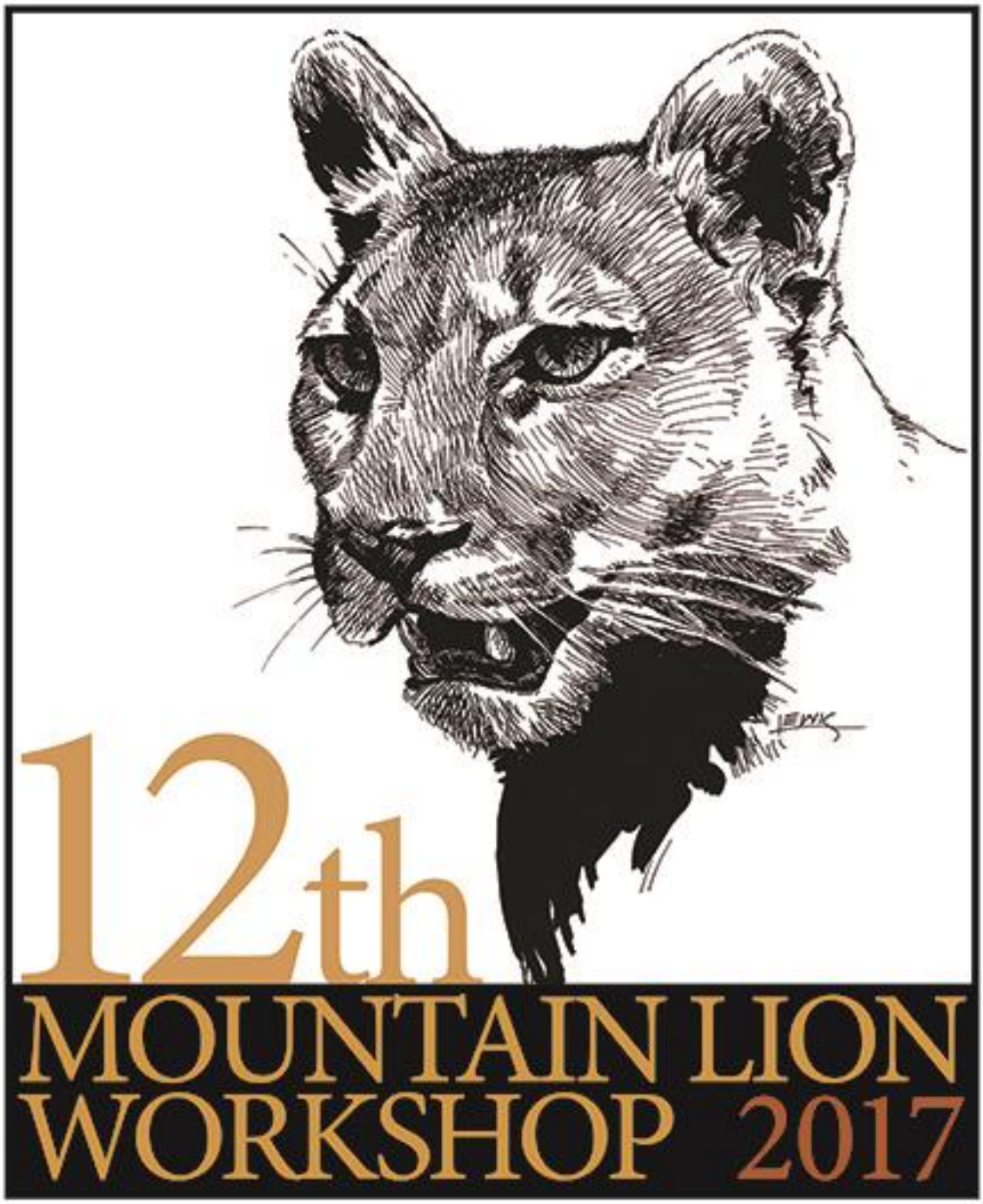

A Synthesis of Management and Research Findings

Hosted by Colorado Parks and Wildlife

May 15–18, 2017

Estes Park, Colorado

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Agenda, 12th Mountain Lion Workshop, May 15–18, 2017, Estes Park, Colorado

Mon. May 15	
4:00 p.m.+	Arrival, registration, East Portal & Bible Point rooms, Emerald Mountain Lodge
6:00–8:00	Meet & Greet, East Portal & Bible Point rooms, Emerald Mountain Lodge, Dinner 5–7 p.m. in Aspen or Walnut dining halls
Tues. May 16	
8:00 a.m.+	Registration
8:00–8:10	Welcome: Craig McLaughlin, Chairman, the *12th Mountain Lion Workshop*, Colorado Parks & Wildlife
8:10–8:45	Keynote address: *Managing Lions: Fandom– Irony– Anachronism* Jerry Apker, Carnivore and Furbearer Manager, Colorado Parks & Wildlife
	Session 1: **MOUNTAIN LION/FELID POPULATION MONITORING** Moderator: Jay Kolbe, Montana Fish, Wildlife & Parks
8:45–9:05	*Evaluating noninvasive survey methods for cougars in northwest Wyoming* by Peter Alexander, Eric Gese, Dan Thompson, Mark Elbroch, and Howard Quigley
9:05–9:25	*Screaming in the woods: Noninvasive techniques for estimating cougar densities* by Mathew Alldredge and Tasha Blecha
9:25–9:45	*A long-term evaluation of biopsy darts and DNA to estimate cougar density: An agency–citizen science collaboration* by Richard Beausoleil, Joseph Clark, and Benjamin Maletzke
9:45–10:05	*A multi-method approach to estimating jaguar & puma density: Integration of home range data into a noninvasive genetic sampling approach* by Anthony Giordano
10:05–10:20	**Break**
10:20–10:40	*Integrating population monitoring and modeling methods to enable an adaptive harvest management strategy for mountain lions in Montana* by Jay Kolbe, Kelly Proffitt, Josh Nowak, and Hugh Robinson
10:40–11:00	*Estimating mountain lion abundance in Arizona 2004–2015* by Frances Peck, April Howard, and Matthew Clement
11:00–11:20	*Estimating puma densities from camera trap data using generalized spatial partial identity models* by Christopher Rowe, Ben Augustine, and Marcella Kelly
11:20–11:40	*Mule deer abundance, cougar home range size, and predator–prey density across a climatic gradient in the Intermountain West* by David Stoner, Joseph Sexton, Heather Bernales, David Choate, Jyothy Nagol, Kirsten Ironside, Kathleen Longshore, and Thomas Edwards
11:40–12:00	*Standarization of cougar population metrics* by Richard Beausoleil
12:00–1:00	**Lunch**– Aspen or Walnut dining rooms

1:00–1:40 **Session 2**: **JURISDICTIONAL MOUNTAIN LION MANAGEMENT SURVEY** by Jerry Apker, Colorado Parks & Wildlife

Session 3: **MOUNTAIN LION GENETICS & GENOMICS**
Moderator: Holly Ernest, University of Wyoming

1:40–2:00 *Interactions between demography, genetics, and landscape connectivity increase extinction for a small mountain lion population in a major metropolitan area* by John Benson, Peter Mahoney, Jeff Sikich, Laurel Serieys, John Pollinger, Holly Ernest, and Seth Riley

2:00–2:20 *Genomic assessment of mountain lions within an urbanized landscape* by Roderick Gagne, Patricia Solerno, Daryl Trumbo, Walter Boyce, Winston Vickers, Seth Riley, Sue VandeWoude, Chris Funk, and Holly Ernest

2:20–2:40 *Statewide genetic analyses identify mountain lion populations and barriers to gene flow in California and Nevada* by Kyle Gustafson, Walter Boyce, Winston Vickers, Becky Pierce, Vernon Bleich, Marc Kenyon, Seth Riley, Chris Wilmers, Tracy Drezenovich, Roderick Gagne, and Holly Ernest

2:40–3:00 *Quality control measures reveal substantial effects of genotyping errors on DNA-based mark–recapture results* by Michael Sawaya, Colby Anton, Mirjam Barrueto, Anthony Clevenger, Howard Quigley, Toni Ruth, Daniel Stahler, and Chris Wilmers

3:00–3:20 *Landscape genomics of mountain lions on the rural Western Slope and urban Front Range of Colorado* by Daryl Trumbo, Patricia Solerno, Ken Logan, Mat Alldredge, Kevin Crooks, Sue VandeWoude, and Chris Funk

3:20–3:35 **Break**

3:35–4:50 **Panel Discussion**: **STAKEHOLDER PERSPECTIVES**
Moderator: Loren Chase, Arizona Game & Fish
Panelists: Bill Canterbury (Cougar hunter & houndsman, Colorado), Patt Dorsey (State Wildlife Agency, Colorado Parks & Wildlife), Patrick Knackendoffel (Ungulate hunter, Colorado), Penelope Maldonado (The Cougar Fund), Delia Malone (Sierra Club), Steve Wooten (Rancher, Colorado)

4:50–6:00 Dinner 5–7 p.m. in Aspen or Walnut dining rooms

6:30–8:30 **Session 4**: **POSTERS, VENDORS, SOCIAL** in Aspen Glen room, Emerald Mountain Lodge
Organizer: Stephanie Durno, Colorado Parks & Wildlife

Wed. May 17

8:00 a.m.+ Registration

8:00–8:10 Announcements: Craig McLaughlin, Workshop Chairman

Session 5: **MOUNTAIN LION–HUMAN RELATIONSHIPS**

Moderator: Mathew Alldredge, Colorado Parks & Wildlife

8:10–8:30 *Community management of jaguars and pumas: multi-stakeholder processes and methods* by Ronit Amit

8:30–8:50 *Puma-human interactions in Brazil: A review of depredation causes and management practices* by Fernando Cesar Cascalli de Azevedo

8:50–9:10 *Spatio–temporal and demographic drivers of cougar predation behaviors in an urban–rural gradient* by Kevin Blecha and Mat Alldredge

9:10–9:30 *Conducting research and conservation efforts for jaguars and mountain lions on ranchlands in the southwestern U.S.: A model for communication and coordination with the ranching community* by Lisa Haynes, Melanie Culver, Susan Malusa, Kirk Emerson, Aaron Lien, George Ruyle, Laura Lopez Hoffman, Howard Quigley, Rafael Hoogesteijn, and Harley Shaw

9:30–9:50 *Gaps of knowledge in recovery actions for jaguars (Panthera onca) in Mexico* by Mircea Hidalgo Mihart, Octavio Rosas-Rosas, Rodrigo Nunez Perez, Carlos Lopez Gonzalez, and Diana Friedeberg

9:50–10:10 *Social acceptance and Florida panther management– Is there a sweet spot?* by Darrell Land, Kipp Frohlich, and Carol Knox

10:10–10:25 **Break**

10:25–10:45 *Landscape and habitat use for a large carnivore in the city: Use and selection for mountain lions around Los Angeles* by Seth Riley, John Benson, and Jeff Sikich

10:45–11:05 *Evaluating potential for human and mountain lion conflict in Big Bend National Park* by Price Rumbelow, Patricia Moody Harveson, Louis Harveson, Bert Geary, Catherine Dennison, and Raymond Skiles

11:05–11:25 *Conserving mountain lions in southern California: Addressing fragmentation, conflict, and excess human-related mortality in comprehensive and collaborative ways* by Winston Vickers, Kathy Zeller, Trish Smith, Brian Cohen, Holly Earnest, Kyle Gustafson, Patrick Huber, Doug Geremenga, Valarie McFall, Niamh Quinn, Lynn Cullens, Jessica Sanchez, and Walter Boyce

11:25–12:25 Lunch– Aspen or Walnut dining rooms

12:25–1:40 **Panel Discussion**: **HUMAN–LION INTERACTIONS AND CONFLICT & DEPREDATION MANAGEMENT**

Moderator: Kristin Cannon, (District Wildlife Manager, Colorado Parks & Wildlife)

Panelists: Mat Alldredge (Wildlife-Human Interactions Scientist, Colorado Parks & Wildlife), Loren Chase (Social Scientist, Arizona Game & Fish), Martin Lowney (Wildlife Conflict Manager, A.P.H.I.S., Wildlife Services, Colorado), Valerie Matheson (Urban City Manager,

Colorado), Jerrie McKee (Urban District Wildlife Manager, Colorado Parks & Wildlife), Fernando de Azevedo, Latin American Representative, Brazil)

Session 6: **MOUNTAIN LION HARVEST MANAGEMENT**
Moderator: Brian Kertson, Washington Department of Fish & Wildlife

1:40–2:00 *Impacts on survival of cougars caught as non-targets in foothold traps* by Alyson Andreasen, Carl Lackey, Jon Beckmann

2:00–2:20 *Can increased quota harvest redistribute human caused cougar mortality in Alberta?* by Paul Frame

2:20–2:40 *Anthropogenic mortality levels shape the characteristics of a lightly hunted cougar population in western Washington* by Brian Kertson

2:40–2:55 **Break**

2:55–3:15 *Effects of hunting on a mountain lion population on the Uncompahgre Plateau, Colorado* by Kenneth Logan

3:15–3:35 *Mountain lion management in western North America: >100 year retrospective* by Steven Torres, Heather Keough, Justin Dellinger, and Marc Kenyon

3:35–3:55 *Evolving mountain lion management in the West: Applying science with human values* by Kenneth Logan

Session 7: **MOUNTAIN LION BIOLOGY & ECOLOGY**
Moderator: Mark Elbroch, Panthera

3:55–4:15 *The role of native prey restoration in reducing livestock depredation by puma (Puma concolor) and jaguar (Panthera onca) in Sonora, Mexico* by Ivonne Cassaigne and Rodrigo Medellin

4:15–4:35 *New insight into utilizing bone marrow to assess the health of mountain lion prey* by Jacob Kay and James Cain III

4:35–4:55 *Re-colonization of bears in the Great Basin and resulting species interactions: Effects on cougar predation behavior and implications for prey* by Jon Beckmann, Carl Lackey, Pat Jackson, and Alyson Andreasen

6:00–8:00 BBQ in the Assembly Hall

Thurs. May 18

8:00–8:10 Announcements: Craig McLaughlin, Workshop Chairman

Session 7 continued: **MOUNTAIN LION BIOLOGY & ECOLOGY**
Moderator: Mark Elbroch, Panthera

8:10–8:30 *Scaredy cats and the big bad wolf: How intraguild competition influences home range selection in a subordinate predator* by Anna Kusler, Mark Elbroch, Howard Quigley, and Melissa Grigione

8:30–8:50 *Preliminary predation patterns of cougars and wolves in an area of sympatry* by Elizabeth Orning, Katie Dugger, and Darren Clark

8:50–9:10	*Foraging behavior of coyotes under intraguild predation risk by cougars: An experimental approach* by Julie Young and Peter Mahoney
9:10–9:30	*Spatial ecology and survival of mountain lions on private lands in west Texas* by Catherine Dennison, Patricia Moody Harveson, Bert Geary, and Louis Harveson
9:30–9:45	**Break**
9:45–10:05	*Mountain lion social organization* by Mark Elbroch, Michael Levy, Mark Lubell, Howard Quigley, and Anthony Caragiulo
10:05–10:25	*Spatial and temporal shifts in cougar presence in the Midwest in response to changing management regimes* by Michelle LaRue, Brent Pease, and Clay Nielsen
10:25–10:45	*Retroviral infections among North American mountain lions (Puma concolor)* by Jennifer Malmberg, Simona Kraberger, Elliott Chiu, Justin Lee, Ryan Troyer, Melody Roelke, Mark Cunningham, Winston Vickers, Walter Boyce, Erin Boydston, Laurel Serieys, Seth Riley, Ken Logan, Mat Alldredge, Chris Funk, Kevin Crooks, and Sue VandeWoude
10:45–11:05	*Vertebrate diversity benefitting from carrion provided by mountain lions* by Michelle Peziol, Mark Elbroch, Connor O'Malley, and Howard Quigley
11:05–11:15	**Final remarks**: Craig McLaughlin, Workshop Chairman
11:15–11:30	**Business meeting**: Craig McLaughlin, Workshop Chairman Choose host for the *13th Mountain Lion Workshop* in year 2020.
11:30	**Adjourn**

12th Mountain Lion Workshop Abstracts

SESSION I: MOUNTAIN LION / FELID POPULATION MONITORING

Evaluating noninvasive survey methods for cougars in northwest Wyoming

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ABSTRACT Cougars are difficult to census due to their large home ranges, low densities, and cryptic nature. The conventional "gold-standard" method for estimating cougar abundance entails the capture, radio-tagging and enumeration of individuals in an area to produce a minimum count. While believed to be accurate, this method is logistically challenging, expensive, and usually infeasible at large spatial scales. Noninvasive survey techniques may offer the ability to both accurately and inexpensively monitor cougar populations, but remain questionable as to their accuracy and comparative cost effectiveness. We estimated the density of a cougar population in Northwest Wyoming using direct enumeration, and used that estimate as a reference with which to evaluate the accuracy and cost-effectiveness of three types of noninvasive surveys: 1) remote camera trapping, 2) winter hair-collection, and 3) scat detection dogs. We captured and GPS-tracked 13 adult cougars (males = 5, females = 8) over 3 annual periods (Sep 2010 – Sep 2013). We used proportional home range overlap to determine a mean density of 0.82 cougars/100 km^2 (± 0.10 SD; n = 3 years) in the 1,570 km^2 study area. Using spatially explicit capture recapture (SECR) models, we estimated a multi-year densities of 0.6 adult cougars/100 km^2 (95% CI = 0.3 – 1.1) from camera trapping, and 4.2 cougars/100 km^2 (CI = 2.8 – 6.7) from the scat dogs. The winter transects failed to produce a sample large enough for a density estimate. Additional analysis indicated that individual identification of cougars in photographs may not be reliable, challenging the validity of photo-based abundance estimates. Scat detection dogs were the most cost effective method (cost-per-detection: scat detection dogs = $341; remote cameras = $3,241; winter transects = $7,627). Our results indicated that, using our methods, scat detection dogs are the most cost effective and least biased method for noninvasively monitoring cougar populations.

KEY WORDS Noninvasive, cougar, camera trap, detection dog, mark-recapture

Screaming in the woods: Noninvasive techniques for estimating cougar densities.

Mathew W. Alldredge[1] and Tasha Blecha
[1]Mammals Research Section, Colorado Parks and Wildlife, Fort Collins, CO

ABSTRACT: Estimating cougar density is a difficult, expensive and error prone task. Many estimates of cougar density come from mark-recapture studies at limited spatial scales (1,000 km^2 or less) and many represent assumed complete counts. Non-invasive genetic mark-recapture techniques present an intriguing option to estimate cougar numbers over broader spatial scales at significantly reduced expenses. However, attempts to sample cougar populations with such techniques have met with limited success, primarily because luring cougars to specific sites is unreliable at best. We developed techniques to sample cougars to specific locations using auditory calls as lures and hair snags and cameras as sampling devices. Results of this study indicate the auditory calls are effective lures to attract cougars to specific locations with detection probabilities exceeding 60% based on camera trap data. However, obtaining hair snags from cougars was less successful (<25%) and uniquely identifying cougars based on genotypes from hair samples was minimally successful (<10%). Based on these data, we were not able to estimate population density using non-invasive mark-recapture techniques. However, this sampling approach does present a unique ability to estimate cougar densities using mark-resight models and may also offer the ability to use spatially explicit approaches. This approach will provide statistically defensible estimates of cougar density, which is an improvement over count data and provides a logistically feasible alternative to intensive mark-recapture approaches.

KEY WORDS: Density estimation, non-invasive genetic sampling, mark-resight

A Long-Term Evaluation of Biopsy Darts and DNA to Estimate Cougar Density: An Agency - Citizen Science Collaboration

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ABSTRACT: Accurately estimating cougar (*Puma concolor*) density is usually based on long-term research consisting of intensive capture and Global Positioning System collaring efforts and may cost hundreds of thousands of dollars annually. Because wildlife agency budgets rarely accommodate this approach, most infer cougar density from published literature, rely on short-term studies, or use hunter harvest data as a surrogate in their jurisdictions; all of which may limit accuracy and increase risk of management actions. In an effort to develop a more cost-effective long-term strategy, we evaluated a research approach using citizen scientists with trained hounds to tree cougars and collect tissue samples with biopsy darts. We then used the DNA to individually identify cougars and employed spatially explicit capture–recapture models to estimate cougar densities. Overall, 240 tissue samples were collected in northeastern Washington, USA, producing 166 genotypes (including recaptures and excluding dependent kittens) of 133 different cougars (8–25/yr) from 2003 to 2011. Mark–recapture analyses revealed a mean density of 2.2 cougars/100 km^2 (95% CI = 1.1–4.3) and stable to decreasing population trends (β = 0.048, 95% CI = 0.106–0.011) over the 9 years of study, with an average annual harvest rate of 14% (range = 7–21%). The average annual cost per year for field sampling and genotyping was US$11,265 ($422.24/sample or $610.73/successfully genotyped sample). Our results demonstrated that long-term biopsy sampling using citizen scientists can increase capture success and provide reliable cougar-density information at a reasonable cost.

KEY WORDS: biopsy, citizen-science, cougar, density, DNA, hound handler, microsatellite, Puma concolor, spatially explicit.

Standardization of Cougar Population Metrics

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ABSTRACT: Long term research, replication, and rigorous analytical methods are the hallmark and guiding scientific principles for a systematic management strategy. However, even where long-term research is conducted and published, findings are often not presented in a consistent and standardized format which may result in inconsistent and ambiguous results. For many wildlife species and disciplines, this lack of standardization has complicated both the scientific and management processes. For example, cougar (*Puma concolor*) metrics including population size, density, harvest rate, and population growth rates have been reported incongruously, and sometimes erroneously, resulting in conflicting application which then manifests into debate amongst researchers, state wildlife agencies, wildlife commissions, and ultimately stakeholders. Without explicit explanation and consistent application the result may be biological uncertainty and stakeholder criticism. These inconsistencies will be discussed as will a recommended standardized approach to reporting cougar population metrics in the future.
KEY WORDS: density, growth rate, harvest rate, management, replication, puma concolor, rate of increase, risk, standardization.

A Multi-Method Approach to Estimating Jaguar & Puma Density: Integration of Home Range Data into a Noninvasive Genetic Sampling Framework

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ABSTRACT: There are number of established techniques for estimating the population density of territorial wildlife species. Not all approaches are optimally suited for all species however, and there are advantages and disadvantages to each. Capture-recapture (CR) models have long represented a gold standard for estimating population abundance; however, how best to define an effective sampling area (ESA) has frequently been a matter of debate. More recently, whereas spatial capture-recapture (SCR) techniques have logically addressed this problem, for many species their use still present logistical or other practical challenges. The capture and recapture of large carnivores over an adequate area for example is often cost-prohibitive, and the physical effort required to accomplish this is generally infeasible for closure models. Moreover, whereas camera-trapping techniques work effectively for animals that can be individually identified, absent this criterion estimates of density are frequently relative, or derived from occupancy parameters. Jaguars and pumas represent both sides of this equation, respectively. Here I demonstrate the use of a multi-technique approach to estimate the density of either species, or any other territorial solitary carnivore. I describe a case study involving a jaguar population of unknown size sampled over a large geographical region. I systematically collected jaguar scats on multiple occasions with the purpose of identifying individuals and estimate the local abundance of jaguar population in Paraguay's largest protected area. I then integrated circle-transformed GPS-collar home range data for

six individual jaguars into a single-session CR sampling framework to buffer my sampling transects and calculate my effective sampling area. I conclude that whereas this approach worked very well for jaguars, which are often equally-suited to individual identification via camera-trapping, it might be most promising for use in management and monitoring of pumas and other large territorial carnivores, for which individual identification using other remote or more labor-intensive means might not be possible.

Integrating Population Monitoring And Modeling Methods To Enable An Adaptive Harvest Management Strategy For Mountain Lions In Montana

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ABSTRACT: Managing harvested mountain lion populations was historically confounded by the lack of methods to affordably, accurately, and repeatedly estimate a population's size, make rigorous predictions about the effect of future harvest prescriptions, and monitor population trends over time. Managers were unable to fully implement an adaptive mountain lion harvest management program because they lacked the necessary monitoring and modeling information. Disagreement about past, and potential, effects of management decisions led to conflict among stakeholders and disagreement about management decisions. Montana Fish, Wildlife & Parks (FWP) recently developed a mountain lion management strategy that directs the agency to actively monitor statewide mountain lion populations using genetic spatial capture-recapture field techniques. These local monitoring data will be extrapolated across discrete mountain lion ecoregions using a resource selection function (developed using local research and validation data) in order to estimate populations at a meaningful scale. Managers will then input these population estimates, along with local lion demographic parameters and harvest information, into a web-based integrated population model to predict the likely effect of future harvest prescriptions on managed lion populations across the State. These new monitoring and modeling methods will enable FWP to fully implement an adaptive harvest management program through which population objectives are set, management alternatives are objectively evaluated, a preferred harvest prescription is applied, the effect of that harvest is directly monitored over time, and management is adjusted based on new information and changing objectives. FWP believes that this strategy will help reduce contention among stakeholders, optimize mountain lion harvest and pursuit opportunities, reduce stakeholder conflicts, and ensure that robust lion populations are conserved through time across their Montana habitats.

KEY WORDS adaptive harvest management, integrated population model, Montana, mountain lion, population estimation, resource selection function, spatial capture-recapture

Estimating mountain lion abundance in Arizona 2004-2015

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ABSTRACT: Hunting harvest of mountain lions (*Puma concolor*) is the primary mechanism for population level management in Arizona. In hunted populations, there is a need for reliable and affordable techniques to monitor population trends for large-scale species management. Population survey techniques, such as track counts and mark-recapture have been used to estimate local abundance in small study areas in Arizona, but there are limitations to extrapolating these estimates to the statewide population. In this paper, we use cementum annuli tooth age data from premolar teeth removed during physical inspection to calculate age at harvest. By applying virtual population analysis, an age-structured population model, age-at-harvest data are used to reconstruct cohort abundance over time and summed across cohorts age class 0 through age class 14 to estimate minimum abundance from 2004-2015. The methods of Gulland were then applied to incorporate natural mortality and harvest of mountain lions with unknown ages into estimates of statewide mountain lion abundance. Virtual population analysis provides a tool for estimating and monitoring mountain lion populations temporally and spatially where survey or mark and recapture methods are unattainable. Hunter harvest data are relatively low cost, easy to collect, and can provide crucial information on survival, productivity, age composition, and abundance. However, uncertainly about natural mortality rates reduces the precision of abundance estimates. These estimates will be useful in developing management recommendations for mountain lions in Arizona.

KEY WORDS age-at-harvest, minimum abundance, virtual population analysis.

Estimating puma densities from camera trap data using generalized spatial partial identity models

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ABSTRACT: Using camera trap surveys to estimate population densities has become increasingly popular over the last 20 years. While the natural markings of some species have allowed analysis in a mark-recapture framework, this has not been possible for species like pumas that lack sufficiently distinctive pelage patterns to allow for individual identification. Mark-resight models have attempted to address this problem by combining data from both marked and unmarked individuals. In such an analysis, a subset of pumas would be “marked” by identifying subtle markings like scars, tail kinks, or parasites. In this study, we developed a generalized spatial partial identity model that allowed us to use natural marks to link together sets of capture events that can be determined to be the same individual and also exclude the possibility that others are the same individual. These identity connections and exclusions reduce the uncertainty stemming from the unknown individual identities in many photographs and thus increase the precision of the density estimates. In mark-resight models,

two marked individuals could be two sides of the same individual. Generalized spatial partial identity models avoid this error and also allow us to make identity exclusions for unmarked individuals based on sex or other features. We used a generalized spatial partial identity model to estimate the population densities of pumas at six sites in Belize from existing camera trap data. Using generalized spatial partial identity models will allow managers to assess puma population densities from camera trap data with more precision.

KEY WORDS: camera trapping, partial identity, population density estimators, puma, spatial models.

Mule Deer Abundance, Cougar Home Range Size, and Predator-Prey Density across a Climatic Gradient in the Intermountain West

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ABSTRACT: Mule deer (*Odocoileus hemionus*) and cougars (*Puma concolor*) are habitat generalists distributed throughout western ecosystems. Local densities vary widely as a function of climatic/environmental conditions. Consequently, natural resource managers require a means of estimating species abundance across the range of conditions found within their jurisdictions. Ecological theory states that energy transfer diminishes predictably across trophic levels, suggesting that measures of primary productivity can be used to estimate consumer abundance. We evaluated this hypothesis by estimating spatial variation in density of mule deer and cougars across a climatic gradient in the Southwest. We measured growing-season primary productivity on mule deer fawning ranges with the Normalized Difference Vegetation Index (NDVI), which was used to predict variation in mule deer abundance among wildlife management units in Utah. We used cougar GPS data sampled from the Great Basin, Colorado Plateau, and Mojave Desert ecoregions to measure variation in home range size with respect to changes in primary production. We then used the reciprocal of home range area as an index of cougar density (adults/100 km^2) to estimate predator-prey ratios as a function of peak-of-season NDVI. Deer and cougar density varied positively and significantly with primary productivity, but the predator-prey ratio remained constant across climatic zones. Cougar

density estimates approximated those derived from intensive mark-recapture techniques. We discuss the utility of integrating satellite imagery with *in situ* data to inform large scale assessments of big game abundance in the Intermountain West.

SESSION 3: MOUNTAIN LION GENETICS & GENOMICS

Interactions between demography, genetics, and landscape connectivity increase extinction probability for a small mountain lion population in a major metropolitan area

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ABSTRACT: The extinction vortex is a theoretical model describing the process by which extinction risk is elevated in small, isolated populations due to interactions between environmental, demographic, and genetic factors. However, empirical demonstrations of these interactions have been elusive. We modeled dynamics of a small mountain lion population isolated by anthropogenic barriers in greater Los Angeles, California using 13 years of field and genetic data to evaluate the influence of demographic, genetic, and landscape factors on extinction probability. Our model was an individual-based population viability model in which we assigned empirical, multi-locus genotypes to all mountain lions in the starting population. We projected the model forward and assigned genotypes to offspring simulated in the model using principles of Mendelian genetics. The population exhibited strong survival and reproduction, and the model predicted stable median population growth and a 15% probability of extinction over 50 years in the absence of inbreeding. However, our model also predicted the population will lose 40-57% of its heterozygosity in 50 years. When we reduced demographic parameters proportional to reductions documented in another wild population of mountain lions that experienced inbreeding depression (Florida panthers), extinction probability rose to 99.7%. Simulating greater landscape connectivity by increasing immigration to ≥1 migrant per generation appears sufficient to largely maintain genetic diversity and reduce extinction probability. We provide empirical support for the central tenet of the extinction vortex as interactions between genetics and demography greatly increased extinction probability relative to the risk from demographic and environmental stochasticity alone. Our modeling approach realistically integrates demographic and genetic data to provide a comprehensive assessment of factors threatening small, isolated wildlife populations.

Genomic assessment of mountain lions within an urbanized landscape

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ABSTRACT: Mountain lions, *Puma concolor,* in southern California are living in an increasingly fragmented habitat due to intensifying urbanization. These populations have low survival rates and humans are responsible for the majority of lion fatalities, with vehicle strikes being the single largest source of mortality. Tracking of collared lions as well as microsatellite DNA analysis reveals that lions rarely cross major highways and at least one population has a high probability to go extinct due to continued loss of genetic diversity. Genomic techniques provide an increase by orders of magnitude in the number of genetic markers (tens of thousands or more as opposed to less than 100 for microsatellites). This higher genetic resolution can refine identification of barriers to gene flow and further assess genetic diversity, allowing state and local managers to identify at risk populations and target key connectivity corridors. In addition, the genomic approach is permitting us to identify loci likely under selection and this will assist in managers attempting to restore functional genetic diversity to genetically degraded populations. Here, we used double digest restriction site associated DNA (ddRAD) to assess genetic structure and diversity of southern California mountain lions. We recovered over 15,000 SNPs which revealed that genetic structure reflects roads as well as major urban development and that gene flow is restricted in several populations. As a result, genetic diversity is troublingly low in two populations within California coastal mountain ranges, which raises concerns of inbreeding depression and the long term viability of these populations. This work shows the utility of ddRAD in determining impediments to gene flow of large carnivores and allowed for direct comparison with microsatellite analyses, providing state and local agencies with information on the cost/benefits of genomic data to informing mountain lion management strategies.

KEY WORDS: Inbreeding depression, genetic restoration, connectivity, gene flow

Statewide genetic analyses identify mountain lion populations and barriers to gene flow in California and Nevada

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ABSTRACT: Populations are the main level at which demographic and evolutionary processes occur. Thus, to conserve and manage species, it is of fundamental importance to understand population structure and how geographic and anthropogenic landscape components dictate that structure. We used statewide genetic data from mountain lions (*Puma concolor*) sampled across California and Nevada to identify and characterize populations. Given that mountain lion habitat in the state of California is highly structured among several mountain ranges and possibly fragmented by a dense human population, we also assessed landscape barriers to gene flow. From 992 individuals genotyped at 42 microsatellite loci, we detected 10 mountain lion populations. Some populations are small and inbred whereas some are large and genetically-diverse. The primary factors acting as barriers to gene flow were roads, specifically interstate highways, and geographic distance. Our results identify populations of conservation priority and critical areas for population connectivity. Although our results have large-scale conservation implications for mountain lions, it is also considered an umbrella species. Thus, the strong effect of interstate highways on mountain lion population genetic structure may indicate a large-scale ecological problem for other wildlife species and communities in one of North America's most biodiverse and rapidly-urbanizing regions.

Quality control measures reveal substantial effects of genotyping errors on DNA-based mark-recapture results.

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ABSTRACT: Carnivore management depends on robust population monitoring programs to provide reliable metrics for success. Wildlife managers have increasingly been turning to DNA-based mark-recapture methods to estimate population parameters of interest as methods have been developed for the collection of DNA samples (e.g., scat, hair, tissue) and the analysis of mark-recapture data. Despite the rapidly growing popularity of these approaches, few studies have examined the reliability of individual identifications from DNA collected in the field. We used a series of quality control measures to assess the prevalence of genotyping errors in two multi-year mark-recapture datasets, cougars (*Puma concolor*) and wolverines (*Gulo gulo*), generated from microsatellite analysis of DNA samples. We compared spatial and temporal information from sample collection with genotypes to identify likely genotyping errors (i.e. dropout, false alleles) that were confirmed through re-analysis. Quality control revealed errors led to large proportions of mis-identified individuals for both species. Our total two-year minimum count of cougars decreased from 36 to 20 (44%) and our total three-year minimum count for wolverines decreased from 64 to 49 (23%). Genetic datasets that exhibit the following pattern, similar to ours, should be given extra scrutiny: 1) unexpectedly high number of individuals detected, 2) unexpectedly low recapture rates, and 3) many individuals detected only once during sampling. To minimize future problems such as these, we recommend researchers take more accountability of genetic data by performing quality control measures with field data and then working closely with laboratories to ensure data integrity. We additionally recommend that it become standard practice to include microsatellite genotypes in all publications using DNA-based mark-recapture results; studies that omit these data cannot be evaluated objectively. Our results demonstrate that genotyping errors continue to undermine the reliability of mark-recapture data, leading to overestimates of abundance; however, quality control can help to alleviate these problems.

KEY WORDS: abundance, carnivore management, DNA, genotyping errors, *Gulo gulo,* individual identification, mark-recapture, microsatellites, population monitoring, *Puma concolor*

Landscape genomics of mountain lions on the rural Western Slope and urban Front Range of Colorado

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ABSTRACT: Accurate population sizes and movement estimates for mountain lions, critical for informed management, are difficult to achieve given their reclusive nature. Thus, estimates of genetic connectivity (gene flow), genetic diversity, and effective population sizes are useful compliments to labor-intensive, field-based studies. The advent of next-generation sequencing (NGS) now allows for cost-effective generation of tens of thousands of genetic markers spread throughout the genome, providing high power for accurate estimates of connectivity and genetic diversity. Landscape genomics is an emerging field that investigates how demographic and habitat factors interact to shape neutral and adaptive genomic variation, taking advantage of recent advances in NGS and Geographic Information Systems (GIS) technologies. We genotyped mountain lions from the rural Western Slope and rapidly-urbanizing Front Range of Colorado at approximately 28,000 single nucleotide polymorphism (SNP) loci. We then used landscape genomic techniques to determine how connectivity and genetic diversity vary in response to environmental factors related to human development and habitat quality. Preliminary results suggest Front Range mountain lions may have smaller effective population sizes and more restricted movement relative to the Western Slope, as expected in a more fragmented, urbanized landscape. On the Western Slope, mountain lion connectivity is strongly associated with forested habitats containing high tree canopy cover, particularly along steep slopes and canyons; whereas connectivity was not significantly associated with low temperatures, low precipitation, roads, streams, or overall vegetation density. Moreover, preliminary results revealed approximately 450 SNP loci that may be associated with genes under selection based on F_{ST} outlier tests and genotype-environment association analyses. Ongoing work includes an assessment of Colorado mountain lion source-sink dynamics from hunter-collected tooth samples across the state, disease dynamics of Colorado mountain lions, and genomic effects of an experimental hunting study conducted on the Western Slope, with collaborators from Colorado Parks and Wildlife and other universities.

KEY WORDS: Circuitscape, effective population size, F_{ST} outlier, genotype-environment association, gene flow, genetic diversity, Geographic Information Systems, landscape genomics, next-generation sequencing, urbanization

SESSION 4: POSTERS

(Titles and authors only)

Attitudes and Perceptions of Mountain Lions (*Puma concolor)* Across 5 Bay Area Communities

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Facial recognition in cougars: initial tests of novel field and analysis methods

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Estimating Cougar (*Puma concolor*) Population Density and Abundance using Noninvasive Genetic Sampling and Spatial Capture Recapture Models

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Carrion on the Landscape: Mountain Lions Support Biodiversity through Predation

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How Should We Measure Human Tolerance of Mountain Lions?

Lara J. Brenner, University of Montana

A retrospective look at mountain lion (*Puma concolor*) populations in California (1906-2016)

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Development of baseline occupancy rates for long-term monitoring of mountain lions in the Mojave Desert of California

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How mountain lions support migratory eagles

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Mountain lion resource selection in the North Dakota Badlands and statewide habitat suitability.

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Documentation of mountain lion occurrence and reproduction in the Sacramento Valley of California

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Texas native cats: raising awareness about mountain lions through education and outreach in Texas.

Monica Morrison

Too much commotion here for a secretive big cat? Puma don't care.

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SAMANTHA Y. CHAMBERLAND, *Furman University, Greenville, SC 29613, USA*

Demographics of Mule Deer Puma Prey in South-Central New Mexico

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Human and large carnivore encounters in Big Bend National Park

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The influence of anthropogenic water on puma habitat use and prey selection in arid ecosystems

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Spatial density estimations of Puma concolor by remote cameras and a novel hair sampling method

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Where do Mountain Lions Kill Deer along the Urban-Wildland Interface?

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State of the Mountain Lion: A Call to End Trophy Hunting of America's Lion

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Estimating Mountain Lion Populations for Improved Management

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Cascading Fear: Plant architecture reflects human-carnivore-herbivore relationships

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Bridging the Gap: Increasing access with a new online reference tool for *Puma concolor* in the U.S.

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SESSION 5: MOUNTAIN LION–HUMAN RELATIONSHIPS

Community management of jaguars and pumas: multi-stakeholder processes and methods

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ABSTRACT: Empowering and supporting rural communities in solving conflicts with wildlife is a necessary step to confront the environmental challenges facing society today. In 2015, we advanced in this effort bringing together more than 158 participants in a participatory structured communication process. The goal was to design incentives for enhancing coexistence among jaguars, pumas and humans in Costa Rica at communities that suffer predation on livestock by big cats. The final product integrated 823 ideas into six types of incentives: organization of communities, mechanisms for dialogue, technical assistance based on citizen science, a green marketing label, a payment for production of biodiversity, and an assessment of financial alternatives. This plan encompassed a diversity of tools, beyond finances, that target benefits for affected ranchers and other community members, and provides opportunities for local development while resolving conflicts with wildlife. Current follow up consists on a pilot test of incentives under a quasi-experimental research design combining social and ecological indicators. All activities include community members in an active role to build on social learning processes, this is a collaborative effort with input from institutions and multidisciplinary experts. Participatory methods and techniques we adapted for our research include focus groups, varied workshop and survey modes, the Policy Delphi, the Nominal Group Technique, the Logic Framework approach, and Problem-Solution trees. We will address the assessment of legitimacy of participatory processes, i.e. their validity, through measurements of consensus, support, satisfaction, engagement and representativeness. By focusing in our methods, we expect to offer a template for reducing human-wildlife conflicts with multi-stakeholder processes.

Puma-human Interactions in Brazil: a review of depredation causes and management practices.

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ABSTRACT: Considered the carnivore species with the widest distribution in the Americas, pumas are present in all Brazilian biomes. Currently classified as vulnerable in Brazil, pumas face several threats, such as habitat destruction and fragmentation, illegal hunting, retaliatory killing, and road mortality. Despite its wide distribution in Brazil, the number of scientific studies of this species is low. From 2000 to 2016, only ten peer-reviewed publications presented data on puma-human relationships in Brazil, by observation or through interviews. Here I present a review of the main causes of attacks and husbandry practices implemented to reduce livestock depredation by pumas in Brazil. Attacks on humans were very rare. In general, attacks were concentrated on sheep, goats, calves, horses and pigs. Proximity to forested areas, poor husbandry practices and lack of wild prey seemed to be the most important causes of depredation on domestic stock. Attempts to reduce depredation

focused on confinement of herds to corrals at night (sheep, goat, adult horses) or permanently (juvenile horses), and establishment of grazing areas away from forest fragments (cattle). In addition, the killing of predators supposedly involved in depredation events was a common practice. The lack of scientific studies dealing with human-puma interactions in Brazil may be explained by the presence of the jaguar in sympatry with pumas for most regions of the country. Jaguars are preferred as a scientific subject because they cause more livestock depredation than pumas and are internationally recognized as threatened species. Moreover, difficulties for financing long-term studies with large cats in Brazil hinder efforts to investigate concurrently both species and to test husbandry practices aimed to minimize losses due to predation on domestic stock. The presence of pumas near rural and urban areas is currently increasing and may become a serious risk for domestic stock and humans in the foreseeable future.

KEY WORDS: Brazil, human-felid interactions, large cats, management, pumas.

Spatio-Temporal and Demographic Drivers of Cougar Predation Behaviors in an Urban-Rural Gradient.

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ABSTRACT: Understanding wildlife community responses to the conversion of undeveloped to residential lands is a challenge that wildlife managers and conservationists are facing more often. Despite conflicts between cougar (Puma concolor) and humans in the urban-wildland interface, cougar appear to persist in some residentially developed landscapes. We test the influence of spatial (i.e., housing density), seasonality, and puma biological covariates on predation parameters (per-capita kill rate, prey composition, handling time) for GPS collared cougar subjects in the Colorado Front Range. A sample of cougar kill sites was used as input for a series of statistical and deterministic models to derive annual and monthly per-capita kill rates for five prey classes: non-ungulates, adult mule deer, fawn mule deer, adult elk, and calf elk. Alternative prey, such as non-ungulate (i.e., meso-carnivore, pets) and elk comprised a mean proportion of 0.23 and 0.13 respectively of items killed. Despite mule deer (fawn and adult) kill rates decreasing as a function of increased alternative prey utilization and increased housing density, the annual per-capita kill rates on mule deer were high relative to past studies. Collinear with increased utilization of higher housing densities, younger cougar killed a higher proportion of non-ungulate than did older cougar, while female cougar killed higher proportion of non-ungulates than did male cougar. Low to moderate housing densities found in the exurban developments appear to be utilized not only for preying upon abundant deer, but also when preying upon alternative non-ungulate prey. Areas of suburban-urban development appear to be used primarily when preying upon non-ungulates. Handling time of adult ungulates varied by season, but not by any spatial or demographic variable. Cougars are likely trading off a higher risk of anthropogenic related mortalities found in the higher housing development for greater availability of prey resources relative to less developed habitat. Managers focused on reducing back-yard residential conflicts in this system may consider managing for a cougar population with an older age structure, reducing synanthropic prey species, discouraging exurban developments from occurring, and discouraging mule deer utilization of current exurban developments.

KEY WORDS: Colorado, demography, exurban, GPS clusters, housing density, kill-rate, prey composition, suburban, synanthropioc prey

Conducting research and conservation efforts for jaguars and mountain lions on ranchlands in the southwestern US: a model for communication and coordination with the ranching community.

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ABSTRACT: From 2012 to 2015 the University of Arizona, funded by US Fish and Wildlife Service (from Department of Homeland Security mitigation funds), conducted a landscape-scale project to survey for jaguars across 16 mountain ranges in southern Arizona and southwestern New Mexico. Using primarily wildlife cameras we detected and monitored one jaguar and three ocelots, plus a variety of other wildlife, over the course of the study. Other than one military reservation and a couple of small US Park Service sites, all of our activities took place on ranchlands, either as leased public lands or private lands. We took a proactive approach, and in conjunction with the ranching community, developed a communication and coordination protocol that we followed while conducting the project. In a second component of the USFWS-funded program, we organized a depredation workshop for ranchers to provide information and facilitate discussions relative to potential depredation incidents. Since there was only one jaguar (with no known depredation problems), and since jaguars only occur in the US infrequently, we opened the forum to include mountain lions, for which there are depredation conflicts in the region. Finally, in a third component, the university embarked on examining the potential for a payment-for-ecosystem-services model on ranchlands to keep working wildlands intact and functioning for jaguars and other wildlife across the region. In summary, these approaches generally resulted in interest and cooperation from the ranching community, which serve as a model for conducting research, management, and conservation efforts for large felids and other carnivores on Western ranchlands.

KEY WORDS coordination, cooperation, depredation, ecosystem-services, jaguar, mountain lion, ranchlands, research protocol

Gaps of Knowledge in Recovery Actions for Jaguars (*Panthera onca*) in Mexico

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ABSTRACT: Endangered species such as jaguars, require a suit of actions to recover, maintain and possibly increment their populations, both at national and regional levels. The Mexican government has implemented a series of recovery actions for the stabilization of jaguar populations initially characterized in the program actions for the conservation of species (PACE). This group of actions has been implemented in different degrees at the State level. Our objective was to identify priority actions that need attention to continue the recovery of the species. We analyzed priority conservation programs implemented by the Mexican government in the past decade and identified gaps of knowledge for the species as well as which conservation actions require more attention. We assessed 21 topics and their implementation both inside and outside protected areas, they included corridors, habitat assessment and restoration, food habits and prey restoration, camera trap and radio-telemetry studies, environmental education, capacity building, depredation and livestock workshops, community surveillance, genetic and disease studies, and feral wildlife. We concluded that gaps in knowledge (ranging from 60 to100% absence of actions) requiring further attention are food habits, radio-telemetry, genetic and diseases, impact of feral wildlife, and habitat restoration. We suggest this analysis provides direction to funding alternative opportunities, as well as collaborations with Academia, communities and Government.
KEY WORDS: jaguar, recovery actions, Mexico, management action prioritization.

Social acceptance and Florida panther management – is there a sweet spot?

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ABSTRACT: Large carnivore conservation is a challenge across the globe as growing human populations continue to encroach upon those remaining wild places where these carnivores have persisted. Exacerbating the issue is the fact that some carnivore populations have increased in size in recent decades as the result of directed conservation efforts and legal

protections. In Florida, we have an endangered subspecies of puma whose current range is surrounded by the majority of Florida's 20 million residents. Protected by the State in 1958, the panther has enjoyed strong public support in Florida. It was designated by the U.S. Fish and Wildlife Service as an Endangered Species in 1967 and was voted the official state animal in 1982. Panther specialty license plates are the fifth most popular plate with over 47,700 owned, raising over $1.1 million dollars annually for panther research and conservation. Many Floridians applaud the rise in panther numbers and are pressuring to keep its population growing. However, as panther numbers have grown over the past 20 years, so too have human-panther conflicts. Depredations on pets and livestock, increases in human-panther interactions, panthers living in ex-urban areas and concerns that certain prey species have declined are issues requiring significant management resources. Groups and individuals that are concerned with the direction of panther conservation in Florida are regularly present at Commission meetings and have an expanding presence on social media. In this presentation, we will provide an overview of panther issues, describe our complex and diverse group of stakeholders and summarize our current research and management efforts that are directed at these social acceptance issues. Human values are the ultimate driver in wildlife management decisions so stakeholders' involvement, both positive and negative towards an expanding panther population, will strongly influence whether panthers will be managed at numbers supported by available resources or as rarities on the landscape. Although we hope that western puma populations are secure for the long-term, Florida panther management may be a harbinger of the challenges that puma managers in North America are or will be facing in the upcoming decades.

KEY WORDS: depredations, Florida panther, human-puma interactions, large carnivore management, social values, stakeholder diversity.

Landscape and habitat use for a large carnivore in the city: use and selection for mountain lions around Los Angeles.

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ABSTRACT: Although some species of wildlife can adapt to and even thrive in urbanized areas, many species are rare or absent there. Large carnivores have some of the largest spatial requirements of any animal, and they have generally been thought to be incompatible with cities. However, in and around Los Angeles, the second largest metropolitan area in the U.S., mountain lions (*Puma concolor*) still persist despite the significant challenges. At Santa Monica Mountains National Recreation Area, we have been studying the behavior, ecology, and conservation of mountain lions since 2002. Here we analyze mountain lion landscape use and selection across the complex urban landscape of southern California using more than 125,000 GPS locations from 30 collared animals over 14 years. In general, mountain lions were rarely in developed areas, as their home ranges consisted on average of just 3% urban and 10% unnatural areas (urban plus "altered open" areas such as golf courses, low density residential areas, landscaped parks, etc.). However, there was significant variation between age and sex classes, and between individuals. Adult females had the smallest percentage of urbanized areas, at 0.8%, whereas subadult males had the highest, at 3.6%. Two adult males, P22 and P41, lived in highly circumscribed parklands, and they had some of the smallest adult male home ranges (24 and 54 km^2) ever documented, and in our study by far the greatest use of

urban areas, at 17.4%, and unnatural areas, at 26.4%. Interestingly, patterns of resource selection were different, in that all age-sex classes strongly selected areas near urbanization, with the exception of adult males, which strongly selected chaparral and riparian woodland areas. Subadults and females may be taking advantage of deer presence near developed areas while avoiding adult males. These results have important implications for mountain lion conservation and management in urban landscapes.

KEY WORDS: urbanization, habitat use, habitat selection, home range size, fragmentation, Los Angeles.

Evaluating potential for human and mountain lion conflict in Big Bend National Park

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ABSTRACT: Big Bend National Park (BIBE) provides the largest area of protection for mountain lions (*Puma concolor*) in the state of Texas and yet BIBE's annual visitation exceeds 300,000. The goal of this study was to evaluate the potential for conflict between humans and mountain lions in BIBE. My objectives were to: 1) evaluate mountain lion occurrence relative to areas of human use (i.e., trails, roads, facilities); 2) examine the temporal and spatial use of park trails by humans, using active infrared trail monitors; 3) evaluate the effects of seasonality on daily activity patterns of mountain lions and humans; and 4) identify areas of overlap between the temporal and spatial use of the park by humans and mountain lions. A total of 3,654 GPS locations from 4 mountain lions (2 M, 2 F) suggests that mountain lions avoided areas of high human use in BIBE. The majority of visitor use in BIBE was diurnal in all seasons and for all trail categories. While my study did show decreased diurnal mountain lion activity, female diurnal activity was less diminished, with 64% of female diurnal movements being active. Based on my analyses of human and mountain lion activity, the likelihood of an encounter was increased during winter crepuscular (morning and evening) periods. In the face of increasing outdoor recreation, using modern technologies such as GPS collars to understand and reduce the potential for human and mountain lion conflict will help to insure the long-term conservation of mountain lions in Texas and across the United States.

KEY WORDS: activity, mountain lion, spatial, temporal, trail monitor, visitor use.

Conserving mountain lions in southern California: Addressing fragmentation, conflict, and excess human-related mortality in comprehensive and collaborative ways

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ABSTRACT: Our UC Davis team and collaborators have been studying pumas *(Puma concolor)* in Orange, Riverside, and San Diego Counties in southern California since 2001, and have identified numerous threats to their long term survival. The study area is highly biodiverse, with landscapes as varied as coastal Mediterranean to high mountain and desert, and contains ~9 million people. Conserved lands vary from national forests to small peri-urban "wilderness" parks. Conserved lands are often separated by development and roads (including interstate highways) that create risks and barriers for pumas, and protected corridors between them are often inadequate. Because male puma home ranges average 375km^2, and females half that, circulation and dispersal often require crossing extensive areas of unprotected lands and encounters with busy highways. These factors have resulted in low annual survival (mean 56%) and genetic isolation. Long term survival of mountain lions in this landscape will be dependent on reversing isolation and mortality trends that currently exist, or will require active population manipulation in the future. To address the isolation and mortality issues, our team has engaged and collaborated with a wide array of stakeholders to provide comprehensive information and leadership. These include collaborations that have or are currently: 1) Using GPS data, cameras, and genetics to model highest priority parcels for conservation, especially for corridors; 2) Defining high-risk highway crossing points and identifying solutions; 3) Designing highway crossings, fencing, jumpouts, etc, and providing construction oversight; 4) Advising planners, NGO's, and wildlife agencies on connectivity challenges and solutions; 6) Improving domestic animal protection measures through education, outreach, and testing of predator deterrence methods, as well as sequentially surveying residents to assess the effects of these measures; 7) Developing best practices through expert workshops and other means for modification or creation of highway crossings, and long term monitoring of the population.

KEY WORDS: Population survival, genetic isolation, collaboration, conservation network, mortality reduction, connectivity

Session 6: MOUNTAIN LION HARVEST MANAGEMENT

Impacts on survival of cougars caught as non-targets in foothold traps

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ABSTRACT: We captured 48 cougars (*Puma concolor*) between 2009-2013 in western Nevada and followed 33 individuals until death (through 2016). During the course of our research, it became apparent that anthropogenic sources of mortality for cougars was high (87%) and that non-target capture of cougars caught in foothold traps and snares set legally by trappers for bobcats (*Lynx rufus*) was likely impacting annual adult survival of cougars. Trapping of cougars is not a legal method of harvest in Nevada and trappers are required to report incidental capture of cougars to the Nevada Department of Wildlife within 48 hours, even if the cougar is released by the trapper. We found mortality associated with non-target capture of cougars is often unaccounted for however because cougars often die several weeks later from associated injuries. We examined cause specific mortality rates of radio-collared cougars and assessed the impacts of non-target capture of cougars in bobcat traps on estimated adult survival in our study area. Using a known fate model with staggered entry in Program MARK we estimated overall annual survival rates for adult cougars (n = 29) examining the impacts of incidental trap history, mountain range, and body condition. Our results indicate that the capture of cougars as non-targets in bobcat foothold traps does impart a negative effect on cougar survival. Given that this source of mortality is unaccounted for in both harvest objectives and harvest data, managers responsible for cougars in all areas should consider the potential for incidental cougar mortalities when setting harvest limits for cougars where snares or foothold traps are used. In addition, these results suggest it may be necessary to make adjustments to current trapping regulations to minimize mortality of cougars associated with non-target trapping in regions with concurrent trapping of bobcats.

KEY WORDS: bobcat, cougars, foothold, furbearer, Great Basin, mortality, Nevada, *Puma concolor*, survival, trapping.

Can Increased Quota Harvest Redistribute Human Caused Cougar Mortality in Alberta?

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ABSTRACT: Cougar mangers in Alberta have initiated an Adaptive Management Project with the objective of improving our lion management program. Provincially, during the past 5 years, 49% of documented cougar mortalities resulted from licenced hunting. Over that period the primary unlicensed causes of cougar mortality were legal landowner kills (19.9%, range 44-73), incidental capture in wolf snares (16.5%, range 14-92), and agency removal (6.3%, range 5-29). To wildlife managers at Alberta Environment and Parks, this non-hunting mortality represents lost recreational harvest opportunities. However, before using this

information to adjust lion quotas across the Province, we need to learn if these are in fact lost opportunities or if increased take by licenced hunters will be additive to the less desirable sources of human caused mortality. We also want to know what effects, if any, increased cougar harvest could have on local and regional population dynamics and space use patterns. To answer these questions, we are deploying 50 GPS telemetry collars on cougars in a 15,580 km^2 area of west central Alberta. This area consists of three cougar management areas (CMA) of similar mortality statistics. CMA 21 (7557 $km^{2)}$ will be our treatment area and CMAs 11/12 combined (8023 km^2) will be our control. We will measure demographic parameters, space use patterns, and mortality causes for 2-years prior to implementing a quota increase equal to the 5-year average removal rate in CMA 21 (25 individuals). This paper is a discussion of the management related factors leading to the project and our methods, with the intent of gaining insights from other jurisdictional managers during and after the workshop.

KEY WORDS: Adaptive management, Alberta, compensatory mortality, harvest management, human caused mortality, quotas.

Anthropogenic mortality levels shape the characteristics of a lightly hunted cougar population in western Washington

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ABSTRACT: Human activities and landscape conversion shape ecosystems and disproportionally impact large carnivores. For cougars, populations occupying landscapes with a substantial human presence are exposed to a greater variety of anthropogenic mortality sources - frequently at levels that translate into population declines and a breakdown of social stability. Consequently, wildland-urban environments are often assumed to be population sinks for cougars. However, levels of anthropogenic mortality can vary considerably in both time and space, contributing to an increase in survival, stabilization of the social structure, and a population that functions as a source for neighboring populations. To demonstrate this phenomenon and its implications for cougar conservation and management, I provide information on survival rates, age structure, and social dynamics from a wildland-urban population in western Washington studied during periods with different levels of anthropogenic mortality. Between 2004 and 2008, my study population experienced limited levels of hunting mortality (≤ 3 individuals/year), but conflict removals, tribal predator control, collisions with motor vehicles, and an outbreak of feline leukemia virus resulted in an average annual survival rate of 55% for individuals > 1 year of age, a mean age of 4.2 years for adults, frequent observations of transients, and a likely decline in the population. Conversely, between 2012 and 2016, an observed reduction in the number of conflict removals and motor vehicle collision combined with the absence of feline leukemia virus and tribal predator control activities translated into an average annual survival rate of 86% for individuals > 1 year of age, a mean age of 7.1 years for adults, robust levels of emigration, and a positive growth rate for the population. These observations reinforce the dynamic nature of human-dominated systems and suggest that some wildland-urban cougar populations have the potential to function as both a significant sink and source for the broader landscape. Accordingly, anthropogenic mortality levels may directly and indirectly shape cougar impacts on ungulate prey, interactions with people, and population viability. Wildlife managers and conservationists would be wise to acknowledge and account for the complex role humans play in cougar ecology and behavior while also developing a better

understanding of all sources of mortality acting upon a population when crafting strategies to achieve desired outcomes.

Effects of hunting on a mountain lion population on the Uncompahgre Plateau, Colorado

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ABSTRACT: We conducted a 10-year (2004–2014) study on effects of sport-hunting on a mountain lion *(Puma concolor)* population. Our design had a *reference* period (years 1–5) without lion hunting, and a *treatment* period (years 6–10) with lion hunting. Lion abundance was estimated during the Colorado lion hunting season. In the *reference* and *treatment* periods, 109 and 115 individual lions were captured and marked, respectively, during 440 total capture events. Those animals produced known-fate data for 75 adults, 75 subadults, and 118 cubs. Lion population responses to hunting and other causes of mortality were based on changes in: 1) abundance of independent lions, 2) survival of adults, subadults, and cubs, 3) reproduction rates, and 4) age structure of independent lions. The *reference* period population of independent lions increased by at least 70% and exhibited high survival. Hunting clearly affected the lion population in the *treatment* period. Hunting was the major cause of death to independent lions and added to other human and natural forms of mortality. Abundance of independent lions declined 25% after the first 3 hunting seasons with a 15% design harvest of independent lions. Actual harvests ranged from 15.4–16.7% of independent lions and total independent lion mortality ranged from 16.1–20.8%. The harvest was reduced to 11–12% of independent lions in the final two years of the *treatment* period with total independent lion mortality ranging 13.6–14.3% in which the population decline ceased. By the fifth year of the *treatment* period, abundance of independent lions had declined by 21%, and adult females and males had declined by 23.3% and 50%, respectively. Survival modeling in MARK indicated that hunting was associated with statistically significant lower adult and subadult male, but not independent female, survival rates. But the decline in adult females by 23.3% in the *treatment* period exhibited the biological significance of lower survival. The age structure for independent males declined in the *treatment* period. Cub survival was most affected by natural causes and in association with fates of the dams. Reproduction rates were not statistically different in the two periods. In the *treatment* period there was no compensatory reproduction and inadequate immigration to offset losses in independent lions. These results can be used to guide mountain lion hunting management in Colorado.

KEY WORDS: Colorado, hunting, mortality, mountain lion, population responses, *Puma concolor*, survival.

Evolving mountain lion management in the West: Applying science with human values.

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ABSTRACT: Mountain lion *(Puma concolor)* management in the western U.S. evolved from unregulated killing and government-sanctioned eradication during the early 1900s to regulated sport-hunting and control actions in most western states during the mid-1960s to

the 1970s. Changes resulted from shifts in peoples' attitudes toward nature, including big carnivores. More protective attitudes toward lions in the 1980s to 1990s resulted in ballot initiatives and litigation that restricted options to lion management. Together, regulated lion hunting and conservation of ungulate prey populations enabled lions to recover from a historical low point to a wide-spread resilient population by the 1990s. Today, regulated lion sport-hunting provides primarily for lion conservation and sustainable use. In other regions heavy lion hunting pressure is used with intent to reduce lion abundance to lower predation on livestock and big game ungulates and to calm human safety concerns. Lion control is also sometimes applied in efforts to restore endangered or threatened ungulates. Research on lions has more recently progressed to a point of enabling managers to learn how to use hunting and control as a management tool and for scientists to test hypotheses. Meanwhile, wildlife management has met with financial and political challenges due to structural changes in society and peoples' attitudes toward hunting. Thus, further evolution of lion management is inevitable. An adaptive lion management structure to consider is called *Zone Management*, one based on current science and theory on lion natural history and population dynamics and that considers the diversity of human values toward nature. Zones delineating lion population segments are specifically managed as high management zones, hunting zones, and reference/source zones. This structure creates a working and teaching landscape, which provides for: a) a broad range of lion management options, b) variation in lion population states for the conduct of reliable management experiments and science to further inform managers and the publics, and c) society's varied values toward nature that is transparent and inclusive to improve collaboration, governance and trust.

KEY WORDS: control, hunting, management, mountain lion, *Puma concolor*, society, values, zone management.

Mountain Lion management in western North America: > 100 year retrospective

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ABSTRACT: Mountain Lion (*Puma concolor*) populations have had a diverse and long history of management in western North America. For the greatest part of the last century mountain lions were a bountied predator, and a transition to game mammal status was reached by the early 1970's. Most states and Canadian provinces have reported increased mountain lion activity since the bounty period through the end of the 20th century, and the year 1999 ended with highest recorded removals. Simultaneously this was a period of dramatic human population increases and land conversion. In the 21st century (last 15 years), this upward

trend of removals has changed. We will present an updated summary of documented mountain lion harvest and changes in policy and management over the last 115 years in western North America. We will also overlay the political and biological factors influencing mountain populations to provide perspective on the potential effects of past and current management practices as they may relate to harvest, hypothesized population increases, and the more recent decreases in removals. This presentation will chronicle the challenges and changing philosophy of predator management.

KEY WORDS: management, harvest, populations, removals, trend, politics.

SESSION 7: MOUNTAIN LION BIOLOGY & ECOLOGY

Re-colonization of bears in the Great Basin and resulting species interactions: Effects on cougar predation behavior and implications for prey

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ABSTRACT: Black bears were extirpated in the Great Basin through targeted removals due to conflicts with humans, along with changes in land use patterns beginning in the mid-1800s. While post-settlement disturbances, including the introduction of domestic livestock, had a negative effect on bighorn sheep and pronghorn, mule deer responded favorably and populations increased, followed by increased numbers of cougars in the Great Basin. As a result of habitat recovery beginning in the early 1900s, bears have begun to re-colonize historic ranges in the region. Cougars have been the apex predator for the past 80+ years, yet our data indicate that cougars and bears now have frequent interactions at cougar kill sites where bears take over and scavenge prey carcasses. Data from >800 kills by collared cougars in Nevada suggest that, on average during months when bears are active,~ 50 percent of cougar-killed deer are scavenged by bears when bears are present at moderate to high densities. We are using GPS cluster analyses, camera traps, and visits to cougar kill sites combined with Vectronic-Aerospace proximity GPS collars (set to record synchronous data every second when lions and bears are within 200 meters of each other) to address the following questions: 1) increase understanding of bear-cougar interactions, especially in areas where bears are expanding into historic habitat; 2) determine if cougar kill rates and composition differ in areas occupied by bears at differing densities (low, medium and high bear density study areas) and if these change over time with bear expansion into historical ranges; 3) determine if human-cougar conflicts increase where bears are newly present; and 4) examine if food subsidies gained by the dominant carnivore (black bears) usurped from subordinate species ultimately aide in population expansion. Here we present preliminary results from the first two years of study from >20 collared bears and 11 collared cougars.

KEY WORDS: Bear-cougar interactions, Great Basin, kleptoparasitism, proximity GPS collars, re-colonization

The role of native prey restoration in reducing livestock depredation by puma (*Puma concolor*) and jaguar (*Panthera onca*) in Sonora, Mexico

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ABSTRACT: Livestock depredation by pumas and jaguars often results in their illegal killing in retaliation by ranchers. Through augmentation of peccaries (*Pecari* tajacu) and white-tailed deer (*Odocoileus virginianus*) on a 7,000 ha ranch we tested the hypothesis of prey switching by both predators, when native prey species became more available. During an 8-month initial control period, we identified the diets of both pumas (*Puma concolor*) and jaguars (*Panthera onca*) in the study area. We estimated the relative abundances of white-tailed deer, peccary and cattle (*Bos tarus)* with camera traps. We collected scat for molecular identification of both prey and the depositing predator species, identified prey consumed at kill sites using GPS kill site clusters and estimated predator diet preference. During a subsequent second 8-month period, we translocated peccaries and increased deer density through artificial feeding during fawning season. Using similar molecular analyses of scat and GPS kill site investigations we detected a 73% and 65% decrease in livestock as prey, respectively. Since completing our study we have added 5 more ranches to a program that includes restoration of peccaries, protection of native prey and improvement of cattle management through synchronized breeding. Actions like killing predators to protect prey species have proven to be unsuccessful in the long term and detrimental to the environment. The conservation of prey and predators in ranching operations should be achieved by actions that consider all species interactions and good livestock management practices.

KEY WORDS: Depredation, diet, jaguar, kill site, livestock, prey-switching, puma.

Spatial ecology and survival of mountain lions on private lands in west Texas

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ABSTRACT Not much is known about the ecology of mountain lions on private lands in Texas. In recent years, west Texas has seen significant changes in landownership patterns and land management strategies on private lands, exacerbating the need for research to understand the behavior and spatial requirements of mountain lions in this area. We used data collected from GPS collars to evaluate the movements, home range, habitat use, and survival of 20 mountain lions on private lands in west Texas. Survival estimates were calculated in program MARK using a known-fate analysis. To estimate home range size, we calculated 100% Minimum Convex Polygons (MCPs), and also used the program T-LoCoH to estimate 95% and 50% utilization distributions (UDs). Nine monitored mountain lions are known to have died over the course of the study, 7 due to predator control. The annual survival rate was 0.536 (95% CI =

0.311–0.728). The average daily movement rate for all mountain lions was 3.74 km/day (SE = 0.38, n = 20), and ranged between 1.07 km/day and 7.53 km/day for individuals. Mountain lions selected for the highest elevations and most rugged terrain within the Davis Mountains, and within the mountains avoided ecological sites dominated by grass species. We observed long range or dispersal movements for 7 individual mountain lions, 2 of which successfully left the Davis Mountains. Adult MCPs ranged from 24–1036 km^2, and averaged 392 km^2. In general, the MCP home ranges we observed were larger than have been recorded in previous studies of west Texas mountain lions. In the Davis Mountains, MCP's covered on average at least 25 properties (SE = 3, n = 19). Our results indicate the large area and multiple land owners that one mountain lion can impact, and be impacted by, and accentuate the need for a landscape level approach to management of Texas' mountain lions.

KEY WORDS: dispersal, habitat, homerange, private land, survival, Texas, mountain lions

Mountain lion social organization

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ABSTRACT: As mountain lion management continues to evolve, there is increasing interest from managers and advocates alike to adapt management to better match the social organization of mountain lions. Intuitively, researchers, managers, and hunters recognize the importance of territorial males in influencing population density and other social structures, but research supporting this intuition is limited. We documented mountain lion social interactions with remote cameras and GPS data. We employed Conditional Uniform Graph (CUG) tests and exponential random graph models (ERGMs) to test assumptions that social interactions in solitary animals are explained by spatial overlap or kinship, as current literature suggests, or more complex social systems associated with social species such as reciprocity. Our results revealed an unexpectedly sophisticated mountain lion social organization. Every mountain lion participated in the network, which was divided into smaller communities explained by the spatial boundaries of territorial males. Overall, conspecific tolerance between mountain lions was best explained by direct reciprocity, establishing a clear benefit to individuals that participated in social behaviors, and hierarchical (transitivity) reciprocity ruled by territorial males. Our work contributes landmark evidence of complex social organization in a solitary carnivore, and an empirical framework for testing hypotheses about the drivers of social behavior in solitary species. Further it provides quantitative evidence of the importance of territorial males in structuring mountain lion populations and smaller societies, useful to managers looking to advance harvest strategies to better support not just mountain lion population stability, but also the stability of social structures central to the make up of the species.

KEY WORDS: Conspecific tolerance, *Puma concolor*, Social network analysis, Social organization

New insight into utilizing bone marrow to assess the health of mountain lion prey

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ABSTRACT: Bone marrow fat content has commonly been utilized as a metric to assess the health of mountain lion (*Puma concolor*) prey species. Evaluating body condition of individuals provides important insight to wildlife managers that allows them to better understand predator-prey interactions and sustainably manage both mountain lions and their prey. Studies have compared different methods of measuring bone marrow fat content as well as identified which bones are most representative of an individual's health. However, no previous research has examined how the amount of time from death to sample collection affects bone marrow fat measurements of ungulates in natural conditions. It is not always feasible to collect marrow samples from an individual at the time of mortality, which could potentially bias fat estimates from bone marrow samples. We examined how bone marrow fat content is affected by time post mortem and other factors by collecting multiple bones from individual elk (*Cervus elaphus*) and deer (*Odocoileus hemionius*) at different time intervals in central New Mexico. We found that marrow fat content can change significantly over time. Our top model that explained this change included time between samples, initial fat content and sex of the species. Future research efforts that utilize bone marrow fat content should attempt to retrieve bone samples immediately after death. Failure to do so can lead to false conclusions regarding the nutritional state of individual animals and subsequent mismanagement of both mountain lion and ungulate populations.

KEY WORDS: *additive vs. compensatory, aging, bone marrow, fat content, health, predation, Puma concolor, ungulate.*

Scaredy cats and the big bad wolf: How intraguild competition influences home range selection in a subordinate predator

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ABSTRACT: In systems with multiple carnivores, dominant competitors exclude or limit subordinate competitors; as such, subordinate predators must balance energy expenditures to collect critical resources with the costs associated with interactions with more dominant

competitors. Cougars are the most widely distributed carnivore in the western hemisphere, but in the Greater Yellowstone Ecosystem they are subordinate to wolves and bears. Our research examined the role that competition refugia may play in cougar home range selection. We used confirmed cougar kill sites to measure hunt opportunity (prey availability), and a novel method to measure competition refugia based upon cougar bed sites. We quantified the attributes of cougar home ranges to test if they were different from attributes of the overall study area to examine if 1) cougars select home ranges based on the availability of hunt opportunity, refugia, or some combination of the two, 2) if there are differences between cougar sexes and seasons, and 3) if cougar home range size is better predicted by refugia, hunt opportunity, or some combination of the two. Our findings demonstrated that cougars selected for both refugia and hunt opportunity when choosing home ranges. Selection for both resources was strongest at the 50% core area, though there was some minor variation across sexes and season. Across both sexes and seasons, refugia was the attribute that best explained home range size. Our results suggested that cougars—a subordinate predator—selected bed sites that facilitated anti-predator and thermoregulatory functions, and that visiting and measuring bed sites may provide a novel method to measure the use of refugia in subordinate predators. Refugia may be a critical resource for cougars, especially as wolves expand in the lower 48 states, and managers and scientists may need to account for this requirement when preparing habitat suitability analyses or proposing management actions.

KEY WORDS: *Puma concolor*, home range, competition, refugia, Greater Yellowstone Ecosystem

Spatial and temporal shifts in cougar presence in the Midwest in response to changing management regimes

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ABSTRACT: In response to increasing activity of mountain lions outside of established ranges in recent decades, the Cougar Network has built a network comprised of the public, state agencies, and researchers to compile physical evidence of mountain lions in the Midwest dating back to 1990. It has long been thought that the Black Hills, SD represents the primary source location for dispersing animals in the North American interior. Using Cougar Network confirmation data, we wished to learn if harvest implementation in the Black Hills, SD in 2005 affected midwestern recolonization, specifically the number of confirmed carcasses in our 13-state study region. We analyzed 117 known-sex carcass confirmations to determine differences in spatial and demographic trends comparing two time frames: before 2005 and after 2005. Compared to before 2005, we found nearly four times the number of carcasses along with a significant clustering pattern, a greater proportion of females, and a 460 km northward shift in the directional distribution of carcass locations in the Midwest region after 2005. Concurrently, we also found that states farther to the west (i.e., Montana, Wyoming, and Colorado) implemented regulations that could result in increased females in their respective populations. These results suggest the Black Hills, SD may not be the most important source of dispersing individuals. Further, our results suggest regional-scale metapopulation connectivity and provide insight for management and public education about the return of this apex predator.

KEY WORDS: cougar, Midwest, *Puma concolor*, spatial analysis.

Retroviral infections among North American mountain lions (*Puma concolor*)

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ABSTRACT: North American mountain lions (*Puma concolor*) are known to be infected by a range of pathogens including at least three retroviruses: lentivirus (feline immunodeficiency virus, FIV), spumavirus (feline foamy virus, FFV), and gammaretrovirus (feline leukemia virus, FeLV). In order to investigate the dynamics of these three viruses in the mountain lion host we undertook large scale molecular analyses. Our results highlight differing evolutionary histories, origins and transmission modes for each of these infectious agents. Our findings show that one subtype of FIV found in mountain lions originated from a cross-species transmission from infected bobcats, while another subtype was likely co-introduced to the Florida panther (*Puma concolor coryi*) during Texas puma translocations aimed at genetic rescue. Florida panthers have also been afflicted by multiple outbreaks of FeLV, a pathogen that poses a threat to the single small remaining population of this subspecies. Our findings implicate domestic cats as a source of panther FeLV infections with the circulation of three documented strains and an additional uncommon fatal FeLV subtype. Similarly, genetic analysis of FFV in North American mountain lions supports likely recent introduction(s) from domestic cats. Collectively, these findings show that mountain lions are frequently exposed to retroviral infections from sympatric mesopredators, likely through predation. These interspecific viral transmissions emphasize the important role of domestic animals in dispersal of infectious diseases to wildlife and thereby the importance of monitoring both domestic and wild felids to aid the implementation of management practices and translocation of individuals. Our analysis lends insights into the emergence of pathogenic agents in mountain lion populations exposed to domestic cats, and can inform management actions that may impact mountain lion space use and interactions with domestic animals.

KEYWORDS: Cross-species transmission, Florida panther, mountain lion, mesopredators, retroviruses.

Preliminary predation patterns of cougars and wolves in an area of sympatry

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ABSTRACT: Expanding gray wolf (*Canis lupus*) populations and interspecific competition with sympatric cougars (*Puma concolor*) presents new challenges for management of multiple carnivore effects on ungulate populations (e.g., elk, *Cervus elephus*; mule deer, *Odocoileus hemionus*) in the western United States. We examined wolf and cougar predation patterns before (2009-2012) and after (2014-2016) wolves recolonized the Mt. Emily Wildlife Management Unit in northeast Oregon. We identified 1,213 and 541 prey items utilized by cougars in the pre- and post-wolf periods, respectively. We also identified 158 prey items utilized by wolves. Cougar diet was similar between the pre- and post-wolf time periods. Cougar preyed predominantly on deer (mule deer and white-tailed deer, *O. virginianus*; 58% and 53% of all ungulate kills pre- and post-wolf, respectively) and primarily killed fawns (53% and 44% of all deer kills, pre- and post-wolf, respectively). When cougar preyed on elk, they primarily preyed on calves pre – (77%) and post-wolf (71%) recolonization. Wolves preyed predominantly on elk (61%) and primarily killed the calf age class of elk in summer (83%) and winter (49%), but used adult elk nearly as often as calves in winter (46%). Strong selective predation on elk calves coupled with high density cougar populations explained the low recruitment and reduced population growth rates of elk in Oregon before wolves recolonized the state. The continued selection of elk calves by cougars coupled with wolf predation may intensify the effects of carnivores on elk populations. Conversely, wolves may ultimately decrease cougar densities such that effects on elk populations remain relatively unchanged in this multi-predator system. As wolf populations continue to expand, additional research is needed to clarify the combined effect of wolves and cougars on elk population dynamics.

KEY WORDS: cougar, wolf, elk, mule deer, competition, prey selection, predation, ungulate mortality, Oregon.

Vertebrate diversity benefiting from carrion provided by mountain lions

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ABSTRACT: Key strategies for building tolerance for controversial carnivores that compete with humans for resources, or threaten (both real and perceived) human safety, include gathering the data necessary to show everyday people the positive roles carnivores play in

natural systems. One such contribution is providing carrion, which ecologists are increasingly recognizing as essential in maintaining biodiversity and supporting ecosystem stability. Evidence suggests that mid-trophic felids have evolved to absorb the costs of kleptoparatism by scavengers, and thus, they likely contribute more carrion to ecological communities than other top predators. We employed motion-triggered cameras and GPS technology to monitor vertebrate scavengers at mountain lion kills. We divided scavengers detected at puma kills into four categories based upon two seasons and pre- or post-departure by the mountain lion (Winter PreCat, Winter PostCat, Summer PreCat, Summer PostCat); then we compared Shannon's Index (*H*) across categories to see whether they supported different levels of biodiversity. We also ranked species detected scavenging at kills, and calculated Kendall's tau coefficients and abundance-based Sorensen's indices to test whether each category supported the same or different scavenger species. We documented 38 species of birds and mammals that benefited from mountain lion kills—more than any other scavenger study in the world and triple the diversity documented on wolf kills in Yellowstone NP. Diversity metrics did not differ across our four categories, but rank did, emphasizing that each season and pre versus post cat departure supported different scavenger assemblages. In conclusion, mountain lion evolution and behaviors make them disproportionately important producers of carrion for their respective ecological communities. Mountain lions play an important and positive role through predation—stabilizing food webs through scavenger vectors—and this information should be used to help promote stable mountain lion populations and to address negativity in areas where mountain lions are recolonizing former range.

KEY WORDS: Biodiversity, Carrion, Kleptoparatism, *Puma concolor*, Scavengers

Foraging Behavior of Coyotes under Intraguild Predation Risk by Cougars: An Experimental Approach

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ABSTRACT: When mesopredators encounter carcasses belonging to a dominant apex predator, they must balance the degrees of risk associated with detection against the loss of fitness-enhancing benefits from kleptoparasitism. Subordinate predators may behaviorally mediate risk by restricting activity to low-risk times of day, increasing latency to consume caches to reduce encounter risk, or increasing vigilance behavior while at cached items. Alternatively, subordinate predators may spatially avoid risk altogether but also lose access to the resource. We tested whether a subordinate predator modified behavior or avoided risk when encountering large, cached prey items of a dominant predator by experimentally placing carcasses with and without cougar (*Puma concolor*) scat and urine and measured coyote (*Canis latrans*) use and behavior via camera traps. In our study system, cougars killed coyotes both as prey and in defense of cached prey, providing in excellent system to evaluate the influence of risks and rewards on foraging behavior of a subordinate predator. We found no effect of cougar scent on the latency to detection (Odds Ratio = 0.85, p = 0.70) nor time from first discovery to contact/feeding (Odds Ratio = 0.86, p = 0.85) on the carcasses. Coyotes

spent 143% ($p < 0.001$) more time exhibiting vigilance behavior and 46% ($p = 0.18$) less time feeding when in the presence of cougar treatments once a carcass was located. Coyotes also spent 10% ($p = 0.02$) less time in a vigilance state in the cover of darkness. Yet, we found no support for an increase in the frequency of specific vigilance behaviors between treatments. Our results strongly indicate that coyotes are willing to capitalize on risky subsidies in the form of cougar caches and balance risk by increasing the duration and not the frequency of vigilant behavior. These findings improve our understanding of how subordinate predators co-occur with dominant predators.

KEY WORDS: Coyote, Cougar, Field Experiment, Intraguild Competition, Vigilance.