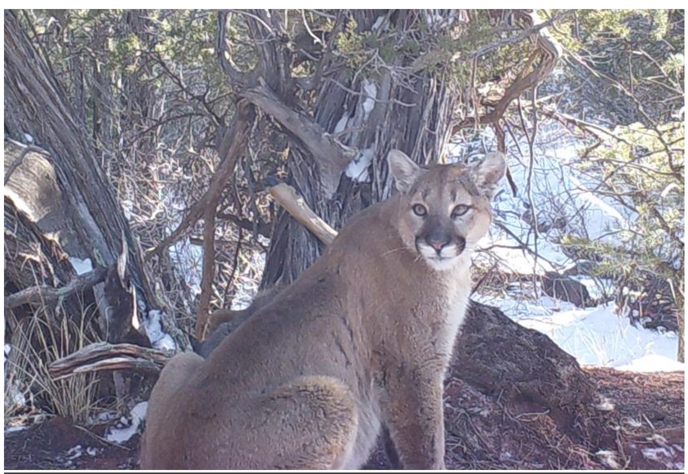
Colorado East Slope Mountain Lion (*Puma concolor*) Management Plan

November 2024

Colorado Parks and Wildlife



Approved by the Parks and Wildlife Commission on xx

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Executive Summary

Colorado Parks and Wildlife (CPW) manages mountain lions (*Puma concolor)* on the East Slope of Colorado to conserve, protect and enhance lions for the use, benefit, and enjoyment of the state's citizens and visitors. CPW's goal is to ensure that lions continue to exist in stable numbers on the East Slope of our state for their scientific, ecological and intrinsic value and for current and future generations to enjoy through hunting and occasional observation. This lion management plan provides the framework for how CPW will achieve this goal in the Northeast and Southeast CPW Administrative Regions and replaces existing lion management plans for populations in Data Analysis Units (DAUs) L-4, L-12, L-11, L-16, L-17 and L-19.

This East Slope Mountain Lion Management Plan is written to address the concern that CPW's six DAU plans for the East Slope of Colorado, five of which were written in 2004, are each individually too small in spatial scale to properly manage solitary, low-density, wide-ranging carnivores like lions (Logan and Runge 2021). This plan increases the size of the management unit at which analysis and evaluation will occur to a more appropriate scale: the pooled CPW Administrative Northeast and Southeast Regions. As under the current lion management framework, hunter harvest will continue to be allocated across groups of Game Management Units (GMUs), but the size of most of these groups will be increased.

This plan incorporates the best available lion science published in the peer-reviewed literature, which strengthens integral parts of the framework of this plan. A strong body of research and management citations support the monitoring thresholds included in this plan. In addition, this plan outlines the process of annual review, evaluation, and adjustment to management. It also borrows heavily from the basic framework established under the West Slope Mountain Lion Management Plan, which has proven to be a successful model for lion management in Colorado since approval in 2020 and implementation in 2021.

<u>East Slope (L-ES) DAU Objective</u>: The management objective across the entire East Slope is to maintain a ***stable*** lion population. This would mean lion population levels will remain similar to what we see today. This replaces historical objectives in the six individual DAUs, two of which were managed for suppression of the population. Allocating allowable harvest mortality across harvest limit groups provides managers the flexibility to distribute harvest limits to meet local management needs, while L-ES DAU-scale thresholds ensure the maintenance of population stability at the larger scale.

<u>Annual Data Collection and Monitoring Thresholds</u>
Two annual monitoring thresholds are established in this plan and will be evaluated independently for the entire East Slope:

1) ***Adult Female Harvest Composition Threshold:*** *Adult female composition in total L-ES DAU harvest will not exceed 22% in any year*
    a. *Adult females are ≥3 years old or a female of any age that shows evidence of past nursing*

2) ***Total Human-Caused Mortality Threshold:*** *The 3-year average of total reported human-caused mortality will not exceed 17% of the extrapolated abundance index from the resource selection function for the L-ES DAU*
    a. *Human-Caused Mortality sources include hunter harvest, depredation or control removal of lions, lions killed by vehicles, etc.*

Current 2024-2025 East Slope DAUs (L-4, L-11, L-12, L-16, L-17 & L-19) harvest limits total: 208 lions

Proposed 2025-2026 East Slope (L-ES) harvest objective: 160 lions. This harvest objective will be in place for 2025-2026 to allow the completion of the 10th and final year of the Upper Arkansas lion research project. This is an initial reduction in DAU-wide harvest limits of 48 lions (23%) from 2024-2025 levels

Proposed 2026-2027 East Slope (L-ES) harvest objective: 155 lions. This is a reduction of 53 lions (25%) from 2024-2025 levels

Proposed East Slope (L-ES) total human-caused mortality threshold: 214 lions

Annual evaluation of adult female harvest composition allows assessment of population trajectory based on the selective nature of hound hunting and the proportional abundance of each age/sex class on the landscape. Limiting adult female harvest also acts to protect the component of the population responsible for reproduction. The use of a total human-caused mortality threshold acknowledges the biological importance of other known human-caused lion mortality factors beyond harvest (Logan and Runge 2021) and sets a ceiling for the maximum acceptable mortality that interacts with information derived from adult female composition evaluations.

By complementing different aspects of our understanding of lion population performance across the East Slope, these monitoring thresholds interact and balance each other during annual analysis. If either threshold is exceeded, this plan lays out clear and supportable steps that will be taken with harvest management to keep the population trajectory from a decline.

This plan also articulates future research needs and programmatic improvements to statewide harvest reporting that will be evaluated as part of the initial implementation of this plan. Additionally, CPW will initiate lion density estimation work on the East Slope as part of this plan to help inform our population projections.

Management Plan Public Engagement:

Given the technical complexities of lion management and the need to inform the general public about the species, CPW staff held eight public meetings before drafting the East Slope plan and releasing it to the public for feedback. Six in-person meetings across the Southeast and Northeast Regions and two virtual meetings were held in February and March 2024. Approximately 700 members of the public attended the eight meetings. The meetings were interactive, with activities such as lion biology trivia, opportunity for discussion, and time for participants to ask questions and hear responses from CPW subject matter experts. Attendees discussed topics such as implications for harvest limits, female harvest thresholds, lion ecology and human-lion interactions.

The draft plan was available online for public review and input for 30 days beginning on May 15th, 2024. Input was gathered and reviewed by CPW staff as part of the planning process prior to the final draft plan being presented to the Parks and Wildlife Commission to consider for approval. 181 individuals shared public input during the 30 day period. Five stakeholder organizations also provided input. Additionally, CPW staff solicited a peer review of the draft plan as well as an academic review by independent, objective professionals in the field.

Appendices to this plan should be referenced for comprehensive explanations on the following topics:

Appendix A: Mountain Lion Life History, Ecology and Monitoring

Appendix B: Mountain Lion Management History in Colorado and the East Slope

Appendix C: Mountain Lion Resource Selection Function Model

Appendix D: Literature Cited

Appendix E: Public Engagement and Input on East Slope Mountain Lion Plan

Acknowledgments:
The development of this East Slope Mountain Lion Management Plan involved the active participation of many people whose professional expertise, knowledge and perspectives were invaluable for critical review and numerous suggestions to improve the content including Northeast and Southeast Senior Wildlife Biologists and their Area Wildlife Biologist staff, Northeast and Southeast Region Area Wildlife Managers and District Wildlife Managers, Regional and Deputy Regional Managers, Terrestrial Programs and Mammals Research staff, Policy and Planning staff, and many others with CPW too numerous to individually mention here. We also thank the Nevada Department of Wildlife and Dr. Jerry Belant with Michigan State University for accommodating our solicitation for independent reviews and comments on this plan. All of the above professionals had many other projects and activities that were balanced against the time needed to develop and attend the public meetings, engage in internal CPW discussions and comment on the draft plan. Colorado Parks and Wildlife thanks all of you.

Colorado East Slope Mountain Lion Management Plan

Table of Contents

East Slope Mountain Lion Management Plan Goal and Strategy

On the East Slope of Colorado, Colorado Parks and Wildlife's (CPW) aim for mountain lion (*Puma concolor;* hereafter lion) management is to conserve, protect, enhance, and manage lions for the use, benefit, and enjoyment of the citizens of Colorado and its visitors. The broad goal laid forth in this plan by CPW is to manage for a **stable lion population**, while allowing for management flexibility at smaller scales.

This plan puts forth a strategy to allow management flexibility at the harvest limit group scale, while regulating lion mortality with thresholds designed to maintain stable lion numbers at the larger East Slope (L-ES) Data Analysis Unit (DAU) scale. At small scales, lions experience great variation in rates of abundance, survival, mortality, immigration, and emigration and therefore while management assumptions about those parameters are quite important, inference at smaller scales is challenging (Logan and Runge 2021). At larger scales, however, it is more likely that differences in initial population density assumptions result in relatively small changes in population growth rate, and uncertainty about dispersal may not be as influential (Robinson et al. 2015). A review of these and other aspects of lion biology and ecology is provided in Appendix A.

With implementation of this plan, we will transition from the six historic lion DAUs on the East Slope to a single DAU comprised of all lion habitat in both the CPW Northeast and Southeast Administrative Regions (Figure 1). This new L-ES DAU will be the management unit of interest, analysis and reporting.

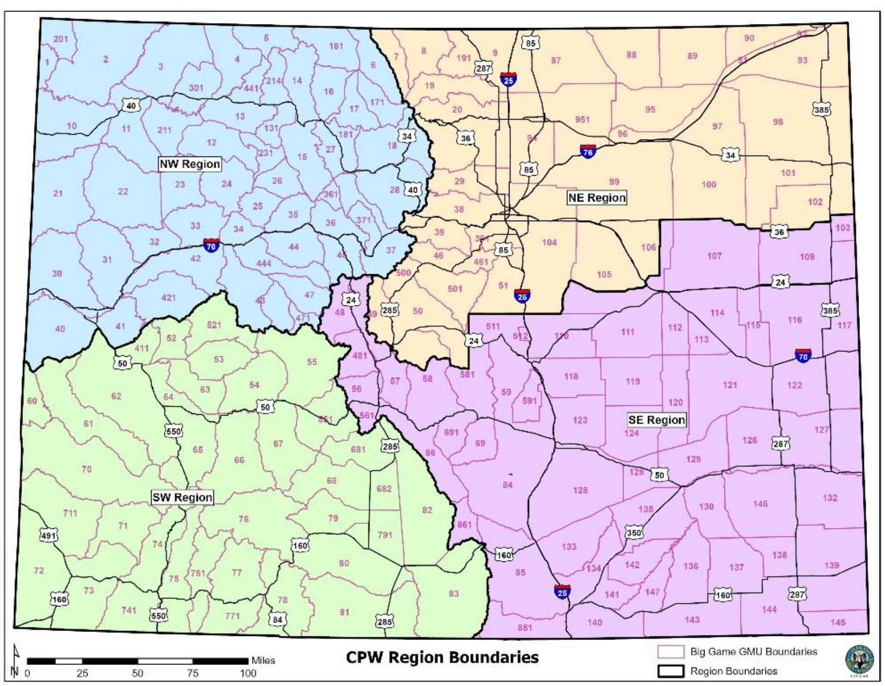

Figure 1. CPW's four statewide Administrative Regions

Since the implementation of the West Slope Mountain Lion Management Plan in 2020, internal CPW and external stakeholders interested in lion management have requested an updated lion plan to cover the East Slope. Completion of this new plan would satisfy Goal I, Objective A, Strategy 1 of CPW's Strategic Plan to "complete timely revisions and amendments of management plans to ensure plans are up to date per 10-year periods (CPW Strategic Plan and 2024-2026 Operational Plan).

The further need for this plan is demonstrated as follows:

- Larger management scales (such as pooling of present DAUs) are most relevant to lion biology and most appropriately support management inferences from mortality and composition data
- Significant advancements in geographic information systems (GIS) modeling, lion monitoring metrics, density estimation and population trajectory information have been published in the peer-reviewed literature over the last 20 years, and need to be incorporated into lion management
- Eliminating objectives that aim to reduce lion populations at DAU scales and enacting thresholds that ensure populations remain stable at current levels throughout their range on the East Slope to assure the important ecological role this apex predator plays among the state's species
- All but one of the existing East Slope lion DAU plans are 20 years old and this plan will leverage updates into one plan
- Without updated East Slope lion management plans, managers setting annual harvest limits are challenged with aligning metrics and objectives in historic plans against contemporary management practices. One example of an improvement would be moving from a total female harvest proportion threshold to an adult female harvest proportion threshold
- Provide consistency with West Slope Mountain Lion Management Plan thresholds recently adopted in 2020

Value of Mountain Lions to the Ecology and Function of East Slope Ecosystems

Colorado is fortunate to have a robust prey base and quality lion habitat with sufficient hiding and stalking cover in a large portion of the state. CPW's conservation-based management practices have made Colorado home to the nation's largest elk herd and strong mule deer and white-tailed deer populations (CPW unpublished data, 2024). By both informal and empirical estimates, Colorado's lion population is as strong as it has ever been since the mid-1900s when predators were persecuted through unregulated take. Population recovery began in 1965 following lions being classified as a big game species.

Knowledge about the public's historic and present values toward wildlife, including lions, can assist with agency planning and management decision-making (Teel et al. 2005, Manfredo et al. 2018, Dietsch et al. 2019). As recommended by Carlson et al. (2023), CPW has embraced the restoration of carnivore biodiversity, reflecting some of the emerging values and desires from the state's expanding constituencies at the wildlife stakeholder table. Many of our state's citizens value abundant lion populations in appropriate habitats simply for their intrinsic value and ecological role.

In the case of lions, which now occupy all available lion habitat in Colorado in strong numbers (Vieira, January 2024 Colorado Parks and Wildlife Commission meeting), their presence at current densities helps contribute to the state's biodiversity. Researchers have demonstrated their possible role as a keystone species in contribution to nutrient cycling via their foraging strategy (Peziol et al. 2023, Monk et al. 2024). Particularly in less productive environments, lion-killed carcasses generate nutrient hotspots on the landscape, which contribute to ecosystem functions (Monk et al. 2024). Peziol et al. (2023) suggest a contribution made by lions to landscape-level heterogeneity in nutrient distributions, which fosters trophic cycling between lions, their prey and both species' space-use of habitat.

Lions, as apex predators, may also play a role in augmenting agency management efforts to control chronic wasting disease (CWD) in ungulate populations. Lions can selectively remove CWD infected mule deer (Krumm et al. 2010, Fisher et al. 2022) and in doing so may help reduce prion burdens in the environment (Baune et al. 2021, Fisher et al. 2022, Miller and Wolfe 2022). However, no field studies have shown evidence of predation reducing CWD prevalence, presumably due to insufficient predation rates of infected individuals (Miller et al. 2008, DiVivo et al. 2017). Published simulations that modeled a predation-linked reduction in prevalence (Wild et al. 2011, Brandell et al. 2022) required rates of predation (Heffelfinger and Krausman 2023; Table 7.3) and selection for infected individuals that are above what has been observed (DiVivo et al. 2017). Colorado's robust lion populations can play an ecological role in disease dynamics, but direct harvest management of ungulate herds by CPW is the primary and most practical method for addressing CWD prevalence reduction objectives.

Beyond the predator-prey dynamic, lions may also provide benefits to a large number of other species across their overall range. In their review, LaBarge et al. (2022) documented lions directly or indirectly interacting with 534 other species across their entire hemispheric range. They argue that protection and restoration of lion populations helps to link energy and nutrients across disparate trophic levels, benefiting a huge suite of species beyond just lions. Even within lion communities themselves, emerging research has observed intricate and complex social strategies employed by these usually solitary carnivores to successfully thrive on the landscapes they inhabit (Elbroch et al. 2017).

Additionally, common, abundant species tend to have large, widespread ranges (Lawton 1993). Therefore, a species like lions may serve as an umbrella species for guiding wider landscape conservation efforts. Recently established lion populations in places like the North Dakota Badlands and the Nebraska Panhandle (Knopff et al. 2014, Winkel et al. 2023) are the result of successful conservation efforts in states like Colorado, where robust populations provide opportunities for dispersing individuals to recolonize historic lion range.

This East Slope Mountain Lion Management Plan directs CPW to manage for a stable lion population and intends to sustain lion numbers similar to what we see today. This stable objective was selected to promote the ecological role that lions play in our state, reflect the intrinsic value of this species by safeguarding their existence in abundance on the landscape, offer culturally important and statutorily mandated hunting opportunity (Colorado Revised Statutes 33-1-101(1 & 4)), and provide managers with tools to address human-lion conflicts and human-safety issues. The myriad benefits provided by Colorado's lion population described above are not mutually exclusive of each other. A successful management plan can balance all these diverse objectives.

Management Plan Update & Revision Process

This plan initiates a long-term management framework for the entire East Slope for approximately the next 10 years. Colorado Parks and Wildlife's management plans are based on credible scientific information, informed by and responsive to the diversity of public interests and concerns, and readily available to the public. Management plans provide an accountability mechanism for agencies that manage lions as a public trust resource. However, management plans that persist over long periods risk becoming unresponsive to new scientific evidence or may outlast changing perspectives of citizens or resource management demands. A common criticism of management plans is that they are overly restrictive and unresponsive to either changing management conditions or to newer information. The challenge is to create guidance that is firm enough to truly guide management, but that is also adaptive to new scientific information, new opportunities to test management applications, and new demands placed upon the agency. Periodic review and examination of new scientific information relevant to the management assumptions contained in this plan will be conducted as needed over the 10 years of this plan.

Following the third year of management under the East Slope plan, CPW will conduct a thorough evaluation of data and assumptions associated with lion harvest and mortality, threshold performance and harvest limit groupings. CPW staff will present those results to interested stakeholders.

Lion Harvest Terminology, Regulations Process and Hunting Seasons

Harvest Limit Groups: The term to describe the pool or grouping of Game Management Units (GMUs) that are combinedunder one harvest limit will be called a "harvest limit group". In the past, harvest limit groups have been as small as one GMU or up to eight or more GMUs. Under this plan, the size of most harvest limit groups will increase, as each group will include more GMUs than under past plans. Under CPW's 2024-2025 regulations, the six East Slope lion DAUs have a total of 21 harvest limit groups. In 2026-2027, under the East Slope plan, we are proposing a single DAU with six harvest limit groups.

L-ES DAU Harvest Objective and Harvest Limit: CPW will establish an annual "DAU harvest objective" for the entire East Slope L-ES DAU. The harvest objective is not a level CPW is trying to achieve, but a numerical ceiling of the annual number of lions that hunters can harvest across the entire DAU. Lion managers divide the harvest objective among the harvest limit groups into allocated harvest limits. In other words, the sum of the harvest limits on the East Slope is equal to the L-ES DAU harvest objective. CPW will continue to use the term “harvest limit” for each harvest limit group. Initial recommendations for harvest limits under the East Slope plan are provided in a later section of this document.

In accordance with lion regulations, the annual harvest limit accounting will begin on April 1 and end on March 31 (license year). Only hunter harvest (lions associated with take on a lion license) will be counted and deducted from the harvest limit. Harvest limits are set annually after wildlife managers consider harvest, composition and total mortality data from the previous year relative to the DAU’s objective.

While DAU harvest limits and harvest limit group composition are traditionally reviewed annually, CPW intends to maintain the proposed lion harvest limits and harvest limit groups static for an initial 3-year period to allow sufficient time for any management efforts to yield results. For example, if efforts are applied to decrease lion abundance in a local area, Anderson and Lindzey (2005) suggest that a 3-year period is necessary to detect changes. Other studies suggest that a time period between three and five years is the minimum time for recovery of previously suppressed populations (Logan and Sweanor 2001, Anderson and Lindzey 2005, Stoner et al. 2006, Robinson and DeSimone 2011, Logan and Runge, 2021). One exception to this initial stability in harvest limits would be if management thresholds are exceeded and management action is needed. Another exception would be if the assumptions made using 2020-2022 averages to predict harvest and non-harvest human-caused mortality for setting the first year’s harvest limits in development of this plan were found to be different once the plan was implemented. Finally, the need to conduct the 10th and final year of the Upper Arkansas lion research project in 2025-2026 will require some changes in harvest limits under the first year of the plan. These harvest limits are laid out in the section on Harvest Limits beginning on page 30.

Annual Lion Regulations Process: This East Slope Mountain Lion Management Plan continues to follow CPW’s regulatory process and timeline. The annual regulatory cycle for lions occurs in two stages. The first stage includes regulations related to season dates, open GMUs or harvest limit groups, method of take, and harvest reporting requirements. The second stage involves the establishment of annual harvest limits by harvest limit groups.

Mountain Lion Regulation Development Process for **Seasons, Method of Take, Other Provisions**:

- July-September: internal considerations, conceptual development, regional review meetings
- October: issues considered at internal regulation review meetings
- November: issues/draft regulations presented for consideration at the Parks and Wildlife Commission meeting
- December: regulation language modified pursuant to November meeting outcomes
- January: final adoption action by the Parks and Wildlife Commission

Mountain Lion Regulation Development Process for **Harvest Limits and April Seasons**:

- June-July: analysis of harvest, total mortality, and adult female harvest composition

- September-November: internal development of harvest limit recommendations, regional review meetings, harvest limits by harvest limit group considered at internal regulation review meetings
- January: final adoption action by the Parks and Wildlife Commission on harvest limits and April seasons along with final approval of all other lion provisions
- February: publication of online Mountain Lion brochure

Every 5 years, CPW's big game season structure (BGSS) is evaluated, which may affect lion seasons. There are multiple stages of BGSS, including issue identification, information gathering, public outreach, development of recommended changes, drafting of regulations, and final structure and approval by the Parks and Wildlife Commission. The approved 2025-2029 Big Game Season Structure is compatible with all aspects of this East Slope Mountain Lion Management Plan.

***Lion Hunting Seasons*:** Two distinct lion hunting seasons occur during the April 1- March 31 license year. Both seasons will be maintained in this plan, but use of an April season will not initially be employed for at least the first three years of this plan. The two seasons have different purposes, but each will operate within the context of the harvest limit system.

1. **April Lion Season:** The season will run from April 1-30 in specific harvest limit GMU groups, annually. The use of dogs as a hunting aid is allowed. This is primarily an additional opportunity season in locations where harvest limits may not be routinely achieved during the regular season. If this hunting opportunity is not compatible with other management considerations or local issues, then an April season will not be initiated. The utilization of an April season is determined annually for each harvest limit group and will continue to be available under the East Slope plan following the first three years of plan implementation.
2. **Regular Lion Season:** Begins the day after the close of 4th rifle deer and elk season and continues through March 31, annually. The use of dogs as a hunting aid is allowed. The bulk of lion harvest is expected during this time and the majority of hunter days will occur in this season. Lion hunting opportunities are available during each license year until harvest limits are reached in each harvest limit group, at which point that harvest limit group will be closed for the remainder of the license year.

***Methods of Take*:** The use of dogs shall be allowed as an aid to take lions as prescribed within the foregoing April and Regular seasons. The use of mouth-operated predator calls is allowed. Electronic calls are illegal for all big game, including lions. Legal rifles, shotguns, crossbows, handguns, and archery equipment are allowed.

Data Collection Scales and Monitoring Thresholds

Lions occupy large spatial scales in terms of home ranges and dispersal patterns. They regularly live, move, and disperse across previously used DAU boundaries, CPW Administrative Region boundaries and state lines. Consequently, monitoring mortality and female composition at small scales is hampered by small sample sizes and large amounts of annual variation. As noted by Logan and Runge (2021), larger regions for lion management are more appropriate to the scale of lion movements and demographics. At the historic DAU scales on the East Slope, the difference between a couple animals of one gender or age class to another could meaningfully alter harvest composition proportions and resulting conclusions about management trajectory in some units. For example, using the most recent age class data from 2020-2022, total annual lion mortality was less than 45 animals for five out of six East Slope DAUs. When samples of each individual DAU's harvest were divided among the four age/gender classes (adult female, subadult female, adult male, and subadult male) the composition of any one class often would be represented by only 5-10 individual lions, causing year to year compositional proportions to commonly vary by 20-30%. This amount of variation in harvest composition confounds data interpretation, making it difficult for wildlife managers to evaluate the effects of different harvest levels on lion population trajectories at the smaller DAU scale used in 2024-2025.

Many lion biologists across the West suggest managing lion populations with respect to source-sink dynamics (CMGWG 2005, Wyoming Game and Fish Department 2006, Cooley et al. 2009*a*, Robinson and DeSimone 2011, Jenks et al. 2011, Logan 2019, Logan and Runge, 2021). Source areas are areas that have low harvest or mortality levels that allow for increased production and survival of dispersing lions that move to other source areas and into sink areas where management objectives or other human causes create higher rates of lion mortality. Thus, source areas retain a capacity for population resiliency region-wide. This approach allows for considerable flexibility in applying variable harvest rates spatially and temporally. This would be in contrast to a management framework with little flexibility where harvest is attempted to be apportioned evenly across the landscape as outlined by Beausoleil et al. (2013). This plan incorporates source-sink dynamics by allocating lion harvest mortality across the entire East Slope at a level appropriate for a stable population objective, while allowing harvest pressure to vary within more local areas defined by harvest limit groups.

Regional Data Analysis Units

The history of lion management in Colorado, and more specifically on the East Slope, is provided in Appendix B. This appendix includes an overview of harvest management, methods of hunting, game damage, and a human-lion conflict discussion, all within the historical DAU-specific management structure. A map showing the six historic lion DAUs is also included in Appendix B.

Under this new plan, the East Slope DAU (L-ES) will be comprised of one large DAU, corresponding to all lion habitat within the combined CPW Northeast and Southeast Administrative Regional boundaries instead of the historic DAU scale (Figure 2). This new L-ES lion DAU is comprised of previous lion DAUs L-4, L-11, L-12, L-16, L-17 and L-19.

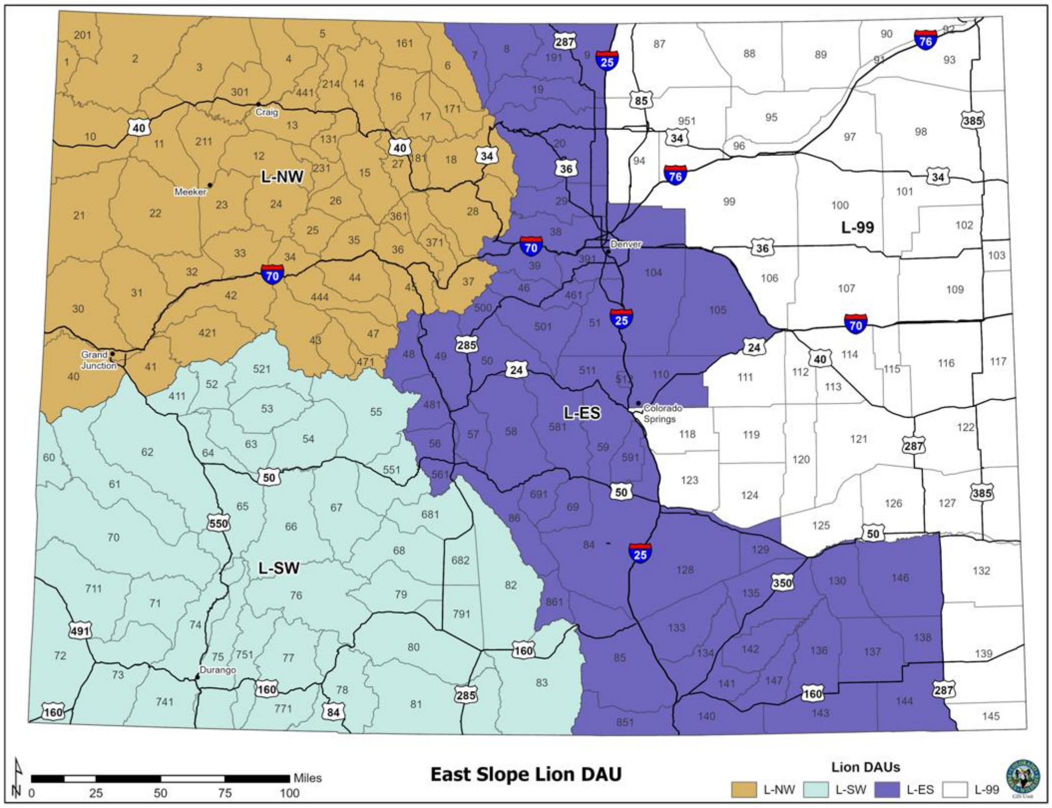

Figure 2. The location of the new East Slope Data Analysis Unit L-ES within Colorado.

The six historic DAUs have existing management plans that were written in 2004, except for L-19, which was updated in 2019. Four of the six plans have objectives of maintaining a stable lion population. Two of the plans, DAUs L-12 (North Central Front Range) and L-17 (SE Plains), have “suppression” objectives primarily to reduce lion populations due to concerns over high rates of game damage and human-lion conflicts. The new L-ES DAU stable management objective will replace all historic DAU objectives in the areas governed by those six previous plans.

L-99 (Northeastern Plains) is not a formal DAU (Figure 2). The area within L-99 is not included in L-ES because it is poor quality lion habitat and only occasionally experiences dispersing lions, and therefore is not included in the East Slope plan. As part of this East Slope plan development, eight GMUs in southeastern Colorado (historically part of L-17) which are largely shortgrass prairie and do not contain lion habitat, were moved into L-99. These GMUs did not belong in a harvest limit group of GMUs that included a viable lion population. While this reorganization is administrative and has no impact on lion mortality or data analysis, L-99 will now include all of the GMUs in that group in 2024-2025, along with GMUs 123, 124, 125, 126, 127, 132, 139 and 145 (Figure 2). Analysis of both the historic L-99 and the new proposed L-99 with the inclusion of these eight GMUs, shows that both groups have a 5-year average harvest of zero lions.

Annual Data Collection

All known lion mortalities in Colorado are recorded during a mandatory check process. For harvest mortalities, every hunter is required to report their harvest within 48 hours and present the hide and head for inspection within five days. During this mandatory check, biological data is collected including sex, evidence of past nursing/breeding status, and age information, including extraction of a premolar for cementum aging (Table 1).

Table 1. Cementum (premolar tooth) aging guidelines

Cementum Age	Age Class
0-12 months old	Kitten
1-2 years old	Subadult
3 years and older	Adult
Female of any age that shows evidence of past nursing	Adult

Lion mortality data are used to evaluate age and sex composition of harvest, distribution of harvest and non-harvest lion mortalities, indices of population trajectory, and to account for and set harvest limits. Due to standard time delays in cementum analysis, the current harvest composition analysis always lags one harvest year behind regulatory cycles.

Harvest data can be used in many different ways. The age of reproductive females can be useful to examine the reproductive potential of lion populations (Stoner 2004, Anderson and Lindzey 2005). Populations maintaining older-age females have higher reproductive potential, and thus resiliency, than populations where adult female survival is lower. Additionally, recording the distribution of lion harvest and other recorded human-caused mortalities allows assessment of potential source areas where little or no lion mortality occurs, and sink areas where lion mortalities may be relatively high. This type of spatial information may be used to help inform harvest limits that are established by harvest limit groups.

As recommended by Beausoleil (2017) and Murphy et al. (2022), we approached all demographic metrics referenced in this management plan with standardization in mind. Since most recent literature focuses on metrics defined by “independent” lions, that is the common standard we have used in all data, thresholds, and models presented in this plan (Murphy et al. 2022). Independent lions are defined as animals that are not dependent on their mother; this includes subadult lions (independent, but have not produced young) and adult lions (Table 1). Logan and Runge (2021) found that female lions in Colorado averaged closer to three years rather than two years old when they birthed their first litter. The adult age class is defined as a cementum tooth age of 3 years and older, or a female of any cementum tooth age showing signs of having nursed. See Appendix A for details on lion life history. Kittens are considered dependent lions, and as such are not legal for harvest and are not included in demographic metrics and thresholds.

Adult Female Harvest Composition Threshold Development

Both the survival rate and relative abundance of adult female lions, as the reproductive component of a population, are important considerations for managers. For instance, in the

Garnet Mountains of Montana during an un-hunted period, 71% of the growth rate in the population was related to reproduction (maternity and kitten survival), while adult female survival accounted for only 22% of the population growth rate. When hunting was added, only 17% of the growth rate in the population was related to reproduction, while adult female survival became more influential and accounted for 40% of the population growth rate. Monitoring and population modeling efforts in this population indicated that when accounting for all forms of known human-caused mortality, adult female annual survival needs to be at least 80% to prevent a decrease in the resident lion population level (Robinson and DeSimone 2011) and therefore limits on adult female harvest mortality would be needed to prevent declines. Logan and Runge (2021) state that lion populations have a greater tendency to decline when annual adult female survival rates are ≤0.78 and tend to increase at ≥0.86.

Recent research findings are presented below reviewing adult female harvest composition and population trajectory.

Wildlife managers have the ability to limit lion population growth using hunter harvest (Robinson and DeSimone 2011). On the Uncompahgre Plateau, Colorado, during the 5-year lion hunting phase of a research project, ***adult females*** comprised 23% of the total cumulative harvest. In this study, lion harvest was considered additive mortality and lion survival rates and independent lion abundance declined, primarily for the male population segment, when compared to the preceding reference phase with no lion hunting (Logan 2015, Logan and Runge 2021).

In southern Idaho and northern Utah, Laundre et al. (2007) tested the effects of changes in prey abundance on lion population dynamics. Through their monitoring of the change in population size and social-age class structure, they suggest that an annual harvest of 15 to 20% of ***resident (adult) females*** would not reduce a population.

Anderson and Lindzey (2005) conducted an experimental population reduction and recovery in the Snowy Range of Wyoming to examine how various gender and age classes are exposed in hunter harvest when a population is increasingly exploited. Because of the differences in daily movement distances, it was assumed that under equal gender ratios, males are more vulnerable to hound hunting, which relies on discovery of tracks in snow. Increasing hunting pressure exposes different genders and age classes until they are relatively less available, subsequently exposing the next most vulnerable sex/age class. Sex and age classes of lions exhibit different and relatively predictable movement patterns, where males move longer distances than females and subadults generally move longer distances than adults (Barnhurst 1986, Anderson 2003). Conceptually, the likelihood of a specific sex or age class of lion being harvested would reflect its relative abundance in the population and its relative vulnerability based on daily movement patterns. The least vulnerable individuals (adult females) should become prominent in the harvest only after the population has been reduced in size by removal of more vulnerable/available lions. Harvest progression of a higher density population would be expected to shift from subadults to adult males and finally to adult females as more vulnerable or targeted individuals are removed and the population is reduced in size (Anderson and Lindzey 2005). Selectivity in harvest where hunters select males over females, or perhaps subadults, is possible from experienced hunters using hounds by examining track characteristics or live animals prior to harvest. Selective harvests may delay or change the order of expected harvest progression, but this relationship should still hold as larger males are removed and the least vulnerable and most biologically important compositional class (adult females) becomes exposed as abundance of other more selected age/sex classes decline. Anderson and Lindzey (2005) tested these predictions by applying varying levels of hunter harvest and found harvest composition to be predominantly subadults for a high-density population with low harvest levels, shifting to adult males as harvest levels increased, and then a shift from adult males to adult females with continued high harvest as the population declined. Likewise, Cooley et al. (2009*b*) noted that adult females increased in harvest composition when hunting increasingly removed other age/sex classes in a population. When harvest levels were reduced, the composition of the harvest returned to primarily subadults. The male segment of the reduced population recovered within two years, primarily due to male immigration from other populations and the female segment within three years from an increased number of females producing young within the population (Anderson and Lindzey 2005). They concluded that the population appeared to support a harvest composed of 10-15% adult females. When ***adult female*** composition in hunter harvest reached approximately 25%, the population began to decline.

The results of these studies suggest that setting an L-ES DAU composition threshold of between 20-25% adult females in hunter harvest will maintain the East Slope goal of managing for a stable population. Therefore, CPW selected **a maximum annual threshold of 22% adult female harvest composition** because it represents a mid-range value based on these independent research efforts. If this threshold is exceeded, the population would likely begin to decline. Because the goal is to not exceed this threshold and to maintain a stable population size, adult female harvest composition will be examined annually and management actions will be enacted to reduce female and/or overall harvest if this threshold is exceeded in any single year.

Applying our new monitoring scale to historic data, the composition of adult females in total harvest over the last five years has ranged from 11-16% across the East Slope (Table 2). These statistics suggest that under recent and fairly consistent harvest levels during this period, the East Slope population has not undergone a decline. In accordance with this plan, data will be evaluated annually to inform management, but voluntary female and overall harvest reduction steps will be required only if the monitoring threshold of 22% is exceeded.

Table 2. East Slope (NE and SE CPW Regions) adult female harvest composition and sample size of interpreted age class (*N*) for the last five years (2018-2022). Data include all legal harvest mortalities for lions with known sex/age classifications for all GMUs in each region.

		2018	2019	2020	2021	2022
East Slope DAU (L-ES)	Adult Female Composition in Total Harvest	16%	15%	12%	11%	15%
	N	*143*	*116*	*125*	*131*	*117*

It should also be noted that less selective methods of harvest are likely to result in harvest composition that reflects the relative abundance of the four age-gender classes. Consequently, significant use of non-selective methods at any broad scale will confound harvest composition analysis. Hound harvest relies on a portion of hunters selecting against taking females based on track size or identification of gender while the lion is bayed, but non-selective methods take lions of each compositional class in the same relative abundance that they are encountered, so much higher rates of female harvest would be expected. Non-selective hunting methods have been shown in Oregon and Washington to have higher adult and subadult female harvest rates when compared to hound hunting (Martorello and Beausoleil 2003). A further discussion on these implications is presented in the “Methods of mountain lion hunting” section in Appendix B. The East Slope plan does not propose the implementation of any new non-selective hunting methods. Use of electronic calls are not legal for big game hunting, including the take of lions.

Total Human-Caused Mortality Threshold Development

Clarification of terminology is an important precursor to the discussion of the total human-caused mortality threshold. Natural forms of mortality (drowning, starvation, disease, intraspecific strife, injury, etc.) are sometimes documented by our mandatory check system, but such natural mortality will not be included in the total human-caused mortality analysis. The primary human-caused mortality factors include hunter harvest, removal of depredating lions by CPW, landowners, and federal Animal and Plant Health Inspections Service/Wildlife Services agents (APHIS/WS), and lions killed by vehicles. As recommended by Logan and Runge (2021) and others, CPW considers all known human-caused lion mortality factors year-round when setting a sustainable total human-caused mortality threshold. The only exception of recorded human-caused mortality sources that is not included in the mortality analysis is for lions that are killed by CPW because they are determined to be dangerous lions pursuant to CPW Administrative Directive OW-13 (formerly W-20), Human-Mountain Lion Incidents. Our reasoning for not including these kills in our calculations related to mortality thresholds is that regardless of lion population trajectory or any other management condition, CPW, as a matter of policy, would always take lethal action on lions that are determined to be a threat to public safety. Therefore, including them in calculations of total mortality thresholds is irrelevant. Additionally, the number of lions that are killed because they are determined to be dangerous has historically been a very small number. For example, during the three license years of 2020-2022, the entire East Slope averaged less than one lion annually reported as being killed by CPW as a result of having attacked or exhibited threatening behavior towards people. Lions removed in accordance with Administrative Directive OW-13 are specifically identified by agency recording protocols to ensure human-lion conflict mortalities with this classification are clearly enumerated, as they will be excluded from analysis in all mortality totals.

Comparing the rate of population growth against population reduction from harvest can give managers information on what human-caused mortality levels would maintain a stable population. Recent research findings are presented below that helped inform this plan’s total human-caused mortality threshold.

The growth rate for a population, or intrinsic rate of population growth, can be described as the rate biologists expect a population to grow in the absence of additive human-caused mortality. In Washington, the intrinsic growth rate for three different lion populations (Selkirk Mountains, Kettle Falls, and Cle Elum) was ***14%*** (+-2%) (Beausoleil et al. 2013). In Montana, the expected intrinsic growth rate of a modeled population through two years was ***15%*** when the results from a protected area and an adjacent hunted area were combined (Robinson and DiSimone 2011). Laundre et al. (2007) observed a lion population increase of ***7%*** during a growth phase that correlated with an increasing deer population on the border of Idaho and Utah. In New Mexico, Logan and Sweanor (2001) observed population growth rates of ***5% and 17%*** for two 4-year periods, averaging ***11%*** for the entire 7-year period for a lion population segment protected from hunting. Furthermore, Logan and Sweanor observed higher growth rates of ***21% to 28%*** for an experimentally manipulated population segment that was substantially reduced in abundance and then protected to allow it to increase. Their research indicates that lion population growth rates are highly variable and most likely density dependent (Logan and Sweanor 2001).

Examined differently in Wyoming, experimental control and recovery of a population determined that a harvest rate of ***18%*** of independent lions allowed recovery of the population that had been intensively harvested in two previous years (Anderson and Lindzey, 2005). On the Uncompahgre Plateau in Colorado, a lion population that was protected from hunting for five years and subsequently subjected to regulated hunting for five years yielded evidence that the marked lion population grew during the non-hunting period when total human-caused annual mortality was 7% or less and began to decline when total human-caused annual mortality was 27% and continued to decline at rates of 24-29% (Logan and Runge 2021). The discrete threshold at which population decline began could not be measured. The authors do note that inference should be made to population-scale harvest and human-caused mortality rates, as rates observed at a smaller scale are biased and represent underestimates (Logan and Runge 2021).

Although growth rates and mortality or harvest rates in expanding populations may act as surrogates for determining maximum sustained yield (the highest sustainable annual rate of removal), caution should be applied in this comparison. Stochastic events can change the assumed population size and may result in over-harvest, and thus are falsely assumed to be supported over the longer term (Caughley and Sinclair 1994).

Whether one looks specifically at Colorado data or examines the span of the 6 reported population growth rates and three reported mortality thresholds, a 16-17% annual total mortality rate is an appropriate range to manage for population stability. Therefore, this plan will use a maximum human-caused mortality threshold of 17% of Colorado's East Slope projection of possible lion abundance. This extrapolated lion abundance index is based on a resource selection function (RSF) model that was applied to each GMU in DAU L-ES to generate an initial representation of how many lions could be in the population and the corresponding maximum human-caused mortality threshold (Table 3). For more information about the abundance index extrapolation and the supporting RSF model as applied to the East Slope, see Appendix C.

Table 3. East Slope total human-caused mortality threshold in relation to 2020-2022 total human-caused mortality data in L-ES.

	17% Annual Total Human-Caused Mortality Threshold	2020 Total Human-Caused Mortality	2021 Total Human-Caused Mortality	2022 Total Human-Caused Mortality	3-year Total Human-Caused Mortality Average
East Slope DAU (L-ES)	214 lions	209 lions	196 lions	177 lions	194 lions

The RSF model developed for Colorado's lion population provides a probability of lion presence across the state and allows application of various densities to those probability classes to generate a projection of possible lion abundance. The RSF extrapolation that is generated is not a representation of actual lion population size, but rather the relative probability of resource selection by a lion population. It provides a method to derive a maximum mortality threshold at a given scale, which if exceeded, would lead to the reasonable conclusion that lion populations are experiencing a decline. The numerical value that is derived as a threshold from this analysis will not be exceeded on a 3-year running average for the DAU. While not necessarily a management target, the human-caused mortality threshold represents the maximum acceptable amount of annual recorded human-caused mortality in the L-ES DAU.

The entirety of lion habitat within the NE and SE Administrative Regions are covered in the analysis for L-ES. The total human-caused mortality threshold in Table 3 may or may not change over the lifespan of this East Slope Mountain Lion Management Plan. This threshold could change during the course of revisions based upon new scientific evidence, density estimates that refine the RSF, or related updates to the RSF model that may occur during periodic plan review.

As described in greater detail in the Lion Density Monitoring section of this plan, CPW plans to initiate lion density estimation work on the East Slope during the life of this plan, similar to what is being done on the West Slope, to allow validation and refinement of densities applied to the RSF. More specific historic data on harvest and non-harvest mortality is available in Appendix B, History of Mountain Lion Management in Colorado and the East Slope.

Annual Management Thresholds

The East Slope Lion Management Plan extends the management framework used on the West Slope that evaluates annual lion mortality data against selected thresholds that are scientifically supportive of a stable lion population. All GMUs with lion habitat in the Northeast and Southeast CPW Administrative Regions will be managed in a pooled framework under a single DAU (L-ES). The following mortality monitoring thresholds will be evaluated in an interactive manner.

1. Proportion of adult female composition of total hunter harvest in L-ES will not exceed 22% in any single year. Adult females are defined as three years or older, or any age if the female shows evidence of previous nursing as determined from nipple characteristics (Table 1)

2. Total human-caused mortality will not exceed 17% of the extrapolated abundance index for L-ES (Table 3, also Appendix C) based on a 3-year running average

The adult female harvest composition threshold and total human-caused mortality threshold are intended to interact and inform each other. Therefore, if either threshold is exceeded, a management response to reduce mortality will be required and implemented during harvest objective setting the following year.

If the 22% adult female threshold is exceeded in any single year (suggesting a decline in the population) the following actions will be taken:

- The L-ES harvest objective (and human-caused mortality threshold) used in that year will be reduced by 1% of the extrapolated abundance index. This represents a decrease from 17% to 16% of the RSF extrapolation and would create a lower harvest rate and lower human-caused mortality threshold
- CPW will also enact a voluntary female harvest reduction outreach process that includes:
    i. Publishing a request for hunters to voluntarily reduce female harvest in the CPW Mountain Lion Hunting brochure
    ii. Reporting harvested lion gender, similar to the Available Harvest Limit Report, so that in-season female harvest or female proportion by GMU is available to the public
    iii. Notifying hunters using the online Available Harvest Limit Report to identify harvest limit groups where CPW is voluntarily asking for reductions in female harvest
    iv. Contacting lion hunters directly to inform them of the voluntary request

If the 17% total human-caused mortality threshold is exceeded or the 22% compositional threshold is exceeded for a second consecutive year, then a 5% reduction of the DAU’s harvest objective (and mortality threshold) will be implemented the following year. This would be in addition to the reduction of the human-caused mortality threshold from 17% to 16% applied the first year. The total human-caused mortality threshold continues to be independent of the adult female composition threshold. Both these thresholds represent possible inflection points, that if exceeded, could push the population trajectory towards decline. Either one provides a feedback mechanism to modify the common currency of human-caused lion mortality which CPW can control; harvest limits.

Each time a reduction in the harvest objective is triggered by exceeding thresholds, the intention is that this reduction will be maintained using the recalculated DAU harvest objective for a minimum of three years. In some cases, if the annual female composition or 3-year average total human-caused mortality return to levels below the thresholds before that time, increases in harvest objectives may be considered.

The annual harvest objective incorporates non-harvest mortality in development of acceptable harvest mortality levels, so as to not exceed the total human-caused mortality threshold. As such, the harvest objective will always be lower than the total human-caused mortality threshold and will likely fall in the annual harvest range of 12-16%, bracketing the 14% harvest off-take level as recommended by Beausoleil et al. (2013). The L-ES harvest objective will be nearer to the lower end of that range to accommodate the high proportion of other known human-caused mortalities (see Regional Summary section for more details). Using the historic averages of recorded non-harvest human-caused mortality to derive the remaining available harvest off-take, we expect the initial annual harvest rate in L-ES to be approximately 12% of the projected population.

Voluntary Female Harvest Reduction Outreach

If the adult female harvest composition threshold of 22% is exceeded, the first action should be to reduce adult female harvest. While differentiating subadult females from adult females before harvest may be difficult, Colorado's lion hunters have a proven track record of being able to decrease harvest pressure on females in general, when requested by CPW (Apker 2008).

From 2005-2007, CPW in collaboration with hound hunting groups, conducted training workshops about the biology and life history of lions as well as the importance of females to sustaining populations. The lion regulation brochure also provided similar written information. In the 2007-2008 lion season, CPW implemented a mandatory lion hunter education requirement. This course provides training information to hunters about lion ecology and hunters must pass an exam demonstrating the ability to identify lion gender characteristics. Subsequently, the average total statewide female composition in harvest declined from about 44% in the 10 years before 2005 to about 40% in the most recent five years. It is important to note this was a reduction in all female age classes, not just adults.

As part of this lion management plan, CPW intends to engage with lion hunters via the brochure, the online harvest limit report, and make informal field contacts to request voluntary reductions in female harvest if the annual adult female composition exceeds the 22% threshold. It would not be practical to ask for reductions just in adult females since age class determination in the field is much more challenging than gender determination. Additionally, age class determination for final DAU-wide annual analysis can only be completed when tooth cementum age results are available, which lag at least 3 months behind the close of the season. Evaluation of adult female versus subadult female composition can only be done after the season has concluded. This hunter outreach would likely decrease overall female harvest (all ages), but adult females would be part of that reduction, and we expect this to move composition trajectory in the desired direction.

To proactively increase hunter knowledge about the in-season level of female take and allow them to act accordingly before any voluntary outreach, CPW will also be undertaking a redesign of our lion harvest limit recording system. The specific focus will be on initiating a way to report "preliminary" data on total female harvest, along with total lion harvest, by GMU. This would be similar to, and improve upon, the Available Harvest Limit Report that is online and required for hunters to check before they hunt each day. This improvement to our online published report has been requested by both lion hunters and lion advocates as part of the early conversations surrounding an East Slope plan.

Harvest Limit Reductions

The harvest limit reduction will be applied to the harvest objective total in the regulatory cycle immediately following management thresholds being exceeded, as outlined above. Any such reduction in the harvest objective due to exceeding either threshold is mandatory and is a reduction minimum. Each time a reduction is applied to the DAU harvest objective, it will generally be maintained for three years; however, there may be cases when it is sustained for less than that period. For example, if during annual evaluations, the total human-caused mortality or adult female compositional proportion returns below the management threshold, and is anticipated to stay below the threshold, managers may consider increasing the harvest objective. Nothing precludes managers from implementing larger reductions of the harvest objective and harvest limit that are determined desirable or necessary to accelerate the lion population response.

CPW will base its management steps on empirical data from previously observed populations and models developed in Colorado. The following section presents an evaluation quantifying areas of minimal lion mortality on the East Slope and outlining the extent of source areas and large-scale lion resiliency to harvest. Further, the application of monitoring thresholds is appropriate to guard against longer term impacts to populations on the East Slope and ensure population stability at that scale.

Lion Population Resiliency

Resiliency to Mortality

Upon reaching the age of independence, lions (particularly males) disperse, which helps to maximize genetic interchange, allowing populations to be resilient against high harvest or rates of removal, as vacated ranges are continuously being re-occupied by immigrants. Natural replacement of mortalities or otherwise vacated home ranges occurs differently between male and female lions. Vacated ranges of resident females are typically re-occupied by their independent-age daughters, adjacent resident females, and some immigrant females (Laing and Lindzey 1993, Logan and Sweanor 2001). In contrast, male dispersal from natal areas appears to occur regardless of resident adult male densities (Hemker et al. 1984). Consequently, vacated ranges of resident males are typically re-occupied by immigrant males, some coming from long distances. Logan and Sweanor (2001) documented this in New Mexico and numerous Colorado studies have recorded the long distances moved by dispersing lions as well as the sex bias in dispersal distance (Anderson et al. 1992, Ken Logan, CPW, personal communication 2018, Mat Alldredge, CPW, personal communication 2023).

Source Population Refuges

In several studies, lion populations subjected to temporary intensive harvest by > 40% over one to six year periods have been demonstrated to recover within three to five years (Ashman 1976, Logan and Sweanor 2001, Anderson and Lindzey 2005, Robinson et al. 2008, Logan 2015). In two such studies, the lion populations were completely protected from hunting for a period of time (Logan and Sweanor 2001, Logan 2015, Logan and Runge 2021). It is also important to understand that in addition to reductions in known human-caused mortality, recovery was facilitated by immigrants coming from proximal source areas (Logan and Sweanor 2001, Anderson and Lindzey 2005, Robinson et al. 2008, Cooley et al. 2011, Logan and Runge 2021). These results confirm that with adequate source populations in sufficient proximity to provide dispersal immigration combined with native recruitment, lion populations can be resilient when localized harvest rates exceed recruitment (Anderson and Lindzey 2005, Robinson et al. 2008, Cooley et al. 2009*a*, Cooley et al. 2011, Logan and Runge 2021). These observations about lion resiliency and ability to rely on adjacent source populations are derived from research areas that range in size from the average GMU in Colorado (~1,500 km^2) to the largest GMU at about 7,500 km^2. The management thresholds of this plan will be monitored at a large scale; therefore, if the thresholds are exceeded and are unmitigated, then longer-lasting negative impacts to the lion population should be expected. At this scale, male immigration is likely to be capable of re-occupying vacant habitat (Logan and Runge 2021). In contrast, female immigration would likely occur initially along the boundary with adjacent DAUs or adjacent states, if intensive lion mortality were not also occurring in those locations. Some amount of female immigration may also occur from refuge areas (i.e., areas of high quality lion habitat with limited harvest as a result of land ownership or other access restrictions), but this alone may not be sufficient to offset continued high levels of mortality.

The following map of Colorado's L-ES DAU (Figure 3) shows what could be considered refuge zones or source areas where lion harvest is low to non-existent. Using the same RSF habitat model (Appendix C) employed within this plan in developing the total mortality threshold, we compared the top 50% of lion habitat in the new proposed DAU to the most recent 10 years of lion harvest mortality. All lion harvest mortalities from 2013-2022 were mapped and a mortality surface was created using ArcGIS, delineating a surface with more than three harvest mortalities per 1,000 km^2 per year. Areas of L-ES that fell below this threshold were considered as having no significant level of harvest (0-3 harvested lions/1,000km^2/year) (Table 4). For comparison, Wyoming's statewide management plan considers a "source" hunt area to have an annual human-caused mortality level of below 5 lions/1,000 km^2, and defines a "stable" hunt area as having annual human-caused mortality between 5-8 lions/1,000 km^2 (Wyoming Game and Fish Department, 2006). As shown in Figure 2 and Table 4, only a small fraction of lion habitat in L-ES exceeds an annual harvest of 8 lions/1,000 km^2. In fact, only

8% of the high-quality habitat in L-ES meets the qualification that Wyoming uses to classify a population "sink" (>8 lions harvested/1,000 km^2/year).

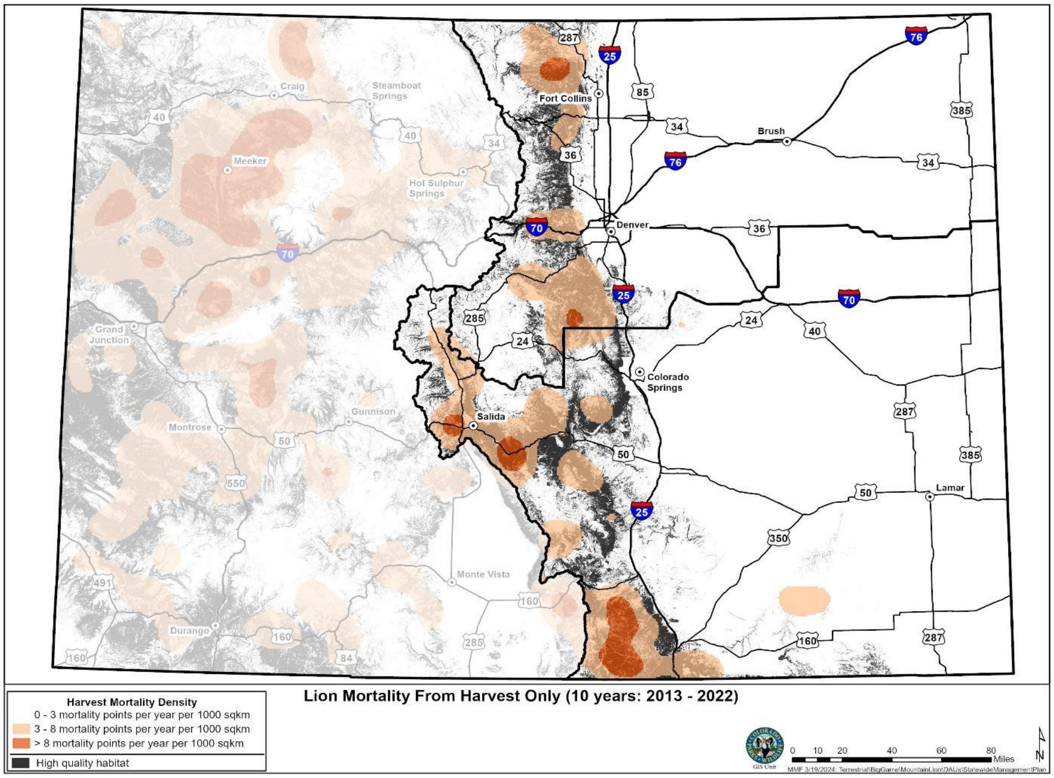

Figure 3. Upper 50%-100% percentile of quality lion habitat from Colorado's resource selection function model and 2013-2022 lion harvest mortality surface from the East Slope (L-ES Data Analysis Unit).

The 17,326 km^2 of higher quality lion habitat, as generated from the top two strata in the RSF, was overlaid with a harvest mortality surface to evaluate the total amount of quality lion habitat in the L-ES DAU where no significant lion harvest occurs. The area of quality habitat with modeled moderate to higher lion densities and yet a low or non-existent level of harvest totaled 8,156 km^2, or just over two million acres across the East Slope (Figure 3 and Table 4). This includes high-quality habitat within a National Park and several Monuments, Bureau of Land Management and US Forest Service Wilderness areas, closed military lands, protected municipality open spaces and natural areas, areas with little significant snowfall making lion harvest difficult, and many large tracts over 1,000 acres of unhunted private land.

Table 4. Comparison of high quality lion habitat and harvest density on Colorado's L-ES DAU.

Total Area of L-ES DAU	Total Area of L-ES DAU with defined lion habitat of any quality	Total High Quality Lion Habitat	Total High Quality Habitat with ≤ 3 harvested lions/1000 km^2/year "source zone"	Total High Quality Habitat with >8 harvested lions/1000 km^2/year "sink zone"
70,858 km^2	50,909 km^2	17,326 km^2	8,156 km^2	1,441 km^2

Zone Management

While the East Slope plan is not explicitly managing for defined source and sink areas or formally employing "zone" management across the DAU (Logan 2019, Logan and Runge 2021), the exercise described above is illuminating. It shows that in addition to monitoring mortality and harvest composition thresholds to ensure viability of lion populations, Colorado's L-ES lion population benefits from **47**% of its highest-quality lion habitat having virtually no lion harvest. These zones are functioning as refuges from harvest mortality. The fact that these robust source areas exist in abundance at large spatial scales and are well distributed across the East Slope affirms an additional safeguard in CPW's lion management strategy. The source areas promote a supply of immigrant lions and bolster recruitment, supporting population viability and resiliency across the entire landscape, as suggested by Logan and Runge (2021). The functional impact of having 47% of the DAU's best habitat as a refuge zone, even if these areas are not explicitly defined by this plan or in regulations, cannot be overstated. While not formally designed this way, this East Slope plan provides an overall population-level framework for a stable lion population while allowing manager flexibility to address local priorities that may require more or less harvest (Logan and Runge 2021, Erwin et al. 2023). Significant portions of the landscape are available to lions as "source" zones that offset any "sink" zones that are implemented through management or occur due to hunter harvest patterns. As an example, Robinson and DeSimone's (2011) initial analysis of the Blackfoot watershed in Montana suggested that an area as small as 12% of a larger landscape (in this study defined as the 8,000 km^2 watershed) without hunting mortality could act as a viable source with increased survival rates and ability to produce emigrants to other, more heavily harvested areas.

East Slope Regional Summaries and Issues

Public Education and Community Outreach on Coexistence with Lions

The vast majority of the state's citizens live on the East Slope and within the L-ES DAU. Therefore, a robust public education campaign to create an informed citizenry on human-lion coexistence remains vital in Northeast and Southeast Regional management. CPW will continue to build and rely on partnerships with local governments, municipalities and organizations to find additional means of reducing conflicts. CPW continues to use various public information resources to provide information to communities and highlight the importance of living responsibly with all wildlife, including lions. This includes dedicated webpage video and written content on Living with Lions and how to live in Lion Country. Common CPW recommendations include bringing pets in at night, not leaving pets unattended or tethered in yards, using fully enclosed outdoor kennels, use of outdoor lights, removing brush and grasses when landscaping, securing hobby livestock in enclosed barns/sheds and removing deer and elk food sources near homes that may attract prey species, which in turn brings lions closer to homes.

Human-Lion Conflict

Appendix B (History of Mountain Lion Management) provides a more thorough discussion of recent literature evaluating the relationship between lion harvest and human-lion conflict rates. However, a review of the current scientific evidence regarding the effectiveness of population scale management to effect reductions in human-lion conflicts is equivocal (Human-Cougar Interactions Science Review Team- Washington 2022). Data from Colorado do not suggest a relationship between high lion harvest and increased conflicts, but rather just the opposite. Areas in L-ES with the highest harvest rates (Figure 3), do not correlate with the areas of highest reported human-lion conflicts. In fact, as shown in Figure 5 of Appendix B, most areas of high human-lion conflict in Colorado have very little or no harvest at all. Nearly all of the published research investigating relationships between harvest or removal of lions and human-lion conflict has been correlative or observational. The Southeast Regional Summary in the section below provides more details on CPW's Upper Arkansas River research project, which employs a study design that permits manipulation of the system, making inference and predictions from results much stronger than many other commonly referenced studies.

Regional Summary: Northeast

The CPW Northeast Administrative Region is composed of lion habitat quality ranging from highly productive to severely impacted by human development. The highest quality lion habitat occurs along the foothills transitional zones of the Front Range. The Northeast Region portion of L-ES is composed of 55% private property (3.3 million acres private, 2.8 million acres public). A recent study conducted by CPW west of Boulder estimated lion densities at 4.1 independent lions/100 km^2 (see Appendix A for details). Productive habitats are generally characterized by broken topography, rocky terrain, shrubland, and ponderosa pine forest vegetation. Those areas also overlap the range of lions' principal food sources, mule deer, elk, and bighorn sheep.

Human population density in Colorado is highest in the Northeast Region. Development occurring in the Northeast Region causes substantial landscape level impacts, including to lion habitats. Large, expanding cities, including Denver and its surrounding suburbs, as well as Boulder, Longmont, Loveland, and Fort Collins are all within the Northeast Region. The high human population in the region has resulted in substantial human-lion conflicts (see Human Safety and Conflict below). Lion habitat is also less productive at higher elevations in the western portions of the Northeast Region and lower elevations east of the foothills.

Mountain lion management plans completed in 2004 implemented stable population size management strategies in the northernmost and southernmost areas of the Northeast Region (west of I-25, formerly L-4 and L-11), while aiming to reduce lion populations in the central portion of the Region (west of I-25, formerly L-12). Over the last three years, the Northeast Region has accounted for approximately 13% of the reported total statewide human-caused lion mortality. From 2020-2022, hunter harvest throughout the Northeast Region averaged 47 lions annually. Total human-caused lion mortality over the same period averaged 83 lions annually.

Human Safety and Conflict: Northeast

Humans and lions share the same landscape in much of the Northeast Region in L-ES. Lions typically avoid people and are primarily active at times when humans are not. Nevertheless, co-occupancy may result in conflicts between people and lions including predation on deer or other wildlife in close proximity to human development. Human-lion incidents vary and run a continuum from mere sightings, depredation on pets or hobby livestock to rare human attacks resulting in human injury or death.

Despite the Northeast Region having the smallest area of available lion habitat of the four CPW Regions in the state, half of the documented human-lion attacks occurred in the Northeast Region. Since 1990, CPW has documented 25 statewide lion attacks on humans that resulted in injury. Eleven of those attacks occurred in the Northeast Region. During the same timeframe, two confirmed human fatalities and one suspected human fatality from lion attacks were reported in the state. One of the confirmed fatalities and the suspected fatality were in the Northeast Region, while the remaining confirmed fatality was on the boundary of the Northeast and Northwest Regions in Rocky Mountain National Park.

In addition to lion attacks/injuries, the number of annual control kills of lions has nearly doubled in the Northeast Region in the last decade, averaging nine annually from 2013-2017 up to 17 from 2018-2022. Given the current human population size along the Front Range and the anticipated population growth in the future, human-lion conflicts will likely increase, especially in areas of increasing human development in occupied lion habitat. Finally, as Colorado’s human population grows, the opportunity to effectively harvest lions is reduced because lion hunting is difficult in a landscape with small parcels of ownership due to high housing density and limits on access.

Opinions vary on appropriate lion abundance in suburban and ex-urban communities. Considerable agency effort is directed toward providing people with information on lion management and how to live with lions, and these efforts will continue in the foreseeable future. Nevertheless, CPW prioritizes human safety above lion occupancy, especially in areas of residential development. In areas where conflicts between humans and lions are of increasing concern, specific management strategies may be necessary to find an appropriate level of human safety and tolerance for lions. The tools CPW uses to manage human-lion conflicts begin with outreach and education of communities and landowners to understand how to live, recreate and own pets or livestock in lion habitat, but may also include hazing, translocation or euthanasia of the lion. Appendix B provides a broader discussion on human-lion conflicts and human safety.

Regional Summary: Southeast

Lion management in CPW's Southeast Administrative Region is complex due to the mixture of rural and urban areas, recreation pressures, property ownership, climatic conditions, and habitat types found in the region. All indications suggest lion populations are robust in southeast Colorado. The region has highly productive lion habitat in most areas west of I-25 and the canyons and mesas east of I-25. This quality habitat provides quality lion hunting opportunities in many parts of the region, and most lion hunters use hounds or hire professional hound handlers to pursue the species. Many residents in the Southeast Region value lions and appreciate the ecosystem functions they provide, including interactions with prey populations. However, other residents are concerned about human safety and loss of livestock and pets to lions.

Over the last three years, the Southeast Region has accounted for approximately 18% of the reported total statewide human-caused lion mortality. From 2020 to 2022, hunter harvest across the Southeast Region averaged 94 lions annually. Total human-caused lion mortality over the same period averaged 113 lions annually.

In remote rural southeastern Colorado communities, the main concern posed by mountain lions is livestock depredation. Additionally, in other parts of the region, large ranches have been broken into 40-acre parcel subdivisions, leading to higher human densities, increased hobby farms, and a loss of historical knowledge on coexisting with large carnivores. These small parcels are also not suitable for lion hunting with hounds. Lion depredation in these areas has shifted from mainly cattle and sheep to alternative livestock, including goats, llamas, and alpacas. Closer to urban areas, the primary concern with lion management is depredation on pets and predation on wildlife in close proximity to development.

Most of the land ownership in the Region, particularly east of I-25, is privately held. The L-ES DAU portion of the Southeast Region has 70% of the surface or 8 million acres in private ownership (3.5 million acres are public). Many residents are farmers and ranchers whose livelihoods depend on livestock production. To mitigate the concerns over lion game damage issues on livestock, GMUs east of I-25 (formally lion DAU L-17) were historically managed to suppress lion populations. This corresponded with harvest limits set high enough to allow for the management of conflict lions through hunting. However, lion hunting with hounds is challenging in this area due to access requirements on private land and the lack of persistent snow during the hunting season.

The area west of I-25 and south of the Arkansas River is excellent lion habitat and has been managed for stable lion populations in the former lion DAUs L-16 and L-19. Snowfall during the hunting season in this part of southeastern Colorado occurs more frequently compared to the lower elevation areas east of I-25. This allows hunters the ability to pursue lions with hounds starting with snowfalls in late November or early December. Long-time residents and CPW field staff believe lion populations are increasing in this area based on the frequency of sightings and the ability to fill harvest limits quickly. Additionally, lions are likely dispersing into this part of Colorado from New Mexico and possibly from the highly productive lion habitat in the canyons and mesas east of I-25. The northern part of the area, which was in the historic L-16 DAU, was managed for an increasing lion population from 2016-2022 as part of the Upper Arkansas research study. Lion densities are thought to be increasing in this area as well. Starting in the 2023-2024 season, lion harvest limits were increased in the L-16 DAU in accordance with research protocol.

The area west of I-25 and north of Highway 50 was the historic L-11 lion DAU, managed for a stable lion population. Vegetative communities within this landscape are varied and correspond to a wide range of elevations, which yields differences in lion densities. Snowfall in the area can be sporadic and may initiate later than other parts of the Southeast Region. The northern and western portions of the unit have relatively lower-density lion habitats compared to the high-elevation Sawatch Range and lower-elevation South Park. The highest-density lion habitat is found in the southern and eastern parts of the area, including the Arkansas River drainage and the topographically varied landscape of the Pikes Peak Region. The landscape is anchored by the Pikes Peak Massive, from which the erosive properties of drainages like Beaver Creek have carved a vast system of steep-sided canyons. Human densities in this area are also highest in the areas with high-density lion habitat, including the communities of Salida, Cañon City, and the Colorado Springs metropolitan area. Lion hunting opportunities are available throughout the unit, but can be challenging due to the mixture of public and private properties and unpredictable snowfall. Additionally, human recreation pressure is increasing, bringing humans and lions together in wildland settings. Conflicts are expected to rise throughout this area as the human population expands. We anticipate the ability to manage lion conflict through hunter harvest will become increasingly difficult in the future.

Human Safety and Conflict: Southeast

Human-lion conflicts in the Southeast Region include verified lion attacks on humans, aggressive behavior by lions, depredation on pets and livestock, and predation on deer and other wildlife in close proximity to development. Human-lion conflict numbers are lower in the Southeast Region than in the Northeast Region. However, conflicts still receive media attention and occur throughout much of the administrative Region. Conflicts are most common where human densities are highest. Many wildlife officers and long-time residents of the Region believe human-lion incidents, including conflicts and sightings, have increased since the previous lion management plans were enacted in 2004 and 2019. This perspective aligns with a known increase in low-density housing communities (ranchette developments) throughout much of the Region. These communities fragment habitat, reduce opportunity for lion management via hunting and also increase the potential for human-lion conflict with the presence of hobby livestock. Additionally, hound handlers, wildlife officers, and long-time residents all report an increase in the lion population throughout the Southeast Region.

As in the Northeast Region, when responding to human-lion conflicts, CPW wildlife officers follow Administrative Directives OW-2 Predator Attack on Humans, OW-13 Human-Mountain Lion Incidents, CPW Regulations Chapter W-17 Damage Caused by Wildlife, and other procedures prescribed by regulations and state statutes. Responses to human-lion conflicts in the Southeast Region begin with education, but may include hazing, translocation or euthanasia of the lion. Appendix B provides a broader discussion on human-lion conflicts and human safety.

Upper Arkansas River Research Project: Southeast

CPW has a decade-long lion-deer research project underway in the Upper Arkansas River drainage. It is the largest scale predator-prey project of its kind conducted in North America. The study was initiated in the winter of 2016-2017, and spanned the areas from Leadville to Cañon City (deer DAU D-16 and parts of the former lion DAU L-11) and Poncha Springs to Walsenburg (deer DAU D-34 and the former lion DAU L-16). Fieldwork for the project will conclude at the end of the winter of 2025-2026.

For this study, CPW has investigated: 1) mule deer survival response to changes in lion harvest, 2) cause-specific mortality of lions, and 3) the relationship between human-lion conflict and changes in lion harvest levels. These questions are being rigorously examined through a manipulative crossover study design that allows greater inference than purely correlative studies. In this design, the lion harvest limit was set higher in D-16 (24-45 lions) than D-34 (15 lions) for the project's first three years. Following the first three years, the harvest limit was reduced to 12 lions in D-16 and kept low in D-34 at 15 lions for four years. In the final three years of the project, the harvest limit in D-34 has been increased to 35 lions, while the harvest limit for D-16 will be maintained at 12 lions. As part of the project, CPW has measured lion densities in both study areas (D-16 and D-34). This adds opportunistically to a data stream, along with similar enumeration efforts on the West Slope, to confirm and align observed lion densities with abundance index projections generated from the RSF output. Most importantly, when published, this study will add to managers' knowledge about how changes in lion harvest, lion density and lion immigration may or may not affect levels of human-lion conflict.

East Slope (L-ES) Lion DAU Harvest Limit Groups and Harvest Limits

Harvest Limit Groups

Due to the Upper Arkansas lion research project, it will take two license years to enact the new harvest limit groups proposed in this plan. In 2026-2027, the L-ES DAU will initially comprise six harvest limit groups (Figure 4a), which is a reduction from the 21 harvest limit groups that comprise the six DAUs on the East Slope in 2024-2025 (Figure 4b). These harvest limit groups represent an increase in group size over previous groupings, particularly in the NE Region, but all other historic harvest management processes at the harvest limit group scale remain intact. Additionally, these six harvest limit groups will remain static for at least three years under the East Slope plan to allow hunter behavior and hunting pressure to stabilize under this new structure.

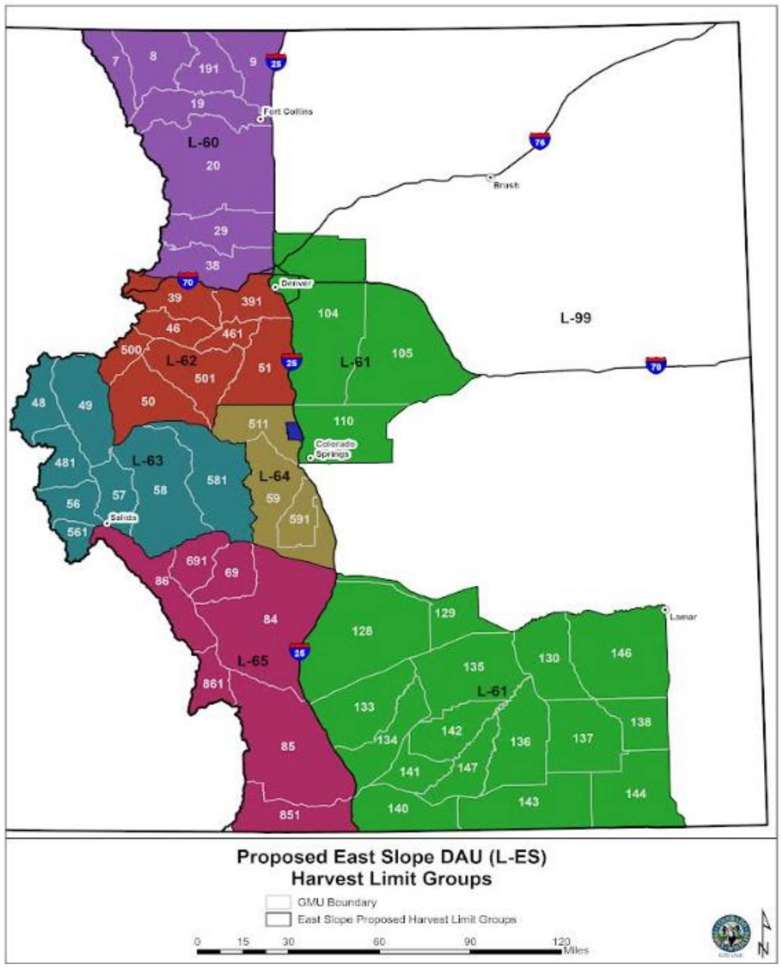

Figure 4a. GMUs in the new L-ES proposed harvest limit groups for 2026-2027. Each harvest limit group is colored differently.

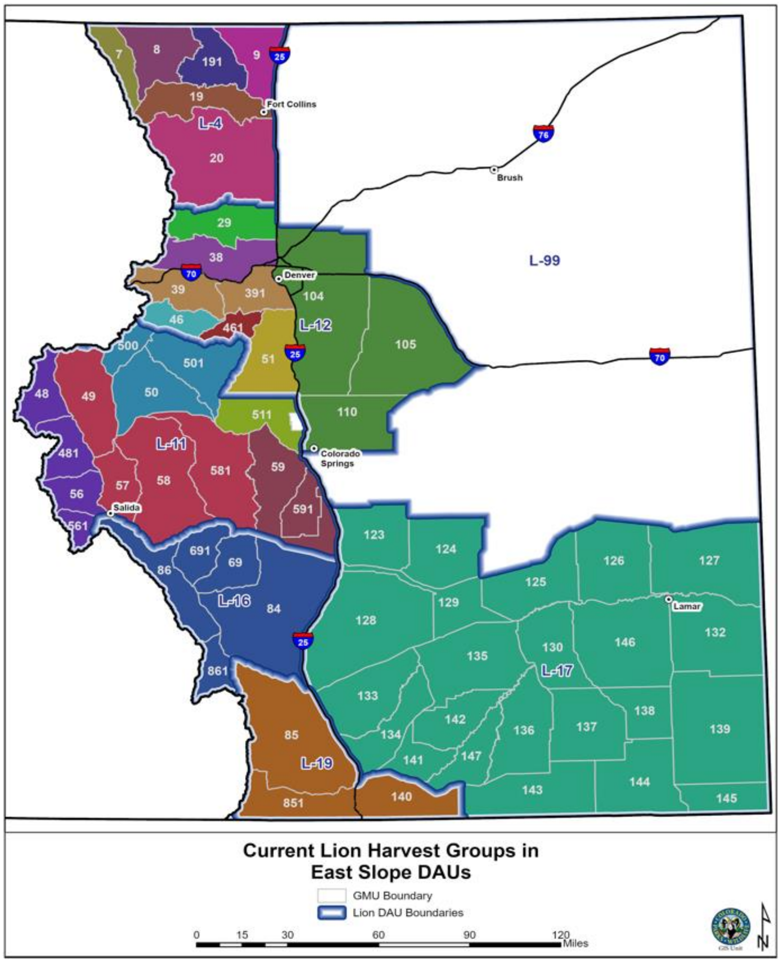

Figure 4b. GMUs in each historic (2024-2025) harvest limit group compared to the new L-ES proposed harvest limit groups for 2026-2027 (Fig. 4a). Each harvest limit group is colored differently.

L-ES Harvest Objective

The six current DAUs on the East Slope have a 2024-2025 sum of harvest limits of 208 lions (Table 5). Applying the new L-ES stable objective mortality threshold to the RSF lion abundance index requires a reduction in these historic East Slope harvest limits. Because the Upper Arkansas research project will conclude in 2025-2026, the first year the entire L-ES DAU will fall under the new total human-caused mortality threshold is 2026-2027. The DAU's total human-caused mortality threshold is **214 lions** (Table 3). To derive a maximum allowable harvest level (DAU harvest objective), we needed to consider historic non-harvest human-caused mortality in the new DAU. The most recent 3-year average of all lion mortality data on the East Slope from 2020-2022 yielded an annual average non-harvest human-caused mortality rate of 27.7% (see Figure 2 in Appendix B). Allocating this assumed average to non-harvest human mortality sources leaves a maximum of **155 lions** available for harvest each year (Table 6). This will be the initial L-ES harvest objective for the first three years of the plan, while incorporating the necessary Upper Arkansas harvest levels in 2025-2026. Therefore, the new L-ES sum of harvest limits for 2026-2027 represents a 26% reduction, or 53 lion decrease, from the current level in the six DAUs in 2024-2025 (Table 5). Table 7 provides hunt code level detail on the harvest limit groups required in 2025-2026 to maintain the final year of the Upper Arkansas study design.

Since lion mortality data are reviewed annually as part of harvest limit setting, changes in non-harvest mortality can affect the DAU harvest objective each year. The harvest objective may increase and decrease as the adult female proportion and total human-caused mortality thresholds are evaluated after the initial three years of implementation.

Table 5. Historic Northeast and Southeast Region (Data Analysis Units L4, L-11, L-12, L16, L-17 & L-19) mountain lion harvest limit groups, harvest limits, and the 2020-2022 average annual harvest.

Harvest limit group huntcode	List of GMU(s) in harvest limit group	2024-2025 Harvest Limit	3-year Average Annual Harvest
LE007O1R	7	1	0.7
LE008O1R	8	4	4.3
LE009O1R	9	3	1.0
LE019O1R	19	5	4.3
LE020O1R	20	9	5.7
LE191O1R	191	8	5.3
LE048O1R	48, 56, 481, 561	10	8.3
LE049O1R	49, 57, 58, 581	12	12.3
LE050O1R	50, 500, 501	10	7.3
LE059O1R	59, 591	7	3.7
LE511O1R	511	4	4.7
LE029O1R	29	2	0
LE038O1R	38	7	4.7
LE039O1R	39, 391	7	2.0
LE046O1R	46	6	2.7
LE051O1R	51	7	4.7
LE104O1R	104, 105, 110	5	3.0
LE461O1R	461	7	1.7
LE069O1R	69, 84, 86, 691, 861	35	16.0
LE123O1R	123, 124, 125, 126, 127, 128, 129, 130, 132, 133, 134, 135, 136, 137, 138, 139, 141, 142	25	13.7
LE085O1R	85, 140, 851	34	35.0
TOTAL		208	141.1

Table 6. L-ES Data Analysis Unit mountain lion harvest limit group name, associated Game Management Units, and harvest limits for 2025-2026 and 2026-2027.

Harvest Limit Group Name	List of GMUs in harvest limit group	2025-2026 Harvest Limit	2026-2027 Harvest Limit
I-70 North	7, 8, 9, 19, 20, 29, 38, 191	28	28
Eastern Plains	104, 105, 110, 128, 129, 130, 133, 134, 135, 136, 137, 138, 140, 141, 142, 143, 144, 146, 147	22	22
I-70 South	39, 46, 50, 51, 391, 461, 500, 501	19	19
Upper Arkansas	48, 49, 56, 57, 58, 481, 561, 581	10 + 12 (See Table 7)	30
Rampart	59, 511, 591	9	9
Greenhorns-Spanish Peaks	69, 84, 85, 86, 691, 851, 861	25 + 35 (See Table 7)	47
TOTAL		**160**	**155**

Table 7. L-ES Data Analysis Unit mountain lion harvest limit group names, associated Game Management Units and harvest limits for 2025-2026 required for study design of final year of Upper Arkansas lion research project.

Harvest Limit Group Name	List of 2025-2026 GMUs in harvest limit group huntcode	2025-2026 Harvest Limit
Upper Arkansas	LE048O1R (48, 56, 481, 561)	10
	LE049O1R (49, 57, 58, 581)	12
Greenhorns-Spanish Peaks	LE085O1R (85, 851)	25
	LE069O1R (69, 84, 86, 691, 861)	35

April Season

Historically, the April season has contributed very little to East Slope lion harvest. However, this season does provide an additional management tool along with a hunting and hound training opportunity, particularly in areas of southeastern Colorado that receive only occasional winter snow. For the first three years of the East Slope plan, April seasons will be closed in the DAU to allow harvest and hunter behavior under the new structure to stabilize. April seasons will be considered annually beginning in the 2028-2029 season.

Public Input Process

CPW staff held several public meetings before drafting the East Slope plan and releasing it to the public for feedback. Following public meetings around the East Slope on lion management in February and March 2024, the Draft East Slope Mountain Lion Management Plan was published on the Engage CPW website on May 15, 2024. A 30 day public input period on the draft plan was open through June 14, 2024. 181 individuals shared public input during the 30 day period. Five stakeholder organizations also provided input. Additionally, CPW staff solicited a peer review of the draft plan as well as an academic review by independent, objective professionals in the field. A detailed summary of public engagement and input is provided in Appendix E. Following the public input period, members of the public were encouraged to submit comments on the plan directly to the Parks and Wildlife Commission for their consideration.

Lion Density Monitoring and Future Research Needs

Lion Density Monitoring

Developing robust estimates of current lion density in survey areas around Colorado will help improve and refine assumptions made in the RSF model. Empirically-derived estimates will also serve to confirm projected lion densities that are being applied as part of the current West Slope and proposed East Slope plans to generate the total human-caused mortality threshold. This type of rigorous lion abundance monitoring is recommended by Beausoleil et al (2016), Alldredge et al. (2019), Murphy et al (2019), Logan and Runge (2021) and others. Additionally, Colorado's present and future density estimation study design structure addresses many of the biases described by Murphy et al. (2022) in many past studies enumerating lion populations.

Beginning in the winter of 2020-2021, CPW initiated work in survey areas on the West Slope that are representative of lion habitat and that reflect a gradient of lion hunting pressure, land ownership and habitat types. A spatial mark-resight density estimation protocol was employed, which produces more precise estimates of lion numbers than mark-recapture efforts used in the past (Alldredge et al. 2019, Murphy et al. 2019, Murphy et al. 2022). This survey technique relies on remote game cameras distributed across the survey area to "resight" lions from repeated photos over time. A proportion of lions in the population are "marked" using GPS collars and eartags labeled with unique visual identifiers. The proportion and capture pattern of known marked lions versus unmarked individuals allows estimation of density. Spatial data acquired from GPS collars addresses geographic closure and improves density estimates based on the proportion of time each collared lion spent on the survey area (Alldredge et al. 2019, Murphy et al. 2019). This correction tends to reduce overall density estimates, but results in a more accurate estimate. To achieve a desired precision so the estimates are meaningful in the context of evaluating the RSF, each survey area is ~2,000 km^2 and requires marking and maintaining a sample of approximately 20-25 independent lions going into the resight period each year. Each survey area is divided into ~25 km^2 cells and a remote game camera and call box is installed in each cell. Resight sampling occurs for a minimum of eight weeks during mid-January to mid-March. This time period was chosen because bears are not active during these months and most of the lion harvest is completed by this time. Therefore, estimated initial lion densities will represent a post-hunt estimate on winter range, similar to the techniques and procedures currently being employed in CPW's Upper Arkansas research project. Involvement of local hound handlers in each study area have proven invaluable to the success of lion captures in these projects.

There is some level of uncertainty around the density or abundance point estimate obtained in all lion population enumeration in Colorado or in the literature. By pursuing field studies that directly measure lion numbers in Colorado, across varying habitat types, landownership patterns and harvest levels, CPW can align population projections with the most appropriate empirical data.

As enacted under the West Slope lion plan, CPW intends to expand lion density monitoring studies on the East Slope upon implementation of this plan. Initial areas identified for these studies include: 1) the canyons, mesas, and plateaus south of Highway 50 and east of I-25 in southeastern Colorado, and 2) the southern portion of the Greenhorns-Spanish Peaks Harvest Limit Group (GMUs 85 & 851). Including one or both of these areas in our density estimation work will serve to support and align CPW's RSF modeling process and its resulting abundance projections to more accurately reflect current lion population status across habitats and land ownership types on both West and East Slopes.

Future Research Needs

Numerous avenues of potential research exist into the future in Colorado. Some are already underway, others require commitment of significant resources that are outside the framework of this plan, and others may be best evaluated after several years of implementing this East Slope Mountain Lion Management Plan. Below are several topics that have been identified as future research needs.

- Investigate and update research on public perceptions and opinions about lion management including a formal human dimensions survey of Coloradans
- Update and realign the statewide Resource Selection Function model using all the additional lion habitat use and density information gathered in the last 10 years
- Evaluate changes in available ungulate and lion habitat on the East Slope under continuing human development during the life of the plan to determine if adjustments to the Resource Selection Function strata are required
- Evaluate presumed source and sink locations to determine if predictions reflect functionality

Colorado East Slope Mountain Lion Management Plan
Appendix A

Mountain lion life history, ecology, and monitoring

Introduction: This review of current scientific literature begins by briefly describing where and how lions live in Colorado, including a review of lion densities and predator-prey relationships. Lastly, a summary is provided of both commonly used field and harvest index-driven methods to monitor lion populations.

Distribution

The historic range of the mountain lion (*Puma concolor*; hereafter lion) was the largest of any terrestrial mammal in the Western Hemisphere, with the exception of humans (Logan and Sweanor 2001). The lion continues to range from the southern tip of South America to northern British Columbia (Logan and Sweanor 2001) but was apparently extirpated from the eastern US and Canada, with the exception of southern Florida, by the late 1800s to early 1900s. Between the mid-1960s and the early 1990s, lion populations increased in many western states, and their distribution expanded to Nebraska, South Dakota, and North Dakota. In Alberta, Canada, lion distribution has expanded to the north and east from 1991 to 2010 (Knopff et al. 2010). The Cougar Management Guidelines Working Group [CMGWG] (2005) and Fecske et al. (2011) suggest that population recovery and expansion may be due in part to reclassifying lions from unregulated predator status to game animal (which has regulated human off-take since 1965), science-based management practices, increases in prey abundance, restricted uses of pesticides since the 1970s, and increased human tolerance for large carnivores.

On the East Slope of Colorado, lions occupy nearly all timbered or tall shrub-covered habitats west of Interstate 25 (I-25). Quality lion habitat on the East Slope is well-connected from the Wyoming border south to the New Mexico border (see Figure 3 in Appendix C). East of I-25, there are resident lion populations beginning around Castle Rock, southeast of Denver to an area known as the Black Forest, which has varied topography, timber with tall shrub cover and abundant deer and elk populations. Additional lion populations exist in the canyons, mesas, and plateaus south and east of Pueblo.

Dispersal patterns and genetic evidence suggest that most western US lion populations are well connected (Culver et al. 2000, Sinclair et al. 2001, Anderson et al. 2004). Extreme movements of male lions in excess of 1,000 km have been documented (Thompson and Jenks 2005). These long-range movements provide a very effective means of genetic transfer and population maintenance to lion populations in distant regions. Gene flow among lion populations in the Central Rocky Mountains suggests this region exists as one large lion population with rapid genetic exchange among suitable habitat patches throughout the region

(Anderson et al. 2004). Consequently, little or no genetic population substructuring has been found in Colorado (Sinclair et al. 2001, McRae 2004, Trumbo et al. 2019).

Habitat Use

The broad geographic distribution of the lion in North America attests to its ability to persist in natural habitats wherever there is adequate prey and cover (CMGWG 2005). Previous lion habitat studies in the western US suggest lions select conifer, deciduous timber, riparian, and tall shrub habitat types at mid-high elevations in steep or rugged terrain (Logan and Irwin 1985, Laing 1988, Koehler and Hornocker 1991, Williams et al. 1995, Dickson and Beier 2002). Tall vegetation or rugged terrain sufficient for concealment provides the necessary hiding and stalking cover for securing prey and raising young (CMGWG 2005). Lions may be found in climates ranging from arid, desert regions to temperate rainforests of the Pacific Coast. Vast, open areas with little hiding cover and the severely cold winter temperatures of northern climates may restrict lion use (Pierce and Bleich 2003).

Despite the lion's broad distribution and adaptability, habitat fragmentation associated with human development can negatively impact lion populations (Beier 1993, Vickers et al. 2015). In southern California, major highways were implicated in restricting the size and configuration of lion home ranges and limiting gene flow in populations by constraining dispersal patterns (Riley et al. 2006, Dellinger et al. 2020). Evaluation of genetic information and Global Positioning Systems (GPS) location data from a monitored lion population in northern Colorado (Alldredge 2015, Trumbo et al. 2019) showed high gene flow through well-connected habitats in contrast to results from California (Riley et al. 2006, Gustafson et al. 2022). The magnitude of the human population in the Greater Los Angeles Area (~20,000,000) may explain the differences in observations. Nevertheless, increased construction of roads and homes in lion habitat may reduce the amount and quality of habitat available to lions and their primary prey [e.g., deer and elk], but may increase the number of alternative prey sources [raccoon, fox, domestic pets and hobby livestock] (Moss et al. 2019). Moreover, medium to low-density ex-urban development in parts of Colorado serve as refugia for mule deer and can experience higher densities of mule deer than those found in similar public land habitats (Colorado Parks and Wildlife Terrestrial Section unpublished data). This is likely the case in significant portions of the East Slope, where high human densities bring pets and hobby livestock into the wildland-urban interface, where mule deer are often protected from hunting pressure. Lions can exist at high densities in these areas where high natural prey density meets higher anthropogenic prey item availability (Alldredge et al. 2019).

Lion Social Structure and Reproduction

The social behavior of lions likely evolved to maximize individual survival and reproductive success (Logan and Sweanor 2001). Lions are solitary carnivores exhibiting a polygynous breeding strategy where dominant males typically breed with females that reside within their home range (Murphy 1998, Logan 2019). Resident males aggressively defend their territories against male intruders, whereas females allow more overlap, but express mutual avoidance (Lindzey et al. 1989, Ross and Jalkotzy 1992, Logan and Sweanor 2001, Logan 2019). The size of female home ranges tend to be large enough to provide sufficient prey for themselves and their young (~50-100 km^2, 20-40 mi^2), while male home ranges tend to be larger (~150-300 km^2, 60-120 mi^2), overlapping several females, apparently to maximize their reproductive success (Murphy 1998). Home ranges found in Colorado vary widely, from 309 km^2 for females and 503 km^2 for males on the Uncompahgre Plateau (Anderson et al. 1992) to 188 km^2 for females and 253 km^2 for males on the Southern Ute Indian Nation in southwestern Colorado (Koloski 2002). In recently completed research on the Uncompahgre Plateau and along the East Slope north of Denver, home range sizes were similar to, if not slightly larger than, those reported by Murphy (1998)(Ken Logan, CPW, personal communication 2015, Mat Alldredge, CPW, personal communication 2020, Logan and Runge 2021). Young females commonly express philopatric behavior (remain in their natal range) upon independence, but males typically disperse from their natal range (Anderson et al. 1992, Ross and Jalkotzy 1992, Lindzey et al. 1994, Logan and Sweanor 2001).

Lion densities are low relative to other large mammals ranging from about 1 independent (>12-18 months old and self-sufficient) lion/100 km^2 (38.6 mi^2) in arid climates (Ashman 1976, Lindzey et al. 1994) to nearly 5 independent lions/100 km^2 in generally more mesic areas (Currier et al. 1977, Hopkins 1989, Ross and Jalkotzy 1992, Robinson et al. 2008, Cooley et al. 2009*b*, Proffitt et al. 2015, Alldredge et al. 2019) (Table 1). Both Whittaker and Wolfe (2011) and Murphy et al. (2019) point out that density estimates are strongly influenced by the methods used to assess the population size in a given area. This may help explain why more recent non-invasive techniques and spatially-explicit models have yielded density estimates on the higher end of the previously observed ranges in some cases.

Table 1. Mountain lion densities reported or derived from surveyed areas in the western United States and Canada, 1986-2023. All densities reported as the number of lions per 100 km^2.

Location	Vicinity	Survey Area Size (km^2)	Independent Mountain Lion Density	Total Mountain Lion Density	Number Survey Years	Notes	Reference
Washington	NE- Wash.	2878	2.2	2.1-2.6	9	Hunted	Beausoleil et al. 2016
Idaho	SE Idaho	~900		3.2-6.5	2	Genetic SCR	Loonam et al. 2020
Colorado	Boulder	800	4.1		3	Lightly hunted	Alldredge et al. 2019
Colorado	Middle Park	2050	2.1- 2.8		2	Post-hunt	Vieira, CPW 2023
Colorado	Gunnison Basin	2000	3.7		1	Post-hunt	Vieira, CPW 2023
Washington	NE- Wash.	1252		3.9	4	Space to event model	McMurry et al. 2023
Utah	Monroe Mts	1300	1.2-3.2		9	Hunted	Stoner et al. 2006
	Oquirrh Mts	480	2.5-2.9		8	Unhunted	
Wyoming	Snowy Mts	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		
Wyoming	Bighorn Mts	741	1.8-2.3	3.5-4.6	2	Hunted. Kittens defined as <24mos comprised 50% of the pop.	Logan et al. 1986
Montana	Bitterroot Mts	2625	4.5-5.2		1	Hunted	Proffitt et al. 2015
Washington	NE-Wash.	735		5.0	6	Hunted, Kittens <12mos = 30% of the population	Robinson et al. 2008
Montana	Blackfoot drainage	7908		3.7 (2.3-5.7) 6.7 (3.1-11.0)	1	Hunted	Russell et al. 2012
Montana	Garnet Mts.	915		4.0	11	Yr 1 Unhunted, Kittens <12mos = 30% of population across all years of study	Robinson and DeSimone 2011
				2.2		After 3 yrs Hunted	
				3.6		After 3 yrs Hunted w/refugia in part of area	
New Mexico	San Andreas Mts	2059	1.5-2.1	1.7-4.3	7	Simulated hunting effect	Logan and Sweanor 2001
Washington	West-central	655		3.6 (3.0-4.2)	5	Lightly hunted	Cooley et al. 2009*b*
	NE	772		3.5 (2.8-4.2)	5	Heavily hunted	
Oregon	NE Oregon	225		4.2-5.0	1	Hunted	Davidson et al. 2014
Utah	South-central	1900	0.4-0.9	0.6-1.4	9	Unhunted	Lindzey et al. 1994
Utah/Idaho	SE-ID & NW-UT	1700	1.0-2.1	1.6-2.8	15	Hunted	Laundre et al. 2007
Alberta	Sheep River	780	2.6	2.7-4.7	8	Hunted. Kittens/“juveniles” defined as <24 mos. are not included in the average independent density	Ross and Jalkotzy 1992
British Columbia	SE-BC	540	1.5-1.7	3.5-3.7	2	Unhunted, but hunted prior to study. Kittens/“juveniles” defined as <24 mos. = 50-58% of population and are not included in the independent density	Spreadbury et al. 1996

Female lions typically produce their first litter at 2-3 years of age (Anderson 1983, Ashman et al. 1983, Logan and Sweanor 2001) and may breed at any time of the year, but exhibit defined seasonal birth pulses. Logan and Runge (2021) found that the average age females in their study produced a first litter was two years and eight months. Data on 66 Colorado kitten birthdates show litters were only born from March to September during this same 10-year study (Logan and Runge 2021). Data from seven lion studies in western North America indicate that May through October are the peak months for lion parturition (CMGWG 2005). Gestation lasts 82-96 days and lions typically produce two to four young (Logan et al. 1986, Ross and Jalkotzy 1992, Logan and Sweanor 2001). Kittens are usually weaned at 2–3 months and typically remain with the female for 12–18 months before becoming independent (Pierce and Bleich 2003).

Food Habits and Prey Relationships

Lion diets consist primarily of large vertebrate prey species. Throughout much of North America, deer comprise the majority of lion diets (Pierce and Bleich 2003), but other large ungulates such as elk (*Cervus canadensis*), bighorn sheep (*Ovis canadensis*), moose (*Alces alces*), and pronghorn (*Antilocapra americana*) may also be consumed (Ross and Jalkotzy 1996, Ross et al. 1997, Murphy 1998, Anderson and Lindzey 2003). In states with feral horse populations, equids are also a prey source (Andreasen et al. 2021). Although lions primarily subsist on large ungulates, small mammals, including porcupines (*Erethizon dorsatum*), skunks (*Mephitis mephitis and Spilogale gracilis)*, raccoons (*Procyon lotor*), lagomorphs (hares and rabbits), ground squirrels (*Spermophilus* spp.), and beavers (*Castor canadensis*) may also supplement lion diets. Other carnivores, including bobcats (*Lynx rufus*) and coyotes (*Canis latrans*), have also been recorded. Lions also occasionally prey on domestic livestock and pets. Sheep and goats are the most commonly killed domestic livestock, but lions also kill cattle, horses, and pets, including dogs and cats (CMGWG 2005, Moss et al. 2016). Scavenging is also a more important contributor to lion diets than was believed 20-30 years ago (Knopf et al. 2010, Blecha et al. 2015).

Scientific efforts reveal the complexity of predator-prey relationships, yet many people are not well-versed in this understanding (Murphy et al. 2011). A fundamental understanding of predation consequences is required to meet societal goals for prey and predator populations (Gassaway et al. 1992). Failure to correctly apply the key principles of predator-prey interactions invites management mistakes, can misspend money (Kie et al. 2003) and may erode public confidence in management agencies. These points stress the importance of reviewing and incorporating the most current and relevant scientific information regarding predator-prey relationships into management.

In single-prey systems, predation by lions and other predators is not believed to widely trigger declines of prey or depress prey populations for extended (>15 years) time periods (Ballard and Van Ballenberghe 1997, Ballard et al. 2001). However, if extreme weather or other disruptions significantly lower prey numbers below maximum sustained yield (Figure 1) predation may delay the prey’s density-dependent response and prolong low numbers. This effect may occur if the expected drop in lion numbers naturally lags behind that of the primary prey (Logan and Sweanor 2001, CMGWG 2005, Laundré et al. 2006), as is common for population cycles of Canada lynx (*Lynx canadensis*) and snowshoe hares (*Lepus americanus*) in Canada and Alaska. The density-dependence model of mortality should be highly familiar to students of wildlife management in North America because it is a foundational principle for hunting many game populations. Under this paradigm of wildlife management, hunters take animals that may die from other causes ("compensatory" mortality), but they are only removing this surplus of animals from the population. When wildlife agencies determine that additional mortality is necessary to manage wildlife populations, harvest and license levels are increased to allow hunters to take more animals. This regulated increase in harvest to reduce population size is then considered "additive" mortality (NFRTC 2001, CPW Hunter Education 2014).

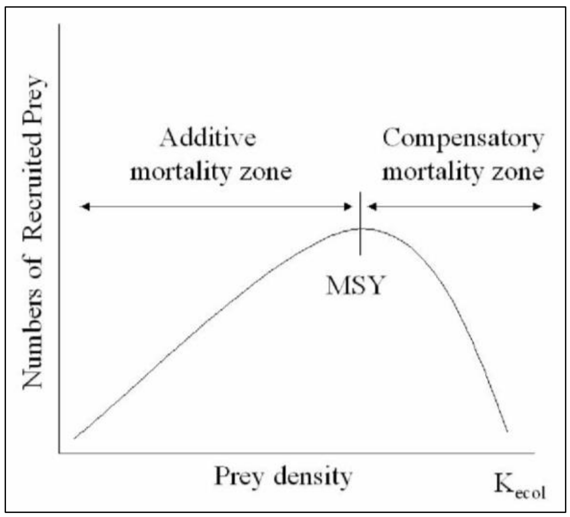

Figure 1. Density dependence: the relationship between the number of prey recruited and the density of the prey population. At low prey numbers mortality tends to be additive. At high prey numbers mortality tends to be compensatory. (Murphy et al. [2011] derived from McCullough [1979], Bailey [1984], and Bowyer et al. [2005]).

Under some circumstances, in multiple prey systems, lions may have sustained limiting effects on their large or mid-sized prey (Berger and Wehausen 1991, Sweitzer et al. 1997, Krausman and Shackleton 2000, Ballard et al. 2001, Kinley and Apps 2001, Novaro and Walker 2005, Wittmer et al. 2005). At the extreme, lion predation, often acting in concert with other factors, also may reduce the viability of small or declining prey populations and mammalian diversity (Sweitzer et al. 1997, Ernest et al. 2002, Wittmer et al. 2005). These situations often involve a mix of primary and alternate prey (wild or exotic), as well as human-induced changes in plant communities that collectively help maintain lion numbers. In these situations, predator populations that would normally decrease as their prey populations are reduced, are supported by other, more numerous prey populations (Pierce and Bleich 2003). In most of Colorado, it is likely that lion predation functions primarily within the multiple prey model; on the Uncompahgre Plateau and the northern Front Range, lions preyed on mule deer and elk, and in the northern Front Range, small prey played a significant role in lion diets (Blecha et al. 2015, Moss et al. 2016).

The potential impacts of lions on prey populations are largely dependent on the condition of the prey and their habitat. In areas where prey habitat is in good condition, prey body condition will also be greater. Thus, more individuals in the prey population are likely to survive in the absence of predation. However, in prey populations where individuals are in poor condition due to poor forage quality, those individuals are more likely to die regardless of predation. Therefore, lion predation on ungulates in good physical condition is more likely to be *additive* to other causes of mortality. Conversely, lion predation on ungulates in poor physical condition (that is, ungulates in populations that exceed K_{ecol} [*ecological carrying capacity*]) is more likely to be *compensatory* (Logan and Sweanor 2001)(Figure 1). In addition, healthy prey populations likely exhibit higher reproductive rates and are more likely to offset predatory regulation by producing more young than are consumed by predators. Ungulate populations exhibiting the characteristics of limitation by predation (Table 2) may benefit from increased lion harvest. Prey populations limited mainly by habitat conditions will not likely benefit from increases in local lion harvest except during the initial phases of habitat recovery, allowing more rapid response of the prey population to improved forage conditions. Additionally, in situations where abundant alternate prey are lacking, a decline in lion numbers will naturally follow the decrease in the ungulate population regardless of lion harvest levels (CMGWG 2005).

Table 2. Characteristics of ungulate-prey populations regulated by predation and populations regulated by forage conditions (CMGWG 2005, page 15).

Life history characteristic	Population size mainly affected by predation[b]	Population size mainly affected by forage
Physical condition of adult females	better	poorer
Pregnancy rate of adult females	higher	lower
Pause in annual production by adult females	less likely	more likely
Yearlings pregnant[a]	usually	seldom
Corpora lutea counts of adult females[a]	higher	lower
Litter size[a]	higher	lower
Age at first reproduction for females	younger	older
Weight of neonates	heavier	lighter
Mortality of young	additive	compensatory
Age at extensive tooth wear	older	younger
Diet quality	higher	lower

[a]Some species of ungulates may show limited variability in these characteristics.

[b]These traits will be evident in *any* population far below carrying capacity, even if it experiences *no* predation. The manager should have evidence that predation is a limiting factor before concluding that reducing predation would increase ungulate recruitment.

The extent to which lion predation influences the abundance of ungulate populations seems to depend upon the ungulate population size, its productivity, the quality of its habitat, the presence of alternate prey, and lion abundance. Most notably, lion predation can suppress the growth of small, island-like populations of bighorn sheep (Ross et al. 1997, Kamler et al. 2002, Rominger et al. 2004*a*, Rominger et al. 2004*b*). In addition, the effect of lion predation on a small population of bighorn sheep can be influenced by the presence of more abundant prey, such as mule deer, that is more important to provisioning the lions on the same range (Johnson et al. 2013).

Lions have annually removed an estimated 15-20% of the mule deer population on the Kaibab Plateau, Arizona (Shaw 1980), 8-12% of the mule deer population on the Uncompahgre Plateau, Colorado (Anderson et al. 1992), and 2-3% of elk and 3-5% of mule deer in the northern Yellowstone Ecosystem (Murphy 1998). Yet, the mere presence of predation does not necessarily indicate that an ungulate population is limited by predators. Nor does lion predation necessarily indicate suppression or regulation of the prey population (Ballard et al. 2001). For example, in the Chihuahua desert of southern New Mexico, where neither lions or mule deer were hunted, Logan and Sweanor (2001) revealed that the effect of lion predation on a population of deer was conditional upon deer habitat quality as influenced by weather. Lion predation apparently slowed the growth rate of the deer population but did not stop it from growing during good habitat years. The data indicated that lion predation was partially additive and partially compensatory as the deer population grew, but it was strongly compensatory as the deer population declined during drought. In California, Pierce et al. (2012) examined the relative strengths of predation, mostly by lions, and habitat quality on a mule deer population and found that predation slowed but did not prevent deer population growth when food was not limiting the deer. They concluded that deer mortality during a time when the deer population declined and was at (or near) winter range carrying capacity, was mostly compensatory. However, during the time when the deer population was rebounding from a low phase and not limited by food, lion predation was likely additive mortality.

Researchers in the New Mexico and California studies identified a period when lion abundance lagged behind the deer population decline, and that it was during this time that lion predation had the strongest effect. They suggested that the lag period for lion numbers following deer declines could be four to eight years (Laundre et al. 2007, Pierce et al. 2012).

Other investigations of mule deer population trends have demonstrated population expansion and contraction to be highly correlated with the availability and quality of forage (Clements and Young 1996, Peek et al. 2002). The severity of winters in the current and previous years was the most influential predictor of deer population growth rates in Idaho (Hurley et al. 2011). In that study, lion control increased fawn:doe ratios, but did not affect deer population growth. Several recent studies support a conclusion that the potential abundance of mule deer is determined mainly by the nutritional quality and availability of forage and not by lion predation (Bishop et al. 2005, Bender et al. 2007, Hurley et al. 2011, Pierce et al. 2012, Montieth et al. 2014). Monteith et al. (2014) suggested a path forward utilizing a model that predicts expected population demographic rates from measuring nutritional carrying capacity (NCC). Their approach focuses on the capacity of the habitat and reduces the need to estimate population abundance. The degree that predation is compensatory or additive can be assessed by comparing the estimated NCC for survival and recruitment of young based on the predictive model (Monteith et al. 2014) to those same demographic rates measured empirically in that system. This would be useful for quantifying the effects of predation and provides a basis for determining the likely efficacy of predator control to enhance ungulate populations.

Bergman et al. (2015) examined the published evidence on mule deer population management and concluded that herds in Colorado are most likely limited by the quality of available winter range habitat and that the influence that lion predation may have on mule deer population dynamics (that is, variation in growth rates) is poorly understood. Considering the extent of lion habitat in Colorado and the conservative approach to lion harvest strategies, they hypothesize that lion predation on mule deer is probably weakly additive. In the Upper Arkansas River, CPW researchers stopped investigating the impact of lion predation on deer survival in 2023 because the first six years of data showed deer survival was relatively high and predation mortality attributed to lions was relatively low, even under different levels of harvest pressure on lions (CPW Mammals Wildlife Research Report, 2024).

Even in a system where lion predation is primarily compensatory, hunters may be in competition with lions for preferred prey (i.e., mule deer). If demand for mule deer is high (hunter interest) and access to the resource is constrained (limited licenses), then deer dying from other means can be seen by some, as lost hunting opportunity. Lion predation can be viewed as competition for access to the resource. The conflict here results from the tension between a short-term desire for hunting opportunities and a long-term view of population management of both lions and mule deer. Ultimately this is not a matter of biological capacity or ecological function; these considerations are outside the bounds of a value-driven decision regarding mule deer and lion management. If lions are perceived as competitors for a limited resource such as mule deer, some may seek reductions in lion numbers to lessen this competition. Determining allocation of deer mortality levels to hunters and how much deer mortality from predation is acceptable is not a decision that science can make. It is a value-based decision, which must be left to evaluation in the social, and not biological, realm.

The body of evidence suggests that in most cases, efforts to reduce the impact of lion predation on mule deer are likely to be expensive and the effect, if any, is likely to be relatively short-lived. Such efforts are also likely to be unpopular with some non-hunting segments of the human population.

Mountain Lion Population Monitoring

Although lion populations have previously been monitored with intensive capture efforts over relatively small areas, reliable and affordable techniques to monitor lion populations for large-scale management programs are lacking. The two main approaches to lion population monitoring are field methods and harvest data analysis. Field methods may obtain information directly about lion abundance, demographics and vital rates and/or population trend, whereas harvest data analysis can provide indications of population trends.

Field Methods

Field methods pertain to efforts by biologists to gather data on lions directly or indirectly via evidence they leave in the environment. Some methods are used to estimate lion numbers, while others are indices to relative lion abundance. A recent review of work related to lion density estimates and related biases is provided in Murphy et al. (2022). The lion abundance estimation methodology that CPW has used the last 8 years (spatially-explicit mark-resight) is described first in the section below, but both mark-recapture and camera-only techniques are employed in a number of recent studies in the literature.

Spatially-explicit Mark-resight: Colorado Parks and Wildlife research and management staff have employed a mark-resight population sampling method for abundance estimation of lions since 2017 (Alldredge et al. 2019, Mat Alldredge and Mark Vieira, CPW, personal communication 2024). Initial work demonstrated that results are valid, have acceptable confidence intervals on estimates, and can be conducted at a reasonable cost at a management scale such as the Upper Arkansas study area. As part of the West Slope lion management plan, CPW initiated lion density monitoring studies using this approach in Middle Park (2020-2022) and the Gunnison Basin (2021-2023). This technique now provides reference densities in various locations with diverse habitat quality to allow testing and improvements of our resource selection function (RSF) model. This approach uses a game call to lure lions to a site where a game camera records photos of the animal. A portion of the lion population in the study area is “marked” with GPS collars and eartags before the camera deployment, so both capture probabilities and rigorous density estimates are obtained while addressing study area closure issues that typically plague lion studies (Mat Alldredge and Jon Runge, CPW, personal communication 2024).

This recent work in Colorado using the spatially-explicit method described above is fundamental in generating site-specific abundance or density estimates. Given the importance of numerical density assumptions in the existing RSF model, CPW continues the commitment of conducting rigorous estimates of density in multiple survey areas of western Colorado. As part of this East Slope plan, CPW will begin implementing additional density monitoring in the L-ES Data Analysis Unit (DAU). These future density estimates will be used in addition to existing estimates from recent Colorado research to further align and improve our understanding of lion populations in the state.

Complete Enumeration: Very intensive field efforts to capture, tag and radio-collar lions along with GPS/radio-tracking to discern movements of unique individuals to combine with ground-tracking and harvest information have historically provided the most reliable estimates of lion abundance in specified study areas (CMGWG 2005). This method produces high-quality data on sex and age structure, survival, agent-specific mortality, reproduction, emigration, and other animal movements that generally cannot be obtained with the other methods. This method is the most expensive and is impractical for lion management on a broader landscape scale beyond a small study area where spatial closure can be assured.

Where abundance estimates are the primary parameter of interest, such as a DAU or other management-level population scale, attempts at complete enumeration are impractical.

Mark-Recapture: Chapman's 1951 modification of the Lincoln-Peterson (L-P) estimator (Pollock et al. 1990) was used in an effort to estimate lion numbers in Wyoming (Anderson and Lindzey 2005) and Utah (Choate et al. 2006). The Wyoming effort used a captured and marked sample of lions at the beginning of each sampling period and used lions killed by hunters and observed by researchers after the hunting season as the recaptured sample. Population estimates had 90% confidence intervals ±20-39% of the estimates (n = 5). The Utah study derived population estimates by determining the identity of lions detected from their tracks on snow as either marked or unmarked by using radio-telemetry or by pursuing the animal to capture and observe it. The estimates tended to track the changes in the reference population adequately. But, estimates were on average negatively biased by 17 ± 14%, and 95% confidence intervals were widely variable from ± 0 to 50% of the estimates (n = 7, Monroe Mts., Choate et al. 2006). Multiple capture occasions can be designed into the mark-recapture field operations with the intent to achieve greater precision in population estimates and allow more mark-recapture-type models to be applied in terms of modeling the data (e.g., variations in capture probability by animal type, time, observer, and incorporation of covariates) (Amstrup et al. 2005). These methods are suitable for intensive research on a specified study area, especially to establish a reference for local population abundance and attendant effects of manipulation and experimentation.

Russell et al. (2012) gathered genetic samples from lions one winter in a management unit-size area (7,908 km^2) in Montana. They used a combination of a non-invasive method (back-tracking to collect hair samples) and treeing and biopsy darting lions to genotype individuals, and used spatial capture-recapture models to estimate abundance. Their lion density estimates, including all lions (i.e., adults, subadults, and kittens) varied by model structure, ranging from 3.7 lions/100 km^2 (95% CI=3.6-5.7) from a base model (including an effect of distance on detection probability) to 6.7 lions/100 km^2 (95% CI=3.1-11.0) from a full model (including effects of distance, sex, survey effort, and distance x sex on detection probability).

Proffitt et al. (2015) also gathered genetic samples from lions one winter in a 2,625 km^2 area spanning two lion management units in Montana. They treed and biopsy darted lions to genotype individuals to estimate abundance using spatial capture-recapture models and predicted habitat use as a covariate. They estimated a median density of independent lions (i.e., adults and subadults only) from 4.5 lions/100 km^2 (95% CI= 2.9-7.7) to 5.2 lions/100 km^2 (95% CI=3.4-9.1). In northeastern Washington, biopsy dart sampling of the population when integrated with hunter harvest data was able to detect a population decline across multiple years that was noted in independent mark-recapture efforts in the same research area (Beausoleil et al. 2016). Wyoming and South Dakota have applied this technique to estimate annual lion abundance. Their experience suggests that it can be effective if a sufficiently high number of marks and recaptures can be obtained on a multi-year basis (Daniel Thompson, Wyoming Game and Fish, personal communication 2024).

Davidson et al. (2014) surveyed a 220 km^2 area with scat detection dogs over a 4-week period in Oregon. The dogs found lion scats that were used in DNA analysis to genotype individuals. Individual capture histories were used in four capture-recapture models to estimate total lion abundance. Density estimates including all lions (adults, subadults, and kittens) were: 4.6 lions/100 km^2 (95% CI=3.8-8.3) for the Huggins model, 4.8 lions/100 km^2 (95% CI=4.2-7.8) for the Multiple Detection Poisson model, 4.2 lions/100 km^2 (95% CI=3.3-5.3) for the CAPWIRE model, and 5.0 lions/100 km^2 (95% CI=3.2-7.7) for the Spatially Explicit Capture-Recapture model.

Photographic Rates as an Index to Lion Abundance: Photographic rates of lions might provide a non-invasive index for assessing trends in lion abundance. Such an approach has been used with tigers and showed camera days per tiger photo correlates with independent estimates of tiger density (Carbone et al. 2001). In addition, photographic rates (i.e., leopard photos/100 trap-nights) were an index to snow leopard abundance (McCarthy et al. 2008). Advances in this method of just using cameras have recently been evaluated for direct density estimation in lions, where a different analytical approach is used to handle the fact that lions don't possess individual "marks" on their pelage.

Loonam et al. (2020) reported success in estimating the density of two lion populations in Idaho from 2016-2019 using camera-only based methods and comparing those results to more conventional genetic spatial capture-recapture models. They estimated lion density using both time-to-event and space-to-event models which employ remote cameras and did not require any marking or handling of the population. Both of these methods compared well to capture-recapture models, and offer several advantages particularly when estimating densities over large study areas with low-density species, like lions. McMurry et al. (2022) provide a density estimate obtained in Washington using a space-to-event modeling approach and compare that to previously obtained lion densities from the state. This type of work suggests that camera-only approaches are cheaper and prove themselves easier in providing density estimates without loss in precision over capture-recapture efforts that require obtaining genetic samples or handling animals.

Alternative Field Methods

These methods are not commonly used in present lion field work but are provided for reference as they have been historically included in methodology.

Helicopter-Based Track Probability Sampling: This method involves detecting and following lion tracks in ideal snow conditions along transects from a low-flying helicopter to estimate lion numbers. It is intended for general lion management purposes in representative areas, but still requires field validation for estimator precision. Results of this approach applied to lions in the wild have been reported twice in the literature and with mixed results. Field operations and data quality (i.e., bias) are limited by the difficulty in meeting conditions to observe lion tracks from a helicopter, including: 1-2 nights after snowfall with no wind to cover tracks or crust snow, dense vegetation canopy, helicopter availability, and avoidance of unstable weather and physical obstacles that makes such low-flying dangerous (Van Sickle and

Lindzey 1991, Anderson 2003, Choate et al. 2006). One study in Utah used this method in one survey and reported an accurate but imprecise lion population estimate when compared to a reference population (i.e., 14.2 ± 6.3 standard error, Van Sickle and Lindzey 1991). In another Utah study, investigators observed poor accuracy, poor precision, and inconsistent biases. Some estimates of the lion population were grossly overestimated by 120 to 284% (using the Becker 1991 method) and exhibited poor precision with standard errors of 25-55% of the reference density (Choate et al. 2006). Adjusted population estimates using Anderson's (2003) correction for low movement lengths derived from computer simulations resulted in underestimates of 26 to 88% of the reference population. In addition, Anderson's (2003) modification using random track lengths resulted in inconsistent biases of ±22-59% of the reference population (Choate et al. 2006).

Ground-Based Track Surveys: This method is intended for use as a trend indicator in representative areas for general lion management purposes. Track surveys have been used to monitor lion populations in California (Smallwood 1994, Smallwood and Fitzhugh 1995) and Arizona (Cunningham et al. 1995). This method requires transect sampling areas where lion tracks are detectable and provides presence-absence data with confidence interval estimates. Beier and Cunningham (1996) reported that sampling 140 and 110 8-km-long transects would be required to detect 30% and 50% population declines, respectively (80% power, $\alpha = 0.05$). The difficulty in implementing track surveys is ensuring that transects are well distributed throughout the population in areas where access may be limited and also the unpredictability of favorable tracking conditions. The level of effort required to detect useful population changes likely limits the application of this method to once every few to several years. Researchers in Utah applied summer track surveys and found statistically significant relationships ($P<0.03$) between winter lion density and summer-time track-finding frequency (i.e., no. track sets/km searched). The investigators concluded that ground-based track surveys are the least expensive and might be the most efficient method, and offered two suggestions for improvement. First, winter track counts would be more efficient than summer track counts because the tracking substrate is superior and should increase track detection rates. Second, because removal of lions during a hunting season may bias survey results, track surveys should be conducted prior to a hunting season to more closely relate the index to the population of interest (Choate et al. 2006).

Harvest Data

Harvest data pertains to information gathered on hunter-killed lions and hunters by the managing agency. Methods based on these data are intended for general lion management as an indicator of population trends.

Relationships of Lion Harvest to Population Abundance: Researchers in Wyoming developed and validated this method on an experimentally manipulated reference lion population (Anderson and Lindzey 2005). The researchers found that the sex and age composition of the harvest varied predictably with lion population size because the likelihood of a specific sex or age class of lion being harvested (with the use of hounds) was a product of the relative abundance of particular sex and age classes in the population and their relative vulnerability to harvest. Wolfe et al. (2015) revealed other potentially useful indices to abundance. The percent of permits filled and the minimum abundance index were positively correlated. The percent of individuals in the harvest >6 years old was positively correlated with annual survival, annual adult male survival, and annual female survival. There was a negative relationship between the annual number of female lions in the harvest and the annual lion survival rate. Likewise, there was a negative relationship between the annual proportion of females in the harvest and the annual lion survival rate.

Catch-Per-Unit Effort: Researchers in Utah quantified catch-per-unit-effort (CPUE) of their research teams and hunters for each year as the number of days to capture a lion. In each case, they found that CPUE was a poor predictor of lion population size (Choate et al. 2006). However, using a data set over a longer period of time, Wolfe et al. (2016) found a strong relationship between the number of lions treed per day during the pursuit season and the index of minimum annual lion abundance.

Colorado East Slope Mountain Lion Management Plan
Appendix B

Mountain lion management history in Colorado and the east slope

Historical Management, Game Damage and Conflicts: This section provides a description of the history of lion management in Colorado. This appendix also provides a review of recent game damage and human-lion conflict information. Data from Colorado is provided, illustrating that areas of high human-lion conflict are not areas of high harvest.

Mountain Lion Management History

Lion management throughout the range of this species is challenging because of the secretive nature and naturally low densities typical of this solitary large carnivore, and the rugged terrain these animals typically inhabit. Consequently, no statewide "census" of lion populations has ever been attempted in Colorado or the East Slope. Historical lion research in Colorado has focused on smaller geographic areas involving population segments where intensive, expensive studies have revealed information for reference values on abundance, sex and age structure, fecundity, survival, mortality factors, predation, depredation, behavioral patterns, movements, dispersal, and effects of hunting.

Current research in the Upper Arkansas study area on Colorado's East Slope using newly validated techniques will provide some data types as described previously, but at much larger scales and with the ability to draw more rigorous conclusions due to the strengths of the study design. Similarly, as part of the West Slope Mountain Lion Management Plan (approved by the Parks and Wildlife Commission in 2020), CPW committed to measuring lion density at meaningful scales in two West Slope study areas each year for the duration of that plan. This approach uses the updated spatial mark-resight approach and has already produced several density estimates in different habitats since 2020. Therefore, research and management work across the state over the last decade have contributed to a much more robust knowledge of lion populations across different habitats, harvest pressures and land ownership. Due to this work, CPW has projected an approximate statewide lion population of 3,800-4,400 independent lions (not including dependent kittens).

Agencies charged with lion management attempt to address the desires of the public, whose values vary and sometimes compete between maintaining abundant populations, providing hunting opportunity, and minimizing the potential for human-lion conflicts. Lions have been classified as a big game species since 1965 in Colorado. Prior to 2000, Colorado had not formulated any plans for lion management. In 1999, the Executive Director of the Department of Natural Resources (DNR) formed the Predator Management Advisory Committee, to provide policy advice to DNR and its subordinate agency, the Colorado Division of Wildlife (CDOW, presently CPW). This group helped develop brief plans that set annual hunter harvest and total mortality objectives based on the preceding 3-year average levels in 25 distinct geographic areas called Data Analysis Units (DAUs). By 2003, these plans were deemed too generic, inflexible and lacked a credible scientific basis. During 2004, a new planning effort was completed, producing 19 separate lion DAU plans for the state. This more comprehensive planning effort provided statewide direction and management sideboards related to habitat models, population extrapolations, and mortality off-take rates. The plans mentioned game damage caused by lions and human conflicts associated with lions, but management objectives were firmly focused on supportable mortality amounts.

In 2020, a process for updating and consolidating the 13 West Slope DAUs and their respective plans was initiated. The result was a single lion management plan covering the entire West Slope and creating two DAUs. The PWC approved this plan in September of 2020, and it was implemented for the April 2021-March 2022 lion season. This left the six remaining East Slope DAUs with individual DAU plans, with five of the six written as part of the planning effort in 2004.

The long-term increase in Colorado's lion population is likely a result from a combination of regulating human-caused mortality of lions since 1965 and recovery in mule deer and elk numbers following lows observed in the early 1900's. Consequently, lion harvest limit allocations and the amount of harvest have generally increased since 1980 (Figure 1) across the state. However, the 2004 DAU management plan updates did result in a decrease in statewide harvest limits. An emphasis of these plans was to reduce hunter harvest of females in select DAUs. Therefore, in 2007, a mandatory lion hunter education course was instituted to help increase the focus of harvest on male lions. As a result, the composition of female lions in harvest declined, and the combined effect of the reduced harvest limits and the emphasis on reducing female mortality caused an initial decrease in the total amount of hunter harvest. Research has revealed the importance of focusing on adult female harvest composition, as opposed to the overall female harvest mortality. The compositional monitoring threshold incorporated in the East Slope Mountain Lion Management Plan focuses on adult female proportions in harvest versus the total female proportion that was previously a standard objective in the 2004 lion DAU management plans.

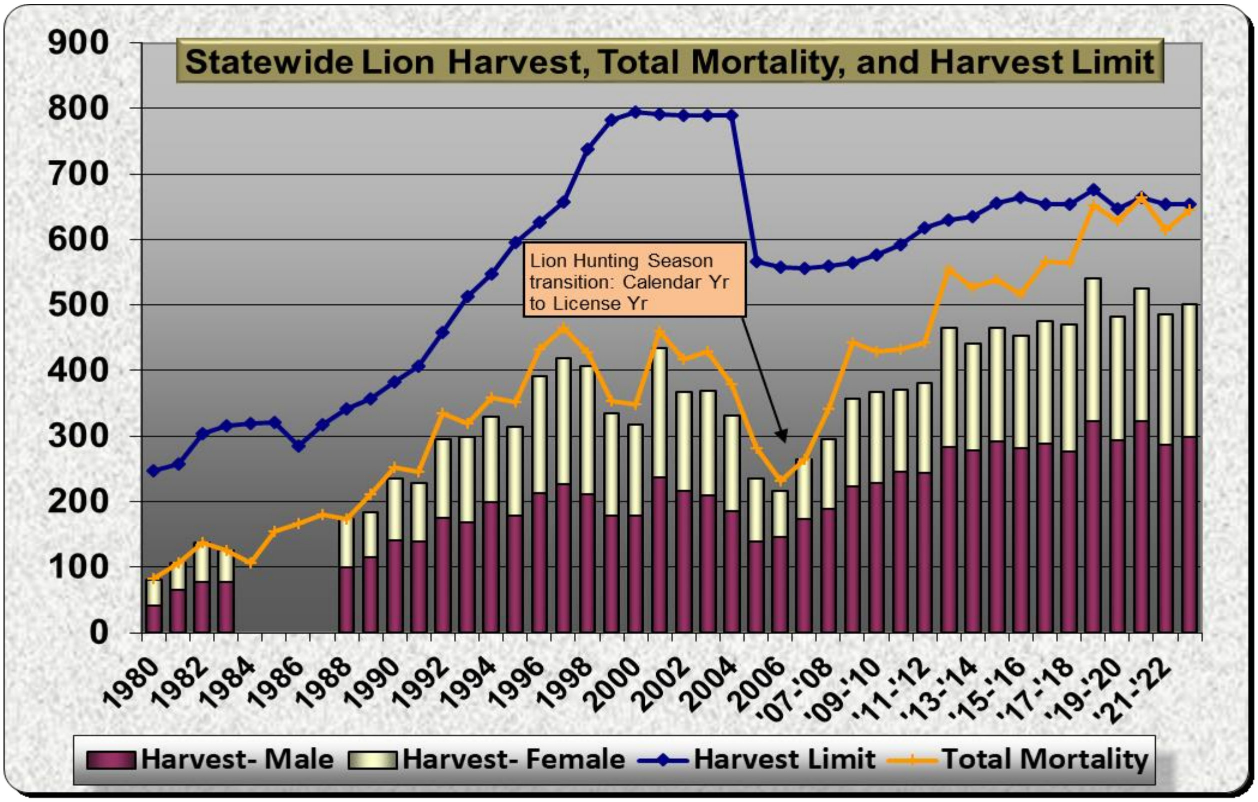

Figure 1. Annual mountain lion harvest by gender, total mortality, and total harvest limit in Colorado from 1980-2022/23. Note transition from calendar year to winter year in 2007.

Non-harvest, human-caused mortality has also increased statewide since the late 1980s (Figure 1) and in recent years on the East Slope (Figures 2 and 3). Some have attributed this to increasing lion populations. However during the past 30+ years the human population, related development, volume of automobile traffic, and the amount of outdoor recreation in Colorado have also increased considerably. It is likely that a combination of factors contribute to the increases in non-harvest lion mortality, including better documentation of these types of mortality in more recent decades.

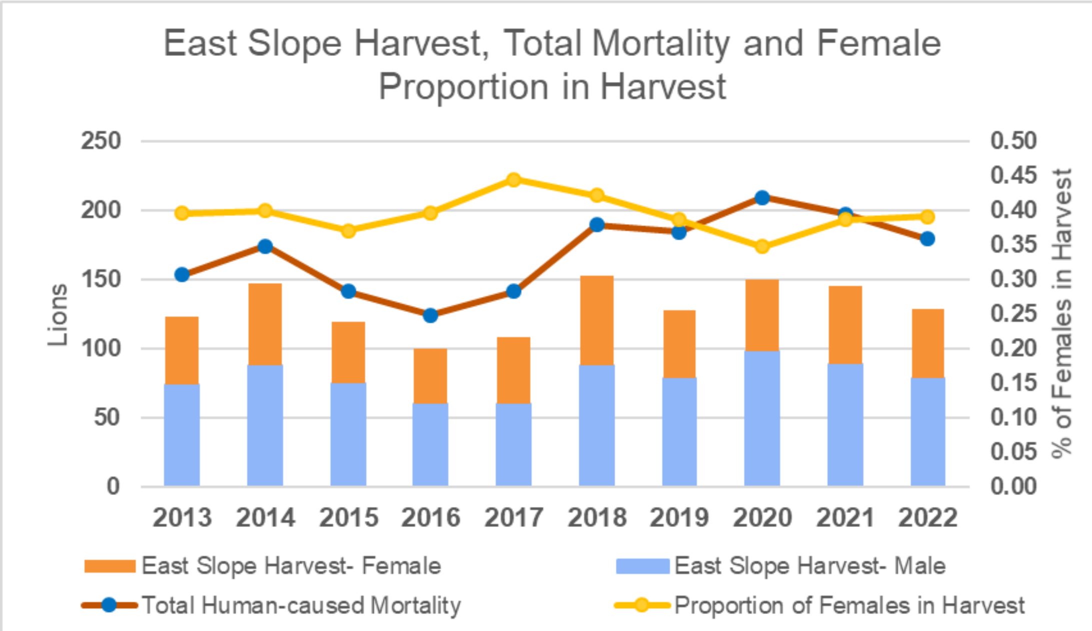

Figure 2. Historic East Slope harvest by sex, total human-caused mortality and proportion of females (adult and subadult) in harvest.

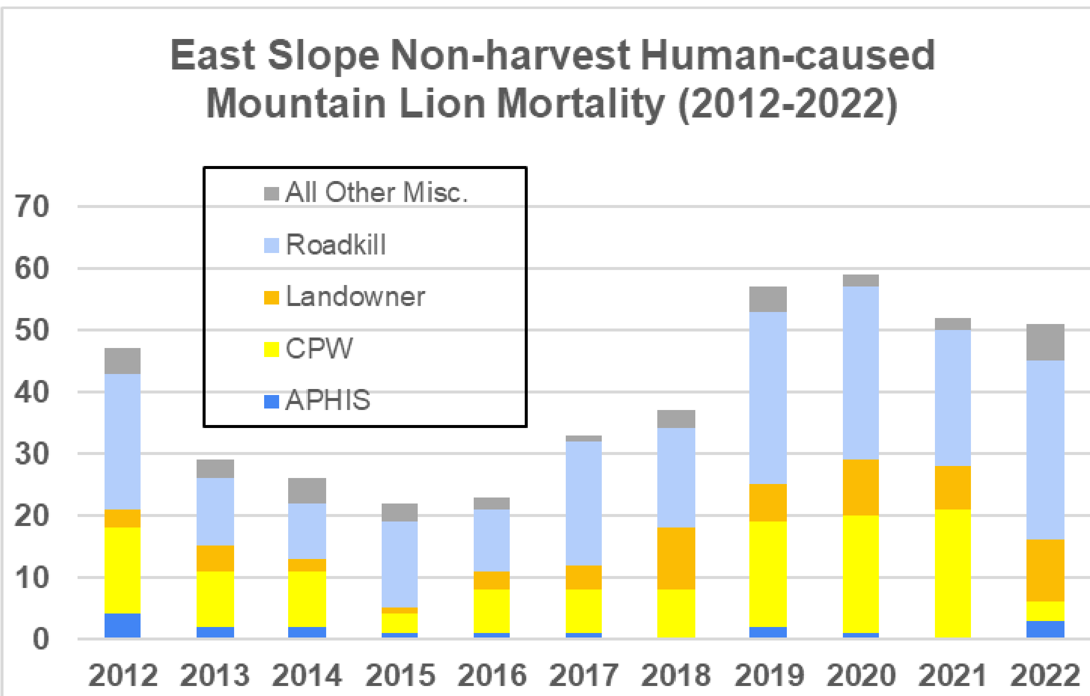

Figure 3. Annual non-harvest human-caused mountain lion mortality in the East Slope from 2012-2022.

The 2004 lion DAU management plans were based on a series of assumptions about lion population size and the population responses to varying mortality levels. The plans noted that information was lacking about how populations responded to these assumptions, as was the ability to collect valid information that could detect population changes in a timely and effective manner. This led to implementation of two long-term research projects in Colorado designed to evaluate lion management assumptions, inform management decisions, and quantify actual population responses to management actions. Research activities were completed on the Uncompahgre Plateau in 2014. Colorado Parks and Wildlife Technical Publication Number 54 reports final project findings which have been incorporated into this plan (Logan and Runge 2021). On the northern Front Range, CPW’s work on estimating abundance, diet composition, and age class from non-invasive sampling has also yielded a number of publications (Alldredge 2015, Blecha et al. 2015, Moss et al. 2016, Alldredge et al. 2019a, Alldredge et al. 2019b). Of particular relevance to the East Slope lion plan, this line of research evaluated lion demographic and behavioral characteristics in a significantly human-altered environment. Colorado Parks and Wildlife is currently in the ninth year of a 10-year lion research project in the Upper Arkansas area of southeastern Colorado with the final year of research harvest study design occurring in 2025-2026. This project will build knowledge of predator-prey dynamics, improved density estimates, evaluate lion population composition structure under different harvest regimes and shed light on the relationship of human-lion conflicts under varying lion harvest and abundance scenarios. Within the East Slope plan, provisions have been made to allow for future periodic evaluation and updating so that the plan can incorporate knowledge gained from the Upper Arkansas project and other research that may be conducted in the future.

Harvest Management

The regulation of hunting for lions in the western states typically follows one of three harvest strategies: general seasons, limited entry and harvest limit/quota systems (CMGWG 2005).

1) General seasons allow unlimited hunting of lions of either sex, and the only restrictions include the number of licenses issued and/or bag limit allowed per hunter (typically one per season), and timing and length of the hunting season. General seasons provide the highest hunting opportunity, but likely result in uneven hunting pressure (i.e., accessible areas are heavily hunted and inaccessible areas are not), which limits control over the amount, composition, and distribution of the harvest.

2) Limited entry programs restrict the number of hunters per hunt area through a limited license allocation, using either first-come-first-serve or lottery license sales. This approach is most restrictive in terms of hunter opportunity, but it can be useful to disperse hunting pressure, control harvest levels, and may increase the opportunity for hunters to be selective (increasing male harvest) in areas where hunting pressure is low.

3) Harvest limit/quota management limits the total harvest and/or number of female lions harvested from defined areas. The hunting season closes in an area once the harvest limit has been met. Hunters are required to monitor the status of the hunting season by checking a website before hunting to determine if an area is open or closed to hunting. Advantages to this approach are that hunting opportunity remains high and the amount and distribution of harvest can be regulated. Potential disadvantages of harvest limit/quota management include the number of hunters per hunt area is unlimited until

harvest limits are filled and desired harvest may be exceeded if more than one lion is harvested the same day the limit is reached. Also, a high amount of competition among hunters/outfitters for the lions available under the harvest limit can result in decreased harvest selection, increasing the amount of females in harvest.

Female sub-quotas can be used to support a management objective of maintaining harvest levels with reduced impact on the lion population. Advantages include the ability to stop harvest based on a female objective, while problems include illegal non-reporting of harvested females to avoid closing units and sacrificing hunter opportunity to pursue males once the smaller female sub-quota is achieved.

Colorado has managed lion hunting recreation with a harvest limit or quota system since before 1980. As originally conceived, the “quota” is the maximum amount of harvest allowable within a specific geographic area. Once the “quota” is met, the hunting season for that area is closed for that year. Lion hunting licenses are unlimited, but hunters must check an online harvest limit report to determine if the harvest limit group of game management units (GMUs) they wish to hunt remains open to hunting. The harvest limit/quota system optimizes hunting opportunity while limiting hunting harvest to acceptable levels on an annual basis. Historically in Colorado, “quotas” have traditionally been set higher than actual harvest objectives, because the full quota may not be achieved each year. This has occurred because of several factors: hunting conditions are not always conducive to harvest, some hunters intentionally deferring harvest opportunities to continue hunting throughout the entire season and the constraints of guided hunts as the primary mechanism to obtain harvest in some areas. However, under the West Slope plan and this proposed East Slope plan, harvest limits align more with the harvest objective. Using the name “harvest limit” instead of “quota” gives a more accurate description of how this term functions within a harvest limit group.

Historic “quotas” in Colorado were not synonymous with the harvest objective, though the term has been mistakenly believed to be one and the same. When quotas went unfilled, it created an erroneous perception for some that management was failing to achieve the desired harvest. The upper end of harvest objectives and the total mortality limits codified in the 2004 lion DAU management plans were intended to be the maximum amount of acceptable annual mortality; a value not to be exceeded. The contrast of perception and intention surrounding these terms has contributed to some of the debate about lion management goals.

In 2013, an April lion season (April 1-30) was implemented to provide hunting opportunity in locations where harvest objectives were not being achieved during the regular season. In these areas, an additional season provides extra hunting opportunity and hunter harvest still within the lion DAU management plan objectives. In its original design, the April season was intended to be a simple extension of the existing lion season structure. The “regular” lion season opens after the last day of the 4th deer and elk season; typically around the third week of November and runs through March 31. However, because Colorado’s license year is April 1 –

March 31, administrative and logistical requirements resulted in the establishment of a regular and an April season harvest limit, which has caused confusion in when, where, and why seasons would be open in April and what the objectives would be. Prior to 2019, CPW used the 3-year running average of residual harvest limit from the regular season and set that amount on an annual basis as the harvest limit for the April season to function as an extension of the regular season. Harvest during 2016-2018 April seasons averaged less than 10 lions each year. Beginning in 2019, to more efficiently manage the lion regulatory cycle and remove confusion over how April harvest limits were set, CPW combined the numeric harvest limits from the April and regular seasons into one single annual harvest limit. Statewide April lion harvest from 2019-2022 has averaged 4.8 animals per year. Since the status of April seasons was evaluated annually for each DAU, the number of open April seasons has changed each year during that period with fewer open April harvest limit groups resulting in a lower April harvest.

All hunter harvest of lions must be reported as part of a mandatory check process required in some form since before 1980. In 1989, the agency included a requirement that all discovered non-hunt mortality must also be documented through the mandatory check process. Data collected at the mandatory check include: harvest date, location (legal description, Universal Transverse Mercator location, and hunt area), sex, lactation history (whether or not females have ever nursed young based on nipple characteristics; Anderson and Lindzey 2000), estimated age from tooth wear and degree of staining, collection of teeth for cementum annuli aging, number of days spent hunting, and hunting method. Trainer and Golly (1992) reported 76% agreement ≤1 year of annuli ages compared using blind tests of two premolars from the same lion (n = 426; 92% agreement for lions <4 years old), and annuli age comparisons of known age lions were 95% accurate (within one year; Trainer and Golly 1992, Anderson 2003). In 2019, the recording system used for these mortality reports was revised to collect data from these mandatory checks primarily on a tablet or phone application.

This mandatory reporting system is the most accurate way of accounting for human-caused mortality, so while time-consuming for staff to implement, it provides CPW with high-quality data. Lion carcasses or pelts harvested by hunters may be frozen, which can reduce the collection of teeth or the ability to inspect evidence of gender. Washington noted that hound hunters correctly determined the gender of lions at bay about 70% (57-88%) of the time, whereas agency personnel correctly determined the gender of lions during mandatory checks 87% (71-90%) of the time (Beausoleil and Warheit 2014). They recommended better training of agency staff and education with hunters to improve the credibility of data that is important to management purposes. In Colorado, hunter education on gender identification is part of the mandatory mountain lion hunter education course. Agency staff are trained annually on the data collection process from mandatory inspections. In addition to mortality data, CPW compiles data on human-lion conflicts and game damage claims, and gauges social concerns through public meetings, contacts with the public, hunter surveys, and public attitude surveys.

Methods of Mountain Lion Hunting

Lion hunting in Colorado is accomplished primarily by tracking and baying lions using trained hunting dogs (i.e., hunting with hounds). However, harvest may also occur through opportunistic encounters (spot and stalk) or by calling lions using non-electronic predator calls (mouth calls). The majority of lions harvested annually in Colorado are taken by hunting with hounds (typically >95%). Compared to 20-35 years ago, recent technological advancements have changed guided hound hunting. Collar technology on hounds allows a hound handler to release hounds and track them on a hand-held GPS device. Collars may be equipped to detect when the dogs have a lion at bay. This allows for examination of the closest or easiest path for the hunter to approach the bayed lion without engaging in foot pursuit from the release of hounds to the point of bay. Collars contribute significantly to improved hound safety, by helping locate dogs that have been lost during a chase and emitting an audible tone to signal dogs to return to the hunter if they are approaching an unsafe situation. All-terrain vehicles (ATVs), snowmobiles, cell phones, and digital radios all combine to make hound-hunting lions more efficient than in past decades.

Some groups and individuals are concerned about the use of dogs as a hunting method for lions, and some states have banned hunting with hounds through voter initiatives (e.g., Oregon, Washington). In 2005, CPW hired Corona Research to survey the attitudes of Coloradans about issues related to lions. Some key elements related to lion hunting include: a) An overwhelming majority of Coloradans thought it was important for lions to exist, even if they never saw one, and it was important for them and future generations to have lions; b) Coloradans were split about hunting lions, with 47 percent in support of legal and regulated hunting and 41 percent opposed; and c) 46 percent disagreed that lion hunting should be banned, while 34 percent agreed with a ban. These results provide a broader representation of the attitudes of Coloradans about lion conservation and hunting, well beyond the traditional constituents that agency personnel more frequently contact during the process of structuring hunting management.

In states where hunting with hounds has been prohibited, opportunistic lion hunting (during big game seasons or predator calling) can result in harvest levels similar to, or higher than before the bans. States in which lion hunting with hounds has been prohibited typically compensate for substantially decreased success rates by reducing the price of a license, increasing the number of licenses, and easing mechanisms by which licenses can be obtained. Results from Washington (Martorello and Beausoleil 2003) revealed that opportunistic lion hunting is less selective of sex and age class than hunting with hounds and female lions are more vulnerable to harvest from opportunistic hunting than from hound hunting. Relative female harvest levels increased from 42% to 59% when hunting with hounds was banned in Washington (mean annual harvest before hound hunting ban = 157 and after hound hunting ban = 199). In Oregon, similar increases in the proportion of females in harvest were observed, and within seven years, total harvest amounts regularly exceeded harvest amounts prior to the ban on hound hunting (Don Whittaker, Oregon Dept. of Fish and Wildlife, personal communication 2015).

Lion harvest data from the three most recent years in Colorado suggest that hunters using the services of an outfitter are more selective in the harvest of females (37% F) than hunters not using an outfitter (46% F). In comparing the methods of hunting lions in Colorado using statewide 2012-2022 data, the use of hounds appears to noticeably improve hunter selectivity regarding female take (38% F hound hunters compared with 54% F for opportunistic hunting). This suggests that applying mechanisms to expand hunting seasons without the use of hounds would likely result in an increase in the absolute amount of and composition of females in harvest. In addition, if opportunistic hunting harvest increased and hunting with hounds was reduced, we would expect an increase in the number of dependent young being orphaned due to hunting because of the apparent increased vulnerability and the higher proportion of females harvested with non-selective methods (Martorello and Beausoleil 2003).

Differences in the composition and amount of females in hunter harvest are likely a combination of a hunter's ability to determine gender (while a lion is treed or at bay), but are also related to differences in lion vulnerability between hunting methods. Anderson (2003) observed that nightly movement distances from GPS data averaged over three times longer for male lions than for females (mean end-point distance = 4.6 km versus 1.5 km, 2.9 mi versus 0.9 mi). These longer distance movements expose males more than females to hunting methods involving tracking (i.e., hunting with hounds). Opportunistic hunters who do not track lions while hunting are more likely to harvest the more abundant sex, typically females, because relative abundance and chance encounters drives harvest vulnerability.

Mountain Lion Conflicts

There are two broad categories of human-lion conflicts: game damage and human safety. Game damage primarily refers to the economic costs of lion depredation on domestic livestock. Human safety primarily refers to the concerns and the real or perceived risks to human safety that lions may pose. State law provides allowance for the public to kill a lion that is considered a threat to people's safety or to livestock [*Colorado Revised Statute §33-3-106(3): Nothing in this section shall make it unlawful to trap, kill, or otherwise dispose of bears, mountain lions, or dogs without a permit in situations when it is necessary to prevent them from inflicting death, damage, or injury to livestock, real property, a motor vehicle, or human life*]. Animals killed under the authority of this provision must still be reported within five days of death to CPW and the state of Colorado retains legal possession of such animals; consequently, CPW can obtain information on the number of such mortalities. If lions are killed in the summer and/or in remote locations or are too badly decomposed, obtaining gender or tooth samples is difficult and less data are generally collected on such animals.

The broadest tool CPW uses regularly to address human-lion conflicts is public education. Providing public educational resources will continue to be a prominent agency tool under the East Slope plan. Education is done both proactively, as a staple when staff interacts with the public in lion habitat or on lion-related issues, and reactively in contacts with the public after a specific human-lion conflict. There are several pamphlets, brochures, videos and educational tools that CPW produces to educate the public on actions they can take to reduce human-lion conflicts. These steps include improved animal husbandry practices for livestock producers, employing guard animals and removing vegetation from near homes that attract deer and elk or provide hiding cover for lions. This agency educational effort also focuses on how to recreate in lion habitat and steps to take if you encounter a lion. Temporary signage is often used to inform the public about areas where lions have been recently seen and to further educate citizens and visitors about the need to take common-sense precautions, particularly with pets and children in these areas.

Beyond the overarching goal of public education on co-existence, immediate agency responses to game damage and human safety conflicts in Colorado are primarily aimed at individual animals involved in the conflict. The actions that can be applied to an individual lion involved in either conflict behavior are broad and are usually determined on a case-by-case basis. Intervention techniques include capture and translocation, lethal removal, and on-site hazing. Hazing can involve harassment with trained dogs and less-lethal projectiles fired at the animal. This has not precluded the agency from applying larger scale management efforts to address such conflicts. Colorado Parks and Wildlife's current lion management plans for two of the six East Slope management areas have an increased harvest objective to suppress the lion population (DAUs L-12 and L-17). Figure 4 shows the location of Colorado's eight current mountain lion DAUs.

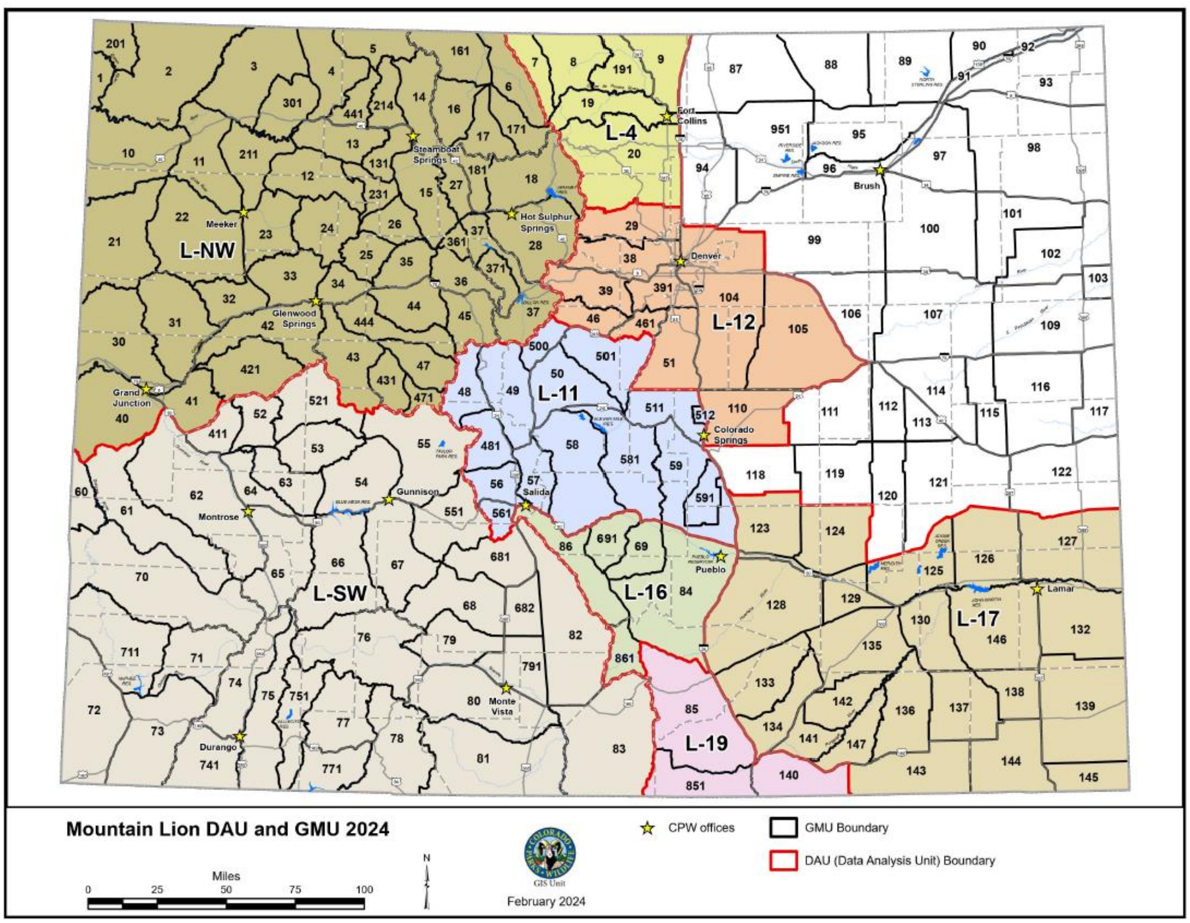

Figure 4. Mountain lion Data Analysis Units for 2024-2025 season.

Some recent research suggests that management targeting an area for increased harvest (rather than an individual conflict animal) may not be effective because of rapid immigration from adjacent source populations (Robinson et al. 2008, Cooley et al. 2009*b*). These authors postulate that it is possible that the increased presence of younger immigrant animals, social disruption of lion populations, and spatial changes in use patterns of immigrants that result from increased harvest may all contribute to increases in human conflicts and game damage (Peebles et al. 2013). A correlative study in British Columbia found that when accounting for human density and habitat productivity, harvest levels comprised the most correlated variable to conflict numbers (Teichman et al. 2016). Unfortunately, this study did not account for underlying lion densities, which could strongly relate to harvest levels, and defined conflict in very broad terms, including roadkill, livestock depredation and perceived risks from sightings. Similar to Peebles et al. (2013), the authors of this study looked at the relationship between conflicts and mortality at very large scales and collapsed data from large spatial scales for purposes of the analysis.

In contrast, an Oregon lion population study found an inverse relationship between conflict lion mortalities and lion harvest (Hiller et al. 2015). The authors present an analysis showing that under high lion population densities, the number of lions killed due to livestock conflicts decreased as harvest density increased. Their results indicated that hunter harvest may be a valuable tool in managing livestock conflicts in circumstances when agency managers can increase prey populations, increase hunter harvest on lions, and reduce the vulnerability of livestock.

To date, the scientific evidence regarding the effectiveness of population scale management to effect reductions in conflicts is equivocal (Human-Cougar Interactions Science Review Team- Washington 2022). Data from Colorado do not suggest a positive relationship between high lion harvest and increased conflicts, but rather just the opposite. Areas of highest harvest removal, as shown in Figure 3 of the East Slope Lion Management Plan, do not correlate with areas of highest non-agricultural conflicts. Many areas of high human-lion conflict in Colorado have very little or no harvest at all (Figure 5).

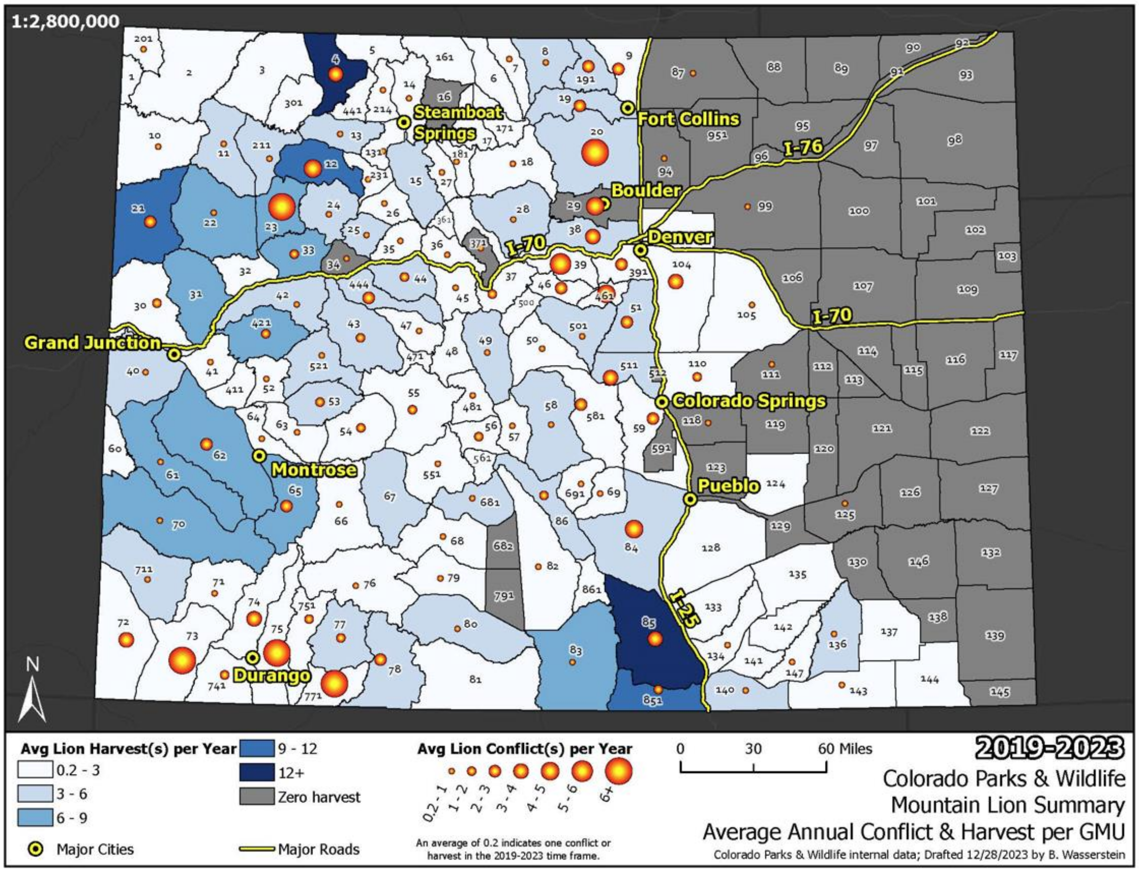

Figure 5. Statewide map of Colorado's average annual lion harvest by GMU (2019-2023 calendar year) and average human-lion conflict levels reported to CPW during that same period shown by increasing circle size.

Laundre and Papouchis (2020) used the example of California, a state without a legal lion hunting season, to test various assumptions that some might make about the role harvest plays in managing conflict, depredations and deer numbers. As in some other studies, the issue of scale of analysis is important. Pooling data on lion population size, human population size, conflicts and harvest across entire states for comparison, as done in this study, ignores other significant differences between states, and more importantly, does not account for the context of those data categories within each state. Research in Colorado regarding the effects of harvest and lion population density suggest management to reduce conflict has varied results and is not solely linked to harvest. Few, if any studies, have been able to look at the value of small-scale, localized harvest or agency removals of lions involved in human-lion conflicts, and then make conclusions about that impact on quantifiable reporting of human-lion conflicts (Human-Cougar Interactions Science Review Team-Washington 2022). As recommended by the authors of the Human-Cougar Interactions Science Review Team for Washington (2022), the ongoing research project in the Upper Arkansas area of Colorado represents a unique manipulative experiment, and as such, will allow stronger inferences on relationships between harvest and overall mortality to conflict levels.

Game Damage

Colorado has been liable for monetary losses caused by lions to livestock since the 1920s. However, it wasn't until the 1970s that game damage laws and liability were first codified in statute. Liability for damage caused by wildlife is governed by Colorado Revised Statute §33-3-103. Regulations establishing the process for submitting a claim and the process whereby a livestock producer can prove their claim and the livestock value were first established in the mid-1970s. Consequently, CPW has a long history of damage payments related to lion depredation on livestock. However, records regarding claim numbers, location, dates, and amounts were not accurately maintained until the 1990s.

In 1996, the Colorado Department of Agriculture (CDA) was granted "exclusive jurisdiction over the control of depredating animals that pose a threat to an agricultural product or resource." Thus, the CDA has exclusive authority to determine the disposition of an individual lion if it is depredating on livestock, while the CPW retains authority to manage lion populations, body parts, and all forms of recreational or scientific use. A Memorandum of Agreement between the CDA and CPW provides operational guidance for both agencies. This aids both agencies in implementing their management authority and helps ensure documentation of agriculture-related lion deaths and the legal disposition of carcasses. As a matter of policy, any lion that is involved in a depredation incident shall be destroyed if it can be captured or identified.

In 2002, the Colorado legislature limited the State's liability for damage caused by lions to livestock or personal property used in the production of raw agricultural products and further limited liability to not more than $5,000 per head of livestock. As a consequence of this change, non-agricultural personal property claim payments have been eliminated.

Over the last six years in the GMUs of the L-ES DAU, the annual number of lion damage claims submitted to CPW has ranged from five to 23 (Table 1). Over that same period, total paid claims have averaged $16,600 per year indexed to 2022 dollars. Monetary values are adjusted by the annual Consumer Price Index (CPI) to reflect 2022 dollar amounts.

Table 1. Number of mountain lion damage claims submitted to CPW from 2017-2022 by livestock type in the L-ES DAU.

Claim Type	2017	2018	2019	2020	2021	2022
Cattle	2	5	1	3	5	1
Other stock	2	11	11	15	12	6
Sheep	1	0	2	2	6	3
Annual Total	**5**	**16**	**14**	**20**	**23**	**10**

Unlike on the West Slope where domestic sheep depredation accounts for the largest share of monetary compensation paid annually, in the East Slope DAU "other stock" represents 73% of the payment dollars over the last six years (Figure 6). The other stock classification includes llamas, alpacas, guanacos, angora goats, chickens, and other livestock typically considered hobby stock animals. Because they are often highly valuable, damage claim amounts for hobby stock are often higher on a per claim basis compared to domestic sheep used in large scale production.

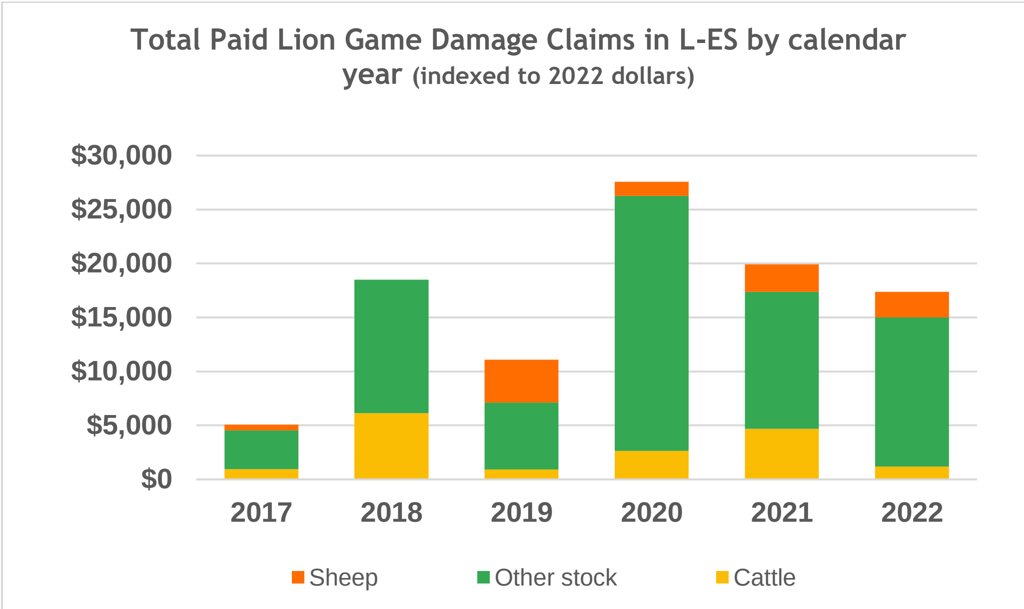

Figure 6. DAU L-ES compensation paid for mountain lion damage from 2017 to 2022. Monetary values are adjusted to 2022 dollars.

Human Safety

Lion attacks on humans across North America are rare, but their frequency has increased in recent decades (Beier 1991, Torres et al. 1996, CMGWG 2005). This has also been found in Colorado. Lion attacks on humans occur primarily in the summer season (June-August), which likely correlates with the increased amount of outdoor recreation activity that occurs in Colorado lion habitat (Figure 7). Mattson et al. (2011) evaluated 386 human-lion encounters, including 29 fatal and 171 non-fatal injury attacks on humans, documented in the U.S. and Canada between 1890-2008 to determine the important risk factors in such encounters. They found that young female lions (≤2.5 years) were more likely to be involved in an attack on people than adult lions. Their examinations show that attacks on people are extraordinarily low-frequency, but high consequence events that are difficult to anticipate or prevent. They noted that aggressive behavior (yelling, throwing objects, charging, or discharging firearms) by people involved in close encounters with lions lessens the likelihood that the lion will attack. Unfortunately, several states have documented their first fatal human attacks over the last several years. Washington, Oregon and California have each recorded a fatal lion attack on a human in the last six years.

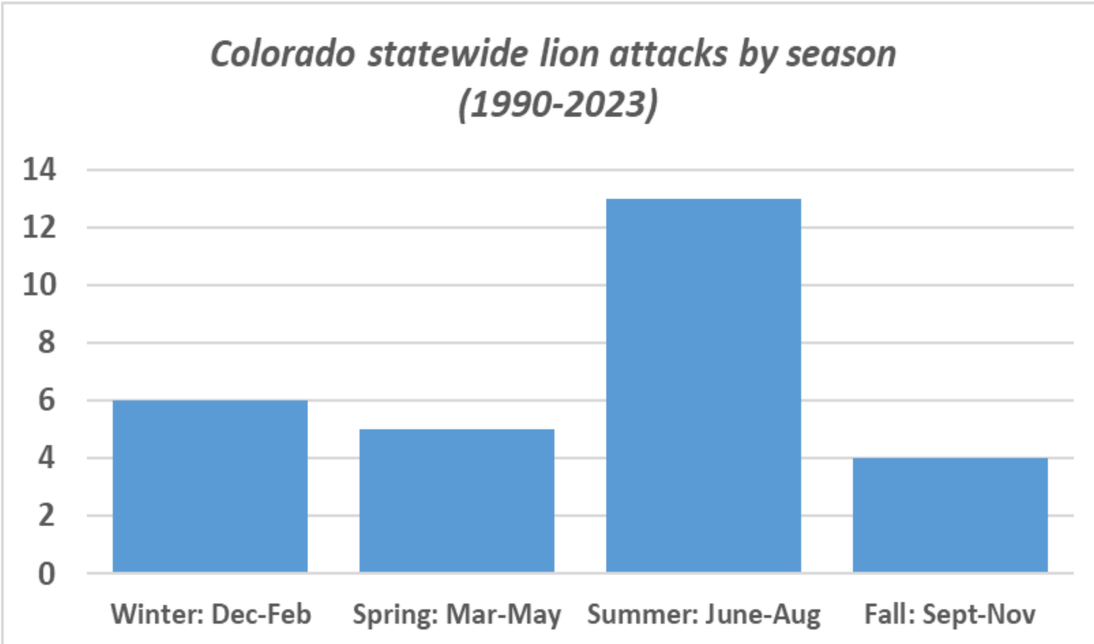

Figure 7. Seasonality of mountain lion attacks on humans in Colorado (1990-2023).

CPW Administrative Directive OW-13 Human-Mountain Lion Incidents, establishes the agency procedures for dealing with general conflicts that may develop between humans and lions. This policy directs that agency management responses to a specific conflict between people and a lion or lions will be directed at the individual lion(s) involved and not at the population management scale. Administrative Directive OW-2 Predator Attacks on Human(s), details the manner in which the agency will respond to an attack by a lion (and any other predator) on a person. Both of these administrative directives allow for lion relocation under certain circumstances and provide direction for when that may happen. However, it is also the policy of CPW per these administrative directives that a lion will be euthanized when it's determined to be dangerous because of its behavior, whereas a lion that is dangerous because of its location may be euthanized or relocated. The determination of relative risk due to location or behavior presented by the individual lion will be made by the Regional staff involved with addressing the incident.

Per these administrative directives, CPW employees are required to document human-lion conflicts via a conflict recording system. Lions lethally removed under Administrative Directive OW-13 will be recorded as such in the Wildlife Incident recording application. The reports generated from this process document essential information about the date, time, location, type of conflict, number of people, and animals involved, and the circumstances of the conflict. Along with the mortality recording system, this wildlife (including human-lion conflict) recording system was revised in April 2019 to provide an electronic recording system that is consistent, standardized and used across the state to record each human-lion interaction reported to CPW. Due to the previous recording system using hardcopy paper forms across the state to record incidents, developing historically accurate and precise enumerations of conflicts is difficult. The new web and mobile-based application currently in use is providing much more consistent and accurate data.

Two separate public opinion surveys in Colorado have revealed that the majority of Colorado citizens prefer that the agency apply non-lethal conflict management tools, except in the case of attacks on people (Zinn and Manfredo 1996, Corona Research 2005). However, when considering the location of an attack on a person, respondents equivocate; 49% opposed destroying a lion involved in an attack if the person was recreating in lion habitat (Corona Research 2005). These results and those previously mentioned regarding public opinions about lion hunting suggest that the public is quite divided in their perspectives about lions. Nevertheless, the Corona survey indicates that the public strongly supports active management of lions and encourages responsible behavior by people to manage human-lion conflicts.

Colorado East Slope Mountain Lion Management Plan
Appendix C

Mountain lion resource selection function model

Colorado Parks and Wildlife (CPW) modeled statewide lion winter habitat using a resource selection function (RSF) approach, which compares where species are present to habitat that is available on the landscape. We used the RSF's final output to establish a total human-caused lion mortality threshold for the new East Slope DAU, L-ES. The winter period is defined as December-February, and all lion locations used in our model correspond to those dates. We used 2,470 male and 1,603 female mortality locations documented through mandatory checks from 2000-2013 as our presence sample in the model. We created a list of 18 variables considered important to how lions choose habitat in Colorado (Table 1). We then removed variables that were highly correlated with each other. This resulted in 6 variables chosen for model development, including distance to mule deer winter range, elevation, low vegetation, short shrub, tall shrub, and slope (highlighted in Table 1). We generated an equal number of random locations (n = 4,100) within lion habitat documented in CPWs species activity maps (http://gisweb/webmaps/sam/sam.html) and used these as the "available" sample.

Table 1. Variables originally considered for development of the 2020 Colorado statewide winter mountain lion habitat resource selection function (RSF) model.

Variable	Keep or Remove	Why Removed
NE aspect	Remove	Correlation with another aspect
SE aspect	Remove	Correlation with another aspect
SW aspect	Remove	Correlation with another aspect
NW aspect	Remove	Correlation with another aspect
Distance to mule deer winter range	Keep	
Distance to elk winter range	Remove	Correlation with mule deer distance
Distance to bighorn winter range	Remove	No contribution to model
Elevation	Keep	
Urban	Remove	Less than 1% of landscape
Suburban	Remove	Less than 1% of landscape
Bare	Remove	Less than 1% of landscape
Low vegetation	Keep	
Short shrub	Keep	
Tall shrub	Keep	
Forest	Remove	Correlated with elevation and TRI
Water	Remove	Less than 1% of landscape
Slope	Keep	
TRI (roughness)	Remove	Correlated with slope and elevation

Using ArcMap 10.1 (ArcGIS 10.1; Environmental Systems Research Institute, Redlands, CA), a continuous predictive surface was created that represented the relative probability of lion presence in winter across the entire state of Colorado (Figure 1). However, with a goal of projecting a potential lion abundance across appropriate habitat in L-ES, a probability of lion presence surface has limited practical use. Harvest rates and mortality thresholds are based on projections of lion numbers or population projections; therefore, a process was used to convert from relative probability of lion presence into projected lion abundance. The process started with stratifying the statewide prediction surface into 4 categories: Strata 1 probability of lion winter presence = 1-25%, Strata 2 probability of lion winter presence = 26-50%, Strata 3 probability = 51-75%, Strata 4 probability = 76-100% (Figure 1).

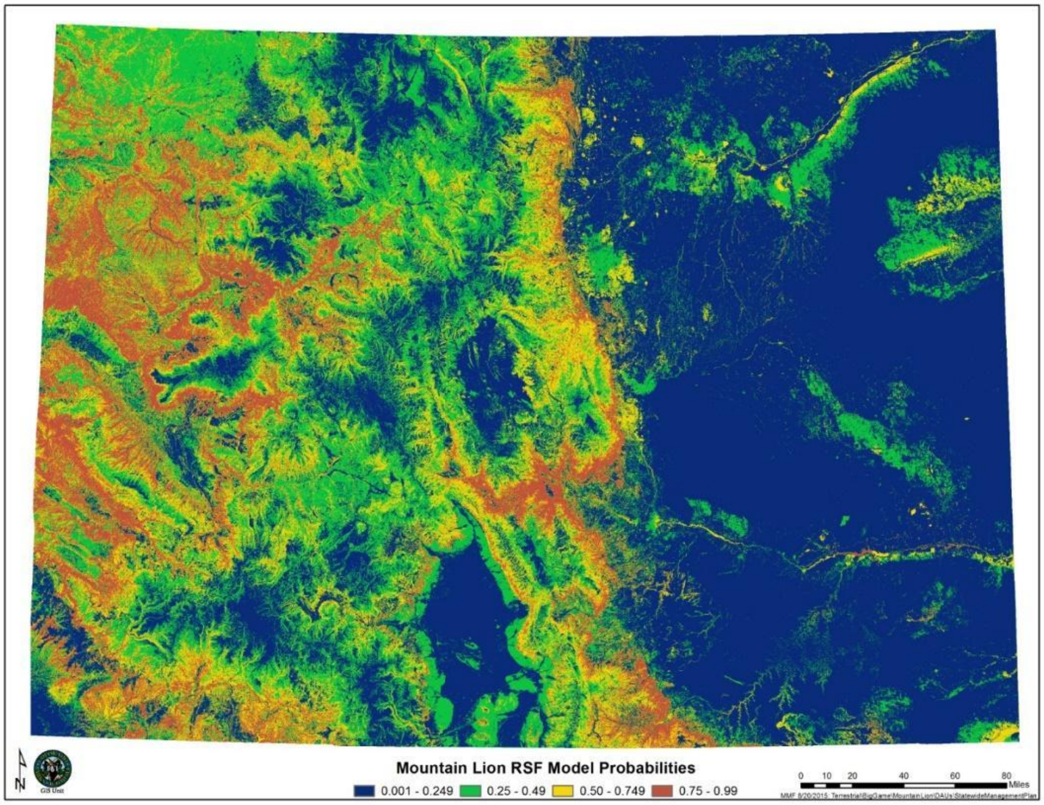

Figure 1. Original 2020 modeled statewide mountain lion winter habitat with the probability of lion presence stratified into four categories of increasing probability. This represents the initial model applied in the East Slope lion plan, before evaluation of non-lion habitat within L-ES.

In a final step, three independent datasets were used for model validation: 164 winter lion predation sites on mule deer documented through CPW mule deer survival monitoring, 14,793 GPS locations from 33 female and 9 male lions researched on the Uncompahgre Plateau from 2004-2015, and 58,593 GPS locations from 45 female and 32 male lions researched in the Northern Front Range west of Denver-Longmont, CO from 2007-2015. For each validation set, we assigned each spatial data point to one of the four categories of the relative probability surface that was above zero. Then we determined the percentage of those points that were within the two highest stratas, which corresponded to >50% relative probability of presence. We found that 86% of the Uncompahgre GPS locations were within Stratas 3 and 4 of our model, 82% of northern Front Range GPS locations were within Stratas 3 and 4, and 73% of the deer predation sites were within Stratas 3 and 4.

We assumed that lions exist in greater density in the two strata with high probability of presence and lower densities in the two strata with lower probability of winter lion occurrence. The top two strata of the RSF model represent “high quality” winter lion habitat for the purposes of the L-ES plan population resiliency source-sink analysis.

Results from this initial statewide modeling effort indicate that lions are selecting areas on the landscape that are closer to mule deer winter range, at lower elevations, within steeper slopes, and within tall shrub habitats compared to all habitat classes available to them. Lions were less likely to be located within low vegetation or short shrub habitats compared to the availability of that habitat class on the landscape.

Adjustments for non-lion habitat in L-ES

Unlike on the West Slope, which is effectively all lion habitat, application of the statewide RSF on the East Slope DAU required a rigorous examination of how this model should incorporate marginal habitat east of Interstate I-25 (hereafter I-25) that does not support breeding resident lion populations. Additionally, the footprints of large municipalities along the I-25 corridor in L-ES presented a similar issue because their effective probability of permanent or resident lion presence was also near zero. L-ES areas that were modeled to encompass lion habitat originally followed the same probabilities of presence stratifications presented in the RSF; and were considered in the same manner as in the West Slope Plan, whereby Strata 1 probability of lion winter presence = 1-25%, Strata 2 probability of lion winter presence = 26-50%, Strata 3 probability = 51-75%, Strata 4 probability = 76-100% (Figures 1 & 2). The four strata used in the 2020 statewide RSF made intuitive sense, where the lowest occurrence probability strata (Strata 1) had a low, but still measurable and biologically meaningful lion presence (Figures 1 & 2). However, the grasslands on the southeast plains and municipal boundaries along I-25 were largely classified under Strata 1 in the RSF, but we knew these areas had no resident lions. Maintaining these areas in Strata 1 over-projects lion occurrence, so we needed a strata that reflected a lion presence probability of zero. Therefore, we elected to re-stratify the prediction surface of L-ES into five categories instead of the original four from the statewide RSF model (Figure 2). This includes a new strata (Strata 0), which is an expansion of how this model was used in the West Slope Lion Plan (West Slope Mountain Lion Management Plan, Appendix C, 2020).

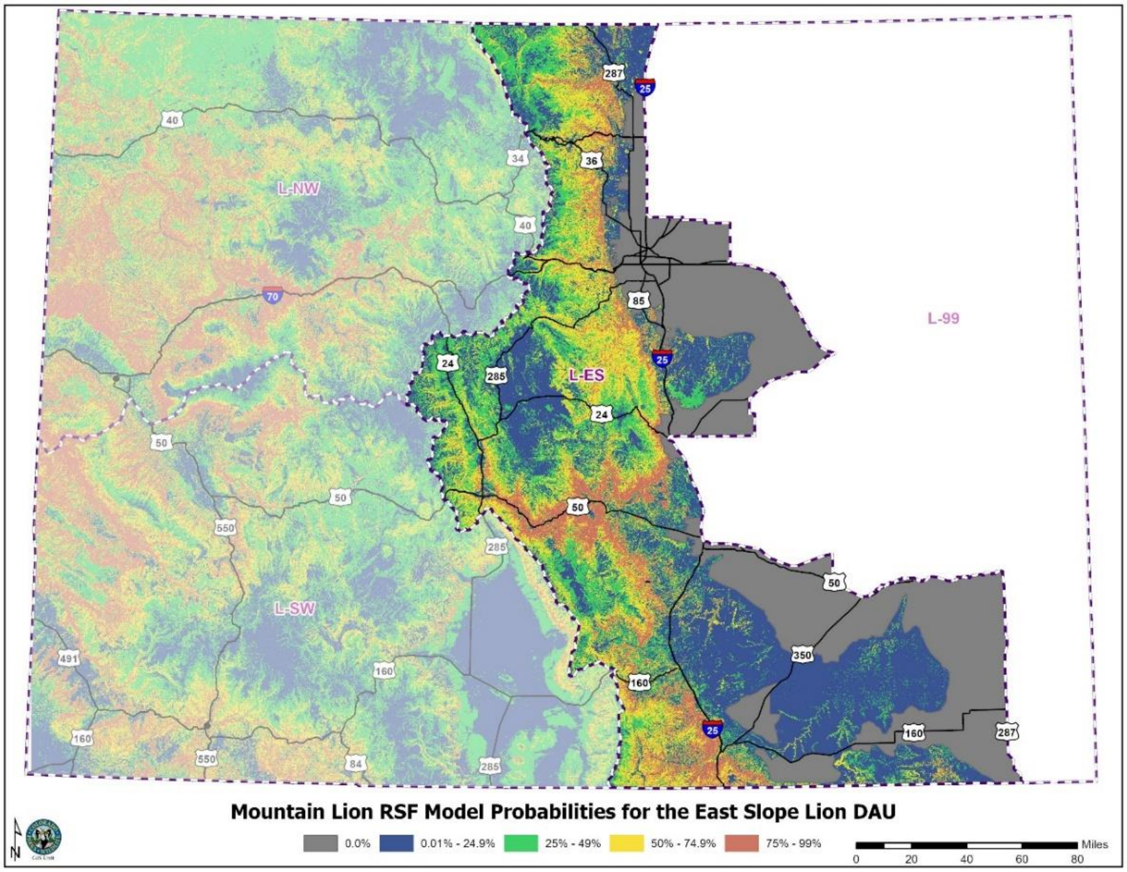

Figure 2. Adjustments made to original 2020 modeled statewide mountain lion winter habitat with the probability of presence stratified into five categories of increasing probability applied to the L-ES DAU. The new gray Strata 0 represents a zero probability of lion occurrence.

For this East Slope RSF modeling exercise, we converted portions of municipalities west of I-25 and grasslands east of I-25 originally assigned to Strata 1 into polygons representing Strata 0. Because these areas are not lion habitat and have no viable lion population, CPW determined that Strata 0 would be applied on these surfaces to represent a winter lion occurrence probability of 0%. Staff expertise, observations, and harvest and mortality location data substantiate that there were effectively no permanent lion populations in these areas; the probability of lion presence on this prediction surface should be zero. These areas east of I-25 and large municipalities may at times have lions documented moving through the area and occasional roadkills or human-lion conflicts. However, areas of Strata 0 are defined as not having a breeding, resident population of lions living within that surface year-round. As guided by policy, CPW will continue to manage occasional dispersing lions traveling through those areas on a case by case basis, usually allowing the lion to move on its own, as long as human-lion conflicts or safety issues do not occur.

Mountain lion population projection

There are several alternate approaches to deriving a lion abundance index extrapolation for the L-ES DAU. One would be to assume that at some low level of habitat selection probability, these areas are functionally not lion habitat; or, alternatively predetermine that some portions of Colorado are not winter habitat and exclude them from the model. Then one has to assign some assumed density smoothed over the remaining area. Although we had to take this step for defining Strata 0, this approach has two problems; there will always be some debate about what is excluded and if a lion is ever observed in excluded habitat, then the model is deemed a failure. Applying some even density in all the remaining habitat fails at very large scales because it is likely to result in too many lions in low probability locations (e.g. eastern plains areas or high altitudes) and too few in high probability locations (e.g. deer winter range, in tall shrubland/forested areas, with high topographic relief). Another approach is to apply a continuous range of lion density from near zero to some upper limit that corresponds with the RSF model prediction surface of 0.2% to 99.7%. The challenge with this approach is selecting what the lower and upper density should be and this seemed no better than the stratification approach that we selected.

For the stratification approach, we calculated the amount of habitat by RSF strata (Strata 0-4) across the entire L-ES DAU (Table 2). Then we applied assumed independent lion densities to each RSF stratum to generate an extrapolated abundance index. We calculated 17% of this extrapolated abundance to determine the maximum total human-caused mortality threshold presented in the East Slope lion plan. An interdisciplinary team of managers and biologists in CPW examined lion densities reported in the literature (Table 1 in Appendix A) and considered habitat quality, prey base, abundance of alternative prey, vegetation characteristics, and the RSF model outputs to arrive at the selected density values to apply.

We did make one adjustment to this approach of applying varying densities across the five probability strata. Since a lion density estimate from within L-ES was recently published in the literature, we applied this best available data source for lion density from the Front Range Cougar Study (Alldredge et al. 2019) to the study area's surface footprint. Additionally, in 465 km^2 of mule deer winter concentration range abutting the study area, which was regularly used by GPS collared lions from the project, we also applied the published density.

Table 2. Amount of area (km^2) within each RSF strata as applied in the L-ES DAU.

Strata 0= Zero Density	Strata 1 = Low Density	Strata 2 = Med-Low Density	Strata 3 = Med-High Density	Strata 4 = High Density	Boulder Study Area	Boulder Study Mule deer winter concentration area
19,952 km^2	**21,087** km^2	**11,967** km^2	**10,573** km^2	**5,570** km^2	**1,244** km^2	**465** km^2
Grand Total L-ES DAU= 70,858 km^2						

The winter-range independent lion densities applied in each strata were selected based on observed lion densities in the literature (Table 1, Appendix A). Particular weight was given to density estimates from the most recent studies in Colorado, including estimates from the northern Front Range in L-ES (Alldredge et al. 2019), and projects that used more modern and rigorous estimation methods including mark-recapture (Proffitt et al. 2015, Beausoleil et al. 2016). These newer techniques estimate capture probabilities and address study area closure. In contrast, past methods of radio-collaring what was assumed to be all the lions in a study area could never account for these issues and were less statistically robust.

The following independent lion densities were applied to each RSF stratum (Figure 3):

Strata 0: 0.0 independent lions/100 km^2. This is a new stratum applied to the 2020 statewide RSF model for this East Slope extrapolation. While the original exercise considered Strata 1 as the lowest quality or lowest probability of lion occurrence strata, evaluation for the East Slope lion plan specifically required this new stratum, where a density of 0 lions/100 km^2 is applied.

Using local knowledge from field staff, GIS spatial data, and satellite imagery, we converted all original 2020 statewide model outputs of any strata to this Strata 0 along the I-25 municipal corridor due to high human presence and no permanent resident lion populations in these areas. This includes Fort Collins, Loveland, Longmont, Boulder, Castle Rock, and Pueblo municipal boundaries. We also incorporated the greater Denver and Colorado Springs Metro areas and portions of smaller adjoining municipalities with significant development that lack appropriate lion habitat. On the northern Front Range, we also converted the agriculture interface east of Highway 287 in Larimer and Boulder counties and small agricultural and industrial carve-outs west of Highway 287 between Fort Collins and Loveland.

Additionally, much of the shortgrass prairie and agricultural areas of southeastern L-ES east of I-25, and the grasslands east and southeast of Denver were converted to Strata 0. However, permanent and reproducing lion populations occur in the canyons, mesas, and plateaus south of Highway 50 and east of I-25 in southeastern Colorado. Lions also inhabit the Black Forest area south of Denver, but east of I-25. Therefore, we continued to include these areas with lion habitat in the RSF-applied density area. In both cases, we drew a polygon with the appropriate topographical features to delineate areas with lion habitat. The topographical features were drawn from aerial imagery and terrain roughness layers that showed the steeper slopes and more rugged terrain that supports lions. We augmented the polygon by overlaying lion mortality locations and the Basinwide Vegetation layer, specifically identifying areas with pinon-juniper in southeastern Colorado and areas of ponderosa pine and oakbrush in the Black Forest.

Strata 1: 1.0 independent lions/100 km^2.This stratum represents lower-quality winter-range. While some lower lion density is documented in these areas from harvest and other mortality locations as well as visual observations, lion use is low and densities are well below average levels from studies in better habitat. This is the largest stratum, in terms of area, in L-ES.

Strata 2: 2.5 independent lions/100 km^2. This stratum represents a mid-level quality of habitat where lion densities are expected to exist in moderate numbers due to variables like slope, elevation and distance to deer winter range.

Strata 3 and Strata 4: 4.2 independent lions/100 km^2. These two strata represent better lion habitat on the East Slope and as such, each represent a smaller portion of the new proposed DAU. Prey densities are very high in these strata as they largely include deer winter range and high-quality lion habitat. The relatively high density applied in these strata is supported by recent work in quality lion habitat both in Colorado (4.1 independent lions/100 km^2, Alldredge et al. 2019) and in other western Rocky Mountain states (4.5-5.2 independent lions/100 km^2, Proffitt et al. 2015).

Boulder Study area and associated mule deer winter concentration: 4.1 independent lions/100 km^2. The Front Range Cougar Project documented a density of 4.1 independent lions/100 km^2 (95%CI= 2.4- 5.8 independent lions/100 km^2)(Alldredge et al. 2019) in northern L-ES, and we applied this density within that project footprint. We also applied the same 4.1 independent lions/100 km^2 density to 465 km^2 of mule deer winter concentration area immediately adjacent to the north and south of the project boundary, extending north to Highway 34 and south extending to Highway 285. Because this adjacent mule deer winter concentration area is similar habitat to the Front Range Cougar Project area and was regularly occupied by GPS-collared lions during the study, we find it appropriate to apply the measured density of 4.1 independent lions/100 km^2 there as well.

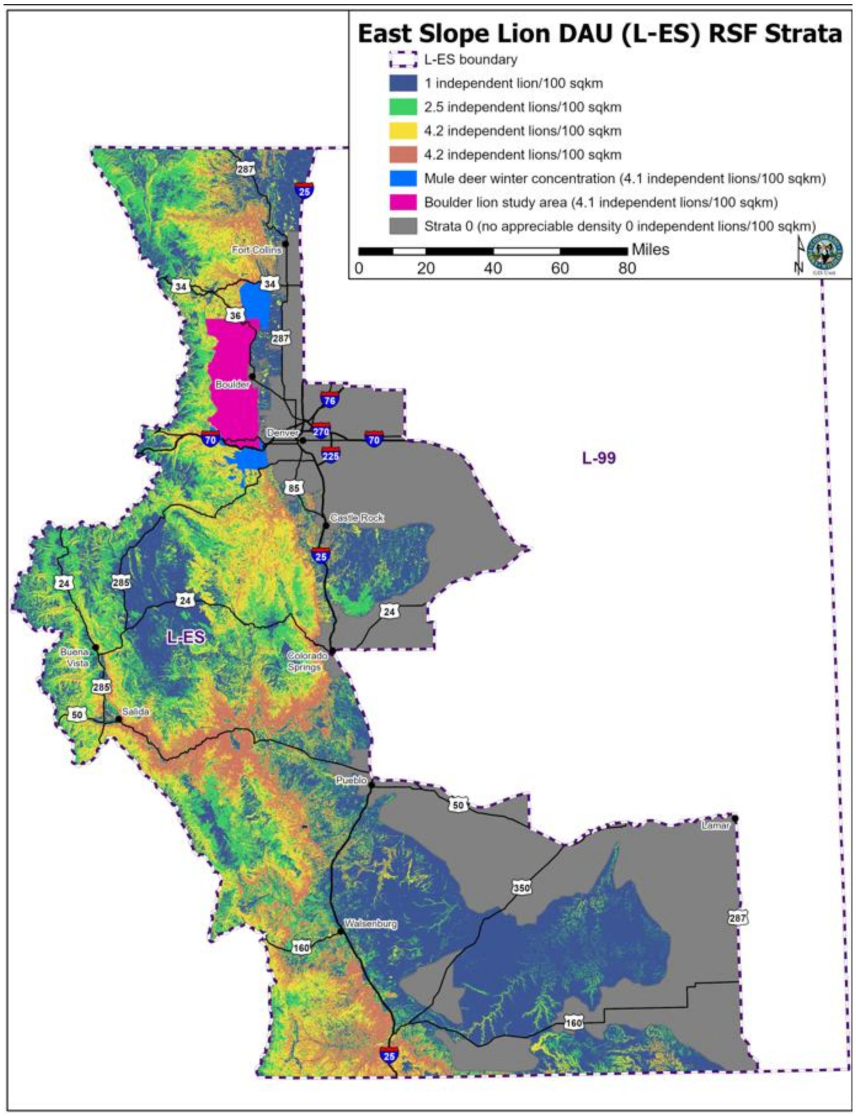

Figure 3. Resource selection function (RSF) winter habitat model of the L-ES DAU and applied lion densities. Areas outside of most municipal boundaries west of I-25 were assigned lion occurrence probabilities (and corresponding densities) as generated from the statewide RSF in Figure 1. Polygons of habitat east of I-25 with negligible lion occurrence due to non-lion habitat were assigned a 0% lion occurrence probability (gray).

The cumulative L-ES average independent lion density from the entire DAU's footprint generated from the RSF after strata densities shown above were applied **is 1.8 independent lions/100 km^2.** Since there are 19,000 km^2 of zero-density lion habitat in the DAU (Strata 0, Table 2), if we remove Strata 0 and consider only Strata 1-4 and the Boulder study area/mule deer winter concentration area surface as actual lion habitat (50,906 km^2, Table 2), the resulting projected estimate of L-ES lion density in suitable habitat is **2.47 independent lions/100 km^2**.

This average point estimate of ~2.5 independent lions/100 km^2 as an extrapolated density across all of the East Slope is strongly supported by numerous studies reporting lion densities

(Table 1, Appendix A). We acknowledge that viewing lion densities from published studies as an estimated numeric range instead of just a point estimate, is important. Point estimates from lion density studies are often the focus for management applications, but these values should be evaluated in the context of the variability shown by the confidence intervals on the estimates provided by study authors.

Nearly all GMUs or landscapes on the East Slope have contributions from at least four of the five strata and therefore will always have a ***total projected density well below the density of 4.2 lions applied in only the highest quality habitat***. For instance, Alldredge et al.'s 2019 study measured 4.1 independent lions/100 km^2 (2.4-5.8/100 km^2 95% CI) around Boulder, while the RSF extrapolation density in the GMU encompassing the study area only projected a density of 2.6 independent lions/100 km^2. As expected from any model, some projected RSF densities are higher and some are lower than empirically-derived densities in study areas of the same geographic area.

CPW also has several other empirical data streams to allow confirmation that at broad scales, our approach of using an RSF model to predict lion occurrence followed by applying stratified lion densities is biologically supported and justified. Our multiple years of lion density estimation as part of the Upper Arkansas research project, along with two lion density monitoring areas on the West Slope, allow a comparison of contemporary measured lion densities against predicted densities from the RSF model in those same areas. These studies have occurred over varying harvest levels, landownership patterns and lion habitats, strengthening their value for inference or comparison. The RSF projected abundances at the study area scale have generally been the same, or lower, than those measured using spatial mark-resight protocols, suggesting our DAU population projection and resulting human-caused mortality threshold could be conservative.

Measured post-hunt lion density in Middle Park in 2021-2022 and 2022-2023 was 2.1-2.8 independent lions/100 km^2 (95%CI= 1.2-3.6/100 km^2, 1.3-5.2/100 km^2, respectively) (CPW preliminary data), while the RSF projection modeled 2.7/100 km^2 in that same 2,000 km^2 study area. In the first year of available results from the Gunnison Basin study area (2022-2023), CPW measured 3.7 independent lions/100 km^2 (95%CI= 1.6-7.4/100 km^2) (CPW preliminary data), while the modeled RSF results projected a density of only 2.7/100 km^2. While part of a greater research project that will be peer-reviewed and published, independent lion densities measured as part of the Upper Arkansas research project also bracketed the modeled density projection from the RSF for the study area footprint (Mat Alldredge, unpublished CPW data).

An RSF model provides a temporal snapshot of what populations could be using densities and model variables applied at that time. That is why CPW's commitment to begin obtaining temporally and spatially relevant density estimates as part of the West Slope and East Slope plans is important. An even more comprehensive modeling approach could be considered by developing an Integrated Population Model (IPM) for Colorado's lion population. Given that lion populations are likely best modeled at a statewide level, our future intention would be to use the research demographic data currently being collected from the various study areas to populate an IPM. We believe an IPM could become a useful tool in later years after we have obtained density estimates and ancillary data from radio-collared animals in a number of representative study areas and habitats. As mentioned in *Future Research Needs* in the East Slope plan document, we expect that within 2-3 years CPW should have sufficient data to undertake this approach.

Colorado East Slope Mountain Lion Management Plan Appendix D

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Colorado East Slope Mountain Lion Management Plan
Appendix E

Public Engagement and Input on East Slope Mountain Lion Plan

Following guidance from the Parks and Wildlife Commission in January 2024 to create an East Slope Mountain Lion Management Plan, CPW staff coordinated a public engagement process including informational, educational and public input opportunities. Public meetings were held throughout the East Slope and virtually prior to CPW writing the draft plan. Following publication of the draft plan, CPW staff sought input from the general public, impacted stakeholders, peer agency biologists, and academics. The perspectives heard from members of the public at the informational meetings and the feedback shared during the draft plan input process were considered by CPW staff when formulating the final draft plan.

Public Meetings on the East Slope Plan

Given the technical complexities of mountain lion management and the need to inform the general public about the species, CPW staff opted to hold several public meetings before drafting the East Slope plan and releasing it to the public for feedback. This strategy aligns with the State of Colorado's Community Partnership Principle[1] of providing the public with easily understandable data and information before asking them to provide feedback.

Six in-person meetings across the Southeast and Northeast regions and two virtual meetings were held in February and March 2024 (Table 1). The events were well publicized and approximately 700 members of the public attended the eight meetings.

The meetings were a chance for CPW staff to present information on mountain lions in Colorado, describe the rationale for developing an East Slope plan, and hear from the public about their perspectives on mountain lions around their community. Attendees were able to learn more about mountain lion biology, research, and interactions with humans from CPW biologists and wildlife managers. Both the in-person and virtual meetings were interactive, with activities such as lion biology trivia, opportunity for discussion, and time for participants to ask questions and hear responses from CPW subject matter experts.

1: See: https://sites.google.com/state.co.us/colorado-equity-alliance/home/tools-resources

Table 1: East Slope Lion Plan Public Meetings and Estimated Attendance		
Meeting Location	**Date**	**Estimated Attendance**
Evergreen	2/22/2024	39
Trinidad	2/23/2024	60
Florence	2/26/2024	160
Golden	2/26/2024	130
Livermore	2/27/2024	120
Virtual #1	2/29/2024	85
Virtual #2	3/6/2024	70
Colorado Springs	3/7/2024	46
Estimated TOTAL Attendance		710

Input and Inquiries Received at Meetings

Implications for Harvest Limits

A topic discussed by several attendees related to how shifting the management unit to a larger regional scale would impact harvest limit areas. Attendees asked whether harvest limits would be set at smaller geographic scales or if limits would be set at the regional level. Currently, hunter harvest limits are allocated across GMUs. Under this approach, lion harvest limits are capped at small geographic scales. When the harvest limit is reached in that GMU, or in a group of GMUs, no additional harvest is permitted in that area.

Under the new East Slope plan, like the West Slope plan, hunter harvest limits will continue to be allocated across GMU groups. The East Slope plan proposes new GMU harvest limit groupings and harvest limits to maintain a stable population goal. Any changes to GMU groupings and harvest limit allocations will be proposed by the Division for approval by the Commission as part of the normal rulemaking process for lion hunting regulations.

Female Harvest Thresholds

Members of the public also frequently discussed the proposed adult female harvest threshold with CPW staff and inquired about how female harvest is regulated. Some attendees discussed how neighboring states manage female harvest and what lessons could be learned from those approaches. Other attendees, when presented with information on female harvest thresholds, expressed general concern over the potential for orphaning juvenile lions that might still be dependent on an adult female. Attendees who raised such concerns generally disagreed with any lion hunting, more so than specific female harvest thresholds proposed for the East Slope plan.

Human-Lion Interactions

Information on interactions between mountain lions and humans, and how CPW responds to various types of lion reports, was presented to attendees who were encouraged to consider and share their own perspectives on human-lion interactions. Attendees also had the opportunity to learn more from CPW staff about how to live with lions in their community.

Frequently asked questions about lion interactions included when to report mountain lions to CPW, whether and how CPW uses information on sightings, and how to prevent conflicts with lions such as attacks on pets and livestock. Other inquiries and feedback related to mountain lion population dynamics, such as reports of increased lion sightings, questions about how many lions live in a particular area, and queries about how CPW measures lion numbers.

Public Input Period on Draft Plan

The Draft East Slope Mountain Lion Management Plan was published on the EngageCPW website on May 15, 2024. A 30 day public input period on the draft plan was open through June 14, 2024.

CPW Staff publicized the draft plan public input opportunity through several communication channels, including regional and statewide social media, advertisements at area offices and parks, multiple statewide news releases, and earned media coverage. Additional announcements were sent directly to interested individuals and impacted stakeholders. Individuals contacted included public meeting attendees, virtual meeting registrants, members of CPW roundtables, stakeholder organizations, and recent mountain lion license holders. CPW staff also met with stakeholder organizations, who expressed interest in discussing their support for and/or concerns with the draft plan, and CPW roundtables.

The communications through CPW channels and directly to stakeholders led to widespread attention on the plan. During the 30 day draft plan public input period, the EngageCPW page on the East Slope Lion Plan was visited by 1,673 individuals, with nearly 80% of visitors engaging with materials on the site (e.g., the draft plan and public meeting materials).

Input from Peer Agency Biologists and Academics

CPW staff solicited a peer review of the draft plan as well as an academic review by independent, objective professionals in the field. The feedback shared is attached to this appendix and the institutions that submitted input are listed below.

- Nevada Department of Wildlife, Pat Jackson, Predator Management Staff Specialist
- Michigan State University, Department of Fisheries and Wildlife, Dr. Jerrold Belant, Boone and Crockett Chair in Wildlife Conservation

Input from Organizations

Five stakeholder organizations provided input to CPW staff on the draft East Slope plan during the 30 day public input period. The feedback shared is attached to this appendix and the organizations that submitted input are listed below.

- Arkansas Valley Audubon Society
- Boulder County Parks and Open Space
- Colorado Nature League
- Mountain Lion Foundation
- Safari Club International

Input Received from General Public

Input Statistics

In total, 181 individuals shared public input during the 30 day period. Members of the public who shared input through EngageCPW were geographically representative of the East Slope region's population. The geographic distribution of input was also reflective of locations chosen for in-person meetings (Table 1). Population centers such as Denver, Boulder, Colorado Springs, and Fort Collins were well represented in the feedback, but public input was also received from individuals in smaller communities along the entirety of the East Slope. A limited number of individuals from outside the East Slope participated in the public input opportunity (6% of submissions originated from the West Slope of Colorado, and 2% originated from outside the state).

Summary of Input from General Public

Input on the draft plan represented a diversity of opinions and human-wildlife value orientations. While a significant proportion of input provided specific suggestions for the draft plan, a greater proportion of submissions voiced either general support for the plan, or general opposition to lion hunting.

General Opposition to Mountain Lion Hunting. The most common theme heard in public input (116 of 181 submissions; 64% of total) was not directly related to draft plan specifics, but rather focused on general opposition to mountain lion hunting. This feedback often expressed value-based concern over the harvesting of mountain lions. Hunting with the aid of hounds was also opposed by several of the commenters, who questioned the practice on ethical grounds (16% of total). Another concern mentioned frequently (40% of total) related to the proposed ballot initiative concerning the hunting of mountain lions and other species, and suggested that the East Slope plan be tabled. This feedback was not directly responsive or applicable to the outreach process asking for input on the specifics of the draft East Slope lion plan.

A limited number of individuals cited more specific concerns when giving feedback in opposition to mountain lion hunting. For example, 11 comments (6% of total) discussed perceived issues with female lion harvest generally or CPW's ability to regulate female harvest through harvest thresholds. However, the specific female harvest threshold proposed in the draft plan was not raised as part of this input against lion hunting. Most concerns expressed over the harvest of female lions, like concerns related to mountain lion hunting generally, voiced opposition to any harvest whatsoever rather than specific harvest or mortality thresholds. Some commenters (3% of total) suggested that CPW spend more resources on studying mountain lion population dynamics.

Support for Draft Plan. Of the 181 submissions, 27 individuals (20%) mentioned some level of support for the draft plan. Individuals who commended the plan often cited a perception that CPW is well suited to conserve wildlife populations and that the plan is based on sound science (9% of total input). Others felt that the inclusion of mountain lion hunting as a management tool is appropriate (6% of total input). Additionally, 4% of total input centered around the necessity of managing wildlife populations broadly, or lion population management specifically. A common theme between the input supporting the draft plan related to perceptions and observations of healthy, robust mountain lion populations on the East Slope.

Plan Specific Suggestions. Specific suggestions related to the draft plan were not as recurring as input supporting the draft plan or opposing mountain lion hunting generally. Suggestions also tended to diverge based on the commenter's perception of mountain lion hunting. Common themes seen in the suggestions are listed below. All of the common themes listed below were mentioned in approximately 4% or less of the total input:

- Recommendations related to harvest limits and Game Management Unit groupings under the new East Slope plan.
- Input encouraging CPW to consider high prevalence of mountain lion conflict (depredation, etc.) in certain areas when planning for an overall stable population.
- Suggestions to increase focus on public education about coexistence strategies.
- Feedback advocating for conservation of mountain lion habitat and habitat corridors.
- Recommendation to use/grow the mountain lion population to combat Chronic Wasting Disease in ungulate populations.

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June 21, 2024

Mr. Mark Vieira
Colorado Parks and Wildlife
317 W. Prospect
Fort Collins, CO 80526

RE: Review of the East Slope Mountain Lion Management Plan submitted by Colorado Parks and Wildlife

Dear Mark,

Thank you for the opportunity to review and provide input on Colorado Parks and Wildlife's East Slope Mountain Lion Management Plan. As a wildlife biologist, predator manager, and Predator Management Staff Specialist at the Nevada Department of Wildlife, I am pleased to see this draft Plan encompasses all critical aspects of successful mountain lion conservation and management. My recommendations are as follows:

Colorado East Slope Mountain Lion Management Plan

1. Page 2, paragraph 1-3; this executive summary does a great job specifying the need for this Plan and what this Plan provides.

2. Page 7, bullet 3; this plan does not address what Colorado Parks and Wildlife's (hereafter CPW) plans would be should the East Slope Lion Plan lead to population increases. Consider adding a paragraph on management should the population transition from stable to increasing.

3. Page 9, paragraph 1; this Plan references a "periodic review." Consider defining what a periodic review is or specify how often this Plan will be reviewed.

4. Page 24, only paragraph; please provide a size or range of sizes for "large tracts of unhunted private land."

5. Page 25, paragraph 1; define "larger landscape."

6. Page 26, first portion; include "known" prior to "human-caused mortality." Make this addition throughout the document.

7. Page 27, paragraph 5; specify what proportion of land ownership is privately held.

Appendix A

8. Page 1, paragraph 3; for context include another map or reference an existing one.

9. Page 11, paragraph 3 and 4; consider moving these to page 9 and placing above the "Field Methods" section. I commend CPW for providing alternative field methods for the reader, however placing existing methods between alternative methods is confusing.

Appendix B

10. Page 8, paragraph 2 and page 16, paragraph 2; I commend the authors for referencing surveys and incorporating human dimensions into this appendix. That said, I recommend the tone of page 8, paragraph 2, mimic page 16, paragraph 2. Page 8 is very detail oriented; it is outside the need of this Plan.

11. Page 11, paragraph 2; "Data from Colorado do not suggest a positive relationship between high lion harvest and increased conflicts, but rather just the opposite." I expect readers and stakeholders will find this interesting and I recommend moving this sentence to the front of the appendix and also providing a paragraph of additional context.

12. Page 13, paragraph 4; provide the definition of the word "indexed" and the rational as to why funds were indexed.

Appendix C

13. Follow the bibliography format used in *The Journal of Wildlife Management*, and combine the Literature Cited and References sections.

Please contact me with any questions.

Sincerely,

Pat Jackson
Predator Management Staff Specialist
Nevada Department of Wildlife
775-688-1676

MICHIGAN STATE UNIVERSITY

9 June 2024

Mark Vieira
Carnivore and Furbearer Program Manager
Terrestrial Programs Unit
Colorado Parks and Wildlife
317 West Prospect
Fort Collins, CO 80526

Dear Mr. Vieira,

I have had the opportunity to review the Colorado Parks and Wildlife (CPW) Colorado East Slope Mountain Lion (*Puma concolor*) Management Plan and corresponding appendices that was developed by you and your team. Below I provide the following general comments for your consideration during the revision process for this plan.

I recognize this plan largely follows the previous plan for Colorado's West Slope and congratulate CPW for mirroring that effort, as from what I can ascertain, the earlier plan has been quite effective in management of mountain lions.

1. I applaud CPW for considering diverse societal and ecological aspects in this plan as it is critical for management of all species, particularly large carnivores.

2. I appreciate the flexibility and adaptive framework for managing harvests, both spatially and temporally. This is absolutely necessary as managing species like mountain lions is difficult compared to many others and considering potential dynamics too in social values surrounding large carnivores, ability to adapt is even more important. This is of particular importance in areas of higher human-mountain lion conflicts.

3. Regarding social values and acceptance of mountain lions, as identified in the plan, I encourage a human dimensions survey following completion of this plan to further ensure that goals and objectives are aligned with Coloradans.

4. I did not adequately understand the rationale for the April season. It was stated that few mountain lions are harvested during this season. Also, there is an independent regulation development process for April seasons. As lions harvested need to be reported within 48 hours and furs inspected within 5 days, my question is why is there a unique April season at all? As units are managed until specific adult female mortality rates ae achieved, would it not be more simplistic and easier to manage by having a single season and closing units when harvest goals are achieved?

5. Though acknowledged in the plan, I suggest there could be greater recognition of uncertainty in extrapolating lion densities beyond areas of original inference. There are numerous factors that can alter species abundance, including many factors not indexed

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in the current model. This would not detract from the plan overall, but would demonstrate greater transparency in the limitations of this approach. I emphasize this does not negate the value of using this approach.

6. The uncertainty mentioned above could be considered exacerbated by not propagating error in density estimates from survey areas. For example, Alldredge et al. (2019. Wildlife Society Bulletin 42:222–230). Estimated mountain lion density in a 800-km^2 area of Colorado's Front Range at 4.1 independent individuals/100 km2 (95% confidence interval [CI] = 2.4–5.8). I could not find that this uncertainty (i.e., CI) was incorporated into the habitat density model.

7. I do not mean to be overly critical of points 5–6 as I recognize the difficulties in abundance estimation of low-density species across large spatial extents. Considering the data available, I likely would have recommended something similar. Too, I acknowledge that there are additional studies in progress or planned that will undoubtedly improve abundance estimates and habitat-density relationships and commend CPW for this effort.

8. I appreciate integrating the concept of source-sink population dynamics into your management framework. This is of particular importance for ensuring 'populations' in areas experiencing comparatively high harvests can be sustained. I note that source areas appear to be those with annual harvests <3 lions/1000 km^2. Considering data from (Alldredge et al. 2019) that estimated 4.1 mountain lions/100 km2 (95% CI = 2.4–5.8), it appears that current areas considered to have source populations with the highest levels of harvest could contribute little to a source effect.

9. I encourage consideration of statistical population reconstruction as an additional estimator of lion abundance. It appears that the annual number of lions harvested could be adequate for this model type and make this a useful tool. Considering that all harvested lions are sexed and aged, that there are likely estimates of number of hunters (e.g., via license sales) as well as reasonably standardized harvest seasons across years, I would encourage your consideration of this. Of note too is that the single best auxiliary data to improve these models is independent estimates of survival, which you have through various GPS-based collaring projects.

Thank you for the opportunity to review this plan and provide comments. Please contact me if you have any questions or require additional information.

Sincerely,

Jerrold L. Belant
Boone and Crockett Chair in Wildlife Conservation

Arkansas Valley Audubon Society Input on Draft East Slope Mountain Lion Management Plan

Arkansas Valley Audubon Society (AVAS), serving all of southern Colorado and the San Luis Valley, applauds the goal of the East Slope Lion Management Plan “to maintain stable mountain lion populations in the region by defining and implementing clear annual thresholds for killing adult female lions and for total human-caused mortality. But we are ambivalent about using hunting as a means of managing mountain lions.

Hunter numbers are in steady decline and have been for years. Hunters make up about 5% of the population of Colorado. CPW says they want to ensure a healthy self-sustaining mountain lion population while allowing hunting of lions for meat. That argument is specious. It’s clear that most hunters’ motivation is to obtain lion skins and lion heads as trophies.

CPW maintains that this plan attempts to minimize conflicts with people where communities have spread on to lion habitat. Degradation of habitat amid Colorado’s out-of-control commercial and residential development are the real threats to wildlife. Adding hunting pressure with hounds, electronic calls, and shooting a treed lion hardly qualifies as sporting, let alone ethical practice.

We hope that Colorado wildlife officials are not sacrificing lions and ecosystem balance in a commercial tilt toward hunters. A wise former hunter once said, “Leave mountain lions alone. Let them make their own population level.”

Additionally, "The intrinsic value of lions, and all wildlife, the emergence of non-consumptive users as a force to be reckoned with, and the values of Coloradoans are moving the discussion to include ethics and morality in dealing with Colorado's iconic wildlife."

Thank you.

Peg Rooney, President AVAS

Boulder County

Parks & Open Space
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303-678-6200 • POSinfo@bouldercounty.gov
www.BoulderCountyOpenSpace.org

Boulder County Parks & Open Space
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Longmont, CO 80503

6/13/2024

Parks and Wildlife Commission
Colorado Parks and Wildlife
6060 Broadway
Denver, CO 80216

Dear Members of the Parks and Wildlife Commission:

Boulder County Parks & Open Space is writing in support of the proposed East Slope Mountain Lion Management Plan developed by Colorado Parks & Wildlife (CPW). This comprehensive plan is a significant step forward in ensuring the long-term stability and health of mountain lion populations on the East Slope of Colorado. By consolidating management efforts across the Northeast and Southeast CPW Administrative Regions, CPW is addressing the challenges associated with managing solitary, low-density carnivores.

The plan's incorporation of two key annual data collection and monitoring thresholds is a sound approach to the long-term management of the species. The Adult Female Harvest Composition Threshold, which limits the proportion of adult females in the total harvest to 22% annually, and the Total Human-Caused Mortality Threshold, which restricts the 3-year average of total human-caused mortality to 17% of the extrapolated abundance index, represent significant changes to prior management strategies. These thresholds are based on the best available scientific research and are essential for maintaining a balanced and sustainable mountain lion population.

The proposed adjustments to harvest limits, with a gradual reduction over the next few years, demonstrates a thoughtful and adaptive approach to wildlife management. While public involvement in the planning process, including hunters and conservationists, ensures that the interests of stakeholders are considered. This plan conserves and protects mountain lions for their ecological and intrinsic value, and also allows for their sustainable use and enjoyment by future generations.

Our team fully supports the implementation of the East Slope Mountain Lion Management Plan and urge the Parks and Wildlife Commission to approve it.

Best Regards,

Mac Kobza

Mac Kobza
Senior Wildlife Biologist
303-678-6203
mkobza@bouldercounty.gov

Claire Levy *County Commissioner* **Marta Loachamin** *County Commissioner* **Ashley Stolzmann** *County Commissioner*

June 13, 2024

Colorado Parks and Wildlife Commissioners
1313 Sherman Street
Denver, CO 80203

Re: East Slope Mountain Lion Management Plan

Dear Colorado Parks and Wildlife Commissioners,

On behalf of the Colorado Nature League, a coalition of conservationists, scientists, sportspersons, and nonprofit organizations, we appreciate the opportunity to comment on the Draft East Slope Mountain Lion Management Plan. We commend Colorado Parks and Wildlife for taking a unified, science-driven approach to managing this vital species across the East Slope region.

We support most aspects of the proposed plan and recognize that the agency has moved towards a more conservative approach to mountain lion management over the last few years. Many concerns that environmental, conservation, and animal welfare groups have voiced in the past are now incorporated into management strategy. We appreciate CPW's meaningful stakeholder engagement and believe that the East Slope proposal demonstrates the agency's desire to manage mountain lions responsibly for the long-term benefit of Colorado.

Below, we have listed the strengths of the current proposal and some areas we believe could be improved upon.

Strengths:

- **Updated, Evidence-Based Thresholds:** CPW continues to rely on its expert researchers and a vast body of peer-reviewed literature to help set management thresholds and goals. The agency is collecting more useful data, like age data, so that we can better understand impacts of harvest on the total population.

- **Stable Population Goal**: This new plan manages for a *stable* population over the entire East Slope, replacing current management goals for population *suppression.* This is a positive shift that recognizes mountain lions' ecological importance and helps protect them well into the future.

- **No April Season for the First Three Years**: There will be no April season for at least the first three years, which is a prudent measure to protect mountain lions during a sensitive time of year.

- **Harvest Objective Aligned with Best Practices:** The harvest objective will likely fall within the annual harvest range of 12-16%. Beausoleil et al. (2013) recommend a 14% harvest off take for reduced conflicts. Conservation groups often cite this study as a good harvest goal, and we are very pleased that Colorado will now be within this range.

- **Acknowledgment of Ecosystem and Other Benefits of Mountain Lions:** The plan acknowledges the benefits of protected mountain lion populations, including ecological, combating chronic wasting disease (CWD), cultural, intrinsic, and social benefits. It also incorporates recent advances in mountain lion population research.

- **Expansion of Mark-Resight Density Estimate Study:** We applaud CPW's intention to expand their density estimate study to the East Slope. We are very excited about this study and look forward to the data that will support updated density and population estimates. This data is invaluable to a science-based management strategy.

Areas for Improvement:

- **Population Monitoring and Thresholds:** Recent studies suggest mountain lion populations are particularly susceptible to adult female mortality. To better account for the species' low reproductive rates and ensure population stability, we recommend lowering the thresholds to 15% for adult female harvest. Research by Logan and Runge (2021) found that a 23% adult female harvest led to a population decline. Anderson and Lindzey (2005) concluded that a population could support a 10-15% female harvest without decline, while Laundre (2007) asserted that a 15-20% adult female harvest would not lead to a population decline. Furthermore, higher harvest rates can disrupt cougar social structures, leading to increased human-lion conflicts and livestock depredation (Maletzke et al., 2014).

- **Human-Lion Conflict Prevention**: While the plan addresses conflicts and game damage, we encourage increased investment in proactive measures like public education programs and non-lethal deterrents to promote coexistence and reduce conflicts. Recent research supports the effectiveness of non-lethal methods in preventing conflicts and maintaining stable, non-problematic mountain lion populations (Peebles et al., 2014; Teichman et al., 2016).

Conclusion:

The Draft East Slope Mountain Lion Management Plan is a significant step forward, and we appreciate CPW's commitment to science-based management. By adopting more conservative thresholds, increasing investment in conflict prevention and research, and engaging stakeholders, CPW can better ensure the long-term sustainability of mountain lion populations while balancing ecological, scientific, and recreational values.

Sincerely,

Colorado Nature League

Colorado Nature League (CNL) protects, conserves, and restores Colorado's native wildlife and habitats through science-based, innovative, collaborative solutions. CNL represents over 150,000 Coloradans dedicated to preserving the state's iconic wildlife.

MOUNTAIN LION FOUNDATION

Saving America's Lion

Our mission is to ensure America's lion survives and flourishes in the wild.

June 14th, 2024

RE: East Slope Mountain Lion Management Plan

Submitted via: dnr_cpw_planning@state.co.us

Dear members of the Commission,

We write to you on behalf of our Colorado members, regarding the upcoming decision on the Draft Eastern Slope Management Plan.[1] While it is generally unnecessary to hunt mountain lions from an ecological or human safety standpoint,[2, 3, 4] if they are to be hunted the draft plan has many management strengths. These include combining smaller data analysis units into one larger unit defined as the Eastern Slope. We are also pleased to see that the department is recommending mountain lion population stability across the eastern slope as opposed to reduction, by maintaining human caused mortality below known intrinsic growth rates for the species. Beyond the specifics of the management plan, we commend the department for its engagement with the public and focus on conserving mountain lions as a valuable part of the ecosystem.

We recommend the following changes to the draft plan:

1) Close mountain lion hunting in GMUs for the season when the adult female

[1] Draft East Slope mountain lion plan: May 10 2024. 2024. Colorado Parks and Wildlife. https://engagecpw.org/23267/widgets/82723/documents/55235

[2] Wallach, A.D., Izhaki, I., Toms, J.D., Ripple, W.J. and Shanas, U. 2015. What is an apex predator?. Oikos, 124: 1453-1461. https://doi.org/10.1111/oik.01977

[3] Laundre´ JW, Papouchis C. 2020. The Elephant in the room: What can we learn from California regarding the use of sport hunting of pumas (Puma concolor) as a management tool? PLoS ONE 15(2): e0224638. https://doi.org/ 10.1371/journal.pone.0224638 Editor: Julio Cesar de Souza, Universidad

[4] Cooley, H. S., R. B. Wielgus, G. M. Koehler, H. S. Robinson and B. T. Maletzke. 2009. Does hunting
regulate cougar populations? A test of the compensatory mortality hypothesis. Ecology 90(10): 2913-2921.

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threshold or total caused human mortality threshold is reached.

2) Adjust the age classifications for mountain lions in Colorado

3) Structure management strategy to avoid the formation of sinks

1) Close mountain lion hunting in GMUs for the season when the adult female threshold or total caused human mortality threshold is reached.

The current draft states that adult female harvest shall not exceed 22% of the harvest in any given year, and that the 3-year average for total human caused mortality shall not exceed 17% of the population estimate. While total human caused mortality for lions will be limited to 17%, harvest objectives will be lower to account for non-harvest mortality causes for lions. If these thresholds are exceeded, the following year limits will be reduced by one percent. If these limits are exceeded in a second year, it will be reduced by five percent in the following year. Each year if harvest objectives are exceeded in a unit in a season, that unit will close. The plan does not propose that units close if the adult female harvest threshold is exceeded in each season.

The draft proposes that once the adult female threshold is reached, CPW will ask hunters to voluntarily avoid harvesting females. While many hunters may take efforts to avoid the harvesting of female mountain lions, research shows that even experienced hunters under ideal conditions often misidentify a mountain lion's sex[5], so this approach is likely to lead to unintentional overharvest of females. We suggest that the plan be amended so that units close when adult female harvest thresholds are exceeded.

There is no risk to "under harvesting" mountain lions from an ecological or human/livestock conflict standpoint.[6,7] However there are negative implications from overharvesting mountain lions both for the lion population and the local ecology, especially females.[8] We recommend the department adopt a preventative approach, by closing the season in units where the 22% adult female threshold is exceeded or when total caused human mortality exceeds 17% in any

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[5] Beausoleil, R. A., & Warheit, K. I. 2015. Using DNA to evaluate field identification of cougar sex by agency staff and hunters using trained dogs. *Wildlife Society Bulletin*, *39*(1), 203–209. https://doi.org/10.1002/wsb.493

[6] Cooley, H. S., R. B. Wielgus, G. M. Koehler, H. S. Robinson and B. T. Maletzke. 2009. Does hunting
regulate cougar populations? A test of the compensatory mortality hypothesis. Ecology 90(10): 2913-2921

[7] Treves, A., Krofel, M., & McManus, J. 2016. Predator control should not be a shot in the dark. *Frontiers in Ecology and the Environment*, *14*(7), 380-388.

[8] Robinson, H. S. and R. DeSimone. 2011. The Garnet Range Mountain Lion Study: Characteristics
of a Hunted Population in West-Central Montana. Final Report. Montana Fish, Wildlife & Parks. Helena, MT

single year.

2) Adjust the age classifications for mountain lions in Colorado

The current draft plan only considers mountain lions greater than three years old as adult mountain lions (as well as any females showing signs of nursing). We suggest that the plan amend these age categories to consider animals greater than two years old as adult mountain lions, as the average age of first reproductive for mountain lions is two and a half years old.[9]

We believe these changes will help prevent the overharvest of adult females, and more accurately representing the harvest of adult animals in the state.

3) Structure management strategy to avoid the formation of sinks

The draft management plan currently focuses on source-sink management for a stable metapopulation. This management strategy is viable for maintaining population sizes for mountain lions,[10] however it does not account for demographic structures in populations. Areas with high levels of human caused mortality—sinks—for carnivores have in some cases been linked to increased levels of conflict with humans.[11] Additionally, these sinks may paradoxically have denser mountain lion populations, if they are comprised of younger males with large, overlapping home ranges.[12] These sink populations may be associated with a greater level of conflict between mountain lions and infanticide of kittens both due to increased density and the number of inexperienced young males.[13]

This area of research into mountain lion management requires more research, but the evidence we do have suggests that avoiding the creation of sinks through hunting regimes may help reduce some of the risks that may occur for both mountain lion populations and the human communities they overlap with. Thus, management strategies that evenly distribute human caused mortality below the intrinsic growth rate has been recommended as an alternative

[9] Ross, P. I., & Jalkotzy, M. G. 1992. Characteristics of a Hunted Population of Cougars in Southwestern Alberta. *The Journal of Wildlife Management*, *56*(3), 417–426. https://doi.org/10.2307/3808853

[10] Laundré, John, and Tim W. Clark. 2003. Managing puma hunting in the western United States: through a metapopulation approach. *Animal conservation forum*. Vol. 6. No. 2. Cambridge University Press.

[11] Peebles, K. A., Wielgus, R. B., Maletzke, B. T., & Swanson, M. E. 2013. Effects of remedial sport hunting on cougar complaints and livestock depredations. *PLoS one*, *8*(11), e79713.

[12] Maletzke, B. T., Wielgus, R., Koehler, G. M., Swanson, M., Cooley, H., & Alldredge, J. R. 2014. Effects of hunting on cougar spatial organization. *Ecology and Evolution*, *4*(11), 2178-2185.

[13] Wielgus, R. B., Morrison, D. E., Cooley, H. S., & Maletzke, B. 2013. Effects of male trophy hunting on female carnivore population growth and persistence. *Biological Conservation*, *167*, 69-75.

strategy.[14]

We suggest that the department change the management plan to adopt a harvest strategy where all GMUs have mortality thresholds below the proposed 17% limit, and source populations are still preserved. We recommend the preservation of source populations to buffer against stochastic events, inaccuracies in monitoring, and unintentional overharvest of mountain lions. We believe this approach will best avoid the potential risks associated with the formation of sinks and excessive mortalities in mountain lion populations.

Thank you for the opportunity to comment on the Draft Eastern Slope Management Plan, and for the extensive efforts made by CPW staff and Commission to engage the public and utilize contemporary science on mountain lion management in the development of the East Slope Mountain Lion Managment Plan.

Please include these comments in the official record regarding this decision.

Sincerely,

Josh Rosenau
Director of Policy and Advocacy
jrosenau@mountainlion.org
916-442-2666 x107

Paige Munson
Science and Policy Coordinator
pmunson@mountainlion.org

[14] Beausoleil, R. A., Koehler, G. M., Maletzke, B. T., Kertson, B. N., & Wielgus, R. B. 2013. Research to regulation: Cougar social behavior as a guide for management. *Wildlife Society Bulletin*, *37*(3), 680-688.

14 June 2024

Colorado Parks and Wildlife
c/o dnr_cpw_planning@state.co.us
6060 Broadway
Denver, CO 80216

Re: Draft Colorado East Slope Mountain Lion Management Plan

Dear Director Davis:

Safari Club International (SCI) appreciates the opportunity to comment on the Draft Colorado East Slope Mountain Lion Management Plan.

In general, SCI supports updating the East Slope Mountain Lion Plan, given that some of the individual unit plans are 20 years old. SCI supports the Draft Plan's continued reliance on regulated hunting to manage lions and to provide a hunting opportunity for this healthy and growing population. But SCI does not agree with the stated "concern" that the six previously identified Data Analysis Units are too small to properly study or manage mountain lions, despite the wide-ranging nature of the species.

SCI generally supports Colorado Parks and Wildlife's (CPW) goal to manage the East Slope mountain lion population for "stability," which is reflected throughout the Draft Plan. Mountain lions are the most widely distributed mammal in the Western Hemisphere. Colorado's mountain lion population is stable and likely increasing, especially into new areas. As Ring camera footage from the City of Boulder demonstrates, mountain lions can and do successfully range into human-dominated landscapes, suggesting they are more-than-healthy on the East Slope. But Colorado's human population on the Front Range is also rapidly expanding, thus a stable population objective is most appropriate to maintain a healthy lion population and maintain social tolerance for the species. As we have seen in the last few years in Colorado, Arizona, Washington State, and more, mountain lion attacks can and do occur.

SCI emphasizes that CPW's decisions must be made on the best available science and for the benefit of long-term mountain lion conservation. Where decisions need to be made to ensure the long-term health of predator and prey populations and ecosystems, as well as to reduce human-wildlife conflict, CPW may need to make decisions that are less popular with the public but serve CPW's mission. While being inclusive of the views of diverse Colorado stakeholders is a laudable goal when it comes to taking public input, CPW's decisions need to be made on the basis of sound science and for the benefit of mountain lion populations and human populations that interface with mountain lions. It is CPW's job to responsibly manage wildlife at a level that promotes acceptance and public safety—which means the appropriate level of mountain lion harvest is CPW's recommendation, based on best available science, and should not be subject to public opinion.

SCI generally supports the use of mortality thresholds that provide CPW with some flexibility. It is important to note that significant mountain lion mortality occurs, whether hunting happens or not. In California, which banned mountain lion hunting by voter initiative in 1990, up to 100 mountain lions are lethally controlled to address human-wildlife conflicts each year. One-to-two lions are killed by vehicle strikes every week. Therefore, it is important to manage mountain lions to maintain a stable population, and to consider total mortality in making management decisions.

As SCI supports maintaining a stable mountain lion population, SCI strongly opposes the proposed reduction of the 2026-2027 East Slope (L-ES) harvest objective to 155 lions, a reduction of 53 lions (25%) from 2024-2025 levels. SCI supports continuing to maintain the harvest limit of 208 lions, given that 47 percent of high-quality mountain lion habitat in the East Slope area has no harvest at all. The "assumed" threshold for 2026 and forward appears to be too low, given the stability of the mountain lion population under the current harvest objective. SCI respectfully requests that CPW reconsider this reduction in harvest objective, as it seems to unnecessarily reduce hunting opportunity with little actual impact on mountain lion populations.

SCI supports the use of hounds in mountain lion hunting and CPW's emphasis on controlling the offtake of female mountain lions (whether higher or lower, depending on management objectives). Hunting with hounds allows for greater selectivity in the sex and age class of the harvested lion.

Finally, SCI strongly supports CPW's attention to using the best available science, including new research, in the Draft Plan. SCI and its four Chapters in the Centennial State are pleased to help support CPW's research goals and would be happy to discuss ways that we can contribute to mountain lion conservation with CPW. SCI is dedicated to protecting the freedom to hunt, and we appreciate every opportunity to collaborate with CPW. SCI is always first for hunters.

Sincerely,

W. Laird Hamberlin
Chief Executive Officer
Safari Club International