COLORADO
Parks and Wildlife
Department of Natural Resources

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M E M O R A N D U M

TO: Parks and Wildlife Commissioners

FROM: Jeffrey Ver Steeg, Acting Director

DATE: 3/28/2019

SUBJ: Supporting document for March PWC staff mountain lion presentation

Supporting Document for Staff Presentation on Colorado Lion History, Research and Management

Introduction of staff

Colorado Parks and Wildlife Staff subject matter experts on mountain lion management and research (see appendix for complete CVs)

Mat Alldredge

B.S. in Mechanical Engineering, University of Colorado
M.S. in Wildlife Resources, University of Idaho
M.S. in Biomathematics, minor in Statistics, North Carolina State University
Ph.D. in Biomathematics and Zoology, minor in Statistics, North Carolina State University

Relevant Work Experience:
Mammals Researcher, Colorado Parks and Wildlife (13 years)
Research Associate, North Carolina State University (2 years)
Biologist, USGS-Patuxent Wildlife Research Center (1 year)
Research Associate, University of Idaho (2 years)

Scientific Publications (peer-reviewed journals, scientific proceedings/technical publications, book chapters):

41 scientific publications addressing various aspects of ecology, management and population sampling.

- 18 publications from CPWs Front-range Cougar project
- 6 publications addressing black bear ecology and management

Professional Service:

- Affiliate Faculty/Adjunct Assistant Professor
  - Department of Forest and Wildlife Ecology, University of Wisconsin
  - Department of Fish, Wildlife and Conservation Biology, Colorado State University
  - Lewis and Clark State College
  - Instructor. National Conservation Training Center, U.S. Fish and Wildlife Service.
- Reviewer for numerous journals
- Chair CPW Animal Care and Use Committee (5 years)

Mark Vieira

Education:
B.A. in Biology, St. Mary's College of Maryland
M.S. in Wildlife Biology, Colorado State University

Recent Work Experience:
Carnivore and Furbearer Program Manager, Colorado Parks and Wildlife (1.5 years)
Area Wildlife Biologist, Colorado Parks and Wildlife (16 years)

Publications and Relevant Experience (published, accepted, in review):
5 peer-reviewed publications, 2 edited

Steering Committee and Editor, Proceedings of the 12th Mountain Lion Workshop, May 15-18, 2017
Committee Chair and Editor, Proceeding of the 13th Western Black Bear Workshop, May 21-24, 2018

Experience with mountain lion harvest limit setting, regulation development, translocation and management on the Northern Front Range for 16 years. Participated in two mountain lion radio collaring projects

Chuck Anderson

Education:
B.S. in Wildlife Biology, Colorado State University, 1990
M.S. in Zoology and Physiology, University of Wyoming, 1994
Ph.D. in Zoology and Physiology, University of Wyoming, 2003

Relevant Work Experience:
Mammals Research Leader and Researcher, Colorado Parks and Wildlife (12 years)
Large Carnivore Manager/Researcher, Wyoming Game and Fish (5 years)
Research Wildlife Biologist, Arizona Game and Fish (1 year)

Scientific Publications (peer-reviewed journals, scientific proceedings/technical publications, book chapters, species management plans):

- 42 scientific publications addressing various aspects of large mammal ecology and management.
  - PhD Dissertation: Cougar ecology, management and population genetics in Wyoming
  - 18 publications addressing large carnivore ecology and management
  - 13 publications addressing mountain lion ecology and management

Professional Service:

- Affiliate Faculty/Adjunct Assistant Professor
  - Department of Biological Sciences, Western Illinois University
  - Department of Fish, Wildlife and Conservation Biology, Colorado State University
  - College of Arts and Sciences, Idaho State University
  - Department of Zoology and Physiology, University of Wyoming
- Peer Referee for 16 scientific journals (reviewed multiple manuscripts for most journals)
- Associate Editor for Wildlife Society Bulletin

Historical Perspective

- Lions historically had the broadest distribution of any mammal in N. America
- Lions persecuted across N. America during European settlement and western expansion
- Extinct in much of their historic range east of the Rocky Mountain states (except Florida)
- Predator designation with no legal protection until classified as big game in 1965
- Populations rebounded in Colorado and throughout the west following protection as a managed game species
- Management success in western North America has resulted in expansion eastward into formerly occupied range with reestablished populations to date in Nebraska, South Dakota and North Dakota as well as increases in sightings and documented lions in the central and upper Midwest

Life History

- Average Litter size 2-3 kittens (range 1-5)
- Females breed around 2-3 years of age
- Dependent young stay with female for approximately 15 months
- Breeding intervals approximately 18 months
- Survival rates are 75 to 90% for adults and 70 to 75% for dependent young
- Sources of Mortality
    - Natural causes
        - Disease (plague, FIV, etc.)
        - Accidental (injuries from killing large prey, falls, etc.)
        - Interspecific—killed by other predators such as bears or wolves
        - Intraspecific—killed by other mountain lions in defense of territories, prey or kittens
        - Infanticide—A mountain lion killing a kitten
            - Ecological definition: Infanticide occurs when a new male takes over another male's territory and kills the offspring from the previous male reducing the genetic contribution of the old male and providing breeding opportunities for the new male increasing his genetic contribution.
    - Human Caused (Hunting, Roadkill, Conflict/Removal, Miscellaneous)

- Social structure
    - Males are territorial but can overlap with other males (can exceed 300 km^2)
    - Females occupy smaller areas (< 100 km^2) and overlap with other females
    - Male territories overlap several female home ranges
    - Age at independence approximately 14-16 months
    - However, offspring can survive on their own by 12 months of age
        - Even at 9 months, kittens exhibit high survival rates
    - Offspring generally disperse from natal range

        - Females may return and occupy a home range within their natal range
        - Males typically disperse larger distances (100 to 200 km)
    - Population densities are variable but average around 3 to 3.5 independent lions per 100 km^2 (depends on quality of habitat, prey availability, and mortality)

Colorado's Research

- Research on lions is extremely difficult
    - Rare and elusive
    - Technology is getting better
        - Satellite GPS collars
        - Remote cameras

- Uncompahgre Plateau study to assess effects of hunting (10 years)
- Front-range study (11 years)
    - Initiated by CPW Director to understand lion-human interactions as these were increasing rapidly
    - Study area located where the greatest conflict was occurring
        - Front-range of Colorado
        - This is one of the areas in Colorado with the lowest lion harvest
    - Major findings
        - Lions generally avoid human activity
        - Lions are in the human-wildland interface seeking prey (females)
        - Lions tend to take domestic animals opportunistically
        - No indication that this is primarily subadults
        - Results very similar to Washington study (Kertson et al. 2013)
        - Causes of mortality
            - Natural (disease, old age, intraspecific, accident)
                - No infanticide was documented
                - Only 1 subadult male killed by another male
                - 4 adult females killed by adult males
            - Human caused
                - Management/conflict related
                - Roadkill
                - Hunting minimal due to limited access (2 within the study area)
- Current ongoing research (SE region) (9 years)
    - Response of mule deer in relation to mountain lion density
    - Probably the largest study ever attempted (2 DAUs, over 10,000 km^2)
    - One of the only truly manipulative lion studies ever done with a crossover design
    - Goal is to maintain 60 collared adult lions for 9 years
    - Harvest Structure

        - Does age and sex structure of the harvest provide good information on population demographics (density, age, and sex structure)
        - Past research indicates harvest structure informs management
            - Low to moderate harvest should include mostly adult males and subadults
            - Adult females would occur in high harvest scenarios or in declining populations
    - Does hunting cause social disruption and infanticide
        - Research is inconclusive
            - Limited by spatial extent
            - Small sample size
            - Lack of control and replication
        - We will monitor interactions among lion and conflict with humans
            - Replicated across increasing and decreasing lion populations
            - Monitored with known harvest and population densities
        - Kittens are marked and monitored
            - Survival and cause-specific mortality will be determined
            - New technology allows for better assessment of cause of death
            - Survival and mortality can be assessed relative to population density, hunting pressure and increasing or decreasing phases of the population
    - Population Density
        - Historic estimates based on counting “all of the lions” in an area or estimating with a mark-recapture study.
            - These estimates are biased
                - They do not account for the true area that lions use (lions travel outside of a given study area creating unrealistic density estimates)
                - Marking lions with capture techniques and then recapturing lions with the same techniques may completely miss a portion of the population that are inaccessible or inhabit remote areas. In other words, these sampling techniques may only sample lions that frequently cross roads or are easily accessed by people.
            - Newer techniques (spatially explicit models)
                - Force sampling efforts to be distributed over entire area
                - Account for animals that move on and off the sampling grid
            - CPW developed a sampling technique on the Front-range study that uses marked (GPS collared) animals as the initial

sample, but relies on predator calls and cameras for subsequent captures.
    - This technique evenly distributes sampling efforts across the study area.
    - Accounts for animal movements on and off the grid
    - Estimates from the Front-range indicate a density of 4.1 independent lions per 100 km^2
- Technique is being used on current research
    - D16 estimate 2018
        - Capture efforts prior to implementation indicated that we had marked almost every lion in the study area. All tracks that were being found were from collared lions and all lions on bait sites were collared. This would have led to a population estimate of 30 to 35 lions in the study area or a density of less than 1 independent lion per 100 km^2
        - Using our technique clearly demonstrated a portion of the population that was not being sampled by typical capture efforts. The density from this was estimated at 2.9 independent lions per 100 km^2.
        - This is currently being applied in D34.
    - Both our technique and other newly developed techniques are demonstrating that historic estimates may be biased low and lion densities may be higher than expected.

Harvest rates and management strategies

- Colorado has a comprehensive mountain lion management program that includes detailed lion management plans for all 19 lion Data Analysis Units (DAUs), a process for data collection involving mandatory checks and collection of detailed biological information into a database, a series of analyses conducted annually to evaluate mortality, harvest composition and other factors that lead to informing annual harvest limit recommendations, and a robust research program.
- Colorado's current statewide total human-caused mortality rates (dominated by harvest) are around 12.5-14.5% of the independent lion population (independent lions are adults and subadults excluding kittens and dependent young). Harvest offtake itself is in the 10-12% range. This off-take rate is generated using conservative assumptions from a recently-developed model used to define statewide lion habitat and lion density estimates acquired from 3 recent studies done across the state (Figure 1 and Table 1).
- This statewide level of off-take or mortality is considered sustainable (not suppressive) when compared to nearly every citation available in the literature.

- This mortality range is ***conservative*** and corresponds to objectives laid out in our current approved lion management plans. The 10-12% harvest mortality rate (12.5-14.5% total human-caused mortality) is similar or below rates of removal seen or recommended in most western states.
- Our harvest is well balanced, with proportions of adult males (3 years and up) and subadults of both sexes making up the majority of mortality. Adult female composition in harvest can be informative of population trend with rates below 20-25% indicative of stable populations. Colorado's statewide adult female harvest proportion is 16%, an indicator of a strong population with high reproductive potential and a stable population trajectory (Figure 2).
- Colorado managers are fortunate to have the use of hound hunting as a tool in lion management unlike states like Washington and Oregon with statutory limits from ballot initiatives. Hound hunters can be selective in the gender of the lions they pursue based on track size and examination of the treed animal. This selective tool available in Colorado lowers female harvest proportion by about 10-15% and is readily apparent when comparing our data to states without legal hound hunting where "boot hunters" during deer and elk season take lions regardless of gender as they are encountered in the field. Female lions, and more specifically, adult females, are the source for sustaining populations.
- While Colorado presently does not explicitly manage for defined source and sink areas or employ a formal "zone" management strategy, nearly half of Colorado's best lion habitat can be considered a population source. Well over 40% of Colorado's highest quality lion habitat has no/very low female (or male) harvest mortality. These areas are functioning as *de facto* refugia. The fact that these robust source areas exist in abundance, at large spatial scales, and are well distributed across Colorado further contribute to supporting lion populations, even after considering conservative annual mortality rates.
- Conflicts in Colorado have shifted over the last 10-15 years from being largely agricultural (depredation on sheep and other livestock) to a much greater proportion representing human-lion conflicts. These include human safety incidents and depredation on pets and hobby livestock along the human-wildland interface.
- Hunting, or the use of harvest to lower lion densities in areas immediately surrounding conflicts, is not a practical option in Colorado in the locations that most conflicts are occurring due to limited access and inability to increase harvest pressure.
- Targeted removal of individual offending lions involved in conflicts is the primary means used by CPW to address human safety and agricultural damage. Landowner, APHIS and CPW removals of lions (conflicts) has only represented between 3-7% of all annual statewide human-caused lion mortality over the last 10 years. This is in comparison to higher conflict removal rates seen in some other western states.

Figure 1.

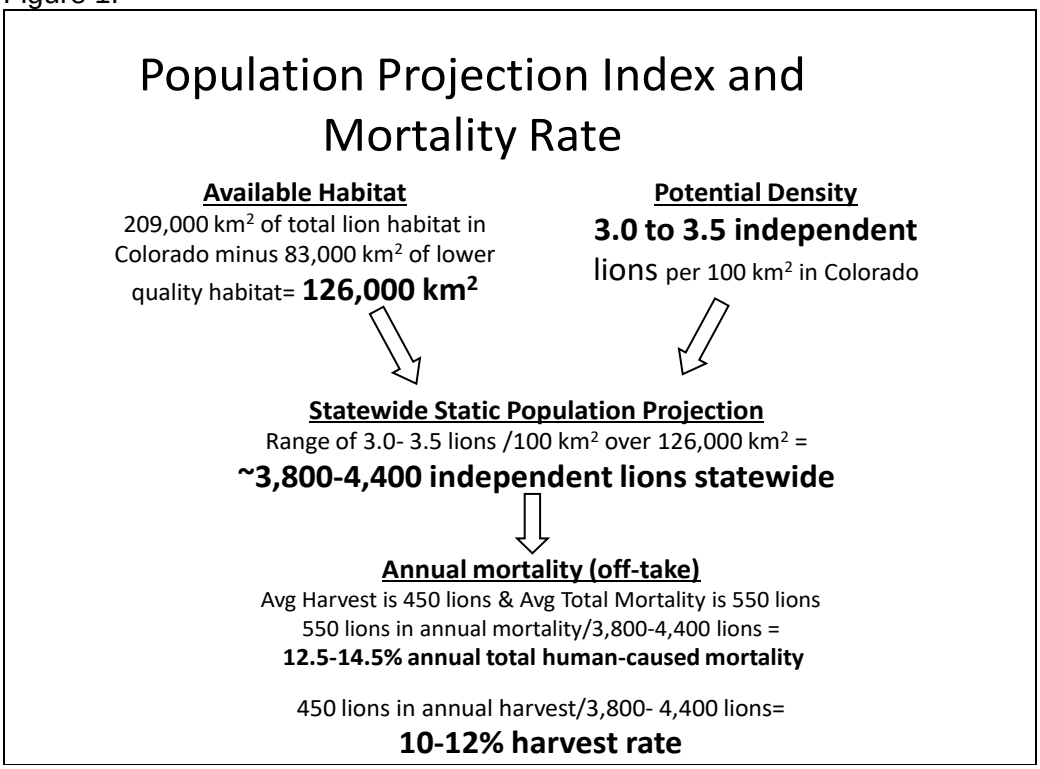

Figure 2.

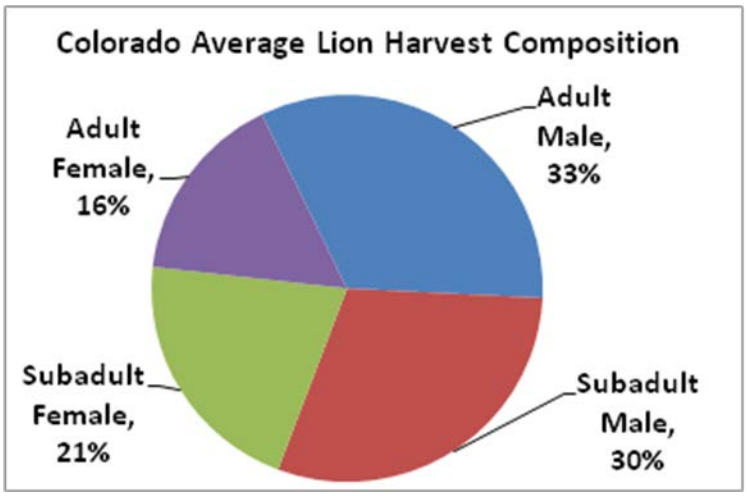

Table 1. Mountain lion densities reported or derived from surveyed areas in the western United States and Canada, 2001-2018. Only studies reporting densities of *independent* lions per 100 km^2 are included. Sorted by density estimation methods.

Location	Survey Area Size (km^2)	Independent Mountain Lion Density (point estimates or range)	Number Survey Years	Notes	Reference
Density estimate generated using spatially explicit capture-recapture (SECR) methods					
Colorado	1701	**1.6-2.8**	8	Hunted and unhunted	Logan and Runge, 2018, in review
Colorado	1250	**4.1**	3	Lightly hunted	Alldredge et al. 2019, in review
Colorado	~4500	**2.9**	1	Hunted	Alldredge, 2019, preliminary data
Montana	2625	4.5-5.2	1	Hunted	Proffitt et al. 2015
Traditional density estimate generated using capture radio collar techniques					
Utah	1300	1.2-3.2	9	Hunted	Stoner et al. 2006
	480	2.5-2.9	8	Unhunted	
Wyoming	383	2.4	1	Pre-treatment. Then thru 2 treatment yrs followed by 3 recovery yrs.	Anderson and Lindzey 2005
	439	3.4			
	1700	1.2-3.2	5		
New Mexico	2059	1.5-2.1	7	Simulated hunting effect	Logan and Sweanor 2001
Utah/Idaho	1700	1.0-2.1	15	Hunted	Laundre et al. 2007