Midpeninsula Regional
Open Space District

R-23-25
Meeting 23-06
February 22, 2023

AGENDA ITEM 7

AGENDA ITEM

Human-Mountain Lion Interaction Study and Management Plan Annual Update (Year 2)

GENERAL MANAGER'S RECOMMENDATION

Receive a presentation and provide feedback on the second annual update of the five-year Human-Mountain Lion Interaction Study. No Board action required.

SUMMARY

The Santa Cruz Puma Project (Puma Project) has completed the second year of a five-year Human-Mountain Lion Interaction Study and submitted their annual progress report (Attachment 1). The purpose of this study is to understand factors that influence human-mountain lion interactions and develop a site-specific management plan to reduce human-mountain lion conflicts.

BACKGROUND

The Midpeninsula Regional Open Space District (District) Board of Directors (Board) approved an agreement with the Puma Project to complete a five-year Human-Mountain Lion Interaction Study and Management Plan on July 22, 2020 (R-20-79, minutes). The purpose of this study is to understand factors that influence human-mountain lion interactions and develop a site-specific management plan to reduce human-mountain lion conflicts. Efforts are focused in areas where human and mountain lion interactions are most common, which include Rancho San Antonio (RSA), Fremont Older, Picchetti Ranch, and surrounding Open Space Preserves.

Research Approach
The research effort has the following objectives:

- Collar mountain lions at top priority study sites (RSA, Fremont Older, and Picchetti Ranch Open Space Preserves), secondary priority sites (Monte Bello, Foothills, and Los Trancos Open Space Preserves), and third priority sites (Saratoga Gap, Coal Creek and Windy Hill Open Space Preserves);
- Estimate the number of individual mountain lions within RSA using a District-provided wildlife camera grid;
- Compare collared mountain lion home ranges (where they primarily live) within the study area to other parts of the Santa Cruz Mountains;
- Assess factors influencing human-mountain lion interactions;
- Determine the efficacy of mountain lion behavioral modification methods;

- Develop a habitat use map that depicts mountain lion space/use, with attention to overlap between high human use and high mountain lion use areas; and
- Develop a site-specific human-mountain lion interaction management plan with actionable strategies for minimizing potential conflicts that is informed by prior research and survey findings.

Human-Mountain Lion Interaction Management Plan

The human-mountain lion interaction study will inform the development of a human-mountain lion interaction management plan (anticipated in years 4 and 5) that will provide management strategies for the District to reduce potential conflicts between preserve visitors and mountain lions. Potential strategies will be dependent on research results and may include the following:

- Preserve access modifications (by type, number, time of day, location, etc.);
- Reduction of vegetative cover in areas with high levels of human use; and
- Mountain lion behavioral modification methods, including the use of deterrents to modify mountain lion activity in areas with high levels of human use.

DISCUSSION

The majority of the study to date has focused on safely and humanely collaring mountain lions (*Puma concolor*) and gathering fine-scale data on lion movement. During year two, the Puma Project successfully collared thirteen (13) mountain lions. Of these thirteen lions, nine (9) were lions that had not been previously collared and nine (9) utilize District preserves. Three (3) of these individuals have home ranges that overlap top priority sites. A total of twenty-two (22) mountain lions have been collared since the beginning of the project with fifteen (15) that utilize District preserves.

Data on mountain lion habitat use, and human recreational activities continue to be collected by the Puma Project. These data will be incorporated into models that will aid in the understanding of mountain lion and human movement patterns.

In year two, the Puma Project successfully treated three individual mountain lions using implementable and humane behavioral modification protocols that were developed during year one of the study.

The Puma Project is also coordinating with District staff to incorporate data from the Wildlife Picture Index (WPI) study at RSA Open Space Preserve (RSA) to develop a population estimate for mountain lions within this preserve with a potential for estimating populations in other District preserves using a model-based approach.

Collaring of mountain lions at top priority study sites

The Puma Project successfully collared three adult mountain lions in top priority District preserves during year two of the study (115F, 124M and 125F). One of these individuals (115F) was initially collared in 2020. The GPS collars must be periodically maintained to upload data and replace batteries, which makes recaptures necessary. 115F, a female lion, was re-collared on April 6, 2022. A male mountain lion designated 124M was collared on January 28, 2022 in Montebello Open Space Preserve. 125F, another female mountain lion, was collared on February 7, 2022 in RSA. To date, the home range of these individuals overlaps with all top priority preserves, including RSA, Fremont Older, and Picchetti Ranch Open Space Preserves as

well as lower priority preserves. including Montebello, Windy Hill, Russian Ridge, Foothills, Skyline Ridge, Coal Creek, Los Trancos.

Other lions collared

The Puma Project also collared ten (10) additional mountain lions outside of top priority preserves during the last year. Six (6) of these mountain lions, 60F, 94F, 114F, 121F, 128M, and 129F have territories that overlap with District preserves. While the remaining four (4) lions are not known to have territories that overlap with District preserves, they will provide useful data that will allow for direct comparisons between lion behavior in areas with high levels of human activity (i.e., RSA) and other locations in the Santa Cruz Mountains where human activity is lower.

Mountain lion population estimate

District staff began a Wildlife Picture Index (WPI) study at RSA in the fall of 2020. The study utilizes a grid of wildlife cameras to assess habitat use by mountain lions and other wildlife. The WPI helps the District to better understand species diversity and relative abundance (for example, the abundance of deer relative to the abundance of mountain lions within RSA), species distribution, and what factors (such as human activity) may affect wildlife behavior or use within the Preserve.

The District has worked in collaboration with the Puma Project to develop photo tagging protocols and began the process of tagging wildlife camera images with the assistance of two trained undergraduate researchers from the University of Santa Cruz California in 2022. These students earn university credits and gain valuable experience in wildlife research techniques. Data from the WPI will be combined with mountain lion collar data to estimate the number of mountain lions on District preserves and evaluate mountain lion activity patterns. The WPI data will also help calibrate estimates of human recreational trail use determined by Strava Metro data (a fitness tracking app that records recreational activities like hiking, jogging, and biking). The data analysis portion of the collaring study will take place in years four (4) through five (5) and a population estimate will not be available until the end of the study's timeframe.

Comparison of mountain lion home ranges

The Puma Project currently has calculated home range estimates from GPS location data for (16) collared mountain lions in the Santa Cruz Mountains (See Table 1). The average home range for male mountain lions in the study is 93.7km^2, while female mountain lions have an average range of 47.8km^2. A table of the available data on each individual collared mountain lion is included below. Not all collard lions have home range estimates at this time.

Table 1.

Puma ID M = male F = female	Date of Collaring	Overlapping District properties (in order of use)	Home Range Estimate
113M	11/16/2020	NA	50km^2
114F	12/22/2020	Sierra Azul, St. Joseph's Hill, Russian Ridge	61km^2
115F	12/23/2020	RSA, Montebello, Foothills, Los Trancos, Windy Hill, Coal Creek	40km^2
25F	1/8/2021	NA	37km^2

Puma ID M = male F = female	Date of Collaring	Overlapping District properties (in order of use)	Home Range Estimate
116M	2/21/2021	Sierra Azul, St. Joseph's Hill, Bear Creek Redwoods	150km^2
117M	3/29/2021	Sierra Azul, El Sereno	NA
118M	4/11/2021	RSA, Montebello, Saratoga Gap, El Sereno, Picchetti Ranch, Fremont Older, Felton Station, Bear Creek Redwoods, Los Trancos, Foothills	150km^2
119M	5/24/2021	NA	NA
120M	5/24/2021	NA	NA
121F	10/21/2021	Russian Ridge, Skyline Ridge, Long Ridge, Montebello, Saratoga Gap	53km^2
122M	11/17/2021	NA	NA
123F	12/1/2021	NA	80km^2
109F	12/6/2021	NA	70km^2
124M	1/28/2022	Montebello, RSA, Skyline Ridge, Russian Ridge, Long Ridge, Los Trancos, Foothills	65km^2
125F	2/7/2022	Montebello, Windy Hill, RSA, Russian Ridge, Foothills, Skyline Ridge, Coal Creek, Los Trancos	46km^2
126M	2/8/2022	NA	NA
60F	3/25/2022	Long Ridge, Saratoga Gap	19km^2
115F	4/6/2022	RSA, Montebello, Foothills, Los Trancos, Windy Hill, Coal Creek	40km^2
121F	4/14/2022	Russian Ridge, Skyline Ridge, Long Ridge, Montebello, Saratoga Gap	53km^2
114F	4/28/2022	Sierra Azul, St. Joseph's Hill, Russian Ridge	61km^2
25F	5/3/2022	NA	37km^2
94F	5/23/2022	Sierra Azul, Bear Creek Redwoods, St. Joseph's Hill	55km^2
127F	9/14/2022	NA	16km^2
128M	9/20/2022	Russian Ridge, Skyline Ridge, Long Ridge, Montebello	53km^2
129F	11/14/2022	Sierra Azul	60km^2
130M	11/18/2022	NA	NA

The Puma Project will continue efforts to collar additional mountain lions near priority preserves to increase the sample size for the study and better understand habitat use on District lands. Further analysis of home ranges, along with a comparison of home ranges for mountain lions outside of District preserves will be completed during years four (4) and five (5) of the study.

The Puma Project maintains a public facing "Puma Tracker" website (http://www.santacruzpumas.org/puma-tracker/), which includes an interactive map of collared mountain lion movement data. There is an eight-week delay before location data becomes available on the website to ensure that the data is not used to seek out the location of mountain lions in real time. Data from several of the mountain lions collared as part of this study are included on the website.

Assess factors influencing mountain lion-human interactions
The Puma Project is utilizing data from Strava Metro to quantify the level of human activity. In addition, the Puma Project incorporated data from OpenStreetMaps, a community-based web mapping effort, to create a trail layer that includes trails both within and beyond District Preserves that encompasses the entirety of the Santa Cruz Mountains. This effort will allow the Puma Project to showcase human use at multiple time scales (hourly, daily, monthly, and yearly). These data will be incorporated into the data analyses of movement and habitat use by collared lions to better understand mountain lion behavioral responses related to the presence of recreational trails. The Puma Project will also use data on the intensity of human activity to understand how different human activity levels affect lion behavior. These data will be used to assess the hypothesis that mountain lions are becoming habituated to human activity in areas with high levels of recreation and trail use.

The WPI study will allow for calibration of the Strava Metro data by comparing actual trail use quantified by number of users captured using the camera array with trail use estimates based on Strava data, which only captures trail use by Strava users. The WPI will also provide an index of deer and other animal activity to evaluate their effect on mountain lion behavior.

If possible, the Puma Project will also assess whether mountain lion age affects the behavioral response to human activity. This analysis is dependent on collaring additional lions representing diverse age-classes.

All the above-mentioned factors will be evaluated to determine the probability of human-mountain lion interactions within District preserves. This will help prioritize management objectives to reduce the potential for human-mountain lion conflict. Preliminary results of these analyses may be available by the end of year three of the study.

Determining efficacy of deterrents
Prior to beginning the study, the Puma Project obtained approvals from CDFW and the Institutional Animal Care and Use Committee (IACUC) for mountain lion collaring activities. On June 25, 2021, the Puma Project received additional approval for mountain lion behavioral modification protocols from the University of California, Santa Cruz IACUC, which oversees the responsible use of animals in university research and ensures the proper treatment of animals to maintain research integrity and ethical practices. These protocols were also accepted by the California Department of Fish and Wildlife and were reviewed by District Natural Resources and Visitors Services Department staff. The goal of behavioral modification is to expose mountain lions to a stimulus that can safely and effectively ward off unacceptable behavior, such as remaining in high visitor use areas for an extended period, approaching preserve visitors, and/or displaying unprovoked aggression. The Puma Project is attempting to instill an appropriate and otherwise instinctual mountain lion response of avoiding humans when coming into contact with human voices. A similar behavioral modification technique that utilizes trained dogs and human voices is also being implemented in northeastern Washington. The Washington project is showing some preliminary success, though findings have not yet been published.

With careful guidance, following approved protocols, and with support from District staff, the Puma Project successfully treated three (3) individual mountain lions during year two. The first lion treated was 124M on April 5, 2022, on land adjacent to RSA (with permission from the property owner). On December 12, 2022, 128M was treated in Russian Ridge Open Space Preserve. On December 14, 2022, 121F was treated near Mindego Creek in Russian Ridge. Treatments include locating previously collared mountain lions by using the signal emitted from

the collars and using the assistance of dogs specially trained to track their scent. Once the mountain lion was located, the researchers played audio recordings of human voices to simulate what a mountain lion is likely to hear from hikers along a recreational trail. The researchers then tagged the lion with no more than five water-based paintballs on its side and rear. The researchers and dogs would then withdraw and allow the mountain lion to leave the area. The researchers would repeat the process again on the same day, when feasible, to increase the likelihood of efficacy.

As part of this study, the Puma Project will collect data on the lions' habitat use pre and post treatment to determine the efficacy of the behavioral modification. Behavioral modification will continue into year three of the study with work continuing into year four if additional data is needed. The puma project will attempt to treat all collared individuals included in the study at least once to obtain a sufficient sample size to determine efficacy.

The Puma Project will begin investigating the effect of shaded fuelbreaks on mountain lion behavior in year three. Mountain lions do not typically move through less dense open habitat and prefer to stay under cover of dense closely spaced vegetation when possible. Data from collared mountain lions will be used to determine how they respond to existing fuel breaks and also to identify habitats that are of significant value to mountain lions (i.e., denning and/or hunting sites) so these sites are identified and protected when developing new fuel breaks. The Puma Project would also opportunistically investigate any changes in lion behavior due to the creation of new fuel breaks as part of the District's Wildland Fire Resiliency Program assuming timing and location fall within the study period and area. The Puma Project is collaborating with CalFire to obtain data for developing regional maps of fuelbreaks that have been created in the last 5 years. If results indicate that lions are avoiding and/or changing the way they move across the landscape in fuelbreak areas, the Puma Project will work with District staff to further test the efficacy of reducing human and mountain lion conflict through the modification and/or creation of fuelbreaks.

FISCAL IMPACT

None.

BOARD AND COMMITTEE REVIEW

This item was first introduced at the July 8, 2020 Special Board Meeting regarding the District's Mountain Lion Conservation Efforts, and the agreement was adopted by the full Board on July 22, 2020 (R-20-79, minutes). The Board received the first annual project update on February 9, 2021 (R-22-14, minutes).

PUBLIC NOTICE

Public notice was provided as required by the Brown Act. Public notice was sent to the Resource Management and RSA interested parties electronic mail lists.

NEXT STEPS

The Puma Project will continue collaring efforts with District support through year three of the study, with the potential to expand into year four if needed. The Puma Project will continue the behavioral modification portion of the study through year three and into year four if needed.

Years four and five will focus on data analysis and the creation of a site-specific human-mountain lion interaction management plan. The results of the study may also be published in peer-reviewed scientific journals and contribute to the current understanding of mountain lion behavior in relation to human activity. A project update will be provided to the Board annually.

Attachments:
1. Annual Report

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Human-Mountain Lion Interaction Study
Annual Progress Report 2022, Year 2
Submitted by the Santa Cruz Puma Project

Background and objectives:
In July 2020, the Midpeninsula Regional Open Space District (District) and the Santa Cruz Puma Project (SCPP) entered into an agreement to conduct a five-year mountain lion collaring study to better understand the factors that influence human-mountain lion interactions, and to develop a site-specific management plan that includes recommendations for reducing potential human-mountain lion conflict. This comes in response to an increase in mountain lion sightings on District preserves, especially high-use preserves such as Rancho San Antonio (RSA). Using a research-based approach, the SCPP will collect data related to local mountain lion population size, habitat use, and activity patterns. This information will help inform recreation and management plans that minimize the risk of potential conflict between preserve visitors and mountain lions.

The primary objectives of the Human-Mountain Lion Interaction Study are:
1. Estimate local mountain lion population size
    i. Capture and collar mountain lions that utilize top priority study sites identified by the District
    ii. Design and implement a mark-recapture study in order to estimate mountain lion abundance on District properties
2. Compare mountain lion home range sizes within the study area versus other parts of the Santa Cruz Mountains
    i. Create home range maps for animals collared on District properties and compare those to data gathered from other animals collared in the Santa Cruz Mountains
3. Assess factors influencing human-mountain lion interactions
    i. Investigate the relationship between mountain lion habitat use and recreational trails
    ii. Evaluate the hypothesis that mountain lions are becoming habituated to human activities on District lands
    iii. Investigate the role that deer play in mountain lion habitat use
    iv. Evaluate the hypothesis that young and/or dispersing individuals end up in areas with high human activity, leading to an increase in human-mountain lion interactions
    v. Evaluate the hypothesis that high human use and higher mountain lion use cause more interactions as a matter of probability rather than mountain lion behavior
4. Determine the efficacy of deterrents
    i. Design and implement a study in which behavioral modifications using dogs and/or people are administered to evaluate mountain lion behavioral response
    ii. Investigate the potential for shaded fuelbreaks to serve as a deterrent that might shift mountain lion activity away from hiking trails

Each of these objectives will be addressed in the following annual report.

Year 2 - Annual Report 2022:
The following document is an annual progress report compiled by the Santa Cruz Puma Project that describes research related activities conducted during the 2022 calendar year as part of the Human-Mountain Lion Interaction Study. During the second year of this project, SCPP focused on data collection and started preliminary analyses. SCPP continues to capture and collar mountain lions within the study area and has collected fine-scale animal movement data from 22 collared individuals. SCPP is also downloading, organizing, and analyzing human trail use data within the study area and is developing models that quantify mountain lion response to outdoor recreational activity. Finally, SCPP is studying the efficacy of deterrents in reducing human-mountain lion interactions using a behavioral modification protocol developed in year 1 of the project. This work is ongoing and will continue over the next two years. The second year of research activities has resulted in a more complete dataset that will contribute to a better understanding of human-mountain lion interactions.

Specific project objectives and updates:
Objective 1: Estimate local mountain lion population size

In year 2, SCPP successfully captured and collared 13 mountain lions. Nine of these mountain lions have territories overlapping District properties, and three mountain lions (115F, 124M, 125F) overlap with top priority sites (RSA, Fremont Older, or Pichetti Ranch). A total of 22 individual mountain lions have been captured since the start of the project. All captured mountain lions are fitted with GPS collars, which allow SCPP to remotely monitor their habitat use, movement behavior, and space use. While collaring mountain lions that overlap District property is a top priority, data from mountain lions at other sites will be used to obtain a sufficient sample size to address all objectives of this project. Moving forward, SCPP will continue to capture mountain lions and collect fine-scale movement data. A list of all captured mountain lions can be found in Table 1. A map of mountain lion home ranges for all individuals monitored during year 2 of the project can be found in Figure 1.

In year 1 of the study, District researchers deployed 9 camera traps in RSA using a standardized grid design to estimate mountain lion abundance. In addition to these 9 cameras, 21 camera sites were established along RSA trails to quantify human recreation activity. During year 2, SCPP worked with District researchers to develop a photo tagging protocol and started tagging RSA camera trap images using Wildlife Insights, a cloud-based photo tagging software. SCPP trained 2 undergraduate interns at the University of California, Santa Cruz to help with the photo tagging process. These students earn university credit and gain valuable experience in wildlife research methods. SCPP will continue training and mentoring students on this project over the next two years. When all photos are tagged, data from these camera traps will be combined with GPS collar data from overlapping mountain lions to estimate mountain lion abundance on District properties and to evaluate mountain lion activity patterns. Data from trail cameras will also be used to accurately quantify human recreation activity and correct regional trail use patterns obtained from the mobile fitness app, Strava (objective 3.ii).

Objective 2: Compare mountain lion home range sizes within the study area versus other parts of the Santa Cruz Mountains

During year 2, SCPP collected GPS location data from 9 collared mountain lions that utilized District properties. Three of these mountain lions (115F, 124M, and 125F) have territories overlapping high priority sites. Female mountain lion 115F was first captured on December 23, 2020 in RSA and later recaptured on April 6, 2022 less than 1km west of RSA to be fitted with a replacement collar. In addition to RSA, 115F's home range includes parts of Montebello, Foothills, and Los Trancos Preserves. Male mountain lion 124M was captured on January 28, 2022 in Montebello Preserve and utilized Montebello, RSA, Skyline Ridge, Russian Ridge, Long Ridge, Los Trancos, and Foothills Preserves. Female mountain lion 125F was collared on February 7, 2022 in RSA and utilized parts of RSA, Montebello, Windy Hill, Russian Ridge, Foothills, Skyline Ridge, Coal Creek, and Los Trancos Preserves. A complete list of all collared mountain lions and overlapping District preserves is detailed in Table 1.

Preliminary 95% minimum convex polygon (MCP) home range estimates for all resident individuals with at least 30 days of GPS data are also detailed in Table 1. Male and female mountain lion home ranges in this study average 93.7 and 47.8km^2 respectively across all sites. In year 3, SCPP will continue to focus on collaring more mountain lions near priority sites. This will increase sample size and allow for a more accurate understanding of mountain lion space use on District preserves. During year 3 of the study, SCPP expects to have sufficient data to begin calculating home range sizes using Local Convex Hull (LoCoH) methods, which offer more spatially accurate estimates of individual space use. SCPP will compare these estimates to LoCoHs estimated from collared mountain lions in other parts of the Santa Cruz Mountains to quantify differences in space use patterns (Objective 2).

Objective 3: Assess factors influencing mountain lion-human interactions

SCPP is using Strava to investigate the relationship between mountain lion habitat use and human recreational activity. Using a combination of Strava data and OpenStreetMaps, SCPP created a comprehensive trails layer for the Santa Cruz Mountains based on active human use. This map accurately reflects real trails in the study area and offers a better representation of their ecological effects. SCPP are incorporating this trail layer into habitat selection and animal movement models to understand how mountain lions respond to the presence and density of recreational trails. SCPP is also using Strava data to quantify the intensity of human use on these trails at multiple temporal scales. This will allow for an improved understanding of how human presence mediates mountain lion behavioral response to recreational trails.

SCPP has downloaded and processed human activity data at hourly, daily, monthly, and yearly timescales for Santa Cruz, Santa Clara, and San Mateo counties from 2018-2022. This provides a relative measure of recreation intensity for every trail in the dataset in all three counties at each timescale. SCPP then linked these data to observed mountain lion GPS locations at multiple spatial scales. SCPP is now incorporating these measures of trail density and recreation intensity into models of animal movement that will help understand how mountain lions respond to outdoor recreation at various spatial and

temporal scales. SCPP will finalize these models in year 3 of this study and results will help inform the creation of the final, site-specific human-mountain lion interaction management plan.

Using the Strava data described above, SCPP will evaluate the hypothesis that mountain lions are becoming habituated to human activities through repeated exposure to humans on District lands. The Strava data will provide an estimate of human activity and SCPP will compare the behaviors of mountain lions that are exposed to high levels of human activity to those that are less exposed to human activity. SCPP have started to calibrate Strava trail use estimates using data from camera traps and trail counters to get an accurate estimate of actual trail use (including non-Strava users). SCPP are still processing camera data for these calibrations and expect to have preliminary results by the end of year 3. This calibration process will provide an estimate of the true number of trail users within each mountain lion territory and a better estimate of human exposure thresholds that might affect mountain lion behavior.

The index of deer activity will depend on data from the District camera grid (objective 1.i). These cameras have been deployed and photo tagging is ongoing. SCPP expect to begin this analysis during year 4 of the study.

Hypotheses related to the influence of mountain lion age on responses to human activity will require more collared animals. SCPP successfully collared 9 new individuals during year 2 and plan to continue collaring efforts during year 3. By the end of year 3, SCPP expects to have data from at least 30 individuals, which should provide a sufficient sample size to begin answering questions related to the influence of age on mountain lion behavior.

The factors that affect the probability of human-mountain lion encounters will be evaluated after mountain lion abundance estimates (objective 1.ii) and intensity of trail use (objective 3.i) have been calculated. These objectives are currently in progress and preliminary results should be available by the end of year 3.

Objective 4: Determine the efficacy of deterrents

Behavioral modification involves exposing an animal involved in an unacceptable behavior to a negative stimulus in an attempt to reduce or eliminate that behavior. For our purposes, mountain lions coming into close proximity or approaching park visitors is the unacceptable behavior. SCPP is using behavioral modification techniques to help mountain lions associate human voices with negative stimuli so as to encourage avoidance of recreationists.

In year 2, SCPP finalized a field protocol for behavioral modification activities and began implementing it. In close collaboration with District staff, SCPP successfully exposed three collared mountain lions to behavioral modification techniques that included a combination of trained dogs, human voice playbacks, and non-injurious projectiles (i.e., paintballs). Male mountain lion 124M was treated on April 5, 2022 on land adjacent to RSA (with permission from property owners), approximately 500 meters west of RSA. Male mountain lion 128M was treated on December 12, 2022 in Russian Ridge Preserve. Female mountain lion 121F was treated on December 14, 2022 in Russian Ridge

Preserve. During each treatment, the mountain lion was pursued by trained hounds into a tree where it was exposed to human voice, played at 80dB, and marked with between 1-5 water-based paintball projectiles. Mountain lion movement behavior was monitored before, during, and after treatment at 5-minute temporal resolution. These data are stored on each individual's GPS collar and will be analyzed when the collars are recovered.

SCPP will continue behavioral modification work during year 3 of the project and will coordinate with District staff to schedule this work on District properties. SCPP will attempt to treat all collared individuals to at least one round of behavioral modification. When sample size is sufficient, SCPP will analyze GPS collar data to evaluate changes in habitat selection, movement behavior, and space use of each mountain lion before and after treatment. SCPP expect preliminary analyses of these data to begin in year 4. If successful, this will serve as a potential management strategy that can promote human-mountain lion coexistence and allow mountain lions to safely use habitat with a lower risk of human conflict.

Shaded fuelbreaks refer to forested areas where understory has been cleared to reduce wildfire risk. These areas may be less appealing to mountain lions because they lack dense vegetative cover suitable for concealing their movements. Thus, shaded fuelbreaks may serve dual functions, as fuelbreaks for preventing fire spread, and as a potential strategy to deter mountain lions from approaching or remaining in high use recreational areas. SCPP will begin testing the effects of fuelbreaks during year 3 of the project. SCPP is in contact with CalFire and currently developing regional maps of fuelbreaks established within the last 5 years. Fuelbreak data from San Mateo County has been collected and SCPP are in the process of collecting similar data for Santa Clara and Santa Cruz counties. Using these maps, SCPP will analyze data from collared mountain lions to test how they respond to already established fuelbreaks. If SCPP observes avoidance or a shift in movement behavior near these locations, SCPP will work closely with District staff to further test the potential of fuelbreaks to shift mountain lion activity away from high-use hiking trails on District property. SCPP will also work closely with District staff to determine the suitable locations for future fuelbreaks and ensure that proposed locations do not interfere with critical mountain lion habitat, such as denning sites.

Insights from other ongoing Puma Project research:

Recent work published by members of the Puma Project and collaborators found that anthropogenic risk is a consistent driver of carnivore movement and that mountain lions often face a trade-off when balancing anthropogenic risk exposure and energetic efficiency (Nisi et al., 2021). Mountain lions in this study were found to move more slowly and more circuitously when navigating risky landscapes. Mountain lions were also shown to exhibit scale-dependent responses to risk, with nighttime risk tolerance becoming more apparent over longer time periods. Our current research will build on these results by evaluating the degree to which mountain lions perceive recreational activity as a source of anthropogenic risk, and what behavioral responses this risk perception might induce at various spatial and temporal scales.

Other recent work from the Puma Project shows that mesopredators exhibit fear responses to human presence, and that for some species like opossums, fear response is

mediated by exposure to human development (Reilly et al., 2022). However, other species like bobcats and skunks, show more consistent fear responses across a gradient of human development. These findings suggest that some species are more likely than others to habituate to anthropogenic disturbance. Our current work will further contribute to our understanding of habituation and how long-term exposure to human disturbance might affect an individual's perception of and response to anthropogenic risk.

Finally, the Puma Project team and collaborators found that mountain lion perception of anthropogenic risk is not always consistent with the actual risk of mortality (Nisi et al., 2022). Nisi et al. (2022) shows that there is often a mismatch between mountain lion risk avoidance behavior and the locations where mountain lions are most likely to be killed. This further contributes to our understanding of fear ecology and how mountain lions respond to human activity. SCPP will build on these results with our behavioral modification research, which attempts to make human voice an accurate cue of anthropogenic risk for mountain lions.

All this work continues to improve our understanding of human-mountain lion interactions and highlights the importance of our current research in collaboration with the Midpeninsula Regional Open Space District.

Management recommendations:

Management recommendations will be provided upon further data collection and analyses.

Conclusions and next steps:

During the second year of the Human-Mountain Lion Interaction Study, SCPP successfully collared 13 mountain lions, 9 of which were previously uncollared individuals, and 9 of which utilize District properties. SCPP is actively collecting data on mountain lion space use and human recreational activity, and began integrating these data into animal movement models. SCPP also successfully treated 3 mountain lions using our recently established behavioral modification protocol. As we move into year three of the project, SCPP will continue collaring mountain lions, collecting data on mountain lion movement and human recreational activity, and performing behavioral modification work. SCPP will continue analyses of mountain lion habitat selection and movement behavior and the effects of human recreation activity on each. These data will contribute to our final human-mountain lion interaction management plan. This management plan will attempt to provide actionable strategies for minimizing human-mountain lion conflict, such as preserve access modifications, habitat modifications along trails, or mountain lion behavioral modifications. This final management plan will aim to reduce potential conflicts between preserve visitors and mountain lions and will contribute to a better understanding of human-mountain lion coexistence in multi-use landscapes.

Table 1: A record of mountain lion captures conducted by SCPP since the start of the Human Mountain Lion Interaction Study.

Study year	Puma ID	Date of capture	Estimated age at capture	Overlapping District properties (in order of use)	95% MCP home range estimate
Year 1	113M	11/16/2020	1.5yrs	NA	50km^2
	114F	12/22/2020	3yrs	Sierra Azul, St. Joseph's Hill, Russian Ridge	61km^2
	115F	12/23/2020	2yrs	RSA, Montebello, Foothills, Los Trancos, Windy Hill, Coal Creek	40km^2
	25F	1/8/2021	10yrs	NA	37km^2
	116M	2/21/2021	2.5yrs	Sierra Azul, St. Joseph's Hill, Bear Creek Redwoods	150km^2
	117M	3/29/2021	2yrs	Sierra Azul, El Sereno	NA
	118M	4/11/2021	7yrs	RSA, Montebello, Saratoga Gap, El Sereno, Picchetti Ranch, Fremont Older, Felton Station, Bear Creek Redwoods, Los Trancos, Foothills	150km^2
	119M	5/24/2021	5wks	NA	NA
	120M	5/24/2021	5wks	NA	NA
	121F	10/21/2021	3yrs	Russian Ridge, Skyline Ridge, Long Ridge, Montebello, Saratoga Gap	53km^2
	122M	11/17/2021	1.5yrs	NA	NA
	123F	12/1/2021	2yrs	NA	80km^2
	109F	12/6/2021	5.5yrs	NA	70km^2
Year 2	124M	1/28/2022	3.5yrs	Montebello, RSA, Skyline Ridge,	65km^2

|				Russian Ridge, Long Ridge, Los Trancos, Foothills	
125F	2/7/2022	2yrs	Montebello, Windy Hill, RSA, Russian Ridge, Foothills, Skyline Ridge, Coal Creek, Los Trancos	46km^2
126M	2/8/2022	10yrs	NA	NA
60F	3/25/2022	4yrs	Long Ridge, Saratoga Gap	19km^2
115F	4/6/2022 (re-collar)	3yrs	RSA, Montebello, Foothills, Los Trancos, Windy Hill, Coal Creek	40km^2
121F	4/14/2022 (re-collar)	5yrs	Russian Ridge, Skyline Ridge, Long Ridge, Montebello, Saratoga Gap	53km^2
114F	4/28/2022 (re-collar)	5yrs	Sierra Azul, St. Joseph's Hill, Russian Ridge	61km^2
25F	5/3/2022 (re-collar)	11yrs	NA	37km^2
94F	5/23/2022	5yrs	Sierra Azul, Bear Creek Redwoods, St. Joseph's Hill	55km^2
127F	9/14/2022	5yrs	NA	16km^2
128M	9/20/2022	2.5yrs	Russian Ridge, Skyline Ridge, Long Ridge, Montebello	53km^2
129F	11/14/2022	3.5yrs	Sierra Azul	60km^2
130M	11/18/2022	4yrs	NA	NA
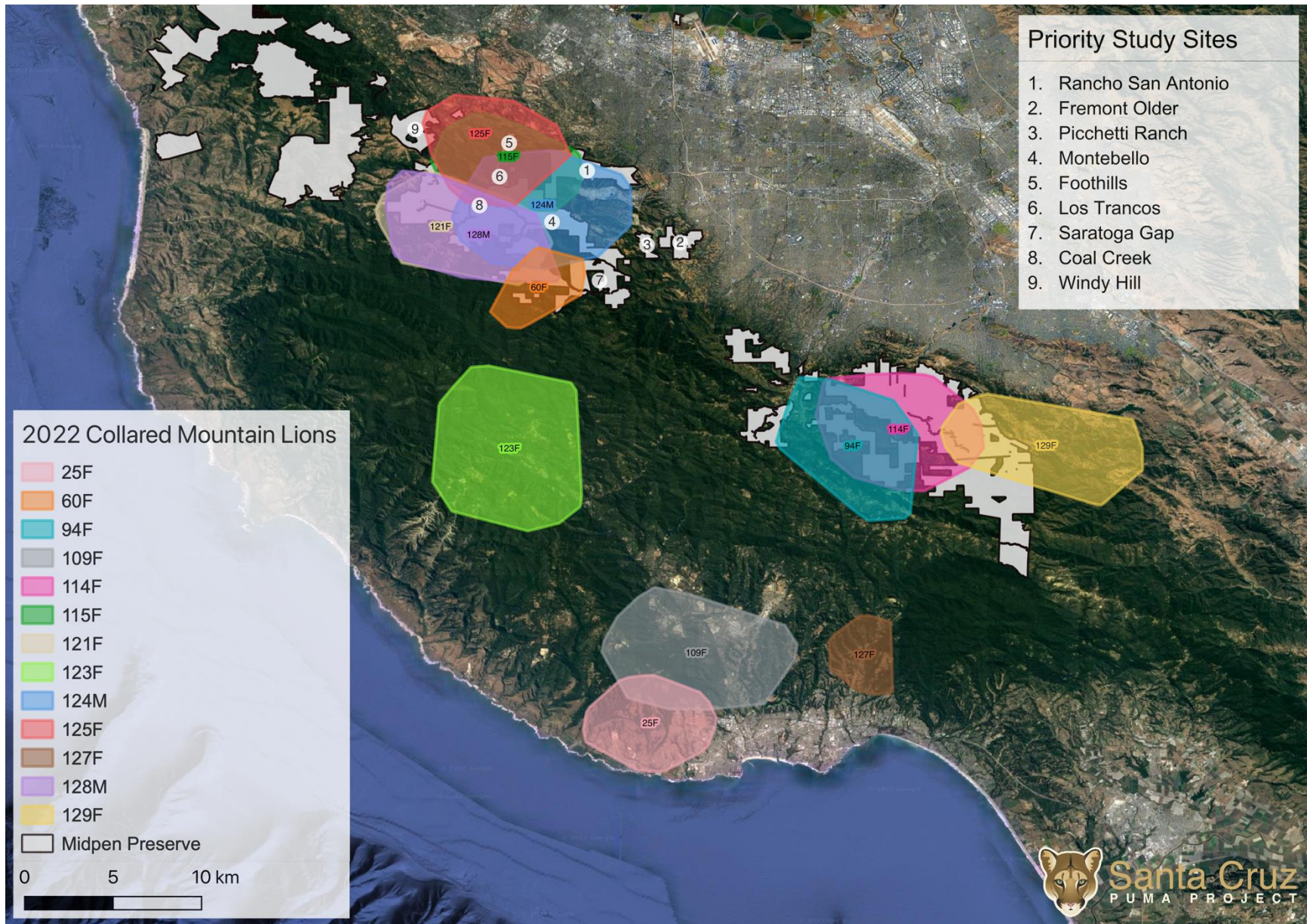
Figure 1: 95% MCP home range estimates for all mountain lions monitored during 2022.

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