Midpeninsula Regional Open Space District

PLANNING AND NATURAL RESOURCES COMMITTEE

R-19-139
October 22, 2019

AGENDA ITEM 3

AGENDA ITEM

Amendments to the Grazing Management Policy

GENERAL MANAGER'S RECOMMENDATIONS

1. Review and discuss the proposed amendments to the Grazing Management Policy, including public and stakeholder feedback.

2. Forward a recommendation to the Board of Directors for approval consideration of the proposed Grazing Management Policy amendments with any additional changes requested by the Committee.

SUMMARY

The Planning and Natural Resources (PNR) Committee received an update on the Grazing Management Policy Amendment process on April 9, 2019 (R-19-40). Since then, District staff held two public stakeholder workshops, a meeting with the San Mateo County Farm Bureau (SMFB) Executive Committee, and phone interviews with three wildlife advocacy group representatives, soliciting feedback on proposed policy amendments to address predation of livestock. Staff have incorporated this input into the proposed Grazing Management Policy amendment, which focuses on the following elements:

1) livestock loss due to predation;
2) strategies for reducing wildlife and livestock conflicts;
3) adaptive management practices for livestock protection; and
4) volunteer support in monitoring the effectiveness of livestock protection measures.

BACKGROUND

The Midpeninsula Regional Open Space District (District) began its conservation grazing program in 2007 to maintain and enhance the diversity of native plant and animal communities by preserving grassland habitat, manage fuel loads for fire protection, sustain the local agricultural community, and preserve the region's rural agricultural heritage. As the District continues to acquire new lands that may be included in the conservation grazing program, there is a growing need to define the individual roles of the District and its tenants in addressing wildlife and livestock conflicts when they arise. Amendments to the Grazing Management Policy are recommended to provide guidance in managing livestock use on District lands that reduce wildlife conflicts, specify the District's role and strategy in managing these conflicts, and set a clear understanding for grazing tenants of District provisions for addressing these issues.

In 2013, grazing tenants began to report livestock losses due to predation by mountain lions and coyotes. In response, in 2014 under the General Manager's authority, the District began compensating grazing tenants for confirmed livestock losses to predators by offering a reimbursement based on the per pound market price of the animal at the time of the loss. District grazing tenants have since continued to experience periodic livestock losses from mountain lion and coyote predation. In 2017, the District began to explore whether changes to existing policies could reduce predation and/or more adequately address the economic losses to grazing tenants while supporting wildlife populations. In 2017, Natural Resources staff conducted a grazing tenant survey and interviews to identify the scope of the issue as well as potential solutions. In 2018, the District contracted with a Wildlife Conflict Specialist to develop a scientific literature review to guide policy development.

DISCUSSION

Public Outreach Summary
District staff held two public stakeholder workshops, one meeting with the San Mateo County Farm Bureau Executive Committee, and phone interviews with three wildlife advocacy group representatives to solicit feedback on proposed policy amendments. A high-level summary of each of meeting is provided below. More detailed information, findings from each meeting, and on-going outreach efforts are presented in Attachment 3.

Partner Agency Meeting
On January 25, 2019, the District hosted a partner agency workshop with a total of nine (9) agencies in attendance. In addition, nine (9) questionnaire responses were received during the comment period. Partner agencies ranked research as the most important implementation measure and livestock/wildlife conflict management as the least supported. Partner agencies ranked passive deterrents as the most supported livestock protection method and collapsing empty coyote dens as the least supported. All measures and methods received some level of support, with none falling into the unsupported categories.

San Mateo County Farm Bureau (SMFB) Executive Committee meeting
District staff met with the SMFB Executive Committee on February 19, 2019 to discuss the policy amendment process and solicit early feedback. Overall, the SMFB was supportive of District efforts in updating existing policies to address wildlife and livestock conflict. However, SMFB expressed concerns over the effectiveness of predator deterrents, as well as the reliance on the California Department of Fish and Wildlife (CDFW) for verification of livestock lost to predators. The SMFB also expressed support for District grazing tenants to lethally remove predators that attack livestock, following existing CDFW regulations. Lastly, they indicated that the existing reimbursement rates offered by the District are too low and do not adequality address the economic losses to grazing tenants.

Agricultural Stakeholder Workshop
The District held an Agricultural Stakeholder Workshop on May 13, 2019 to gauge the level of support for the policy amendments from the local agricultural community. A total of 18 members of the public attended the workshop. The overall level of support from the agricultural community was greatest for economic support to grazing tenants experiencing predation and for research on livestock protection method efficacy. The lowest support given was for wildlife and livestock protection measures and the establishment of a volunteer

livestock protection program. Attendees expressed a desire to be able to lethally remove predators that harm livestock under existing CDFW regulations.

Wildlife Advocacy Stakeholder Workshop

One June 6, 2019, the District held a wildlife advocacy stakeholder workshop to receive feedback from regional wildlife advocacy groups. Despite extensive outreach, a total of four (4) people attended the workshop. However, the meeting did result in a productive dialog between a representative from Felidae Foundation (a mountain lion conservation organization), a SMFB representative, a District grazing tenant, and District staff. Due to the low turnout, staff is conducting additional direct outreach to conservation groups and will be preparing a summary of the additional input when complete.

To date the District has received input from the University of California Davis's associate wildlife veterinarian and regional mountain lion expert, Winston Vickers, as well as from The Committee for Green Foothills and TomKat Ranch. The level of support varied between respondents. There was generally high support for research, and moderate to high support for economic assistance. There was moderate support for livestock protection with either no support for lethal removal, or only support for lethal removal if the predator was identified as a problem individual. Responses were mixed on the establishment of a volunteer program with one respondent strongly supporting the measure, one unsure, and one unsupportive.

Proposed Grazing Management Policy Amendment

An amendment to the Grazing Management Policy to address livestock predation on District lands (Attachment 1) is provided for Committee review and feedback. The policy amendment was informed by the findings of a comprehensive literature review (Attachment 2), partner discussions, stakeholder meetings, and conversations with grazing tenants and members of the SMFB (Attachment 3). The policy amendment focuses on the following existing gaps:

1) livestock loss due to predation;
2) strategies for reducing wildlife and livestock conflicts;
3) adaptive management practices for livestock protection measures; and
4) volunteer support in monitoring the effectiveness of livestock protection measures.

Adoption of the policy amendment would result in several changes to the District's conservation grazing program. These changes are summarized below and fall into three categories: economics, wildlife and livestock protection, and research.

Economics:

The recommended policy amendment would allow for a combined economic assistance approach consisting of a modified reimbursement protocol for tenants participating in the Livestock Protection Program and a an across the board 10% reduction in the AUM rent rate regardless of participation, as described below.

Reimbursement for Confirmed Losses:

The proposed policy amendment would direct the General Manager to adopt practices that provide economic assistance in the form of reimbursement to grazing tenants experiencing losses from predators ***if*** they are actively using livestock protection methods. Reimbursement would be for confirmed livestock losses for the anticipated market value of that animal at time of planned sale (had the livestock survived) rather

than at time of loss. To be eligible for reimbursement, tenants would be required to (1) provide annual data on livestock losses from predation and other causes and (2) participate in the Livestock Protection Program by taking proactive, documented efforts to reduce predation. The District's current practice of expunging the rent for the mother cow, in instances where a calf is lost to predation, would remain in place.

Reduced Animal Unit Month Rent Rate:
A reduction in the AUM rate is proposed as a standalone form of economic assistance. This rate reduction is in consideration of the economic impacts to grazing tenants, given District policy of not allowing the take of predators threatening or taking livestock (including, if approved by the Board, only allowing take under very strict provisions as described below under *Wildlife and Livestock Protection*). Staff heard from grazing tenants that it is more difficult to make a living on properties that do not allow tenants to get depredation permits than on private or public properties that allow the take of predators under CDFW regulations. The proposed rate reduction would apply uniformly to all grazing leases. The reduced rate would not require participation in the Livestock Protection Program. Annual livestock loss data reporting would still be required. The AUM rate is set in individual lease language. If the policy amendment is approved, the General Manager would be authorized to amend and update existing leases to include this reduced AUM provision.

Wildlife and Livestock Protection:
Under the proposed policy amendment, the District would develop a tiered adaptive livestock protection protocol and purchase a suite of deterrents that would be made available to grazing tenants participating in the Livestock Protection Program. The District would work with grazing tenants to select appropriate livestock protection methods. The main components of the livestock protection program are summarized below:

- Livestock protection methods include: enhanced fencing and barriers; passive and active deterrents; use of livestock protection animals; removal of attractants (such as livestock carcasses); landscape feature alterations (such as removing vegetative cover around water troughs and other areas that livestock congregate); changes in cattle operations; increased human presence; hazing; and, under very specific conditions (as described below), targeted lethal take of predators.
- The District would limit authorization of hazing and lethal take specifically to problem predators that have developed a habitual behavior of attacking livestock. This authorization would only be issued to tenants who have previously worked with District staff on utilizing an adaptive tiered response to deter predation, and only after alternative methods have been deemed ineffective by District staff. In response to livestock predation from mountain lions, which are designated as a specially-protected mammal, the authorization would be implemented in conjunction with CDFW and follow a 'three-strikes' process as detailed in CDFW bulletin 2017-07 (Attachment 4). This process was developed for the Santa Ana and Santa Monica mountain region where lion populations are experiencing poor genetic diversity and habitat connectivity issues. This process would allow for the use of deterrents methods to reduce predation after the first confirmed livestock loss to lions. A second confirmed loss would result in allowance of hazing of the offending lion. A third confirmed loss would result in an issuance of a depredation permit to lethally remove the offending lion. Authorization for the targeted removal of coyotes would follow a similar pattern and only require two confirmed losses

before lethal take is considered, and would not require a permit through CDFW as coyotes are designated as nongame mammals and can be taken without a permit if causing property damage.

- The District will investigate development of a pilot Volunteer Livestock Protection program to assist willing tenants with tracking livestock losses and predator activities.
- If feasible, predators that attack livestock will be marked and/or a DNA sample will be obtained to identify individuals habituated to taking cattle.

Research:
The proposed policy amendment includes District support for research on the effectiveness of livestock protection methods and their effects on native wildlife populations, grazing productivity, and livestock health. Research may include marking, collaring, and tracking predators, and evaluating environmental DNA to identify predators that have adapted to consuming livestock.

Mountain Lion Listing Petition Under the California Endangered Species Act
On June 25, 2019, the Center for Biological Diversity and the Mountain Lion Foundation filed a Notice of Petition to list an Evolutionarily Significant Unit of six mountain lion populations, including the Santa Cruz Mountains population, as threatened under the California Endangered Species Act. The justification for this petition relies on genetics studies that indicate that these populations are genetically compromised and therefore face a risk of extinction. This development is an indicator of the current assessment by environmental conservation groups of the lion population in California, and more specifically within our region.

The petition lists Recommended Management and Recovery Actions. One measure relates to reducing depredation (legal lethal removal) of mountain lions by expanding CDFW's "three step depredation permit policy" to include all lions across the state. The District's proposed "three-strike" protocol follows CDFW's conservative policy interpretation, and would therefore be consistent with the petition if it is approved at the State level.

FISCAL IMPACT

Developing amendments to the Grazing Management Policy to address livestock predation has been staff led, with an external contract utilized for scientific advisory services. If adopted by the Board of Directors (Board), implementation measures (as discussed above) will result in budgetary and staff impacts as estimated in the table below. Funding for these implementation measures would be requested in future years as part of the annual Budget and Action Plan process. Staff time is broken into two categories: program development and implementation.

To date, the District has reimbursed tenants for a total of sixteen (16) calves. The average amount that the District has paid per lost calf is $635.75. Under current market rates these calves would have been valued at roughly $850 per calf (if sold after grazing for a single season). The proposed change in reimbursement practices would result in an increase reimbursement of roughly $164 per lost calf.

Policy Component	Year 1 Budget	Subsequent Annual Budget	Staff Time Program Development	Staff Time Implementation/ Year
Economics	$10,000 - $15,000	$10,000 - $15,000	40 hours	100 -125 hours
Livestock Protection	$10,000 - $15,000	$2,000 - $5,000	150 hours	150 - 200 hours
Research	$30,000	$10,000 - $15,000	100 hours	50 -100 hours
Totals	***$50,000 - $60,000***	***$22,000 - $35,000***	***290 hours***	***300 – 425 hours***

In addition to the items above, a reduction in the AUM rate paid by tenants would result in reduced rental income for the District's Conservation Grazing Program. The expected District-wide reduction in annual rental income is included in the table below. This is based on current stocking rates and the rental income to the District from 2018.

Total Lease Income (2018)	Reduction in AUM	Reduction in Annual Lease Income	Adjusted Lease Income
$72,329	10% (Staff Recommendation)	$7,494	$64,835
$72,329	25%	$18,734	$53,595

BOARD COMMITTEE REVIEW

The draft Grazing Management Policy Amendment and process were reviewed by the PNR Committee on April, 9, 2019 (R-19-40).

PUBLIC NOTICE

Public notice was provided as required by the Brown Act. Notification was provided to 802 individuals, including the SMFB, partner agencies, wildlife advocacy groups, and District grazing tenants.

CEQA COMPLIANCE

The District's existing Resource Management Policies were adopted in 2011 and evaluated in an Initial Study/Mitigated Negative Declaration (IS/MND). Additional California Environmental Quality Act (CEQA) evaluation of the recommended updates to the Policies is underway and will be presented to the Board when it considers adopting changes to the Policies.

NEXT STEPS

The development of this policy amendment is planned to proceed as follows:

Timeline:

1) SMFB Executive Committee Meeting: November, 2019
2) CEQA Analysis: November – February, 2019
3) Board Study Session: January 22, 2019
4) Public Review Period: January, 2019
3) Board Adoption of Final Policy: March 11, 2019

Attachments:

1. Draft Grazing Management Policy Update
2. Literature Review
3. Summary of public comments
4. California Endangered Species Act Petition for Listing Mountain Lion

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I. GRAZING MANAGEMENT

BACKGROUND

The greatest diversity within California's coastal grasslands can be seen in the forbs or wildflowers that emerge in the spring following winter rains. Sites with adequate management of non-native vegetation will reward these efforts with bountiful displays of colorful spring wildflowers.

The vegetation of the Santa Cruz Mountains is comprised of a rich and diverse assemblage of plant species. This wealth of diversity was most evident within the grassland **ecosystems** that evolved under a variety of disturbance pressures including fire and grazing by large herds of **ungulate animals**, which are now mostly extinct. The **flora** that emerged has been described as one of the most diverse and species rich ecosystems in the United States.

By some estimates, nearly 80 percent of the vegetation cover within California grasslands is exotic vegetation.

The arrival of early Spanish and Anglo settlers initiated a particularly dramatic change in species composition of California grasslands, primarily as a result of tilling the grasslands for agricultural crop production, reduction of **native** grazing animals and introduction of cattle herds brought over from Europe and let loose on the new rangeland. This introduction of **non-native** plants and animals, coupled with the concurrent suppression of fire on the landscape as the western United States was settled, resulted in the substantial replacement of the native grassland vegetation with a predominately **exotic**, annual flora. The exotic vegetation is often more competitive, productive, and prolific than the native plants within which it coexists, and tends to dominate and replace existing native grasses and wildflowers. Over the last 150 years, coastal grassland areas have also experienced large-scale conversion to agriculture or urban development. The remaining undeveloped grasslands face continued development pressure and are severely impacted by exotic, invasive organisms.

District lands currently contain approximately 5300 acres of grassland habitat. The largest contiguous grassland areas are within District lands in western San Mateo County.

The District's **open space** preserves contain large acreages of grasslands that in many areas have been degraded due to the pressures described above. Management of these grassland habitats is desirable to reduce the risk of wildfire and to maintain viable native plant communities. **Vegetation management** using **livestock** grazing or other **resource management** tools can be a substitute for native grazing animals and recurring fire to achieve the District's objective of preserving, protecting and restoring the **natural** environment.

Livestock ranching is a small but vital part of the Bay Area's agricultural economy. As with any business that depends on local infrastructure and services, livestock ranching is increasingly threatened with each ranch that goes out of business. Every livestock rancher depends on services and supplies including veterinary care, feed sales and delivery, farm and ranch infrastructure supplies, and livestock transportation services. As land is taken out of ranching, all of these services and supplies are incrementally affected and may cease to operate, increasing the burden for families and businesses that choose to keep ranching.

*Typical fencing used to control livestock movement is **five-strand barbwire fencing**. Other fencing types that may be used include four-strand barbwire for interior fencing, wood rail fencing and temporary electric fencing that can be installed to seasonally restrict livestock to target areas or exclude livestock from sensitive areas. Wildlife-friendly fences enable virtually all wild animals to move through an area without harm and with minimal impediment.*

In 2003, the District completed the Service Plan and accompanying Environmental Impact Report for the San Mateo Coastal Annexation Area expansion of the District's boundaries to include coastal San Mateo County. The Service Plan recognized the unique value of the San Mateo County coastal area and established Agricultural Policies to preserve and encourage viable agricultural use of land. The Policies and Implementation Measures established in this Grazing Management Policy are intended to supplement and complement the Agricultural Policies in the Service Plan. Furthermore, these Grazing Management Policies will be implemented in a manner that is consistent with the Service Plan.

GRAZING MANAGEMENT GOALS, POLICIES, AND IMPLEMENTATION MEASURES

Goal GM-	**Manage District land with livestock grazing that is protective of natural resources and that is compatible with public access; to maintain and enhance the diversity of native plant and animal communities, manage vegetation fuel for fire protection, help sustain the local agricultural economy, and preserve and foster appreciation for the region's rural agricultural heritage.**

Policy GM-1 Ensure that grazing is compatible with and supports wildlife and wildlife habitats.

- Inventory and assess sensitive habitats to identify areas requiring special management practices. The conservation of these areas will take precedence over other uses and management practices that are determined to have an adverse effect on these **resources**.
- Prepare site-specific grazing management plans by a certified rangeland manager including **best management practices (BMPs)** for preserves where grazing will be utilized as a resource management tool. The site-specific grazing management plan will be a component of the

agricultural production plan developed through the Use and Management Planning process. The Use and Management Planning process provides for public input and Board approval of site-specific grazing management plans.

- Manage agricultural leases and easements to protect and enhance **riparian** areas and to maximize the protection or **enhancement** of **water quality**. (See WR-4)

Policy GM-2 Provide necessary infrastructure to support and improve grazing management where appropriate.

- Utilize fencing that allows wildlife movement and fosters habitat connectivity. (See WM-3:Measure 3)
- Manage access to existing water features and where needed supply supplemental drinking water through stock ponds and water troughs to preserve clean water for livestock, protect water quality, and enhance habitat for wildlife.
- Encourage and assist grazing tenants on District land to provide range improvements to **restore** or conserve **wildland** resources and to enhance range condition.
- Inventory and assess roads and trails on District lands to identify significant erosion and sediment sources – abandon and where feasible restore to a natural condition poorly designed or sited roads. (See WR-4)

Policy GM-3 Monitor environmental response to grazing on District lands.

- Monitor forage utilization and distribution by grazing animals to assure appropriate amounts of **residual dry matter (RDM)** remain on the ground to achieve desired resource management objectives. In the course of RDM monitoring, evaluate and report on wildland fire **fuel** levels that may result in an increased risk of wildland fire (See WF policies).
- Monitor livestock use levels and **agricultural infrastructure** condition to insure conformity with lease provisions to contribute to improved management.

Residual Dry Matter (RDM) is a measure of the amount of vegetation left on the ground, typically measured at the end of the summer or fall. Appropriate levels of RDM strive to minimize thatch, which can inhibit new plant growth, while maintaining adequate levels of vegetation to prohibit soil erosion.

Fire reduction is a great concern for some landowners. However, cattle are not able to graze all land areas effectively for fire protection purposes, such as steep slopes or slopes partially vegetated with brush. In these instances, goats may be an effective alternative. Goat herds can be rented for a short period of time and can be moved with a goat herder and dog(s) along with portable fence enclosures.

- Monitor wildland conditions with an emphasis on documenting the location, distribution and abundance of native grasses, wildflowers, and other native flora and fauna.
- Monitor water quality in ponds, **wetlands,** and **watercourses** with unrestricted livestock access.
- Monitor non-native vegetation response to grazing with an emphasis on documenting the location, distribution and abundance of **target**, **invasive species**.
- Use information collected from monitoring to annually review rangeland conditions and response to livestock grazing. Use **adaptive resource management decision making framework** within grazing management plans.

Policy GM-4 Utilize different livestock species to accomplish vegetation management objectives.

- Research the effective use of cattle, goats, sheep, and horses to manage vegetation on District lands.
- Utilize appropriate species depending on management needs.

Policy GM-5 Preserve and foster existing and potential grazing operations to help sustain the local agricultural economy.

- Establish longer term grazing leases to promote financial viability for the operators and efficient land stewardship for the District.
- Seek grants or other economic support for agricultural infrastructure maintenance and improvements.
- Ensure site-specific grazing management plans are economically feasible and practical for grazing operators.

Policy GM-6 Provide information to the public about the region's rural agricultural heritage. (See PI-1)

- Install display boards and give presentations highlighting historical and educational facts about ranching families and industry at appropriate sites.

Policy GM-7 Provide public access in a manner that minimizes impacts on the grazing operation. (See PI-1)

- Grazing operators on District lands or lands under easement to the District shall be consulted when public access is being planned and considered for the property to minimize conflicts between the public and the grazing operation.
- Prepare and distribute a brochure to educate visitors about etiquette for use of open space property with livestock animals.
- Install signage where appropriate to educate the public about the resource benefits of grazing and to educate visitors about approaching animals, closing gates, and other etiquette appropriate for moving through lands with livestock animals.

Policy GM-8 Grazing operations on District lands in San Mateo County ~~in the Coastside Protection Area~~ will be managed in accordance with the policies established in the Service Plan for the San Mateo Coastal Annexation Area.

- Consult with appropriate agencies and interest groups, including the San Mateo County Farm Bureau and San Mateo County Agricultural Advisory Committee in the development of site-specific Use and Management plans and agricultural production plan components in the Coastside Protection Area.

Policy GM-9 Ensure the sustainability of conservation grazing in areas where **predation** of **livestock** may occur.

- Provide economic relief, for grazing tenants that are actively utilizing **livestock protection methods**, in response to losses from **predation** to sustain conservation grazing as a viable tool for natural **resource management**. Coordinate with grazing tenants to document livestock losses due to **predation** as well as the total annual non-predation-related losses.
- Reduce conflicts between livestock and wildlife by promoting and implementing **livestock protection methods** that reduce livestock losses while safeguarding **native wildlife** populations. Select methods on a site-specific basis and prioritize the protection of **livestock**

by the most ecologically sustainable means available. Develop and implement an adaptive administrative Livestock Protection Protocol to standardize **wildlife** and **livestock** protection methods and procedures, and designate responsibilities for implementing **livestock protection methods**. Consider authorization of **targeted lethal removal** of predators, utilizing a tiered Livestock Protection Protocol, only in reaction to multiple losses of cattle within a time period that suggests predator habituation to predating **livestock** and when other **livestock protection methods** are deemed ineffective.

- Support and promote scientific research on the effectiveness of **livestock protection methods**, and their influence on **native wildlife** populations. Monitor results and modify methods over time as conditions change and techniques improve.

GLOSSARY AMMENDMENT

Livestock Protection Methods – a variety of wildlife and livestock conflict mitiagion tools ranging from visual and auditory frightening devices to hazing and targeted lethal removal (Grazing Management)

Targeted Lethal Removal – Selected removal of a problem individual predator that has developed a behavior of attacking livestock (Grazing Management)

Population – the number of organisms in a particular species that occupy the same geographic region at the same time and are capable of interbreeding (Vegetation Management, Wildlife Magagement, Water Resources, Ecological Succession, Habitat Connectivity, Wildland Fire)

Livestock and Carnivore Protection Policy Literature Review

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Executive Summary

In order to effectively manage livestock-carnivore interactions, it is important to understand how the ecological, legal, and management dynamics interact with one another. This review is designed to help District managers and producers evaluate which livestock protection tools may be most suitable for each particular operation on leased land.

This review can be broken down into the following five sections. The first provides an overview of relevant carnivore behavior and ecology for each of the three native focal species, mountain lion (*Puma concolor*), coyote (*Canis latrans*), and bobcat (*Lynx rufus*). Second is a summary of the laws and regulations governing the management of each of the native focal carnivore species, as well as an additional non-native species, domestic dog (*Canis familiaris*). This information serves to guide how various preventative tools may be legally implemented. Additional carnivore species (such as wolves and bears) are present in other parts of California, however, they are not present on District properties and are not covered by this review. The third section provides a review of direct (mortality and injuries) and indirect (weight loss, reduced reproductive potential, etc.) impacts to livestock that are incurred during livestock-carnivore interactions. Next follows an overview of policies implemented by other local land management agencies (such as East Bay MUD, East Bay Regional Parks, National Parks Service, etc.) that could serve as a model for the District. The final section, and bulk of the review, synthesizes research on a variety of conflict mitigation tools, ranging from lethal removal to visual and auditory frightening devices. Each method is described in detail, outlining the means of protection, suitability for which species of livestock, suitability for which species of carnivore, potential drawbacks and benefits, and scalability (as tenant operations vary from small 200 to 500 acre ranches with 20 to 100 cattle to large ranches covering over 3,000 acres with a few hundred cattle). The District defines livestock as horses, cattle, sheep, and other useful animals kept or raised on farms or ranches; there are tools outlined below designed to protect each of those species. The ultimate goal is to promote and implement practical, effective animal husbandry practices that will allow livestock and carnivores to coexist on District properties.

Introduction

Midpeninsula Regional Open Space District's (hereafter "the District") mission is to provide opportunities for public enjoyment and education while conserving and restoring open space in perpetuity. Preserving these wild habitats requires maintaining the diverse array of native plant and animal species that play important roles in overall ecosystem health. One way in which the District achieves this goal is by implementing conservation grazing activities that simultaneously maintain natural processes in a landscape that coevolved with large grazing animals (Edwards 1996), help mitigate the impacts of nonnative species (Stromberg et al. 2007), as well as support the deep historic roots of livestock ranching in the Central Coast. Preserving the local plant community provides the foundation on which native wildlife persist. Among the species that indirectly rely on these healthy rangelands are the native carnivores, such as

mountain lions, coyotes, and bobcats. These populations both rely on and contribute to maintaining habitat integrity by helping regulate prey populations (Miller et al. 2001), reducing pest species density and disease transmission to humans (Ostfeld and Holt 2004, O'Bryan et al. 2018), etc.

Balancing these varied, and sometimes at odds, components of healthy open space habitats requires careful, dynamic management. The District is dedicated to fostering viable livestock production alongside a healthy carnivore community. To this end, this document explores strategies for preventing negative interactions between livestock and carnivores, thereby promoting sustainable conservation while protecting domestic animals, native carnivores, and human livelihoods alike.

The most common livestock on District property is cattle, however there are smaller operations with llamas, alpacas, sheep, goats, pigs, donkeys, mules, horses, chickens, and other species may be present in the future. This review addresses strategies to keep each of these types of livestock safe from predation by mountain lions, coyotes, domestic dogs, and bobcats.

Much of the current research on depredation prevention in North America has focused on interactions between coyotes and sheep, wolves and cattle, or wolves and sheep. In addition, experimental studies evaluating tool efficacy are rare (Eklund et al. 2017), and were most often developed in other parts of the country. Though there has been little research on mountain lion predation on cattle, especially in California, this review extrapolates results from studies focusing on interactions between other species, and combines that information with distinct facets of mountain lion behavior and ecology to provide guidance where rigorously tested data are lacking.

This document is meant to be as comprehensive as possible to allow District staff and tenants to weigh potential options, but it is by no means exhaustive. This review is informed by scientific research wherever possible, however, there is a significant scarcity of rigorous experimental testing within the field of livestock-carnivore conflict prevention (Miller et al. 2016, van Eeden et al. 2018). While the lack of research limits our ability to fully evaluate the efficacy of each method and weigh them against one another, there is appreciable amount information available to guide producer decisions. It should also be noted that there are legal restrictions on activities; some tools and techniques may be legal on a state or federal level, however they may not be currently permitted under District policies. All activities should be pursued in coordination with the District and granted written permission before implemented.

I. Carnivore Natural History, Management, and Ecology

Coyotes

Coyotes are a plains and grassland adapted species whose flexibility has allowed them to thrive in a wide variety of habitats. Before European settlers first arrived to the U.S., coyotes were mostly limited to the Central U.S. and Mexico. As humans extirpated wolves and expanded agricultural land throughout the 1800s, new habitat opened up for coyotes. Despite

heavy persecution via poisoning, trapping, and hunting, coyotes successfully expanded their range across the U.S. and into much of Canada (Agocs 2007, Levy 2012).

As human and livestock populations grew, so did conflict with coyotes. Though up to 90 percent of their natural diet consists of small mammals (Bekoff 1977), coyotes can predate on small to medium livestock (such as sheep, calves, fowl, etc.), and harass larger animals (such as cattle). The traditional approach to solving these problems has been to reduce or eradicate coyotes with the goal of reducing depredations. However, in order for these programs to be successful, a significant portion of the coyote population, roughly 75 percent, needs to be eliminated each year (Connolly and Longhurst 1975). This kind of eradication program is resource intensive, not practical in most locations, and runs counter to the District's mission. In addition, public attitudes have shifted over time and acceptance of predator eradication programs has diminished, making it increasingly important to find new tools for preventing conflict (Andelt 1996, Reiter et al. 1999, Bruskotter et al. 2009, Slagle et al. 2016).

New research has also begun to shine light on the important ecological role coyotes play by regulating smaller carnivores and indirectly increasing songbird and water fowl diversity and abundance (Soule et al. 1988, Rogers and Caro 1998, Crooks and Soulé 1999). Coyotes can also benefit livestock and their human counterparts. Coyote removal can allow rodents and rabbits to become more abundant, in some cases to the point of competing with livestock for forage (Henke and Bryant 1999, Ranglack et al. 2015). In addition, rodents can also have significant negative economic impacts on California's agriculture (Gebhardt et al. 2011). Left intact, coyote populations control rodent and rabbit populations as their primary prey species, which can help alleviate rodent-caused economic burdens on agricultural producers. A benefit extending beyond rangeland managers, by helping control rodent populations, coyotes can reduce the prevalence of rodent-borne zoonotic diseases as well (Ostfeld and Holt 2004, O'Bryan et al. 2018).

Tenant survey respondents indicated that solo coyotes do not pose a significant threat to cattle, but that group hunting is an issue (see Supplementary Materials Tenant_Survey). Research on pack formation suggests that coyotes may coalesce in groups in response to decreases in small prey and switch to larger animals, such as deer (Bowen 1981). In order to prevent coyotes from forming social groups, it could be beneficial to look into whether small prey item abundance has decreased on District properties (such as from rodenticide use), and whether there are ways to avoid reducing lagomorph and rodent populations. Research suggests that coyotes prefer native prey, and bolstering these populations may reduce feeding on livestock (Linnell et al. 1995, Sacks and Neale 2002). Other research suggests that coyotes may form packs in order to ensure pup survival (Messier and Barrette 1982). One way to manage this aspect of pack formation could be to modify or halt activities that decrease pup survival (such as culling adults during breeding season, restricting domestic dog access to areas with known dens, rodenticide use, etc.).

Informal tenant reporting also suggests that livestock grazing in pastures containing coyote dens or in close proximity to den sites are at greater risk of being harassed or killed. Coyotes living on District property appear to routinely use established den sites for rearing pups year after year, and many of these site are readily identifiable (Chaney, personal

communication). If a particular pair of resident coyotes has a history of living in the area without depredating livestock, it may be in the producer's best interest to let them be; as removing the pair would open the territory, and it could become occupied by coyotes with a greater tendency to prey on livestock. However, if there have been injuries or depredation incidents, CDFW personnel suggest disrupting denning behavior (collapsing the den or filling it in with rocks) close to pupping season (usually May through June). A variation that might more closely align with District objectives would be to disrupt the den site during a time of year when the site is vacant (usually August through February). With the established den rendered inoperable, the breeding pair may decide to choose a new location in an area with fewer livestock, thereby reducing local depredation risk. CDFW has no specific restrictions on how property owners may alter unoccupied coyote dens on their property.

In general, coyote predation may be higher in pastures that contain rough terrain, creeks, or brush sufficient to conceal a coyote – therefore, stocking younger or sick calves in more open habitat (where possible) could help improve safety (Pearson and Caroline 1981) (see Altering Pasture Vegetation and Grazing Regimes below). Similar to mountain lions, coyotes are more effective predators on cattle in closed habitat and/or rugged conditions than in open areas (Hulet et al. 1987, Jones 1987). Coyotes select for newborns, calves, and birthing cattle over adults, making it prudent to keep these groups in open pastures, behind coyote-proof fences (see fencing section for description), or protected by some other method to decrease risk to predation (Jones 1987, USDA 2015a).

Mountain Lions

Historically, mountain lions had the widest distribution of any terrestrial mammal in the western hemisphere, occupying habitat from the Yukon to the southern tip of South America (Logan and Sweanor 2001). Native to California, including San Mateo, Santa Clara, and Santa Cruz Counties, they were once widely distributed across the state and resided in nearly any type of habitat, from the Mojave to the Sierra. As an effective ungulate predator, almost everywhere deer were found, mountain lions could be found too.

As European settlers moved West and their population in California grew, conflicts with mountain lions increased. Mountain lions and other carnivores were subject to government eradication programs in an attempt to reduce their potential impact on livestock. Starting in 1907, mountain lions were classified as a "bountied predator," and over 12,000 mountain lions were harvested before the bounty was lifted in 1963 (data available from CDFW). Habitat models created by CDFW estimate that California's mountain lion population could have been as high as 6,000 (CDFW 2018), but by 1921, they speculated that eradication efforts had successfully reduced this "varmint" down by as much as 90 percent of the natural population statewide (CDFG 1921). This large scale population reduction made mountain lion occurrences rare in many parts of the state, including San Mateo County, and is likely the source of the perception that mountain lions are a newcomer or introduced to the Central Coast, despite historic records indicating their longstanding presence (Lawrence 1913, CDFG 1921, MVZ 1940, Field, 2003, Williams 2003, Marciel 2006, Dougherty 2007).

The bounty was repealed in 1963, and the species was reclassified as a "non-protected mammal." Six years later, they were once again reclassified as a "game mammal" so that wildlife managers could use regulated hunting in an attempt to curtail livestock depredations. Proposition 117 was passed in 1990, designating mountain lions a "specially protected mammal." Mountain lions were not state or federally threatened or endangered, but Californians decided to protect the state's last remaining apex carnivore. This title confers special protections against take of any variety without a depredation permit. In the years since the bounty was lifted and protections were put in place, mountain lion populations have made a significant recovery.[1] This relatively recent population rebound has likely contributed to the rise in depredations and human encounters with mountain lions.

Despite the attention mountain lion management has received over the last 100 years, surprisingly little is known about the size of California's mountain lion population. Their cryptic nature and lack of individually identifiable traits, makes mountain lions notoriously difficult to survey. Recent habitat models created by CDFW suggest the statewide population is close to 3,000 individuals, however further research is currently underway to create a more finely tuned estimate (Dellinger 2018).

Mountain lions prefer to hunt away from human development, and even in rural or exurban environments with abundant secondary prey, roughly 98 percent of the biomass consumed by mountain lions comes from deer (Yovovich 2016, Wilmers et al. 2013). Though mountain lions strongly select for deer, they may opportunistically eat other prey items, such as opossums, raccoons, feral pigs, elk, or domestic pets and livestock (Yovovich 2016). Like most other carnivores, they will also opportunistically scavenge carcasses they encounter.

When mountain lions take livestock, it is more common that they take sheep or goats. Less than 10 percent of statewide lethal take permits are cattle-related (Dellinger 2018), despite there being far more cattle than goats or sheep in California (CDFA 2014). In most cattle depredation cases, calves are taken when they are smaller than 140kg (308lbs) (Shaw 1977). Keeping cattle in close proximity to human activities or in protective structures during vulnerable times can successfully prevent depredations (Shaw et al. 1988, Linnell et al. 1996, Larson 2018). Though more appropriate for small-scale livestock operations, this may be a useful tool for temporarily isolating and protecting injured, sick, or other high-risk individuals.

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[1] Monitoring mountain lion population size at the state level is a logistically difficult and resource intensive. Though there is little direct measure of mountain lion populations in California through time, by piecing together data from a variety of sources, one can piece together indirect estimates of population size and trajectory. Harvest rates are often used as an index for population trends when suitable monitoring data are not available (Cattadori et al. 2003). Holding hunting effort constant, a change in the ability for hunters to harvest animals indicates a change in the animal population. Using bounty records in this same way could reflect patterns in the mountain lion population. Data collected by the state show a marked decline in bounties collected between the early 1900s and when the practice was ended in 1963, indicating that the mountain lion population likely declined during this period. State records of mountain lions harvested between the late 1960s and now, this time through hunting and depredation permits, remain low until the late 1970s, then rise through the 90s, and level off in the mid 90s. This could indicate that the population was greatly reduced by the early 60s, began to recover in the 70s and 80s, reaching a high point in the 90s, and has leveled off to some degree since then. (Bounty records and depredation data are available from CDFW)

Mountain lions rely on stealth when hunting, making habitats with thick vegetation a higher risk for livestock. Feeding and watering livestock in open habitat where there is little cover to hide and stalk within a close distance can help increase livestock safety.

Bobcats

Bobcats inhabit a wide variety of habitat types across southern Canada into central Mexico. They primarily feed on rabbits, and rodents, though they may also consume birds, insects, ungulate fawns, and small livestock or domestic animals. Bobcats can be significant predators to pronghorn or deer newborns/fawns; however, predation risk rapidly decreases as wild ungulate young grow (Linnell et al. 1995). Bobcat predation on wild ungulate young is typically higher in forests than in mountainous or open areas (Linnell et al. 1996).

Though bobcats may prey on wild ungulate young, there is little evidence that they pose much risk to livestock. Research at Hopland Research Extension Center suggests that bobcats may scavenge sheep carcasses, but are not likely to hunt medium to large livestock, not even lambs (Neale et al. 1998). There is scant information in the scientific literature about the relationship between beef cattle or calves and bobcats, which could indicate that there has been little conflict between the two. One study addressing this directly found that bobcats were not responsible for cattle depredations of any variety (Scasta et al. 2017). This result is reflected in the livestock operator surveys conducted by District staff (see Supplemental Material Tenant_Survey). With all of this in mind, it is very likely that cattle and calves are simply too large for bobcats to pose a significant threat, however, they could prove problematic to chickens, fowl, or other small livestock.

II. Legal Status and Regulations

Coyotes

In California, coyotes are designated as a nongame mammal and may be hunted any time of year with no limit on number, provided that all other hunting laws and local regulations are followed (CCR14 §472). Any body-gripping traps, including Conibear traps, and snares are prohibited for recreational or commercial purposes (FGC §3003.1 and CCR 14, §465.5). As nongame mammals, coyotes that injure livestock may be taken at any time or in any manner in accordance with the Fish and Game Code by the owner, tenant of the premises, or employees thereof (FGC §4152 and §4180) assuming no conflict with local ordinances or regulations. In San Mateo, Santa Cruz, or Santa Clara Counties, dogs may be used by federal and county animal damage control officers or permittees authorized under a depredation permit to pursue or take depredating coyotes (FGC §265). CDFW does not live trap and relocate problem coyotes.

Bobcats

Bobcats are considered non-game mammals in the state of California. As such, they may be hunted in season, and hunters with appropriate tags may take up to 5 bobcats of either sex per

season (14 CCR §478(b)). FGC §3960.6 allows livestock operators to use livestock guarding dogs to protect their domestic animals and property from bobcats as long as the dogs are maintained within or in close proximity to the property.

A bobcat caught in the act of injuring or killing livestock may be taken immediately, as long as a permit is obtained within 24 of the incident (14 CCR §401(a)). This depredation permit allows a landowner to use up to three trailing hounds to pursue, haze, or lethally remove the offending bobcat. The permit is valid for up to 20 consecutive days and may be renewed if depredations continue (14 CCR §401(b), FGC §3960.2). It is illegal to use steel-jawed leghold traps or poison, and the animals must be dispatched in a humane manner in which death is delivered instantly. Third party compensation for performing depredation services is illegal (FGC § 3960.2).

Coyote and Bobcat Hazing and Hunting Regulations

In 1998, California voters passed Proposition 4, which banned the use of sodium cyanide and sodium fluoroacetate (Compound 1080), two poisons employed by federal USDA WS trappers for killing coyotes, bobcats, and other carnivores. It also prohibited the use of steel jawed leg-hold traps and body-gripping traps for commercial and recreational trapping (CDFG 1998). Both non-lethal (with the proper permits) and lethal snares remain legal for trapping, animal damage management, and predator control purposes.

Hazing is legally permitted by CDFW code (14 CCR § 251.1 § 251.1. Harassment of Animals), which states the following, "except as otherwise authorized in these regulations or in the Fish and Game Code, no person shall harass, herd or drive any game or nongame bird or mammal or furbearing mammal. For the purposes of this section, harass is defined as an intentional act which disrupts an animal's normal behavior patterns, which includes, but is not limited to, breeding, feeding or sheltering. This section does not apply to a landowner or tenant who drives or herds birds or mammals for the purpose of preventing damage to private or public property, including aquaculture and agriculture crops." The CDFW code does not enumerate every legal tool, however, yelling; throwing rocks; advancing on coyotes; shooting them with a water gun, rubber bullets, or other less-than-lethal munitions are permissible; as are other non-lethal tools (Kasteen, personal communication; Monroe, personal communication).

Mountain Lions

Though California Department of Fish and Wildlife does not currently have a formal mountain lion management plan, laws do restrict how humans may interact with them. Proposition 117 (FGC §4800-4809), passed in 1990, designated mountain lions a "specially protected mammal" in California, permanently banning mountain lion hunting, possession, and take of any variety. The only context in which take is legally permissible is if a mountain lion poses an immediate safety threat, or a mountain lion threatens a human's personal safety or the safety of their livestock or companion animals. In those cases, state law requires CDFW to issue a depredation permit for the offending animal, or appropriate responding agents can lethally remove an individual animal. A game warden or other authorized agent may visit the site in

person to verify that the animal responsible for the incident was a mountain lion, however in some cases, a permit may be issued over the phone. A mountain lion caught in the act of injuring or killing livestock or domestic animals, may be lethally taken immediately by the owner of the property, an employee, or agent of the property owner, provided the incident is reported to CDFW within 72 hours. At that point, CDFW personnel will investigate and verify the incident (FGC §4800-4810).

A depredation permit allows one mountain lion to be killed or harassed, and expires 10 days after it is issued. The permittee is allowed to begin pursuing the mountain lion no greater than one mile from the depredation site, and the pursuit is limited to a 10-mile radius from the initial incident. Under a depredation permit, a mountain lion must be dispatched in an efficient and humane manner in which death is delivered instantly; they may not be poisoned, trapped by leg-hold or metal-jawed traps, or snares. If depredations continue to occur, the livestock operator may apply for additional permits (FGC §4800-4810).

There are two notable exceptions to the general depredation process, the Santa Ana Mountains and the Santa Monica Mountains. These two locations have a few characteristics in common; they are each home to an isolated population of mountain lions in danger of extirpation within the foreseeable future (Ernest et al. 2014, Benson et al. 2016), and a growing number of ranchette-style development and associated small-scale livestock. This intersection of vulnerable livestock and a precarious mountain lion population elicited special attention from state biologists. In 2017, CDFW decided to provide extra support to livestock operators in the region and redefine how the state manages depredation incidents in these two areas.

In these two locations, if a confirmed depredation event occurs (FGC §4803), CDFW will grant permission to the livestock operator to haze the depredating mountain lion if "the immediate pursuit will assist in the non-lethal removal of the mountain lion from the property" (FGC §4805). In addition, the responding agent will discuss potential preventative tools for preventing further depredation incidents. If a second depredation event occurs in a timeframe that "suggests an affinity for the site," the livestock operator is again granted permission to haze the offending individual and the issuing agent will suggest additional preventative tools. If a third event occurs in a similar time window, and the livestock operator requests a lethal removal permit, the permit will be granted.

In 2013, Senate Bill 132 (FGC §4801.5) was passed, creating new protocols and protections for "no harm no foul" mountain lions that wander into human-populated areas and do not pose an immediate public safety threat. This law allows CDFW staff to partner with other qualified organizations or individuals to safely tranquilize and transport mountain lions a safe distance from humans and re-release the individual into habitat from which it may have come. Animals are usually released in a location within their likely home range, which makes this tool distinct from translocations in which animals are transported into new habitat with the goal of reestablishing that animal in a new territory where it is unlikely to encounter humans. In the case of translocations, animals may return to the area in which they were captured, resume their previously problematic behavior, and/or suffer high mortality rates in their new location. Translocation as a conflict management tool is resource intensive and does not improve the

underlying husbandry context in which the issue arose (Linnell et al. 1997). CDFW does not currently use translocation as a tool for resolving conflicts between mountain lions and humans. As mentioned above, there are rare situations in which CDFW will move a mountain lion a short distance, such as in the event that a one is found in an urban or suburban area and it is displaying nonaggressive behavior. In such a case, local agents may tranquilize and move the mountain lion back into the nearest suitable habitat from which it most likely originated (with permission from the owner of the release site property).

Domestic Dogs

Fish and Game Code governs how to manage interactions between dogs and native ungulates (see FGC § 3961), while Civil Code manages dog-livestock interactions. Section 31103 states that "any dog entering any enclosed or unenclosed property upon which livestock or poultry are confined may be seized or killed by the owner or tenant of the property or by any employee of the owner or tenant," and goes on to say that "if a livestock owner suffers injuries from livestock killed by dogs and the owner cannot be identified, he may recover from the county in which the damages occurred." The dog owner may be liable for up to twice the amount of the actual damages inflicted by the dog (Cal. Food & Agric. Code § 31501). Civil Code (Ch 5 §31102) allows any person to kill dogs caught in the act of killing, wounding, or harassing livestock on land or premises which are not owned or possessed by the owner of the dog, or if proof is presented that conclusively demonstrates that the dog has been recently engaged in killing or wounding on land not owned or possessed by the dog's owner.

District Land Use Regulations

The District follows management policies that ensure proper care of the land, that provide public access appropriate to the nature of the land, and that are consistent with ecological values and public safety. All District lessees, contractors, consultants, agents and representatives shall abide by all provisions of the below ordinances unless the provision(s) conflicts with a written contract or agreement with the District. Some of these regulations directly relate to potential actions meant to deter depredation. Exceptions to these regulations can be made by written agreement. Pertinent ordinance sections are detailed below:

Section 403. Firearms, Traps, Weapons, and Dangerous Devices

403.1 General.

a) No person shall carry, possess, use, set, leave or deposit, fire or discharge, or cause to be fired or discharged, across, in, on, or into any portion of District Lands any gun or firearm, spear, missile, bow and arrow, cross bow, sling shot, trap, snare or hunting device, ammunition, throwing knife, hatchet, axe, sword, machete, martial arts throwing device, any device capable of firing or launching a projectile, or any other weapon or device not otherwise specified, capable of injuring or killing any person or animal. Violation of this sub-section is punishable as a misdemeanor.

b) No person shall carry, possess, set, leave or deposit, fire or discharge, or cause to be fired or discharged, across, in, on, or into any portion of District Lands any paint ball gun, BB gun, air gun or similar device.

403.2 Exceptions. This section shall not apply to:

a) the possession of otherwise lawful unloaded firearms or dangerous weapons on public roads solely for the purpose of transporting such firearms or dangerous weapons through District Lands for lawful purposes;

b) the possession of otherwise lawful firearms or other dangerous weapons at a place of residence or business located on District Lands by a person in lawful possession of the residence or business;

c) the possession and use of such firearms or weapons granted by written permit for resource management or educational purposes

Section 700. Hunting, Fishing, Collecting, and Feeding

700.1 Hunting.

No person shall possess, hunt, pursue, molest, disturb, injure, trap, snare, take, net, poison, introduce, release or harm or attempt to hunt, pursue, molest, disturb, injure, trap, take, net, poison, introduce, release or harm any mammal or bird, or any other wild animal living or dead. This section shall include taking of any part of the mammal or bird. Violation of this sub-section is punishable as a misdemeanor

Section 701. Animals.

701.1 Dogs.

a) No person shall have more than three dogs per person within areas where dogs are allowed on District Lands.

b) No person shall allow or have a dog on District Lands except in those areas designated by the District. This subsection shall not apply to:

1) guide and service dogs under physical control, specifically trained to assist the blind, deaf, or disabled;

2) guide and service dogs in training to assist the blind, deaf, or disabled, and under physical control, and participating in a training program,

3) use authorized by written permit.

c) Leash Required.

No person shall allow or have a dog on District Lands, unless the dog is at all times under control, and on a leash not to exceed 6 feet, or on a self-retracting leash with a maximum extended length of 25 feet. The leash must be held by person responsible for the dog and must be made of material and construction sufficient to restrain the dog. Electronic or other “invisible leashes” do not meet the leash requirement. The self-retracting leash must have the capability of being retracted and locked in a position not to exceed 6 feet.

Within a designated area, no person shall have or allow a dog on a lead greater than 6 feet when:

1) Within 100 feet of any parking area, trailhead, picnic area, campground, horse stable, public roadway, restroom, visitor center, ranger station, or other place or structure of public assembly;

2) Within 50 feet of any person that is not the person or persons who entered District lands with the dog; or

3) Within 50 feet of any District Water Area.

4) When the dog is not visible to the owner

d) Off-Leash Areas.

Dogs shall be permitted off leash only in areas specifically designated and signed by the District as off-leash areas. No person shall allow or have a dog in an off-leash area unless the dog is at all times under the verbal or radio collar control, and in sight of, its owner or person responsible for the dog. The owner or person responsible for the dog shall have a leash in his/her possession at all times.

e) Nuisance Dogs.

No person shall allow or have on District Lands a dog that is a nuisance to people, other animals, or property. This includes, but is not limited to: growling, excessive barking, scratching, jumping on any person or animal, or challenging in any manner, people, animals, or property.

f) Dogs in Water Areas.

No person responsible for a dog shall allow said dog to enter any District Water Area unless it is specifically designated to allow such entry.

g) Dangerous Dog.

No person shall allow or have on District Lands a dog that exhibits dangerous behavior including, but is not limited to: attacking, biting or causing injury to any person or animal. Violation of this section is a misdemeanor.

701.2 Disturbance or Injury to Wildlife.

No person shall allow a dog, cat, or domesticated animal, even if leashed, to disturb, chase, molest, injure, or take any kind of wildlife, whether living or dead, or remove, destroy, or in any manner disturb the natural habitat of any animal on District Lands. Violation of this sub-section is punishable as a misdemeanor.

701.3 Horses and Livestock.
No person shall keep, raise or allow cattle, horses, sheep, or other livestock on District Lands, unless pursuant to a lease, license, written permit, or other entitlement of use granted by the District. Violation of this sub-section is punishable as a misdemeanor.

701.4 Other Pets.

No person shall allow or have any pet, domesticated animal, or other animal on District Lands, unless specifically permitted by another section of these regulations.

III. Direct and Indirect Predation Impacts

Carnivores can have direct (such as injuring or killing) as well as indirect (such as harassing, persistent stress, etc.) impacts on livestock. Regardless of the outcome, these impacts can deliver significant economic costs to producers (Muhly and Musiani 2009). When ranchers are able to locate a carcass and determine whether the animal was lost to a carnivore, the economic impact to the producer can be quantified to some degree. However, indirect predation costs are far more complex. Recent research has begun to attempt to measure the impacts that carnivore presence and activities may have on livestock, and quantify the costs related to increases in stress, such as failure to gain weight, reduced reproductive output, additional livestock handling labor, etc. (Ramler et al. 2014). In addition, indirect costs may arise from lost genetic stock held within a depredated individual, training, and other difficult to measure internal factors. Every livestock animal represents generations of selective breeding. When that animal is killed, the profit from that individual is lost, and it also represents lost cost in the years invested by the rancher, as well as an opportunity cost to the future genetic potential of that lineage (Naughton-Treves et al. 2003). In fact, new research has shown that while ranches with resident wolves may not experience negative indirect impacts from wolf presence alone, ranches with a confirmed depredation incident may incur indirect costs greater than the cost of the depredation loss itself (Ramler et al. 2014).

National and Local Depredation Losses

Nationwide, and in California, non-carnivore sources of mortality, such as respiratory illness, foul weather, or calving related problems, dwarf the impact of predation. In 2015, carnivore predation accounted for 2.4 percent of cattle mortality and 11.1 percent of calf mortality across the U.S., whereas non-carnivore sources accounted for 97.6 percent and 88.9 percent of cattle and calf mortality respectively. It is important to recognize, however, that depredation rates vary regionally and by livestock operation type. For example, beef calves and cattle may have depredation rates several times higher than dairy operations, and grizzly bear depredations are much more likely to be an issue in Idaho than in Oklahoma (USDA 2015a). On a more local scale, depredation rates can vary dramatically on a parcel-by-parcel basis (Treves et al. 2004). For example, overall livestock loss for the District as a whole has not exceeded 2 percent for any given year in the last 4 years. However, loss to a single producer has been as high as 14 percent in a year (see Table 2).

In California, 1.1 percent of reported mature cattle mortality was attributed to carnivore predation, and 5.8 percent of reported calf mortalities were attributed to carnivore predation in 2015. Non-carnivore mortality sources accounted for 98.9 percent of adult cattle mortality, 94.2 percent of calf mortality. These various mortality sources amounted to an overall 2.4 percent of cattle inventory lost, and predation accounted for less than 0.1 percent of this overall lost inventory. For calves, non-carnivore mortality sources accounted for 6.6 percent overall calf

crop loss, and predation accounted for 0.4 percent overall calf crop loss (see Table 1). Even at such low rates, predation cost the state's livestock industry $1,896,631 in lost cattle and $4,789,565 in lost calves, and can have far greater proportional impact on individual operations (USDA 2015a).

Mortality Source	Percent Livestock Inventory Lost	
	Cattle	Calves
Predation	>0.1	0.4
Non-Predation	2.4	6.6
Respiratory Problems[1]	0.6	2
Mastitis	0.3	>0.1
Digestive Problems[2]	0.3	1.5

Table 1: Percent California's overall cattle and calf inventory loss derived from the most common mortality sources. Predation mortalities are the pooled losses to any carnivore found within California (wolves, mountain lions, bears, coyotes, domestic dogs, etc.). Non-predation mortalities are the pooled losses from any non-predation source (including respiratory issues, mastitis, lameness, etc.). At the state level, illnesses from respiratory or digestive issues are responsible for more calf and cattle deaths than depredations from mountain lions or coyotes, or all of the carnivore species combined. However, mortality sources on a local level may vary widely. (Data calculated from USDA 2015a)
[1]Such as pneumonia or shipping fever.
[2]Such as bloat, scours, parasites, enterotoxaemia, or acidosis.

On District grazing allotments, there has been a growing incidence of livestock depredation. Though livestock producers operating in the Central Coast have been ranching alongside carnivores for generations, and under District management since 2007, as local carnivore populations have recovered in recent years, depredations and other conflicts between livestock and carnivores have increased. In recognition of this growing trend, the District started a compensation program in 2014. Between the program's inception and 2017, overall carnivore-derived cattle mortality ranged from 0.15 to 1.16 percent between 2014 and 2017 (Table 2). This costs the District an average of $2,647 a year in livestock compensation, and $13,235 total (Table 3). Tenants reported livestock harassment by groups of coyotes, but none was able to quantify the costs incurred (see Supplementary Material Tenant_Survey). Some mentioned that they thought stress, failure to gain weight, and failure to rebreed were likely costs. None of the tenants surveyed listed increased labor or preventative tools as added costs (See Appendix 1 and Appendix 2 for additional information on mountain lion depredations in California).

Year	Stocking Rate	Animals Lost			Percent Lost
		Heifers	Calves	Total	
2014	509	4	2	6	1.18
2015	575	0	4	4	0.70
2016	554	0	1	1	0.18
2017	563	0	2	2	0.36

Table 2: Reported cattle losses to carnivore depredations on Midpeninsula Regional Open Space District grazing allotments (See supporting document Grazing_Data.xlsx and Depredation 2014 to 2017.xlsx). The percent loss is expressed as the overall loss for the District. Individual livestock operation loss ranged from 0 to 8.5% of livestock managed. Of the 14 total confirmed losses reported between 2014 and 2017, 8 were determined to be from mountain lions, and 6 were lost to coyotes between 2015 and 2016. At the time of writing, an additional 4 calves were lost in 2018, all were likely coyote predation.

Year	Animals Reimbursed		Reimbursement Costs
	Heifers	Calves	
2013	NA	2	$1,890.00
2014	***6***	2	$7,330.00
2015	***4***	4	$4,308.00
2016	***1***	1	$693.00
2017	***2***	2	$1,399.00
Total			$15,620.00
Yearly Average			$3,124.00

Table 3: Depredation reimbursement costs to Midpeninsula Regional Open Space District for 2013 to 2017 (See supporting document Predation reimbursement.xlsx and Depredation 2014 to 2017.xlsx). Bold and italicized numbers include heifers that were killed as well as those who were not killed but did lose their calves were. As such, rent for heifers that lost calves was expunged.

While Tables 2 and 3 account for livestock killed by carnivores, harassment and injuries can bring about indirect costs such as failure to gain weight, spontaneous abortions, increased labor, and other expenses that are difficult to measure (Ramler et al. 2014). Data on livestock harassment and the resulting potential changes in stress, movement patterns, productivity, susceptibility to disease, etc. are poor and the overall picture is not well-understood (Ramler et

al. 2014, Clark et al. 2017). Clark et al. (2017) found that cattle living in wolf country had shorter daily movement patterns than those living in wolf-free areas, but these results were not tied to any sort of fitness outcome. Ramler et al. (2014) found that the weight of calves living on ranches with a confirmed wolf depredation decreased by 3.5 percent, or 22 pounds, for that year. This translated into an average of $6,679 loss across the 264 calf herd at the time of sale.

Obviously wolves are not an issue with which the District's producers need to be concerned, but there are no similar data available for cattle harassment by coyotes, bobcats, or mountain lions. One can imagine that wolves present a more extreme version of coyote damage, and this could provide a helpful context for anticipating potential damages on District properties.

The USDA (2015a) provides some data enumerating the cost of wounds dealt to cattle in California by carnivores. They estimate these costs at $550,000 for injured cattle and $571,000 for injured calves in California for 2015 (these estimates assume that the animals had no value after they were injured). Unfortunately, these costs are not broken down by carnivore species.

Impacts by Species

According to national data collected by the USDA (2015a), the four main carnivores discussed in this review can be ranked in order of potential negative impacts to cattle and calves as follows:

Coyotes >> Dogs > Mountain Lions > Bobcats

In California, where mountain lions are more common than in other parts of the country, the relative ranking changes slightly:

Coyotes > Mountain Lions > Dogs > Bobcats

According to the District's tenant survey, the ranking is as follows:

Mountain Lions > Coyotes > Dogs

Half of the tenants surveyed classified predation as a critically important management issue, two thirds ranked it as important, and the remaining tenant ranked predation as not important. Other than the producer who thought predation was not important, all of the tenants have had predation issues on leased land, and almost all of the conflict was with mountain lions. Some tenants felt that coyotes pose little threat to cattle unless they form packs, or attack young or sick calves. There was also concern expressed about the stress of coyotes harassing cattle. None of the District tenants surveyed gave accounts of incidents involving domestic dogs or bobcats.

Mountain Lions

The level of impact mountain lions have on livestock operations varies greatly depending on the habitat (open grassland, rugged mountains, etc.), livestock species (cattle, goats, or sheep), operation type (cow-calf, steer, etc.), and location (California, Midwest, Colorado, etc.). Accounting for less than 1 percent of cattle or calf deaths across the U. S., mountain lions do not appear to have a nationally significant impact on cattle operations (USDA 2015a). However, it

is important to remember that mountain lions were extirpated from the Eastern U.S. and Midwest over a century ago; excluding livestock that do not live in mountain lion country will increase the percentage of cattle or calf deaths in this calculation considerably (Shaw et al. 1988, Cougar Network 2018).

In most western states with healthy mountain lion populations, cattle depredation is an infrequent issue. For example, mountain lion research conducted in Colorado found that with over 200 mountain lions collared, and ample cattle on open range, there was not a single incidence of loss to mountain lions between 2004 and 2013 (Logan, personal communication). In New Mexico, mountain lion researchers documented cattle, including newborn calves, and mountain lions sharing habitat without any cattle killed in 10 years of study (Logan and Sweanor 2001). In that area, herds were composed of cow-calf groups with few bulls.

However, research conducted in Arizona, where there is a more temperate climate and year round grazing, found contrasting results. This work indicated that livestock operations with year round grazing and early season calving may be more susceptible to depredations (Shaw et al. 1988) (For a chart of seasonal versus year round grazers on District property, see Appendix 3). These data support observations on District properties were mountain lion depredations are the most common form of carnivore conflict and are the greatest concern with respect to depredation management (see Supplemental Material Tenant_Survey).

Significant differences in mountain lion versus wolf hunting styles likely makes the indirect impacts mountain lions may have on livestock far lower than is the case with wolves. Wolves are cursorial predators, which means they use a prolonged chase that can last upwards of several miles to select and subdue their prey (Kauffman et al. 2007, Wikenros et al. 2009). Mountain lions, on the other hand, are ambush predators that rely on stealth and surprise to capture their prey (Williams et al. 2014). As such, mountain lions are much less likely to chase or harass cattle and other livestock, and ranchers operating in mountain lion country are much less likely to suffer from these indirect predation costs.

Coyotes

Nationally, dogs and coyotes are responsible for more livestock depredations than all other carnivores combined (USDA 2015a, USDA 2015b). This elevated risk could be related to the fact that coyotes are also the most widely distributed carnivore in the U.S., so probability alone would work in their disfavor. That being said, coyotes can reach higher population densities than mountain lions, live in closer proximity to people, and make use of more marginal habitat, potentially putting them at greater odds with livestock (Fedriani et al. 2001, Gehrt et al. 2010). Though they tend to pose a more substantial risk to sheep and goats, among carnivore-derived mortality across the U.S. in 2015, coyotes accounted for the highest percentage of cattle (40.5 percent) and calf (53.1 percent) depredations (USDA 2015a). Coyotes present a higher danger to newborns, sick calves, and cows giving birth than to adult cattle, and tend to be more lethal to dairy calves than to beef calves (USDA 2015a). There are numerous mentions of coyotes harassing and/or injuring cattle in scientific literature, however, data on rates, impacts, and associated costs are scant (Dorrance 1982, Jones 1987, Shwiff et al. 2016, Larson 2018).

The size difference between cattle and coyotes may work in cattle's favor. Cattle often stand their ground and may even cooperatively charge coyotes threatening their calves. This type of aggressive behavior may also deter further harassment. In some situations, cattle have been added to groups of sheep to protect them against coyote predation (Hulet 1987).

Domestic Dogs

In some geographic locations, domestic dogs may pose a significant risk to livestock. In 2015, dogs were responsible for 11.3 percent of cattle and 6.6 percent of calf losses to predation, and in 2014, dogs were responsible for 21.4 percent of sheep and 10.3 percent of lamb depredations across the U.S. (USDA 2015a, USDA 2015b). Direct as well as indirect impacts on livestock by dogs can be significant, and in some areas, greater than other sources of predation (Young et al. 2011). Even when dogs fail to kill livestock, they can injure or persistently worry animals. Dog depredation or harassment is generally more of an issue on the urban-wildland interface, making it a potential concern for the District. Domestic dogs guilty of livestock harassment or depredation are often friendly to humans, increasing the difficult of determining the culprit. Further interfering with a proper identification, dogs can deliver injuries difficult to distinguish from other predators, and may participate in "excess killing" where multiple animals are injured or killed and not consumed (Jennens 1998). One study found that free-roaming domestic dogs consumed, and likely killed, more livestock than local wolves (Echegaray and Vilà 2010). In addition, dog predation may be a growing concern; California producers anecdotally report an increase in free-ranging dogs associated with marijuana production in some regions (Macon et al. 2017). Though dogs are not currently allowed on any of the preserves that have cattle, this could also be a future concern as this policy may change in the coming years.

Bobcats

Bobcats pose little threat to large livestock, especially cattle. As such, it is likely unnecessary to put specific animal husbandry practices in place to protect cattle or any other large livestock from bobcat depredations or even injury. In 2015, bobcat and lynx predation combined accounted for 1.4 percent of beef cattle predation losses nationally, and 0.0 percent in California (USDA 2015a). In 2014, bobcat and lynx predation accounted for 0.11 percent of lost lamb, and 0.2 percent of adult sheep crop nationally, and 0.0 percent in California (USDA 2015b). Other studies found that bobcats may scavenge livestock carcasses, but are unlikely to be responsible for killing any large livestock, such as cattle, sheep, or equines (Neale et al. 1998, Scasta et al. 2002). They may take smaller animals, such as chickens, turkeys, fowl, or piglets. These sentiments were shared by the District livestock operators surveyed, who said that bobcats may eat chickens, but were not considered a threat to cattle (see Supplementary Material Tenant_Survey).

IV. Local Indemnification and Depredation Prevention Programs

Most local land management agencies do not have formal depredation prevention or response policies. For many of these agencies, depredations do not pose a significant challenge, allowing them to handle each depredation on case-by-case basis (e.g. EBMUD and NPS). For example, Point Reyes National Seashore and the Golden Gate National Recreation Area, operated by NPS, have had very little depredation pressure and have been able to deal with incidents as they arise. Others, on the other hand, have had significant depredation challenges and have designed policies to help support local livestock operators. Marin County implemented the most formal of these policies, a depredation prevention and indemnification program called the Marin County Livestock Protection Cost-Share and Livestock Loss Compensation Programs. This program compensated livestock operators for losses to carnivores and helps cost-share preventative tools for livestock protection.

National Park Service Point Reyes (NPS) Livestock Grazing

NPS operates 28,000 acres of rangeland with around 6,000 head of cattle run by 24 ranching families (six dairy operations and 18 beef), and a couple other smaller sheep and chicken operations in Marin County. Ranch size ranges from 30 to 35 head on 230 to 330 acres to 856 head on 1076 acres. There are bobcats, coyotes, and mountain lions in the area, but depredation has not been a significant issue in the recent past. Since 2011, there have been fewer than a dozen reported depredations. In each of these instances, coyotes took beef calves that had wandered away from the herd. There was one case that may have been a mountain lion, but the parties involved were unable to confirm the species of carnivore involved. Lethal removal is usually reserved for animals that pose an immediate human safety risk, rather than for depredation, and no animals have been lethally removed for livestock depredations since before 1997.

On these NPS lands, federal law supersedes state law, so CDFW does not have jurisdiction and the depredation policies governing the rest of California are not applicable. Incidents are reported to NPS and a course of action is decided for each individual situation. Any preventative tool is subject to review by NPS before it can be implemented. Livestock guarding dogs have been approved for one small sheep operation and one chicken operation. None of the other operations are currently utilizing any approved depredation prevention techniques, but NPS would consider other alternative tools, such as frightening devices, or livestock guarding donkeys or llamas.

The NPS Management Policies (2006) state, “native predators, scavengers and prey are all integral to healthy native ecosystems and are protected by NPS Management Policies. The occasional damage that is caused by wildlife, to fences, ranching structures, agricultural animals and livestock forage, is to be expected on permitted lands. Lessee shall not engage in any activity that causes harm to or destroys any wildlife. Conversely, Lessee shall not engage in any activity that purposely supports or increases populations of non-native or invasive animal species. On a case-by-case basis, the Lessor will evaluate incidences of depredation and choose a course of action. The nature of the course of action taken, if any, will be determined by the wildlife species, the extent and frequency of the damage and park-wide management objectives.” On

Point Reyes National Seashore and the Golden Gate National Recreation Area properties, ranchers are indirectly compensated for any predation costs they may incur by offering a reduced grazing fee of $7.00 per AUM. This reduced cost takes into account the overarching principle that local ranchers are operating under strict NPS guidelines and are not able to manage their operations with as much flexibly as they could under other land designations (Press, personal communication).

Local Compensation and Depredation Prevention – Marin County Program (MCP)

The Marin County Program was one generally focused on sheep depredations, however, the principles and structures may serve as a model for a program geared toward cattle or livestock more broadly. Before 1999, Marin County was spending $60,000 each year on lethal coyote control, however, livestock (mostly sheep) losses were still a regular occurrence (Agocs 2007). In 2001, the County decided to discontinue its contract with Wildlife Services (WS) and replaced it with a county-run preventative program originally designated the Marin County Strategic Plan for Protection of Livestock and Wildlife. The WS federal trapping program was phased out, however, the new program did not impede ranchers from lethally removing carnivores from their own property. Slated to run for a five-year pilot period, the program redirected county funding that would have supported USDA trappers into assistance for ranchers implementing non-lethal carnivore deterrent tools, such as livestock guarding dogs, fencing improvements, birthing sheds, etc. When the pilot program ended in 2005, the County shifted to approving funding on an annual basis, and now the MCP has become an established county program. Each year, the Marin County Department of Agriculture conducts a meeting with ranchers to evaluate the program and to solicit recommended changes to program operations (Larson 2006, Fox 2008).

Indemnification Program Overview

The original county-run program design did not include an indemnification program, but one was added at the request of the local ranching community. In order to receive compensation for depredations, ranchers were required to be an active participant in the proactive cost-share predation prevention program and to have at least two non-lethal livestock predation deterrents in place. These deterrents were verified and documented during an onsite ranch visit by the County Agricultural Commissioner's office. Once a ranch has been deemed qualified for indemnification, any losses suffered from that date on are eligible for compensation. When losses occurred, livestock operators needed to report losses to the Marin County Agricultural Commissioner's office by telephone, as well as to the University of California Cooperative Extension (UCCE) through a monthly mailed "livestock loss" card. UCCE provided third party loss verification and maintained a central database for depredation records. When necessary, onsite verification visits were performed by the Marin County Agricultural Commissioner's office (Larson 2006, Fox 2008).

Depredation compensation payments were made for each animal based on market value (calculated on a 3-year average of market rates for lamb at a weight of *ca.* 100 lbs.), up to $2,000

per year for ranchers managing operations larger than 200 head, and up to $500 per year for ranchers managing fewer than 200 head. Operations below 200 head were not considered commercial and were ineligible to participate in the MCP. In addition, show animals and special breeding stock were not eligible for indemnification. Confirmed depredation payments were made twice a year, once in June and once in December, through the Marin County Agricultural Commissioner's office. If the cumulative market value for the animals lost that year exceeds the available funds, compensation payments were prorated. At the end of each year, ranchers were required to sign an affidavit verifying their livestock loss claims (Larson 2006, Fox 2008).

Cost-Share Program Overview

The initial proposal was to have cost-share funds administered by a third party, such as the California Woolgrowers Association. However, after meeting with local livestock operators, it was decided that Marin County Agricultural Commissioner's office would administer the program. The MCP was designed in collaboration with ranchers, the Agricultural Commissioner's office, and the Farm Advisors office. Projects eligible for cost-share reimbursement were any material or property improvements that deter depredation, such as fencing, barriers, and birthing sheds; as well as animal husbandry strategies such as shepherding, penning, livestock guardian animals, noisemakers, and any other non-lethal carnivore protection measures or animal husbandry practices (Larson 2006, Fox 2008).

To submit a reimbursement claim, livestock operators needed to complete a form documenting the specific activity employed, and the costs for which funds were being requested. Ranchers were required to contact the Agricultural Commissioner's office and set up an on-site review to be conducted by either the Agricultural Commissioner's staff or the Cooperative Extension's local Livestock and Range Management Advisor. After the activities were verified, the County Inspector and/or the Livestock Advisor would submit the claim to the Agricultural Commissioner for review. Once approved, an invoice for the amount of the claim would be submitted to the Treasurer's office and a check in the name of the respective rancher was issued. Once a year, a County Inspector or the Livestock Advisor would visit each participating ranch to verify that subsidized predation deterrents were in place, as well as make recommendations for additional potential deterrents or animal husbandry practices (Larson 2006, Fox 2008).

The most common purchases that the program helped cost-share were fences (electric, patch, and cross fencing), livestock guardian animals (dogs and llamas), and protective pasture corrals. Ranchers utilizing guardian animals were eligible to receive $250 to help defray animal maintenance costs, such as vet bills and food. This $250 pool of funding for animal care counted towards the cap set for that livestock operation size ($2,000 for operations greater than 200 head and $500 for operations smaller than 200 head) (Larson 2006, Fox 2008).

Outcome

Nearly all of the commercial sheep operations in the region participated in the MCP (Fox 2008), however, by 2009, program officials decided that the benefits provided by the indemnification program were outweighed by the implementation cost. The compensation

portion of the MCP was terminated, and funds were redirected to support cost-sharing preventative tools such as fencing improvements, shepherding, changes in animal husbandry, livestock guarding animals, etc.

Overall, this program has increased the use of non-lethal deterrents, reduced depredations, reduced lethal removal, and increased support for preventative tools (Fox 2008). A study on the program indicated that livestock losses decreased by over 25%, while program costs were reduced by nearly 20% per year (Agocs 2007, Fox 2008). Participating livestock operators indicated that they were with the MCP, with most ranchers reporting a high degree of satisfaction with the program's level of cost-sharing and depredation compensation rate. In addition, overall lethal carnivore removal decreased by over 50% (Fox 2008).

Key Points to Consider

As the MCP ultimately found, compensation schemes can be very expensive and difficult to administer. In many cases, locating dead livestock and having them inspected in the timeframe required for positive verification can be incredibly difficult (Linnell and Brøseth 2003). Some research goes so far as to suggest that compensation schemes may be counterproductive, rewarding passivity and failing to motivate producers to adopt effective mitigation strategies (Boitani et al. 2010). There are, however, ways to overcome some of these issues, such as attaching conditions on the payments (e.g. setting minimum husbandry requirements, or stepwise payments scaled to the level of preventative measures in place), cost-sharing, or compensating producers for carnivore presence rather than depredations. This last approach of conservation performance payment scheme could help encourage producers to adopt carnivore-compatible husbandry practices by incentivizing coexistence. In this type of system, financial incentives reward stewardship that allows livestock and carnivores share habitat; the payments offset the risk, as well as the indirect impacts carnivores impose on livestock (see "Direct and Indirect Predation Impacts" above) rather than paying for difficult to measure damages after they are incurred. The main requirements for a payment-for-presence system are that the parties involved agree on a fair rate of payment, fiscal support for the payments is secured, and a system is put in place to accurately document carnivore activity[2]. In addition to

[2] In order to create a successful conservation performance payment program, administrates must first select indicators of carnivore presence, decide how these indicators will be monitored, and determine how the monitoring results will be used to inform compensation payments. Other programs have used the presence of carnivore offspring as the indicator for carnivore presence (Zabel and Holm-Müller 2008), however, depending on the monitoring technique, it may prove logistically simpler to use any age individual. Carnivore presence could be monitored indirectly via camera traps or scats (e.g. surveys, such as in Gese 2001; or genotyping scats, such as in Prugh et al. 2005), or directly through mark-recapture (review in Gese 2001). For a review of monitoring methods, see Gese 2001 or Gompper et al. 2006. The amount of payment should be calculated by the monetary damage the offspring are expected to cause over the course of their life. Because depredation rates on District properties are relatively low, this calculated amount could be too small for a pay-for-presence program to be attractive to tenants. Benefits to a pay-for-presence program include compensating livestock producers for hard to document costs, such as livestock harassment; removing the burden of searching for animals killed by carnivores in the timeframe necessary for validation; removing the administrative burden of verifying predation events; eliminating potentially contentious verification events in which trust between producers and administrators may be eroded. The largest

promoting coexistence, a payment-for-presence program would support monitoring native wildlife on District properties, an outcome aligned with the District's mission.

V. Conflict Prevention Tools

Creating and maintaining a livestock operation in which livestock and carnivores may flourish is an iterative and dynamic process. It will involve producers leveraging intimate familiarity with their particular operation to select appropriate preventative tools, and adaptively managing their practice as new situations arise. There are many different strategies and tools available to help livestock operators protect their livestock and coexist with carnivores. These tools can work on one or more pathways by altering human behavior, carnivore behavior, and/or livestock husbandry practices (Shivik 2004). A lack of consensus on when a particular tool or set of tools will be most effective makes it difficult to determine when to use which approach. The practicality and efficacy of any particular tool will depend on the type of operation, livestock species and products being produced, topography, carnivore community, native ungulate community, producer familiarity with and confidence in a given tool, associated cost-benefit considerations, public perception, and many other factors (Miller et al. 2016, Eklund et al. 2017). For a summary table of tool efficacy for each carnivore species, see Appendix 4. Every ranch is different, and local producers must weigh a unique set of site-specific considerations when selecting appropriate tools. It is also important to recognize that every producer has a unique perspective and set of experiences that make some tools more palatable than others.

Ultimately, the most reliably effective protection will likely come from applying multiple tools (Koehler et al. 1990, Shivik 2006, Miller et al. 2016, Stone et al. 2017). Carnivores are smart, adaptive, and have a great deal of motivation and time to dedicate to finding prey. The more impediments livestock producers can provide, the more incentive there will be for carnivores to hunt native prey instead of livestock. The tools that follow are potential options to consider; clearly not every tool will be practical or suitable to every operation.

Lethal Control

Improving animal husbandry practices can reduce carnivore predation on livestock, but there are certain situations in which lethal removal of habitual problem animals may be the most appropriate course of action. There are two forms of lethal control - indiscriminate hunting and targeted removal. Indiscriminate control operates on the principle that decreasing the overall carnivore populations reduces encounters between livestock and carnivores, making it less likely for negative interactions. This approach seldom reduces conflict and can actually increase depredations (Shaw et al. 1988, Conner et al. 1998, Harper et al. 2008, Peebles et al. 2013, Wielgus and Peebles 2014). Centuries of lethal control on coyotes (hunting, trapping, and

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benefit this type of program creates is that it provides producers with a higher incentive to both keep carnivores alive, and to be proactive about protecting livestock.

bounties) have had little impact on coyote cattle depredations unless the population is reduce by greater than 75 percent each year (Connolly and Longhurst 1975, Boggess et al. 1978). Increasing mountain lion hunting quotas may cause nuisance complaints and livestock depredations to increase by 36 to 240 percent (Peebles et al. 2013). Hunting removes territory-holding adults and disrupts social structure. When a resident male is removed, his territory becomes vacant. Multiple males may disperse into that vacancy and compete for exclusive rights to the area, a process that may locally increase the mountain lion population until the territorial boundaries are resettled. Further exacerbating the situation, the open territory makes space for young dispersal-aged males (Lambert et al. 2006), a demographic more likely to run into conflict with people (Peebles et al. 2013). A similar pattern could occur in areas where there is heavy poaching or an abundance of lethal removals under depredation permits.

Selective, targeted removal may be a more effective option. For this tool to be applied appropriately, certain criteria should be met to ensure that the tool is being used effectively, namely that 1) an individual is a repeat offender, and 2) the correct individual is targeted. Most carnivores will take easy to kill prey, such as livestock, when given the opportunity. In some situations, producers may experience "excess killing," when a carnivore kills more prey than it can practically consume in one night. This is certainly very upsetting and costly to the producer, however, it does not necessarily indicate the presence of a problem animal. Carnivores evolved to eat prey that can potentially escape, but when livestock are corralled or penned, they cannot retreat to safety. In this situation, the carnivore is presented with a novel situation far beyond the context in which it evolved. Natural carnivore behavior, pursuing and killing prey, in this scenario can result in killing an unnaturally high number of animals, as multiple confined animals repeatedly trigger a predatory response from the carnivore. It is a mismatch between the context in which the carnivore evolved over millennia (available prey is dispersed and able to flee), and the context in which it now lives (available prey is confined in relatively high numbers). The behavior is problematic, but it does not mean is that the individual itself is necessarily predisposed to causing further conflict (Linnell 1999). A carnivore exhibiting this natural behavior does not indicate the presence of a problem animal, instead it indicates the presence of a novel situation and highlights the importance of proper penning, fencing, and other animal husbandry practices needed to protect livestock.

A problem individual is one that has developed specialized skills that allows it to seek out and access well protected livestock, and the individual has demonstrated this ability on multiple occasions, especially when appropriate protective animal husbandry practices have been put into place. If lethal control is deemed appropriate for such a case, that specific animal needs to be properly identified and targeted appropriately. Neither mountain lions nor coyotes have spots, stripes, or other markings that facilitate individual identification. In addition, their population densities are high enough in the Central Coast that there are likely a few members of each species that occupy any given location. This makes targeting the appropriate perpetrator very difficult, unless it is caught in the act. The following section on "Identifying Recidivists" explores tools for distinguishing individuals.

When the targeted individual is successfully removed, this can lead to a temporary reduction in depredations. Targeted removal outcomes practiced on coyotes were improved when the breeding individuals of the territory in which that depredation occurred were killed (Eklund et al. 2017). However, in most cases, without further changes in animal husbandry practices, further depredations are likely to occur (Linnell et al. 1996). Ultimately, the conflict is most often created by placing attractive and easy to kill prey in habitat occupied by opportunistic carnivores. An additional consideration, removing a specifically targeted individual can produce the same dynamics that occur when there is carnivore hunting – that is, when a territorial individual is removed, multiple young individuals may move in to fill the vacancy and cause additional conflicts.

As discussed above, carnivores play an important role in maintaining a healthy and balanced ecosystem, however, lethally removing a single individual carnivore in a stable population is unlikely to have a significant impact on the overall long-term ecosystem viability. In contrast, in systems where there are several threatening forces, such as habitat degradation, loss of connectivity, rodenticides or other environmental toxins, etc., the larger the impact will be for each individual removed. This is the case in the Santa Monica Mountains and the Santa Ana Mountains in Southern California. Urbanization, isolation, and lack of connectivity have driven what used to be thriving mountain lion population to the brink of local extinction (Ernest et al. 2014, Benson et al. 2016). In these two areas, livestock producers experiencing livestock or companion animal losses are given more extensive help in preventing further conflict rather than being issued lethal take permits when a depredation occur.

Identifying Recidivists

In order to employ targeted lethal removal, it is necessary to be able to identify individual carnivores, determine that there is a behavioral pattern, and select that individual for intervention. It can be very difficult to identify individuals members of a species that lacks unique features (such as coyotes and mountain lions), however, researchers have developed some methods that can facilitate this process. There are two main alternative pathways for identifying individuals; methods that allow remote identification in real time, and methods that enable identification after the fact.

Marks, Tags, and Collars

One set of tools for identifying animals in real time is to capture the offending animal and mark it with a collar, unique ear tag, or unique dye marking. These three strategies allow anyone observing the animal, be it through direct observation or via camera traps or other indirect means, to identify the individual. In order to employ these strategies, the animal must first be captured using CDFW-approved protocols, then processed by trained personnel that can safely set and monitor traps, as well as immobilize, handle, and release the animal.

Capturing animals is a resource intensive process, and is frequently unsuccessful. Cage traps set for mountain lions must be monitored every 20 minutes from the time they are opened at sunset, until an animal is caught or until they are closed (usually at sunrise). If trailing hounds

are used, it requires specially trained dogs, the dog handler, and the gear and personnel for darting, extracting, and handling the mountain lion. Most hound capture days require long hours, often starting before sunrise and ending around dark. When trapping bobcats or coyotes, the process is much simpler and less time intensive, as the traps do not usually require as frequent monitoring, but it still make take many capture attempts before an animal is trapped. Capture success will be greatest if the animal is targeted soon after the depredation event; odds of capturing the offending individual drop significantly with each night that passes after the incident. Any area where trapping is being conducted should be closed to the public to avoid tampering with traps or trapped animals, driving wildlife away from traps, accidentally trapping pets, etc. The traps permitted by CDFW for capturing mountain lions, bobcats, or coyotes tend to be fairly selective when used properly, however, protocols should be in place for even occasional non-target capture situations. Some species may be safely handled without chemical immobilization, such as coyotes, while others need to be tranquilized, such as mountain lions and bobcats.

With a trapped animal in hand, it can be marked with a unique ear tag or fur dye that will allow it to be identified from a distance. Fur dye is a technique commonly used in species monitoring in which a unique marking is dyed onto an animal's fur, providing a large, easily visible, distinct identity that will last up to several months, depending on the type of dye, the environment, hair shedding schedule, etc. This method can be deployed quickly and inexpensively, and it is minimally invasive. Ear tags provide a permanent identification that is also commonly used in wildlife monitoring. It is marginally more invasive, provides a longer lasting mark, but care must be paid to other tags in the area to make sure that similar ear tags are not deployed in overlapping territories. Though the tags often have a unique number printed on the tag itself, these number are often not visible from afar, so it may be necessary to use color, shape, and other features to distinguish between tags. If ear tags are not placed properly, they can tear out, injuring the animal and making it difficult to identify that individual.

Tracking collars are the most invasive of these tools, impose the greatest risk of injury to the animal, but they also provide the greatest amount of information about the animal and its habits. There is a wide range in collar types; more basic collars emit a high frequency radio signal that can be monitored with a handheld telemetry receiver, while others collect real time tracking data that can be monitored remotely. There are a corresponding variety of collar prices ranging from a couple hundred dollars to a few thousand dollars, depending on the features required. Collar battery life can last up to a couple years before the collar needs to be replaced, however, this timeline is highly dependent on the features being used and the size of the battery deployed; higher GPS acquisition rates and other energy intensive features dramatically shorten battery life. Fitting the collar properly is extremely important and should only be performed by trained personnel, as an ill-fitting collar can easily kill the animal that is wearing it.

In addition to being useful as a way to identify individuals, tracking collars can also be used as a preventative tool. High-end collars can be set to send an email alert when the animal wearing it enters a user-determined area, such as a particular pasture, allowing producers to proactively manage their livestock and respond to a potential threat. This is most useful when a

high portion of the local carnivore community is collared; in places where only a small fraction of the carnivores are collared it could provide a false sense of security when a known collared animal is not in the area, and potentially encourage practices that leave livestock vulnerable to predation from unmarked carnivores.

Biopsy Darts and Environmental DNA

Another set of tools make it possible to identify individual carnivores by their unique genetic signature, either through sampling it from the animal directly (as in the case with biopsy darting), or by collecting it from the environment. Whichever the method used, nuclear DNA extracted and the genetic sequence contained within the sample provides a unique identity that may be compared to other samples to find matches.

If the genetic material is collected via a biopsy dart, the animal must first be captured, treed, or located in another situation in which it can be safely shot with a collection dart. It is more common to use this tool on bears or mountain lions and less common with bobcats and coyotes. When used with mountain lions, the most common method is to tree the individual with trailing hounds and then shoot it with a sampling dart once it is stationary in a tree. The dart itself is outfitted with a sharp sampling tip that extracts a small flesh punch and falls off after impact. The dart is recovered by tracking a small telemetry beacon in the base of the dart, or by finding it visually.

A variation on traditional biopsy darts is a blunt dart outfitted with sticky tape that collects a small number of hairs on impact (method described in detail in Valderrama et al. 1999). Biopsy darts are somewhat invasive, whereas the sticky dart is far less so. In either case, it is important for the animal to be stationary and oriented such that the person collecting the sample can get a clear shot at the animal's its caudal thigh, and that the dart gun is set for an appropriate pressure level; a poorly placed dart or a dart gun that is firing with too much force can turn a nonlethal projectile into a lethal one.

Collecting DNA from the environment is completely noninvasive; does not require the animal to be trapped, treed or stationary; and can be applied to any species. However, it can also be difficult to get high quality samples suitable for analysis. Usually DNA is collected from hair or scats, but it is possible to sample urine, shed skin, or saliva as well. Scats and carnivore hair often remain at kill sites and may be collected for analysis. The genetic material in hair is found in the follicle at the base of the hair. Several hairs with the follicle present are required for analysis; the greater the number of hairs available, the higher the chance of a successful analysis. Fecal DNA is collected from the outside of the scat where there are shed intestinal epithelial cells from the scat producer. There is also DNA from the prey, but there are methods for determining which DNA belongs to the scat producer. Saliva is also proving to be a successful sample material and can be collected from wounds left on the deceased animal. It is important to sample from hemorrhagic wounds, as those will reflect injuries inflicted when the animal was still alive rather than bites taken after the carcass was potentially scavenged by other carnivores (methods described in Mumma et al. 2013).

Regardless of the material used, there are a number of considerations that must be taken into account while designing data collection protocols and post processing. For example, the biologist needs to determine the number of microsatellites (short, repeated DNA sequences) necessary to be able to distinguish individuals. This number will depend on how closely related individuals are, how many individuals will be sampled, etc. In addition, how the sample is handled and stored will have a large impact on whether the sample can be successfully analyzed (specific methods are reviewed in Waits and Paetkau 2005).

Genetic tools are powerful, but implementation hurdles limit their practical utility. Genetic sampling is relatively new and growing field, and lab spaces set up to analyze genetic samples for outside entities are limited, expensive, and can take a long time for processing. Much of the current work currently conducted using eDNA occurs at university labs where the focus is on research. This tool could become more accessible to the District if the data were to align with lab research objectives, but as a management tool there are many logistical constraints.

Fencing

Separating livestock and wildlife with fencing has been one of the most common practices since livestock were first domesticated. Fences can provide protective physical barriers, psychological barriers (such as by delivering an unpleasant shock), or both. As is the case with other tools, practical considerations, such as habitat type, pasture size, livestock species and number, carnivore community, native ungulate community, topography, etc., are especially influential in determining which type of fencing is most feasible and effective. Additional regulatory constraints, constructions and maintenance costs, etc. will further restrict fencing options. An important point to keep in mind is that nearly any fence that will successfully exclude carnivores will exclude other non-avian wildlife as well. This tool could be in conflict with District fencing guidelines that deem wildlife passage a high priority. Fencing capable of hindering carnivores will likely be most useful at a small spatial scale, so as to avoid obstructing local wildlife from utilizing large swaths of habitat on District land.

Most research to date has evaluated the efficacy of using fencing to prevent coyote and dog depredation (Thompson 1976, Gates et al. 1978, Wade 1982, Acorn and Dorrance 1994). Little work has been conducted to determine proper fence construction for excluding mountain lions (Linnell et al. 1996). Fencing is likely best employed in combination with other tools, however, if producers wish to use fencing as a stand alone tool, they may find it to be most successful and cost-effective for preventing canid entry on small pastures with flat and relatively open habitat (Macon et al. 2017). Mountain lions are skilled climbers; they can scale nearly any type of fence practical for use in a livestock operation. Most electric fences are not high enough to be an effective tool for excluding mountain lions.

Fencing to exclude carnivores is likely an option best suited to small-scale use. Any fence appropriate for blocking carnivore passage will likely be effective at excluding other wildlife, which runs counter to the District's mission. Producers and the District must carefully weigh the tradeoff between the level of protection afforded by fencing and the cost of effectively

losing that area as wildlife habitat. Impacts to non-target wildlife may be minimized by making sure that fences are well maintained, wires are kept taught, the top of the fence is clearly visible (fladry or flags may be used to increase visibility), installing sections of lay-down fence in seasonal pastures for when they are not in use, and that appropriate materials are used for game trails and other areas of high wildlife activity. However, any concessions afforded to other species will likely make it easier for carnivores to cross the fence line as well.

Permanent Wire Fencing

As a physical barrier, conventional 5- or 6-strand barbed wire fences may be effective at confining cattle to a pasture, but coyotes, dogs, and mountain lions can generally penetrate this type of fence. Many producers prefer permanent steel-wire net fences. An adult coyote can climb fences less than 66 inches high, and can fit through openings greater than 4 inches by 6 inches (Thompson 1976, Linnell et al. 1996). Combining conventional woven wire fencing outfitted with an electrified top strand to prevent climbing, or adding an exterior tripwire makes them more effective than traditional fencing alone (Gates et al. 1978; Acorn and Dorrance 1994). Coyotes are expert diggers; placing a barbed wire at ground level or using a buried wire apron can discourage this. However, these additional features can become expensive, even for small pastures. Such elaborate fencing materials tend to be expensive and may be best used in calving areas or other places where calves may be vulnerable to coyote and dog predation.

Permanent Electric Fencing

Depending on the type of fence used, this tool can provide livestock and carnivores with a physical and/or psychological barrier. These fences provide an unpleasant stimulus that is uncomfortable, but ultimately not actually harmful to livestock or wildlife. The number of wires required and voltage depends on the carnivore species the producer wishes to exclude. For coyotes, there are a few designs that are considered effective. Twelve-strand smooth wire fences with alternating hot and ground with an external electrified trip wire were deemed “coyote proof” (Gates et al. 1978). Similarly, 9-strand high-tensile smooth wires with alternating hot and ground were also deemed effective options (Acorn and Dorrance 1994). In either design, the bottom strand should be hot and placed no higher than 5 inches above the ground to ensure that a coyote attempting to dig beneath the fence will receive a shock (Acorn and Dorrance 1995). As vegetation allows, the lower the bottom hot wire can be, the better it will be for preventing digging. This type of fence can be difficult in rugged terrain, as it can be difficult to maintain tension on the wires to make sure they do not touch, and ensuring that wires are close enough together such that a coyote could gain entry. For any electric fence, reducing the spacing between wires and increasing the number of wires will make it more effective and also more expensive.

The most frequent problems encountered with permanent electric fences are 1) inadequate grounding, 2) the bottom hot wire is too high above ground level (>5 inches) to prevent coyotes from digging beneath the fence, 3) wires spaced more than 6 inches apart, 4) inadequate vegetation control causing short-circuiting, 5) issues with the energizer (Acorn and

Dorrance 1995; Macon, personal communication). Dry soil conditions can also decrease electric fence efficacy.

Temporary Electric Fencing

Temporary electric fencing is a more common practice in sheep and goat husbandry than it is for cattle. Most temporary electric fences are constructed from strands of poly-wire or tape woven with steel wire to conduct electricity. As a part physical, part psychological barrier, it is important to train cattle before they will respect the boundary. Introducing large livestock to the fence in a damp area or after wetting the paddock soil can make training bouts more effective. In addition, cattle and horses have a more difficult time recognizing thin wire as a barrier; producers may increase their success by using electric tape as a visual cue (Macon, personal communication). These fences tend to have a shorter expected lifespan (3 to 7 years) than permanent fencing, however, upfront costs and construction tend to be much lower (Macon et al. 2017). To reduce labor, producers may set the ground rods strategically so the rods stay put as paddocks are rotated.

Standard electronet fencing constructed 5 feet high can effectively deter coyote and dog predation, however, this is unlikely to be a helpful tool for producers operating on open rangeland (Larson and Salmon 1988, Linnell et al. 1996). This tool may be more suitable for protecting calving grounds or other areas where cattle (calf specifically) or other livestock use is concentrated. When used in a very small area where an intruding mountain lion is nearly certain to make contact with the fence, this tool can be effective protection for any type of livestock (Cavalcanti et al. 2012). Research on specific fence designs for mountain lions is lacking, but some producers have had luck with two types of designs. The first is electronet with 3 wires, and an additional external trip wire set 3 to 4 feet away from the perimeter fence. The external wire cannot be set any closer than 3 feet or a mountain lion will be able to clear both fences without receiving a shock. Second is 8-foot fence with an overhanging hot wire on top (UCANR 2017). Mountain lions may be able to scale the fence, but this design is devised to deliver a discouraging shock when they reach the top. Keep in mind, these two designs have been recommended by livestock producers and have not been experimentally tested.

Fladry and Turbo Fladry

Originally developed to funnel quarry for hunting, fladry is a cord from which brightly colored strips of cloth or plastic flags hang at regular intervals and flap in the wind to create a displeasing novel visual stimulus. Turbo fladry has an electrified wire running through the cord with the goal of adding an additional unpleasant physical stimulus. Studied extensively with wolves, the efficacy of this psychological barrier for other species is low or remains to be studied (Musiani et al. 2003, Shivik 2003, Miller et al. 2016). Fladry and turbo fladry rely on wariness to be effective. Though wolves are deterred by these flags blowing in the wind, coyotes may be too curious for these tools to provide much of a deterrent (Musiani et al. 2003, Shivik 2003). Results from studies looking at coyote responses to fladry have provided mixed results (Musiani et al. 2003, Shivik 2003, Young et al. 2015). However, over time, even wolves habituate to

fladry and turbo fladry, making this tool appropriate for small scale, short duration use at best (Linnell et al. 1996, Musiani et al. 2003, Shivik 2003). It appears that no studies to date have assessed the potential influence fladry or turbo fladry on mountain lions, domestic dogs, or bobcats.

Night Penning

One of the most consistently effective methods for protecting livestock from predation is housing them in a fully enclosed structure during times when predation is highest (Linnell et al. 1996, Miller et al. 2016, Eklund et al. 2017). This period could be when carnivores are most active (usually from dusk until dawn each day), or it could be a life stage when livestock are particularly vulnerable (such as lambing or calving). With proper construction, protective structures can be used for nearly any type of livestock and any type of carnivore (including humans). Different carnivore species require specific building considerations. For example, coyotes and other canids are capable diggers, so effective enclosures require a solid floor, placing a barbed wire at ground level, or a buried wire apron. Mountain lions, on the other hand, do not dig, but are expert climbers. Enclosures designed to protect against mountain lions must have a sturdy roof and any openings must be too small for a mountain lion to gain entry (4 inches by 6 inches at most).

When using night pens for a prolonged period of time or with a large number of livestock, sanitation becomes an important consideration. Livestock may need more frequent anti-parasite treatment and the enclosure will need regular cleaning (Linnell et al. 1996). Small ruminants in particular, are susceptible to orthopedic infections that may be exacerbated by being enclosed with conspecifics. One potential solution is to place a therapeutic footbath at the pen entryways so animals' feet are cleaned and treated as they enter the enclosure.

Some fear that enclosing livestock restricts their access to forage and will reduce their ability to adequately gain weight. Research conducted on cattle and sheep suggest that they compensate for lost grazing time and are able to gain weight as well as they would if left unconfined (Linnell et al. 1996). Night penning also permits daily contact and inspection of livestock.

Though enclosures can provide extremely effective protection, they are only suitable for small-scale operations in which a human can be present each morning and evening to let animals in and out. In the future, there may be technological tools available to operate enclosures automatically or remotely, but these tools are not currently commercially available. Night penning is likely the most effective option for District tenants with chickens, alpacas, horses, or other small-scale livestock operations; this is not likely a suitable tool for cattle producers on open range.

Livestock Guarding Animals (LGA)

One of the oldest practices in the livestock protection toolbox, livestock guardian animals make also be one of the best tools for keeping livestock safe and healthy. More common in sheep and goat operations, these animals may be used with cattle as well. Benefits to using

LGAs may include reduction in predation and labor, as well as more efficient pasture use, potentially without displacing predation risk onto neighboring pastures (Linnell et al. 1996, Webber et al. 2012, Miller et al. 2016). Similar to deciding on appropriate fencing, LGAs come in a wide variety of species and breeds, and choosing the right type of guardian animal, and number needed, will depend on a variety of criteria, such as the size and type of livestock operation, terrain, level of use by the general public, carnivore species present, etc. The cost to acquire and maintain LGAs varies greatly by species and breed, and requires proper training and years of commitment from the producer. Since people started using LGAs, they have employed a wide variety of species such as dogs, llamas, cattle, ostriches, and even baboons (cited in Linnell et al. 1996). This review will focus on the three most common species in North America, dogs, llamas, and donkeys. Livestock guarding dogs are likely the most effective option for protecting against the carnivores present on District properties. Llamas and donkeys are usually less expensive to acquire and maintain, easier to train, and live longer than dogs, but they are not as effective at protecting against mountain lions (Linnell et al. 1996, Smith et al. 2000, Miller et al. 2016, Macon et al. 2017, Scasta et al. 2017). There is an extensive literature on training livestock guarding animals, breed selection, care, and maintenance, the details of which are beyond the scope of this review (see Smith et al. 2000, Dawydiak and Sims 2003).

Livestock Guarding Dogs (LGDs)

There are many breeds of livestock guarding dogs that have been developed over thousands of years of selective breeding. Though many more exist, commonly found breeds in North America include Great Pyrenees, Bernese Mountain Dog, Anatolian Shepherd, Komondor, Akbash, and Maremma (Linnell et al. 1996). Animal Plant Inspection Services in collaboration with Utah State University is currently conducting research to determine whether additional breeds developed in other countries, such as Kangal, Karakachan, and Cao de Gado Transmontano, may provide reliable carnivore protection while remaining safe for use on public lands that overlap with human recreation (Kinka, personal communication). Much of the research on LGDs has focused on protecting sheep, however this is a tool that has been successfully used with cattle and other livestock species as well.

Likely to be the most effective for District producers, however, LGDs are the most expensive LGA in time and money. In order for them to be effective, LGDs must be properly trained and strongly bonded to the herd. The average time spent supervising, training, and feeding averages 9 to 10 hours each month (cited in Smith et al. 2010). If they are improperly trained and treated as pets, “the only thing they will effectively guard is the front porch” (Macon, personal communication). Initial costs range from $240 to $1000 depending on age and breed, and first year costs of shipping, food, vet bills, travel, damages caused by dogs, etc. average $700 to $900. Subsequent mean annual expenses range from $250 to $290 (cited in Smith et al. 2010). Not all dogs are appropriate for the job, roughly a quarter of LGDs injure or kill the livestock they are protecting, making selecting the right individual important. However, LGDs are more commonly used with sheep and goats, which may be easier for the dogs to harm than cattle.

Depending on their personality, guarding dogs should be temporarily removed when using shepherding dogs, as conflict between the two may arise.

If properly trained and bonded, LGDs can be highly effective, reducing depredations by up to 100% (Linnell et al. 1996, Gehring et al. 2010, Smith et al. 2010, Miller et al. 2016). They are among the most highly praised tool available. In a survey of 400 producers using over 700 dogs, 82% of respondents deemed dogs an "economic asset" and 9% ranked them as a "break even" investment, and the remaining 9% categorized them as lower value (cited in Smith et al. 2010). Compared with other preventative tools, LGDs are likely the most effective tool for operations ranging from a few animals in a small paddock to large herds on open range (cited in Macon et al. 2017).

LGDs are effective against felids as well as other canids. Properly trained LGDs with appropriate dispositions can also be effective against free-ranging dog depredations, a concern for producers operating on the urban-wildland interface (Larson and Salomon 1988). LGDs can help keep encourage herding behavior in livestock, making this tool especially effective for large-scale open range situations, and helpful to for gathering and moving livestock. In addition, LGDs disrupt a carnivore's behavior without displacing it. That is, the carnivore can still live alongside the livestock operation and maintain its territory, so protection of one pasture does not necessarily mean increased predation on a neighboring pasture or ranch (Coppinger et al. 1988). In effect, an LGD can "train" the local carnivores to respect the boundary between the dog and the carnivore. Together, the LGD and the resident carnivore, in turn, defend that area from intrusion by other members of the carnivore's species (Macon, personal communication).

A major concern for livestock operators working on District properties would be how LGDs interact with park visitors and domestic dogs. Different breeds of dogs differ in their level of aggression toward people, as do individuals within a breed. LGDs intended for use on District land where they may encounter members of the public and their pets need to be carefully screened, as overly aggressive LGDs could pose a significant risk to the public as well as companion animals. Producers may wish to post signs alerting the public to LGD presence, and temporarily bar domestic dog access. In order to bolster support and compliance, it may be wise to include information on the proactive conflict prevention program, and provide information on how to handle potential interactions with LGDs. The USDA has produced informational material to help avoid conflict between recreationalists and LGDs (USDA 2010a, USDA 2010b). Before considering LGDs, it would be prudent to consult the District's legal counsel for advice on potential liability created by their presence.

Llamas

Llamas are a member of the South American camelid family that includes alpaca and others. Though some people use alpaca as LGAs as well, llamas tend to be more territorial and aggressive than alpaca, making them better suited to livestock protection (Linnell et al. 1996). Some llamas are naturally aggressive towards dogs and coyotes; however, they are not an effective tool against mountain lions. This feature likely makes them ill suited for use by District producers, unless threats shift and District producers find a growing need to protect against

domestic dog predation. In addition, there is scant information on using llamas for protecting cattle. All of the following information is from studies addressing llamas protecting sheep. These results may or may not be transferable to cattle.

Gelded males are most commonly used and can be purchased for $700 to $800. Maintenance costs are low, as they have similar dietary and management requirements to cattle (other than needing to be sheared) (Smith et al. 2010). There is virtually no need for training, as llamas usually assimilate to sheep herds within a couple of hours to one week, however data are not available for bonding time between llamas and other species of livestock. Llamas may work best in small- to mid-sized operations on pastures up to 300 acres. Average operators recommend one gelded male llama for 250 to 300 sheep; using more than one llama per group often results in the llamas bonding with one another rather than to the herd (Andelt 2004). When confronting a carnivore, typical behaviors include alarm calling; approaching; chasing, kicking, spitting; or positioning themselves between the carnivore and the herd. It is important to note, llama's aggression towards canids makes them incompatible with LGDs or shepherding dogs. Llama size and alertness are positively correlated with aggression, making large, alert llamas likely to be the best guardians (cited in Macon et al. 2017).

Donkeys

Similar to llamas, donkeys tend to be used for protecting sheep more often than for protecting cattle, and most of the literature pertains to the former. Again, the principles may or may not be transferable to cattle operations.

Donkeys are less expensive to purchase than LGDs or llamas (between $65 and $250), and inexpensive to maintain ($66 per year on average, with a range of $0 to $300) (Smith et al. 2010). The most common varieties of donkeys used are standard or mammoth. Single jennies or gelded males are most effective, and generally need to be introduced to the herd between 3 to 6 months of age. Herd bonding should be solidified for 4 to 6 weeks before donkeys are turned on pasture with livestock. They are longer lived than LGDs, with an average life expectancy of 10-20 years. Llamas and donkeys are compatible with other depredation prevention, livestock management tools (other than shepherding dogs), and are less likely to wander beyond fence lines than LGDs (cited in Macon et al. 2017).

Typical guarding behaviors include braying, running towards or chasing the intruding carnivore, biting, and kicking. Individual donkey personality and propensity for aggression toward canids vary greatly, so introducing a donkey to a dog to evaluate their reaction before relying on that animal to protect livestock would be wise (Smith et al. 2010). Donkeys that display aggressive behavior to carnivores are most effective at deterring coyotes and dogs in small (up to 600 acres), relatively open pastures (Macon et al. 2017). Donkeys are less effective against mountain lions than LGDs.

Some donkeys are aggressive towards lambs or kids, so caution should be used when calving. It is often ineffective to use donkeys in pastures adjacent to other donkeys, horses, or mules, as they may bond with their fellow equines rather than with the target herd. Donkeys have similar dietary requirements to cattle; however, it is critical that donkeys do not have access

to feeds with ruminant-only feed additives (like Bovatec, Rumensin, and other ionophores), which are extremely toxic to all equines.

Frightening Deterrents

Various frightening devices, primarily visual and auditory, have been used to prevent livestock depredation. Some carnivore species have a tendency to avoid novel stimuli, such as randomly flashing lights (eg. Foxlights), radios, propane cannons, etc. Very little is known about the effect of acoustic and visual deterrents on livestock predation by mountain lions or bobcats, however, some research suggests that randomly emitting strobe/siren devices may temporarily deter coyote depredation. In one study with fenced-pastured sheep, coyotes were deterred for up to 91 days and reduced lamb losses by 44 to 95 percent (Linhart 1984, Linhart et al. 1992, Linnell et al. 1996). In another, random strobe lights were found to be effective at reducing coyote predation on sheep by 60 percent for the 3 months they were deployed (cited in Linnell et al. 1996). The only study addressing the efficacy of flashing lights on preventing mountain lion depredation found Foxlights to be an effective deterrent for protecting camelid bed sites for up to 4 months (Ohrens et al. 2018). A study measuring the efficacy of timed gas exploders set to go off every 7 to 8 minutes from dusk until dawn found that they were effective against coyote predation for an average of 31 days to 6 weeks before animals became habituated to the sounds (cited in Linnell et al. 1996). Acoustic devices alone seem to be less effective, but they have only been rigorously tested on bears (Miller et al. 2016). Unfortunately, there has been little rigorous testing of these methods, and the few studies that exist are often hampered by small sample sizes, poor experimental control, lack of strong inference, and limited ability to reliably inform management (Miller et al. 2016, Eklund et al. 2017, van Eeden et al. 2018).

Some tools are designed to emit an unpleasant stimulus at random intervals, while others are triggered by animal presence. Foxlights, Predator Guard, and other similar devices belong in the former group of tools that randomly emit bright, displeasing lights from sunset until sunrise when most carnivores are most active. Motion-activated sprinklers, lights, and sound devices, on the other hand, are only triggered when an animal is present. Each of these tools provides a psychological barrier by making the immediately surrounding area more unpredictable and frightening, however motion-sensitive sprinklers are the only tool that deliver a physical penalty for trespass, which could increase the amount of time it takes for carnivores to habituate to them.

While deterrent devices may provide some immediate short-term protection, animals may become habituated to these tools in a matter of days or weeks, depending on the species and context in which they are being used. When used alone, these tools are likely best suited for high-risk, short-duration, small-scale use, such as calving paddocks (Koehler et al. 1990, Linnell et al. 1996, Shivik 2006, Miller et al. 2016, Ohrens et al. 2018). Combining acoustic and visual techniques may enhance efficacy and increase the time before carnivores habituate (Koehler et al. 1990, Miller et al. 2016). Additionally, tools that are behaviorally triggered (i.e. motion-sensitive devices), or provide a physical penalty (eg. sprinklers) are more likely to remain effective for a longer period of time (Shivik and Martin 2001).

Changing Cattle Breed and Operation

Generations of breeding have selected for livestock with traits that decrease their ability to identify, respond to, and avoid predation threats (Johansson 2001, Price 1999, Muhly 2010). Behavioral traits, such as docility, and physical traits, such as exaggerated meat growth, leave livestock more vulnerable than their wild ancestors (Flörcke and Grandin 2013). Switching from a more docile breed to one better equipped to protect itself could help prevent depredations. For example, changing from a gentle breed, like Hereford cattle, to a more territorial one, such as Raramuri Criollo or San Martineros, could provide more robust stock (Shaw et al. 1988). The USFWS is currently experimenting with a mixed herd of traditional beef cattle and Raramuri Criollo cattle (11 cows and 1 bull) to see whether mixing in this species of cattle will result in fewer losses to federally endangered Florida panthers. This experiment has only been running for a short duration and it is too early to tell whether this will be a successful strategy (Lotz, personal communication). Similarly, San Martineros, a little-known subspecies of Criollo cattle that descended from Spanish fighting bulls, are being introduced to mixed herds in Columbia. This breed is reportedly docile with humans, but fiercely defensive of their young and territory, even against carnivores (Economist 2017, Hoogesteijn and Hoogesteijn 2014). Maintaining docile temperaments in cattle ranging on land shared with the general public is likely an important factor to keep in mind on District property; there is an important balance to be struck between reducing the changes of livestock predation and increasing the chances that a member of the public could be hurt by cattle.

In addition to changing cattle breed, altering the type of operation can also shift the level of predation risk. Some demographics are more vulnerable than others (newborns, calves, females giving birth), and converting from a cow-calf operation to steer only could reduce depredations and be effective on any spatial scale (Shaw 1977, Shaw et al. 1988). The idea is to stock animals that are large enough to be able to escape predation, which means running only cattle that have reached 140kg or greater (Shaw 1977). Again, these considerations need to be weighed against producer preferences and public safety. Combining different livestock types (such as mixing cattle and sheep) may decrease risk as well, this may be especially beneficial for the smaller livestock (USDA 2015a).

Altering Pasture Vegetation and Grazing Regimes

Ideal carnivore hunting habitat is often determined by a combination of habitat type, topography, prey species habits, and hunting modality. Coursing predators, such as wolves, prefer open habitat where they can locate their prey and chase them for long distances, during which time they may select for weaker members of the herd (Kauffman et al. 2007). Ambush predators, such as mountain lions, rely on more heavily structured environments in which they may conceal their presence and pounce on their prey at close range (Williams et al. 2014). Altering pasture vegetation on a scale that would alter predator-prey dynamics between livestock and native carnivores likely falls outside the mission of the District, however, there are actions that could be taken on a small scale.

Rather than altering the pasture vegetation, producers can use vegetation as a guide for where and how to graze particular areas. Depredations may occur in particular "hot spots" where topography, vegetation, and animal behavior coincide to produce locations where livestock are more vulnerable (Jackson et al. 1996, Linnell et al. 1996, Miller et al. 2016). In the Santa Cruz Mountains, this is likely to be areas with rough terrain and shrubby vegetation. Oak savanna, grasslands, and other open habitats are likely to be safer areas for livestock (Yovovich 2016). Livestock producers may wish to select open habitats for calving and grazing cattle until they reach a size less vulnerable to predation (>140kg), and avoid grazing young calves in shrubby pastures where possible (Shaw 1977).

Mapping depredation occurrences to look for spatial patterns could help inform stocking decisions as well. Areas deemed higher risk could be avoided or stocked with a less vulnerable livestock demographic, or more aggressive breeds or individuals could help improve livestock safety. For example, if producers wish to graze in shrubby habitat, they could replace cow-calf pairs with bulls or individuals they know to be more aggressive.

Altering Production Calendar

Carnivores tend to optimally forage, selecting prey that is easiest to find and subdue (Lima and Dill 1990). Most carnivores will select newborns and young juveniles over adult members of the same species, as they are generally easier prey to consume. In addition, many species have a seasonal birth pulse during which time there may be an abundance of young animals afoot. Livestock producers can time their own calving to coincide with deer fawning to take advantage of easy alternative prey source that may draw mountain lions and coyotes away from livestock (Shaw 1977, Shaw 1981, Linnell et al. 1995, Sacks and Neale 2002). Research has shown that the number of cattle taken by mountain lions is likely inversely related to the abundance of local prey (Shaw 1977, Shaw 1981). Coyotes are better suited to eat small prey than they are to hunt down cattle, equines, camelids, or large pigs. Research suggests that coyotes eat livestock opportunistically, and in proportion to its availability. This means that bolstering native alternative prey could help take predation pressure off of livestock of any species (Linnell et al. 1995, Linnell et al. 1996, Sacks and Neale 2002). A different way to apply probability to protect livestock is to synchronize births. When births are staggered, a resident carnivore can predate a calf in one pasture, and then move to the next pasture when the next calf is born. If all of the calves, kids, lambs, etc. are born at the same time, it reduces the opportunity for carnivores to rotate between pastures (cited in Linnell et al. 1996)

Attractant Removal

Although they are primarily hunters, coyotes, mountain lions, dogs, and bobcats are all opportunistic scavengers as well. Dead and downed animals may attract these carnivores into areas where other livestock are grazing and can increase depredation (cited in Linnell et al. 1996). Removing sick, injured, and dead livestock may help reduce attractants that are appealing to carnivores, and may prevent further injuries to live animals. Some evidence suggests that carnivores are attracted to bone yards and may be more likely to kill livestock grazing in adjacent

pastures, and bone yards may attract livestock guarding dogs away from the livestock protection duties (cited in Macon et al. 2017). The risk to suffering additional depredations is highest immediately following an initial depredation, as the carnivore returns to feed and may injure or kill additional animals.

When possible, it is best to isolate sick or injured animals and place them in a protected area or structure. For animals that have already died, it is best to bury or remove the carcass as soon as possible, as is stated in the current District policy, to discourage carnivores from returning to the site to feed. On open range, it may be difficult or impossible to locate and retrieve carcasses. In addition, extracting and transporting carcasses to a rendering facility may be resource intensive and expensive (Antonelli et al. 2016). In these cases, the best option may be to bury carcasses as far as possible from live animals or recreational trails, while making sure to follow local laws dictating burial depth, regulations on limiting potential disease transmission, ensuring the site is appropriately far from waterways, etc.

Carcasses may be treated with lithium chloride, cupric sulphate, anthelmintic thiabendazole, emetine hydrochloride, or alpha-naphthyl-thiourea to reduce palatability, however producers will need to seek CDFW permission before applying any of these chemicals (cited in Linnell et al. 1996). These chemicals are known to cause severe nausea and could be a useful tool in conditioning carnivores against preying upon cattle, however, results on taste aversion conditioning have been mixed. If the chemicals and dosages are carefully selected, this technique is thought to have limited negative effects on non-target species (Linnell et al. 1996). Many of these chemicals have been safely used on a wide variety of species (For example, emetine hydrochloride has been safely used with coyotes, raccoons, opossums, striped skunks (cited in Linnell et al. 1996); lithium chloride has been safely used with coyotes, domestic dogs, bears (Linnell et al. 1996), amphibians and reptiles (Paradis and Cabanac 2004), and avian scavengers (Nicolaus et al. 1989); etc.). It is possible that emetic chemicals could cause aversive behavior in scavengers. Whether or not chemical aversion is a successful tool, it is best to remove a carcass where possible, as the smell of rotting meat may attract carnivores and cause further depredations even if the meat is not palatable.

Current District regulations regarding animal remains are as follows:

701.7 Depositing of Animal Remains.

No person shall bury, leave, scatter or otherwise deposit animal remains on District lands, except for cremated animal remains as specified in Section 807.

807. Scattering of Cremated Remains

807.1 Regulations for the Scattering of Cremated Remains.

No person shall scatter any cremated human or animal remains (cremains) without first having obtained a written permit from the District, and shall abide by the permit conditions which shall include, but not be limited to, the following conditions:

a) The scattering of cremains is prohibited: within 1,000 feet of any residence or dwelling, within 500 feet of any creek, stream, or other body of water, or within 50 feet of any road or trail.

b) Cremains must be scattered, must not be left in a pile, and must not be readily visible to the public.
c) No containers for the cremains, identification tags, vases, flower pots, or other associated non-organic materials, or non-native plants, may be left at the site.
d) No memorial, plaque, or other site marker may be left at the site.
e) Any person scattering cremains on District lands shall possess and present a valid District permit when scattering cremains.
f) The scattering of cremains for commercial purposes is prohibited.

E-Shepherd Collars

Designed for sheep, this tool is an electronic collar that monitors the animal's movement, recognizes when it is running, and triggers an ultrasonic alarm along with a set of LEDs with the goal of deterring the carnivore. The collar is only effective for the individual wearing it, unless the animal wearing the collar responds to a fellow animal being harassed and is close enough to the incident for the collar to discourage the predator. Collars cost roughly $130 (plus shipping from South Africa), manufacturers recommend 1 unit for every 10 sheep, and batteries last from 16 to 19 months (replacement batteries cost roughly $16 plus shipping). These collars have been successfully used on cattle in India and Nambia (Delport, personal communication), however, since the collars are triggered by fleeing behavior, this may not be an effective tool for use with ambush predators, such as mountain lions. E-Shepherd Collar manufactures make no claims on efficacy against free-roaming dogs. There are no data on the efficacy of these collars on any type of livestock operation, as these collars have not been subject to rigorous scientific testing to date.

Cowbells

Producers may outfit livestock with bells to help locate animals, or to alert shepherds to when an animal is being chased, but there are little data established on whether this practice helps deter predation. Bells on sheep alone had no impact on coyote predation (cited in Linnell et al. 1996). There were no data on whether livestock guarding dogs and bells could used together to help alert dogs to an animal in distress. There were also no data on whether cowbells could allow livestock to keep closer track of one another and aggregate when threatened. If a range rider, a shepherd who stays with livestock to protect them against predation, is within earshot of the herd, a loud bell could allow them to intervene in the event that a carnivore is harassing an animal or the herd, but this would require a person to be on site at all times, making it a very resource-intensive tool. As a standalone tool, cowbells are unlikely to be helpful for District producers unless the livestock were being grazed near a ranch home or other site where people would be within earshot.

Human Presence

Intermittent human presence among widely dispersed livestock and low-density carnivores is unlikely to have a significant positive impact (Linnell et al. 1996). However,

human presence, via herding, range riding, etc., can be highly effective in preventing depredations, as the shepherd can keep the herd together, monitor their safety, and intervene in the event of an intrusion. Unfortunately, this tool is incredibly labor and cost intensive, and likely infeasible without some form of subsidy.

Some carnivores, mountain lions in particular, are somewhat sensitive to human presence and will avoid hunting in areas with high human activity (Wilmers et al. 2013). However, other carnivores may recognize that human activities are often restricted to daylight hours and may instead shift their activities to after sunset (cited in Macon et al. 2017). Similar to visual and auditory deterrents, it is important to alter human activities so carnivores do not become habituated to certain routines and able to respond to times when they know the shepherd is absent. The key is to create an unpredictable landscape that carnivores prefer to avoid.

Since wolves were reintroduced in the mid 1990s, range rider programs have become a relatively common form of shepherding in the Northern Rockies. Some ranchers perceive range rider programs to reduce depredations, as well as a variety of social benefits (including reduced stress, reduced trespass and littering, improved public perception, and community trust building). Easier to verify benefits include identifying and treating sick animals, as well as finding and removing carcasses (Parks 2015). Many range rider programs rely on guest worker (H-2A) shepherds, most of whom come from South America. Changes in U.S. immigration policies may influence access to guest workers and could significantly affect the cost of range riding programs (American Sheep Industry Association 2015).

Volunteer Range Shepherd Program

In addition to range riders, or perhaps as an alternative, some projects have had success with volunteer range shepherds. The Wood River Wolf Project (WRWP) in Idaho designed a program in which volunteer shepherds helped protect bands of sheep against predation from black bears, grizzlies, mountain lions, coyotes, bobcats, and of greatest concern, wolves. Wolves were reintroduced to Idaho in 1995 and 1996, and as their population increased, so did conflict with livestock. The Wood River watershed is home to the "sheep superhighway," one of the largest grazing sectors in the state, and also experienced some of the highest sheep losses to wolves. A collaboration between conservation organizations, ranchers, scientists, federal government agencies, and county officials, the WRWP was started to implement and test predation deterrent strategies in an attempt to ameliorate the growing conflict between livestock producers and carnivores. Ultimately, the strategies the WRWP put in place reduced their depredation rate to 90 percent lower than neighboring sheep grazing operations (WRWP 2018). One of the strategies they utilized to achieve this remarkable success was a volunteer range shepherd program intended to deter carnivores by increasing human presence near livestock.

The WRWP worked with herders who managed bands of 1,000 to 2,000 sheep, and organized a fleet of volunteers to support the herders. These volunteer shepherds provided predation deterrence by increasing human presence near sheep bands, as well as contributing non-technical support to field staff and herders by shuttling supplies to the herders; assisting with injured animals (sheep, guard dogs, herding dogs or horses); installing, monitoring, and

collecting game cameras in the field; collecting and entering data; driving personnel to and from the field; transmitting information between herders and field staff; and implementing other nonlethal deterrents. The volunteer range shepherds performed scheduled duties, and in the event that wolves were detected nearby, they were rapidly deployed to guard a specific band. It should be noted that a program that incorporates impromptu scheduling requires a much larger supply of volunteers than a program that strictly relies on preplanned activities (Martin personal communication, WRWP 2018).

There are a few notable features that would need to be addressed make a program like the WRWP suitable for implementation on District properties. First, most of the livestock productions on District land are low-density cattle operations, whereas the WRWP runs bands of grouped sheep. A single person is much more effective monitoring and protecting a concentrated group of animals than it is for a group scattered across the landscape. Second, the local wolf packs in the Wood River watershed had one or more members collared, enabling a level of monitoring not possible for livestock producers on District land. Third, livestock in the WRWP were owned by 4 producers and protection efforts were coordinated by a single entity with staff dedicated to conflict prevention. In contrast, the District has a greater number of producers and does not currently have staff capacity earmarked for coordinating livestock protection efforts.

Aside from increasing human presence on the landscape and thereby reducing predation, range riders or range shepherds could also provide additional benefits to producers, as well as the general public. Previous range rider and range shepherd program users have reported appreciating extra help detecting injured animals and carcasses; maintaining and monitor camera traps, fencing, and other preventative tools (Foxlights, motion-activated sprinklers, etc.); detecting and reporting lost ear tags; collecting data on carnivore presence and habitat use patterns; etc. Potential benefits to the public would include increasing potential recreational activities on District land, including access to restricted areas, horseback riding, citizen science opportunities, etc. Even more importantly, this type of partnership between livestock producers and an increasingly urban general public would also provide a rare opportunity to teach Bay Area residents about the value of grazing and ranching, two frequently undervalued and often vilified practices.

When employing range riders or volunteer shepherds is impractical for producers, there are other strategies they can use to increase human presence. Feeding livestock each day could encourage herd aggregation and herding behavior, and human scent could act as a carnivore deterrent. In addition, frequent monitoring helps identify sick or injured individuals that could attract carnivores. Producers on District lands could use areas with high human recreational use as a potential shield against predation. Vulnerable livestock (such as cow-calf pairs when calves are young) could be give preferential access to highly frequented trails or camping areas to capitalize on increased human presence.

Hazing

When an animal is in an area that overlaps with vulnerable livestock, or is performing an unwanted behavior, a producer can deter the animal with unpleasant stimuli. Potential methods could include, but are not limited to, making loud noises in the carnivore's vicinity, chasing with trucks or hounds, throwing rocks, shooting with less-than-lethal munitions, etc. The target species and context will determine which tools are most appropriate. Hazing can be implemented as a general practice whenever a carnivore is seen in certain areas, or performing certain behaviors; or it can be used to target a particularly bold or aggressive individual. The most important components to hazing are to make sure the animal associates the negative stimulus with the undesired activity, and to follow through until the behavior has ceased. Though behavior-dependent, individually tailored hazing deterrents may be effective. Tools that rely on a direct interaction between a carnivore and a human potentially put both parties at risk of injury and are very resource intensive. Any person conducting hazing activities should be specially trained and following strict protocols. It would be wise to consult legal counsel before implementing any hazing program. In addition, potential hazing strategies are nearly limitless, and CDFW policy surrounding hazing is relatively vague; it would be prudent to consult local CDFW personnel before selecting any questionable methods.

Coyotes

When hazing coyotes, the person conducting the hazing activity should be sure to stand their ground; make eye contact to make sure the coyote is focused on them as the source of the disturbance. Hazing tools should be exaggerated, assertive, and when possible, should capitalize on as many senses as possible by using tools that involve sound, light, and motion. It is helpful to have variety in tools as well as the individuals administering the hazing. Coyotes can learn to recognize and avoid individual people, so varying both the tools and people involved or the clothing of the people involved (i.e. perform the hazing activity in street clothes rather than a uniform) will help avoid habituation and can decrease the number of hazing bouts necessary to teach the coyote to avoid the area more quickly.

If the coyote hesitates (freezes or moves away only a short distance), the person involved should intensify their efforts and advance toward it with the hazing tools (yelling, noisemaker, throwing rocks, waving arms, water gun, etc.). Always be sure to haze the animal until it has fully retreated to send a clear message that they should associate humans with discomfort.

It is critical to provide an escape path for the animal (i.e. never corner a coyote). It is most effective to haze on foot rather than from a building or a car where the coyote may not be able to see the person; the goal is to have the animal associate humans with danger, so it is best if they can clearly draw a link between the two. To ensure that coyotes do not return to displaying unacceptable behavior over time, it is helpful to maintain a practice of hazing in even casual interactions. Hazing should not take place if the coyote looks sick or injured, or if it has pups. In those cases, the best thing to do is to maintain eye contact and back away.

Mountain Lions

Mountain lions are very cryptic and secretive, making their behavior difficult to observe in a natural setting. As such, there is very little data on hazing practices and their efficacy; most of the information available comes from anecdotal reports. Washington Department of Fish and Wildlife uses Karelian bear dogs to haze bears, and on occasion, mountain lions, that have wandered into residential areas. They have been effective at reducing recidivism in bears, but there is insufficient data to determine whether this is an effective tool for mountain lions (Beausolei, personal communication). A study in Brazil found that targeted firecrackers and night patrolling were effective hazing tools for preventing jaguar and mountain lion depredations (Cavalcanti et al. 2012).

Increase Human Tolerance for Carnivores

Whether it is delivered when an animal is harvested, or prematurely from an unintended source, death will always be a certainty in livestock production. Perhaps more so than other sources, depredations are both an emotional and financial issue. Though it is difficult as an agency to tackle the emotional side of depredations, there are tools that can be used to lessen the financial burden. By removing some of the financial cost to operating livestock in carnivore country, perhaps the District can increase tolerance for carnivores and predation on livestock.

One option for improving producer experience with carnivores is to create or support labeling programs that allow producers access to markets where consumers are willing to pay a premium on products utilizing practices that support consumer values (in this case, carnivore friendly ranching). This has been very successful for promoting and mainstreaming practices such as organic, grass-fed, etc. For producers selling their beef locally, the Bay Area is likely a prime market for selling wildlife-friendly meat.

There are currently a few groups that certify and/or promote wildlife-friendly and/or carnivore friendly livestock management practices. For example, Wildlife Friendly Enterprise Network certifies a variety of livestock operation types and other agricultural producers from across the country who commit to a strict set of criteria to qualify for "Predator Friendly" status. Started in 1991, the program requires that participating producers employ only non-lethal preventative livestock predation deterrents. Each operation is audited and monitored annually to ensure that preventative practices remain in place. In turn, Wildlife Friendly Enterprise Network provides various marketing incentives for producers to join the program. Though this does not prevent conflict, it uses the market to help defray the cost of coexisting with carnivores and makes that relationship more profitable for producers. If producers operating on District lands can pass the cost of ranching alongside carnivores on to consumers willing to pay a premium on local products in which they believe, perhaps carnivores will become less of a burden to producers.

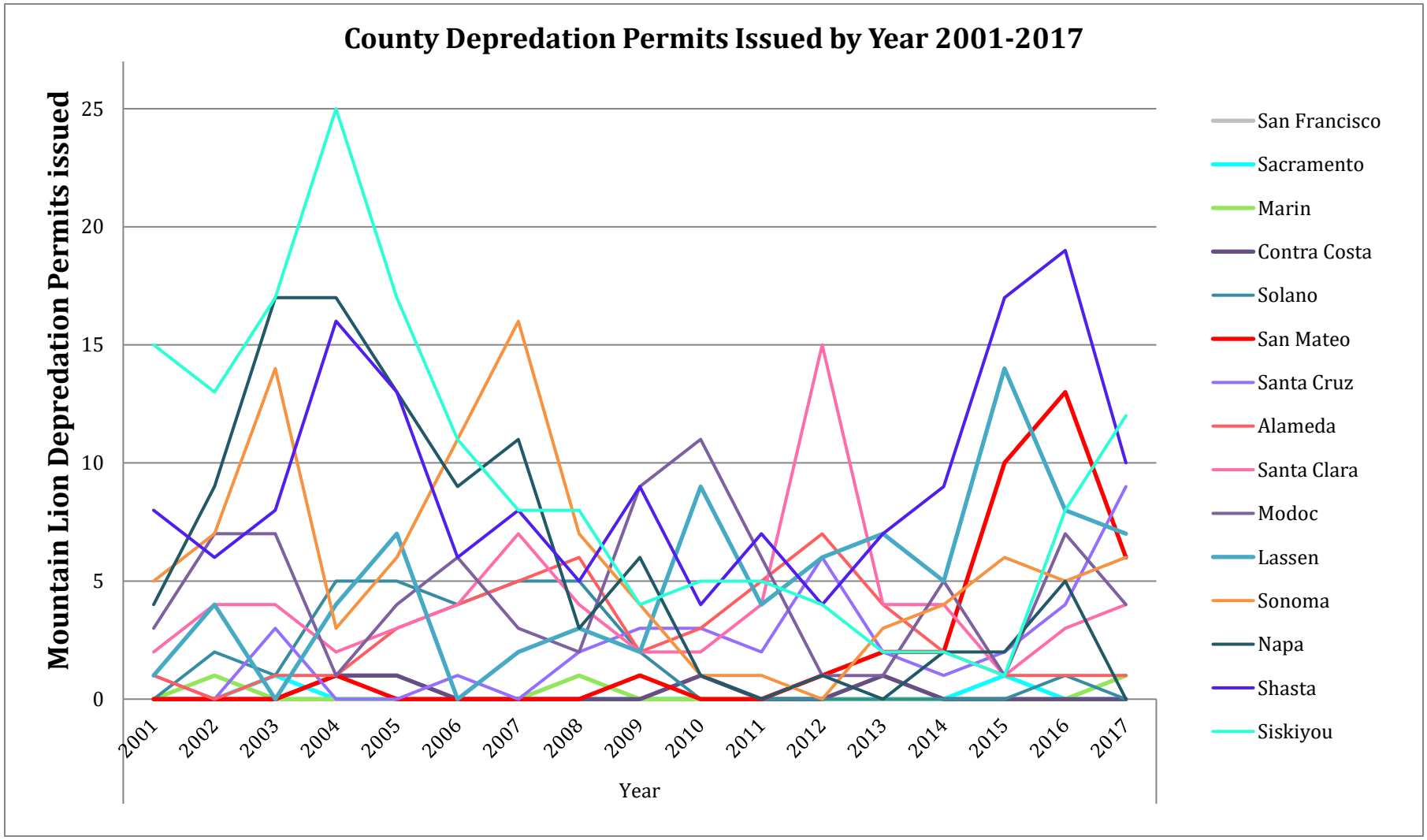
An alternative option for decreasing the cost of ranching alongside carnivores is to provide producers with reduced grazing fees. As mentioned above, this is a tool used at Point Reyes National Seashore, where livestock producers are indirectly compensated for costs associated with carnivores with a reduced grazing fee of $7.00 per AUM. The District currently charges a reduced fee of $16.15 per AUM in part to help defray costs associated with raising

livestock in rugged carnivore habitat. Producers that run cattle on federal land under the Bureau of Land Management and Forest Service were charged a grazing fee of $1.87 per AUM for 2017 (BLM 2018). In contrast, this year the East Bay Regional Park District is charging $20.75 per AUM (EBRPD 2018, Defreese, personal communication); East Bay Municipal Utilities District is charging $26.40 per AUM (Swann, personal communication), and SFPUC is charging $19.90 per AUM (Dakin, personal communication).

Communicate Dog Restrictions to the Public

Though District tenants do not report dogs as their main concern, there are a few things that the District could to do keep dog issues to a minimum. It could be beneficial to communicate the logic behind the District's leash policies. On the District's website addressing dog rules and regulations (https://www.openspace.org/what-to-do/activities/dogs), there is no mention of being vigilant around cattle, and especially calves. The District is home to a vast network of trails, and much of the adherence to following park rules is done so voluntarily. It could build support and leash rule compliance to create online materials and/or signage that let dog owners appreciate their roles as rangeland stewards. Additionally, alerting the public to their level of potential liability should their dog injure livestock (see Legal Status and Regulations - Dogs above) could help prevent negative interactions.

Appendix



Appendix 1: Reported depredation permits issued to each of the Bay Area counties and the counties in which wolves have had a significant presence. Overall, San Mateo County has lower reported depredation permits than neighboring counties, however, there has been an increase in the last 4 years (Data are available from CDFW 2018).

County	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Alameda	1	0	1	1	3	4	5	6	2	3	5	7	4	2	1	1	1
Alpine	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Amador	15	13	8	7	5	3	7	8	6	3	5	3	4	16	4	5	3
Butte	0	3	3	5	6	1	3	0	5	5	5	1	3	7	8	6	10
Calaveras	7	10	13	22	19	9	13	6	7	16	9	6	14	30	13	10	6
Colusa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
Contra Costa	0	0	0	1	1	0	0	0	0	1	0	0	1	0	0	0	0
Del Norte	0	0	0	4	1	3	0	1	0	2	1	0	0	1	1	0	2
El Dorado	22	14	19	19	5	7	4	4	4	17	13	16	16	23	29	13	15
Fresno	3	4	1	2	1	1	2	4	0	2	1	2	2	4	7	2	2
Glenn	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Humboldt	6	4	8	12	9	11	10	5	8	8	6	6	3	3	8	0	10
Imperial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inyo	0	2	0	2	1	0	0	0	0	0	3	1	0	0	0	1	0
Kern	3	4	2	1	4	4	3	0	4	1	1	2	3	1	8	7	1
Kings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lake	1	2	3	1	5	1	2	3	1	1	1	0	4	1	1	3	1
Lassen	1	4	0	4	7	0	2	3	2	9	4	6	7	5	14	8	7
Los Angeles	1	1	1	1	1	0	2	1	0	0	0	1	0	5	1	1	0
Madera	0	3	1	1	0	2	1	0	3	4	1	3	2	3	11	5	4
Marin	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Mariposa	2	3	0	2	5	3	10	2	3	2	7	8	5	12	11	8	11
Mendocino	26	35	20	31	18	10	17	9	5	6	13	7	5	4	7	21	13
Merced	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	1	0
Modoc	3	7	7	1	4	6	3	2	9	11	6	1	1	5	1	7	4
Mono	1	0	0	0	1	1	0	1	0	1	0	2	0	0	1	0	0
Monterey	2	8	5	7	6	2	13	2	5	0	3	3	5	7	4	8	2
Napa	4	9	17	17	13	9	11	3	6	1	0	1	0	2	2	5	0
Nevada	2	6	5	12	4	7	6	1	2	2	5	3	5	4	7	14	10
Orange	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2
Placer	7	5	3	2	0	4	1	0	1	4	2	4	1	4	7	5	4
Plumas	8	7	4	3	8	4	4	2	0	0	1	10	3	4	2	4	4

County	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Riverside	4	6	2	9	2	4	1	0	4	0	0	1	7	4	1	0	0
Sacramento	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
San Benito	1	0	0	0	0	0	1	0	0	0	4	0	0	0	0	0	0
San Bernardino	1	3	1	1	0	2	4	0	0	2	0	0	3	1	0	1	1
San Diego	7	4	1	0	0	1	1	0	0	0	2	2	2	5	2	6	2
San Francisco	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
San Joaquin	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
San Luis Obispo	3	5	7	16	8	9	6	6	2	1	7	3	10	11	24	6	7
San Mateo	0	0	0	1	0	0	0	0	1	0	0	1	2	2	10	13	6
Santa Barbara	1	2	0	1	7	2	7	3	3	2	0	0	3	3	4	6	1
Santa Clara	2	4	4	2	3	4	7	4	2	2	4	15	4	4	1	3	4
Santa Cruz	1	0	3	0	0	1	0	2	3	3	2	6	2	1	2	4	9
Shasta	8	6	8	16	13	6	8	5	9	4	7	4	7	9	17	19	10
Sierra	2	1	1	0	0	0	2	1	1	0	1	0	0	1	0	0	1
Siskiyou	15	13	17	25	17	11	8	8	4	5	5	4	2	2	1	8	12
Solano	0	2	1	5	5	4	5	5	2	0	0	0	0	0	0	1	0
Sonoma	5	7	14	3	6	11	16	7	4	1	1	0	3	4	6	5	6
Stanislaus	1	0	0	1	1	2	2	4	2	0	0	0	1	2	0	0	0
Sutter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tehama	1	1	0	3	2	1	1	0	1	4	0	0	2	1	4	4	1
Trinity	9	8	9	8	10	11	10	9	11	5	4	4	2	2	4	0	2
Tulare	1	1	1	3	2	2	0	0	0	0	0	0	0	0	0	2	0
Tuolumne	10	8	12	5	5	3	10	23	10	5	2	1	14	18	20	12	11
Ventura	0	0	1	2	1	4	3	0	1	0	0	0	1	1	1	1	0
Yolo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Yuba	0	0	4	1	1	0	0	3	0	0	0	0	1	0	2	6	2

Appendix 2: Reported depredation permits issued for all counties in California from 2001 through 2017. It is important to note that not all depredations are reported; these data may not reflect ever depredation incident that occurred within that county for a given year. It should also be noted that not all of the permits issued resulted in mountain lions being removed (These data were used to make the graph in Appendix 1 and available from CDFW 2018).

Operation Timing	Acreage	Percent Grazed Acreage	AUM	Percent AUM	Operation Type	
					Stockers	Cow/Calf Pairs
Seasonal	2,096	19	1,096	23	1	3
Year Round	8,717	81	3,640	77	2	6

Appendix 3: Year round and seasonal grazing on District properties. There are 10 properties that have cattle grazing, 4 of which are seasonal (representing 19 percent of grazed land), and the remaining 6 are year round (representing 81 percent of grazed land). Both the type of operation and operation timing can influence predation risk. For example, whether an operation is running stockers versus cow/calf pairs (with higher predation risk for cow/calf pairs) or whether an operation is seasonal versus year round (with higher predation risk for year round operations). Factors may also interact, elevating or decreasing risk accordingly. For example, holding all other factors constant, the rank order of highest potential relative risk to least would be the following:

Year round cow/calf pairs > seasonal cow/calf pairs > year round stockers > seasonal stockers

Tool	Coyote	Mountain Lion	Bobcat	Dog
Lethal removal	Moderately Effective	Moderately Effective	No Data	No Data
Permanent wire fencing	Moderately Effective	Not Effective	Not Effective	Effective
Permanent electric fencing	Effective	Moderately Effective	Effective	Effective
Temporary electric fencing	Effective	Results Vary	Effective	Effective
Fladry / Turbo fladry	Results Vary	No Data	No Data	No Data
Night penning	Effective	Effective	Effective	Effective
Livestock guarding dogs	Effective	Effective	Effective	Effective
Llamas	Moderately Effective	Not Effective	No Data+	Effective
Donkeys	Effective	Moderately Effective	No Data+	Effective
Frightening deterrents	Moderately Effective	Moderately Effective ~	No Data+	No Data
Changing cattle breed	No Data+	No Data+	No Data+	No Data+
Altering pasture vegetation	No Data+	No Data+	No Data+	No Data
Altering production calendar	Moderately Effective	Moderately Effective	Moderately Effective	No Data*
Attractant removal	Effective	Effective	Effective	Effective
E-shepherd collar	No Data+	No Data*	No Data	No Data+
Cowbell	No Data*	No Data*	No Data*	No Data*
Human presence	Results Vary	No Data+	No Data+	No Data
Hazing	Effective	No Data+	No Data+	No Data

Appendix 4: Livestock protection toolkit. The practicality and efficacy of any particular tool will depend on the type and scale of the operation, livestock species, duration of use, etc. In addition, each tool may have very specific implementation instructions, and deviation from those guidelines may render the tool ineffective.

+ Likely moderately effective to effective

* Likely ineffective

~ Limited results - one study with small sample size

Appendix 5: Acronyms and Abbreviations

AUM	Animal Unit Month
BLM	Bureau of Land Management
CDFW	California Department of Fish and Wildlife (2013- present)
CDFG	California Department of Fish and Game (1909-2012)
CCR	California Code of Regulations
District	Midpeninsula Regional Open Space District
DNA	Deoxyribonucleic acid
EBMUD	East Bay Municipal Utilities District
FGC	Fish and Game Code
GPS	Global Positioning System
LGA	Livestock Guarding Animal
LED	Light emitting diode
LGD	Livestock Guarding Dog or Livestock Guardian Dog
MCP	Marin County Program
MVZ	Museum of Vertebrate Zoology
NPS	National Park Service
SFPUC	San Francisco Public Utilities Commission
UCANR	University of California Agriculture and Natural Resources
UCCE	University of California Cooperative Extension
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
WS	Wildlife Services
WRWP	Wood River Wolf Project

References:

Acorn, R.C. and Dorrance, M.J., 1994. An evaluation of anti-coyote electric fences. *Journal of Range Management*, pp.385-387.

Agocs, C. 2007. Conservation in Action: Making Peace with Coyote. Bay Nature. Berkeley, California. Jan.-March, 2007. Available online at https://www.predatordefense.org/docs/coyotes_article_Bay_Nature_Jan-March-07.pdf (accessed March 11, 2018).

Andelt, W.F., 1996. Carnivores. *Rangeland wildlife. Society of Range Management*, Denver, Colorado, pp.133-155.

Andelt, W.F., 2004. Use of livestock guarding animals to reduce predation on livestock. *Sheep & Goat Research Journal*, pp. 72-75.

Antonelli, S., 2016. An Analysis of Wolf-Livestock Conflict Hotspots and Conflict Reduction Strategies in Northern California. *Defenders of Wildlife and Bren School of Environmental Science and Management.* p.116.

Beausolei, R. 2018. Washington Department of Fish and Wildlife, Cougar and Bear Biologist, Personal communication.

Bekoff, M., 1977. Canis latrans. *Mammalian species*, (79), pp.1-9.

Benson, J. F., P.J. Mahoney, J.A. Sikich, L.E.K. Serieys. J.P. Pollinger, H.B. Ernest and S.P.D. Riley. 2016. Interactions between demography, genetics, and landscape connectivity increase extinction probability for a small population of large carnivores in a major metropolitan area. *Proc. R. Soc. B* Vol. 283, Issue 1837.

Boggess, E.K., Andrews, R.D. and Bishop, R.A., 1978. Domestic animal losses to coyotes and dogs in Iowa. *The Journal of Wildlife Management*, pp.362-372.

Boitani, L., Ciucci, P. and Raganella-Pelliccioni, E., 2010. Predation on livestock in Italy: A tool for conservation? Wildlife Research 37: 722-730. *Wildlife Research*, *37*, pp.722-730.

Bowen, W.D., 1981. Variation in coyote social organization: the influence of prey size. *Canadian Journal of Zoology*, *59*(4), pp.639-652.

Bruskotter, J. T., J. J. Vaske, and R. H. Schmidt. 2009. Social and cognitive correlates of Utah residents' acceptance of the lethal control of wolves. *Human Dimensions of Wildlife* 14:119–132.

Bureau of Land Management (BLM). 2018. BLM and Forest Service Announce 2017 Grazing Fee. Accessed March 3, 2018. <https://www.blm.gov/press-release/blm-and-forest-service-announce-2017-grazing-fee>

California Department of Agricultrure (CDFA), 2014. California Agricultural Statistics Review 2013-2014. Available from https://www.cdfa.ca.gov/statistics/pdfs/2013/LivestockandDairy.pdf

California Department of Fish and Game (CDFG). 1998. California Fish and Game Code. Trapping practices. Bans use of specified traps and animal poisons. Initiative statute. Sections 3003.1–3003.2, 12005.5.

California Department of Fish and Game (CDFG). 1921. California Fish and Game Report. Vols. 1-20, 1914-34. 1 v. (Issued as Contribution no. 157 from the California State Fisheries Laboratory) https://archive.org/details/californiafisha00commgoog

California Department of Fish and Wildlife (CDFW). 2018. Mountain Lions in California. Accessed on 5/3/18 <https://www.wildlife.ca.gov/Conservation/Mammals/Mountain-Lion>

California Food and Agricultural Code. 1967. Division 14. Regulation and Licensing of Dogs. Chapter 8, Sections 30501-30508

Cattadori, I.M., Haydon, D.T., Thirgood, S.J. and Hudson, P.J., 2003. Are indirect measures of abundance a useful index of population density? The case of red grouse harvesting. *Oikos*, *100*(3), pp.439-446.

Cavalcanti, S.M., Crawshaw, P.G. and Tortato, F.R., 2012. Use of electric fencing and associated measures as deterrents to jaguar predation on cattle in the Pantanal of Brazil. *Fencing for Conservation* pp. 295-309.

Conner MM, Jaeger MM, Weller TJ, McCullough DR. 1998. Effect of coyote removal on sheep depredation in northern California. *Journal of Wildlife Management* 62:690–699.

Coppinger, R., Coppinger, L., Langeloh, G., Gettler, L. and Lorenz, J., 1988. A decade of use of livestock guarding dogs. *Proceedings of the Thirteenth Vertebrate Pest Conference*. p. 43.

Cougar Network, 2018. Confirmed cougar occurrences recorded by the Cougar Network. <www.cougarnet.org>, Accessed 20 March 2018.

Dakin, R. 2018. San Francisco Public Utility District, Biologist. Personal communication.

Defreese, D. 2018. East Bay Regional Park District, Wildland Vegetation Manager. Personal communication.

Dellinger, J. 2018. Mountain Lion Research & Policy. California Rangeland Conservation Coalition, Rangeland Summit. January 16, 2018, Stockton, Ca.

Delport, J. 2018. E-Shepherd Collar, Marketing Manager and Researcher. Personal communication.

Dorrance, M.J., 1982. Predation losses of cattle in Alberta. *Journal of Range Management*, pp.690-692.

Dougherty, B., 2007. *La Honda*. Arcadia Publishing.

Dawydiak, O. and Sims, D.E., 2003. Livestock protection dogs: selection, care, and training. Alpine Blue Ribbon Books. Loveland, CO.

East Bay Regional Park District (EBRPD). 2018. East Bay Regional Park District Grazing License. Accessed March 3, 2018. <http://www.ebparks.org/civicax/filebank/blobdload.aspx?BlobID=23201>

Echegaray, J. and C. Vilà 2010. Noninvasive monitoring of wolves at the edge of their distribution and the cost of their conservation. *Animal Conservation*, *13*(2), pp.157-161.

Economist. 2017. Breeding cows that can defend themselves against jaguars. February 23. Accessed March 1, 2018. https://www.economist.com/news/americas/21717415-if-big-cats-dont-kill-livestock-farmers-wont-shoot-them-breeding-cows-can-defend

Edwards, S.W., 1996. A Rancholabrean-age, latest Pleistocene bestiary for California botanists. *Four Seasons*, *10*(2), pp.4-34.

Eklund, A., López-Bao, J.V., Tourani, M., Chapron, G. and Frank, J., 2017. Limited evidence on the effectiveness of interventions to reduce livestock predation by large carnivores. *Scientific Reports*, *7*(1), p.2097.

Ernest, H. B., T.W. Vickers, S.A. Morrison, M.R. Buchalski, W.M. Boyce. 2014. Fractured Genetic Connectivity Threatens a Southern California Puma (*Puma concolor*) Population. *PLoS ONE* 9(10): e107985. doi:10.1371/journal.pone.0107985.

Fedriani, J. M., Fuller, T. K., Sauvajot, R. M. 2001. Does Anthropogenic Food Enhance Densities of Omnivorous Mammals? An Example with Coyotes in Southern California. *Ecography*. 24(3): 325-331.

Field, L.W. and Leventhal, A., 2003. What Must It Have Been Like! Critical Considerations of Precontact Ohlone Cosmology as Interpreted through Central California Ethnohistory. *Wicazo Sa Review*, *18*(2), pp.95-126.

Flörcke, C. and Grandin, T., 2013. Loss of anti-predator behaviors in cattle and the increased predation losses by wolves in the Northern Rocky Mountains. *Open Journal of Animal Sciences*, *3*(03), p.248.

Fox, C.H., 2008. Analysis of the Marin County Strategic Plan For Protection Of Livestock & Wildlife: An Alternative to Traditional Predator Control. Masters thesis, Prescott College Master Of Arts Program.

Gates, N.L., Rich, J.E., Godtel, D.D. and Hulet, C.V., 1978. Development and evaluation of anti-coyote electric fencing. *Journal of Range Management*, pp.151-153.

Gebhardt, K., Anderson, A.M., Kirkpatrick, K.N. and Shwiff, S.A., 2011. A review and synthesis of bird and rodent damage estimates to select California crops. *Crop Protection*, *30*(9), pp.1109-1116.

Gehring, T.M., VerCauteren, K.C., Provost, M.L. and Cellar, A.C., 2011. Utility of livestock-protection dogs for deterring wildlife from cattle farms. *Wildlife Research*, *37*(8), pp.715-721.

Gehrt, S.D., Riley, S.P. and Cypher, B.L. eds., 2010. Urban carnivores: ecology, conflict, and conservation. JHU Press. p. 304.

Gese, E.M., 2001. Monitoring of terrestrial carnivore populations. USDA National Wildlife Research Center, 27 pp.

Gompper, M.E., Kays, R.W., Ray, J.C., Lapoint, S.D., Bogan, D.A. and Cryan, J.R., 2006. A comparison of noninvasive techniques to survey carnivore communities in northeastern North America. *Wildlife Society Bulletin*, *34*(4), pp.1142-1151.

Harper E, Paul W, Mech L, Weisberg S. 2008. Effectiveness of lethal, directed wolf-depredation control in Minnesota. *Journal of Wildlife Management*, 72:778–784.

Henke, S.E. and Bryant, F.C., 1999. Effects of coyote removal on the faunal community in western Texas. *The Journal of Wildlife Management*, pp.1066-1081.

Hoogesteijn, R. and A. Hoogesteijn. 2014. Anti-Predation Strategies for Cattle Ranches in Latin America: A Guide. Panthera. Eckograf Soluções Impressas Ltda., Campo Grande, MS, Brazil. 64 pp.

Hulet, C.V., Anderson, D.M., Smith, J.N. and Shupe, W.L., 1987. Bonding of sheep to cattle as an effective technique for predation control. *Applied Animal Behaviour Science*, *19*(1-2), pp.19-25.

Jackson, R.M., Ahlborn, G.G., Gurung, M. and Ale, S., 1996. Reducing livestock depredation losses in the Nepalese Himalaya. *Proceedings of the Seventeenth Vertebrate Pest Conference*, pp. 241-247.

Jennens, G., 1998. Dog attacks on livestock. *Proceedings of the seventh national conference on urban animal management*, (Ed. S Hassett) (pp. 17-25).

Johansson, Ö., McCarthy, T., Samelius, G., Andrén, H., Tumursukh, L. and Mishra, C., 2015. Snow leopard predation in a livestock dominated landscape in Mongolia. *Biological Conservation*, *184*, pp.251-258.

Jones, E.J., 1987, October. Coyote damage in the southeastern United States. In *Third Eastern Wildlife Damage Control Conference*, p. 30.

Kasteen, T. 2017, 2018. California Department of Fish and Game, Wildlife Biologist. Personal communication.

Kauffman, M. J., N. Varley, D. W. Smith, D. R. Stahler, D. R. MacNulty, and M. S. Boyce. 2007. Landscape heterogeneity shapes predation in a newly restored predator-prey system. *Ecology Letters 10*:690-700.

Kinka, D. 2015. Utah State University, Department of Wildland Resources, Doctoral Candidate. Personal communication.

Lambert, C.M., Wielgus, R.B., Robinson, H.S., Katnik, D.D., Cruickshank, H.S., Clarke, R. and Almack, J., 2006. Cougar population dynamics and viability in the Pacific Northwest. *Journal of Wildlife Management*, *70*(1), pp.246-254.

Larson, S. 2006. The Marin County Predator Management Program: Will It Save the Sheep Industry? *Proceedings of the 22nd Vertebrate Pest Conference*, Published at University of California, Davis. Pp. 294-297.

Larson, S. 2018. California Rangeland Conservation Coalition. Feb 8, 2018. Stockton, CA

Larson, S. and T. P. Salomon. 1988. Predators and Sheep Management Practices in Sonoma County, California. *Proceedings Vertebrate. Pest Conference*, Printed at Univ. of Calif., Davis. 13:230-234

Lawrence, W. B., 1913. Letter Regarding Mountain Lion Hunting on Crystal Springs Property, Executive Department Spring Valley Water Company, San Francisco, CA, May 28, 1931

Levy, S. 2012. Rise of the coyote: The new top dog. *Nature* 485: 296–297.

Lima, S.L. and Dill, L.M., 1990. Behavioral decisions made under the risk of predation: a review and prospectus. *Canadian Journal of Zoology*, *68*(4), pp.619-640.

Linhart S. 1984. Efficacy of light and sound stimuli for reducing coyote predation upon pastured sheep. *Protection Ecology*, 6:75-84.

Linhart, S.B., Dasch, G.J., Johnson, R.B., Roberts, J.D. and Packham, C.J., 1992. Electronic frightening devices for reducing coyote predation on domestic sheep: efficacy under range conditions and operational use. Available from: <http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1046&context=vpc15>

Linnell, J.D., Aanes, R. and Andersen, R., 1995. Who killed Bambi? The role of predation in the neonatal mortality of temperate ungulates. *Wildlife Biology*, *1*(4), pp.209-223.

Linnell, J.D., Aanes, R., Swenson, J.E., Odden, J. and Smith, M.E., 1997. Translocation of carnivores as a method for managing problem animals: a review. *Biodiversity & Conservation*, *6*(9), pp.1245-1257.

Linnell, J.D.C. and Brøseth, H., 2003. Compensation for large carnivore depredation of domestic sheep 1994–2001. *Carnivore Damage Prevention News*, *6*(1), pp.11-13.

Linnell, J.D., Odden, J., Smith, M.E., Aanes, R. and Swenson, J.E., 1999. Large carnivores that kill livestock: do "problem individuals" really exist. *Wildlife Society Bulletin*, *27*(3), pp.698-705.

Linnell, J.D.C., Smith, M.E., Odden, J., Kaczensky, P. and Swenson, J.E., 1996. Strategies for the reduction of carnivore-livestock conflicts: a review. *Nina Oppdragsmelding*, *443*(1), p.188.

Logan, K. 2013. Colorado Parks and Wildlife, Mammals Researcher. Personal communication.

Logan, K.A. and Sweanor, L.L., 2001. Desert puma: evolutionary ecology and conservation of an enduring carnivore. Island Press.

Lotz, M. Florida 2017, 2018. Florida Fish and Wildlife Conservation Commission, Panther Biologist. Personal communication.

Macon, D. 2017. UC Cooperative Extension, Livestock and Natural Resources Advisor. Personal communication.

Macon, D., Baldwin, R., Lile, D., Stackhouse, J., Koopmann Rivers, C., Saitone, T., Schohr, T., Snell, L. Harper, J. Ingram, R., Rodrigues, K., Macaulay, L., Roche, L., Livestock Protection Tools for California Ranchers.

Marciel, D., 2006. *San Lorenzo*. Arcadia Publishing.

Martin, J. 2018. UC Berkeley Geography Department, PhD Candidate, Researcher studying the Wood River Wolf Project. Personal communication.

Messier, F. and Barrette, C., 1982. The social system of the coyote (Canis latrans) in a forested habitat. *Canadian Journal of Zoology*, *60*(7), pp.1743-1753.

Miller, B., Dugelby, B., Foreman, D., Del Río, C.M., Noss, R., Phillips, M., Reading, R., Soulé, M.E., Terborgh, J. and Willcox, L., 2001. The importance of large carnivores to healthy ecosystems. *Endangered Species Update*, *18*(5), pp.202-210.

Miller, J.R., Stoner, K.J., Cejtin, M.R., Meyer, T.K., Middleton, A.D. and Schmitz, O.J., 2016. Effectiveness of contemporary techniques for reducing livestock depredations by large carnivores. *Wildlife Society Bulletin*, *40*(4), pp.806-815.

Monroe, V. 2018. California Department of Fish and Wildlife, Human Dimensions of Wildlife, Wildlife Conflict Programs Coordinator. Personal communication.

Muhly, T.B. and Musiani, M., 2009. Livestock depredation by wolves and the ranching economy in the Northwestern US. *Ecological Economics*, *68*(8-9), pp.2439-2450.

Muhly, T.B., Alexander, M., Boyce, M.S., Creasey, R., Hebblewhite, M., Paton, D., Pitt, J.A. and Musiani, M., 2010. Differential risk effects of wolves on wild versus domestic prey have consequences for conservation. *Oikos*, *119*(8), pp.1243-1254.

Mumma, M.A., Soulliere, C.E., Mahoney, S.P. and Waits, L.P., 2014. Enhanced understanding of predator–prey relationships using molecular methods to identify predator species, individual and sex. *Molecular Ecology Resources*, *14*(1), pp.100-108.

Musiani, M., Mamo, C., Boitani, L., Callaghan, C., Gates, C.C., Mattei, L., Visalberghi, E., Breck, S. and Volpi, G., 2003. Wolf depredation trends and the use of fladry barriers to protect livestock in western North America. *Conservation Biology*, *17*(6), pp.1538-1547.

Museum of Vertebrate Zoology (MVZ), University of California. 1940. California Mountain Lion (*Felis concolor californica*) skull sample number 7823 collected in 1939 from San Mateo County, CA. Publ. Jour. Dent. Res. Vol. 19, No. 2.

Naughton-Treves, L., Grossberg, R. and Treves, A.N.D.A., 2003. Paying for tolerance: the impact of livestock depredation and compensation payments on rural citizens' attitudes toward wolves. *Conservation Biology*, *17*(6), pp.1500-11.

Neale, J.C., Sacks, B.N., Jaeger, M.M. and McCullough, D.R., 1998. A comparison of bobcat and coyote predation on lambs in north-coastal California. *Journal of Wildlife Management*, pp.700-706.

National Park Service. 2006. Ranch Comprehensive Management Plan: Ranching and Dairying Lease/Permits, accessed 3/22/2018 <https://www.nps.gov/pore/getinvolved/planning_ranch_cmp_leases_permits.htm>

Nicolaus, L.K., Herrera, J., Nicolaus, J.C. and Dimmick, C.R., 1989. Carbachol as a conditioned taste aversion agent to control avian depredation. *Agriculture, Ecosystems & Environment*, *26*(1), pp.13-21.

O'Bryan, C.J., Braczkowski, A.R., Beyer, H.L., Carter, N.H., Watson, J.E. and McDonald-Madden, E., 2018. The contribution of predators and scavengers to human well-being. *Nature ecology & evolution*, pp. 1-18.

Ohrens, O., Bonacic, C., Treves, A. 2018. Non-lethal defense of livestock against predators: Flashing lights deter puma attacks in Chile. *Frontiers in Ecology and the Environment*. (in press).

Ostfeld, R.S. and Holt, R.D., 2004. Are predators good for your health? Evaluating evidence for top-down regulation of zoonotic disease reservoirs. *Frontiers in Ecology and the Environment*, *2*(1), pp.13-20.

Paradis, S. and Cabanac, M., 2004. Flavor aversion learning induced by lithium chloride in reptiles but not in amphibians. *Behavioural Processes*, *67*(1), pp.11-18.

Parks M and Messmer T. (2016). Participant perceptions of range rider programs operating to mitigate wolf-livestock conflicts in the western United States. *Wildlife Society Bulletin*. (40)3:514-524.

Prugh, L.R., Ritland, C.E., Arthur, S.M. and Krebs, C.J., 2005. Monitoring coyote population dynamics by

genotyping faeces. *Molecular Ecology*, *14*(5), pp.1585-1596.

Pearson, E.W. and Caroline, M., 1981. Predator control in relation to livestock losses in central Texas. *Journal of Range Management*, pp.435-441.

Peebles, K. A., R. B. Wielgus, B. T. Maletzke, and M. E. Swanson. 2013. Effects of Remedial Sport Hunting on Cougar Complaints and Livestock Depredations. PLoS One 8:e79713.

Press, D. 2018. National Park Service, Point Reyes National Seashore, Wildlife Biologist. Personal Communication.

Price, E.O., 1999. Behavioral development in animals undergoing domestication. *Applied Animal Behaviour Science*, *65*(3), pp.245-271.

Ranglack, D.H., Durham, S. and Toit, J.T., 2015. Editor's Choice: Competition on the range: science vs. perception in a bison–cattle conflict in the western USA. *Journal of Applied Ecology*, *52*(2), pp.467-474.

Reiter, D. K, M. W. Brunson, and R. H. Schmidt. 1999. Public attitudes toward wildlife damage management and policy. *Wildlife Society Bulletin*, 27:74&758.

Sacks, B.N. and Neale, J.C., 2002. Foraging strategy of a generalist predator toward a special prey: coyote predation on sheep. *Ecological Applications*, *12*(1), pp.299-306.

Scasta, J.D., Stam, B. and Windh, J.L., 2017. Rancher-reported efficacy of lethal and non-lethal livestock predation mitigation strategies for a suite of carnivores. *Scientific Reports*, *7*(1), p.14105.

Shaw, H.G., 1977. Impact of mountain lion on mule deer and cattle in northwestern Arizona. *Montana Forest and Conservation Experiment Station*. pp. 17-32.

Shaw, H.G., 1981, April. Comparison of mountain lion predation on cattle on two study areas in Arizona. In *Proceedings of the Wildlife-Livestock Relationships Symposium*. Forest, Wildlife, and Range experiment Station, University of Idaho, Moscow, pp. 306-318.

Shaw, H.G., N.G. Woosley, J.R. Wegge, R.L. Day. 1988. *Factors affecting mountain lion densities and cattle depredation in Arizona: a final report*. Research Branch, Arizona Game & Fish Department.

Shivik, J.A., 2004. Non-lethal alternatives for predation management. *Sheep & Goat Research Journal*, p.14

Shivik, J.A., 2006. Tools for the edge: what's new for conserving carnivores. *AIBS Bulletin*, *56*(3), pp.253-259.

Shivik J and Martin D. 2001. Aversive and disruptive stimulus applications for managing predation. *Proceedings of the 9th Wildlife Damage Management Conference*. 111-119. Available from: <https://pdfs.semanticscholar.org/3ec2/d1810bde532534463e058195bb5e76460590.pdf>

Shivik, J.A., Treves, A. and Callahan, M., 2003. Non-lethal techniques: Primary and secondary repellents for managing predation. *Conservation Biology*, *17*, pp.1531-1537.

Shwiff, S.A. and Merrell, R.J., 2004. Coyote predation management: An economic analysis of increased antelope recruitment and cattle production in south central Wyoming. *Sheep & Goat Research Journal*, p.15.

Slagle, K., J. T. Bruskotter, A. S. Singh, and R. H. Schmidt. 2016. Attitudes toward predator control in the United States: 1995 and 2014. *Journal of Mammalogy*, *98*(1), pp.7-16.

Smith, M.E., Linnell, J.D., Odden, J. and Swenson, J.E., 2000. Review of methods to reduce livestock depredation II. Aversive conditioning, deterrents and repellents. *Acta Agriculturae Scandinavica, Section A-Animal Science*, *50*(4), pp.304-315.

Soulé, M.E., Bolger, D.T., Alberts, A.C., Wrights, J., Sorice, M. and Hill, S., 1988. Reconstructed dynamics of rapid extinctions of chaparral-requiring birds in urban habitat islands. *Conservation Biology*, *2*(1), pp.75-92.

Stone, S.A., Breck, S.W., Timberlake, J., Haswell, P.M., Najera, F., Bean, B. and Thornhill, D., 2017. Adaptive use of nonlethal strategies for minimizing wolf–sheep conflict in Idaho. *Journal of Mammalogy*, *98*(1), pp.33-44.

Stromberg, M.R., Corbin, J.D. and Antonio, C.M. eds., 2007. *California grasslands: ecology and management*. University of California Press.

Swann, C. 2018. East Bay Municipal Utilities District, Watershed Manager. Personal Communication.

Treves, A., Naughton-Treves, L., Harper, E.K., Mladenoff, D.J., Rose, R.A., Sickley, T.A. and Wydeven, A.P., 2004. Predicting human-carnivore conflict: A spatial model derived from 25 years of data on wolf predation on livestock. *Conservation Biology*, *18*(1), pp.114-125.

University of California Agriculture and Natural Resources (UCANR). 2017. Electric Fence Workshop. Penn Valley, CA. November 9, 2017.

US Department of Agriculture (USDA) 2010a. Livestock Protection Dogs: Protecting sheep from predators. Accessed March 15, 2018. Available from: <https://www.aphis.usda.gov/publications/wildlife_damage/content/printable_version/LPD-Poster.pdf>

US Department of Agriculture (USDA) 2010b. Livestock Protection Dogs: Protecting sheep from predators. Accessed March 15, 2018. Available from: <https://www.documentcloud.org/documents/3936247-Livestock-Prevention-Dogs-Protecting-Sheep-From.html>

US Department of Agriculture (USDA). 2015a. Cattle and Calves Death Loss in the United States Due to Predator and Nonpredator Causes, 2015. USDA–APHIS–VS–CEAH. Fort Collins, CO #745.1217

US Department of Agriculture (USDA). 2015b. Sheep and Lamb Predator and Nonpredator Death Loss in the United States, 2015. USDA–APHIS–VS–CEAH–NAHMS Fort Collins, CO #721.0915

Wade, D.A., 1982, February. The use of fences for predator damage control. In *Proceedings of the Tenth Vertebrate Pest Conference*, p. 47.

Waits, L.P. and Paetkau, D., 2005. Noninvasive genetic sampling tools for wildlife biologists: a review of applications and recommendations for accurate data collection. *Journal of Wildlife Management*, *69*(4), pp.1419-1433.

Washington Department of Fish and Wildlife. Karelian Bear Dog Program. Accessed February 9, 2018. <https://wdfw.wa.gov/enforcement/kbd/>

Webber, B.L., Weber, K.T., Clark, P.E., Moffet, C.A., Ames, D.P., Taylor, J.T., Johnson, D.E. and Kie, J.G., 2012. Movements of domestic sheep in the presence of livestock guardian dogs. *Review at the Journal of Rangeland Ecology and Management. Manuscript Number REM-S-12-00018*.

Wielgus RB, Peebles KA. 2014. Effects of wolf mortality on livestock depredations. *PLoS One*, 9(e113505) https://doi.org/10.1371/ journal.pone.0113505.

Wikenros, C., H. k. Sand, P. Wabakken, O. Liberg, and H. Pedersen. 2009. Wolf predation on moose and roe deer: chase distances and outcome of encounters. *Acta Theriologica*, 54:207-218.

Williams, J.S., 2003. *The Ohlone of California*. The Rosen Publishing Group.

Williams, T.M., Wolfe, L., Davis, T., Kendall, T., Richter, B., Wang, Y., Bryce, C., Elkaim, G.H. and Wilmers, C.C., 2014. Instantaneous energetics of puma kills reveal advantage of felid sneak attacks. *Science*, *346*(6205), pp.81-85.

Wilmers, C.C., Wang, Y., Nickel, B., Houghtaling, P., Shakeri, Y., Allen, M.L., Kermish-Wells, J., Yovovich, V. and Williams, T., 2013. Scale dependent behavioral responses to human development by a large predator, the puma. *PLoS One*, *8*(4), p.e60590.

Wood River Wolf Project (WRWP). 2018. Wood River Wolf Project. Accessed May 9, 2018. <https://www.woodriverwolfproject.org/>

Valderrama, X., Karesh, W.B., Wildman, D.E. and Melnick, D.J., 1999. Noninvasive methods for collecting fresh hair tissue. *Molecular Ecology*, *8*(10), pp.1749-1750.

van Eeden LM, Eklund A, Miller JRB, Lopez-Bao JV, Chapron G, Cejtin MR, et al. 2018. Carnivore conservation needs evidence-based livestock protection. *PLoS Biology* 16(9):e2005577.

Young J., Miller E., and Essex A. 2015. Evaluating fladry designs to improve utility as a nonlethal management tool to reduce livestock depredation. *Wildlife Society Bulletin*, *39*(2):429-433.

Young, J.K., Olson, K.A., Reading, R.P., Amgalanbaatar, S. and Berger, J., 2011. Is wildlife going to the dogs? Impacts of feral and free-roaming dogs on wildlife populations. *BioScience*, *61*(2), pp.125-132.

Yovovich, V. 2016. The Intersection of Carnivores and Humans: Addressing current challenges in carnivore ecology, conservation, and management. Doctoral dissertation. UC Santa Cruz, Environmental Studies Dept.

Zabel, A. and Holm-Müller, K.A.R.I.N., 2008. Conservation performance payments for carnivore conservation in Sweden. *Conservation Biology*, *22*(2), pp.247-251.

Attachment 3: Grazing Management Policy Amendment Public Outreach Responses

This document contains the details of the responses provided to the District during the Public Outreach portion of the Grazing Management Policy Amendment policy development process.

Partner Agency Workshop

The District also held a Partner Agency Workshop on January 25, 2019 to help inform policy development. The goal of this workshop was to solicit feedback on potential policy options and processes. The District gave presentations on our current conservation grazing program and grazing management policy. A representative from the California Department of Fish and Wildlife presented on the legal framework surrounding local carnivore species and Veronica Yovovich presented on the findings of the tenant survey and literature review.

Representatives from the following agencies participated in the meeting and completed a questionnaire to ascertain their agency's level of support for various potential policy options.

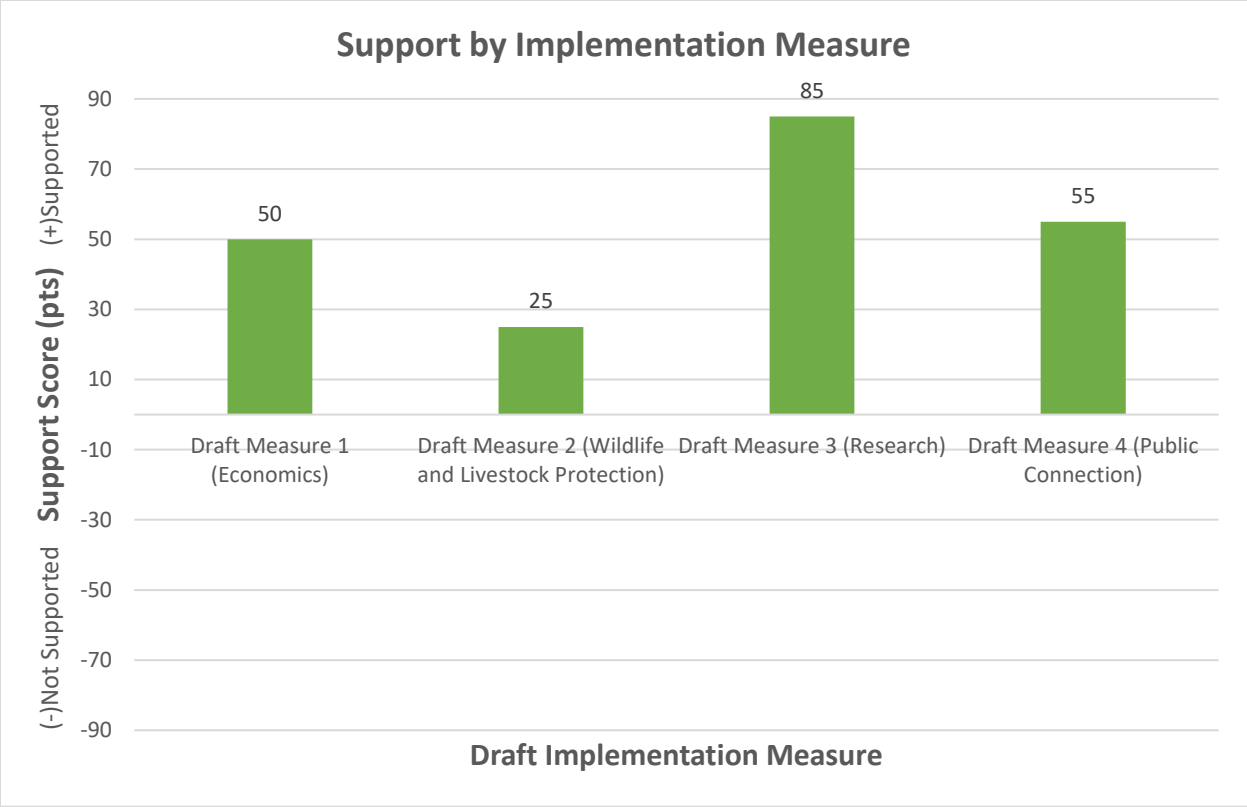
- Peninsula Open Space Trust
- San Mateo County Agricultural Commission
- San Mateo County Parks
- Santa Clara Open Space Authority
- Santa Clara County Parks
- University of California Cooperative Extension
- California Department of Fish and Wildlife
- East Bay Regional Park District
- San Francisco Public Utilities Commission
- Audubon Canyon Ranch

Partner agency representatives were asked to rate their level of support for potential implementation measures and livestock protection methods on a sliding scale (very supportive, supportive, unsure, unsupportive, very unsupportive). A numerical value was assigned to each of the potential levels of support and all responses were pooled together and ranked to gauge the overall level of support from each partner agency.

Partners ranked the potential implementation measures and livestock protection measures as follows, listed in order of support:

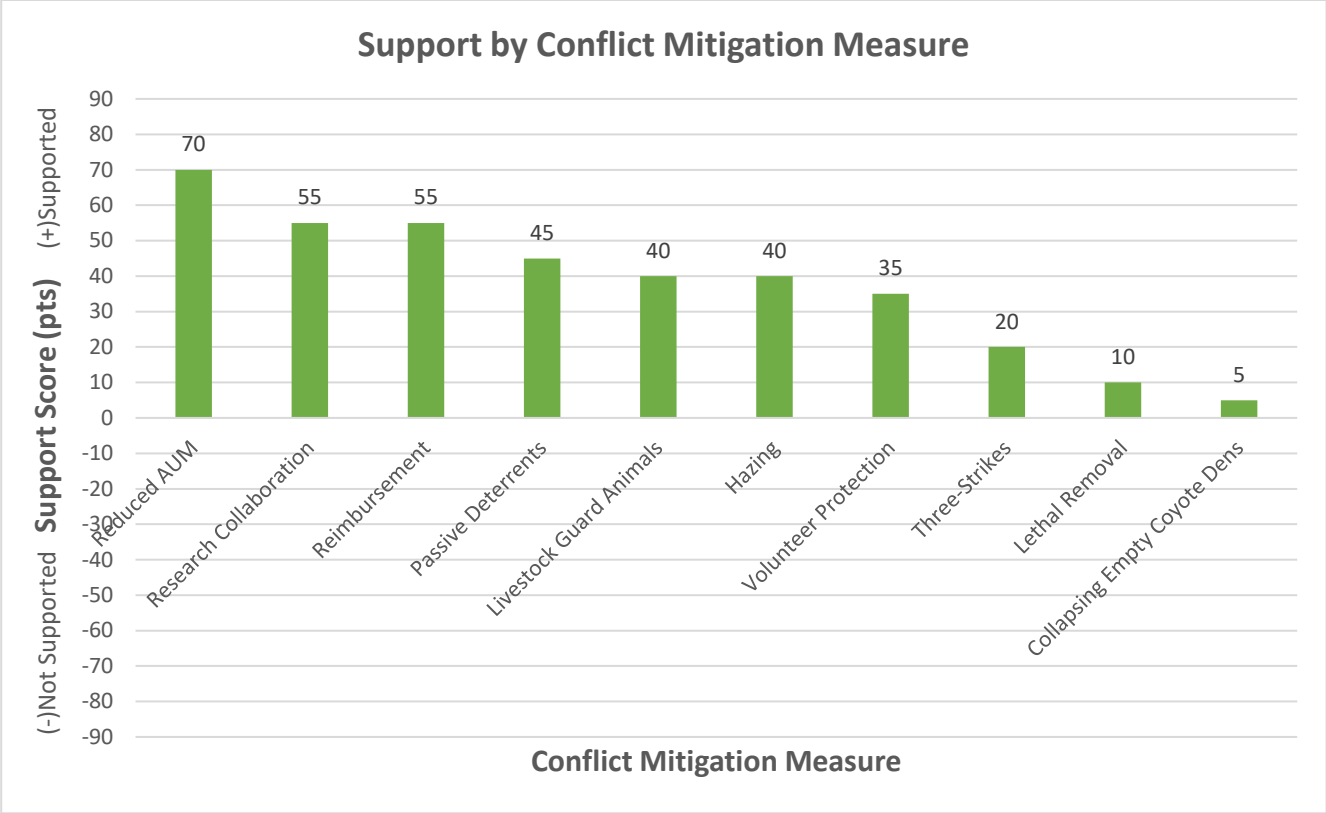
Implementation Measures

1. Research
2. Public connection
3. Economics/reimbursements
4. Livestock/wildlife conflict management



<u>Livestock protection methods</u>

1. Passive deterrents
2. Hazing
2. Livestock guard animals
4. Volunteer livestock protection program
5. Three-strikes tiered lethal removal protocol
6. Standard lethal removal
7. Collapsing empty coyote dens



All of the draft implementation measures and livestock protection methods received some level of support from the group, with none falling into the unsupported categories.

Farm Bureau Executive Committee meeting

District staff met with the San Mateo County Farm Bureau Executive Committee (SMFB) on February 19, 2019 to discuss the policy amendment process and solicit early feedback. The SMFB Committee's feedback included the following points.

- SMFB expressed their opinion that none of the deterrent methods work and that targeted removal is the only action that will work.
- SMFB expressed a willingness to use predator deterrents/management tools if the District is willing to reimburse them for their expenses.
- SMFB was concerned that removing carcasses is often logistically difficult but that they would be supportive of burying carcasses on site.
- SMFB expressed concerns over the existing reimbursement rates offered by the District to tenants. SMFB presented a calculation that current reimbursement only provides 20% of the market value.
- SMFB expressed concerns over reliance on CDFW to confirm cause of death due to predation for dead cattle, feeling that CDFW is unreliable and slow to respond.
- SMFB affirmed that the reimbursement rate should make tenants whole for the lost market value, believing it would reduce the tension between ranchers and the general public who are interested in protecting mountain lions.

- SMFB expressed more support for reimbursement than for a reduction in the rental rate and would like any carcass that has been fed on by a predator to be considered a predation related loss. Currently the District requires confirmation that a predator killed the livestock, which is only possible to determine on relatively fresh carcasses. Coyotes and mountain lions will opportunistically scavenge livestock carcasses, which may lead to the false assumption that a predator caused the loss.

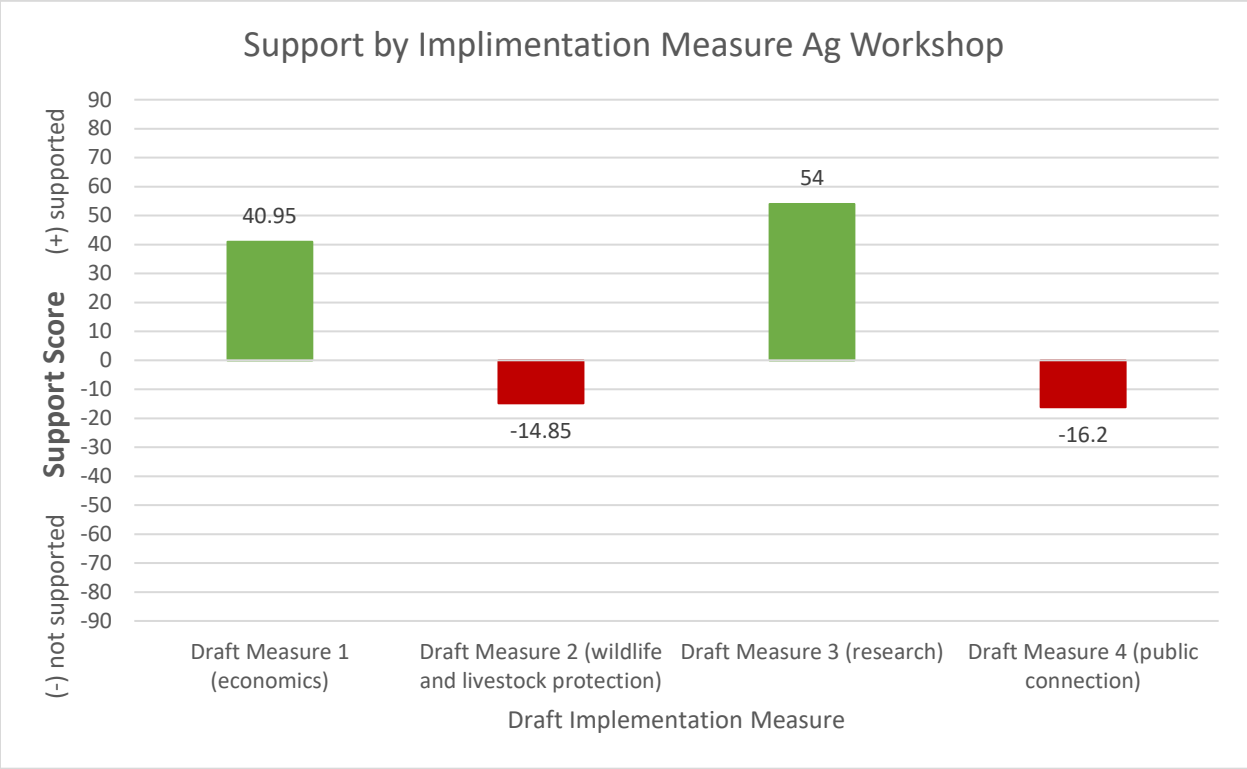
Agricultural Stakeholder Workshop

The District held an Agricultural Stakeholder Workshop at the Senior Coastsiders in Half Moon Bay on May 13 to gauge the level of support for the draft policy language from the local agricultural community. District staff invited 20 individuals representing the following organizations:

- District grazing tenants
- The San Mateo County Farm Bureau
- The San Mateo Agricultural Commission
- The California Coastal Commission
- The County of San Mateo
- The City of Half Moon Bay
- San Mateo County Resource Conservation District
- MidCoast Community Council
- Pescadero Municipal Advisory Council

In addition, a mailed invite went out to 50 individual members of the public from our interested parties list. A total of 18 members of the public attended the workshop.

The meeting consisted of indoor presentations by District Staff, The University of Santa Cruz Puma Project, District grazing tenant Ronnie Seever, and Wildlife Conflict Specialist Veronica Yovovich. The meeting was facilitated by Sheila Barry, Livestock and Natural Resources Advisor with the UC Cooperative Extension. The presentations were followed by an open discussion/question and comment period. This was then followed by a breakout small group discussions in which components of the draft policy were discussed. Feedback from these discussions were reported out to all workshop attendees by elected group representatives. After the meeting concluded, District staff arranged the feedback from each group and completed a ranking exercise to determine the level of support for each implementation measure (see chart below for details). A numerical value was assigned to each of the potential levels of support and all responses were pooled together and ranked to gauge the overall level of support from the agricultural community.



Economics:
The economics measure received a fair amount of support with the majority of respondents being supportive of reimbursement and a reduction in AUM. The majority opinion from those in attendance was that the District should reimburse for the value of the full grown cow based on the average weight of that class of livestock, sold by the grazing tenant that year . In addition, attendees requested a reduction in the AUM rate that ranged between 90% (in line with BLM prices) and 20%. Attendees were open to the idea of reporting livestock data to the District.

Wildlife and Livestock Protection:
The draft Wildlife and Livestock protection measure was not supported by the agricultural community. Attendees reported issues with the proposed 'three strikes' tiered response depredation program for mountain lions predating livestock. Meeting participants expressed doubts with California Department of Fish and Wildlife's (CDFW) ability to adequately investigate, and issue permits for reported losses. In addition, a majority of participants felt that 3 losses were too many to have to endure before being able to remove a problem predator. Some participants recommended a two strikes program, or allowing depredation permits to be issued under current CDFW policy after one confirmed loss. Hazing and the use of other deterrents was seen as simply pushing a problem animal out to neighboring properties. There was moderate support for removing or burying livestock carcasses on site, and having the District modify habitat to discourage predators (removal of vegetative cover around calving areas, as well as food and water sources). There was a general willingness to participate in livestock protection efforts if the District were willing to provide funds for time and materials.

Research:

The Research implementation measure received the most support from the agricultural workshop participants. Attendees were interested in seeing research on mountain lion effects on the local ecosystem, as well as population estimates for lions, coyotes, and deer in the region to inform management decisions. There was some doubt over the efficacy of the use of environmental DNA to identify problem wildlife that have habituated to taking livestock. A minority or participants expressed that they would only support research in non-grazing areas.

Public Connection:
The public connection, volunteer livestock protection draft policy was the least supported measure with a majority of participants being very unsupportive. The primary concerns with this measure were that cattle would be disturbed by the activities of untrained volunteers, volunteers may leave gates open or locks out of sequence, increased scrutiny of grazing operations and privacy issues, and concerns about liability. A minority of respondents expressed a willingness to work with well trained volunteers to monitor livestock for sick, injured, or dead livestock, and identify any grazing infrastructure issues.

Bayside Stakeholder Workshop
One June 6, 2019, the District held a Bayside Stakeholder workshop with the goal of receiving feedback from regional wildlife advocacy groups. The meeting format was consistent with the Agricultural workshop. A total of 31 invitations where sent out to representatives from the following organizations:

- CDFW
- Felidae Foundation
- San Francisco Public Utilities Commission
- Santa Cruz Puma Project
- Point Blue
- Defenders of Wildlife
- Swanton Pacific Ranch
- Earth Island Institute
- Peninsula Open Space Trust
- Hidden Villa
- East Bay Regional Park District
- UC Berkeley
- Santa Clara Open Space Authority
- San Mateo County Parks
- Santa Clara County Parks
- Mountain Lion Foundation
- Grass Roots Ecology
- San Mateo County RCD
- Elkhorn Slough Research Reserve
- Committee for Green Foothills

In addition, invitations went out to 184 individual members of the public pulled from an interested parties list. A total of four people attended the workshop. Two of the four attendees were from the agricultural community.

Due to low turnout from the intended audience for this workshop it is difficult to compare the feedback received with that of the previous workshops. However, the meeting did result in a productive direct dialog between a representative from Felidae, a San Mateo County Farm Bureau representative, a District grazing tenant, and District representatives. After this discussion, the representative from Felidae did offer the following insights on the proposed policy language:

Economics:

- The resource of land is in heavy demand with little supply.
- How severe are losses of livestock? They do not seem to be significant.
- Is compensation sufficient? Unsure- Have heard that only reimbursement is not sustainable.

Wildlife and Livestock Protection:

- Predators forced into smaller areas by humans will have conflicts with livestock.
- Predators are needed for biodiversity.
- Lions that attack livestock are typically young that haven't learned how to attack deer.
- There is only one puma in Marin county do to recreation usage.
- Puma are only in 14 states.
- Disease increases when predators are absent.
- Safe housing good for small livestock.
- Generally only sub-adults take livestock so eliminating adult males actually increases the problem.
- Llamas are not effective at deterring predators.
- Donkeys sometimes are able to deter predators.
- Fencing and lighting may work but pumas are intelligent and deterrents will need to be moved frequently.
- Guard dogs can be effective for coyotes.
- Coyotes are a growing problem in absence of apex predators.
- Get the message out to those illegally taking lions illegally to take young vs. mature lions.
- The three strikes plan is good because it identifies a true problem animal. It provides time/opportunity for animal to have behavior modified.

Research:

- What other causes kill cattle?
- A lot of research has been done but need to be able to approach it with an open mind. Models exist that have a holistic approach that works for ranchers, conservationists, and provides income.

Public Connection:

- Volunteers must be well trained.
- Provide good communication and information on the area.
- Ask for volunteers from within the ranching/agricultural community as well as other local entities.
- Pair volunteers up so no one goes out alone.
- Provide these volunteers feedback.
- Use wildlife cameras to monitor predator activities.

- Felidae is operating a La Honda camera trap study using local volunteers to manage the cameras. These same people might be interested in participating in a livestock protection volunteer program.

Canceled Third Combined Workshop

The District originally planned on holding a 3rd combined stakeholder workshop in Late July, 2019 that would have invited the attendees from the agricultural, and bayside, workshops to come together and hear the combined feedback from each group. Due to the low attendance at the second workshop, this meeting was cancelled and NR staff shifted strategies and began reaching out individually to target organizations to solicit feedback.

Additional Phone Interview Outreach

Outreach to individual organizations is currently ongoing. To date, NR staff has received comments from representatives from UC Davis, TomKat Ranch, and the Committee for Green Foothills. There is general support for the draft policy language from these groups. NR is continuing to reach out to other organizations that were invited to attend the bayside workshop. Once additional responses have been obtained NR staff will rank responses to form a generalized synopsis of the level of support from these groups.

Department of Fish and Wildlife
DEPARTMENTAL BULLETIN

Number: 2017-07
Date Issued: December 15, 2017
Expires: Until Superseded

To: Department of Fish and Wildlife Staff

Subject: Human/Wildlife Interactions in California: Mountain Lion Depredation, Public Safety, and Animal Welfare – Amendment to Department Bulletin 2013-02

Overview and Background

More than half of California is mountain lion habitat. Mountain lions are solitary and elusive, and their nature is to avoid people. These majestic animals, however, may prey on pets or livestock, creating depredation concerns. In some situations, mountain lions present threats to public safety.

In the spring of 2013, the Department revisited and updated the 2007 policy regarding mountain lion depredation, public safety, and animal welfare. Among other reasons, the Department reviewed the policy because human/wildlife interactions had substantially increased during that period, requiring greater staff time in the areas of research and response in the field when interactions occur. The 2013 Departmental Bulletin (Bulletin 2013-02) primarily focused on human/wildlife interactions to ensure public safety, provided stepwise guidance for incidents to field staff, and created non-lethal management options for incidents not involving public safety. Since 2013, the Department has implemented this approach, monitored results, and invested in staff training consistent with the Bulletin. Bulletin 2013-02 did not focus on the issues related to loss of property or property damage (“depredation”) from mountain lion incidents.

Landowners and property owners have legitimate concerns regarding mountain lion depredation. The Department not only understands these concerns, but is required by law to be responsive to depredation permit requests. Population growth in California’s urban/wildland interface is often manifested in 1–40 acre parcels, many of which contain livestock that may be for commercial, recreational, or aesthetic purposes. This is especially prevalent in the Santa Monica and Santa Ana mountains leading to increased conflict with wildlife in these areas as well as other rural areas of California.

Similar to the Department’s efforts to improve management of human/wildlife conflicts, in December 2015, the California Fish and Game Commission’s (Commission) Wildlife Resource Committee established its Predator Policy Working Group (PPWG). The PPWG’s role is to provide the Commission recommendations on policy and regulatory options for managing predators in California. Among the PPWG’s membership are stakeholders interested in mountain lion depredation, and the PPWG’s efforts involve many of the same challenges the Department is addressing herein.

Fundamental to the Department's conservation, education, and outreach regarding mountain lions, the Department works to (a) maintain genetically diverse and demographically viable populations, (b) minimize conflicts between mountain lions and humans, (c) identify and protect important habitats, (d) improve public awareness, and (e) identify and research emerging management and scientific issues.

This 2017 amendment is the result of consideration of recent biological and scientific information as well as human population growth; the amendment will guide depredation incident response in a defined and limited geographic area of Southern California. Bulletin 2013-02 and the emphasis on public safety is not superseded. This document is subject to further deliberation and possible amendment as new information and implementation results dictate.

Issue Statement

The purpose of this Bulletin Amendment is to establish policy for issuance of permits related to mountain lion depredation within specific Southern California mountain lion populations. Recent research indicates a lack of genetic diversity in specific areas of Southern California (Ernest et al. 2014[1]) and concomitant human population growth along with anthropogenic barriers that restrict connectivity with other populations, justifying a tailored approach to depredation response in this limited area. In addition to specific policy measures, the Department is pursuing many actions toward managing mountain lions, including coordination with federal, state, and non-governmental organization partners on projects to improve habitat connectivity, and to increase public outreach and education.

This Bulletin Amendment seeks to improve training, communication, transparency, and decision making as they relate to managing human/wildlife conflicts involving mountain lions, within a defined and limited geographic area of Southern California (i.e. the implementation area). The Department also seeks to avoid, where possible, mountain lion mortality resulting from the issuance of depredation permits in these areas. Department staff recognize that each depredation incident may be unique. Therefore, in addition to the geographically specific process defined in this policy amendment, staff responding to depredation reports should consider all factors relevant to the incident and respond appropriately given the circumstances. This amendment supplements and, where relevant, replaces Bulletin 2013-02.

Implementation Area Defined

The geographic area for purposes of implementing the policy in this Bulletin is defined in the attached Figures 1 and 2 and below in Section 6 of *Stepwise Process for Mountain Lion Incidents*. Generally, it includes parts of the Santa Monica Mountains south of Interstate 101 from Newberry Park to Burbank; west of Interstate 5 to Malibu;

[1] Ernest, Holly B., T.W. Vickers, S.A. Morrison, M.R. Buchalski, W.M. Boyce. 2014. Fractured Genetic Connectivity Threatens a Southern California Puma (*Puma concolor*) Population. PLoS ONE 9(10): e107985. doi:10.1371/journal.pone.0107985.

north of Interstate 10 near Santa Monica; and the Santa Ana Mountains south of the Anaheim/Pomona area to south of Escondido; and an eastern boundary into western Riverside County.

HUMAN/WILDLIFE INTERACTIONS POLICY AND PROCEDURES: MOUNTAIN LIONS

Mountain lions in California are a "specially protected" species (Fish and Game Code Section 4800) and may not be taken,[2] injured, possessed, transported, or imported except under specific circumstances related to depredation, public health and safety, to protect sensitive bighorn sheep populations, and other purposes as described in Division 4, Part 3, Chapter 10 of the Fish and Game Code. As the human population increases in California and communities expand into wildland areas, there has been a commensurate increase in direct and indirect interaction between mountain lions and people and an increase in calls for assistance to the Department from the public. Refer to Bulletin 2013-02 for complete policy language relative to human/wildlife interactions involving mountain lions.

Definitions

The working definitions below are additional to those in Bulletin 2013-02. All definitions apply to this policy document, and are included to assist Department employees who respond to reports and to improve the communication of the Department's response to mountain lion situations.

Reporting Party (RP) – The individual who contacts the Department about a mountain lion sighting or incident. This is most commonly a member of the public, frequently a property owner in the case of a report of depredation, or local government official.

Responder[3]: A Department employee or Department-authorized animal damage control officer who is first on the scene or otherwise designated as the responder for a particular incident. A Department-authorized responder may only serve this function if the other officer's agency or governmental entity and the Department have previously entered into a written agreement specifying protocols and clear delegation of authority. The Department retains the authority to make the final determination of qualification and authority of a responder. For an event requiring the Incident Command System, ultimately, the Incident Commander or their designee becomes the official representative of the Department.

Sensitive Population: A population that is constrained geographically and for which scientific studies suggest significant lack of genetic diversity, and/or a regional population that has low viability due to human or environmental stressors.

[2] "Take" is defined in Fish and Game Code section 86 as to "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill."

[3] This definition is updated from Bulletin 2013-02 to include the range of potential responding parties.

Training

Training is a necessary part of a professional and reasoned response to mountain lion conflict incidents. The Department has provided and will continue to provide training for staff who respond to wildlife conflict incidents. Refer to Department Bulletin 2013-02 for specific training categories relative to mountain lion incident responses.

Communications

History shows that internal and external communication is important to enhancing the public's understanding of mountain lion and human conflicts. The Office of Communications, Education, and Outreach (OCEO) is part of the Response Guidance Team (RGT) and will designate a single point-of-contact for media calls who will be responsible for information dissemination to media and public if necessary. Responders should contact their immediate supervisor and the RGT by any means available including phone, email, or dispatch. The Department will develop an internal automated email notification system for the RGT and Responders. Such development will look to our Office of Oil Spill Prevention and Response and Data Technology Division for advice on creating the system, which shall be operational in 2018.

GUIDANCE FOR MOUNTAIN LION INCIDENTS

Receiving reports of Mountain Lion Sightings, Depredation, Potential Human Conflict, or Public Safety Situations (for non-sensitive populations refer to Department Bulletin 2013-02)

STEPWISE PROCESS FOR MOUNTAIN LION INCIDENTS IN THE IMPLEMENTATION AREAS

1) First Depredation Event

a. **Confirmation of depredation.** Per Fish and Game Code section 4803, a mountain lion depredation must be verified by a responder.

b. **Oral authorization.** Per Fish and Game Code Section 4805, oral authorization to pursue (haze) the depredating mountain lion may be granted if the immediate pursuit will assist in the non-lethal removal of the mountain lion from the property. A depredation permit shall be issued as soon as practical.

c. **Education.** The responder should discuss site-specific options for managing mountain lion depredation with the RP and educate the RP regarding mountain lion behavior. Additionally, the responder should communicate that as a condition of any depredation permit, the property owner should institute logistically and economically feasible measures designed to reduce the potential for attracting mountain lions. Potential

measures include, but are not limited to: 1) removing the carcass and carcass parts of depredated animals; 2) install/repair/replace fencing or other shelter designed to exclude mountain lions from the attractant; 3) removing potential suitable habitat (e.g., cover) from the immediate vicinity by clearing brush or removing lower limbs from shrubbery.

d. **RP requests a permit.** If the RP requests a depredation permit, the Department shall issue a permit. The Department should issue a 'non-lethal' depredation permit to pursue/haze the mountain lion. Measures that could be part of a permit include, but are not limited to: 1) deploying temporary deterrent systems (e.g., motion-sensitive lighting, loud music), and 2) the use of livestock protection dogs, etc. Such permits shall explicitly indicate that no mountain lion shall be intentionally killed during this phase of the permitting process. Unique characteristics or specific collar/tag information on suspected lions shall be noted and monitored by the Department when possible.

2) **Second depredation event**. If a mountain lion depredation is reported at the same physical location (e.g. reported on animals owned by the same RP within the same geographic ownership or area) within a time period strongly suggesting a lion's affinity for the site, the Department will confirm the reported mountain lion depredation, and issue, if necessary, oral authorization in accordance with Sections 1(a) and (b) above.

a. **RP requests a permit**. If damage is confirmed, and the property owner has demonstrated that all reasonable preventative measures recommended by the Department were implemented, the responder should modify the existing permit or issue a new non-lethal depredation permit specifying additional measures not included in the previous permit (e.g., use of bean-bag shots). Such permits shall explicitly indicate that no mountain lion shall be intentionally killed during pursuit.

3) **Third depredation event**. If a mountain lion depredation is reported a third time at the same physical location (e.g. reported on animals owned by the same RP within the same geographic ownership or area) within a time period strongly suggesting a lion's affinity for the site, the responder will first verify the reported mountain lion depredation in accordance with Section 1(a) above.

a. **RP requests a permit**. If damage is confirmed by the Department, the RP has demonstrated that all reasonable preventative measures required in the existing permits were implemented, and the RP requests a lethal depredation permit, the Department shall issue a depredation permit to lethally remove the mountain lion. This permit could be via oral authorization per Fish and Game Code Section 4805.

4) **Terms and conditions of mountain lion depredation permits**. Only one mountain lion may be killed under a depredation permit. In order to ensure that

only the depredating lion will be taken, the permit shall: (1) expire 10 days after issuance; (2) authorize the permittee to begin pursuit of the depredating mountain lion not more than one mile from the depredation site; and, (3) limit the pursuit of the depredating mountain lion to within a 10-mile radius from the location of the reported damage or destruction. If damage continues to occur following the killing of a mountain lion under a permit, the Department may issue an additional depredation permit, or Fish and Game Code Section 4807 may allow for immediate additional take.

5) Tracking of permits. Upon concluding the incident, the responder shall ensure completion of the reporting requirement and close the incident. All reporting shall be complete not more than three business days after the incident is concluded. If a mountain lion is lethally taken under authority of a depredation permit, the carcass shall be collected by the Department and a necropsy performed.

6) Implementation area defined. For the purposes of this amendment the implementation area shall be defined as the following:

Santa Monica Mountains (see Figure 1)

Those portions of the state east of the junction of SR-1 and Las Posas Road; continuing north to Portero Road and the intersection of Lynn Road; the area south of Lynn Road to its intersection with US-101; the area south of US-101 continuing to CA-134; the area south of CA-134 to its intersection with I-5; the area west of I-5 to SR-2; the area west of I-405 to its intersection with I-10; the area north of I-10 to its intersection with SR-1; the area north of SR-1 to its intersection with Las Posas Road.

Santa Ana Mountains (see Figure 2)

Those portions of the state east of the junction of SR-72 and I-605; the area south of SR-60 to its junction with SR-71; the area west of SR-71 to its intersection with SR-91; the area south of SR-91 to its intersection with I-215; the area west of I-215, continuing to I-15 and its intersection with SR-79; the area south of SR-79 to its junction with SR-78; the area north of SR-78 to its intersection with I-5; the area east of I-5 to its intersection with SR-1; the area north of SR-1 to its intersection with SR-55; the area east of SR-55 to its intersection with Newport Avenue; the area east of Newport Avenue to its intersection with Cannon Street; the area east of Cannon Street and its intersection with CA-90; the area north of CA-90 to its intersection with N Puente Street; the area east of N Puente Street to SR-72; the area north of SR-72 to its junction with I-605.

7) Implementation monitoring. The Department will monitor the effects of mountain lion depredation in the implementation area to assess the efficacy of the actions described in this amendment. Subjects to be monitored include, but are not limited to, the following: social acceptance (community, agency,

stakeholder), operational feasibility (e.g., workload), and benefits to the mountain lion population within the implementation area.

Signed original on file
Charlton H. Bonham
Director

Attachments: A. Figure 1
B. Figure 2
C. Wildlife Conflict Evaluation Form

Supporting Literature

Benson, John F., P.J. Mahoney, J.A. Sikich, L.E.K. Serieys. J.P. Pollinger, H.B. Ernest and S.P.D. Riley. 2016. Interactions between demography, genetics, and landscape connectivity increase extinction probability for a small population of large carnivores in a major metropolitan area. Proc. R. Soc. B Vol. 283, Issue 1837.

Ernest, Holly B., W.M. Boyce, V.C. Bleich, B. May, S.J. Stiver and S.G. Torres. 2003. Genetic structure of mountain lion (*Puma concolor*) populations in California. Conservation Genetics Vol. 4, pp. 353–366.

Ernest Holly B., T.W. Vickers, S.A. Morrison, M.R. Buchalski, W.M. Boyce. 2014. Fractured Genetic Connectivity Threatens a Southern California Puma (*Puma concolor*) Population. PLoS ONE 9(10): e107985. doi:10.1371/journal.pone.0107985.
Gustafson K.D., T.W. Vickers, W.M. Boyce, and H.B. Ernest. 2017. A single migrant enhances the genetic diversity of an inbred puma population. R.Soc.opensci. 4: 170115. http://dx.doi.org/10.1098/rsos.170115

Morrison, Scott A. and Boyce, W.M. 2009. Conserving Connectivity: Some Lessons from Mountain Lions in Southern California. Conservation Biology, Vol. 23, No. 2, pp. 275-285.

Riley, Seth P.D., J.P. Pollinger, R.M. Sauvajot, E.C. York, C. Bromley, T.K. Fuller, R.K. Wayne. 2006. A Southern California freeway is a physical and social barrier to gene flow in carnivores. Molecular Ecology Vol. 15, pp. 1733–1741.

Riley, Seth P.D., L.E.K Serieys, J.P. Pollinger, J.A. Sikich, L. Dalbeck, R.K. Wayne, and H.B. Ernest. 2014. Individual Behaviors Dominate the Dynamics of an Urban Mountain Lion Population Isolated by Roads. Current Biology Vol. 24 No. 17, pp. 1989-1994.

Torres, S.G., T.M. Mansfield, J. Foley, T. Lupo, and A. Brinkhaus. 1996. Mountain lion and human activity in California: testing speculations. The Wildlife Society Bulletin 24(3):451-460.

Figure 1. Area of Sensitive Mountain Lion Population – Santa Monica Mountains (See Section 6 of Stepwise Process for Mountain Lion Incidents for detailed description).

Figure 2. Area of Sensitive Mountain Lion Population – Santa Ana Mountains (See Section 6 of Stepwise Process for Mountain Lion Incidents for detailed description).

Wildlife Conflict Evaluation Form

Date: _____ Time: _____

Employee Evaluator: _____

Species: _____

Descriptors (Age, sex, size, weight etc.):

Animal Behavior:

Animal Location:

Environmental Conditions:

Extenuating Circumstances: