an incident that resulted in the death of 2 juvenile mountain lions in the city of Half Moon Bay. This incident, coupled with a history of similar situations, resulted in legislative changes requiring CDFW to consider utilizing the expertise of non-agency personnel (local veterinarians, university researchers, wildlife rehabilitators, and NGO's) and recommended the use of non-lethal measures as an initial step to resolving human-mountain lion conflicts. These legislative requirements were incorporated into the new policy, which has been in effect since January, 2013, and we are developing coordinated 'regional response teams' to assist our efforts when necessary. CDFW has recently allocated funding to begin developing a statewide conservation management program. This program will be highly collaborative and involve diverse stakeholders to help define conservation, management and research priorities throughout the state. This effort will also evaluate using habitat suitability models and resource selection functions coupled with population genetics to develop regionalized population monitoring priorities for assessing the state's mountain lion population.

Alberta Cougar Management

Jay Honeyman, Alberta Environment and Sustainable Resource Development

***Abstract*:** Cougar populations in Alberta had undergone significant decline and range contraction as a result of prey decline and direct persecution over the last century. More recently, from the time they were first declared a big game species in 1971, cougar populations have increased in numbers and expanded in distribution. Cougar management has been adjusted through the 1900's and 2000's to reflect the growing population, with new hunting areas and seasons added as cougars continue to expand their range. In 2014, cougar management in Alberta reflects a need to balance cougar conservation with strong public sentiment that opposes the presence of cougars in rural residential and agricultural landscapes.

To read Alberta's cougar management plan go to:
http://esrd.alberta.ca/fish-wildlife/wildlife-management/documents/WildlifeMgmtPlan-Cougars-Nov2012B.pdf

Nebraska Mountain Lion Status Report

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***Abstract*:** Mountain lions were extirpated from Nebraska by the early 1900s due to unregulated hunting, trapping, poisoning and decimation of prey species. In 1991 a female was legally shot in the Pine Ridge region of northwestern Nebraska marking the first documented presence in modern times. A female mountain lion with kittens was documented in this region in 2007, which provided the first evidence of a resident population since extirpation. Recent evidence of reproduction and resident animals suggests mountain lions are also recolonizing the Wildcat Hills in the southern panhandle and the Niobrara River valley in north-central Nebraska. The Commission initiated genetic surveys utilizing scat detector dogs in 2010 to estimate the size of the mountain lion population in the Pine Ridge. The amount of suitable habitat was also estimated using GIS based habitat modeling. The genetic survey was repeated during 2012. Nebraska's inaugural mountain lion harvest season opened on Jan 1, 2014. The state is divided into four units: 1) the Pine Ridge unit – which encompasses the largest known population, 2 and 3) the Upper Platte and Keya Paha units – which encompass the two newly documented populations, and 4) the Prairie unit – which consists of 87% of the state where no populations have been documented and habitat may be limited. Hunting in the Pine Ridge unit resulted in a harvest of two males and one female. The Prairie unit remains open year-round and there is no harvest limit. No harvest is allowed during 2014 in the Upper Platte and Keya Paha units. Additional research is planned for 2014 and 2015 in order to create population estimates for the Pine Ridge and the recently recolonized areas.

New Mexico Cougar Management Update 2014

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Frederic Winslow**,** New Mexico Department of Game and Fish, 1 Wildlife Way, Santa Fe, NM 87507

Abstract: Cougars (*Puma concolor*) became a protected species in New Mexico in 1971, and hunting management was based on a zone management system starting in 2000. Habitat modelling estimates a cougar population of 3,100 to 4,300 individuals. There are 19 management zones, 11 are managed for increasing populations, and 8 are managed for stable to decreasing populations. For increasing populations, total harvest cannot exceed 25% of the population, with female harvest not to exceed 30% of the total harvest. For stable to decreasing population, total harvest cannot exceed 30% of the population, with female harvest not to exceed 50% of the total harvest. Currently, only sport harvest counts towards the maximum sustainable harvest limit. From 2010-2013, 40% of total harvest was females, ≥50% of females harvested were <2.5 years old, and the average annual total harvest was 215 animals. Annually, 4-7% of the cougar population is killed from all sources of human-caused mortality.

Desert bighorn sheep (*Ovis canadensis*) were listed as a state endangered species in 1980, and in the 1990s it was documented that 85% of known cause morality was caused by cougar predation. From 1979 to 2001, 249 bighorn were transplanted into the wild, and from 2002-2013 231 bighorn were transplanted into the wild. In 2001, a cougar removal effort was implemented in desert bighorn habitat in New Mexico; the area constitutes ~1% of cougar habitat, and an average of 2.6 cougars per mountain range per year is removed under this program. Cougar predation mortality rates for desert bighorn declined from 0.16 prior to cougar removal to 0.06 following cougar removal. All other causes of mortality remained fairly constant at 0.05 prior to cougar removal and 0.06 following cougar removal. This demonstrates that cougar predation is an additive source of mortality for desert bighorn. Desert bighorn increased from <170 animals in 2001 to approximately 800 in 2013. When high cougar predation rates are limiting bighorn populations, a cougar removal program may allow bighorn populations to expand.

A Cause to Pause in Montana, Again – What's- up with Montana Mountain Lions? 2011-2014

Jim Williams, Montana Fish, Wildlife and Parks; USA, *jiwilliams@mt.gov*

***Abstract*:** Montana is in the process of dedicating resources to create a new statewide mountain lion management plan. We are currently operating under a plan that was written in 1996. The Journal; of Wildlife Management has tentatively accepted a new monograph titled "Linking Resource Selection and Mortality Modeling for Population Estimation of Mountain Lions in Montana". This statewide research effort will help refine harvest Montana management goals. More specifically, in the Bitterroot Valley of west central Montana, mountain lion density estimates are being produced by current research efforts that challenge traditional density paradigms. Lastly, ecological discussions from the last WAFWA workshop were incorporated into some regional Montana mountain lion hunting season structures.

Arizona Game and Fish Report

April Howard, Arizona Game and Fish Department

***Abstract*:** Research has shown that predation by mountain lions can limit bighorn sheep populations and impede restoration efforts or induce population decline. After mountain lions colonized southwestern Arizona in the early 2000's, bighorn sheep populations in that area declined by 50%. In 2013, a translocation of 31 bighorn sheep into southeastern Arizona, which once contained a robust and indigenous population of desert bighorn sheep, were quickly reduced to 14 within 4 months. After analyses of the probable causes of the sheep decline in both areas, predation by mountain lions was identified as one factor that could potentially be limiting the recovery of the bighorn sheep populations. Arizona implemented Adaptive Mountain Lion Predation Management Plans for each site. An important component of each Plan is to use research and monitoring approaches to increase knowledge and to evaluate management actions across a broader area of these lower desert habitats. Although it is premature to form any conclusions, current information collected from collared sheep and mountain lions, and survey data are used to implement and evaluate management strategies such as "offending " lion removal, multiple bag limits, and mountain lion management zones.

Evolution of mountain lion management in North Dakota, 2011-2014

Stephanie Tucker, North Dakota Game and Fish Department, Bismarck;
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***Abstract*:** Management of mountain lions in North Dakota focused on human conflicts and harvest management during the past 3 years. Also during this time, the first active research project on mountain lions in North Dakota began. This first phase of research concentrated on adult mountain lion survival and food habits as a scientific comparison to landowner and hunter concerns. Landowner tolerance for mountain lions remains low. Additionally, mountain lions continue to be a scapegoat for low mule deer numbers. An upcoming second phase of research will attempt to verify our population and habitat models, so that a realistic level of certainty can be achieved to aid in harvest management. The small population size of mountain lions in North Dakota adds challenges to the species' management.

Plenary Session 2: Keynote

A big cat in a small body: Do Eurasian lynx have what it takes to survive the Anthropocene?

Dr. John Linnell, Norwegian Institute for Nature Research, Trondheim, Norway

***Abstract*:** There is currently a huge focus on the global status of large carnivores, with some species such as tigers, snow leopards, cheetah and African lions attracting most attention. Although there is no doubt that these species are in need of all the help they can get, the dominance of these species in the public's eye detracts from the more complex situations facing other species. These include species like mountain lions, leopards and Eurasian lynx. These species are widespread and have highly variable status. Populations vary from large, well connected and expanding, to small, isolated and highly endangered. This talk focuses on the Eurasian lynx, exploring what we know, and don't know, about its ecology and conservation status across its wide distribution that stretches across Eurasia. The talk will address details of its ecology and management, especially focusing on issues with parallels to mountain lions – including competition with hunters for wild ungulates, depredation on livestock, monitoring and hunter harvest. The talk will summarize what is known from the many study sites in Europe where it has been well studied – but will also profile just how much is unknown about its status and ecology across the majority of its range in Asia.

John Linnell discusses lynx ecology.

Session 3:

Felid Ecology, Conservation, and Populations, Part 1

Ashwin Naidu talks about barriers and gene flow.

Potential barriers restricting gene flow among mountain lions in Arizona.

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Robert R. Fitak, Institut für Populationsgenetik, Veterinärmedizinische Universität Wien, Vienna, Austria, *rfitak9@gmail.com*

Melanie Culver, Graduate Interdisciplinary Program in Genetics and School of Natural Resources and the Environment, University of Arizona; *mculver@email.arizona.edu.*

***Abstract*:** We investigated the population genetic structure of mountain lions (*Puma concolor*) in Arizona from hunter-harvested tissue and scat samples collected during 2008-2012. Our goal was to examine what geographic features (e.g. interstate highways, the Colorado River, the Grand Canyon) are potentially restricting gene flow among mountain lions in the state. We genotyped 466 DNA samples for 10 well-known *Felis catus* microsatellite DNA markers, and with "PumaPlex" – a panel of 26 single nucleotide polymorphisms (SNPs) recently developed for population genetic studies on mountain lions. We found the highest statistical support for four sub-populations of mountain lions in Arizona. Geographic visualization of these sub-populations suggested that Interstate highways (particularly Interstate-10 west of Phoenix, Interstate-17 and Interstate-40) and the lower Colorado River might be restricting gene flow among mountain lions. To corroborate genetic data on mountain lion population substructure and connectivity, we are currently creating a GIS-based habitat suitability model for mountain lions that will provide us with the potential corridors for mountain lion movement across these barriers. Data generated from this study will be useful for wildlife managers, stakeholders, and conservation planners in making regional or statewide management decisions for mountain lions, designating wildlife corridor areas, and facilitating collaborative research between individuals, laboratories and agencies.

The importance of scale and behavioral state in puma resource selection functions.

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***Abstract*:** Puma habitat relationships are typically estimated with resource selection functions (RSFs), which are based on a paired 'used'/'available' design. Many puma RSFs use the area of the home range, or larger, for the available extent. Additionally, most RSFs use all data points for analysis, regardless of the behavioral state of an individual. We were interested in examining selection at finer scales and for different behavioral states. GPS telemetry data collected at 5-minute fix intervals from pumas in southern California were used in a paired used/available design to explore the sensitivity of RSFs to the extent, or scale, of available habitat and to the behavioral state of individuals. We examined 37 scales of available habitat, from 250m to 10,000m, and two behavioral states, resource use and movement. Across the full factorial of scales and behavioral states, we compared parameter estimates to determine the strength of selection, and model performance to assess predictive ability. RSFs were sensitive to the scale of available habitat. Multiple characteristic scales were found across our predictor variables, indicating that pumas in the study area are responding at different scales to different landscape features and that multi-scale models may be more appropriate. Across behavioral states, pumas respond to grasslands, coastal oak woodlands and coastal scrub at fine scales, and urban and agriculture at coarse scales. RSFs were also sensitive to behavioral state; specifically, pumas engaged in resource use behavior had an opposite selection response to some land cover types than pumas engaged in movement behavior. All models performed well, with coarser scale and multi-scale models outperforming fine-scale models and resource use models generally outperforming movement models. Our results indicate that multiple scales of selection and behavioral states should be examined in puma RSFs, especially when results will be used for management purposes.

California's cougar connectivity: genetics informing conservation and management

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***Abstract*:** Mountain lions (*Puma concolor*) in California live amongst habitat mosaics spanning a range between extremes of urbanized fragmented coastal environments and vast montane wild lands in the north state and inland. Coast regions extending between San Francisco, Los Angeles, and San Diego have burgeoning human populations while the North Coast Range, Sierra Nevada, and Modoc Plateau encompass vast sections of intact puma habitat less impacted by human developments. In order to assess population connectivity and genetic health of California mountain lions across these extremes, we conducted a detailed appraisal of the genetic diversity, relatedness, and population structure of California puma populations using 354 samples and a 46-locus microsatellite DNA panel. This study follows up on work conducted ten years ago and employs an expanded genetic tool set and larger coast region sample size. We evaluated and compared levels of genetic diversity, inbreeding, relatedness, effective population sizes, and tested whether genetic data supported hypotheses of recent bottlenecks in key populations including the Santa Cruz Mountains (n=78), Santa Monica Mountains (n=26), Santa Ana Mountains (n=42) and adjacent Peninsular Ranges (N=55). We found that coast populations near large urban centers had much lower genetic diversity than inland populations such as those in Sierra Nevada. Specific instances of repeated inbreeding and signs of potential genetic defects were detected. These findings raise major concerns about the current status of California coastal mountain lion populations, and the longer-term outlook for pumas in southern and central coastal California. In particular, the finding highlight the urgency to maintain – and enhance – what connectivity remains for pumas (and presumably numerous other species) across human barriers including multilane highways and developments. We are hopeful that these new genetic results, coupled with the demographic findings, will motivate greater conservation focus and effective outcomes.

Population genetics of a small, isolated population of mountain lions: Barriers, inbreeding, and genetic rescue.

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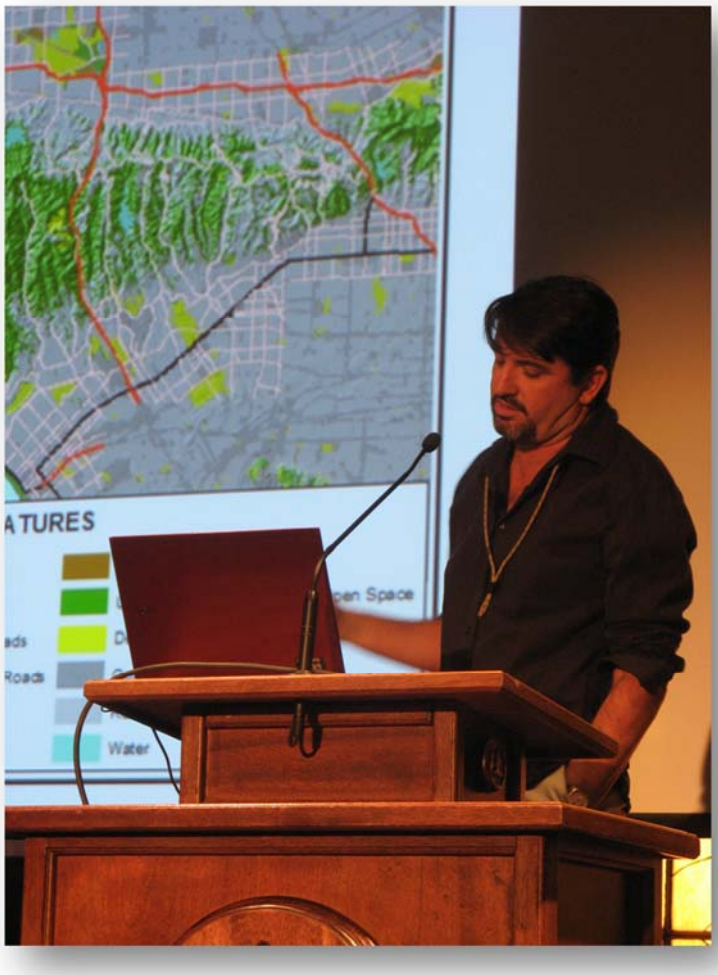
Abstract: Mountain lions persist naturally at low densities and can be particularly sensitive to the effects of habitat loss and fragmentation, including genetic effects such as inbreeding and the loss of genetic diversity. The Santa Monica Mountains, northwest of Los Angeles area, are completely isolated from other large natural areas by urban development and large freeways, specifically the 101 Freeway to the north. Locations of GPS radio-collared mountain lions indicate that these freeways are a significant barrier to mountain lion movement. To evaluate the effects of these barriers in more detail, we genotyped 26 lions captured as part of a long-term National Park Service study, as well as 16 other lions in the area at 54 microsatellite loci. Mountain lions in the Santa Monica Mountains had significantly lower genetic diversity than those north of the freeway as measured by expected heterozygosity and numbers of alleles. More broadly, this small population also exhibited the lowest levels of genetic diversity that have been reported both in California and throughout the west. Based on pedigree construction and gene-drop analysis, individual male mountain lions can have very high reproductive success and dominate the gene pool of this population. Because of our detailed knowledge of this small population, we were able to document that individual events significantly affected its population genetics. Specifically, a young male (P12) immigrated into the population from north of the 101 Freeway, He possessed 20 alleles that were not

previously present in the Santa Monica Mountains population, 19 of which he passed on to his offspring, increasing the population-level diversity. However, we also documented multiple instances of close-inbreeding, specifically between fathers and daughters, something that has rarely been reported in this species and which had measurably negative effects on genetic diversity. Currently, connectivity between the Santa Monica Mountains and other natural areas to the North is very limited; maintaining and enhancing connectivity will be critical for the long-term demographic and genetic health of mountain lion populations in this and other fragmented landscapes.



Seth Riley discusses mountain lion population genetics.

Session 4:

Felid Ecology, Conservation, and Populations, Part 2

Proceedings of the

11th Mountain Lion Workshop

Integrating Scientific Findings into Management

Home range characteristics of a subordinate predator: selection for refugia or prey availability?

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Abstract: Cougars (*Puma concolor*) are described as "habitat generalists", but little is known about which ecological factors drive their home range selection, particularly in the presence of dominant competitors (i.e. wolves, *Canis lupus*). We tracked cougars using VHF (2001 to 2005) and GPS (2006 to 2011) technology in the Southern Yellowstone Ecosystem (SYE) in northwestern Wyoming, USA. We tested whether data type (VHF vs. GPS), cougar sex, access to forests (refugia), or prey availability explained the size of 50% and 95% kernel density estimator (KDE) home ranges. Second, we quantified attributes of cougar home ranges and tested whether they were different from attributes of the overall study area, to address the ecological question: Do cougars select home ranges based on the availability of refugia, prey availability, or some combination of the two? Cougar sex and data type proved significant predictors of home range size for both 95% and 50% KDEs, and the amount of forest partly explained the size of 50% KDEs. Cougar home ranges derived from VHF data were 1.4-1.9 times larger than home ranges derived from GPS data, however, home range attributes determined from VHF and GPS data were remarkably equivalent. Female cougars selected home ranges with higher hunt opportunity than males, and higher than expected when compared to the mean value of the study area, supporting the long-standing assumption that females primarily select home ranges with suitable prey to sustain themselves and their dependent young. All cougars selected home ranges further from known wolf packs, providing evidence for newly established competition between resident cougars and recolonizing wolves, but did not select home ranges with greater access to landscape refugia. Our results provided evidence that cougars in the SYE select home ranges that provide high prey availability and a spatial buffer that mitigates potential conflicts with a dominant competitor.

Genetic structure of cougars in the Black Hills, South Dakota.

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Abstract: Assessing genetic structure of game species populations, such as cougars (*Puma concolor*), provides knowledge of population demographics and is vital for long-term management. Having re-populated the Black Hills by 1998, the cougar population reached saturation in 2005, prompting an initiation of a harvest season by South Dakota Department of Game, Fish and Parks. Increasing harvest quotas in conjunction with the relative isolation of the Black Hills may deter connectivity and act to decrease long-term viability. Our objectives were to assess genetic structure of cougars in the Black Hills, South Dakota, measure effective population size (N_e), and compare results with those found before a harvest season had been implemented using 20 microsatellite loci. We also compared genetic structure and conducted population assignment tests with the neighboring cougar populations in Wyoming and North Dakota. We conducted genetic analysis on 712 DNA samples from cougars in the Black Hills collected from 2003-2013. Captured animals were fitted with radio-collars and ear tagged. Blood/tissue samples were collected from all radio-collared and harvested individuals, as well as non-harvest related mortalities. Genetic analysis was measured using GenAlEx, HP-Rare, ONeSAMP, and STRUCTURE. Pre-harvest genetic analysis found an expected heterozygosity (H_E) of 0.55, observed heterozygosity (H_O) of 0.55, and effective population size of 27.9 (23-39; 95%CL). In comparison, we determined that cougars in South Dakota post initiation of harvest had an average expected heterozygosity (H_E) of 0.56, and an average observed heterozygosity (H_O) of 0.55. Effective population size of cougars in the Black Hills, South Dakota was 28.4 individuals (23-37; 95%CL). We were able to successfully assign cougars from South Dakota, North Dakota, and Wyoming into separate populations. Genetic variability of cougars in the Black Hills remains stable, possibly as a result of emigration and immigration. Continued genetic assessment of cougars in South Dakota is recommended.

Integrating Resource Selection and Harvest into Spatial Capture-Recapture Models for estimating mountain lion abundance.

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***Abstract*:** The lack of rigorous mountain lion abundance estimates has contributed to making mountain lion management one of the most contentious wildlife issues in western Montana. Recent advances in spatial capture recapture (SCR) models have provided new approaches for addressing this important need and providing an objective basis for mountain lion management. We developed extensions to standard SCR models to incorporate simultaneous live sampling and harvest events and habitat quality information. We demonstrate the use of these novel methods in estimating mountain lion abundance and density in two mountain lion management units in western Montana, hunting districts 250 and 270. We identified individuals through DNA samples collected by 1) biopsy darting treed mountain lions located during systematic surveys, 2) opportunistically collecting hair and scat samples, and 3) sampling all harvested mountain lions. We included 80 DNA samples collected from 62 independent individuals in the analysis. We estimated the abundance of 85 (95% CI = 54, 141) independent mountain lions in hunting district 250 and 82 (95% CI = 51, 137) in hunting district 270. These results are 2 -3 times higher than previously estimated minimum mountain lion abundances in this area, and correspond to density estimates of 4.6 and 5.4 lions per 100 km^2. Because current harvest regulations in western Montana were developed under the assumption of lower population abundance, lion management objectives are unlikely to be met unless harvest prescriptions are adjusted to account for this new understanding of lion population status. More broadly, the analytic improvements in SCR methods will enhance the ability of wildlife managers to reliably and economically estimate abundance of mountain lions, as well as other large carnivores.

Evaluation of harvest indices currently used for cougar management in Utah: Oquirrh-Stansbury and Monroe units as case studies.

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Abstract: We present demographic estimates from two cougar populations in Utah that have been intensively monitored for 17 years, and compare these demographic rates to harvest statistics provided by the Utah Division of Wildlife Resources (UDWR) covering the length of the study period. We quantify the relationship between harvest indices and estimated demographic rates for the Monroe and the Oquirrh-Stansbury management units, respectively. The first is a hunted population in the Monroe Mountains, a remote location in south-central Utah; and the second is a semi-protected population in the Oquirrh Mountains, on the periphery of Salt Lake City. Our overall objective was to assess the relationships between the harvest indices currently used for cougar management in both the Oquirrh-Stansbury and Monroe wildlife management units and provide the UDWR with recommendations to help calibrate currently used indices to actual population dynamics. Because the Oquirrh-Stansbury (i.e., where anthropogenic sources of mortality, other than harvest, are predominant) and Monroe management units (i.e., where harvest is the main cause of mortality) are subjected to contrasting mortality regimes, results provided by this study could be expanded to other management units that exhibit similar characteristics to the units described here.

Survival rates of cougars in Oregon from 1989 – 2011: a retrospective analysis

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Abstract: We conducted a retrospective analysis of survival and causes of mortality of 222 radiocollared cougars (*Puma concolor*) in 3 lightly hunted cougar populations in Oregon from 1989 – 2011. Two studies [Catherine Creek (1989 – 1996) and Jackson Creek (1993 – 2002)] overlapped the passage of Measure 18 in 1994, which prohibited the use of dogs to hunt cougars, but the Wenaha-Sled Springs-Mt. Emily (WSM) did not (2002 – 2011). Hunting mortality was the most common cause of death at Catherine Creek and WSM. In contrast, natural mortality was most common at Jackson Creek. Annual survival rates of adult males were lowest at Catherine Creek pre-Measure 18 (0.57) and increased post-Measure 18 (0.86), similar to those rates observed at Jackson Creek (0.78) and WSM (0.82). Sub-adult male survival increased pre-Measure 18 (0.57) to post-Measure 18 (0.86) at Catherine Creek, which was greater than survival rates observed at Jackson Creek (0.60) and WSM (0.45). Regardless of hunting regulations, annual survival rates of adult and sub-adult females were similar among study areas (0.85 – 0.89). We observed an effect age on annual survival at both Jackson Creek and WSM, where young (1 – 3 years) males had lower survival than young females, but survival of males and females were similar by age 4 or 5 years. Survival of both genders declined at older ages (6+ years) at WSM but not Jackson Creek. We did not observe an effect of age on survival at Catherine Creek. Our results indicated sources of mortality varied within jurisdictions, even if management practices were similar. Hunting cougars with dogs lowered of adult males compared to areas where cougars are hunted without dogs. The effect of increasing age on cougar survival should be considered when using survival rates to estimate population growth rates.

Using DNA to evaluate field identification of cougar gender by agency staff and hunters using trained dogs

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***Abstract*:** Cougar hunting has typically been classified as either selective-hunting with the aid of dogs or non-selective-hunting without dogs, based on the assumption that hunters using dogs can better identify gender of cougars prior to harvest. Subsequent to hunt activity, 94% of all wildlife agencies that allow cougar hunting have mandatory inspections where gender is identified and recorded by agency staff. To test the ability of hunters and agency staff in Washington to correctly identify gender of cougars in the field during hunting seasons and inspection of mortalities, respectively, this project used DNA analysis of tissue samples collected with biopsy darts and during inspection. The gender assigned by dog hunters in the field matched gender from DNA analysis 70% of the time (n = 159); correct identification varied between 57 and 88% per year. The gender identified by agency staff during inspection of mortalities matched DNA analysis 85% of the time (n = 1,331); correct identification varied between 71 and 90% per year. Because gender misclassification has the potential to alter intended hunter harvest as well as how success of management prescriptions are interpreted, agencies may want to initiate internal and hunter education programs. Since the majority already have mandatory inspections, agencies may also want to consider DNA collection during mandatory inspections to identify error rates of gender identification by staff within their jurisdiction. Finally, considering the size of cougar management units in jurisdictions can be a valuable way for agencies to prevent complications of potential gender misidentification.

Session 5:

Posters

Proceedings of the

11th Mountain Lion Workshop

Integrating Scientific Findings into Management

Orphaned kittens in Washington result in a decade of nationwide cougar education

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Abstract: Between 2002 and 2012, 26 orphan cougar (*Puma concolor*) cubs have been reported to Washington Department of Fish and Wildlife (WDFW), captured by staff, and placed with facilities accredited by the Association of Zoos and Aquariums (AZA) throughout the U.S. In addition to over 15 million visitors per year at these facilities, innumerable television and newsprint stories have covered the capture, transport, and arrival of these animals, thus reaching out to countless millions more people. This has not only resulted in high quality cougar education programs benefiting people who may never have the chance to see a cougar in the wild, but also brought prominent national attention to WDFW. The process of responding, capturing, and providing care until arrangements are finalized, and transporting animals requires organization, commitment, and on occasion personal donations of time and money. In almost all cases, orphaned cougar kittens are reported to WDFW by a member of the public concerned that the animals will not survive on their own. Many times, the reports are given without the reporting party knowing the specifics; only that the kittens have been seen without an adult. If it's the first sighting, and we do not have background knowledge, we ask that they leave the animals alone and keep us informed daily; this avoids removing kittens that are not orphaned and left temporarily while the adult female is hunting for food. As additional information is obtained, and we are certain the adult is no longer present, a response is initiated. In addition to using several types of box traps, kittens have been captured using WDFW's Karelian Bear Dogs (treeing kittens), and by hand on several occasions. Once captured, all kittens are tested for FeLV/FIV, transported to a veterinarian and given a thorough examination, care is administered if needed, and biological measurements are gathered and recorded. Health certificates and import permits are then obtained to facilitate transfer. Many times, kittens need to travel by aircraft to their final destination. Regulations require an absorbent material be used as a base layer in the transport crate, windows and doors are securely covered with breathable burlap, doors are securely locked, and food and water is provided. Flights are almost always direct to the destination to limit time in the crate. As much as possible, we keep the reporting party involved throughout the process; this had resulted in respect, credibility, and much appreciation. We acknowledge the assistance of Michelle Schireman, North America Section AZA Felid TAG Puma Population Manager & Regional Studbook Keeper, who has been an invaluable collaborator in placing these animals, and the AZA organizations throughout the U.S. that have provided a place for these animals to become ambassadors for the species. Please come by and see this descriptive poster and learn more about this process during the poster session.

Foraging patterns of cougars in the Pryor Mountains of Wyoming and Montana

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***Abstract*:** The impact of cougar predation on their prey species varies regionally. To document the relationships between cougar predation and the bighorn sheep, mule deer, and feral horse populations of the Bighorn National Recreation Area and the Pryor Mountains, we deployed GPS collars on 6 cougars and visited their location clusters to determine their kill rates and foraging patterns. We examined the prey composition of their kills (n = 200) by species, mule deer sex and age classes, prey size classes, as well as the sex or social class of the cougar. We examined selection relative to ungulate population composition obtained through an aerial survey. We found mule deer were the primary prey of cougars in the Pryor Mountains, while bighorn sheep and feral horses constituted secondary prey species. While cougars selected for bighorn sheep, this was all attributable to one individual that specialized on bighorn sheep. This cougar population also selected for adult male and juvenile mule deer. Female cougars killed more does and males killed more bucks. Family groups had the shortest time intervals between kills, while adult males had the longest. We recommend that managers continue to investigate options to reduce predation pressures from cougars on the bighorn sheep population. Modification of predation risk through habitat manipulation could be considered. Managers should be aware that small, isolated bighorn sheep populations can be difficult and expensive to maintain. In addition, at the time of this study, the cougar population was not depredating any feral horses; thus managers will need to continue actions to reach their management objectives of reducing the feral horse population.

Improvements on GPS location cluster analysis techniques for predicting feeding activities

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***Abstract*:** GPS location cluster analysis has become a staple technique in large predator feeding studies. We demonstrate three improvements to the method based on study design and technological advancements in a four year study of 4600 cluster ground-truthing visits to GPS location clusters from 53 cougar subjects: 1)

Ground-truthing potential feeding sites have generally relied on either exhaustively visiting all clusters of an individual subject or by opportunistic non-random sampling. The former may be cost prohibitive and limit the sample size of animal subjects, while the latter may lead to biased estimates of kill-rate/prey composition. We demonstrate a stratified random sampling scheme for monthly visitation periods, along with a sample of "single point clusters" consisting of a single GPS location. 2) Feeding event prediction models using classic cluster analyses are likely biased toward larger prey items. We demonstrate a simple integration of accelerometer sensor data as an additional covariate to help improve prediction models. 3) It is suspected that the probability a technician successfully classifies a cluster while ground-truthing declines as the visitation lag (time delay between technician visitation and cougar feeding date) increases. Direct satellite communication capabilities now allow real-time downloading of GPS data, and thus near real-time ground-truthing. We tested this on a sample of clusters (n = 202) with visitation by one technician 1-3 days post initiation by the cougar, and then by a second independent blind observer 1-60 days later. The double observers concurred in the presence/absence of feeding remains in 98.6% of the cases, while concurring on species identification in 93.6%. While classification success of prey species, sex, and age will likely decrease as prey remains degrade, researchers should be confident that the presence/absence classification component is robust for the logistically feasible visitation lags that were tested.

Trichinella in two disjunct populations of puma

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***Abstract*:** *Trichinella* spp. are zoonotic nematodes common in carnivores throughout the world. These parasites are unique because the same individual is host to all stages of the nematode and transmission is based on ingestion of infected tissues. We determined the prevalence of *Trichinella* spp. infections in Florida panthers (*Puma concolor coryi*) and cougar (*P. concolor couguar*) from Colorado. Tongue samples from 114 panther and 40 cougar mortalities were collected at necropsy and examined by artificial digestion. *Trichinella* spp. larvae were detected

in 24 (21.1%) panthers and 18 (45.0%) cougars. Of these *Trichinella* samples, 19 from Florida and 9 from Colorado were genotyped to species. From Florida, *T. pseudospiralis* was detected in 16, *T. spiralis* in 1, and 2 panthers were infected with both *T. pseudospiralis* and *T. spiralis*. From Colorado, *T. murrelli* was detected in 5, *T. pseudospiralis* in 3, and 1 cougar was infected with *Trichinella* genotype T6. Our results indicated that infection of *Trichinella* is common throughout different populations of pumas in the U. S. This is the first report of *Trichinella pseudospiralis* in panthers and cougars and only the third report in U. S. wildlife. Infection of *Trichinella* spp. in puma is usually subclinical and rarely causes disease. However, understanding the epidemiology of *Trichinella* spp. in puma becomes increasingly important since Florida panthers are endangered and cougars harvested in Colorado are often consumed by humans.

Confirmed mountain lions in Oklahoma

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***Abstract*:** The Mountain lion (*Puma concolor*) historically roamed much of the United States prior to early settlement. Earliest reports of mountain lions in Oklahoma date back to the mid 1800's. Since 2002, fourteen mountain lions have been confirmed in Oklahoma by the Department of Wildlife Conservation. Confirmation consists of photos, tracks, scat, or other physical evidence. When possible, sex of the lions was determined. Seven males and four females were classified. Three lions were unclassified. Necropsies were performed on 3 lion carcasses and all females examined to date have shown no evidence of reproduction. As mountain lion populations in the western U.S. continue to expand, dispersal is likely to continue into Oklahoma, bringing transient lions seeking new, uninhabited territories to establish home ranges.

Puma activity and mesocarnivores

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***Abstract*:** Apex predators may exert top down effects on ecological communities directly by affecting the abundance and distribution of herbivores through predation and predator avoidance, or indirectly by affecting herbivores through similar effects on mesocarnivores. Our objective was to determine whether there was a significant negative association between puma (*Puma concolor*) activity and the activity of mesocarnivores coyote (Canis latrans), bobcat (Lynx rufus), and gray fox (Urocyon cinereoargenteus) activity as measured by photographic rates on

remote cameras. We used photographic data collected from 18 May 2008 to 1 June 2012 from 25 remote cameras distributed at fixed locations over 100 km^2 in south-central New Mexico. We logged a total of 25,475 camera nights and collected 538 photos of puma, 892 of coyote, 278 of bobcat, and 2,945 of gray fox. Negative binomial regressions revealed a significant negative association between puma activity and coyote activity ($z = -14.423$; $df = 25$; $p < 0.0001$) and puma and bobcat activity ($z = -2.417$; $df = 25$; $p = 0.008$). We also found a negative association between puma and gray fox but this relationship was not statistically significant ($z = -0.932$, $df = 25$, $p = 0.176$). Our data support the hypothesis that puma reduce the presence smaller carnivores. If puma do displace mesocarnivores to the degree we have observed, puma may exert additional effects on ecosystem processes quite apart from the large herbivore mediated processes with which we are more familiar. However, we cannot rule out the possibility that differences in fine scale habitat preferences among these species are responsible for the patterns we observed in this study. Rigorous comparisons between areas with and without puma, or before and after puma are removed/added, could address this ambiguity.

Effects of puma sex, season, and habitat type on diet

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***Abstract*:** Our objective was to determine whether puma sexes responded differently to season and habitat type with respect to diet. From February 26, 2008 to June 6, 2012, we investigated 392 prey caches, representing the diets of 15 adult puma total across two study areas in south-central New Mexico. We used log-linear analyses and post-hoc Chi-Square tests of Independence to elucidate the interactive effects of season (cold-dry versus hot-wet), habitat type (riparian flood plain on Bosque del Apache National Wildlife Refuge (BDA) versus canyon-land foothills on the Ladder Ranch (LR)), and puma sex on diet. We found a marginally significant sex x habitat type x prey size effect ($G=-7.661$; $df=3$; $p=0.053$). Both male and female puma ate more small and medium sized prey items on the BDA. This pattern was statistically significant for females ($G=58.7$; $df=2$; $p<0.001$) but not for males. On the BDA we found a marginally significant sex x season x prey size effect ($G=-7.1008$; $df=3$; $p=0.069$). Here males and females consumed more medium and small prey in the warm-wet season. This pattern was much more pronounced for males ($G=6.875$; $df=3$; $p=0.076$). On the LR we found a significant sex x season x prey size effect ($G=-11.023$; $df=3$; $p=0.012$). Females tended to consume more large and medium prey in the warm-wet season whereas males consumed more medium and small prey during this time. This was trend was statistically significant for males ($G=16.099$; $df=3$; $p=0.001$) but not for females. In general, male puma diet demonstrated more dramatic temporal changes than spatial changes. On both the BDA and LR male puma diet shifts corresponded to the ungulate birth pulse. While

female puma also responded to the ungulate birth pulse on both study areas, female puma exploited the increased availability of small prey species in the floodplain to a greater extent than males.

Effects of ambient light on puma, deer, and elk activity

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***Abstract*:** Puma (*Puma concolor*) depend on concealment to prey primarily on ungulates. We asked whether puma activity, as measured by remote cameras, and predation, as measured by individual predation events, was affected by ambient light and particularly by lunar phase. We also asked if activity of mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*), were similarly affected. To examine the effects of lunar illumination on puma predation we compared the mean fraction of the moon illuminated between nights when kills were made and nights when kills were not made using a t-test. To examine activity patterns across illumination periods we conducted two sets of Chi-squared tests of independence. First, we compared photo counts across illumination periods of dawn, sunlight, dusk, dark, and moonlight for two study areas, the Bosque del Apache National Wildlife Refuge (BDA) and the Ladder Ranch (LR) which differed in habitat type and human activity. The BDA is located in riparian floodplain and experiences high human visitation. The LR is in canyon land foothills and human visitation is rare. Second, we repeated these analyses across the lunar phases of dark, 1st quarter, 2nd quarter, 3rd quarter, and 4th quarter. Using data from 35 cameras operated for varying periods from 18 May 2008 to 1 July, 2012, we recorded 791 puma photos, 2,922 mule deer photos, and 1,201 elk photos. Puma were primarily nocturnal; deer and elk were primarily diurnal. However, all three species were more active at night on the BDA and more active during daylight on the LR (puma X^2=9.0173; df=4; p=0.061; deer X^2=213.6; df=4; p<0.001; elk X^2=90.75; df=4; p<0.001). Puma activity was not associated with lunar phase. Deer and elk were significantly more active in moonlight (X^2=24.24; df=4; p<0.05 and X^2=21.14; df=4; p<0.05). Lunar illumination was not greater on nights when puma made kills.

Camera trapping vs radio-telemetry: a comparison of noninvasive and invasive methods for monitoring cougar populations

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***Abstract*:** Conventional methods for monitoring cougar populations involve capture and radio-collaring, followed by intensive radio-tracking and, essentially, simple enumeration of individual cougars. This method is assumed to be accurate, but prohibitively expensive and logistically challenging. Noninvasive survey techniques may offer opportunities to accurately monitor cougar population trends at lower costs than conventional capture and radio-collar research. However, few of these survey techniques have been employed in conjunction with conventional cougar monitoring methods in order to validate the noninvasive population estimates against those derived from radio-telemetry. A long-term cougar ecology study currently being conducted in the Jackson Hole region of Northwest Wyoming (the Teton Cougar Project (TCP)) offers an opportunity to test noninvasive monitoring techniques on a population of cougars with an estimated known density. We setup an array of 43 remote camera stations across the TCP study area from June to September in 2012 and 2013. The array comprised of 6x6 km cells, covering a total of 1,548 km^2. Camera stations were setup using a non-reward blood lure to increase detection probability and to increase probability of identification through repeated photographs per detection. We recorded 17 and 16 cougar photo-events in 2012 and 2013, respectively. We identified individual cougars based on size, morphology, and natural markings. We produced estimates of abundance using capture-mark-recapture analysis. Preliminary analysis indicates that the telemetry-derived population estimates fall within the confidence estimates produced by the camera survey. However, low numbers of unique individuals detected and potential violations of mark-recapture assumptions present issues that still need resolving.

P22: Will this mountain lion make it in Hollywood?

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***Abstract*:** Understanding the movements and ecology of mountain lions (*Puma concolor*) is critical for the effective conservation of this wide-ranging and low-density species, especially in urban fragmented landscapes. In February 2012 a mountain lion was discovered by remote cameras in Griffith Park, an isolated 20 km^2 patch of habitat next to downtown Los Angeles that is completely surrounded by freeways and development. In March 2012, the National Park Service captured and GPS radio-collared a young male (P22), who we continue to follow as part of our long term study of mountain lion ecology, behavior, and conservation in Santa Monica Mountains National Recreation Area (SMMNRA) and the surrounding region. Genetic testing indicates that P22 is closely related to mountain lions in the Santa Monica Mountains to the west, in which case he would have had to cross two major freeways (405 and 101) to arrive in Griffith Park. We report on P22's movement patterns, diet, and locations within Griffith Park's natural areas and the surrounding urban communities. Griffith Park receives 10 million visitors yearly, and yet P22 remains elusive and is rarely seen by people. P22 has also become an ambassador for wildlife and corridor needs in the Los Angeles area, as his story has been well covered in media outlets. We have documented many anthropogenic threats to mountain lions over the course of our research, including anticoagulant rodenticide exposure, road mortality, and potentially increased intraspecific conflict. Continued tracking of P22 will provide important insights on mountain lion survival and movement in an isolated and urban landscape, including whether and where he moves out of Griffith Park. Following mountain lions, including P22, in the fragmented habitats surrounding SMMNRA will allow us to identify habitat linkages and corridors critical to the survival of mountain lions and other large mammals. In addition, we hope to determine how mountain lions can best coexist with humans in this complex urban-wildland interface.

Compensation and additivity in cougar mortality: learning from heavily and lightly harvested populations

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***Abstract*:** The interaction between anthropogenic and natural mortality has long interested ecologists and is of central importance to species conservation and management. We studied mortality patterns of two cougar (*Puma concolor*) populations in Utah, one (Monroe) exposed to high levels of hunting mortality and the second (Oquirrhs) was subjected to moderate levels of exploitation. We used competing risk analysis to determine survival and cause-specific mortality rates using information on 224 cougars that were captured and equipped with radio-collars. During this 17-year investigation, 146 animals died of a known cause of mortality (11 died of unknown causes), and the remaining 67 individuals were right-censored at the end of the study period. Anthropogenic mortality counted for 85.8% and 51.9% of the total deaths in the heavily and lightly exploited populations, respectively. In both populations, the primary causes of death were hunting and poaching, with the exception of females on the Oquirrh mountains that primarily died of natural causes. Regression of annual survival as a function of all sources of human exploitation revealed a significant negative relationship, indicating strong additivity of anthropogenic and natural mortality in the heavily exploited population. Exploitation in the semi-protected population did not lead to any significant declines in annual survival, suggesting some level of compensation between natural and anthropogenic causes of mortality. Empirical studies that directly address additive *versus* compensatory mortality in exploited populations of large carnivores are rare. Our results demonstrate the need for, and power of, sustained long-term data collection in addressing important questions concerning the conservation and management of long-lived carnivores.

The relationship of rural depopulation to puma-human conflict in the Altiplano region of Tarapacá, Chile

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***Abstract*:** In the Altiplano region of Tarapacá in Chile, the Aymara people have reported an increase of puma-human conflict, mainly including predation on livestock. The lack of information about the status of this species and the absence of verification of puma attacks on livestock make it difficult to apply interventions. Moreover, the migration of numerous Aymara to cities has meant changes in traditional agricultural practices, which may account for an increased sense of vulnerability to pumas. We interviewed Aymara livestock owners to understand how certain patterns of rural depopulation (older people, smaller household sizes, less supervision, low residency) could be related to the conflict between pumas and people. We found that older respondents, with smaller household sizes and less time spent in their residence, perceived a decline in puma predation events. However, respondents who perceived an increase in predation events presented the opposite patterns. We found an association between the perceived level of conflict and the use or not of a guard. Respondents that perceived a high risk of puma attack implemented the use of a guard when they were absent from their residence, indicating certain adaptations to their traditional practices. The mitigation of the conflict and therefore the future of puma conservation in the region may depend on the implementation of interventions that influence people's perceptions. We propose the highest-priority intervention includes verifying and measuring losses and further human dimensions work to identify causes of complaints. Subsequent interventions to prevent losses or prevent retaliation against pumas can then be targeted more precisely.

Wild pumas in Britain – exploring evidence and gauging people's attitudes

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***Abstract*:** Across Britain, alleged sightings of pumas and black panthers have occurred from the 1970s. In some counties, scores of alleged sightings are documented annually by volunteer groups. It is assumed many encounters are kept secret, with people fearing ridicule or concerned at attracting trophy hunters. With no knowledge of pumas, people have described the form, colour, locomotion, calls, and in rare cases the young, of cats resembling *Puma concolor*. Puma-like cats account for up to a third of the descriptions in the documented reports, year on year. Melanistic leopard is the main candidate for plausible black panther reports. Despite the consistency and continuity of witness reports, primary evidence is less apparent, but includes a small number of carcass remains verified by vets and up to a handful of DNA results. The paucity of hard evidence should be judged against the lack of resources applied to date, and the absence of past systematic work. An emerging study at the Royal Agricultural University explores the evidence for big cats and links with communities and landowners. Trusting relationships are important, given property owners' reticence in drawing attention to big cats linked with their land and business. People's attitudes towards possible big cats are also documented at the study's outreach events. Under the new study, as well as DNA testing, early progress includes the collection of skeletal remains for tooth pit analysis. The scale and pattern of carnassial impressions on four specimens to date, from different areas, weighs in favour of puma/leopard size cats. The attitudinal results show a marked consistency across the different samples: offered a range of options, including scepticism and intolerance, people mainly express fascination and conclude that (conditional) tolerance, and proper study, is the responsible way forward for understanding possible big cats in their locality.

The ecology of a conflict: Eurasian lynx depredation on domestic sheep and semi-domestic reindeer in Norway

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Abstract: Public attitudes towards large carnivores have changed dramatically during the last 30 years, and many large carnivore populations are now recovering and expanding into new areas. In Norway, the Eurasian lynx (*Lynx lynx*) population

increased rapidly in the mid 1990's resulting in increased depredation and conflicts with semi-domestic reindeer (*Rangifer tarandus*) and sheep (*Ovis aries*) herders. Annually, close to two million sheep are grazing in forest and alpine-tundra habitats from June until September. Sheep grazing areas are found throughout Norway, but grazing is especially intensive in the mountains of south-western Norway. In addition, indigenous Sámi people manage 230 000 semi-domestic reindeer in the central and northern parts of Norway. There is a legal requirement that all losses to large carnivores should be fully compensated. An ex post facto compensation scheme is based on an estimation of losses and is paid directly to the owners. In 2013, a lynx population of approximately 350 individuals was held responsible for killing 7111 sheep and 8054 reindeer. Personnel from the State Nature Inspectorate (SNO) examine all livestock found dead, and document the cause of death through a necropsy. However, the detection rate of carnivore-killed reindeer is very low (9% in winter and 2% in summer) so there is a high degree of uncertainty concerning the real magnitude of depredation. Understanding the factors shaping the dynamics of carnivore–livestock conflicts is vital to facilitate large carnivore conservation in multi-use landscapes. In this study we quantified lynx kill rates on sheep and reindeer in two study areas, one northern area (sheep and reindeer) and one southern area (sheep). Data on diet, kill rates on sheep and domestic reindeer, and movement of 80 individual lynx were collected from 1995 to 2013. In the southern area we investigated how the density of their main wild prey, roe deer (*Capreolus capreolus*) modulates lynx kill rates on sheep across a range of sheep and roe deer densities. We used zero-inflated negative binomial (ZINB) models including lynx sex, sheep density and an index of roe deer density as explanatory variables to model observed kill rates on sheep, and ranked the models based on their AICc values. The model including the effects of lynx sex and sheep density in the zero-inflation model and the effect of lynx sex and roe deer density in the negative binomial part received most support. Irrespective of sheep density and sex, we found the lowest sheep kill rates in areas with high densities of roe deer. As roe deer density decreased, males killed sheep at higher rates, and this pattern held for both high and low sheep densities. Similarly, females killed sheep at higher rates in areas with high densities of sheep and low densities of roe deer. However, when sheep densities were low females rarely killed sheep irrespective of roe deer density. In the northern area we quantify lynx kill rates on reindeer across a range of ecological conditions. Kill rates were strongly affected by sex and social status (i.e. females with and without kittens), as well as season and reindeer availability. The highest kill rates were observed in summer for male lynx, and the lowest were observed during winter for solitary lynx at low reindeer density. Our quantification of depredation rates on sheep and reindeer can be the first step towards establishing fairer compensation systems based on more accurate and area specific estimation of losses. This study demonstrates how we can use ecological theory to predict where losses of sheep will be greatest, and can be used to identify areas where mitigation measures are most likely to be needed.

Cougar response to different levels of residential development

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***Abstract*:** The proximity of cougars (*Puma concolor*) and people has always been a management concern, but little is known of how use of residential areas is affected by housing density levels and patterns. We used utilization distributions (UDs) derived from GPS, ARGOS and VHF collar data from 101 cougars to compare how different levels of residential development influence use across 4 study areas in Washington. We compared the UDs of cougars with residential development quantified from county tax parcel data using a Weibull modeling analysis and multiple comparison techniques. Cougars used predominantly undeveloped parcels at both the hectare ($\overline{x}$ = 98.09% of use, SD = 3.12, n = 101) and km^2 ($\overline{x}$ = 81.59%, SD = 15.60, n = 101) scales and use decreased with increasing residential densities. Ninety-nine percent of cougar use of residential areas in western Washington occurred in areas with ≤ 846.0 residences/km^2, which was significantly higher than in the eastern Washington study areas where cougars used areas with residential densities ≤ 55.2 residences/km^2. Diffuse, low density development facilitates higher levels of cougar use, but residential development at urban densities with adjacent wildland habitat comprised of dense vegetation appears to increase cougar use of residential development with minimal direct use of developed parcels. Wildlife managers and landscape planners could use the model to identify and maintain wildlife corridors in developing areas, locations to construct highway crossing structures to preserve connectivity, reduce use of residential areas by cougars, or identify where cougar use of residential development is likely to occur so as to target education and outreach efforts.

Session 6:

Predators and Prey, Part 1

Proceedings of the

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Integrating Scientific Findings into Management

Program Cluster: identifying predation events through clustered GPS data

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***Abstract*:** Non-parametric kernel density estimators are commonly used to classify home ranges or utilization distributions from animal location data. Here, we extend the r-LoCoH estimator of Getz *et al.* (2007) using time-constrained convex hulls. This extension was originally developed with the intent of identifying predation events using global positioning system data derived from predator space-use monitoring efforts, but can be applied to any system where frequent and accurate relocation data are available and relocation clustering in space and time are indicative of behaviors of interest (i.e. denning, nesting). The present method is wrapped in a Python program called Program Cluster to allow easy and rapid implementation by users with limited programming knowledge. The output from Program Cluster resembles a fragmented utilization distribution, with each fragment corresponding to areas identified as intensely used in the location data based on user-specified spatial and temporal tuning parameters. Further, each fragment can be interpreted as an individual utilization distribution with more heavily shaded regions (i.e. greatest hull overlap) corresponding to areas with the highest intensity of use. We discuss the extended r-LoCoH method, program implementation, and output in the context an on-going cougar (*Felis concolor*) study on Monroe Mountain, Fishlake National Forest, Utah.

Cougar strategies of feeding site selection: energy maximization, classical optimal foraging, or fear driven human aversion?

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***Abstract*:** Understanding predator foraging ecology in regions of increasing anthropogenic development is important when devising management strategies to

reduce cougar-human conflicts. A pure energy maximization strategy predicts that patch use of a foraging cougar is driven by the selection of landscape factors that maximize encounters with primary prey species. However, previous research on fine scale patch-use rarely shows linear relationships with direct measures of prey availability. A pure fear-driven strategy predicts that patch use is driven by landscape factors associated with higher risk of mortality. While it is logical that a cougar would avoid areas linked to higher rates of mortality, testing this has been met with only limited success. Optimal foraging theory would attempt to explain patch usage as a behavioral balancing act between energy maximization and fear-driven human aversion. To test this, measures of prey availability and cougar usage must be attained at scales suitable to the behavior. A novel camera trapping survey technique using 41,000 trap nights was used to model the background encounter rates across the landscape of various prey species of cougars, with particular emphasis on a range of housing densities. Predicted feeding site locations were derived for 49 cougars by a model using a training set of 4,400 clusters of ground-truthed GPS locations. Using conditional logistic regression analysis, characteristics of feeding sites (human housing, background prey encounter probabilities, and natural habitat) were compared to characteristics of GPS locations within the prior travelling sequence to test the degree of optimal foraging at a fine spatial scale. Preliminary results indicate direct and indirect relationships in reference to humans and background encounter rates of primary prey (deer). However, some difficulties arise when teasing out additional influences of highly used alternative prey species (i.e., raccoon, domestic cat), whose background encounter rates are driven by the presence of human dwellings.

Estimating mountain lion (*Puma concolor*) predation rates in the recently recolonized region of the Little Missouri Badlands, North Dakota, USA

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***Abstract*:** Recent recolonization of mountain lions (*Puma concolor*) into the Badlands of North Dakota, USA has led to questions on the potential impacts of predation on prey populations in the region. From 2012-2013, we deployed 9 real-time global positioning system (GPS) collars to investigate mountain lion feeding

habits. We monitored mountain lions for 1,845 days, investigated 506 GPS clusters, and identified 292 feeding events. We used logistic regression to predict feeding events and size of prey consumed at an additional 535 non-investigated cluster sites. Our top model for predicting presence of prey items produced a receiver operating curve (ROC) score of 0.90 and an overall accuracy of 81.4%; top model for predicting prey size had a ROC score of 0.89 and an overall accuracy of 84.6%. Application of our models to all GPS clusters resulted in an estimated ungulate kill rate of 1.09 ungulates/week (95% CI=0.83–1.36) in summer and 0.90 ungulates/week (95% CI= 0.69–1.12) in winter. We estimated mountain lions consumed 39.6 kg/week (95% CI=30.4-48.8) in summer and 51.6 kg/week (95% CI= 37.4–65.8) in winter. Overall scavenge rates were 3.7% in summer and 11.9% in winter. Prey composition included higher proportions of non-ungulates in summer (female=21.5%; male=24.8%) than in winter (female=4.8%; male=7.5%). Proportion of juvenile ungulates in mountain lion diets increased following the ungulate birth pulse in June (June–August=60.7%, 95% CI=43.0–78.3; Sept-May=37.2%, 95% CI= 30.8–43.7), resulting in an ungulate kill rate 1.61 times higher during fawning season (1.41 ungulates/week, 95% CI= 1.12–1.71) than during the remainder of the year (0.88 ungulates/week, 95% CI= 0.62–1.13). Our results document feeding habits of a recently recolonized mountain lion population and will increase effective management of this species in the Badlands Region of North Dakota.

Estimating cougar (*Puma concolor*) consumption rates and prey composition in the Black Hills, South Dakota.

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***Abstract*:** Following declines in the 19th and 20th centuries, recent range expansions of cougars (*Puma concolor*) into the upper Midwest are challenging effective management of these new predator–prey systems. These regions provide a unique opportunity to assess the role of this apex predator on prey population dynamics and ecosystem processes in areas where anthropogenic influences are significantly different (e.g., higher road densities, higher human populations) from previous studies. Our objectives were to: 1) determine prey composition of cougar diets, 2) quantify ungulate kill rates, 3) assess the influence of season and demographic status on predation rates, and 4) determine the influence of scavenging on overall cougar consumption rates in the Black Hills, South Dakota. From 2009–2012, we

captured 41 cougars (29 females; 11 males) and used global positioning system (GPS) telemetry to locate 1,506 feeding events. Deer (*Odocoileus spp*.) comprised the majority of cougar diets (83%), and in cases where we could identify species, white-tailed deer (*Odocoileus virginianus*) dominated (63%). Overall ungulate kill rate averaged 0.79 ungulates/week, but was highly variable (range = 0.13–1.75 ungulates/week) among individuals. We found kill rates were significantly higher ($P < 0.001$) in summer ($\bar{x} = 0.92$; 95% CI = 0.81–1.03) than in winter ($\bar{x} = 0.62$; 95% CI = 0.51–0.74); however, we found no differences by demographic status (e.g., sex, age, or presence of cubs) within the same season (summer: $P = 0.581$; winter: $P = 0.607$). Scavenging accounted for 17.3% ($n = 260$) of all prey items found in terms of relative frequency with higher rates observed in winter ($\bar{x} = 0.21$ events/week) than in summer ($\bar{x} = 0.08$ events/week). Our results highlight how adaptable and opportunistic cougars are at foraging for prey and provide information to direct future cougar and ungulate management in the Black Hills ecoregion.

Nowhere to hide: pumas, black bears and competition refuges

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***Abstract*:** Interspecific competition is a significant influence on the diversity and membership of community assemblages, and a prevailing question is how competitive carnivores coexist without the dominant carnivore driving the subordinate competitor to local extinction. One hypothesis is that the subordinate carnivore requires and utilizes "competition refuges," where the influences of the dominant competitor are minimized. American black bears (*Ursus americanus*) are sympatric with pumas (*Puma concolor*) across most of the puma's range in North America, and a dominant scavenger that displace pumas from their kills. We tested for the effect of black bear kleptoparasitsim on puma search time, handling time and kill rates in two study systems: western Colorado and northern California. Pumas exhibited increased kill rates and shorter handling times, and selected for smaller prey, when bears were active. Our Resource Selection Function analyses showed that when bears were active, they were as likely to find puma kills anywhere on the landscape. We concluded that during the bear season, pumas could not effectively hide from them; instead our results suggested that undiscovered puma kills were random events or due to some variable we did not test. Further, our findings suggested that bear kleptoparasitsm may be driving higher puma kill rates in the warmer seasons where the two species overlap, which has implications for both carnivore and ungulate management, as well as potentially impacting puma fitness.

Session 7:

Predators and Prey, Part 2

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Integrating Scientific Findings into Management

Top-down versus bottom-up forcing: evidence from mountain lions and mule deer

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***Abstract*:** We studied mountain lions (*Puma concolor*) and mule deer (*Odocoileus hemionus*) inhabiting a Great Basin ecosystem in Round Valley, California, to make inferences concerning predator–prey dynamics. Our purpose was to evaluate the relative role of top-down and bottom-up forcing on mule deer in this multiple-predator, multiple-prey system. We identified a period of decline (by 83%) of mule deer (1984–1990), and then a period of slow but steady increase (1991–1998). For mule deer, bitterbrush (*Purshia tridentata*) in diets, per capita availability of bitterbrush, kidney fat indexes, fetal rates (young per adult female), fetal weights, and survivorship of adults and young indicated that the period of decline was typical of a deer population near or above the carrying capacity (K) of its environment. Numbers of mountain lions also declined, but with a long time lag. The period of increase was typified by deer displaying life-history characteristics of a population below K, yet the finite rate of growth (k ¼ 1.10) remained below what would be expected for a population rebounding rapidly toward K (k ¼ 1.15–1.21) in the absence of limiting factors. Life-history characteristics were consistent with the mule deer population being regulated by bottom-up forcing through environmental effects on forage availability relative to population density; however, predation, mostly by mountain lions, was likely additive during the period of increase and thus, top-down forcing slowed but did not prevent population growth of mule deer. These outcomes indicate that resource availability (bottom-up processes) has an ever-present effect on dynamics of herbivore populations, but that the relationship can be altered by top-down effects. Indeed, top-down and bottom-up forces can act on populations simultaneously and, thus, should not be viewed as a stark dichotomy.

Cougar predation in the Mojave Desert: seasonal spatio-temporal overlap influences prey selection more than water use

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***Abstract*:** Cougar (*Puma concolor*) predation in desert environments may be enhanced when ungulate prey increase their use of water sources during summer months. Understanding the conditions in which different factors influence predation remains an important issue for wildlife managers. For water sources to function as ecological traps it is necessary not only to detect predation events proximate to water sources, but also to determine that these events occur more frequently than expected by spatial overlap of cougars and prey. We investigated the spatio-temporal patterns of cougar predation on desert ungulates in relation to water use on the Desert National Wildlife Refuge (DNWR) NV, by tracking GPS-collared cougars and bighorn. Annual survivorship for collared bighorn was high (~93%). Cougar kills comprised ~64.3% mule deer (*Odocoileus hemionus*) and 30.3% bighorn sheep, and occurred closer to water sources (3.4 ± 2.4 km) than random points (6.6 ± 3.2 km). However, only 1 kill occurred within 200 m of a water source and <5% of all kills occurred <0.5 km from water (range = 0.32 – 16.7 km). Cougar locations were more closely related to sheep locations than water sources, with no significant difference in spatial overlap across seasons. Although bighorn used water sources most extensively during daylight hours of summer months, as recorded by 24-h camera-monitors, few bighorn were killed during summer. Instead, most were killed during winter/spring at the greatest distances from water sources. Conversely, mule deer were killed across all seasons, despite a similar proximity to water sources. Differential use of the landscape by mule deer may explain their increased risk of predation by cougars in this desert environment. On the DNWR, water sources do not appear to function as ecological traps; rather, seasonal differences in spatio-temporal overlap influence the risk of cougar predation for prey more than simply proximity to water sources.

Variation in prey selection and incidence of individual specialization on novel prey in the Great Basin

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***Abstract*:** Variation in predation behavior and prey selection of predators can have important implications for ecology, conservation and management. We tested hypotheses pertaining to the degree of individual diet specialization, and potential fitness consequences, of mountain lions (*Puma concolor*) in areas with varying abundances and types of prey in the western Great Basin and eastern Sierra Nevada. We visited 1,330 GPS clusters made by 21 mountain lions (7 males; 14 females) fitted with GPS collars from 2009 - 2012. We followed individuals an average of 55 weeks (SD = 36) and located remains of predation events at 804 of the clusters searched (61%) comprising 14 species. Diets varied among individuals within and between mountain ranges. Mule deer were the most common prey in the diets of 13 individuals and feral horses were the most common prey killed by 8 individuals. Ten of 13 mountain lions with access to feral horses in Great Basin ranges consumed horses as prey. However, there was considerable variation among the diets of those individuals with some individuals specializing on horses to the near exclusion of other prey items. In some areas of the Great Basin, feral horses provided ecological opportunity for prey specialization where mule deer densities were relatively low; in areas of low availability of total prey, however, all individuals had generalist foraging strategies. We found no difference between specialists and generalists in biological correlates of fitness. Nonetheless, our results suggest that predation on feral horses in arid Great Basin Ranges may result in fitness comparable to those of mountain lions in areas where densities of mule deer are substantially greater, such as the Sierra Nevada.

Range abandonment by ungulates: Predator avoidance or response to habitat changes induced by drought?

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***Abstract*.** We investigated influences of risk of predation by mountain lions (*Puma concolor*), measures of topographic ruggedness at multiple scales, and vegetation, land, and snow cover, on resource selection in winter by Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*), an endangered taxon. We hypothesized that those mountain ungulates would trade off rewards accrued from use of critical low-elevation habitat in winter for the safety of areas with reduced risk of predation.

We also investigated the tradeoff between forage and risk of predation by testing the hypothesis that differences in quality of forage at low-elevations versus high-elevations were reduced in years of below-average precipitation than in wet years, yielding a reduced benefit of migration to low-elevations during drought years. Sierra Nevada bighorn sheep did not trade off benefits of forage for reduced risk of predation, but selected areas of high solar radiation, where risk of predation by mountain lions was greatest, while mitigating indirect risk of predation by selecting for steep, rugged terrain. Bighorn sheep selected more strongly for areas where mountain lions were active and killed bighorn sheep, than for low elevation habitat in winter, likely because mountain lions were most active in those areas of bighorn winter ranges overlapping ranges of mule deer (*Odocoileus hemionus*), where both ungulates accrued forage benefits. We demonstrated reduced benefit of migration to low elevation during drought years, when the difference in quality of forage was significantly lower than in years of above-average precipitation, providing an alternative explanation to the predator-induced abandonment hypothesis for the disuse of low-elevation winter range observed during drought years.

Demographic response of mule deer to experimental reduction of coyotes and mountain lions.

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***Abstract*:** We tested the efficacy of removing coyotes and mountain lions on mule deer population dynamics in southeastern Idaho, 1997-2006. We monitored aspects of mule deer ecology while experimentally manipulating predator populations within 10 Game Management Units. To determine survival and causes of mortality, 250 neonates, 284 6-month-old fawns, and 254 (521 deer years) adult females were monitored with radio telemetry in 2 study sites, one with coyote and mountain lion removal and one without 1998-2002. Survival of neonates was related to alternate prey abundance, coyote removal rates, and weather conditions. Winter fawn survival was influenced by summer precipitation, winter precipitation,

mountain lion removal, and fawn mass. Adult female winter survival increased with mountain lion removal. December fawn-to-adult female ratios (fawn ratios) increased significantly at maximum rates of mountain lion removal. Coyote removal had no significant effect on fawn ratios, except after a weather-related population reduction. Coyote or mountain lion removal alone did not influence mule deer population growth rate, although the top model, including previous year's mountain lion removal and winter severity, explained 27% of the variance in population rate of increase. The lack of fawn ratio or population response to coyote reduction indicates that decreased neonate mortality due to coyote removal is partially compensatory. Mountain lion removal increased mule deer survival and fawn ratios, producing a minimal positive effect on growth rates. However, we observed some evidence for compensatory mortality in adult female mule deer during periods of prolonged mountain lion removal and when coupled with significant weather effects may reduce the effect of predator removal on population growth rate.

Panel Q&A, Predators and Prey.

Participants: Becky Pierce, Alyson Andreasen, Dave Choate, Mark Hurley, & Jeff Villepique

Moderator: David Stoner

The following is adapted from a tape-recording of the discussion. Questions and responses have been shortened and are not verbatim.

Q: *A problem we have with managing wildlife is the complexity of the environment. Our tools are fairly coarse. Ultimately most populations are food limited. With respect to puma control or harvest being a common management tactic to enhance prey numbers and survival, at what point in the cycle might puma predation be additive? Where might predator removal have some beneficial effect**?***

Becky – Based on our research other mort factors become more additive when a prey population is below K. We see fluctuations between forage and its impact on deer fetal rates and recruitment because other factors come into play. For predator removal to be effective you need to know the relationship of the prey to K. If the prey are in poor condition because of density dependent effects, much of predation is compensatory and predator control won't make much difference.

Q- *What influence have you had on public perceptions concerning predation and predator control?*

Becky – Including locals in the research made a big difference. For example, volunteers that went out to locate collared deer would see 1 collar in a group of 50 deer and realize the deer population was higher than they realized. However, CA is

different than other areas; the various publics demand that control efforts be well justified.

Alyson – Initially the sportsmen's groups we approached thought they knew everything. Some surprising results opened the public's eyes. As to how predation on horses has been perceived, the sportsmen think it is great. Although I thought horse advocates would be upset, they seem to appreciate the results and that puma predation on horses (a species that was assumed to have no predators) actually helps their cause.

Mark – We spent a significant amount of time talking to people. Talking to sportsmen seemed to help. A lot of the study was funded by sportsmen and there was a better acceptance of the results (which were contrary to what they expected) because they helped fund it.

Dave – Sportsmen directly involved with the research were more supportive. There was a difference in public perceptions based on where they lived in the state. Las Vegas was different than other parts of the state. The general public had a poor understanding of what density is all about, showing surprise that animals could survive on the harsh landscape and that individuals needed so much space.

Jeff – Provided the observation that it is easier to convey results showing predation is not limiting the prey when you have growing populations of ungulates.

Q – *There is annual variation in weather patterns, and the estimates of K. How can we incorporate this information into a timely management response? Do we have enough time to get regulations in place to achieve a predator control goal?*

Mark – We are conducting predator control in Idaho right now. We need special conditions to make predator control work. Our structure is 2 years out. So what ID's done is that we saw lion removal had some effect so we increased quotas. However the increases are probably not enough because we need to remove a lot more to cause an effect. We are not killing many more lions than we were before. We know that coyote control on the fawning range is where we can make a difference.

Becky – We need to consider the relationship of prey to K. We were lucky to find that bitterbrush leader growth was a critical factor. That's something you can do (measure). Another measure is scoring deer body condition in the field. Rather than predator, go look at the prey (it's easier and cheaper).
Alyson – Our results might suggest that at high densities of prey, the best approach is to only remove individual predators that are doing damage is the best approach. When prey densities are low, a broad brush approach to predator removal may be more effective.

David – The window of inference may be short term observation. But we respond to long-term issues. Work with public to explain that we can't manage season to

season. We could incorporate noninvasive assessments such as camera traps at water sources to determine prey condition. Easier to do with sheep than deer.

Q. *Mark, in your experimental removal of predators, did you find meso-predator release and did that have an impact on fawn mortality. Also, do you think it's possible that the constant removal of territorial animals results in an artificially large predator population?*

Mark – We had some anecdotal observations of increased bobcat mortality on fawns. Removal rates and social dynamics was certainly an issue in coyotes; we had no opportunity to look at the puma social system. However, the puma kittens that we did collar emigrated to area where we were removing pumas and all were killed.

Q. *Alyson, where were the pumas killing the horses?*

Alyson – Horses were killed wherever they were active: across shale slopes, in canyon bottoms, in open sagebrush. It was really variable.

Q. *Did any of your studies show any long-term demographic consequences?*

Becky – We saw a shift in migration patterns of deer, but we think this was caused by bear predation on fawns. A primary migratory pattern ceased to be the best choice.

Mark – An older age structure in the does leads to senescence. Adult deer start into senescence at about 6.5 years. These older deer produce fewer fawns. Many deer populations have an older doe age structure so anything we can do to reduce the age on the does would help.

Dave Stoner's closing statement: From management standpoint it is important to increase efforts at conveying science to the various publics that we serve. There has been a lot of basic research presented this morning, It will be nice to see it applied in the future.

Session 8:

Felids and Humans, Part 1

Proceedings of the

11th Mountain Lion Workshop

Integrating Scientific Findings into Management

Correlates of puma-livestock conflicts in the Espinal of Central Argentina

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***Abstract*:** Puma (*Puma concolor*) still has a widespread distribution in Argentina. However, many populations are threatened by habitat destruction and direct killing associated to the spreading of croplands and ranchlands. This is the case of pumas inhabiting the Espinal of the central Argentina lowlands, an ecoregion marking the transition from the Pampas grasslands, where the puma has almost gone extinct, to the Monte woodlands. In this region, the intense fragmentation of natural habitats and decrease of native prey has increased the encroachment of pumas with livestock. Retaliatory killing, which is the common response to puma predation on cattle, is increasing and local ranchers are requesting a legal bounty system to hunt pumas. We report the results of the first steps of a project aiming to understand the ecology of puma populations in the Espinal, characterize puma-livestock conflicts, and identify conflict mitigation strategies. Our 148 semi-structured interviews to local ranchers showed that 45.7% of respondents think that pumas cause major damage, 47.5% reported losses caused by pumas in the previous year and 70.2% considered that predator control was the best solution to conflicts. Landscape-scale camera trap surveys (totaling an effort of 7054 trap-days) produced 45 records of pumas in 11.5% of 184 sampling stations. A preliminary habitat suitability analysis based on 110 presence records suggests that most suitable locations for puma were away from cropland or urban areas and from the main roads, distances to roads and to scrubland patches were the variables affecting the most its niche breadth, and only 16.3% of the region has a high quality for this felid. Our results suggest that whereas pumas in central Argentina may tolerate some degree of habitat degradation and human-related mortality, humans are rarely willing to tolerate economic losses caused by depredation and that conflict mitigation measures are required to ensure puma conservation.

Road impacts on mountain lions in Orange County, California: using multiple data types to prioritize management actions

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***Abstract*:** Road impacts are a threat to many species due primarily to habitat fragmentation and direct mortality from vehicle collisions. We studied the effects of a relatively new highway on mountain lions and several other species in Orange County, California. We used three different types of data: road kill records, GPS collar data, and least cost connectivity models. Road kill records indicated that 11 mountain lions had been killed by cars in the 15 mile long study area since highway construction, with an additional 6 killed on another section of the highway or at its junctions with other roads. Mountain lion GPS collar data were collected at varying intervals from every five minutes to every six hours. GPS points taken at five minute intervals were used to identify 20 crossing locations, and least cost connectivity models using longer interval data were utilized to estimate the locations of 55 additional crossing events. Because impacts were being assessed for multiple species, deer survey and road kill data were used to identify areas of high risk for other species. The highway section being studied was then split into 500-meter segments. The various data were combined into a final impact score and values were assigned to each 500-meter segment. Results are currently being used to prioritize management actions by the highway management agency, including installation of extensive new fencing and monitoring of existing crossing structures with cameras. In addition, we used the data to advise the agency on the design of a potential future extension of the highway in order to reduce the expected impacts on mountain lions and other species.

An overview of puma depredation trends in California, 1972-2013

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***Abstract*:** Factors relating to mountain lion depredations include geographic attributes (landscape scale), property attributes (property scale), and attributes of the depredating individual (organismal scale). We expand on previous work by applying Geographic Information Systems methods and classification tree analysis to California's statewide puma depredation permit database, which contains records

from 1972 – 2013. These methods allow us to discern relationships between environmental and organismal variables affecting depredation patterns that could otherwise be obscured by impacts of scale. We supplement this analysis by including records in the state's puma necropsy database, which contains necropsy records of nearly all pumas taken pursuant to depredation permits from 1993 – 2013. Here, we present descriptive statistics and analyses explicating temporal and spatial trends in frequency of puma depredation, domestic species affected, environmental and geographic correlates, and mitigating factors that must be considered when examining these data. We discuss how these factors can inform local wildlife management and ecological conservation planning efforts.

Cougar space use on a landscape with high levels of anthropogenic disturbance in southcentral Utah

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***Abstract*:** We evaluated cougar (*Puma concolor*) space use in relation to general patterns of human landscape use on Monroe Mountain in southcentral Utah. Cougars on Monroe Mountain are exposed to heavy human pressure both directly during chase, limited-entry, and harvest objective seasons during the winter and spring and more indirectly due to traffic associated with recreational OHV activity and game hunter use throughout the summer and fall. To assess how cougars respond to human activity, we evaluated relative selection (RSF with a used vs. available design) using Bayesian generalized linear mixed models with weakly informative priors and a random effect of individual to account for differences in individual sampling intensity. Seasonal home ranges (99% isopleths) were generated for each individual within our dataset using a kernel density estimator with a plugin bandwidth estimation algorithm. Availability was estimated systematically using a complete census of 30 meter pixels within each home range. Distance to secondary and tertiary roads, distance to water, distance to nearest human residence, ruggedness, aspect, slope, and vegetative cover were calculated for each used and available point within the data set and utilized as explanatory fixed effects in the RSF model. We compared cougar response to roads and human residence across seasons and between night and day in an effort to identify patterns of cougar response to human activity. Our results suggest illustrate the indirect impacts humans have on cougars and the need for more studies that directly account for human activity when evaluating spatial and habitat use.

Livestock and lions: A research program to learn coexistence strategies

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David J. Mattson, People and Carnivores; *davidjmattson@gmail.com* (Presenter)

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***Abstract*:** Conservation of ecologically functional populations of cougars (*Puma concolor*) is dependent, in part, on reducing conflicts with livestock producers and reducing related preventative or retaliatory kills. Appreciable depredation of livestock by cougars is largely restricted to either sheep or to cow calves in warm semi-arid to arid regions. Our preliminary investigations in Arizona suggest that terrain ruggedness, warmth, and aridity together engender husbandry practices that lead to greater availability of vulnerable cow calves. We hypothesize that polled breeds, cow-calf operations, low stocking densities, and year-round breeding and calving are at the root of problematic dynamics, in places amplified by source-sink dynamics that recruit young dispersing cougars into livestock-producing areas. Given the potential importance of coexistence between livestock and cougars to long-term conservation of cougar populations, we advocate a large-scale research effort to test the efficacy of different husbandry practices in reducing cougar depredation. Such a program would ideally focus on ranges with histories of depredation and employ controls through a paired design. Candidate treatments would include use of more aggressive horned breeds, abbreviation of breeding and calving seasons, and concentration of calving cows under conditions where they could be given greater protection. Execution of such studies would, at a minimum, depend upon recruiting ranchers to participate and finding financial resources to alleviate the economic costs and risks of participation. We recommend that any such study include assessment of economic feasibility and practicality to the rancher, as well as potential impact on range condition.

Session 9:

Felids and Humans, Part 2

Proceedings of the

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Integrating Scientific Findings into Management

Florida panther recovery: Livestock depredation, predation risk maps, and new approaches to compensation programs

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***Abstract*:** Calf depredation by the federally endangered Florida panther (*Puma concolor coryi*) on ranches in southwest Florida is an important issue because ranches provide habitat critical to panther recovery. As the panther population increases, conflict between ranchers and panthers will likely increase as well. To better understand this conflict, the goals of this study were to quantify calf depredation by panthers on two ranches in southwest Florida, identify factors that influence predation risk, and develop predation risk maps to inform management decisions. To monitor calf loss we ear tagged 409 calves with VHF transmitters on two ranches during 2011-2013. We evaluated calf mortalities for cause of death and placed camera traps at cache sites to identify individual panthers. We used ArcGIS and Fragstats to quantify landscape variables around each kill site and for each ranch. We developed predation risk maps with MaxEnt using landscape variables and panther GPS data. Calf depredation by panthers varied between ranches, with an average calf loss to panthers of 5.3% / year on Ranch A and 0.5% / year on Ranch B. Panthers killed calves ranging from <1 week old and <25 kg to >8 months old and >150 kg. Camera trap data revealed that panthers of different ages and sexes killed calves and that some panthers made multiple kills. Landscape analysis indicated that Ranch A contained a greater percentage and patch density of upland forest, greater connectivity between forest patches, greater edge density, and smaller patches of improved pasture than Ranch B. These results suggest that the landscape on Ranch A may provide a more optimal hunting environment for panthers. MaxEnt results suggest that predation risk maps can inform conflict mitigation strategies and potentially help to structure compensation programs that are based on landscape features rather than on verified kills.

Conflict without end: Cougar depredation in east-central Arizona

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***Abstract*:** Graham and Greenlee counties in east-central Arizona have experienced high levels of cougar (*Puma concolor*) predation on cow calves for at least the last 20

years. Kills of cougars for depredation control in these two comparatively small counties have accounted for 62% of the state's total. Our analysis of this case suggests that high levels of depredation are not adequately explained by densities of cougars, cattle, or native prey. More likely, this pattern of depredation conflict is due to husbandry practices rooted in economic necessity and unproductive range conditions, coupled with institutionalized depredation control. Most stakeholders active in this case seem to share the view that nature is primarily something to be dominated and utilized. But divergent goals arise from differences in the extent to which stakeholders value conservation of lions for hunting, prioritize livestock rearing for profit, or distrust government. We found little evidence to suggest that current practices and perspectives served anyone's material interests. Calf losses and kills of lions for depredation control persist at high levels which potentially jeopardize regional sport hunting and conservation of lions. Current management of lions affirms prevailing worldviews, which makes lethal control of lions a "necessity," but without resolving any on-the-ground problems. Although alternatives can be imagined, limited resources, limited salience, and prevailing worldviews will very likely perpetuate current dynamics in the short term. Longer term, patterns of depredations and associated human behaviors in this region will more likely be changed by large-scale climatic and economic forces currently reconfiguring wildlife management and ranching in the semi-arid West.

An integrated regional outreach and research model for wildlife conservation across the San Francisco Bay Area

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***Abstract*:** The San Francisco Bay Area hosts a vibrant and expanding economy and an environmentally concerned populace. Heavily developed areas and congested highways abut critical networks of protected open space and large working ranches. We provide an overview of region-wide collaborative efforts to model, design and conserve functional networks of contiguous wildlife habitat. Yet, in addition to scientifically valid conservation design, sustaining wildlife communities requires addressing differing concerns for urban edge versus rural residents. We describe the combined ecological research and outreach model we have designed to incorporate these distinct populaces into the work of the Bay Area Puma Project, a landscape-scale research and conservation program. Urban edge puma conservation needs include identifying landscape movement barriers; providing safe highway crossings; protecting landscape-scale corridors; alleviating depredation on pets and hobby animals; identifying and alleviating inadvertent poisoning; addressing human levels of fear and defining safety threats; and developing protocols for removing pumas from high-density residential areas. In contrast, where the same pumas'

home ranges intersect rural ranches, potential impacts on livestock, interactions with deer population, and occasionally, inadvertent poisoning become the main concerns. We present data from puma GPS collars, GIS-based analyses, and findings from 3 seasons of region-wide camera-trapping that documented varying occupancy and activity patterns of pumas and other mammals between urban edge and rural environments. We describe how we have used these findings and input from diverse human communities to dynamically link research with rural and urban stakeholder outreach and involvement. The project thus creates the impetus for landscape conservation outcomes within the process of conducting a research program, from choosing appropriate questions to conducting fieldwork, and from analysis to collaborative management planning.

Banquet Speech

Michael L. Wolfe, Professor Emeritus, Utah State University

***Abstract*:** This narrative weaves a tale of humankind's relationship with predatory animals largely within the context of western culture. From prehistoric times humans developed conflicted relationships with large carnivores, perhaps stemming from mutual kleptoparasatism and biophobia. With the development of pastoral and agrarian societies these relationships morphed into a cultural enmity with certain large predators incorporated into legend and folklore and abetted by the advent of non-animistic monotheistic religions. However, not all large predators perceived were viewed equally with the wolf being almost universally reviled and lions and bears were viewed in somewhat more favorable terms. European colonists brought these traditions with them when they settled North America and applied the anti-predator mentality vigorously in their conquest of the American frontier. This resulted in a virtual pogrom against predators, and the near eradication of several large carnivores by the 20th century. With the demise of larger predators, the coyote became the principal target of predator control efforts. However, there emerged in the latter half of that century a more enlightened perception of large carnivores, largely occasioned by the research and teachings of several visionary ecologists and the writings of several popular authors. Changing public attitudes resulted in often controversial efforts to protect and restore large carnivores. The past several decades have witnessed a veritable explosion in predation-related research enhanced by significant advances in technology and aired publicly in modern media. This work and a paradigm shift in ecology have resulted in development and slow acceptance of a modern synthesis, whereby predators are viewed in their appropriate and diverse ecological roles neither as universal villains or messiahs. However, attitudes towards predatory animals remain sharply polarized and significant challenges persist. These include range expansion or recolonization by coyotes and cougars as well concerns for human safety prompted by the presence of potentially dangerous animals in near urban environments.

Session 10:

Non-invasive Techniques

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Integrating Scientific Findings into Management

Estimating Cougar Densities in northeast Oregon Using Conservation Detection Dogs

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***Abstract*:** Estimating densities of cougar (*Puma concolor*) is important for managing cougars and their prey but remains challenging due to cougar's elusive and solitary behavior. Traditional methods for estimating abundance and density of cougars require several years of extensive and expensive mark-recapture work. To evaluate a non-invasive, genetic capture-recapture method to estimate cougar population size and density, we surveyed a 220-km^2 area using conservation detection dogs trained to locate scat over a 4-week sampling period in northeast Oregon. We collected 272 scat samples and conducted DNA analysis on 249 samples from which we determined individual identification from 73 samples that represented 21 cougars (9 males and 12 females). We evaluated 4 models to estimate cougar densities: Huggins closed population mark-recapture (Huggins), CAPWIRE, multiple detections with Poisson (MDP), and spatially explicit capture recapture (SECR). Population estimates for cougars using our study area were 26 (95% CI = 22–35, 9 males and 17 females) from Huggins models, 24 (95% CI = 21–30, 9 males and 15 females) from CAPWIRE, and 27 (95% CI = 24–42, 9 males, 18 females) from the MDP model. We accounted for the edge effect in density estimates caused by individuals whose home ranges included only a portion of the survey grid by buffering the study area using the mean home range radius of 8 cougars equipped with Global Positioning System collars on or near the study area. We estimated densities of 4.6 cougars/100 km^2 (CI = 3.8–8.3) for the Huggins model, 4.8 cougars/100 km^2 (CI = 4.2–7.8) for the MDP model, 4.2 cougars/100 km^2 (CI = 3.3–5.3) for the CAPWIRE model, and 5.0 cougars/100 km^2 (CI = 3.2–7.7) for the SECR model. Our results suggested estimating cougar densities using scat detection dogs could be feasible at a broader scale at considerably less effort over a shorter duration than traditional mark-recapture methods.

DNA-based diet identification of mountain lions in southwestern Arizona

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***Abstract*:** Mountain lion (*Puma concolor*) diets have long been a subject of controversy and have been studied using various methods in the past 30 years. Most early attempts to ascertain predator diet were focused on methods employing analyses of contents in feces based on morphological identification of hair and bone fragments. These methods can be subject to significant variation in individual interpretation and can lack in certainty of identification of the prey species consumed by predators. In this study we employ genetic analyses of scat contents to identify mountain lion prey. We opportunistically collected 152 scat samples suspected to be of mountain lion in origin from mountain ranges in southwestern and south central Arizona during 2006–2012. We amplified and sequenced a 472 bp fragment of the mitochondrial cytochrome *b* gene to identify predator species. We confirmed 77 (50.7%) scats to be from mountain lions. We dismantled these mountain lion scats to recover bone and connective tissue fragments contained therein. We then pulverized these fragments in a freezer mill and identified prey species also using the cytochrome *b* gene. Our preliminary results demonstrated that mountain lion diet consisted of 44% mule deer (*Odocoileus hemionus*) and 27% desert bighorn sheep (*Ovis canadensis*) as the major prey items, among other minor prey items. With seasonal division of diet, we observed a potential positive correlation between mountain lion predation and the desert bighorn sheep lambing season, and an inverse relationship between mule deer and desert bighorn sheep predation. We concluded that DNA-based identification is an effective tool in generating data on mountain lion diets, and such data can be useful for wildlife management, particularly in modeling the impact of predation and vulnerability of prey species to mountain lions.

PumaPlex: A rapid and high-throughput method to genotype single nucleotide polymorphisms in mountain lion tissues and scats

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***Abstract*:** Population genetic analyses have become a powerful tool for the conservation and management of wildlife populations. However, the most common genetic markers, microsatellites, often incur a high cost of examination, suffer from homoplasy, and produce data difficult to compare across studies. Recently, alternative genetic markers, called single nucleotide polymorphisms (SNPs), have received much attention for their analytical simplicity, high-throughput capabilities, consistency across studies, and potential utility in ancient, degraded, and non-invasively collected samples. In our study we designed a high-throughput assay (called PumaPlex) to simultaneously genotype 26 SNPs in mountain lions (*Puma concolor*). To date, we have genotyped more than 700 mountain lions, including ~500 individuals from Arizona. Our results from using PumaPlex produced comparable results to that of microsatellites, with a substantial decrease in overall costs and turnaround time. Additionally, we directly compared genotyping success of PumaPlex with a panel of 12 well-known *Felis catus* (FCA) microsatellite loci in 46 mountain lion scat samples. We found that measures of genotyping success were significantly improved for PumaPlex relative to microsatellites. The advantages of PumaPlex compared with traditional microsatellite genotyping make it a valuable addition to existing methods to assist genetic monitoring and management of mountain lions throughout their range.

In the lion's footsteps: Monitoring Mountain lion using a non-invasive and cost-effective footprint identification technique

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***Abstract*:** Mountain lions are solitary, elusive and cover very large areas, and as a result, it is very difficult to collect reliable data on population characteristics (parameters) and distribution. While telemetry and/or camera-trapping techniques can provide useful information, they are relatively expensive and difficult to deploy over large areas. Also, if monitoring data are to be reliable and reflect the true population dynamics then the method of collection must have minimal or no impact on natural behavior or physiology of the target animal.

The authors developed a footprint identification technique (FIT), initially for use with black and white rhino in southern Africa, and have since adapted it for use with felids including Bengal and Amur tiger, African lion and cheetah.

Digital images of multiple left-hind footprints from individual animals are captured using a basic digital camera. They are uploaded to an FIT add-in for JMP data visualization software from SAS Institute. Feature extraction allows >120 measurements of length, angle and area to be collected. Using a customized cross-validated pairwise discriminant analysis with Ward's clustering technique, the footprints can be classified by individual, sex, age-class, and species with a high degree of accuracy. Jewell and Alibhai have collaborated with Jonah Evans, Mammalogist for Texas Parks and Wildlife, to adapt FIT for use in monitoring free-ranging mountain lion populations. They have collected 535 footprints from 35 captive (16:19) animals of known sex and identity to form the initial reference database. Accuracies of >90% have been obtained in classifying by individual and sex. FIT is inexpensive, non-invasive, and provides high accuracy when compared with other methods. This tool could potentially be used to estimate mountain lion populations at dramatically reduced costs in areas with suitable substrate. The authors will invite those with access to free-ranging mountain lion tracks to join this effort by contributing footprints for field validation trials

Use of camera traps to assess prey availability and distribution relative to mountain lion predation in the Davis Mountains, Texas

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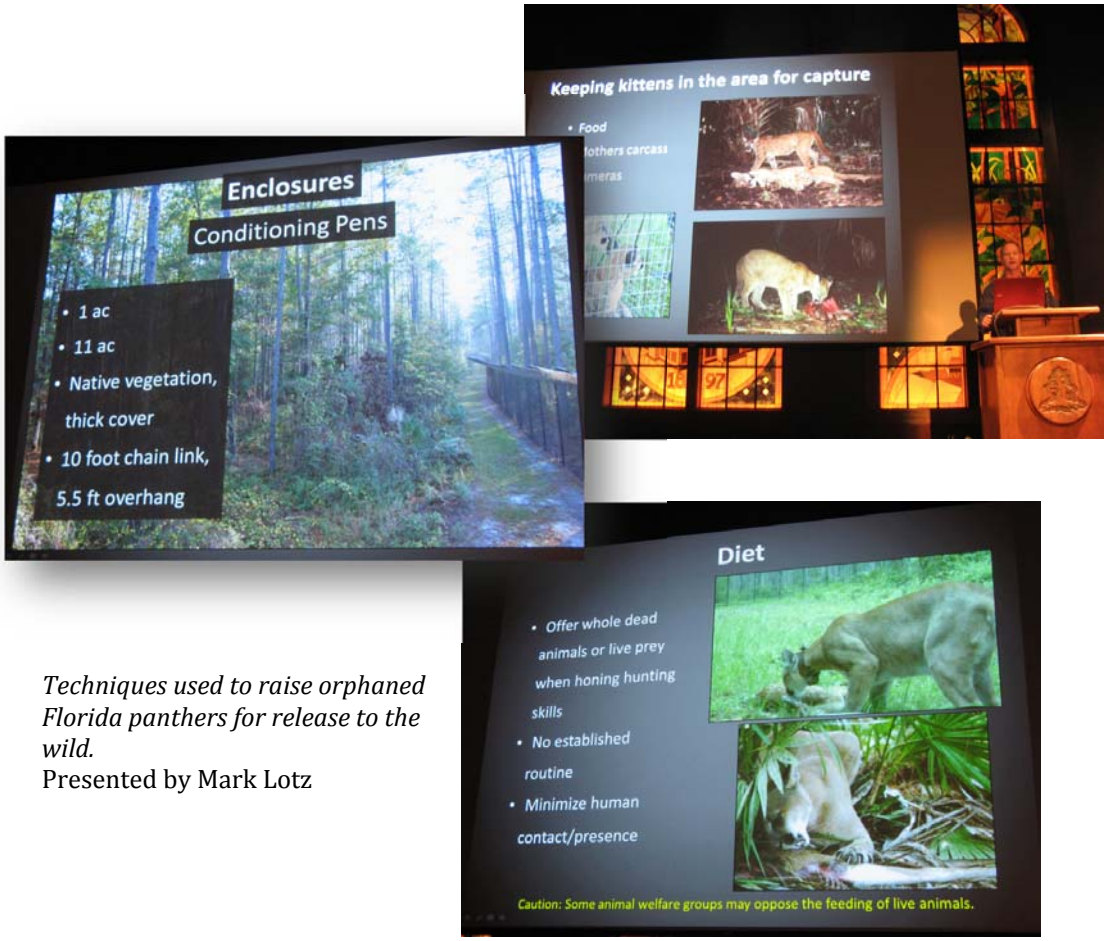
***Abstract*:** We used an array of camera traps and information collected from GPS collared animals to test the relationship between prey availability and mountain lion predation in the Davis Mountains of west Texas. Camera traps were used to estimate the relative abundance and distribution of mountain lions and their prey. GPS collar data was used to identify likely kill sites and field investigations confirmed whether or not a kill was present, as well as the species that was killed. We compared prey availability across the study site to the composition of all kill sites observed. Camera trap data was used to investigate the distribution of prey, including habitat preferences for several categories including elevation, terrain ruggedness, and ecological site. We also looked at individual kill sites and compared those to the relative prey abundance based on camera trap data in the more immediate area surrounding the kill. While feral hogs were the most abundant prey species on camera traps (composing 23% of total animals observed) they were the fourth most common species preyed upon by mountain lions after mule deer, elk, and white-tailed deer. We observed significant differences between the diets of the male and female cats present on the study site, as well as differences in diet based on the age of the animal. However, we also noted variation in the diet preferences of individual mountain lions that fall within the same sex and age groups. A better understanding of how local prey availability both on a fine and broad scale affects mountain lion predation will help land managers to better manage for both mountain lions and their prey.

Session 11:

Management Strategies



Techniques used to raise orphaned Florida panthers for release to the wild.
Presented by Mark Lotz

Proceedings of the

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Integrating Scientific Findings into Management

Conservation of pumas (*Puma concolor*) in a rapidly urbanizing landscape; research informing the need for more action

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***Abstract*:** Wide-ranging large carnivores such as pumas pose myriad challenges for conservation, perhaps especially in urbanizing landscapes. We conducted a 12-year study of pumas (*Puma concolor*) in southwestern California, USA, an area that is the focus of multiple landscape-scale conservation planning efforts aimed at protecting a network of habitat reserves amidst extensive urban, suburban and exurban development. The majority of urban (74%) and rural (79%) residents in this region agreed that pumas are a sign of a healthy environment, and >60% said pumas have a right to exist wherever they occur. However, despite protection from recreational hunting, annual survival was similar to heavily hunted populations, and human activities, especially vehicle collisions and depredation permits, were the leading causes of death. Our analyses showed that despite landscape-scale conservation planning that has been vigorously pursued in this region, habitat fragmentation has resulted in demographic isolation and genetic restriction and the *de facto* creation of two puma populations separated by an interstate highway (I-15). Dominant causes of death varied significantly between the two populations, and by gender, with vehicles causing over half of mortalities west of I-15 in the Santa Ana Mountains. Our data highlight the importance and urgency of protecting and restoring wildlife corridors if puma populations are to be viable in fragmenting landscapes. We discuss applications of our data to efforts to reduce human-caused mortality of puma, including corridor planning, highway improvements, and public outreach. Without these expensive solutions, intensive management of the Santa Ana Mountain population may be necessary, possibly in perpetuity. We predict that positive human attitudes toward pumas in this region will have to be combined with concerted efforts by conservation and governmental organizations in order to avoid this outcome.

Predation-specific resource selection by cougars in the Pryor Mountains of Wyoming and Montana

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***Abstract*:** Cougars are an ambush predator whose landscape selection and predation patterns intertwine. Where feasible, modification of landscape features could manipulate predation risk. Our objective was to examine predation-specific resource selection at two different scales (fine and coarse) in the Pryor Mountains of Wyoming and Montana. We visited clusters (n = 388) of GPS locations from 5 radio-collared cougars during 2011 – 2012 to locate prey remains. It is often impossible to identify specific kill locations, so many studies have relied on the characteristics of cache sites to describe kill site characteristics, likely resulting in some inaccuracies. To avoid this, when possible we backtracked from cache locations to kill points and used a fine-scale analysis to examine landscape characteristics within 25 m of these confirmed kill points (n = 30). At this scale, kill sites had lower horizontal visibility and elevations than random sites, and were more apt to be in juniper-mountain mahogany vegetation and less likely to be in grasslands. For our coarse scale analysis of predation risk we used our entire dataset of kills (n = 195) by using the 95% upper cut-off point of the known distances-dragged (94.9 m) to buffer caches sites, thereby creating risk zones which had a high likelihood of containing the kill. We modeled cougar predation site selection by constructing resource selection functions for these risk zones. The top model for summer risk zones consisted of vegetation class, distance-to-water and a quadratic term for slope, while the top model for winter risk zones included vegetation class and elevation. Local wildlife managers who have an interest in reducing predation to bighorn sheep will be able to intersect the predation risk resource selection functions with bighorn sheep habitat to guide habitat modification efforts aimed at increasing horizontal visibility to reduce the risk of cougar predation.

Techniques used to raise orphaned Florida panthers for release to the wild

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***Abstract*:** The Florida panther (*Puma concolor coryi*) is an isolated subspecies of puma with a breeding population restricted to approximately 800,000 hectares in southern Florida. Genetic restoration efforts in the mid-1990's increased heterozygosity and were successful at helping the population rebound to 100-160 adults. Nevertheless, the current size of this population is insufficient to ensure a genetically diverse, self-sustaining population and individual panthers still represent a significant proportion of the genetic structure in the wild. The Florida Fish and Wildlife Conservation Commission, in cooperation with White Oak, has raised ten (4 M, 6 F) orphaned or injured dependant-aged kittens and released them back to the wild where they had an opportunity to be recruited into the breeding population. Female recruitment has been excellent and most have produced litters. Additionally, several of the captive raised female's offspring have been documented to produce litters. Male recruitment results have been mixed. We describe captive habitat conditions, feeding regimens, staff-panther interaction protocols, and pre-release considerations implemented while panthers are being held captive that appear to be critical for improving the probability of successful recruitment of individuals back into the wild population. Investing in individuals, especially in small, isolated, and endangered populations has genetic consequences for conservation, management, and recovery. As other state agencies develop alternate policies for dealing with orphaned pumas, the knowledge gained in Florida may assist in increasing the likelihood of successful releases.

Effects of Remedial Sport Hunting on Cougar Complaints and Livestock Depredations

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***Abstract*:** Remedial sport hunting of predators is often used to reduce predator populations and associated complaints and livestock depredations. We assessed the

effects of remedial sport hunting on reducing cougar complaints and livestock depredations in Washington from 2005 to 2010 (6 years). The number of complaints, livestock depredations, cougars harvested, estimated cougar populations, human population and livestock populations were calculated for all 39 counties and 136 GMUs (game management units) in Washington. The data was then analyzed using a negative binomial generalized linear model to test for the expected negative relationship between the number of complaints and depredations in the current year with the number of cougars harvested the previous year. As expected, we found that complaints and depredations were positively associated with human population, livestock population, and cougar population. However, contrary to expectations we found that complaints and depredations were most strongly associated with cougars harvested the previous year. The odds of increased complaints and livestock depredations increased dramatically (36 to 240%) with increased cougar harvest. We suggest that increased young male immigration, social disruption of cougar populations, and associated changes in space use by cougars - caused by increased hunting resulted in the increased complaints and livestock depredations. Widespread indiscriminate hunting does not appear to be an effective preventative and remedial method for reducing predator complaints and livestock depredations.

Abundance of pumas (*Puma concolor*) in the northern Sierra Madre Occidental, Mexico: are we ready to have a harvest quota?

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***Abstract*:** Pumas in Mexico although consider a game species are treated as varmints. This non glamorous status is the result of predator control campaigns associated to livestock depredation. Nevertheless, there is no accounting to the number of mountain lions killed as there is no direct benefit to the ranching community. Our objective was to determine the number of lions present in the landscape of the northern Sierra Madre Occidental (SMOcc) to provide baseline information to assist management agencies in the region. Our study area is the northern SMOcc including NW Chihuahua and NE Sonora. The habitats include a mosaic of Sonoran Desert, grasslands, oak woodlands, and Chihuahuan desert. We used camera traps to assess the abundance of lions in different habitats. Puma abundance range from 1 to 4 ind/100 km^2 with a 1 M:1 F sex ratio, using these results, management units should have a minimum surface of 1250 to 5000 km^2 (habitat dependent). Additional variables in this proposal should incorporate prey abundance, livestock production and conservation status of the land. The ranching

community should favor a sustainable hunting scenario instead of the traditional predator control by supporting outfitter guides dedicated to this species.

Research to Regulation: Cougar Social Behavior as a Guide for Management

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***Abstract*:** Cougar (*Puma concolor*) populations are a challenge to estimate because of low densities and the difficulty marking and monitoring individuals. As a result, their management is often based on imperfect data. Current strategies rely on a source–sink concept, which tends to result in spatially clumped harvest within management zones that are typically approximately 10,000 km^2. Agencies often implement quotas within these zones and designate management objectives to reduce or maintain cougar populations. We propose an approach for cougar management founded on their behavior and social organization, designed to maintain an older age structure that should promote population stability. To achieve these objectives, hunter harvest would be administered within zones approximately 1,000 km^2 in size to distribute harvest more evenly across the landscape. We also propose replacing the term 'quota' with 'harvest threshold' because quotas often connote a harvest target or goal rather than a threshold not to exceed. In Washington, USA, where the source–sink concept is implemented, research shows that high harvest rates may not accomplish the intended population reduction objectives due to immigration, resulting in an altered population age structure and social organization. We recommend a harvest strategy based on a population growth rate of 14% and a resident adult density of 1.7 cougars/100 km^2 that represent probable average values for western populations of cougars. Our proposal offers managers an opportunity to preserve behavioral and demographic attributes of cougar populations, provide recreational harvest, and accomplish a variety of management objectives. We believe this science-based approach to cougar management is easy to implement, incurs few if any added costs, satisfies agency and stakeholder interests, assures professional credibility, and may be applied throughout their range in western North America.

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