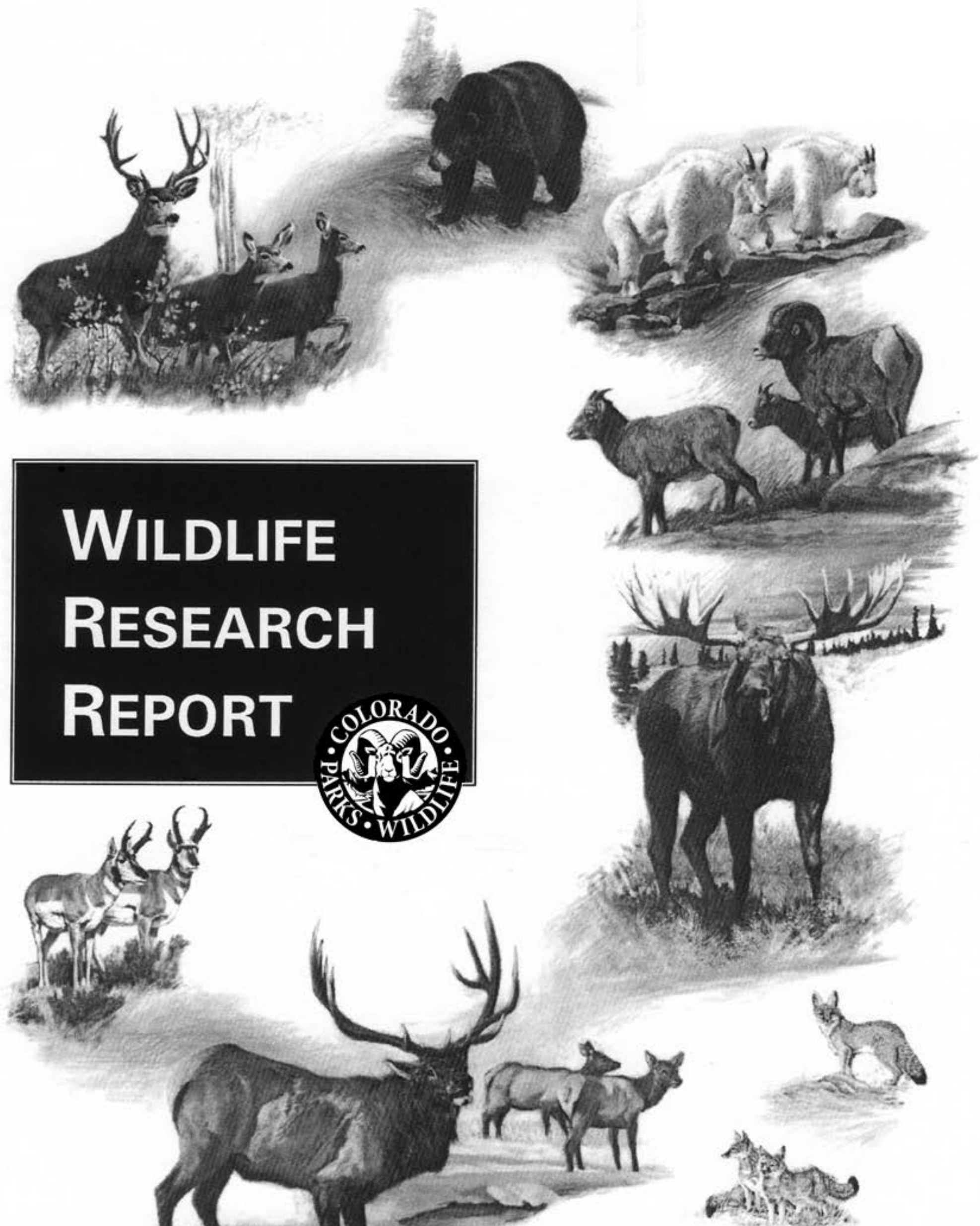
MAMMALS - JULY 2014



WILDLIFE RESEARCH REPORTS

JULY 2013 – JUNE 2014

MAMMALS PROGRAM

COLORADO PARKS AND WILDLIFE
Research Center, 317 W. Prospect, Fort Collins, CO 80526

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Executive Summary

This Wildlife Research Report represents summaries (<5 pages each) of wildlife research projects conducted by the Mammals Research Section of Colorado Parks and Wildlife (CPW) from July 2013 through June 2014. These research efforts represent long term projects (2 – 10 years) in various stages of completion addressing applied questions to benefit the management of various mammal species in Colorado. In addition to the research summaries presented in this document, more technical and detailed versions of most projects (Annual Federal Aid Reports) and related scientific publications that have thus far been completed can be accessed on the CPW website at http://cpw.state.co.us/learn/Pages/ResearchMammals.aspx or from the project principal investigators listed at the beginning of each summary.

Current mammals research projects address various aspects of wildlife management and ecology to enhance understanding and management of wildlife responses to various habitat alterations, human-wildlife interations, and investigating improving approaches to wildlife management. The Mammals Conservation Section addresses mammal and breeding bird responses to the recent bark beetle outbreak influencing about 3.7 million acres of spruce and pine forests in Colorado. The Ungulate Conservation section includes 3 projects addressing mitigation approaches to benefit mule deer exposed to energy development activities, an assessment of potential factors influencing mule deer declines the past 40 years, and an evaluation of moose demographic parameters that will inform future management of this recently established ungulate species in Colorado. The Predatory Mammals Conservation section addresses improved understanding and management approaches to address black bear and mountain lion-human interactions, evaluation of sport harvest for mountain lion management, and assessment of non-invasive sampling methods to estimate abundance, diet composition, and age class distribution of carnivore populations. The Support Services section describes the CPW library services to provide internal access of CPW publications and online support for wildlife and fisheries related publications.

We are greatful for the numerous collaborations that support these projects and the opportunity to work with and train gradute students that will serve wildlife management in the future. Research collaborators include the CPW Wildlife Commission, statewide CPW personnel, Federal Aid in Wildlife Restoration, Colorado State University, Idaho State University, University of Wisconsin-Madison, the Buerau of Land Management, City of Boulder, Boulder and Jeffereson County open space, City of Durango, Big Horn Sheep and Moose Auction/Raffle Grants, Species Conservation Trust Fund, Safari Club International, Boone and Crocket Club, Colorado Mule Deer Association, The Mule Deer Foundation, Wildlife Conservation Society, SummerLee Foundation, EnCana Corp., ExxonMobil/XTO Energy, Marathon Oil, Shell Exploration and Production, WPX Energy, and private land owners who have provided access for research projects.

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Colorado Division of Parks and Wildlife
July 2013 – June 2014

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Colorado Parks and Wildlife

WILDLIFE RESEARCH PROJECT SUMMARY

Mammal and breeding bird response to bark beetle outbreaks in Colorado

Period Covered: July 1, 2013 – June 30, 2014

Principal Investigators: Jacob S. Ivan, Jake.Ivan@state.co.us; Amy Seglund, Amy.Seglund@state.co.us ;

All information in this project summary is preliminary and subject to further evaluation. Information MAY NOT BE PUBLISHED OR QUOTED without permission of the principal investigator. Manipulation of these data beyond that contained in this summary is discouraged.

Mountain pine beetle (*Dendroctonus ponderosae*) and spruce beetle (*Dendroctonus rufipennis*) infestations have reached epidemic levels in Colorado, impacting approximately 3.7 million acres since the initial outbreak in 1996 (Figure 1). Though bark beetles are native to Colorado and periodic infestations are considered a natural ecological process, the geographic scale of their impact and simultaneous infestation within multiple forest systems has never been observed. This historic outbreak is having significant impacts on composition and structure of forest stands that will propagate for decades into the future. The widespread mortality of forested systems in Colorado is likely to have a dramatic, but poorly understood effect on wildlife species that depend on these habitats. The project described here uses occupancy estimation to determine which wildlife species (both species of conservation concern and game species) decrease their use of an area as bark beetles pass through, which increase their use, and which exhibit use similar to levels prior to infestation.

Statewide sampling was conducted during the summers of 2013 and 2014 (Figure 2). We sampled 150 Engelmann spruce (*Picea engelmanni*)/subalpine fir (*Abies lasiocarpa*) sites and 150 sites consisting mostly of lodgepole pine (*Pinus contorta*) or lodgepole pine mixed with other conifers. For both strata, sampling covered conditions ranging from sites that have yet to be impacted by bark beetles to those that were impacted by beetles more than a decade ago. At each 1-km^2 site, we sampled the breeding bird community using the Rocky Mountain Bird Observatory's protocol for "Integrated Monitoring in Bird Conservation Regions" (Hanni et al. 2014). We sampled the mammal community by deploying a remote camera near the center of each sample unit. Fieldwork for this phase of the project is now complete. However, data entry for 2014 is ongoing. For the purposes of this interim document, we report preliminary results for 3 mammalian species of conservation concern based on 2013 data only: snowshoe hares (*Lepus americanus*) and red squirrels (*Tamiasciurus hudsonicus)*, which together comprise nearly 100% of the diet of the federally listed Canada lynx (*Lynx canadensis*), and American marten (*Martes americana*), which is a USFS Region 2 sensitive species.

We collected 197,092 photos of 25 species during summer 2013. Occupancy analyses of these data indicate that snowshoe hares are more likely to use spruce/fir stands than lodgepole stands, but in both cases, use of these stands declines as bark beetle infestations pass by. We expected use to increase dramatically at some point as the understory responds to increased light, but that response will apparently take longer than the decade or so that has passed since the earliest infestations. Unlike hares, red squirrel use is similar for spruce/fir and lodgepole stands, but similar to hares, use of these stands declined after bark beetle infestations. This may be related to significant mortality of cone-bearing trees that occurs with beetle infestations. Use of the 2 stand types by marten was similar, but in contrast to the previous 2 species, use is expected to increase following bark beetle infestations. We expect to complete a full analysis and report for this project by Fall 2015.

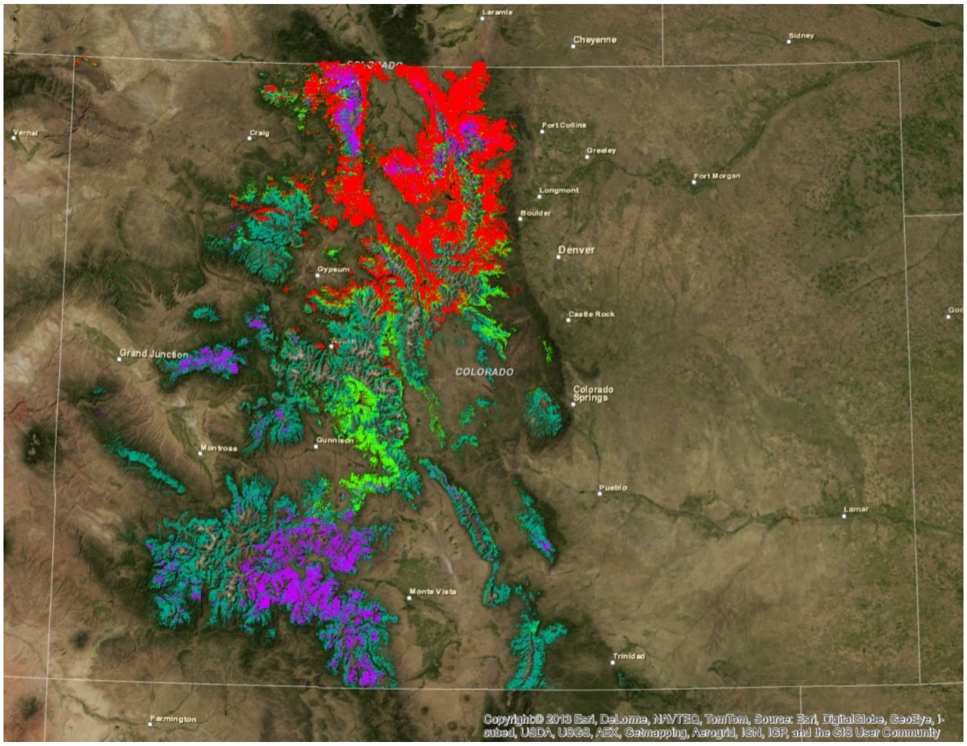


Figure 1. Current (2013) extent of mountain pine beetle (red) and spruce beetle (purple) infestations in spruce/fir (blue-green) and lodgepole pine (bright green) forests in Colorado. Bark beetle data were collected via USFS aerial surveys.

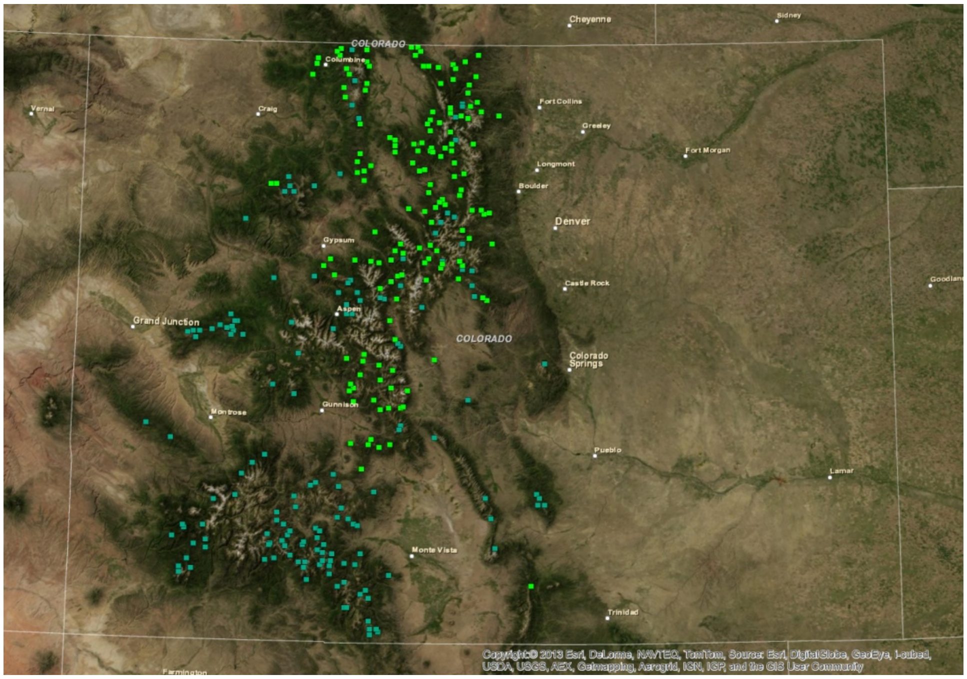


Figure 2. Sites sampled via point counts and remote cameras to assess impacts of bark beetle infestations on breeding bird and mammal species in spruce/fir (blue-green, N = 150) and lodgepole pine (bright green, N = 150) stands in Colorado, 2013–2014.

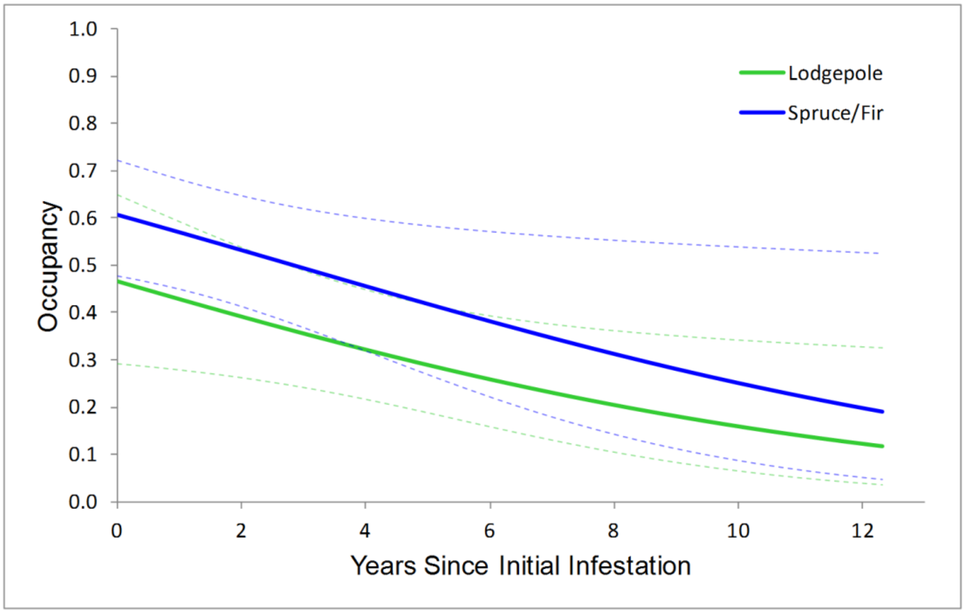


Figure 3. Snowshoe hare occupancy (i.e., use) of stands in relation to the number of years since initial infestation by bark beetles. Note that "0" years since infestation represents stands that have not yet been impacted. Use of spruce/fir stands is generally higher than use of lodgepole stands, but in both strata, use is expected to decline through time as bark beetles pass over an area.

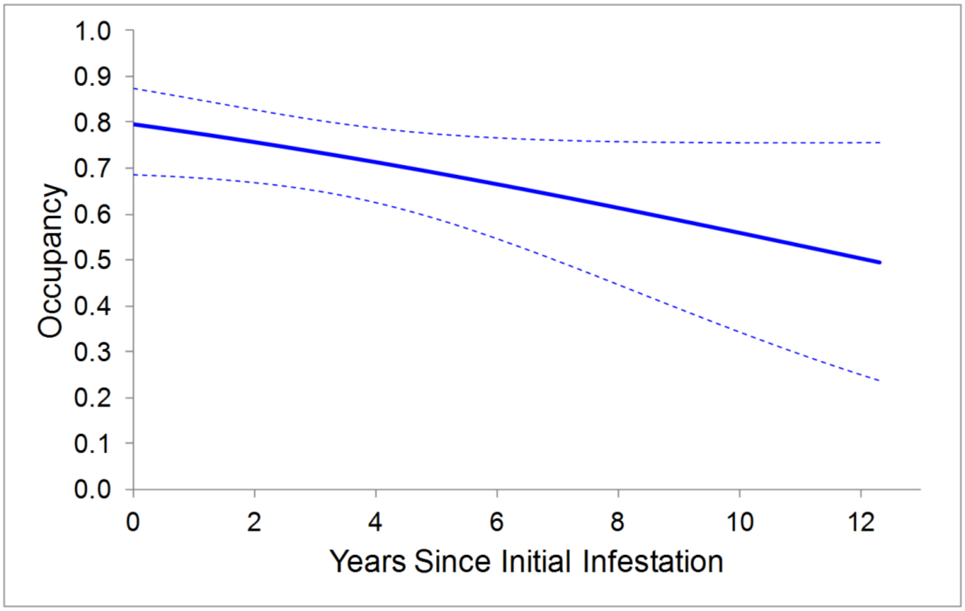


Figure 4. Red squirrel occupancy (i.e., use) of stands in relation to the number of years since initial infestation by bark beetles. Note that "0" years since infestation represents stands that have not yet been impacted. Use of spruce/fir and lodgepole stands is generally similar (only a single line here compared to 2 lines for snowshoe hares above) and is predicted to decline through time as bark beetles pass over an area.

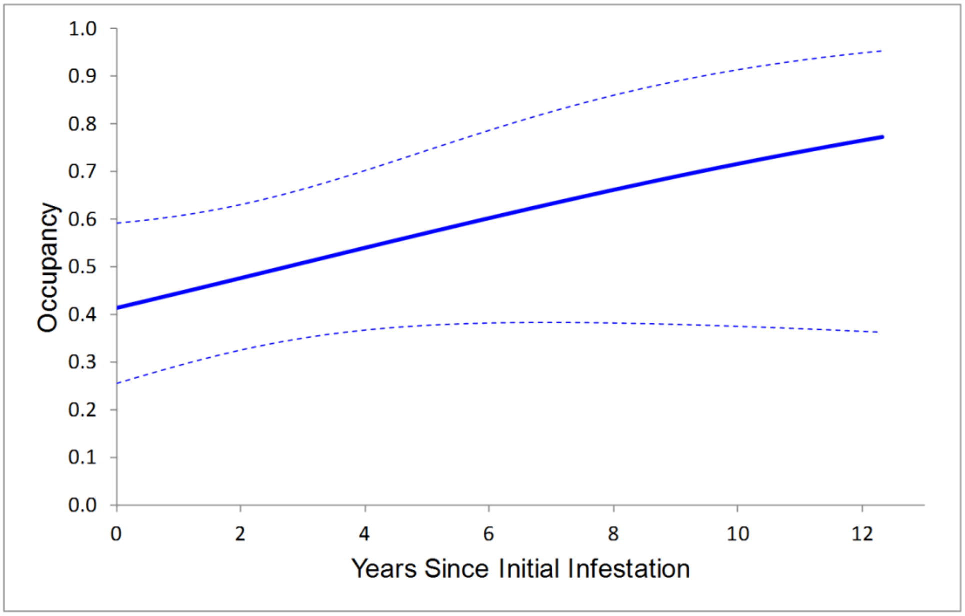


Figure 3. American marten occupancy (i.e., use) of stands in relation to the number of years since initial infestation by bark beetles. Note that “0” years since infestation represents stands that have not yet been impacted. Use of spruce/fir and lodgepole stands is generally similar (only a single line here compared to 2 lines for snowshoe hares above) and is predicted to increase through time as bark beetles pass over an area.

Colorado Parks and Wildlife

WILDLIFE RESEARCH PROJECT SUMMARY

Population performance of Piceance Basin mule deer in response to natural gas resource extraction and mitigation efforts to address human activity and habitat degradation

Period Covered: July 1, 2013 – June 30, 2014

Principal Investigator: Charles R. Anderson, Jr., Chuck.Anderson@state.co.us

All information in this project summary is preliminary and subject to further evaluation. Information MAY NOT BE PUBLISHED OR QUOTED without permission of the principal investigator. Manipulation of these data beyond that contained in this summary is discouraged.

We propose to experimentally evaluate winter range habitat treatments and human-activity management alternatives intended to enhance mule deer (*Odocoileus hemionus*) populations exposed to energy-development activities. The Piceance Basin of northwestern Colorado was selected as the project area due to ongoing natural gas development in one of the most extensive and important mule deer winter and transition range areas in Colorado. The data presented here represent the first 5 pretreatment years and 1 year post treatment of a long-term study addressing habitat improvements and evaluation of energy development practices intended to improve mule deer fitness in areas exposed to extensive energy development.

We monitored 4 winter range study areas representing varying levels of development to serve as treatment (North Magnolia, South Magnolia) and control (North Ridge, Ryan Gulch) sites (Fig. 1) and recorded habitat use and movement patterns using GPS collars (≥5 location attempts/day), estimated overwinter fawn and annual adult female survival, estimated early and late winter body condition of adult females using ultrasonography, and estimated abundance using helicopter mark-resight surveys. During this research segment, we targeted 240 fawns (60/study area) and 170 does (30–70/study area) in early December 2013 for VHF and GPS radiocollar attachment, respectively, and 120 does in March 2013 (30/study area) for late winter body condition assessment. Winter range habitat improvements completed spring 2013 resulted in 604 acres of mechanically treated pinion-juniper/mountain shrub habitats in each of the 2 treatment areas (Fig. 2) with minor and extensive energy development, respectively. Post-treatment monitoring will continue for 4 years to provide sufficient time to measure how vegetation and deer respond to these changes.

Based on data collected during the 5-year pretreatment phase and 1 year post-treatment: (1) annual adult survival was consistent among areas averaging 80-84% annually, but overwinter fawn survival was more variable ranging from 48% to 95% within study areas, with annual and study area differences primarily due to annual weather conditions on seasonal ranges and in some cases density dependent influences; (2) migratory mule deer (Fig. 3) selected increased cover and increased their rate of travel through developed areas, but did not avoid development structures and avoided negative influences through behavioral shifts in timing and rate of migration; (3) mule deer body condition early and late winter was generally consistent within areas, with higher variability among study areas early winter, which likely relate to seasonal moisture within areas and relative forage capacity among areas; (4) mule deer densities have increased in 3 of 4 areas, with fluctuating and recently increasing deer densities evident in the 4th area (Fig. 4); (5) post treatment vegetation responses have been promising with evidence of improved forage conditions, but longer term monitoring will be required to address the full potential of habitat mitigation efforts. Detailed habitat use analyses are still pending for the pretreatment period.

We will continue to collect population and habitat use data across all study sites to evaluate the effectiveness of habitat improvements on winter range. This approach will allow us to determine whether it is possible to effectively mitigate development impacts in highly developed areas, or whether it is better to allocate mitigation efforts toward less or non-impacted areas.

In collaboration with Colorado State University, we are also evaluating deer behavioral responses to varying levels of development activity in the Ryan Gulch study area and neonate survival in relation to energy development from all study areas. This will allow us to assess the effectiveness of certain Best Management Practices (BMPs) for reducing disturbance to deer and include neonatal data to other demographic parameters for evaluation of mule deer/energy development interactions.

The study is slated to run through 2018 to allow sufficient time for measuring mule deer population responses to landscape level manipulations. A more detailed version of this project summary (Anderson 2014, Federal Aid Report W-185-R) and information about recent publications from this effort can be accessed at http://cpw.state.co.us/learn/Pages/ResearchMammalDeer.aspx

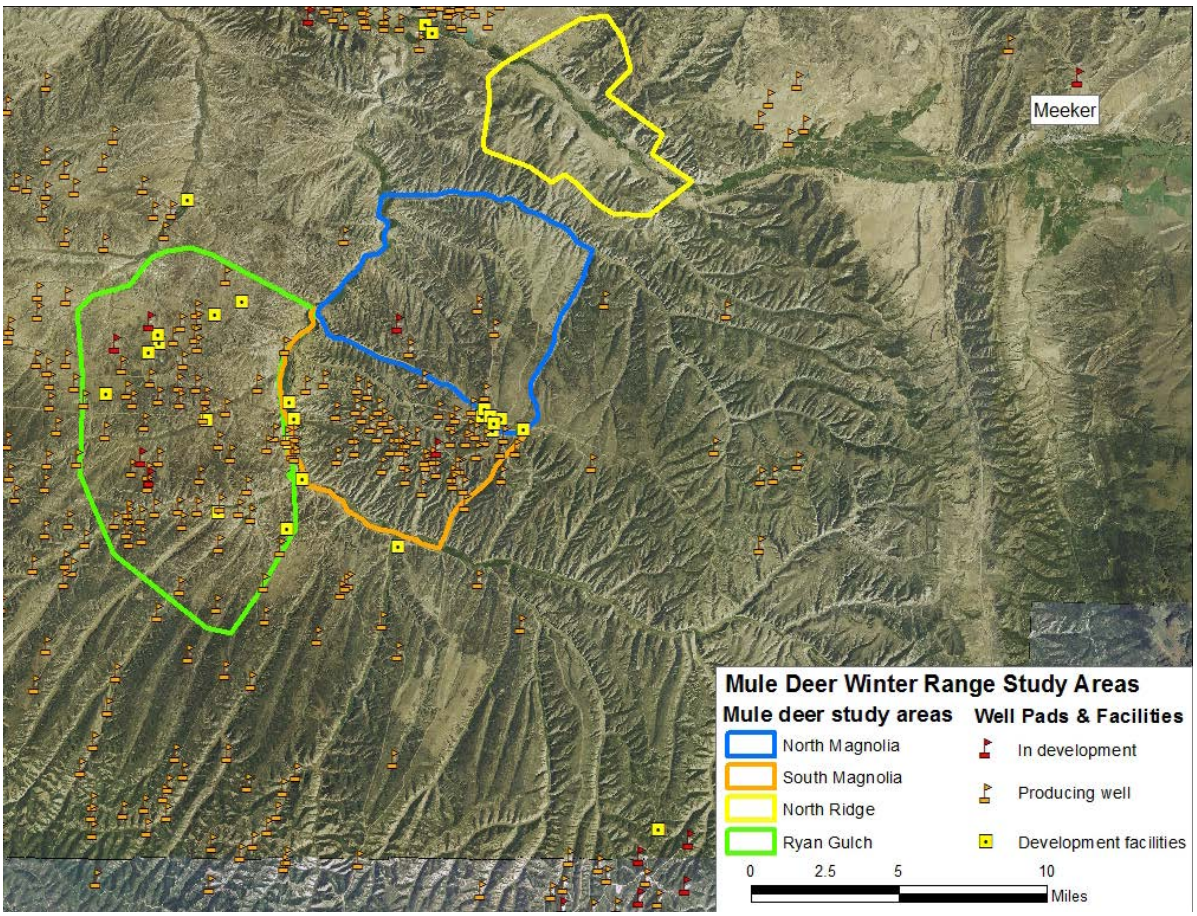


Figure 1. Mule deer winter range study areas relative to active natural gas well pads and energy development facilities in the Piceance Basin of northwest Colorado, winter 2013/14 (Accessed http://cogcc.state.co.us/ Dec. 31, 2013).

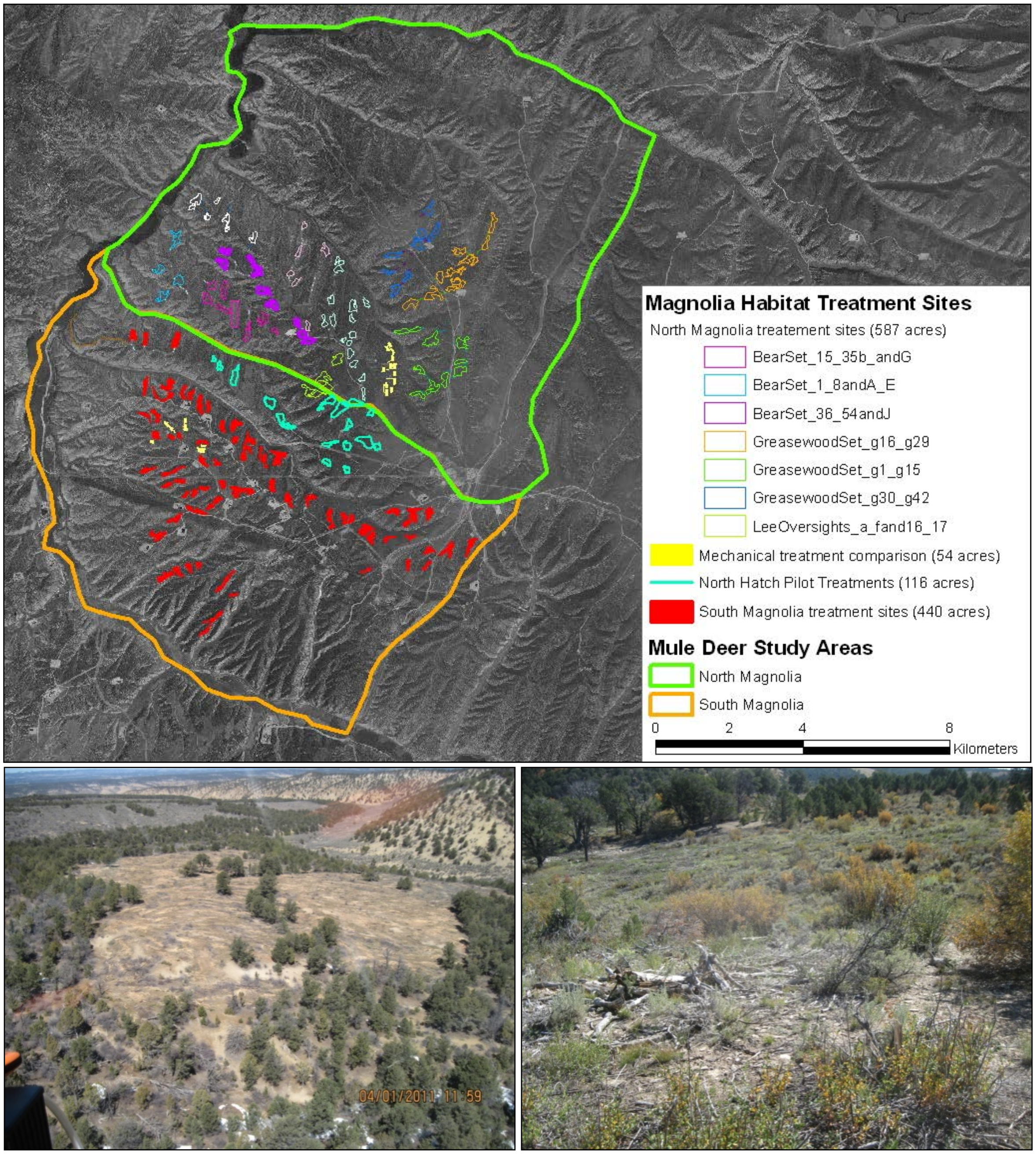


Figure 2. Habitat treatment site delineations in 2 mule deer study areas (604 acres each) of the Piceance Basin, northwest Colorado (Top; cyan polygons completed Jan. 2011 using hydro-axe; yellow polygons completed Jan. 2012 using hydro-axe, roller-chop, and chaining; and remaining polygons completed April 2013 using hydro-axe). January 2011 hydro-axe treatment-site photos from North Hatch Gulch during April (Lower left, aerial view) and October, 2011 (Lower right, ground view).

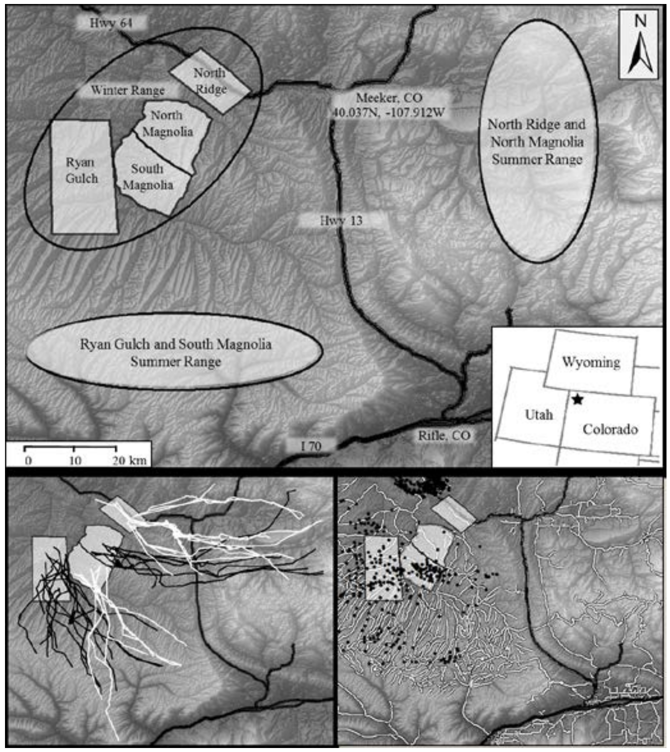


Figure 3. Mule deer study areas in the Piceance Basin of northwestern Colorado, USA (Top), spring 2009 migration routes of adult female mule deer (n = 52; Lower left), and active natural-gas well pads (black dots) and roads (state, county, and natural-gas; white lines) from May 2009 (Lower right; from Lendrum et al. 2012).

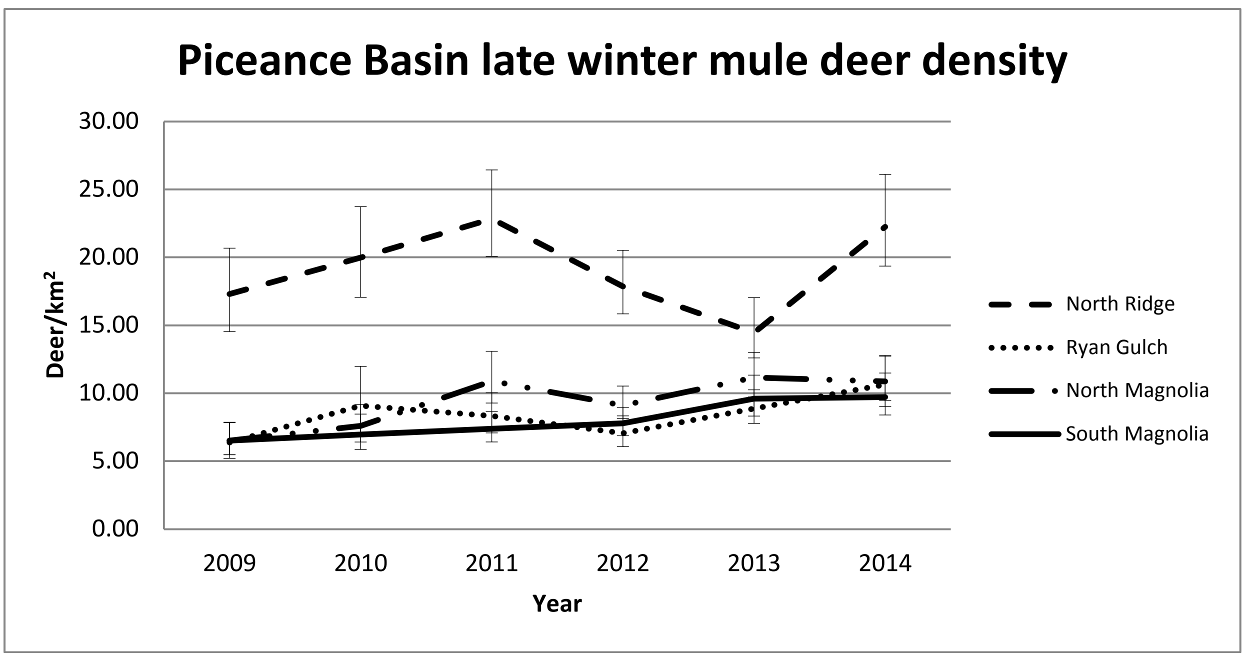


Figure 4. Mule deer density estimates and 95% CI (error bars) from 4 winter range herd segments in the Piceance Basin, northwest Colorado, late winter 2009–2014.

Colorado Parks and Wildlife

WILDLIFE RESEARCH PROJECT SUMMARY

Quantifying loss and degradation of mule deer habitat across western Colorado

Period Covered: July 1, 2013 – June 30, 2014

Principal Investigator: Heather E. Johnson, Heather.Johnson@state.co.us

Project Collaborators: Sarah E. Reed, Jessica R. Sushinsky, Andy Holland, Trevor Balzer, Jim Garner

All information in this project summary is preliminary and subject to further evaluation. Information MAY NOT BE PUBLISHED OR QUOTED without permission of the principal investigator. Manipulation of these data beyond that contained in this summary is discouraged.

In recent decades, mule deer populations have declined across the western U.S., causing wildlife management agencies to seek factors limiting deer performance and strategies to increase their population sizes. The trend of declining mule deer populations has been primarily attributed to loss and degradation of deer habitat, through mechanisms such as urban/exurban development, resource extraction, agriculture, roads and vehicular traffic, fire suppression, and changing patterns in weather and plant productivity. While wildlife managers are well aware that these different factors can negatively affect deer populations, there is no information on their relative or cumulative impacts. In a report to the Colorado state legislature in 2001 titled, "Declining mule deer populations in Colorado: reasons and responses" Gill (2001) concluded that habitat factors had likely taken the greatest toll on deer populations but that there was no information quantifying the extent of habitat loss or deterioration across the state; critical information that is still lacking today. To address this issue, our objective is to conduct the first spatial and temporal analysis of landscape changes that have occurred to mule deer habitat across western Colorado (west of Interstate 25; Fig. 1). Specifically we are 1) mapping and quantifying changes to deer habitat that have occurred over the last ~40 years (in 5-10 year increments) related to residential development, energy development, fire, climate, and plant productivity, 2) calculating the amount of habitat that has been degraded and lost (directly and indirectly) due to these factors on an individual and cumulative basis for each deer data analysis unit (DAU) and within winter and summer ranges of each DAU, and 3) examining whether spatial and temporal changes to habitat conditions may be associated with observed trends in deer recruitment rates.

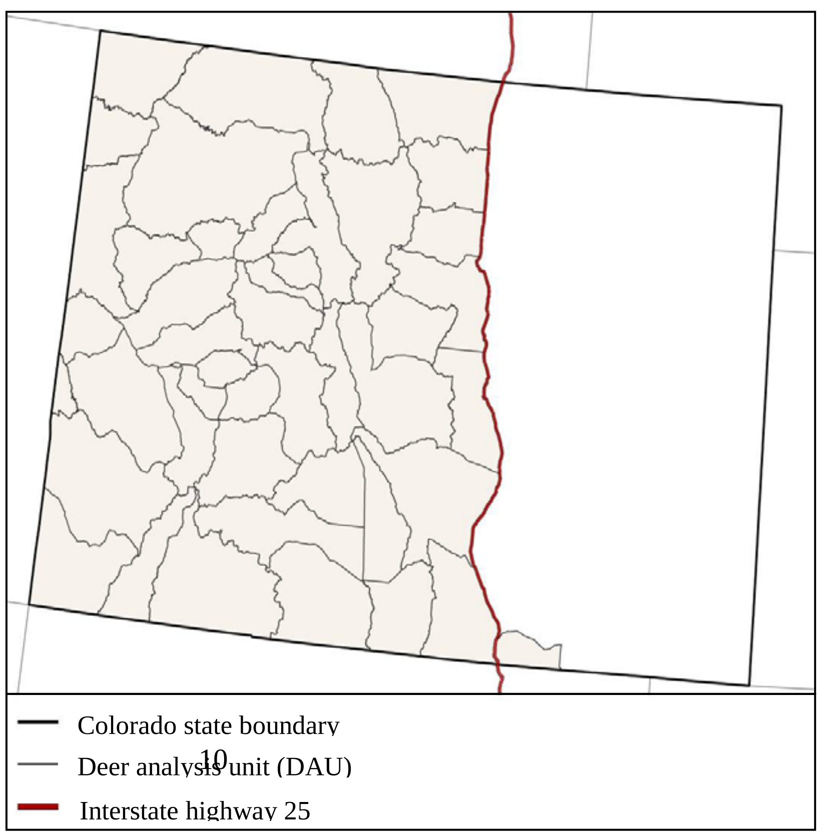
During fiscal year 2013-2014 we completed the first two objectives of this project, and quantified the total area and proportion of deer habitat that was impacted by each land use land cover (LULC) factor, summarized by DAU. While we wanted to conduct these calculations across all LULC types for the past ~40 years, we were limited by the available data. We calculated metrics for climate and wildfire on an annual basis and in 5-year increments. Habitat loss due to residential development was summarized by decade because that is the finest temporal resolution available for the selected data source. Changes to deer habitat were determined on 5-year increments for energy development and annually for vegetation productivity, because collaborators agreed these were the most useful temporal resolutions for these LULC types. A brief summary of the data used to quantify each type of LULC change is described below:

- Climate data were acquired from Parameter-elevation Regressions on Independent Slopes Models (PRISM) to quantify changes to precipitation and temperature. This dataset is considered to be one of the highest-quality historical climate datasets currently available, and was summarized at a 800 m spatial scale. From this dataset we calculated annual precipitation, June precipitation, summer precipitation, winter precipitation, and June minimum temperatures.

- Data on energy development were acquired from the Colorado Oil and Gas Conservation Commission. We obtained a spatial dataset representing the point locations of all oil and gas wells statewide and a tabular dataset representing years of well activity. We merged these datasets to produce a database which attributes all wells with the year the wells were drilled or first became active. At 5-year increments, we calculated the cumulative area affected by energy development at three distances: 200 m, 700 m, and 2,700 m.
- Changes to residential development were mapped and quantified using the Spatially Explicit Regional Growth Model (SERGoM) dataset. This nationwide dataset models housing density by decade at a spatial resolution of 100 m. Changes to deer habitat by DAU were calculated for urban, suburban, exurban, rural and undeveloped housing categories.
- We quantified plant productivity or “greenness” from the Normalized-Difference Vegetation Index (NDVI), which has been widely used to assess forage quality for deer and other large herbivores. We used NDVI metrics derived from 1 km Advanced Very High Resolution Radiometer (AVHRR) satellite imagery. For each DAU, on an annual basis, we determined the length of the growing season, time peak plant productivity, the rate of “green-up” across the season, and the cumulative area under the curve for the growing season.
- Data on fire history were obtained from the Monitoring Trends in Burn Severity (MTBS) project of the US Geological Survey and USDA Forest Service. This nationwide dataset maps the boundaries of wildfires as polygons on an annual basis between 1985 and 2010, on a 100 m spatial resolution.

Information on changes to deer habitat due to climate, energy development, residential development, plant productivity and wildlife will be 1) distributed to biologists and relevant CPW staff in western Colorado to aid in future DAU planning, and 2) used to assess whether spatial and temporal changes to mule deer habitat are related to deer recruitment, a key measure of deer population performance. Results of this work will benefit wildlife professionals at statewide, regional, and local scales that will be able to use project results to help prioritize habitat enhancement efforts, connect deer population objectives to landscape conditions, identify key areas for habitat protection, provide comments on land-use proposals, develop policies related to land-use in critical deer ranges, and quantify general habitat impacts that are relevant to deer across western Colorado.

Figure 1. The area of interest including all deer analysis units west of Interstate 25 in Colorado.



Colorado Parks and Wildlife

WILDLIFE RESEARCH PROJECT SUMMARY

Evaluation and incorporation of life history traits, nutritional status, and browse characteristics in Shira's moose management in Colorado

Period Covered: July 1, 2013 – June 30, 2014

Principal Investigator: Eric J. Bergman, eric.bergman@state.co.us

All information in this project summary is preliminary and subject to further evaluation. Information MAY NOT BE PUBLISHED OR QUOTED without permission of the principal investigator. Manipulation of these data beyond that contained in this summary is discouraged.

We initiated a large scale moose research project in November of 2013. Preliminary field efforts were centered on ground and helicopter darting of moose. The majority of captures occurred during January of 2014. Capture efforts were focused in 3 study areas in Colorado — the Laramie River and Red Feather Lakes areas (NE Colorado), the Rabbit Ears range that separates North Park from Middle Park (NW Colorado), and along the Upper Lake Fork, Rio Grande Reservoir, and near Slumgullion Pass (SW Colorado). All captured moose were fitted with either GPS or VHF collars. Body condition and pregnancy status of each captured animal was also evaluated at time of capture. Survival status of collared animals was monitored through June 2013. Additionally, preliminary calf twinning rates and observations were documented in the northeast region. Survival rates tended to be high and little variation was observed among study areas but pregnancy rates were highly variable among study areas.

A total of 58 moose were captured and collared during the 2013–2014 field season. Twenty moose were captured in each of the NW and NE study areas. Eighteen moose were captured in the SW study area. Of these 58 animals, 2 animals in the NE study area were captured via ground darting. The remaining moose were captured via helicopter darting. The majority of captures (n=55) occurred in late January. For purposes of body condition evaluation, it is expected that the greatest amount of variation will be observed during early winter, such that the majority of variation can be explained by individual reproductive and habitat use characteristics. Thus, captures during the late January time frame were not ideal and future efforts will concentrate on early time periods.

Survival of radio collared animals was high in all study areas. Survival rates ranged between 0.94–1.00 from the time of capture through the end of June. Pregnancy rates by study area at the time of capture were highly variable (range: 0.60–0.95). Anecdotal calf:cow ratio data were also collected at the time of capture. While these ratios are vulnerable to observer bias (i.e., false negatives can be expected to occur at a greater frequency), the observed rates shadowed pregnancy rates and ranged between 0.27–0.72. Mean measured rump fat at the time of capture ranged between 2.6–4.2 mm among study areas. Mean measured loin depth at the time of capture ranged between 40.9–49.6 mm among study areas. Pregnancy status was best predicted by measured loin depth.

Moose data collected during this period largely met expectations. In particular, survival rates were high in all study areas. However, it was also assumed that not all of Colorado's moose herds are equally productive. This assumption was largely validated by variation in pregnancy rates. However, additional years of data collection are needed to confirm this result. Within this, the age of captured animals remains unknown and could partially explain the variation in pregnancy data. Addition of annual browse utilization data will occur during spring 2015, and will hopefully provide insight into body condition and pregnancy status of animals. This study is scheduled to continue through 2021.

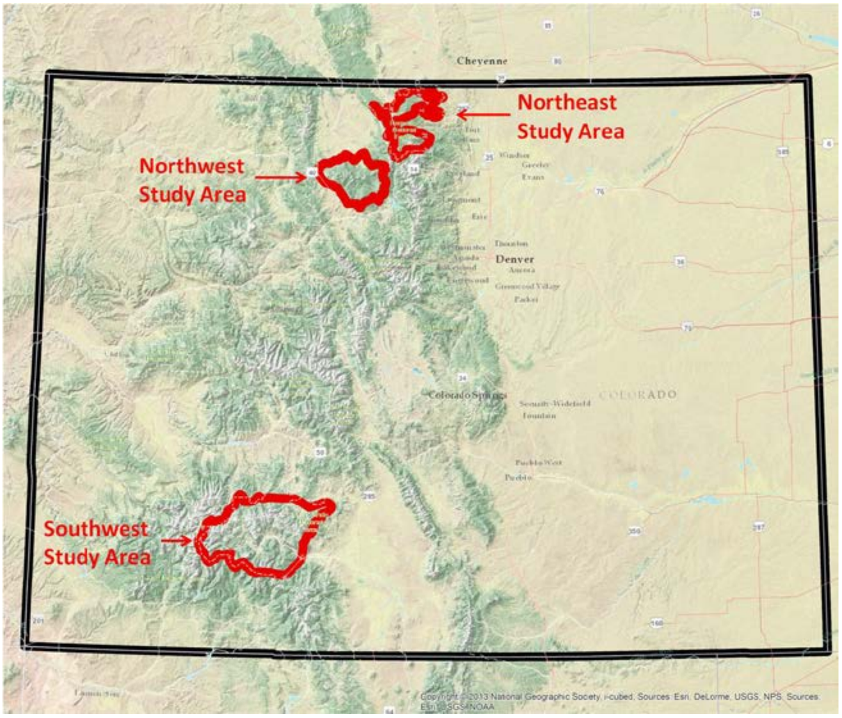


Figure 1. Moose research study areas, located in 3 regions in Colorado. A total of 58 moose were captured during the winter of 2013–2014. Twenty moose were caught in the Northeast and Northwest regions, 18 moose were caught in the Southwest region. Survival of moose was high in all study areas.

Figure 2. At the time of capture, moose were fitted with either a GPS or VHF collar. Data on body condition and pregnancy status were also collected at this time.

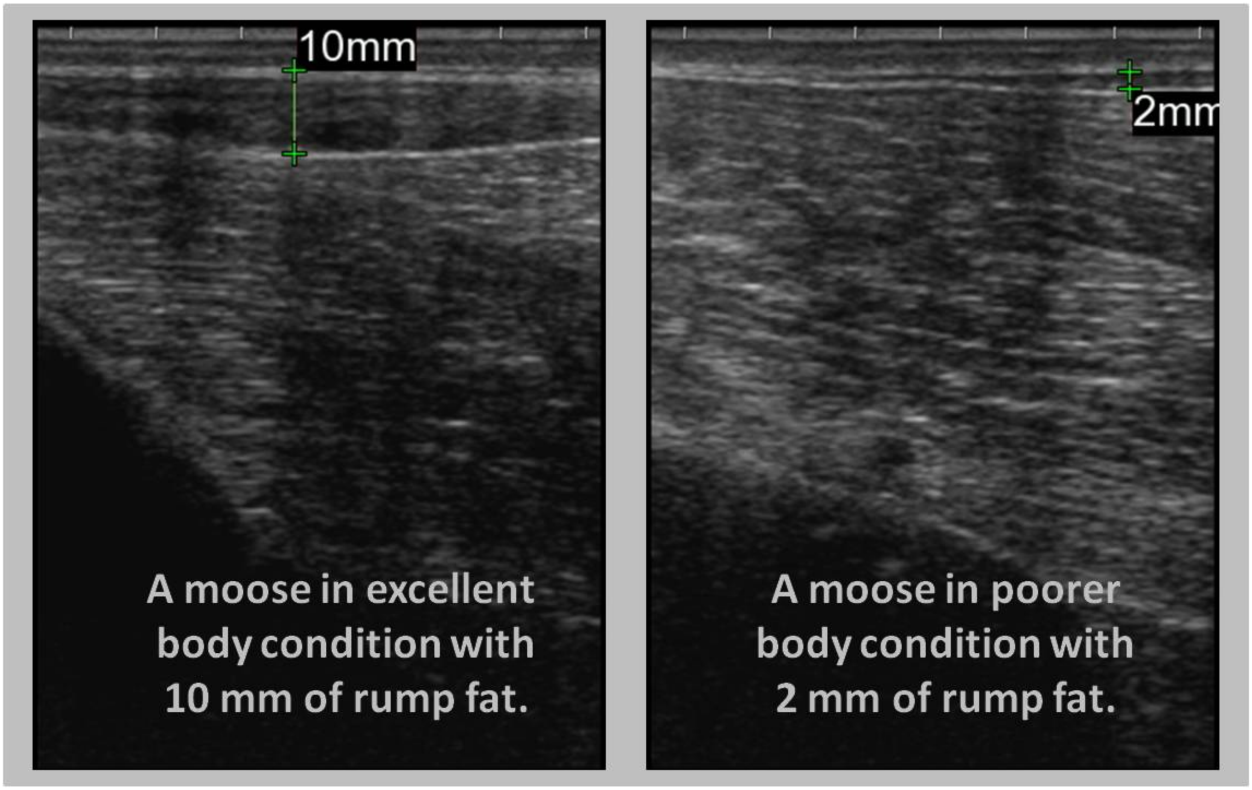


Figure 3. Moose body condition was highly variable within study areas, although variation among areas was not as pronounced.

Colorado Parks and Wildlife

WILDLIFE RESEARCH PROJECT SUMMARY

Black bear exploitation of urban environments: finding management solutions and assessing regional population effects

Period Covered: July 1, 2013 – June 30, 2014

Principal Investigator: Heather E. Johnson, Heather.Johnson@state.co.us

Project Collaborators: S.A. Lischka, S. Breck, J. Beckmann, J. Broderick, J. Apker, K. Wilson, and P. Dorsey

All information in this project summary is preliminary and subject to further evaluation. Information MAY NOT BE PUBLISHED OR QUOTED without permission of the principal investigator. Manipulation of these data beyond that contained in this summary is discouraged.

Across the country conflicts among people and black bears are increasing in frequency and severity, and have become a high priority wildlife management issue. Whether increases in conflicts reflect recent changes in bear population trends or just bear behavioral shifts to anthropogenic food resources, is largely unknown, with key implications for bear management. This issue has generated a pressing need for bear research in Colorado and has resulted in a unique collaboration that builds on the resources and abilities of personnel from 4 entities: Colorado Parks and Wildlife (CPW), the USDA National Wildlife Research Center, Wildlife Conservation Society and Colorado State University. Collectively, we have designed and implemented a study on black bears that 1) determines the influence of urban environments on bear behavior and demography, 2) tests a management strategy for reducing bear-human conflicts, 3) examines public attitudes and behaviors related to bear-human interactions, and 4) develops population and habitat models to support the sustainable monitoring and management of bears in Colorado.

This project was initiated in FY2010-11; during this past fiscal year we have primarily focused on collecting field data in the vicinity of Durango, Colorado. Our efforts focused largely on field data needed to meet research objectives 1-3, information which will eventually be used to address objective 4. Specifically, we worked with collaborators and stakeholders on research logistics, trapped and marked black bears, collected GPS collar location data on bears along the urban-wildland interface, monitored bear demographic rates (adult female survival, adult female fecundity and cub survival) through telemetry and winter den visits, collected data on the availability of late summer/fall mast, tracked human-related bear mortalities and removals from the study area, performed non-invasive genetic mark-recapture surveys, deployed an additional ~150 bear-resistant containers for an experiment on the effectiveness of urban-bear-proofing for reducing bear-human conflicts, obtained data on garbage-related bear-human conflicts, monitored resident use of project-supplied bear-resistant garbage containers, and conducted a survey assessing resident attitudes about bears and bear-human interactions.

Major research accomplishments from fiscal year 2013-14:

- Between June 2013 and April 2014 (the 2013-2014 capture year), an additional 75 unique bears were marked during 206 bear captures. To date on the project there have been 280 different individuals marked during 601 captures. Nine new adult females were collared during summer 2013 to collect demographic and habitat-use data. Bear capture and marking efforts are allowing us to track bear population parameters and habitat-use patterns along the urban-wildland interface.
- During January - March 2014, we visited the winter dens of 35 collared females (Photo 1). Of those females, 13 did not have any cubs or yearlings, 9 had yearlings (13 total yearlings in total), and 13

had newborn cubs (26 cubs). We found that reproductive success, measured as the number of live cubs/adult female was 0.74 (SE = 0.18) for winter 2014, compared to 0.95 (SE = 0.24) in 2012 and 0.52 (SE = 0.16) in 2013. Cub survival for 2014 (survival from newborn to 1 year) was 50% (based on 12 cubs), compared to 40% in 2013.

Photo 1. Sow and cub in a den.

- To date, we have obtained >300,000 locations from GPS collars on 67 different adult female bears along the urban-wildland interface; 42 different bears provided location data during the active bear year of 2013 (May – October; Fig. 1). While most locations were in close proximity to Durango, a few animals ventured outside the primary study area, including a sow that moved to New Mexico (Fig. 1). Location data are being used to assess drivers of bear resource-use of human development.
- In summer 2013, we collected 1,365 hair samples for a non-invasive genetic mark-recapture study designed to estimate bear densities and population sizes around the vicinity of Durango and an adjacent "wildland" site. Over a 6 week sampling period, a total of 680 hair samples were collected from the Durango grid and 685 samples from the wildland grid. From those samples, 693 valid genotypes were obtained; 334 from the Durango grid and 359 from the wildland grid. Around Durango, 86 different individuals were detected during 160 "captures" (multiple hair samples from a single bear during 1 week were considered 1 "capture"). For the wildland site, 110 different individuals were detected during 183 "captures." Detailed mark-recapture analyses of these data will be conducted in the future to estimate annual density and abundance at each site.
- During summer 2013 (July through September) we collected our first year of post-treatment data on an experiment designed to assess the effectiveness of wide-scale urban bear-proofing for reducing bear-human conflicts (pre-treatment data were collected during 2011 and 2012). Within treatment and control areas we observed 330 instances of bears accessing residential garbage during morning patrols; observations peaked in early September. Of those garbage containers accessed by bears, 84% were regular and 16% were bear-resistant; 131 garbage conflicts were observed in treatment areas (across 1,231 total residences) and 156 occurred in control areas (across 1,259 total residences). In spring 2014 an additional 150 containers were deployed to "clean up" treatment areas and ensure that all residences had a bear-resistant garbage container (Fig. 2). We will continue to collect post-treatment data through 2015.
- Between January and April 2014, a second mail survey of resident attitudes about bears was administered. Surveys were sent to all residents within Durango city limits and a random sample of 1,500 residents outside city limits but within the study area. A total of 5,853 residents were surveyed, yielding an adjusted response rate of 45%. Detailed analysis of tolerance for black bears, compliance behaviors and perceived risk of bear-human conflicts will be conducted in future years.

In addressing our research objectives we hope to better understand the influence of urban environments on bear populations, elucidate the relationship between bear-human conflicts and bear behavior and demography, understand the effect of bear-human interactions on human attitudes and actions, develop tools to promote the sustainable management of bears in Colorado, and ultimately, identify solutions for reducing bear-human conflicts in urban environments. See Johnson et al. (2014, Federal Aid Report W-204-R1) for a more detailed version of this project summary.

Figure 1. GPS collar locations from 42 adult female black bears collected during 1 January–31 December 2013 in the vicinity of Durango, Colorado (different colored clusters of points represent different individual bears): A) an overview of all locations and B) locations around the town of Durango.

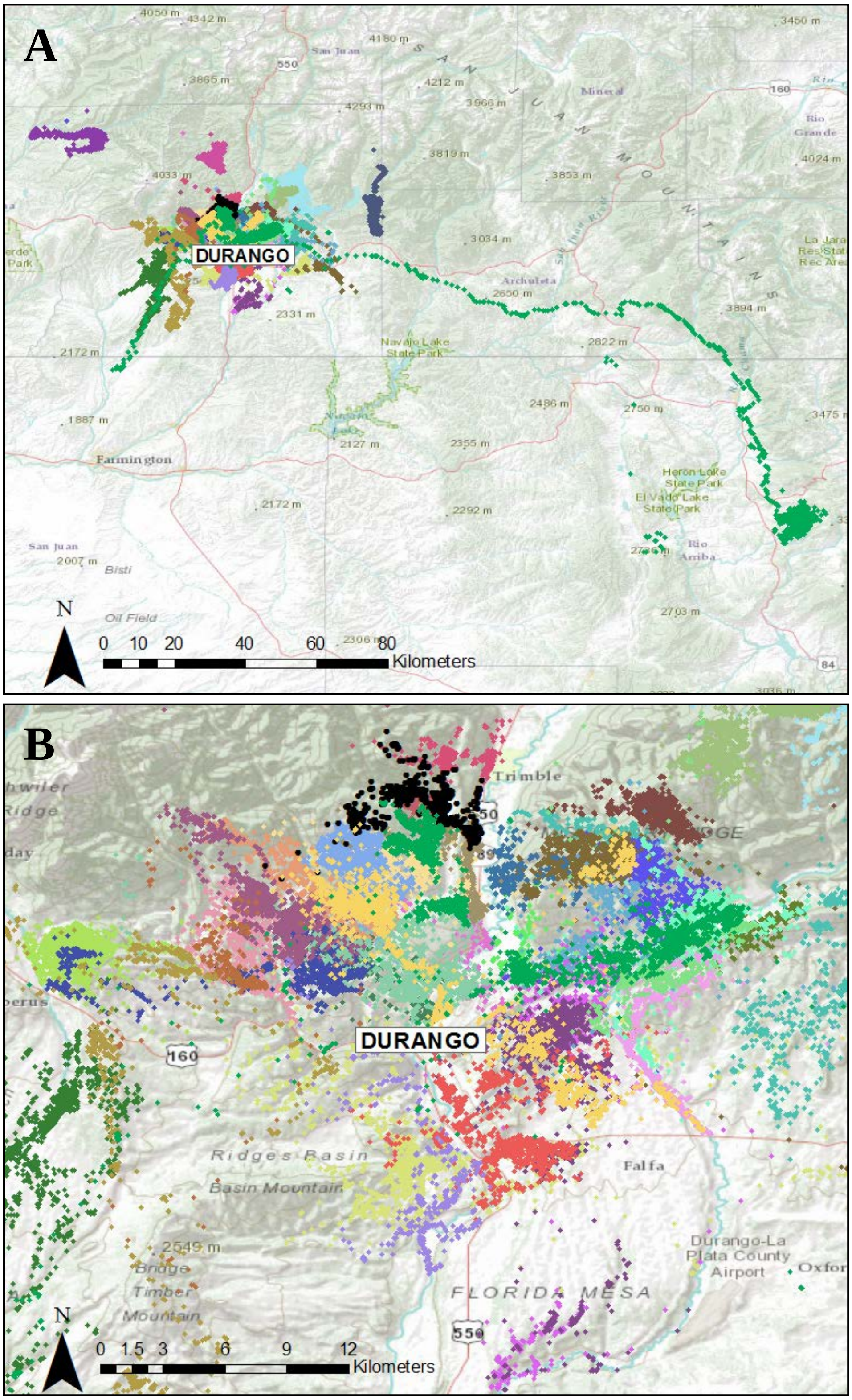
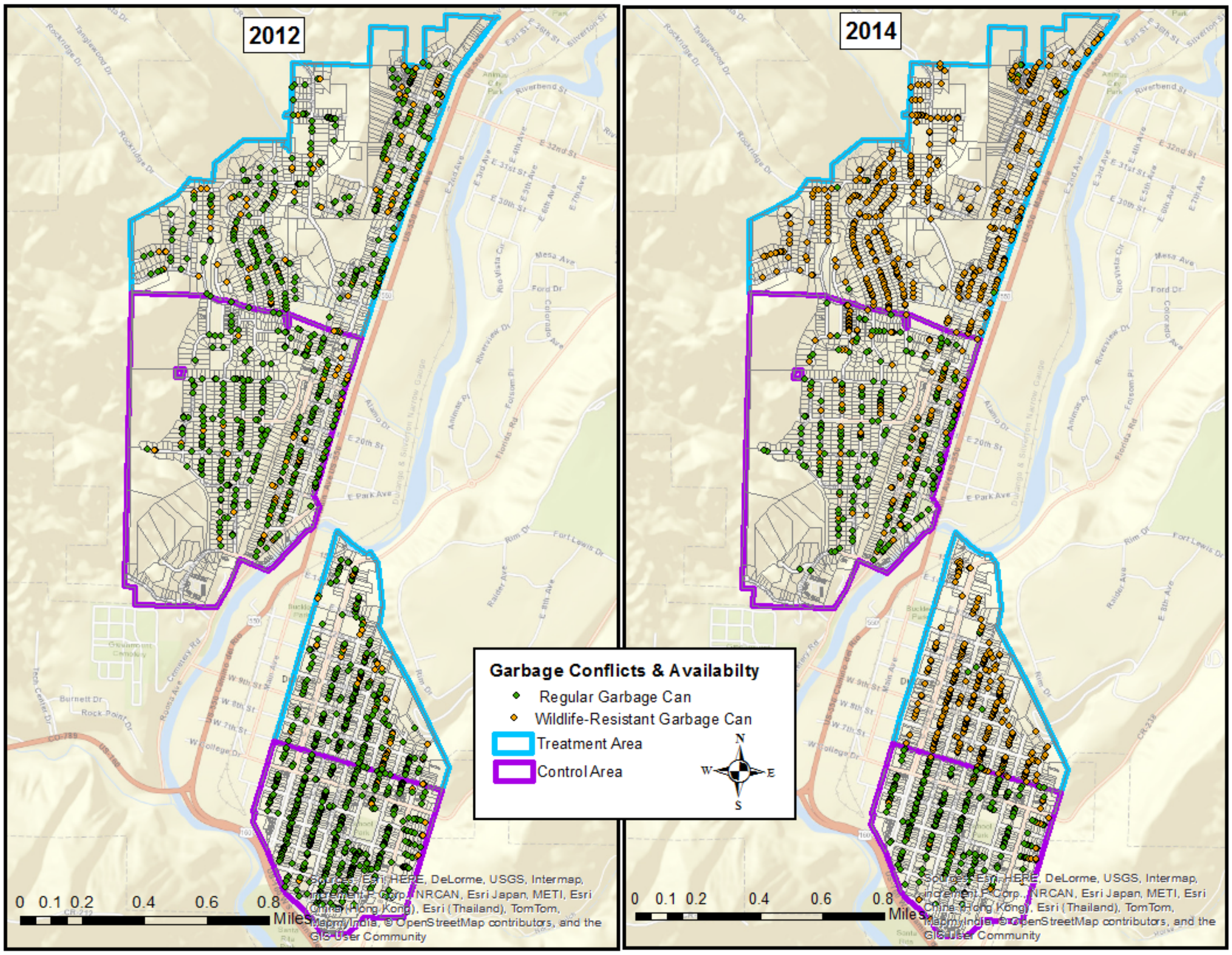


Figure 2. Change in garbage containers (regular to bear-resistant) at residences in experimental areas pre-treatment (2012) and post-treatment (2014), Durango, Colorado.



Colorado Parks and Wildlife

WILDLIFE RESEARCH PROJECT SUMMARY

Shifting perceptions of risk and reward: temporal and spatial variation in selection for human development by black bears around three urban systems

Period Covered: July 1, 2013 – June 30, 2014

Principal Investigator: Heather E. Johnson, Heather.Johnson@state.co.us

Project Collaborators: Stewart W. Breck, Sharon Baruch-Mordo, David L. Lewis, Carl W. Lackey, Kenneth R. Wilson, John Broderick, Julie S. Mao, and Jon P. Beckmann

All information in this project summary is preliminary and subject to further evaluation. Information MAY NOT BE PUBLISHED OR QUOTED without permission of the principal investigator. Manipulation of these data beyond that contained in this summary is discouraged.

As landscapes across the globe rapidly change due to increased human development, there is uncertainty about the behavioral responses of wildlife to these changes given associated shifts in resource availability and risk. Human development typically reduces native foods for animals, but introduces novel anthropogenic foods (crops, livestock, garbage, watered landscaping, etc) along with risks associated with foraging in human-dominated landscapes. The initial response of animals to human development is typically a change in behavior, as animals have been observed to alter patterns of habitat selection, vigilance, daily activities and foraging, often in highly diverse ways. These behavioral responses reflect perceived trade-offs between the benefits of acquiring key resources and the risks associated with human activity. While these trade-offs should be dynamic in space and time as a function of habitat quality, natural food conditions and the physiological states of individuals, little is known about how animals in human-altered landscapes behaviorally adapt to such variation, particularly under varying ecological conditions.

Elucidating the behavioral responses of wildlife to human development is particularly important for large carnivores as their home ranges frequently overlap with human infrastructure and activities, and their interactions with people are often a major source of conflict. In many cases, large carnivores avoid people indicating they associate humans with risk. Some carnivores, however, forage within human development on their natural foods or on anthropogenic foods, exploiting resources associated with human infrastructure. Such behavior has been associated with increased human-carnivore conflicts, generating concern over human safety and property, and stymieing conservation efforts for some carnivore species. If wildlife managers are going to be successful at reducing human-carnivore conflicts and promoting public tolerance for these species, they need to understand how these animals are behaviorally responding to increased development, and the conditions that modify their behavior.

These concerns are particularly relevant for black bears (*Ursus americanus*). Bears can readily exploit the wealth of reliable, high-calorie food resources available around residential development (i.e., garbage, fruit trees, livestock), but are also susceptible to increased mortality from vehicle collisions, conflict-related euthanasia, and other human-related factors. Although studies have found that bears perceive risk associated with human activity, human-bear conflicts have generally increased over time, albeit highly variable. As a long-lived species with relatively stable population dynamics, variation in conflict activity is likely a consequence of shifting foraging behavior, not shifting population sizes, as bears reassess trade-offs of using human foods. Factors such as natural food conditions, a bear's gender, age, physiological state (e.g., reproductive status), or degree of exposure to human activity, may influence the benefits and risks of foraging in human-dominated landscapes, driving observed variation in conflict activity.

To understand how a large carnivore weighs the benefits and risks of using human development, we examined patterns of black bear resource selection in three developed areas in the western US (Aspen [CO], Durango [CO], and Lake Tahoe [NV]). Using data from 109 bears, our objectives were to 1) examine temporal patterns of selection for development within and across years, 2) compare spatial patterns of selection for development across study systems, and 3) identify individual attributes (e.g., age, maternal status) associated with increased selection for development.

Using mixed effects resource selection models we found that use of development by bears was similar across study sites, modifying their selection within and across seasons based on changing environmental and physiological conditions (Fig. 1). Results were based on 331851 locations collected May - October; 87,530 locations for Aspen females (14 different bears), 82,272 for Aspen males (29 bears), 152,365 for Durango females (50 bears), and 9,684 for Tahoe females (16 bears). Selection for human development was tied to nutritional demands, as bears increased their use of anthropogenic foods throughout the summer-fall and in years with poor natural food availability (Figs. 1 and 2). Selection also appeared to be related to bear experience, increasing with animal age.

While there were general trends in how bears selected for human development across sites, there were also idiosyncratic differences between them. For example, Aspen males, Aspen females, and Tahoe females tended to select for intermediate development densities, while Durango females displayed a bimodal pattern of either selecting for very high or very low development densities (Fig. 1). In Aspen, males selected for intermediate densities of development in both good and poor natural food years (amplifying their selection for development in poor food years), while females avoided areas with high development densities in good natural food years and strongly selected for high development in poor years, particularly during hyperphagia (Fig. 1).

Our findings illustrate that for three areas in the western US black bears selected positively for human development, increasing their use of development in years with poor natural food conditions, throughout the summer-fall, and as bears increased in age. These patterns were generally consistent across study systems and over numerous years of data collection, despite variation in individual bear behavior. Such patterns suggest that bears are similarly interpreting the shifting benefits and risks associated with foraging in human-dominated landscapes, as factors such as natural food conditions, physiological state (i.e., hyperphagia), and experience with anthropogenic foods, simultaneously shape their habitat selection decisions. Variation in bear use of development appeared to be primarily tied to nutritional demands, as the benefits of obtaining anthropogenic foods likely outweighed the risks of foraging around human activity when bears needed additional food resources.

Results from this study have key implications for bear management. Wildlife agencies often assume that bears exposed to human food will consistently exhibit nuisance behavior, but our results suggest that bear behavior can be highly variable within and across years, and that bears may often use anthropogenic resources as a source of subsidy rather than relying on those resources outright. Because bear populations are notoriously difficult to monitor, wildlife agencies also often assume that increases in human-bear conflicts reflect increases in bear populations. Our work, however, suggests that bear selection for development may be increasing over time, particularly as individuals get older and gain experience with anthropogenic foods. This behavior may then be the source of additional conflicts without an associated increase in population size, a pattern that has been observed for polar bears. As human development continues to permeate bear habitat, and as changes in climate reduce natural foods for bears in some areas, we expect that bear exposure to development and anthropogenic foods will increase as will their selection for these resources.

Figure 1. Black bear probabilities of selection for density of human development from May through October in Aspen (CO), Durango (CO), and Tahoe (NV), USA. Warm colors depict selection during poor natural food years and cooler colors depict selection in good natural food years. Data for bears in Tahoe were not available for years with different natural food conditions. Note: Durango experienced a maximum of 375 human structures/km^2, while Aspen and Tahoe had maximum densities of 540 and 660 structures/km^2, respectively.

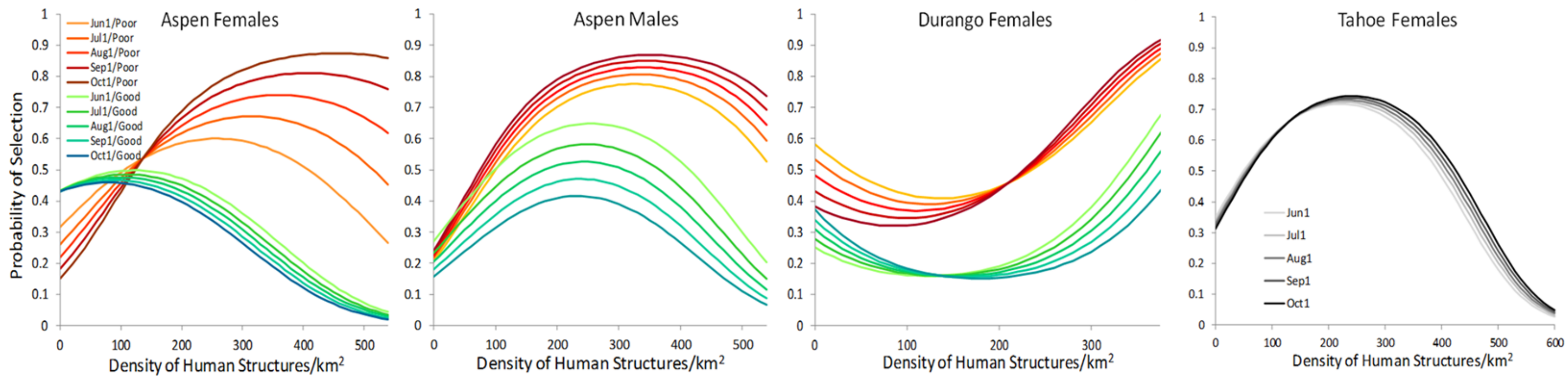
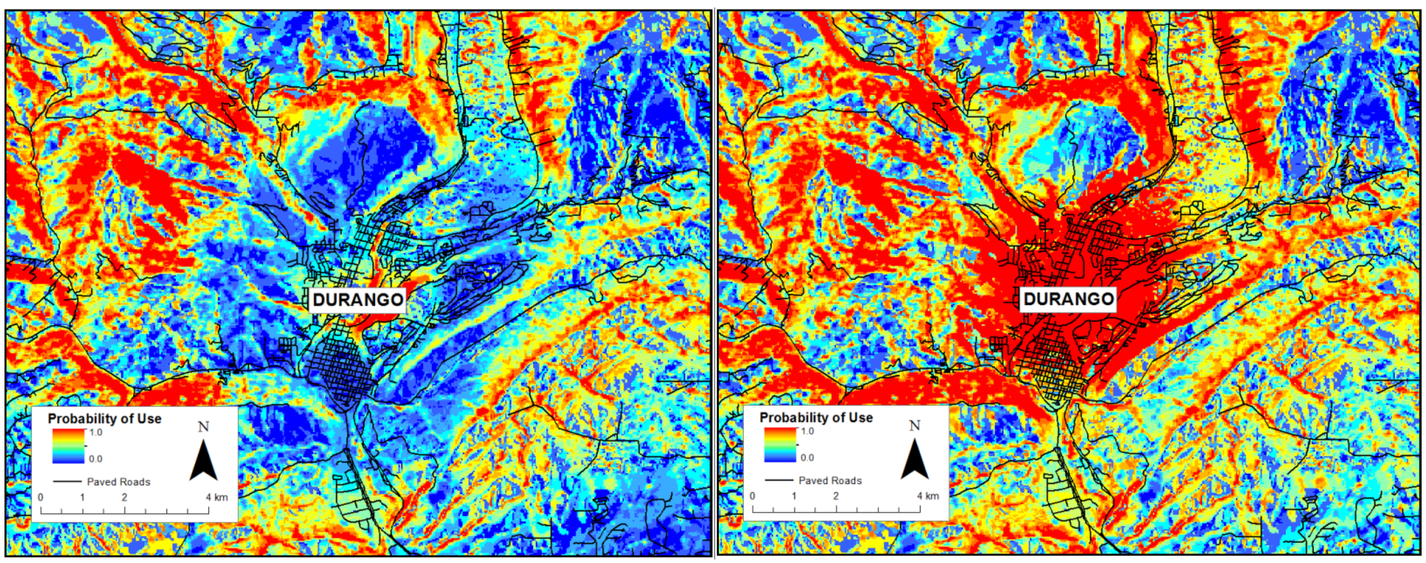


Figure 2. Spatial predictions of resource selection from female black bears in Durango, Colorado, for a good (A) and poor (B) natural food year during fall (Oct 1st).



Colorado Parks and Wildlife

WILDLIFE RESEARCH PROJECT SUMMARY

Mountain lion population responses to sport-hunting on the Uncompahgre Plateau, Colorado

Period Covered: July 31, 2013 ─ June 30, 2014

Principal Investigator: Kenneth A. Logan, Ken.Logan@state.co.us

All information in this project summary is preliminary and subject to further evaluation. Information MAY NOT BE PUBLISHED OR QUOTED without permission of the principal investigator. Manipulation of these data beyond that contained in this summary is discouraged.

The Colorado Parks and Wildlife (CPW) initiated a 10-year study in 2004 on effects of sport-hunting on a mountain lion population on the Uncompahgre Plateau. This study was designed to provide information that can be applied to lion management. The study quantifies lion population characteristics in the absence of hunting (termed the *reference period*, years 1-5) and the application of hunting (termed the *treatment period*, years 6-10). The purpose of the study is to evaluate the current biological assumptions used by CPW to manage lions with hunting and to learn how lion hunter behavior may influence harvest. Testing the management assumptions is important because managers normally have no information on lion abundance, population sex and age structure, or effects of hunting on lions for any region of Colorado. Therefore, managers are highly dependent on assumptions. Lion hunter behavior is important to understand because it may influence the sex and age structure of lions killed by hunters, and those harvest data are used by CPW managers in an effort to make biological judgments about lion populations and effects of hunting.

The *reference period* began December 2004 and ended July 2009, during which we captured, sampled, and marked 109 individual lions for research purposes. During this period without sport-hunting as a mortality factor the population of independent lions comprised of adults and subadults increased from a low of 33 lions counted in *reference* year 4 to a high of 55 lions counted in the *treatment* year 1 (Fig. 1). This was an indication that lion management on the Uncompahgre Plateau previous to this study may have suppressed the lion population. Along with the population increase during the *reference period*, adult lion survival was high and the age structure of independent lions increased; expected characteristics of an increasing population. The main cause of death in adults was aggression by other lions. Only one death of a radio-collared independent lion was due to human causes; an adult female killed for depredation control purposes. Infanticide by male lions was the main cause of death for cubs.

The *treatment period*, in which managed sport-hunting of lions was applied on the study area, began August 2009. Since then 115 additional lions were captured and marked for research purposes. As indicated previously, *treatment* year 1 was the first year that hunting influenced the lion population after 5 years of no hunting and it was marked with the highest estimate of independent lions (55) on the study area. During *treatment* years 1 through 3, the lion harvest rate was set with a quota of 8 lions to test a prediction that a 15% harvest of independent lions would result in a stable-to-increasing lion population. This is an important management assumption to test because it represents a maximum mortality rate on independent lions that was assumed to achieve a stable-to-increasing population trend; one of two CPW lion population management objectives that are applied to certain regions (Data Analysis Units, DAUs, each comprised of multiple Game Management Units, GMUs). This objective provides a capacity for a lion population to be resilient to all causes of mortality, including hunting and assists CPW to achieve a goal for a healthy, self-sustaining lion population state-wide while providing hunting opportunity. However, the expectation that a 15% harvest results in a stable-to-increasing population was not supported as the population of independent lions declined from 55 in *treatment* year 1 to 42 by *treatment* year 4 (Fig. 1). The other CPW lion management objective is to manage certain regions to substantially reduce or suppress lion abundance with hunting. Results from *treatment* years 1 through 4 indicated that reducing a lion population with hunting is achievable with as low as 15% harvest of independent lions.

The lion population was expected to continue to decline if the quota remained at 8 lions because 8 lions represented a 19% harvest by *treatment* year 4, a larger percentage than the 15% harvest that had already contributed to population decline. Therefore, in an effort to find a harvest rate useful to managers that would result in a stable-to-increasing population for the remainder of the study, the quota was reduced to 5 lions. This quota represented about 11-12% harvest rate of independent lions for treatment years 4 and 5. The count of independent lions in treatment years 4 and 5 were 42 and 44 lions, respectively, suggesting that the lower harvest rate of 11-12% resulted in a cessation of the decline and a stabilization, if not marginal increase, in the number of independent lions. During the *treatment*, the main cause of death to independent lions was hunting. Survival rates of adult lions declined as did the age structure of independent lions, as expected in a declining population. Infanticide by male lions was the main cause of death for cubs, just as it was in the *reference period*.

During the *treatment period*, additional independent radio-collared lions were killed by hunters outside of the study area during the Colorado lion hunting season spanning November through March each winter. Those lions were counted as part of the harvest quotas in other GMUs. This occurred even though the study area was a large GMU in Colorado. Home ranges of most lions, particularly of males, were large enough to span at least two GMUs so lion movements put some individuals at risk to hunting mortality even after the study area quota was filled and closed to hunting for the remainder of the season. The total hunting mortality plus other human causes of mortality, such as road kill and depredation control, and natural mortality that occurred throughout the year contributed to the lion population decline and low phase (Fig. 1). This indicated a need for managers to consider how all mortality might impact a lion population. The phenomenon of lion movements spanning GMU boundaries also revealed that hunting can affect lion populations at considerably larger spatial scales than the current GMU structure.

Data from voluntary surveys of lion hunters on the study area revealed that a large majority of lion hunters used dogs. A large majority of lion hunters considered themselves to be *selective hunters*, meaning they specifically hunted for a specific type of legal lion such as a male, large male or large female, and therefore attempted to distinguish between male and female tracks, and large and small males or females. Moreover, data on the actual hunting experience of hunters that answered the survey supported the hunters' claims and indicated that they generally detected female lions in the field more frequently than male lions, yet they strongly selected to kill male lions, and they sometimes captured and released female and small male lions. The lion harvest composition was strongly influenced by hunter predilections. Hunters did not merely sample the lion population at random or kill the most detectable lions. Even though lion hunters generally selected to kill males, the lion population declined with a 15% harvest of independent lions (Fig. 1).

Besides the study on effects of sport-hunting on lions, other projects associated with lion ecology were developed in collaboration with colleagues in CPW, Colorado State University, Colorado Cooperative Fish and Wildlife Research Unit, Oklahoma State University, and University of Arizona. We collaborated with Ph.D. student Jesse Lewis and Dr. Kevin Crooks (C.S.U., Dep. of Fish, Wildlife, and Conservation Biology) from August to December 2009 in a study of relationships of bobcats to mountain lions and considerations in using a camera grid with marked lions to estimate lion detection, abundance, and density. Jesse is currently involved with data analysis and writing on that project, projected completion December 2014. We collaborated with Master's student Kirstie Yeager (Colorado Cooperative Fish and Wildlife Research Unit) and Dr. Mat Alldredge (Mammals Researcher, CPW) from December 2012 to March 2013 to test non-invasive methods for tissue-sampling lions for efforts to estimate abundance. This effort also allowed us to assess the proportion of lions marked in the population in winter on the Uncompahgre Plateau study. A sampling grid with 2 by 2 kilometer cells covering 540 square kilometers was established on the study area. A total of 54 random cells were sampled with digital wildlife cameras and electronic predator calls. Eighteen photographs of lions were recorded by cameras, and all 18 photos depicted radio-collared lions that could be identified to the individual. Of the 11 collared lions known to use the grid, seven of them were photographed one to four times each. The probability of detecting collared lions during the entire survey time was 0.64. Projected completion of Kirstie's study is May 2015. We are involved in ongoing studies of diseases in mountain lions with Dr. Sue VandeWoude (C.S.U., Dep. Of Microbiology, Immunology, and Pathology), Dr. Kevin Crooks and their colleagues and graduate students. Diseases and pathogens to which lions sampled from the Uncomphagre Plateau study area were exposed, included: plague (caused by the bacteria *Yersinia pestis*), Feline immunodeficiency virus (a lentivirus), *Bartonnela* sp. (a vector-borne bacteria), and *Toxoplasma gondii* (a protozoan). In addition, Dr. Mason Reichard (Dep. of Veterinary Pathology, Oklahoma State University) found that up to 45% of independent lions sampled may be infected with *Trichinella* sp. (a nematode). Finally, we are collaborating with Dr. Melanie Culver (Arizona Cooperative Fish and Wildlife Research Unit, Univ. of Arizona) and Ph.D. student Alex Erwin (Univ. of Arizona, Conservation Genetics Lab) to examine lion genetic relatedness, reproductive success, and population structure.

Field operations for this study will be completed by end of December 2014. Starting January 2015 the principal investigator along with collaborators will begin a formal phase of data analysis and write-up to prepare the information for application in lion management in Colorado.

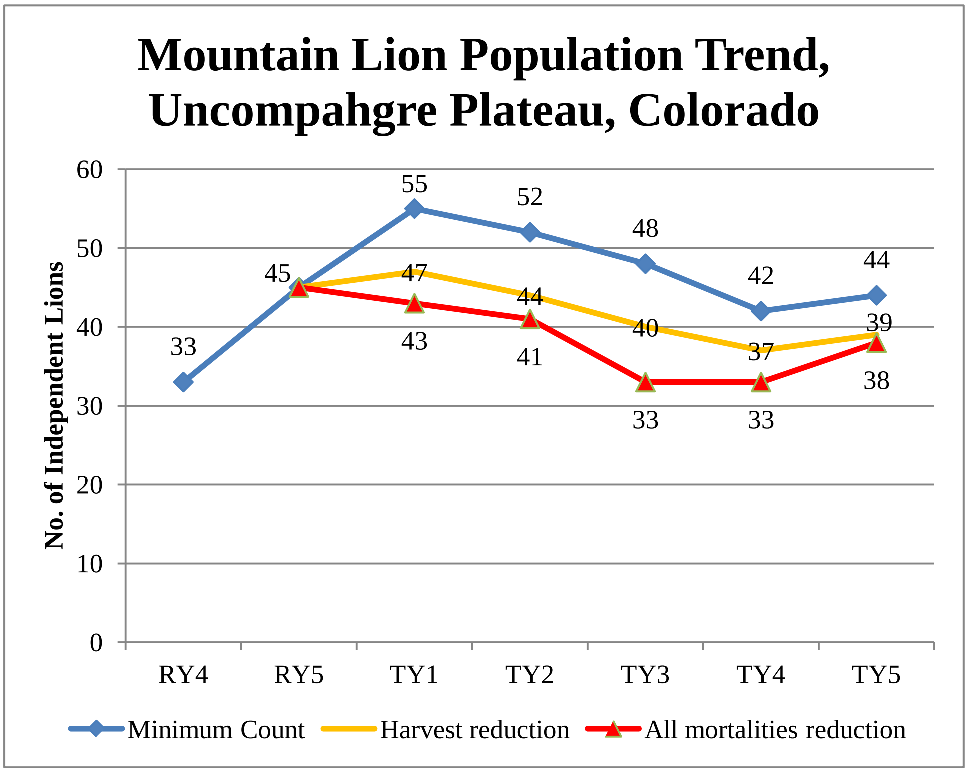


Figure 1. Trends in the population of independent mountain lions associated with no sport-hunting in the *reference period* years 4 and 5 (RY4, RY5) and with sport-hunting in the *treatment period* years 1 through 5 (TY1 to TY5), Uncompahgre Plateau, Colorado. The minimum count data were gathered from November through April each winter in efforts to canvass the study area thoroughly to count the number of independent lions in addition to non-marked lions killed by hunters. These data represent the number of independent lions expected to be on the study area during November through March each winter and coincided with the Colorado lion hunting season.

Colorado Parks and Wildlife

WILDLIFE RESEARCH PROJECT SUMMARY

Cougar and black bear demographics and cougar-human interactions in Colorado

Period Covered: July 1, 2013 – June 30, 2014

Principal Investigator: Mathew W. Alldredge, mat.alldredge@state.co.us

All information in this project summary is preliminary and subject to further evaluation. Information MAY NOT BE PUBLISHED OR QUOTED without permission of the principal investigator. Manipulation of these data beyond that contained in this summary is discouraged.

PROJECT NARRITIVE OBJECTIVE

1. To assess cougar (*Puma concolor*) population demographic rates, movements, habitat use, prey selectivity and human interactions along the urban-exurban Front Range of Colorado.
2. Develop methods for delineating population structure of cougars and black bears (*Ursus americanus*), assessing diet composition and estimating population densities of cougars for the state of Colorado.

SEGMENT OBJECTIVES

Section A: Telomeres and Stable Isotopes

1. Evaluate the potential to develop a model for estimating age of bears and cougars based on telomere length.
2. Determine diet composition of bears and cougars using stable isotopes.

Section B: Front Range cougars

3. Capture and mark independent age cougars and cubs to collect data to examine demographic rates for the urban cougar population.
4. Continued assessment of aversive conditioning techniques on cougars within urban/exurban areas, including use of hounds and shotgun-fired bean bags or rubber bullets (Completed).
5. Continue to assess relocation of cougars as a practical management tool.

6a. Assess cougar predation rates and diet composition based on GPS cluster data (Completed).
6b. Assess kill site dynamics and prey selection of cougar kills.

7. Model movement data of cougars to understand how cougars are responding to environmental variables.
8. Develop non-invasive mark-recapture techniques to estimate cougar population size.

2013-2014 Project Overview

Field efforts during 2013-2014 were primarily focused on the development of noninvasive population estimation techniques for cougars and bobcats (see summary for **Noninvasive genetic sampling to estimate cougar and bobcat abundance, age structure, and diet composition**). The field efforts for the remaining segment objectives listed above have been completed and are in various stages of data analysis and publication.

Section A: Telomeres and Stable Isotopes

1. Evaluate the potential to develop a model for estimating age of bears and cougars based on telomere length.
   Field work completed—data analysis and publication in progress (see summaries **Spatio-temporal patterns of diet and telomere length in Colorado black bears** and **Effect of human activity on cougar diet and age structure: non-invasive approaches**)

2. Determine diet composition of bears and cougars using stable isotopes.
   Field work completed—data analysis and publication in progress (see summaries **Spatio-temporal patterns of diet and telomere length in Colorado black bears** and **Effect of human activity on cougar diet and age structure: non-invasive approaches**)

Section B: Front Range cougars

3. Capture and mark independent age cougars and cubs to collect data to examine demographic rates for the urban cougar population.
   Field work nearly completed—see Federal Aid report for preliminary summaries

4. Continued assessment of aversive conditioning techniques on cougars within urban/exurban areas, including use of hounds and shotgun-fired bean bags or rubber bullets.
   Field work completed—see Federal Aid report for preliminary results and summaries

5. Continue to assess relocation of cougars as a practical management tool.
   In progress—see Federal Aid report for preliminary data

6a. Assess cougar predation rates and diet composition based on GPS cluster data.
   Field work completed—data analysis and publication in progress (see summary **Puma foraging in an urban to rural landscape**)

6b. Assess kill site dynamics and prey selection of cougar kills.
   Field work completed—data analysis and publication in progress (see **Predator-prey dynamics in relation to chronic wasting disease and scavenging interactions at cougar kill sites)**

7. Model movement data of cougars to understand how cougars are responding to environmental variables.
   Field work completed—contact Mat Alldredge for current publications.

8. Develop non-invasive mark-recapture techniques to estimate cougar population size.
   Field work completed—data analysis and publication in progress (see summary **The Use of Lures, Hair Snares, and Snow Tracking as Non-Invasive Sampling Techniques to Detect and Identify Cougars**)

Noninvasive genetic sampling to estimate cougar and bobcat abundance, age structure, and diet composition

Cougar and bobcat populations are actively hunted throughout the state of Colorado and management is applied using the best available information. Unfortunately, reliable information on cougar and bobcat populations is nascent. The best information available comes from long-term studies on relatively small populations where animals have been repeatedly captured. However, to better manage these populations, broad-scale information for these species is necessary.

We have begun developing noninvasive genetic sampling (NGS) techniques to provide better, less expensive data for cougars and bobcats that can be implemented at broad geographic scales with state-wide application. The methods being developed should provide information on population size/trend, sex structure, age structure, and diet composition. This information is valuable to the future management of these species and for the justification of harvest levels imposed on them.

Over the next few years we intend to further refine these NGS techniques for cougars and bobcats so that they can be reliably implemented to inform management decisions. We also intend to perform at least one full survey over multiple years so that we can assess the reliability and repeatability of this approach. Following these efforts our hope is that we will have a fully developed NGS approach for cougars and bobcats that can be implemented at a state-wide level for future monitoring of these species.

Objectives:

1. Continue to evaluate the use of auditory calls for NGS sampling of cougars.
2. Implement a NGS survey for cougars over multiple years to evaluate the consistency of the approach.
3. Use collared cougars to evaluate trap response of cougars and assess potential biases in the NGS approach.
4. Evaluate the potential to sample bobcats using the same NGS approach.
5. Test alternative hair snaring devices for felids.
6. Assess a simultaneous sampling approach for bobcats and cougars relative to differences in home-range size.
7. Implement an NGS survey over multiple years for bobcats and cougars to determine the logistics, cost and feasibility of sampling to obtain estimates of density, sex structure, age structure and diet composition.

Following on the success of the development of noninvasive techniques for sampling cougars (reference attached summary) we initiated a three year study to continue to develop noninvasive methods for sampling cougars and bobcats. Sites were built in November and December, 2013, and were monitored for 12 weeks during January – April, 2014 (Reference FA report – website link?). A total of 105 sites were set starting on January 6, 2014 and concluding on April 9, 2014. Individual sites were active for an average of 82 days (range 26-82) for a total of 5,178 site days.

A minimum of 61 cougar detections were documented during the sampling at 37 different sites. A total of 78 hair samples were collected from cougars, but these did not always have photographic evidence of the detection. Although it was not emphasized 16 cougar tracks were recorded at sites. There were also many occasions where cougars were detected but did not leave hair samples on the snags.

A minimum of 18 bobcat detections were documented on camera during the sampling at 16 different sites. Only 1 hair sample was obtained from these bobcats. Likely this is because hair snags were set at heights more appropriate for snagging cougar hair. The potential for setting vertical snags instead of horizontal snags needs to be investigated as they may be less sensitive to animal size. Bobcat tracks were seen at 3 different sites. This study is scheduled to continue through spring of 2016.

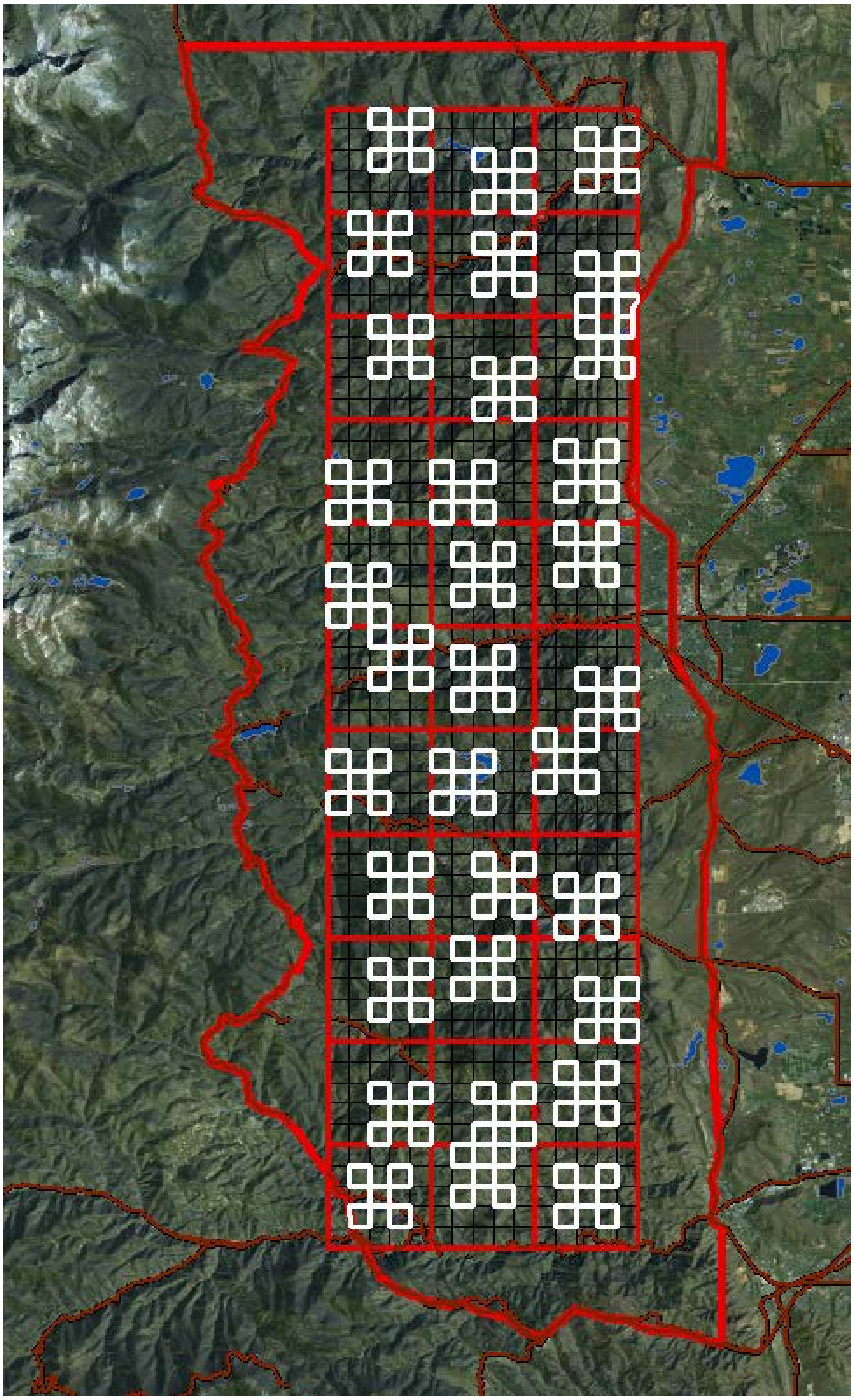


Figure 1: Study area boundary and grid layout for NGS cougar and bobcat sites. Larger squares represent the 5 km^2 grid overlaid with a 1 km^2 grid. White 1 km^2 cells represent the randomly selected cells where actual lure sites will be placed.

Spatio-temporal patterns of diet and telomere length in Colorado black bears

Becky Kirby (UW-Madison), Jonathan Pauli (UW-Madison), Mat Alldredge (Colorado Parks & Wildlife)

The effect of human-derived food on free-ranging wildlife populations is a growing problem across North America, and is particularly evident among carnivore populations. In Colorado, American black bear (*Ursus americanus*) conflicts have been increasing, and research is focused on elucidating factors that drive such conflicts. Understanding the influences of food availability and population trends is necessary to mitigate risks posed by these conflicts. To this end, this project aims to assess broad-scale patterns of diet and age in black bears across Colorado in hunter-harvested bears.

We are quantifying diet and telomere length of black bears, in relation to geographic and habitat variables. Specifically, we are examining the amount of human food consumption, compared to native foods. Because human food is often underestimated using traditional diet reconstruction analyses due to issues such as digestibility, we are using stable isotope analyses that reflect assimilated diet. Further, we are examining a non-invasive technique related to aging in black bears, using genetic analyses of telomere length measured by qPCR. Telomere length is related to chronological age, but also can be a valuable indicator of fitness and senescence.

In fall 2011, we collected hair and blood samples from ~400 hunter-harvested and nuisance bears, and have analyzed the isotopic signature in $\delta^{13}C$ and $\delta^{15}N$. Enriched (higher) signatures likely indicate greater consumption of human-derived foods and animal matter, respectively. Adults and eastern bears are significantly enriched in both $\delta^{13}C$ and $\delta^{15}N$ in hair samples. Females are also enriched in $\delta^{13}C$, as well as nuisance/roadkill bears (Table 1). Using stable isotopic mixing models parameterized with diet samples, preliminary results indicate that as a whole population, Colorado bears are primarily consuming vegetation (80-90%), followed human-derived foods (~10%), and very little animal matter (Figure 1). These preliminary analyses suggest individual and seasonal differences in diet, and refined analyses are forthcoming.

We also quantified relative telomere length from these hair follicles in 248 individuals, ranging in age from 1-21 (estimated by cementum annuli). Samples exhibit wide variation among telomere length (T/S) across ages, showing no significant trend (Figure 2). Further, we found no relationship with either sex or head size of individuals and telomere length. Because these individual characteristics seem to play little role in telomere attrition in this population, we sought to examine other factors that may be driving telomere length in Colorado bears. So far, the strongest patterns of telomere length emerge along latitude and elevation; telomere length is negatively correlated with both (Figure 3). Because we are starting to see interesting patterns in telomere length, ongoing longitudinal studies are necessary to elucidate rates of change rather than single time-point samples and increase resolution of covariates.

This study will yield insight into bear foraging ecology and aging, especially how human food and land use impacts both. Further development of these isotopic and molecular techniques will be aid in future bear management and biological studies.

Table 1. Stable isotope signatures of Colorado bear hair (represents summer diet) and blood (represents fall diet) grouped by region, age class, mortality type, and sex. Eastern bears are generally enriched in $\delta^{13}C$ and $\delta^{15}N$ in hair samples, as are adult bears. Blood samples of each, however, are less differentiated, suggesting a more uniform fall diet. Conflict bears are enriched in $\delta^{13}C$ and $\delta^{15}N$. Females are enriched in $\delta^{13}C$ in hair compared to males, but there is no difference between sexes in blood samples.

Group Comparisons	**Stable Isotope Signature**					
	Hair			**Blood**		
	n	**$\delta^{13}C$**	**$\delta^{15}N$**	***n***	**$\delta^{13}C$**	**$\delta^{15}N$**
NE	*45*	-20.93^{a}	4.95	*19*	-22.18^{a}	5.93
NW	*126*	-22.20^{b}	5.05	*49*	-23.85^{b}	5.52
SE	*86*	-20.90^{a}	5.81	*41*	-22.34^{a}	5.92
SW	*97*	-22.01^{b}	5.05	*43*	-23.78^{b}	5.17
p-value		*<0.001*	*<0.001*		*<0.001*	*0.03*
Adults	*156*	-21.46^{a}	5.51	*67*	-23.31^{a}	5.61
SubAdults	*61*	-21.58^{ab}	5.38	*27*	-22.89^{a}	5.87
Juveniles	*106*	-22.09^{b}	4.78	*41*	-23.37^{a}	5.33
p-value		*<0.001*	*<0.001*		*0.37*	*0.22*
Hunter-harvested	*325*	-21.77	5.15	*127*	-23.37	5.45
Nuisance/Roadkill	*29*	-20.55	6.02	*25*	-22.43	6.24
p-value		*<0.001*	*0.001*		*0.01*	*0.007*
Male	*218*	-21.80	5.32	*95*	-23.19	5.69
Female	*135*	-21.47	5.06	*56*	-23.24	5.39
p-value		*0.01*	*0.05*		*0.82*	*0.16*

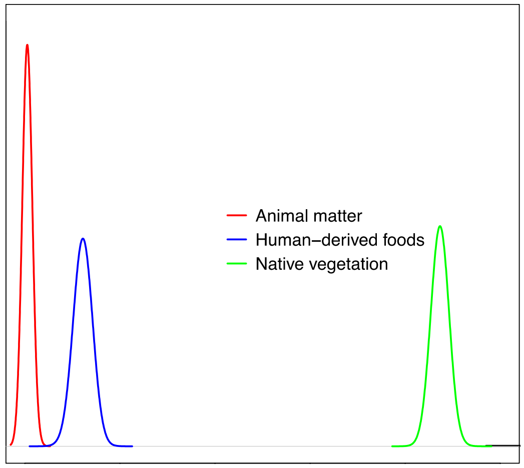


Figure 1. Results from SIAR for Colorado bear hair (n=354) analyzed as a single population, characterized by diet mixing space indicating proportional contributions of each diet group.

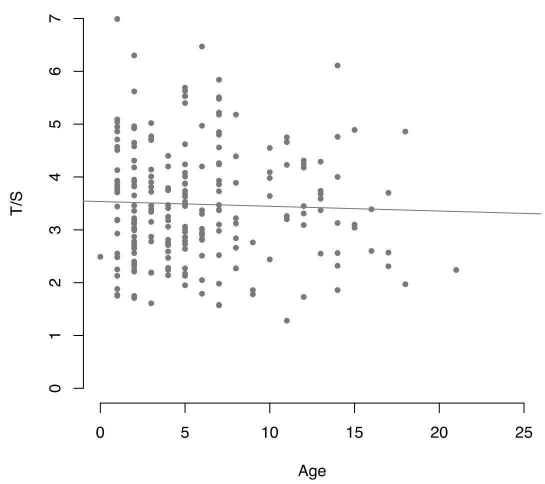
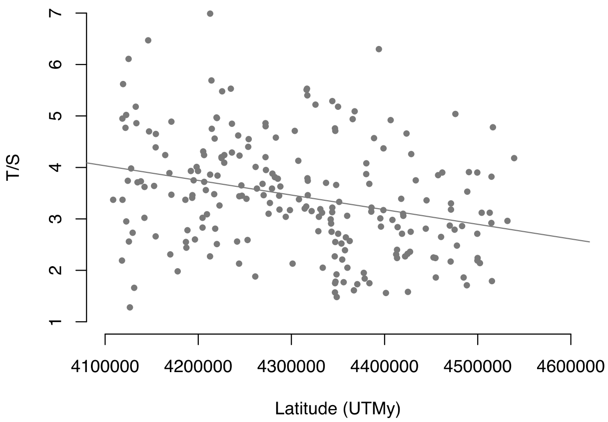
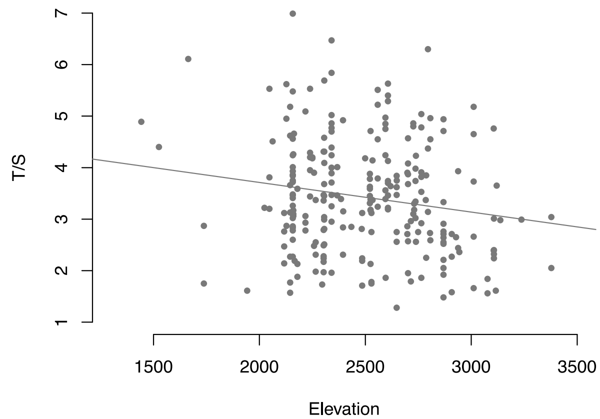


Figure 2. Age and telomere length (T/S) (n=220). No significant relationship.



a)



b)

Figure 3. a) Telomere length (T/S) regressed on UTMy coordinates (latitude) showing a significant trend toward shorter telomeres farther north. P<0.001, Adj. R-squared = 0.09. b) Telomere length (T/S) regressed on elevation showing a significant trend toward shorter telomeres at higher elevations; P<0.007, Adj. R-squared = 0.03.

Effect of human activity on cougar diet and age structure: non-invasive approaches

Wynne Moss (UW-Madison), Jonathan Pauli (UW-Madison), Mat Alldredge (Colorado Parks & Wildlife)

The cougar (*Puma concolor*) is an ecologically important top predator, and one that is increasingly found in urban areas. In the Front Range of Colorado, cougars frequently utilize rapidly expanding urban and exurban habitats, leading to a high incidence of cougar-human conflict. Understanding how and why cougar use these habitats would help mitigate risk to both humans and cougars. In particular, examining the foraging behavior of cougars is a high priority, as it can drive habitat use and propensity for conflict, and is important for predicting their influence on native prey species.

We are quantifying the habitat use and diet composition of cougars in both wildland and near-urban environments of Colorado to understand how urbanization may alter foraging ecology. Specifically, we are comparing the diets of cougars on the Uncompahgre Plateau (a wildland area) to those in the Front Range (a near-urban area). To better understand the factors influencing cougar prey use, we are also examining how diet composition in the Front Range is related to cougar age-sex class, body condition, and habitat use. Because cougars are cryptic in behavior, we are utilizing stable isotope analysis, which has the potential to be applied non-invasively, to study diet. In addition to developing a non-invasive approach for studying diet, we are also exploring ways to non-invasively monitor cougar age structure through genetic analysis of telomere length.

Beginning in 2012, we have collected hair samples from both cougar and potential prey species, and have analyzed the isotopic signature in $\delta^{13}C$ and $\delta^{15}N$ (Table 1). Using stable isotope mixing models, we estimated the relative importance of different classes of prey to cougar diets. We found that cougars in the Front Range obtained 67-76% of their diet from native herbivores, mostly elk and deer, whereas in the Uncompagre Plateau, nearly all of the diet (98-100%) came from native herbivores (Figure 1). Individuals in the Front Range population were much more heterogeneous in diet, and these differences appeared to be driven mostly by habitat use. Individuals who foraged in areas of higher housing density relied more heavily on smaller-bodied prey, like synanthropic wildlife and domestic species (Figure 2). Males were also more likely to use non-ungulate prey than females.

Finally, we have obtained blood and hair samples from known-age cougars on the Front Range and have begun extracting DNA to measure relative telomere length. In numerous mammals, telomeres shorten as an individual ages, and thus shorter telomeres indicate an older individual. This relationship has not been characterized in cougars; therefore it is not known whether such a correlation exists. In the upcoming year, we will utilize quantitative PCR to estimate telomere length, and examine whether this technique could be used to age non-invasively obtained hair samples.

This study will yield novel insights into cougar foraging ecology, primarily how diet is affected by human activity. In addition, we are developing important tools to non-invasively monitor cougars that could help implement more cost-effective and wider-scale studies of their behavior and population biology.

Table 1. Stable isotope values for cougars and their potential prey in the Front Range (FR) and Uncompahgre Plateau (UP) study areas, 2007-2013. Isotope values are given in ‰, relative to international standards and are not corrected for trophic discrimination. When prey signatures were not different between study sites, they were grouped. The Front Range population has higher variability in isotopic signature, and therefore diet.

		$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)
Sample	*n*	Mean ± SD	Mean ± SD
Cougar			
FR	41	-21.3±0.7	8.1±0.8
UP	63	-21.6±0.5	8.5±0.5
Prey			
Small domestics[1]	29	-16.7±2.4	6.2±1.3
Synanthropic wildlife[2]	38	-20.6±1.3	7.4±1.4
Large domestics[3]	26	-22.5±1.4	6.9±1.6
Native herbivores[4] (FR)	48	-24.4±1.0	3.8±1.5
Native herbivores (UP)	15	-24.1±0.4	5.0±1.1

[1]Small domestics: cat (*Felis catus*), dog (*Canis familiaris*), chicken (*Gallus domesticus*)
[2]Synanthropic wildlife: raccoon (*Procyon lotor*), skunk *(Mephitis mephitis*), fox (*Vulpes vulpes*), coyote (*Canis latrans*), squirrel (*Sciurus spp.*)
[3]Large domestics: llama (*Llama glama*), sheep (*Ovis aries*), goat (*Capra aegagrus*), alpaca (*Vicugna pacos*)
[4]Native herbivores: mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), rabbit (*Sylvilagus nuttallii*)

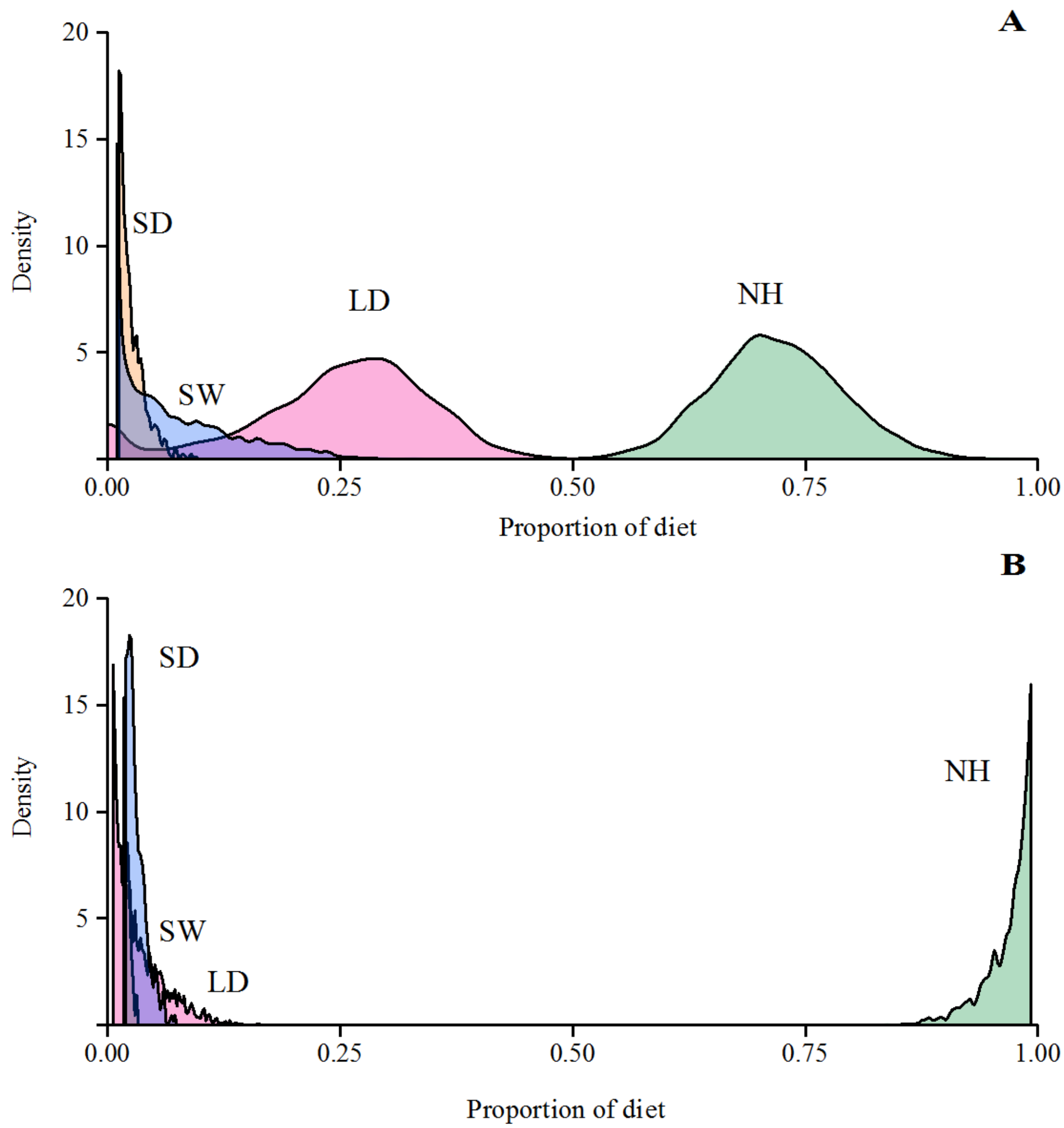


Figure 1. Relative contributions of diet items to the cougar populations in the Front Range (left) and Uncompahgre Plateau (right). Output from isotope mixing models are shown as density plots from simulations, or the relative likelihood of a diet item occurring in a given proportions. Native herbivores (NH) contribute the most to both populations' diet, followed by large domestics (LD), synanthropic wildlife (SW), and small domestics (SD). Cougars in the Uncompahgre Plateau rely much more heavily upon native herbivores, primarily elk and mule deer.

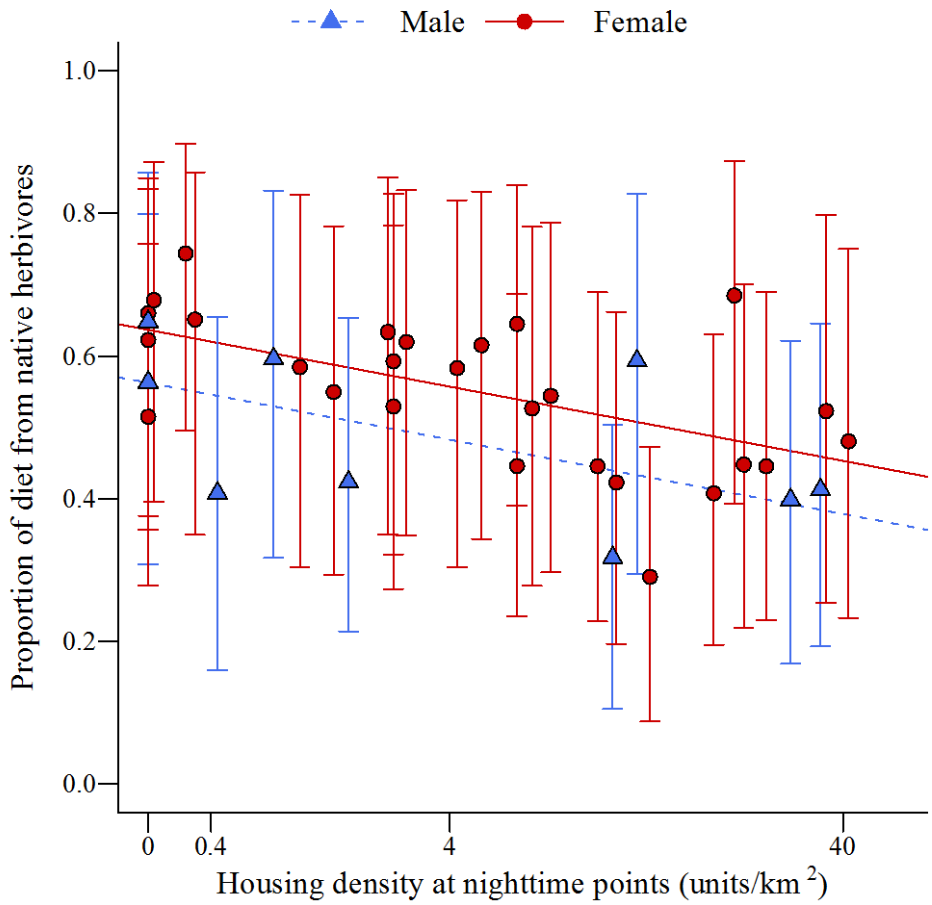


Figure 2. Effect of housing density and sex on proportional contribution of native herbivores to cougar diet. Housing density at foraging locations and sex were the two most important covariates in predicting isotopic signature. The percent of diet from native herbivores was estimated using mixing models and mean and 95% credibility intervals are plotted for each individual. As individuals foraged in more urban areas, where housing density is greater, their use of primary prey decreased. Overall, males utilized less primary prey than females, across all levels of housing density.

Puma foraging in an urban to rural landscape

Kevin Blecha (Colo. State Univ.), Mat Alldredge (CPW), and Randy Boone (Colo. State Univ.)

Improvements on GPS location cluster analysis for the prediction of large carnivore feeding activities: Model based sampling, detection probability, and inclusion of activity sensor measures

Animal space-use studies using GPS collar technology are increasingly incorporating behavior based analysis of spatio-temporal data in order to expand inferences of resource use of animals. GPS location cluster analysis is one such technique increasingly applied to large carnivores to identify the timing and location of feeding events. Integral to identifying feeding events, is a ground-truthing component, in which GPS location clusters are visited by human observers to confirm the presence or absence of feeding remains. Despite the high cost of conducting ground-truthing visits, model-based methods for making predictions to non-visited clusters are often overlooked. Published feeding prediction models seemed to have explored a small range of covariates; usually limited to spatio-temporal characteristics of the GPS data. We include activity sensor data as an additional covariate to increase prediction performance using a simple logistic regression GLM. Additionally we include covariates influencing the probability of ground-truthing observers to detect prey remains given a search delay of 2-60 days. Using a separate double observer study, we assess how much prey may be missed by an observer 2-60 days post cougar presence. We conclude that very few larger prey items are missed in our system and that the false-absences are from missing the prey remains of smaller species. Failing to account for sources of ground-truthing error can bias feeding rate predictions. The methods demonstrated will help future studies improve ground-truthing efficiency and model prediction accuracy while decreasing biases. We urge future studies to use shorter GPS fix intervals when possible along with a design based ground-truth sampling strategy, especially when predation on small prey is of concern.

Testing optimal foraging theory, energy maximization, and fear driven human avoidance of a large carnivore's foraging strategy

Understanding predator foraging ecology in regions of increasing anthropogenic development is important when devising management strategies to reducing cougar-human conflicts. A pure energy maximization strategy predicts that patch use of a foraging cougar is driven by the selection of landscape factors that maximize encounters with primary prey species. However, previous research on fine scale patch-use rarely shows linear relationships with direct measures of prey availability. A pure fear-driven strategy predicts that patch use is driven by landscape factors associated with higher risk of mortality. While it is logical that a cougar would avoid areas linked to higher rates of mortality, testing this has been met with only limited success. Optimal foraging theory would attempt to explain patch usage as a behavioral balancing act between energy maximization and fear-driven human aversion. A novel camera trapping survey technique using 41,000 trap nights was used to model fine scale background encounter rates across the landscape of various prey species of cougars, with particular emphasis on a range of housing densities. Predicted feeding site locations were derived for 49 cougars by a model using a training set of 4,400 clusters of ground-truthed GPS locations. Using a step-selection function analysis, characteristics (human housing, prey availability, and natural habitat) of hunting and feeding locations were compared to matched available locations. Then, landscape characteristics of feeding sites were compared to characteristics of GPS locations within the prior travelling sequence to test which factors led to a successful kill. Preliminary results indicate direct and indirect relationships in reference to humans and background encounter rates of primary prey (deer). Interestingly, successful hunting locations were more likely to occur with an increase in human housing intensity. However, some difficulties arise when teasing out the influence of alternative prey species (i.e., raccoon, domestic cat), whose background encounter rates may have increased the likelihood of this relationship.

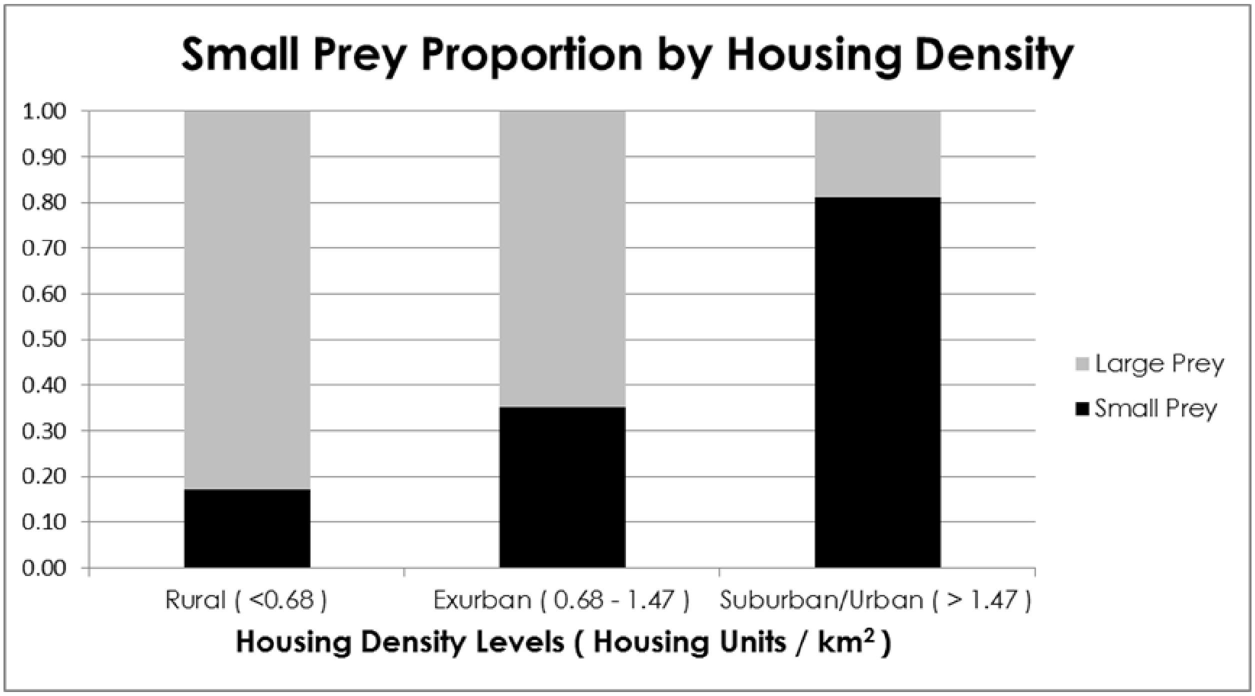


Figure 1. Proportion of cougar feeding sites composed of small (raccoon, house cat) and large-sized prey (adult wild ungulates) in the Colorado Front Range categorized by the housing density level the feeding site was located in. – not referenced in the above abstracts.

Predator-Prey dynamics in relation to chronic wasting disease and scavenging interactions at cougar kill sites

Joe Halseth, Matt Strauser, and Mat Alldredge (CPW)

The current Colorado Parks and Wildlife (CPW) cougar (*Puma concolor*) research on the Front-range is utilizing GPS radio collar technology allowing researchers to track cougar movements on a real time basis. With up to seven uploads a day, the roughly 20 current active project collars give researchers the ability to identify possible kill sites quickly, sometimes as soon as 6 to 12 hours after a kill is made. This provides the opportunity to explore previously un-researched facets of cougar behavior during the relatively short time interval from the point a cougar makes a kill, to the point at which it abandons the carcass. Feeding behavior, intraspecific kill site interaction, and scavenger competition can now be investigated.

Similar data to that collected in Krumm et al.'s (2005) and Miller et al.'s (2008) cougar studies, which examined cougar selection of Chronic Wasting Disease (CWD) positive mule deer (Odocoileus hemionus), can now be collected with a greater degree of efficiency. The study areas of each of the two prior CWD cougar projects lie within the more broad boundaries of the current Front-range cougar project, and a larger number of known cougars will increase sample sizes of CWD tissues from cougar-killed mule deer. Additionally, much of the field work from the two previous studies is nearly a decade old which justifies another project to compare to past results. The ability to collect a potentially larger sample size will yield more accurate findings, identify gaps in need of further study, and/or detect developing trends in regards to possible temporal patterns.

The ongoing cougar project's available technology and resources, and the relatively minor additional project costs, provide the opportunity to initiate a camera study to explore cougar feeding behavior and scavenger interaction in the period immediately following a cougar kill. Site visitation of fresh cougar kills also allows for the collection of adequate tissue samples to test for CWD, in order to further explore if cougars are selecting for CWD positive mule deer or other ungulates.

Objectives:

1. Document sharing and/or abandonment rates of cougars occupying kill sites in response to presence of other cougars and/or scavengers
2. Document time from kill until presence of competing scavengers
3. Document feeding patterns and length of individual feeding sessions.
4. Compare CWD infection rates from cougar-killed deer and elk to existing CPW CWD infection rates to determine if cougars are selecting for CWD positive deer and elk.

Scavenging and Kill Site Interactions

Placing cameras at kill sites was completed in January 2014 wrapping up 25 months of data collection. Over the course of the study we placed cameras on 225 kill sites recording over 400,000 photos. Pictures have been identified once and are currently in the process of a second round of identification.

Timely approaches to kill sites continued to be successful in 2013 and early 2014, usually occurring within 24 hours of a cougars first GPS location at a kill site. This allowed technicians to evaluate the prey item to ensure the estimated time of death matched the carcass condition in order to rule out other possible causes of death (road kill, hunting loss, etc). Cougars were often present at the kill site upon approach but usually retreated as the researcher neared the site. There were several situations where a cougar had been unwilling to move from a kill. In these situations technicians left the area, and if time allowed, returned at a later time.

We documented 6 instances throughout the study where carcasses were abandoned following camera placement. Four of these abandonments were due to the cougar occupying a second kill site and never returning to the first, and not likely a result of human visitation and camera placement on the first carcass. Cameras continued to document bear visitation in both scavenging and direct competition situations and photo sequences continue to be analyzed to determine frequency of these scenarios.

Red fox (Vulpes *vulpes)* were commonly observed scavenging at cougar kill sites. Other scavengers documented include striped skunk (*Mephitis mephitis)*, spotted skunk (*Spilogale gracilis)*, raccoon (*Procyon lotor*), ringtail cat (*Bassariscus astutus)*, grey fox (*Urocyon cinereoargenteus)*, coyote (*Canis latrans*), domestic dog (*Canis lupus familiaris)*, bobcat (*Lynx rufus)*, golden eagle (*Aquila chrysaetos)*, red-tailed hawk (*Buteo jamaicensis*), great-horned owl (*Bubo virginianus)* and a variety of *Corvidae* bird species.

Over the course of the study there have been at least 12 camera sites where we have identified multiple cougars simultaneously occupying a kill site. These observations include two 'sharing' situations involving two cougar family groups and multiple sharing situations involving an adult male and female. Other interactions include two instances of female cougars stealing food items from another female, three unrelated adult females, and one instance of an adult male feeding on a prey item occupied by a female and three young kittens. There have also been several instances where non-focal cougars scavenge on the remains of prey items already consumed and abandoned by the focal cougar.

CWD sample collections from cougar-killed ungulates were completed in April 2014 wrapping up 30 months of data collection. In 2013 and 2014, there were no problems with obtaining tissue samples to test for CWD except in rare situations where tissues have been consumed by the cougar. Samples collected in the field were issued a head tag and transferred to the CPW Wildlife Health Lab in Fort Collins for testing. Throughout the course of the study, we collected 192 samples from cougar-killed ungulates of which 190 were testable. Of these, 163 were adult mule deer (65M, 98F), 11 were adult elk and the rest comprised fawn mule deer (n=14), an elk calf (n=1), and an adult white-tailed deer (n=1).

Table 1 shows the breakdown of species, age and test results within each deer DAU from adult mule deer sampled within the broad boundary of the front-range cougar project. Tables 2 and 3 show mule deer sampling by sex and figure 1 shows the sampling breakdown by month throughout the entire study.

Table 1. Total CWD results

DAU	GMU	Total Sampled	Total Positive	% Positive
D-10	20	28	4	14.29%
D-27	29	78	17	21.79%
D-27	38	45	13	28.89%
D-17	39	2	0	0.00%
D-17	391	10	3	30.00%
	Total	163	37	22.70%

Table 2. Male mule deer CWD results

DAU	GMU	Males Sampled	Males Positive	% Positive
D-10	20	8	1	12.50%
D-27	29	32	10	31.25%
D-27	38	18	8	44.44%
D-17	39	2	0	0.00%
D-17	391	5	1	20.00%
	Total	65	20	30.77%

Table 3. Female mule deer CWD results

DAU	GMU	Females Sampled	Females Positive	% Positive
D-10	20	20	3	15.00%
D-27	29	46	7	15.22%
D-27	38	27	5	18.52%
D-17	39	0	0	0.00%
D-17	391	5	2	40.00%
	Total	98	17	17.35%

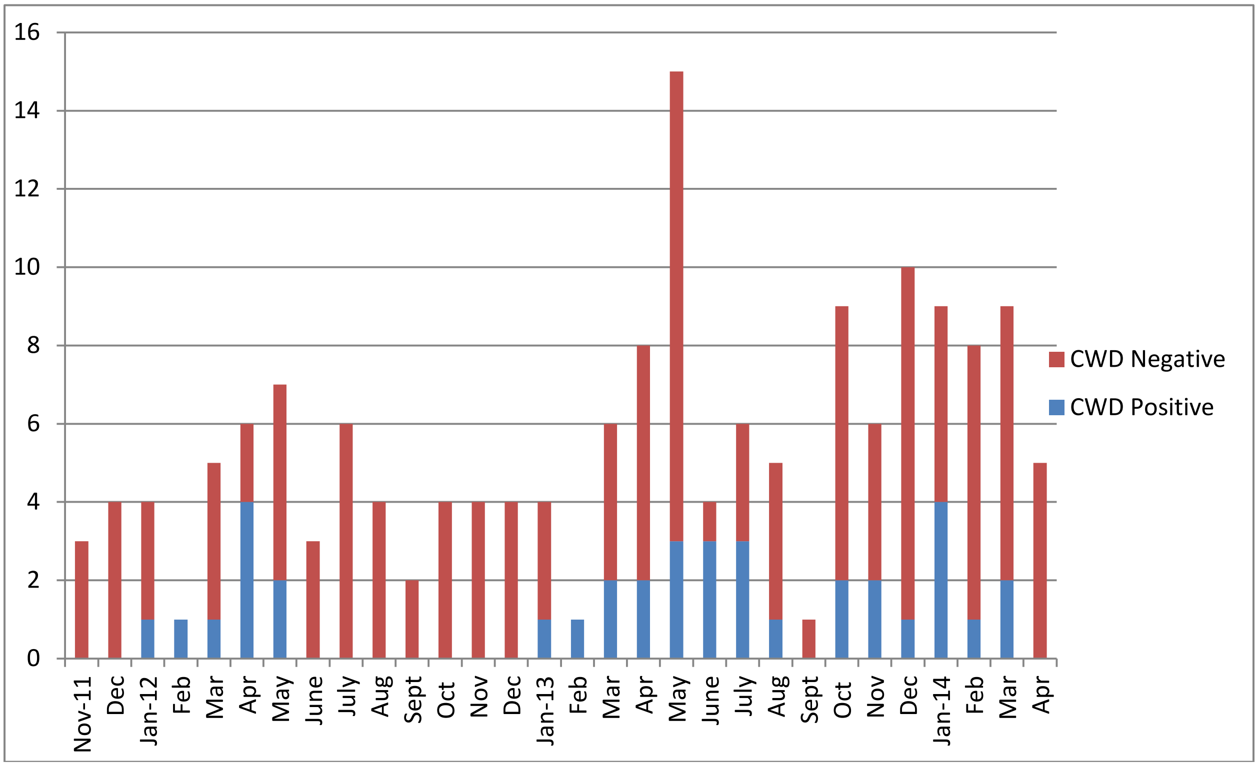


Figure 1. Mule deer CWD results by month.

The use of lures, hair snares, and snow tracking as non-invasive sampling techniques to detect and identify cougars

Kirstie Yeager, (Colo. State Univ.) Mat Alldredge (CPW), and Bill Kendall (Colo. State Univ.)

Development of a non-invasive method to sample cougars(*Puma concolor*)

A noninvasive method that will sample all individuals in a population over multiple occasions is a useful tool in assessing population demographics with little disturbance to the target animals. However, finding such a method for large carnivores, such as cougars, is a challenging task due to their elusive nature and large home-range sizes. Current methods to sample cougars usually involve a capture component, but obtaining reliable estimates can be difficult and cost prohibitive when using capture as the sole sampling method. Because cougars leave sign, and exhibit behaviors like territoriality and curiosity, a noninvasive-genetic-sampling (NGS) method can be a plausible alternative. Hair contains DNA which can be genetically analyzed to yield the individual identification necessary for population assessments and can be obtained without handling the animal. We tested NGS techniques to obtain genetic samples from cougars. We evaluated attractants and hair-snaring techniques at lure sites in Boulder and Jefferson Counties on the Front Range, Colorado during February – April, 2012 and November – April, 2013. We tested auditory predator calls and scent lures in conjunction with hair-snaring techniques. We established 16–20 sites over four ≈ 30-day sampling periods. At 18 (out of 33) sites with auditory calls, we observed 40 site visits by ≥ 13 individual cougars (Table 1). In addition, we obtained 14 hair samples. We conclude that auditory calls and hair snares are an effective way to assess the various population demographics that are needed to inform management decisions.

Table 1. Sixty-eight sites were established on the Front Range, Colorado, over two winter field seasons to sample cougars. Attractants were placed at each site. Four different types of sites, varying by the attractant present, were established (16 – 18 of each type). The average time a site was active ranged from 29.0 – 33.3 days. The total sampling effort for each site type was 464 – 600 days. Motion-censor cameras placed at each site documented cougar detections. Some cougars were uniquely marked with ear tags indicating the number of individual marked cougars detected (n = 13). Some were detected at multiple site types. In addition, we estimated the proportion of sites (±SE) where > 1 cougar was detected.

Attractant(s)	No. of sites	Avg. days active	Total days active	Total no. of detections	No. of different marked cougars detected ‡	Proportion of sites w/detections
Bait only	17	31.6	538	5	2	0.24 ± 0.11
Bait & scent	18	33.3	600	12†	3	0.28 ± 0.11
Bait & call	16	29.0	464	15	7	0.50 ± 0.13
Bait, scent, & call	17	32.2	547	25	9	0.59 ± 0.12

† Seven detections were at the same site and probably by two individuals.
‡ Several individual cougars were detected at multiple site types.

Assessing the probability of individually identifying cougars using auditory predator calls and hair snares

Detecting all individuals in a population equally and with certainty will yield unbiased population estimates; however, many current sampling techniques have inherent variation, such as a trap response or individual heterogeneity. From November – April, 2013, we applied a noninvasive method to sample cougars and assessed variation in detection in two study areas in Colorado; one on the Front Range (FR; 1,270 km²) in Boulder, Jefferson, and Gilpin Counties and one on the Uncompahgre Plateau (UP; 540 km²) in Montrose and Ouray Counties. In total, we established 148 lure sites with auditory predator calls and hair snares over three (UP) and four (FR) sampling periods. Each site was active an average of 28.5 days (4,214 sampling nights). On the FR, we observed 98 detections by 13 independent marked cougars, two sibling groups, and ≥ 16 unmarked animals (Table 1). On the UP, we documented 18 detections by seven independent marked cougars and no unmarked animals. Collectively, 14 of the 20 detected cougars were observed multiple times. We used the GPS location data of 27 previously radiocollared cougars to determine availability and estimated detection probabilities. The probability of detecting an independent marked cougar at least once during the study adjusted for partial availability was 0.83 ± 0.10 (FR) and 1.00 (UP). We collected 59 hair samples. Thirty-two were genotyped at ≥ 8 loci identifying 26 unique cougars. Given our results, we concluded that a noninvasive-sampling technique using auditory calls and hair snares can be a useful tool in assessing population demographics of cougar populations.

Table 1. From November to April, 2013, 21 – 25 lure sites for each of four sampling periods were placed across the Front Range, Colorado, to sample cougars. We observed 98 detections. We estimated the probability of detecting a marked cougar (via photograph) given that it was in the study area at least one night during the sampling period (± 1 SE). In addition, we estimated the probability that a cougar entered the site given that it was observed and the probability of obtaining a hair sample given that the cougar entered the site.

	No. of detections	Detected/ available	Entered/ detected	No. of samples	Samples/ entered
Period 1	27	0.38 ± 0.15	0.74 ± 0.09	8	0.40 ± 0.10
Period 2	30	0.39 ± 0.13	0.77 ± 0.08	19	0.83 ± 0.07
Period 3	25	0.35 ± 0.13	0.80 ± 0.08	16	0.80 ± 0.08
Period 4	16	0.35 ± 0.13	0.69 ± 0.12	9	0.82 ± 0.10

Colorado Parks and Wildlife

WILDLIFE RESEARCH REPORT SUMMARY

Research library, annual report

Period Covered: July 1, 2013– June 30, 2014

Author: Kay Horton Knudsen, kay.knudsen@state.co.us

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The Colorado Parks and Wildlife Research Center Library has existed for several decades in the Ft. Collins office. Early librarians can be credited with the physical organization of the Library including seven decades of Federal Aid reports, over 50 years of Wildlife Commission reports and a unique book and journal collection. The goal of the Library is to provide an effective program of library services for Colorado Parks and Wildlife employees, cooperators and wildlife educators. The Library also serves as a historic archive for CPW publications. The mission of outreach and support is fulfilled using technology to provide a library website with the online catalog, wildlife databases and digitized documents available to CPW staff statewide.

As of June 30, 2014, the Research Library held 18,948 titles and 31,559 items (these are the multiple copies of a title) and had 169 registered patrons (CPW staff). As part of the project to digitize CPW documents, the equivalent of 6GB of data has been scanned and uploaded to the catalog vendor.

Current wildlife databases include BioOne, four of EBSCO's specialty databases (Environment Complete, Fish and Fisheries Worldwide, Wildlife and Ecology Studies Worldwide and CAB Abstracts), Birds of North America, ProQuest Dissertations and Theses and the JSTOR Life Sciences collection. Print subscriptions to the major wildlife journals were cancelled several years ago, however online access to the journals was retained and continues as a primary usage point for staff. CPW staff statewide are authenticated through WildPoint (intranet) eliminating the need for individual usernames and passwords.

A major project has been the digitization of CPW publications. In the last 3 years, Terrestrial Federal Aid reports (1948 to present) along with the report collections *Outdoor Fact, Special Reports, Technical Publications* and *Division Reports* have all been scanned. The resulting PDFs are attached to bibliographic records for each title within the series and are available via the Library catalog for download. At CPW staff request, digital scans of Big Game Hunting brochures from 1950-1995 were made at a local commercial vendor in the spring of 2014. These and other hunting brochures will eventually be made available to staff and the public.

With expanded library services, the number of requests for documents or research assistance has grown. The Library website provides more full-text resources than ever before, however there are also more abstract-only indexes. The Library is not open on a walk-in basis to the general public but the librarian does assist the Denver Help Desk and area staff with questions they receive from citizens. The chart below shows the number of reference questions and document requests handled by the librarian each month during the past 6 years (Table 1); the highest number of monthly requests occurred October 2013. Please note that one request from a CPW staff member may be for multiple journal or book titles.

Table 1. Monthly CPW Research Library reference requests August 2008–June 2014.

	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
July		20	45	28	37	60
Aug	15	25	34	52	44	45
Sept	21	30	37	53	48	46
Oct	33	38	41	42	39	**74**
Nov	14	28	46	52	51	48
Dec	28	32	34	52	49	46
Jan	33	62	48	64	46	53
Feb	30	43	43	43	54	62
Mar	35	36	46	36	53	48
Apr	24	23	30	42	70	57
May	13	17	51	53	65	39
June	20	26	27	36	35	34
TOTAL	266	380	482	553	591	612