Colorado Division of Parks and Wildlife
July 2015 - June 2016

WILDLIFE RESEARCH REPORT

State of:	Colorado	:	Division of Parks and Wildlife
Cost Center:	3430	:	Mammals Research
Work Package:	3003	:	Predatory Mammals Conservation
Task No.:	2	:	Cougar Demographics and Human Interactions
		:	Along the Urban-Exurban Front Range of
		:	Colorado
Federal Aid Project No.	W-204-R5		

Period Covered: July 1, 2015 - June 30, 2016

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ABSTRACT

Our principal research objective was to assess cougar population ecology, prey use, movements, and interactions with humans along the urban-exurban Front Range of Colorado. This year capture efforts focused on removing collars from previously collared cougars. Only 4 cougars remain with collars as batteries died before they could be captured and collars removed. Only 1 mortality was documented this year, an adult male injured while preying on an elk (Table 1). Home-range patterns remained consistent to previous years. Mule deer are the predominant prey in cougar diets, although cougars will also utilize elk regularly. The focus of this year's efforts was on noninvasive sampling of cougars and bobcats and removing collars. This project has been completed with the exception of preparing and submitting final publications.

WILDLIFE RESEARCH REPORT

COUGAR AND BEAR DEMOGRAPHICS AND HUMAN INTERACTIONS IN COLORADO

MATHEW W. ALLDREDGE

PROJECT NARRITIVE OBJECTIVES

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

Front Range cougars

1. Capture and mark independent age cougars and cubs to collect data to examine demographic rates for the urban cougar population. Remove collars in final year (Completed).
2. 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).
3. Continue to assess relocation of cougars as a practical management tool (Completed).
4. Assess cougar predation rates and diet composition based on GPS cluster data (Completed).
5. Model movement data of cougars to understand how cougars are responding to environmental variables (Field work completed, publication pending).
6. Develop non-invasive mark-recapture techniques to estimate cougar population size (Field work completed, publication pending).

FRONT RANGE COUGARS

BY M. ALLDREDGE

INTRODUCTION

Given that cougars currently coexist with humans within urban/exurban areas along Colorado's Front Range, varying levels of cougar-human interaction are inevitable. CPW is charged with the management of cougars, with management options ranging from minimal cougar population management, to dealing only with direct cougar-human incidents, to attempted extermination of cougars along the human/cougar spatial interface. Neither inaction nor extermination represent practical options, nor would the majority of the human population agree with these strategies. In the 2005 survey of public opinions and perceptions of cougar issues, 96% of the respondents agreed that it was important to know cougars exist in Colorado, and 93% thought it was important that they exist for future generations (CPW, unpublished data).

There is a growing voice from the public that CPW do more to mitigate potential conflicts, and the leadership of CPW has requested that research efforts be conducted to help minimize future human/cougar conflicts. In order to meet these goals, CPW believes it is necessary to directly test management prescriptions in terms of desired cougar population and individual levels of response.

Long-term study objectives for the Front Range Cougar Research project involved directly testing management responses of cougars at various levels of human interaction, as well as collecting basic information about demographics, movement, habitat use, and prey selection. The Cougar Management

Guidelines Working Group (CMGWG) (2005) recommended that part of determining the level of interaction or risk between cougars and humans is to evaluate cougar behavior on a spectrum from natural, to habituated, to overly familiar, to nuisance, to dangerous. The CMGWG (2005) clearly stated that there is no scientific evidence to indicate that cougar habituation to humans affects the risk of attack.

The use of GPS collars (obtaining up to 8 locations per day) allows for a detailed examination of demographic rates. We monitored cougars that utilize natural habitats and cougars that use a mixture of natural and urban habitats. This allowed for an assessment of demographic rates, movement patterns, and habitat use among cougars utilizing these two habitat configurations. We also monitored cubs (approximately 6 months of age or older), primarily to determine survival but potentially to understand movement patterns and dispersal.

The use of GPS collars also allowed us to study predator-prey relationships and diet composition. GPS locations were divided into selection sets based on the likelihood of the set of locations (clusters) representing a kill site. A random sample of these clusters was investigated to determine what a cougar was doing at the site, and whether or not it represented a kill site. Kill sites were thoroughly investigated to determine as much information as possible about what was killed at the site.

Researchers have tested several noninvasive techniques, some quite creative, on a variety of carnivores to detect and count individuals. Track surveys have been used with success in occupancy studies but fall short in their ability to produce accurate and precise abundance estimates (Diefenbach et al. 1994, Sargeant et al. 1998, Wilson and Delahay, 2001, Hayward et al. 2002, Choate et al. 2006, Gompper et al. 2006). However, when track surveys are combined with the collection of genetic material, species identification can be confirmed (McKelvey et al. 2006) and/or individuals identified, allowing for abundance estimates using mark-recapture analysis (Ulizio et al. 2006). Cameras, lures, and/or hair snares have also been used to survey cougars (Long et al. 2003, Choate et al. 2006, Sawaya et al. 2011), lynx (McDaniel et al. 2000, Schmidt and Kowalczyk 2006), bobcats (Harrison 2006), ocelots (Weaver et al. 2005), multiple felids (Harrison 1997, Downey et al. 2007), and carnivore communities (Sargeant et al. 1998, Long et al. 2007, Ruell and Crooks 2007, Castro-Arellano et al. 2008, Crooks et al. 2008). Though dozens of lures have been tested along with several novel hair-snaring devices, results have been variable, suggesting no single method superior above all others.

With regard to cougars, the potential of NGS has not been realized. Inconsistent results have left the techniques needing further testing and refinement. In past studies involving attractants, almost all have primarily used scents. Few surveys have incorporated auditory calls despite the fact that felids may exhibit a greater response to auditory cues than to olfactory stimulus (Chamberlain et al. 1999). Further testing of this component is needed to assess whether calls will attract cougars to sites. Furthermore, McDaniel et al. (2000) described a hair-snaring device that consisted of a board with a scent-lure-covered carpet pad and nails protruding through it nailed to a tree. Harrison (2006), McKelvey et al. (2006), Schmidt and Kowalczyk (2006), Long et al. (2007), and Sawaya et al. (2011) tested similar mechanisms on a variety of felids. These designs snagged hair part of the time though the quality of the hair and whether or not the hair was from the target species was inconsistent. Modifications in snare designs are needed to improve the reliability of the hair snagged, thus increasing the likelihood of obtaining a usable sample.

Barbed wire is an alternative hair-snaring mechanism to traditional scratch-pad designs. Barbed wire has long been used to collect hair samples from grizzly and black bears (Woods et al. 1999, Mowat and Strobeck 2000, Poole et al. 2001, Boersen et al. 2003, Belant et al. 2005, Boulanger et al. 2006, Dreher et al. 2007, Kendall et al. 2008, Settlage et al. 2008, Proctor et al. 2010). Ebert and Schulz (2009) used barbed wire to snag hair from wild boar; and Belant et al. (2007) obtained hair from white-tailed deer. We could not find a study that used barbed wire in an attempt to snag hair from a felid species.

Recent efforts by Yeager et al. to develop NGS as part of the Front-Range Cougar study have shown a great deal of promise (unpublished data). The use of an auditory call placed in a cubby with a barbed wire snag effectively sampled the majority of collared cougars on the Front-Range study and all of the collared cougars on the Uncompahgre Plateau cougar study. A significant proportion of the cougars sampled also provided hair that has yielded good quality DNA for genotyping.

Although this study has demonstrated positive results, there remain details on sampling design and field logistics that still need to be examined. Cubby sets can be extremely time consuming to build and cougars do not always enter the sets. Therefore it is important to investigate alternative designs to snag hair that still utilize the auditory call. It is also necessary to further investigate the detection process in order to develop the optimum site density and placement for snags. Finally, a full survey needs to be implemented and replicated to evaluate the technique, logistical constraints and long-term cost.

In addition to detecting cougars, the NGS design that we developed also provided a significant number of bobcat detections. With the increasing pelt prices for bobcats it is likely that harvest pressure will continue for bobcats. In order to better manage bobcats and justify harvest levels an estimate of bobcat density would also be useful. Preliminary data suggest that it could be possible to sample bobcats as well as cougars in the same NGS survey.

GPS collars were used to assess the effectiveness of lures or calls to attract cougars to hair snag locations as part of the development on noninvasive population estimation techniques. Understanding the effectiveness of these attractants was crucial to the development of these techniques and an assessment of potential biases that existed. We attempted to maintain 20 collared cougars for this portion of the study. We implemented a cougar/bobcat hair snag survey in 2013 and continued it through this year in order to further develop and assess these population estimation techniques.

STUDY AREA

The original pilot study was conducted in Boulder and Jefferson counties, in an area near Interstate 70 north to approximately Lyons, Colorado, which was also a likely area for addressing long-term research objectives and is the current study area for the development of noninvasive techniques (see Figure 3). The study area for portions of the long term study included this original area but was expanded south to highway 285. Research efforts in the additional southern portion were generally limited to capturing cougars that were in the urban setting and/or had interacted directly with humans. The study area is comprised of many land ownerships, including private, Boulder city, Boulder County, Jefferson County, and state and federally owned lands. Therefore, we have been directly involved with Boulder city and Boulder and Jefferson county governments to obtain agreements from these entities on conduct of research and protocols for dealing with potential human/cougar interactions prior to conducting any research efforts. We have also acquired permission to access numerous private properties to investigate cougar clusters and to trap cougars.

METHODS

As the study concluded this year we utilized GPS location data to efficiently remove collars from any active cougars in the study. Potential kills were identified and traps were set at these locations to capture cougars. We also used locations as a starting point to use hounds to capture cougars. Some baiting was conducted in areas where we knew cougars with non-functioning collars would potentially visit. Captured cougars were anesthetized, monitored for vital signs, aged, measured, and collars were removed.

We have concluded the evaluation of cougar diet composition by using GPS location data to identify likely kill sites. Characteristics of clusters of GPS locations representing cougar-killed ungulate sites (Anderson and Lindzey 2003, Logan 2006) were used to develop a standard algorithm to group GPS points together, to provide a sound sampling frame from which statistical inference could be made about clusters that were not physically investigated. These methods have been published in Blecha and Alldredge (2015).

Additional work on cougar movement modeling is being conducted as part of a Ph.D. project in collaboration with CSU. This work is utilizing existing GPS location data and does not involve field work. Analyses are an expansion on previous movement modeling work that has been done on this project and will examine various factors affecting movement of cougars across the landscape. This work will be completed in December 2016.

The final project to develop techniques for noninvasive sampling of cougars and bobcats has also been completed this year. Field work for this portion of the study was similar to previous year's. Cubbies for non-invasive sampling were constructed during November and sampling was done December 2015 through February 2016. This year we designed and built our own predator calls for use in this effort.

RESULTS AND DISCUSSION

Collared cougars from the previous year were captured and collars were removed. Baits were also used to attract and capture cougars with non-functioning collars. Despite our efforts, 4 cougars with non-functioning collars could not be captured. Only 1 mortality (natural) occurred this year (Table 1), which was expected given a small number of collared cougars.

Franny Buderman has been analyzing the cougar GPS location data with movement models to determine factors driving animal movement as part of her Ph.D. dissertation. This project will be completed in December 2016. The following is an abstract that she wrote documenting the work that is being conducted on cougar movement modeling:

> Assessing preferential use of the landscape is important for managing wildlife and can be particularly useful in transitional habitats, such as at the wildland-urban interface. We characterized preferential habitat selection by a population of mountain lions (Puma concolor) inhabiting the Front Range of Colorado, an area exhibiting rapid population growth. Preferential use is often evaluated using resource selection functions (RSFs), but they do not account for the habitat available to an individual at a given time and may mask conflict or avoidance behavior. Contemporary approaches to account for availability based on movement include spatio-temporal point process models, step-selection functions, and continuous-time discrete-space (CTDS) models. We used a continuous-time discrete-space (CTDS) framework to model transition rates among grid-cells as a function of landscape covariates. The CTDS framework is based on an underlying movement model and allows for inference on the same spatial scale as the covariates. We exploited the flexibility of the CTDS framework to accommodate location- and gradient-based drivers of movement, individual variation, and time-varying responses to variables such as prey availability, development, topography, and canopy cover. We failed to detect a significant population-level response to any of the covariates except for distance to kill site (Fig. 2), which had a positive effect on both transition rates (as individuals were further from a kill site, they were more likely to transition out of a grid cell) and directionality (Fig. 3; individuals were more likely to transition towards a kill site).

Following on the success of the development of noninvasive techniques for sampling cougars 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 (see study plan for details, Appendix VI). In 2014/15 and 2015/16 sites were built during November and monitored for three months starting the 1st of December and continuing through the first week of March.

Sites were modified in 2014/15 to use vertical hair snags instead of horizontal snags in an attempt to get more animals to enter the cubbies and to create a snag that could obtain samples from both bobcats and cougars. The number of unique observations of cougars increased this year compared to the previous and was comparable to the first year (Table 3). Hair samples from cougars increased accordingly and was comparable to the first year of the study. Hair samples from bobcats increased from 5 the first year to 12 the second year and 31 this year. This is likely a result of narrowing the spacing between the barbed wire to approximately 6 inches. Genotypes from bobcat hair has had limited success but is more successful for cougars. Field efforts for this portion of the study have concluded.

All field work for this study has concluded and much of the analysis and writing has been done. Below is a list of publications that have been written or are in progress.

Blecha, K.A., R.B. Boone, and M.W. Alldredge. (in prep). Acknowledging predator and prey population characteristics for understanding human-large carnivore conflicts in residential developed landscapes. Journal of Applied Ecology

Blecha, K.A., R.B. Boone, and M.W. Alldredge. (in review). Risk-reward tradeoffs of a large carnivore foraging in the urban wildland interface: prey availability and hunger. Journal of Animal Ecology.

R. Kirby, M.W. Alldredge, and J.N. Pauli. (in prep). The tension between foraging and hibernation shapes biological aging in bears.

R. Kirby, M.W. Alldredge, and J.N. Pauli. (in review). Extrinsic, not intrinsic, factors drive biological aging in black bears. Conservation Genetics.

W.E. Moss, M.W. Alldredge, K.A. Logan, and J.N. Pauli. (in review). Niche sprawl in an opportunistic apex carnivore.

R. Kirby, M.W. Alldredge, and J.N. Pauli. (2016). The diet of black bears tracks the human footprint across a heterogeneous landscape. Biological Conservation.

W.E. Moss, M.W. Alldredge, and J.N. Pauli. (2016). Quantifying risk and resource use for a large carnivore (Puma concolor) in an expanding urban-wildland interface. Journal of Applied Ecology.

Blecha, K.A. and M.W. Alldredge. 2015. Improvements on GPS location cluster analysis for the prediction of large carnivore feeding activities: ground-truth detection probability and inclusion of activity sensor measures. PLoSOne 10(9):e0138915.doic10.1371/journal.pone.0138915.

Lewis, J.S., K. A. Logan, M.W. Alldredge, L.L. Bailey, S. VandeWoude, K.R. Crooks. 2015. The effects of urbanization on population density, occupancy, and detection probability of wild felids. Ecological Applications 1880-1895.

Hanks, E.M., M.B. Hooten, and M. Alldredge. (2015). Continuous-time discrete-space models for animal movement. *Annals of Applied Statistics*, 9: 145-165.

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Bevins, S.N., S. Carver, E.E. Boydston, L.M., M.W. Alldredge, K.A. Logan, S.P.D. Riley, R.N. Fisher, T. W. Vickers, W. Boyce, M. Salman, M.R. Lappin, K.R. Crooks, and S. Vandewoude. 2012. Three pathogens in sympatric populations of pumas, bobcats, and domestic cats: implications for infectious disease transmission. PLoS ONE 7(2):e31403.Doi:10.1371/journal.pone.0031403.

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Bevins, S.N., J.A. Tracey, S. P. Franklin, V. L. Schmit, M. L. MacMillan, K. A. Logan, L. L. Sweanor, M.W. Alldredge, W. M. Boyce, W. Vickers, S. P. D. Riley, L. M. Lyren, E. E. Boydston, C. Krumm, M. Salman, M. E. Roelke, K. L. Gage, M. E. Schrieffer, K. R. Crooks, and S. VandeWoude. 2009. Plague and wild felids: zoonotic disease in the western US. Emerging Infectious Diseases 15: 2021-2024.

Manuscripts in preparation:

Cougar movement dynamics in the wildland-urban interface

Cougar-human interaction in Colorado's front-range.

Cougar kill site dynamics and prey consumption

Cause specific mortality of cougars in the urban front-range of Colorado

Non-invasive techniques to estimate cougar and bobcat population size.

Effectiveness of cougar kitten rehabilitation: Do they make it in the wild?

SUMMARY

In this final year of the front-range cougar study, capture efforts focused on removing collars from all collared cougars. All collars were removed from cougars with the exception of 4 with non-functioning collars that could not be captured. Only 1 mortality was documented this year, which was an adult male killed while preying on an elk. Mule deer are the predominant prey in cougar diets, although

some utilize elk regularly. An assessment of landscape factors driving cougar movement will be completed in December 2016. The final field season was conducted this year to assess population estimation techniques. Data analysis and publication will be finished in the coming year.

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Table 1: Capture history, aversive conditioning treatments and current status of all independent age cougars captured as part of the Front Range cougar study.

Cougar ID	Sex	Age	Date	Location	Occurrence	Capture	Release Loc	Conditioning	Status
AM02	M	1	6/14/07	Lacey Prop.	Baiting	Cage	On-site	NA	Alive
		1.5	1/10/08	White Ranch	Capture effort	Hounds	On-site	NA	Alive
		1.5	2/9/08	Coal Creek	Intraspecific mortality				Dead
AM04	M	7	7/14/07	White Ranch	Baiting	Cage	On-site	NA	Alive
		7	10/17/07	Eldorado Springs	Livestock depredation	Cage	White Ranch	Beanbag	Alive
		8	4/29/08	Magnolia/Flagstaff	Replace Collar	Hounds	On-site	NA	Alive
		8	5/5/08	South Boulder	Seen in town	Free-dart	Lindsey	Beanbag	Alive
		8	8/4/08	North Boulder	Killed deer in town	Cage	Centennial Cone	Beanbag	Alive
		9	2/24/09	Boulder Canyon	Punctured intestine				Dead
AM06	M	5	11/21/07	Heil Valley Ranch	Capture effort	Hounds	On-site	NA	Alive
		6	12/30/08	Heil Valley Ranch	Replace Collar	Hounds	On-site	NA	Alive
		7	2/2/10	Reynolds Ranch	Replace Collar	Hounds	On-site	NA	Alive
		7	2/15/10	White Ranch	Hunter				Dead
AF03	F	4	11/29/07	Flagstaff	Deer kill	Cage	On-site	NA	Alive
									Unknown
AF01	F	2	12/17/07	Table Mesa	Deer kill	Cage	On-site	NA	Alive
		4.5	12/15/10	White Ranch	Replace Collar	Hounds	On-site	NA	Alive
			3/12/12	BCOS Lindsey	Deer kill	Free-dart	On-site	NA	Alive
		7	11/5/14	Boulder	In town (natural mort)				Dead
AM05	M	2	12/19/07	White Ranch	Capture effort	Hounds	On-site	NA	Alive
		4	12/4/09	White Ranch	Replace collar	Hounds	On-site	NA	Alive
		5	4/4/10	Golden	Roadkill				Dead
AM07	M	1.5	12/26/07	Heil Valley Ranch	Capture effort	Hounds	On-site	NA	Alive
			4/19/08	Highway 7	Roadkill				Dead
AF08	F	1.5	12/26/07	Heil Valley Ranch	Capture effort	Hounds	On-site	NA	Alive
		3	6/18/09	West Horsetooth	Deer kill-remove collar	Cage	On-site	NA	Uncollared
AM09	M	1.5	12/28/07	Heil Valley Ranch	Capture effort	Hounds	On-site	NA	Alive
		2.5	12/27/08	Hwy 34 (mile 70)	Roadkill				Dead
AF10	F	7	1/15/08	Apex Open Space	Deer Kill	Cage	On-site	NA	Alive
			2/13/08	I-70	Roadkill				Dead
AF19	F	8+	3/4/08	Heil Valley Ranch	Capture effort	Hounds	On-site	NA	Alive
		8+	3/18/09	North Boulder	Deer Kill	Cage	Heil Valley Ranch	Beanbag	Alive
			4/13/09	Left Hand Canyon	Deer Kill	Cage	Heil Valley Ranch	NA	Alive
		8+	1/20/09	Dowe Flats	Deer Kill	Cage	On-site	NA	Alive
			11/5/10	Foothills Hwy, N. Boulder	Roadkill				Dead

AF11	F	1.5	3/5/08	South Table Mesa	Deer Kill	Cage	On-site	NA	Alive
			8/20/08	US-40/Empire	Roadkill				Dead
AM20	M	4	3/6/08	White Ranch	Capture effort	Hounds	On-site	NA	Alive
			5/18/08	West of White Ranch	Livestock Depredation	Shot			Dead
AF15	F	6	3/18/08	Coffin Top	Capture effort	Hounds	On-site	NA	Alive
		7	4/2/09	Hall Ranch	Replace Collar	Hounds	On-site	NA	Alive
			3/25/10	Coffin Tip	Replace Collar	Hounds	On-site	NA	Alive
		8-9	2/4/11	Hall Ranch	Deer Kill	Snare	On-site	NA	Alive
		9+	2/2/12	Longmont Dam Rd	Deer Kill	Snare	On-site	NA	Alive
		9+	11/8/12	Button Rock	Natural Mortality				Dead
AF17	F	9+	3/29/08	Sugarloaf	Pet depredation	Cage	Within 1 mile	Beanbag	Alive
			5/20/08	Four-mile Canyon	Unknown mortality				Dead
AF12	F	2	5/8/08	N. Boulder	Deer Kill	Cage	US Forest Boulder Canyon	Beanbag	Alive
			5/29/08	N. Boulder	Livestock depredation	Cage	Near Ward	Beanbag	Alive
			2/13/09	N. Boulder	Deer Kill/Shot	Snare	None		Dead
AM13	M	2	5/8/08	Sugarloaf	Livestock depredation	Cage	On-site	Beanbag	Alive
			12/17/08	Heil Valley Ranch	Replace Collar	Hounds	On-site	NA	Alive
		3	12/17/09	Heil Valley Ranch	Replace Collar	Hounds	On-site	NA	Alive
			3/27/12	Hall Ranch	Detected by camera				Alive
			5/30/13	Apple Valley Rd.	Shot/depredation				Dead
AM14	M	2	5/15/08	South Boulder	Seen under deck	Free-dart	Lindsey	None	Alive
			5/20/08	South Boulder	Deer kill	Free-dart	West of Rollinsville	Beanbag	Alive
			4/14/09	Rollins Pass	Replace Collar	Hounds	On-site	NA	Alive
		3	2/16/10	Left Hand Canyon	Replace Collar	Hounds	On-site	NA	Alive
		4.5	6/22/11	Allenspark	Elk Kill	Cage	On-site	NA	Alive
		4-5	11/9/11	Hwy 72	Raccoon Kill	Free-dart	On-site	NA	Alive
		4-5	12/4/11	Allenspark	Shot/depredation				Dead
AF34	F	1.5	12/5/08	Heil Valley Ranch	Capture effort	Hounds	On-site	NA	Alive
			3/18/09	N. Boulder	Deer kill	Cage	Heil Valley Ranch	Beanbag	Alive
		2.5	1/4/10	Heil Valley Ranch	Replace Collar	Hounds	On-site	NA	Alive
		3.5	12/31/10	Hall Ranch	Replace Collar	Hounds	On-site	NA	Alive
		4.5	12/28/11	Hall Ranch	Replace Collar	Hounds	On-site	NA	Alive
		5.5	2/13/12	W of Hall Ranch	Unknown mortality				Dead
AM18	M	1.5	12/24/08	Evergreen	Deer kill	Cage	Mt. Evans SWA	None	Alive
			3/14/09	Evergreen	Livestock depredation	Cage	None		Dead
AF16	F	3	12/29/08	Evergreen	Deer Kill	Snare	Flying J Open Space	None	Alive
			3/20/09	Evergreen	Livestock depredation	Cage	Mt. Evans SWA	Beanbag	Alive
									Unknown
AF45	F	5	1/2/09	Gold Hill	Deer kill	Cage	On-site	NA	Alive

			11/24/10	N.Boulder	Euthanized/Lisa Wolfe			NA	Dead
AF40	F	1.5	1/27/09	White Ranch	Capture effort	Hounds	On-site	NA	Alive
		1.5	1/28/09	White Ranch	Replace Collar	Hounds	On-site	NA	Alive
		2.5	2/22/10	White Ranch	Replace Collar	Snare	On-site	NA	Alive
		4-5	3/4/12	Idaho Springs	Fawn Kill	Snare	On-site	NA	Alive
		5	10/13/12	Idaho Springs	Shot by hunter				Dead
AF24	F	10+	2/12/09	North Boulder	Deer Kill	Cage	Hall Ranch	None	Alive
			2/25/09	Hwy 7	Replace Collar	Hounds	On-site	NA	Alive
			4/4/09	North Boulder	Raccoon Kill	Free-dart	Heil Valley Ranch	None	Alive
			5/31/09	North Boulder	Encounter	Shot			Dead
AM31	M	1.5	12/31/08	Evergreen	Chicken coop	Hounds	On-site	None	Alive
			3/29-09	Conifer	Livestock depredation	Cage	Mt. Evans SWA	None	Alive
		2.5	2/16/10	Douglas, WY	Hunter				Dead
AF37	F	1.5	12/31/08	Evergreen	Chicken coop	Free-dart	On-site	None	Alive
			8/11/09	I-70	Roadkill				Dead
AM21*	M	1.5	8/29/09	N. Boulder	Encounter	Free-dart	Ward	None	Alive
		2	3/01/10	Loveland	Livestock depredation				Dead
AF32	F	1.5	9/28/09	Indian Hills	Livestock depredation	Cage	Within 1 mile	None	Alive
		3.5	11/28/10	Golden	In neighborhood	Free-dart	White Ranch	None	Alive
		3.5	12/1/10	Golden	In neighborhood	Cage	Radium	None	Alive
			9/23/11	Green Mtn. Res.	Found dead				Dead
AM46	M	2	11/13/09	Evergreen	Elk kill	Cage	On-site	None	Alive
			3/5/10	Genesee	Livestock depredation	Shot			Dead
AF50	F	3	11/24/09	West of Boulder	Deer kill	Cage	On-site	NA	Alive
									Unknown
AM44	M	6	12/15/09	White Ranch	Capture effort	Hounds	On-site	NA	Alive
			3/18/10	White Ranch	Replace collar	Hounds	On-site	NA	Alive
		7-8	3/20/11	White Ranch	Elk kill	Snare	On-site	NA	Alive
		9	5/30/12	SW of White Ranch	Shot/depredation				Dead
AM606	M	2	1/6/10	Boulder	Seen in town	Free-dart	MacGregor Ranch	None	Alive
			9/23/11	Laporte	Shot killing goat				Dead
AF54	F	4	1/14/10	White Ranch	Capture effort	Hounds	On-site	NA	Alive
			5/16/11	White Ranch	Deer Kill/Replace Collar	Cage	On-site	NA	Alive
		7	3/14/13	White Ranch	Replace Collar	Hounds	On-site	NA	Alive
			4/18/14	White Ranch	Livestock depredation	Shot			Dead
AF52	F	4	1/28/10	Hall Ranch	Capture effort	Hounds	On-site	NA	Alive
		5-6	3/24/11	Hall Ranch	Deer Kill	Cage	On-site	NA	Alive
		10+	2/24/16	Hall Ranch	Baiting	Cage	On-site	NA	Uncollared
AM51	M	1.5	1/28/10	Hall Ranch	Capture effort	Hounds	On-site	NA	Alive

			1/6/2014	Larimer Cty	Hunter Harvest	Hounds			Dead
AF56	F	1.5	2/22/10	Conifer	Livestock depredation	Cage	Mt. Evans SWA	Beanbag	Alive
			5/24/12	Conifer	Shot				Dead
AF55	F	4	2/23/10	Conifer	Livestock depredation	Cage	Mt. Evans SWA	Beanbag	Alive
			3/13/10	Conifer	Pet Depredation	Cage		Euthanized	Dead
AM53	M	4	3/13/10	Genesee	Elk Kill	Cage	On-site	NA	Alive
			3/3/11	Medved property	Shot/hunter				Dead
AM60	M	2	3/29/10	Walker Ranch	Baiting	Cage	On-site	NA	Alive
									Unknown
AF58	F	1.5	4/4/10	Table Mesa	Baiting	Cage	On-site	NA	Alive
			6/3/10		Roadkill				Dead
AF62	F	5	4/13/10	Walker Ranch	Elk Kill	Cage	On-site	NA	Alive
		6	4/13/11	Walker Ranch	Baiting	Cage	On-site	NA	Alive
			12/10/11	Gross Dam	Non-target/released	Cage	On-site	NA	Alive
		6	11/14/12	Walker Ranch	Recollar	Cage	On-site	NA	Alive
			2/16/12	Walker Ranch	Natural Mortality				Dead
AF59	F	5	4/22/10	Blue Jay/Jamestown	Deer Kill	Cage	On-site	NA	Alive
		5	1/6/11	N. Boulder	Deer Kill	Cage	On-site	NA	Alive
		5-6	12/29/11	Sunshine Canyon	Deer Kill	Free-dart	On-site	NA	Alive
		6	3/6/12	NW of Boulder	Unknown mortality				Dead
AM63	M	1	9/22/10	Paradise Park	Deer Kill	Cage	White Ranch	None	Alive
			9/30/10		Road Kill				Dead
AF57	F	3	11/3/10	Lacy Property	Baiting	Snare	On-site	NA	Alive
		4-5	2/4/12	JCOS Ralston Buttes	Replace Collar	Hounds	On-site	NA	Alive
		5-6	3/5/13	Boulder/OSMP	Recollar	Cage	On-site	NA	Alive
			1/15/14	Lacy property	Recollar	Cage	On-site	NA	Alive
			3/7/16	Last Location					Unknown
AF61	F	4-5	11/18/10	Flagstaff	Deer Kill	Free-dart	On-site	NA	Alive
		4-5	3/2/11	Coal Creek Canyon	Raccoon Kill	Cage	Walker Ranch	None	Alive
		5	12/10/11	Gross Dam Rd	Baiting	Snare	On-site	NA	Alive
			1/27/14	Magnolia	Recollar	Hounds	On-site	NA	Alive
			2/17/16	Last Location					Unknown
AF64	F	1.5	1/20/11	Heil Valley Ranch	Baiting	Cage	On-site	NA	Alive
		3-4	7/19/12	N of Nugget Hill	Kill	Snare	On-site	NA	Alive
									Unknown
AM67	M	1.2	12/16/10	White Ranch	Baiting	Cage	On-site	NA	Alive
			3/4/12	Big Thompson	Shot/Depredation	Snare			Dead
AF69	F	1.5	12/1/10	N. Boulder	Deer Kill	Free-dart	On-site	NA	Alive
		2	4/6/11	N.Boulder/Town	Deer Kill	Free-dart	Reynolds Ranch	None	Alive
		4	3/31/12	Wonderland	Deer Kill	Cage	On-site	NA	Alive

			1/21/14	Last Location					Unknown
AM70	M	2	1/23/11	Gold Hill	Deer Kill	Cage	On-site	NA	Alive
			3/2/11	Boulder Heights	Dog Kill	Cage	Reynolds Ranch	None	Alive
		3	2/26/12	Buckhorn Rd	Unknown mortality				Dead
AM71	M	2	1/27/11	Heil Valley Ranch	Baiting	Cage	On-site	NA	Alive
		3	12/23/11	Casper, WY	Shot/hunter	Hounds			Dead
AM72	M	4	2/6/11	Heil Valley Ranch	Baiting	Snare	On-site	NA	Alive
		5	5/2/12	Heil Valley Ranch	Unknown mortality				Dead
AF73	F	4	3/6/11	Sunshine Canyon	Baiting	Cage	On-site	NA	Alive
		3-4	10/28/11	Four Mile Canyon	Deer Kill	Cage	On-site	NA	Alive
		4-5	3/27/13	Magnolia	Recollar	Hounds	On-site	NA	Alive
			1/25/14	Magnolia	Unknown Mort.				Dead
AM74	M	4	2/23/11	White Ranch	Baiting	Cage	On-site	NA	Alive
		5	3/7/12	Golden Gate Canyon	Deer Kill	Snare	On-site	NA	Alive
			12/31/12	Crawford Gultch	Shot				Dead
AM76	M	2-3	3/6/11	Heil Valley Ranch	Baiting	Cage	On-site	NA	Alive
		3	12/27/11	Heil Ranch	Replace collar	Hounds	On-site	NA	Alive
		4	2/13/13	Heil Ranch	Recollar	Snare	On-site	NA	Alive
			12/12/13	Heil Ranch	Unknown Mort.				Dead
AF77	F	5	3/9/11	Morrison Mountain	Baiting	Cage	On-site	NA	Alive
		5	11/15/12	Indian Hills	Recollar	Snare	On-site	NA	Alive
			1/22/15	Last Location					Unknown
AM78	M	2	3/18/11	W. Evergreen	Deer Kill	Cage	On-site	NA	Alive
			5/12/11	Soda Creel/I-70	Road Kill				Dead
AF23	F	2.5	12/8/12	Lacy Property	Initial Collar	Cage	On-site	NA	Alive
			3/27/14	Booth Property	Recollar	Hounds	On-site	NA	Alive
			5/14/16	Last Location					Unknown
AF79	F	4	3/18/11	Mt. Evans	Dumpsite	Cage	On-site	NA	Alive
		4-5	2/17/12	Mt. Evans	Replace Collar	Hounds	On-site	NA	Alive
									Unknown
AM80	M	1.7	3/18/11	Mt. Evans	Dumpsite	Cage	On-site	NA	Alive
									Unknown
AM84	M	2	4/9/11	Shield Park HOA	Sheep depredation	Cage	Deer Creek Canyon	None	Alive
		3	5/4/12	S. Deer Creek	Shot/depredation				Dead
AF86	F	1.5	3/13/12	Gross Dam Road	Recollar	Snare	On-site	NA	Alive
		2	1/31/13	Flagstaff	Recollar	Cage	On-site	NA	Alive
		3	3/5/14	Walker Ranch	Recollar	Hounds	On-site	NA	Alive
		4	5/22/15	Walker Ranch	Recollar	Cage	On-site	NA	Alive
		5	3/31/16	Walker Ranch	Collar Removed				Uncollared

AF91	F	1.5	2/4/12	Cotter Mine	Capture effort	Hounds	On-site	NA	Alive
		2	7/20/12	I-70	Road Kill				Dead
AF22	F	1.5	2/29/12	Golden	Baiting	Cage	On-site	NA	Alive
		2	10/5/12	Idaho Springs	Road Kill				Dead
			4/3/15	Golden	Hunting				Dead
AF87	F	4-5	11/18/11	Heil Ranch	Baiting	Snare	On-site	NA	Alive
		4	12/7/11	Hall Ranch	Deer Kill	Cage	On-site	NA	Alive
		5	3/11/13	Hall Ranch	Recollar	Hounds	On-site	NA	Alive
									Unknown
AF88	F	1.5	10/14/11	N. Boulder	Deer Kill	Cage	On-site	NA	Alive
		2	1/11/12	White Ranch	Possible Intraspecific				Dead
AF26	F	1.5	2/27/13	White Ranch	Initial Collar	Hounds	On-site	NA	Alive
									Unknwon
AF27	F	1.5	10/31/12	White Ranch	Initial Collar	Cage	On-site	NA	Alive
		2	1/26/13	White Ranch	Non-target	Snare	On-site	NA	Alive
		2	2/14/13	Ralston Creek	Non-target	Cage	On-site	NA	Alive
		4	4/14/15	White Ranch	Intraspecific Mort				Dead
AM49	M	3	4/1/13	Ralston	Initial Collar	Hounds	On-site	NA	Alive
			1/4/14	Lacy Property	Recollar	Hounds	On-site	NA	Alive
			2/17/15	Gultra Property	Shot/Hunter				Dead
AM98	M	1.5	1/4/13	Eldorado Springs	Deer Kill	Cage	On-site	NA	Alive
			5/31/13	Big Thompson	Unknown Mortality				Dead
AM99	M	1.5	12/2/12	Lyons	Human conflict	Free dart	New Hall	None	Alive
			1/6/13	Lyons	Human conflict	Free dart	HWY 72	None	Alive
			1/16/13	Boulder	Human Conflict	Free dart	Buckhorn Rd.	None	Alive
			1/31/13	Livermore	Depredation/Shot				Dead
AM100	M	2	12/23/12	Boulder	Initial Collar	Cage	On-site	None	Alive
			5/27/12	Boulder	DWM Capture Mort	Dart			Dead
AM109	M	1.5	7/23/13	Sugarloaf	Initial Collar	Cage	On-site	None	Alive
			12/16/13	Coal Creek	Recollar	Cage	On-site	NA	Alive
			1/18/15	Idaho Springs	Human Conflict	Cage		Euthanized	Dead
AF122	F	1.5	3/19/13	Hall Ranch	Initial Collar	Cage	On-site	NA	Alive
		3	1/8/14	Hall Ranch	Recollar	Hounds	On-site	NA	Alive
		4	3/5/15	Hall Ranch	Recollar	Hounds	On-site	NA	Alive
		5	2/24/16	Hall Ranch	Remove Collar	Hounds	On-site		Uncollared
AM123	M	1.5	3/19/13	Hall Ranch	Initial Collar	Cage	On-site	NA	Alive
			1/13/14	W. Loveland	Human Conflict	Shot			Dead
AM124	M	2	3/30/13	Hall Ranch	Initial Collar	Cage	On-site	NA	Alive
			3/25/14	Heil Ranch	Unknown Mort.				Dead
AF126	F	1	5/16/13	W. Boulder	Human Conflict	Cage	Sugarloaf	None	Alive

			12/7/14	Last Location					Unknown
SW023	F	1	4/9/09		Rehab	Release	Pike forest	None	Alive
			11/14/09	Lost Valley Ranch	Found dead				Dead
SW026	M	1	10/20/09		Rehab	Release	Hermit Park	NA	Alive
		3	8/19/11	New Mexico	Shot/hunter				Dead
SW107	M	1	5/7/10		Rehab	Release	Radium	NA	Unknown
			3/22/11		Shot/hunter				Dead
AF995	F	1	8/25/11		Rehab	Release	Reynolds Ranch	NA	Alive
		2	6/23/12	Sunshine Canyon	Road Kill				Dead
AF110	F	1	4/25/14	Flagstaff	Initial Collar	Cage	On-site	NA	Alive
			1/4/15	Hwy 7	Shot/Hunter				Dead
AM110	M	1.5	12/19/13	Marietta	Initial Collar	Cage	On-site	NA	Alive
									Unknown
AM111	M	2	1/9/14	Hall Ranch	Initial Collar	Cage	On-site	NA	Alive
		4	2/24/16	Hall Ranch	Collar Removed	Hounds	On-site		Uncollared
AM117	M	4	1/17/15	Heil Valley	Initial Collar	Cage	On-site	NA	Alive
			4/12/16	Estes	Natural Mortality				Dead
AF43	F	4	1/23/15	Heil Valley	Initial Collar	Cage	On-site	NA	Alive
									Unknown
359	F	2	8/16/14	Boulder	Management	Cage	Boulder Creek	NA	Alive
			4/7/15	Heil Valley	Initial Collar	Cage	On-site	NA	Alive
									Unknown
AM108	M	3	4/10/15	Heil Valley	Initial Collar	Cage	On-site	NA	Alive
			3/17/16	Hall Ranch	Remove Collar	Hounds	On-site		Unknown
AM92	M	1	5/1/15	Walker	Not collared	Cage	On-site	NA	Unknown

Table 2: Capture history, aversive conditioning treatments and current status of all cougar cubs captured as part of the Front Range cougar study.

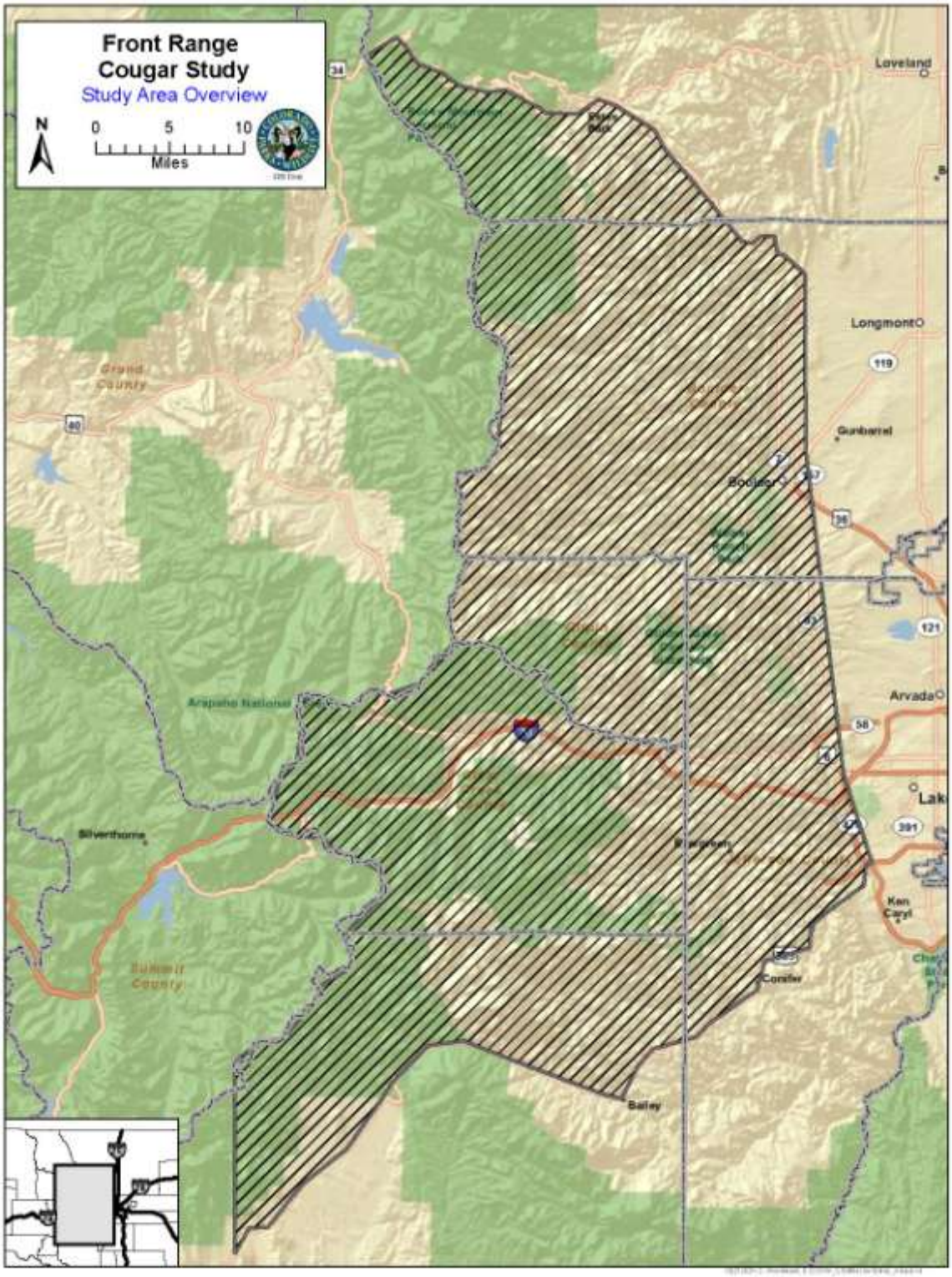
Cougar ID	Sex	Age	Mother	Date	Location	Occurrence	Capture	Release Loc	Conditioning	Status
AF35	F	3	AF16	12/29/08	Evergreen	Deer Kill	Cage	Flying J Open Space		Alive
				12/31/08	Evergreen	Roadkill				Dead
AM36	M	3	AF16	12/29/08	Evergreen	Deer Kill	Cage	Flying J Open Space		Alive
				1/8/09	Evergreen	Starvation				Dead
AM30	M	8	AF01	1/30/09	S. Boulder	Deer Kill	Cage	On-site		Alive
										Dead
AM38	M	8	AF01	1/30/09	S. Boulder	Deer Kill	Cage	On-site		Alive
				3/27/09	S. Boulder	Encounter	Free-dart	Lindsey	Beanbag	Alive
				3/30/09	S. Boulder	Pet Depredation	Free-dart	Centennial Cone	None	Alive
				4/9/09	Morrison	Encounter	Free-dart	None	Euthanized	Dead
AM29	M	6	Euth.	2/11/09	N. Boulder	Deer Kill	Free-dart	Hall Ranch	None	Alive
		12		6/15/09	N. Boulder	Encounter	Free-dart	Masonville	Beanbag	Alive
				10/23/09	Big Thompson	Goat Depredation	Shot			Dead
AM21* collared	M	12	Unkn	3/25/09	Table Mesa	Baiting	Cage	On-site	NA	Alive
										Dead
AM25	M	12	Unkn	5/22/09	Indian Hills	Deer Kill	Cage	On-site	None	Alive
				9/13/09		Raccoon	Free-dart	Perforated intestine		Dead
AM41	M	12	Unkn	5/22/09	Indian Hills	Deer Kill	Free-dart	On-site	None	Alive
					Indian Hills	Encounter	Shot			Dead
AM65	M	4-5	AF32	11/28/10	Golden	In Neighborhood	Free-	White Ranch	None	Alive

AM66	M	4-5	AF32	11/28/10	Golden	In Neighborhood	dart Free-	White Ranch	None	Alive
				12/1/10	White Ranch	Recapture	dart Hounds	Radium	None	Alive
AF68	F	10	AF50	2/9/11	Flagstaff	Deer Kill	Cage	On-site	NA	Alive
AM83	M	9	AF52	3/24/11	Hall Ranch	Deer Kill	Cage	On-site	NA	Alive
AM85	M	9	AF62	4/13/11	Walker Ranch	Baiting	Cage	On-site	NA	Alive
AF86* collared	F	9	AF62	4/13/11	Walker Ranch	Baiting	Snare	On-site	NA	Alive Alive

Table 3: Noninvasive hair snag capture results for bobcats and cougars. Number of animals seen, number of hair samples collected and number of successful genotypes.

Species	Year	Pictures	Hair Samples	Genotypes
Bobcat	2014	31	5	0
Bobcat	2015	68	12	1
Bobcat	2016		31	4
Cougar	2014	86	55	20
Cougar	2015	42	32	11
Cougar	2016		51	15

List of figures:


Front Range
Cougar Study
Study Area Overview
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Loveland
Longmont
Boulder
Gunbarrel
Arvada
Lak
Silverthorne
Ken Caryl
Conifer
Bailey
Grand County
Arapaho National
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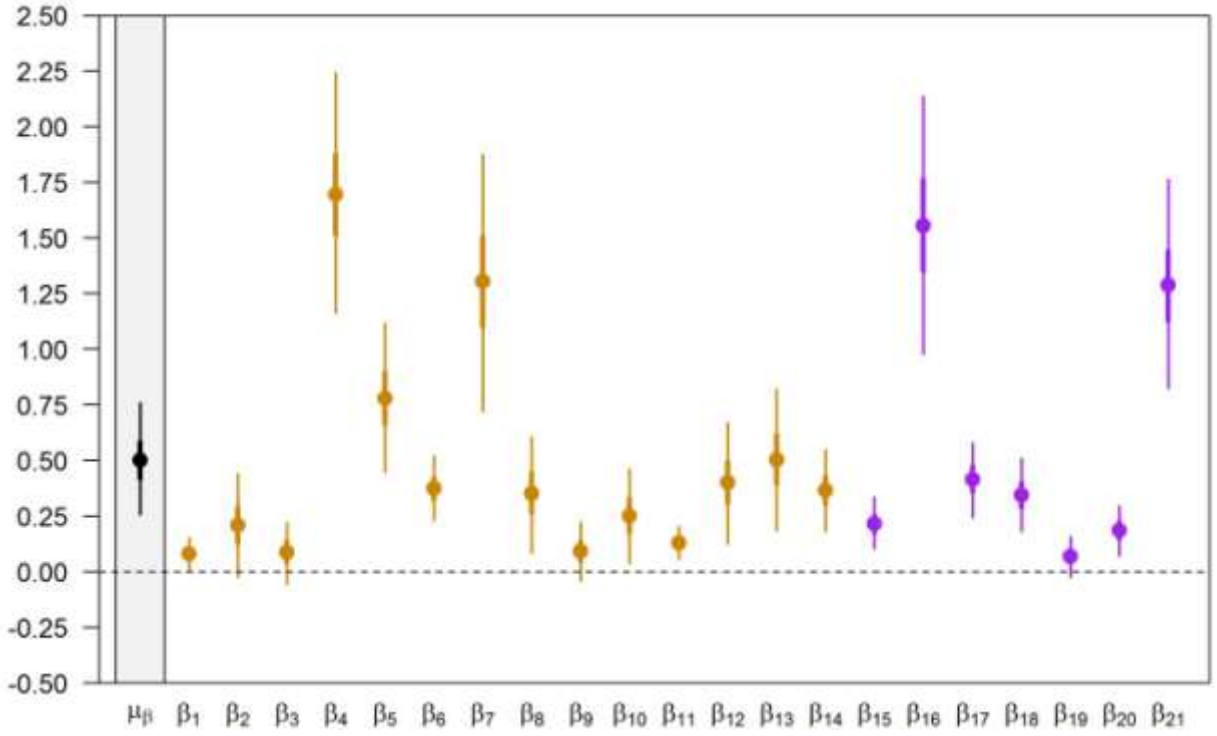
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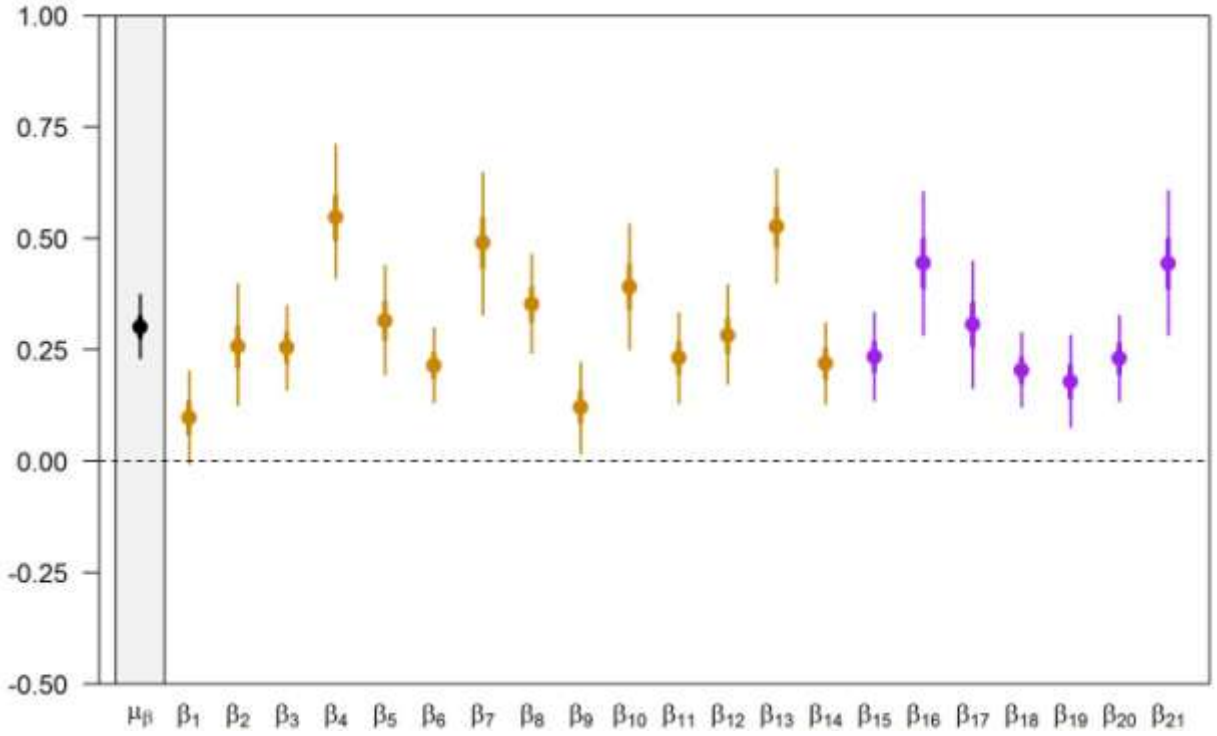
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