Midpeninsula Regional
Open Space District

R-25-39
Meeting 25-11
April 9, 2025

SPECIAL MEETING AGENDA ITEM 1

AGENDA ITEM

Human-Mountain Lion Interaction Study and Management Plan Annual Update (Year 4)

GENERAL MANAGER'S RECOMMENDATIONS

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

2. Amend the existing agreement with the Santa Cruz Puma Project to extend the end date to May 31, 2026, and increase the total budget by $100,000, to a grand total of $600,000.

SUMMARY

The Santa Cruz Puma Project (Puma Project) has completed the fourth 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 as an important measure for protecting and sustaining the local mountain lion population.

The Puma Project has requested a six-month extension, as well as $100,000 in additional funding, to complete mountain lion collaring and behavioral fieldwork for obtaining a sufficient sample size to satisfy project objectives.

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. There are significant data gaps in the understanding of these factors and with the candidate listing of mountain lions within Evolutionary Significant Units, including the Santa Cruz Mountains, ecologically sensitive strategies for managing conflict are a high priority. 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 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 year 5) that will provide management strategies for the District to reduce potential conflicts between preserve visitors and mountain lions as an important measure for protecting and sustaining the local mountain lion population. 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
- Mountain lion behavioral modification methods, including the use of deterrents to modify mountain lion activity in areas with high levels of human use
- Education and outreach on safely recreating in mountain lion habitat

DISCUSSION

The fourth year of the project has focused on safely and humanely collaring mountain lions (*Puma concolor*), data collection and preliminary data analyses, and collection of fine-scale animal movement data. To date, the project has captured and collared a total of 34 unique individuals, details can be found in Attachment 1. 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 four, the Puma Project treated three individual mountain lions using implementable and humane behavioral modification protocols approved by the California Department of Fish and Wildlife and the Institutional Animal Care and Use Program, which 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. A capture-recapture analysis will be used in year five to estimate mountain lion densities throughout the study area.

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 year five (5) of the study.

The Puma Project has requested a project extension for an additional 6-month period, along with an additional $100,000 in funding, to gather the necessary collar data in high-priority sites to complete objectives 1-4 of the Human-Mountain Lion Interaction Study.

1. Estimate local mountain lion population size
2. Compare mountain lion home range sizes within the study area versus other parts of the Santa Cruz Mountains
3. Assess factors influencing human-mountain lion interactions
4. Determine the efficacy of deterrents

The additional funding will allow the Puma Project to collar additional mountain lions in high-priority preserves, including Rancho San Antonio, as well as obtain significant data to inform the analysis of the efficacy of deterrents. To date the Puma Project has treated eight mountain lions using behavioral modification methods. A total of at least ten individuals will need to be treated to determine if this approach effectively alters mountain lion behavior. The improved dataset will allow for greater inferences into the assessment of human-mountain lion interaction factors. The additional 6-month extension will allow for analysis of new data, publication of results, and the development of the final Human-Mountain Lion Interaction Management Plan.

The results of the study are expected to provide a new source of rigorous science-based data and findings for land managers across the State of California to utilize in identifying and implementing new, effective strategies for reducing negative human-mountain lion interactions and therefore further protect and sustain regional mountain lion populations. The results of the study are expected to be published in peer-reviewed scientific journals to more broadly contribute toward the current understanding of mountain lion behavior in relation to human activity.

FISCAL IMPACT

The current fiscal year budget contains:

☒ sufficient funds.

☐ insufficient funds; the next quarterly budget update will include a reallocation of unspent funds from other project budgets to cover for this expenditure.

☐ insufficient funds; approval of this item requires a fiscal year budget augmentation.

☒ future fiscal year budgets will include additional funds to complete the contracted work.

Measure AA

☒ No, this contract is not part of a Measure AA project.

☐ Yes, this contract is part of a Measure AA project.

PRIOR BOARD AND COMMITTEE REVIEW

July 8, 2020: Special Board Meeting regarding the District's Mountain Lion Conservation Efforts (R-20-71, minutes)

July 22, 2020: Board authorized an agreement for a five-year Mountain Lion Study and Site-Specific Management Plan (R-20-79, minutes).

February 9, 2022: The Board received the first annual project update (R-22-14, minutes).

February 2, 2023: The Board received the second annual project update (R-23-25, minutes).

March 13, 2024: The Board received the third annual Project update (R-24-34, 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 through year five of the study and the behavioral modification portion of the study into year five. Year five, and the 6-month extension, pending Board approval, will focus on continued data analysis, publications in peer reviewed scientific journals, and the creation of a site-specific human-mountain lion interaction management plan. A project update will be provided to the Board annually.

Attachments:
1. Annual Report

Responsible Department Head:
Kirk Lenington, Natural Resources Manager

Prepared by:
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2024

Human/Mountain Lion Interaction Study Annual Progress Report

YEAR 4

JOHN JOSEPH MORGAN

Human-Mountain Lion Interaction Study
Annual Progress Report 2024, Year 4
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 Open Space Preserve (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 capture-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 through repeated exposure to humans 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 select for 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 fuel breaks 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.

Annual Report 2024:
The following document is an annual progress report compiled by the Santa Cruz Puma Project (SCPP) that describes research related activities conducted during the 2024 calendar year as part of the Human-Mountain Lion Interaction Study. During the fourth year of this project SCPP focused on both data collection and data analyses. SCPP continues to capture and collar mountain lions within the study area and has collected fine-scale animal movement data from a total of 34 unique individuals since the project began. In 2024, SCPP collared 13 adults and 3 kittens from 2 unique litters, gathering behavioral data as well as demographic data related to survival and reproduction. During year four, SCPP used Strava, a cell phone-based fitness application, to compile and process six years' worth of human trail use data from within the study area and incorporated these data into animal movement models that quantify mountain lion response to outdoor recreational activity. SCPP is now in the final stages of writing these results into a manuscript for publication. Finally, SCPP continues to study the efficacy of deterrents in reducing human-mountain lion interactions using a behavioral modification protocol developed in year one of the project. In 2024, SCPP treated three additional individuals following this protocol. This work is ongoing and SCPP hopes to continue this work into year five of the project to achieve a sample size of 10-15 individuals treated. The fourth year of research activities resulted in a more complete dataset, and an increased focus on data analyses and the development of a manuscript for publication. These efforts will contribute to a better understanding of human-mountain lion interactions and the development of a site-specific human-mountain lion management plan.

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

i. In year four, SCPP successfully captured and collared 16 mountain lions. This included eight previously uncollared adults, five collared adults in need of replacement collars and three kittens from two unique litters. One of these adult mountain lions (162F) has territory overlapping Fremont Older, a high priority research site. In addition, one of the two litters monitored in 2024 (145F's litter) was born adjacent to top priority site RSA. This further validates RSA as a priority site, not only for its popularity amongst recreationists, but also for its role in providing important mountain lion reproductive habitat. During monitoring, kittens are fit with expandable VHF collars that do not exceed five percent of their total body weight. Kittens are handled with gloves, weighed, fit with collars, and immediately returned to the den site. SCPP then monitors kittens at each den site on a weekly basis using VHF telemetry to check for mortality signals. As of January 2025, 145F is still traveling with at least one collared kitten that is now approximately 9 months old. This is the longest we've been able to monitor a kitten via VHF telemetry since beginning this project. A camera trap photo from November 2024 taken within RSA, confirmed an additional uncollared kitten traveling with 145F, suggesting she is continuing to support at least 2 kittens. Monitoring den sites offers valuable information related to birth rate, litter size, and kitten survival rates. These data help inform our understanding of mountain lion population dynamics and are essential to understanding long-term population trends.

A total of 34 unique adult 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 into year five, the final year of this project, SCPP will continue to capture mountain lions and collect fine-scale movement data with a particular focus on individuals overlapping top priority sites. Extending the collaring effort into year 5 of this study will increase sample sizes and allow for more robust analyses to answer questions related to project objectives. A list of all captured mountain lions organized by date of capture can be found in Table 1. A map of mountain lion home ranges for all adults monitored during year four of the project can be found in Figure 1.

ii. In year one of the study, District researchers deployed nine camera traps in RSA using a standardized grid design using the Wildlife Picture Index methodology to estimate mountain lion abundance. In addition to these nine cameras, 21 camera sites were established along RSA trails to quantify human recreation activity. All cameras are positioned to avoid, as much as possible, the collection of images containing personal identities of preserve visitors. Only non-personal information is collected from images and policies are followed to maintain user privacy. During years two through four, SCPP worked with District researchers, interns, and volunteers to tag RSA camera trap images using Wildlife Insights, a cloud-based photo tagging software, following a tagging protocol collaboratively developed by District and SCPP researchers at the start of year two. In 2024, SCPP trained an additional 18 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 has trained a total of 33 interns on this project and will continue training and mentoring students over the next year. Tagging efforts in year 4 resulted in over 45,000 additional independent records, bringing our total to over 100,000 independent records across 28 camera stations. This includes 232 independent records of mountain lions recorded over 19 unique camera stations in RSA. These data offer valuable insight into mountain lion activity patterns and space use and are used to inform mountain lion trapping efforts. During the final year of this project, SCPP will finish tagging and analyzing camera data to estimate mountain lion density, prey abundance, and the role of human activity in affecting mountain lion space use.

We are currently in the preliminary stages of performing spatial capture recapture analyses (Royle et al., 2014) to estimate mountain lion densities throughout the study area. These analyses will utilize a combination of camera trap data and GPS collar data from overlapping mountain lions to estimate local densities and evaluate the effects of both anthropogenic and environmental features on mountain lion abundance. We are in the process of creating a database of all camera trap images collected over the course of the project and identifying all collared mountain lions in these images based on GPS data. We will then use the combination of images and overlapping GPS data to generate spatially explicit estimates of mountain lion densities throughout the region.

The collection, processing and analysis of camera trap images is ongoing and will continue into year 5 of this project. Data from trail cameras will address grant objectives related to mountain lion abundance estimates as described above, as well as all objectives related to mountain lion – human – deer interactions. This includes accurately quantifying human recreation activity and correcting regional trail use patterns obtained from the mobile fitness app, Strava (see Objective 3.ii). This work is ongoing and will be completed during year 5.

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

i. Mountain lions are a territorial species that occupy large home ranges, or areas of habitat essential for individual survival and reproduction. Understanding home range sizes and distributions is critical to understanding the spatial structure of a population and the spatial requirements necessary to sustain a viable population. Home range sizes also offer insight into the ecology of a species, often reflecting social structure, prey availability, habitat preferences and movement decisions. Using GPS data acquired from collared mountain lions, SCPP is estimating home range sizes and comparing space use patterns across individuals. This includes a comparison of space use patterns of mountain lions overlapping and outside of District preserves to better evaluate any potentially unique behaviors occurring on District properties.

   Minimum convex polygons (MCPs) offer a rapid and straightforward way to estimate home range size by calculating the minimum area that contains by a fixed percentage of total GPS locations for each individual. SCPP estimated the 95% MCP home range, which represents the area containing 95% of GPS locations, for all resident adult mountain lions with at least 30 days of GPS data. Male and female mountain lion MCP home ranges across the study area average 152.0 km^2 and 60.3km^2 respectively. While male and female home range sizes differ significantly, we do not find evidence that home range size differs significantly based on overlap with District preserves. This means that male and female mountain lions that overlap District preserves have similar home range sizes to those that persist in other parts of the Santa Cruz Mountains. Males with territories overlapping District preserves have a mean 95% MCP of 156.0km^2 (n=8), while males outside of District preserves average 144.0km^2 (n=3). Females overlapping District preserves have a mean 95% MCP of 58.1km^2 (n=11), while females outside of District preserves average 64.4km^2 (n=6). These estimates come from 28 adult mountain lions with at least 30 days of GPS tracking data. Figure 1 represents a map of the MCP home range estimates for all collared mountain lions monitored during 2024. Figure 2 shows the distribution of home range estimates for male and female mountain lions overlapping and outside of District preserves.

   Moving into year five, SCPP will continue collaring and collecting movement data on mountain lions both within and outside District lands. SCPP will refine home range estimates by using local convex hull (LoCoH) nonparametric kernel methods, which improve upon the MCP methods described above by more accurately representing realized animal space use (Getz et al., 2007). Recently, many previously used LoCoH

home range estimators have grown outdated as the necessary software packages are no longer being maintained by their creators. Despite this, SCPP is actively looking into alternative methods to generate convex hull home range estimates, and we are confident that these efforts will be successful. Over the next year, SCPP will develop LoCoH home range estimates for all collared adult mountain lions and use these estimates to better understand differences in space use across the study area. For example, forthcoming analyses will aim to quantify the effects of recreation intensity on mountain lion home range size both within and outside of District lands.

Objective 3: Assess factors influencing mountain lion-human interactions

i. In 2024, SCPP completed major analyses related to the effects of outdoor recreation activity on mountain lion habitat use and movement behavior. Using Strava, a cell phone-based fitness application, SCPP integrated human activity data into models of animal movement to understand the scale and severity of recreation impacts on mountain lions. Several significant results have emerged from this work. First, we found that mountain lions respond most strongly to long-term averages in hourly recreation. This suggests that mountain lions track long-term trends in human mobility and use fine-scale avoidance behaviors to navigate human-dominated landscapes. In comparing mountain lion avoidance of recreation activity to other forms of human disturbance, we found that the effect of recreation activity can be just as impactful as housing density on mountain lion behavior. This result is significant as housing density was previously shown to have significant impacts on mountain lion movement behavior and survival (Nisi et al., 2022, 2023). This highlights the potential for human presence to act as major form of human disturbance that ought not be overlooked when considering the full extent of anthropogenic impacts on wildlife.

   Next, we looked at individual variation in mountain lion response to recreation and found that individuals exposed to higher levels of recreation activity showed less of avoidance of recreation activity. This suggests mountain lions may habituate to human presence in human dominated areas, potentially to reduce unnecessary energetic costs of avoidance. However, it's important to note that even the most habituated individuals still show signs of avoidance behavior, and we found no evidence that mountain lions are positively selecting for (or attracted to) recreation activity.

   Finally, we asked how habituation to human presence might affect the likelihood of human-mountain conflict. We found that habituated individuals are not more likely to attack people or engage in other forms of conflict. Instead, our results suggests that conflict is better explained by a combination of habitat quality and concentrated human presence. This result relates directly to Objective 3v and suggests that human presence may affect the probability of human-mountain lion encounters more than individual differences in mountain lion behavior.

   We are currently finalizing a manuscript with these results, and we will submit this work to a peer-reviewed scientific journal in February 2025. We will also incorporate results from this work into our final mountain lion management plan.

ii. Building on the analysis described above, SCPP is working to evaluate the hypothesis that mountain lions are becoming habituated to human activities through repeated exposure to humans on District lands. Our results to-date suggest that mountain lions exposed to high levels of recreation activity show less avoidance of outdoor recreationists. This suggests that habituation may occur, likely as a mechanism to reduce the energetic costs of avoidance, or due to a lack of alternative functional habitat in high human use areas. However, even amongst mountain lions exposed to the highest levels of outdoor recreation, we do not see evidence of attraction to recreation activity. This suggests that some fear of humans is maintained, even in the most concentrated recreation areas. Furthermore, our results suggests that habituated mountain lions are not more likely to attack humans or engage in other forms of conflict and that such events are more likely explained by high concentrations of human presence on high quality mountain lion habitat.

iii. The index of deer activity depends on data from the District camera grid (Objective 1.i). These cameras have been deployed and photo tagging is ongoing. In year 5, we will complete all photo tagging and generate relative deer abundance estimates for all camera stations. We will then integrate these deer abundance estimates into spatially explicit density estimates and our home range calculations to better understand how deer presence affects mountain lion space use.

iv. During each capture event, SCPP estimates a mountain lion's age using both visual assessments and canine gumline recession estimates (Laundré et al., 2000). These estimates are then combined to estimate each individual mountain lion's date of birth. Since the start of this project, we have performed over 65 captures and fit 34 unique mountain lions with GPS collars. The resulting dataset includes mountain lions over a wide range of age classes and offers an opportunity to better understand how age might influence mountain lion behavior. In our analysis on the impacts of recreation on mountain lion habitat selection, we found evidence that an individual's exposure to recreation affects its response to this activity. In some cases, an individual's age might be correlated to exposure level as experiences with human activity accumulate overtime. Therefore, we might expect age to also play a role in determining its response to human activity. For example, we might hypothesize that older individuals have been more exposed to recreation over their lifespan and thus more likely to show signs of habituation. Moving into the final year of this study, we plan to explore these types of questions, as well as the relationship between mountain lion age and home range size.

v. Over the last year, we began evaluating the factors that affect the probability of human-mountain lion encounters, with a specific focus on human-mountain lion conflict events. We found that such events are not explained by habituation. Instead, human - mountain lion conflict is better explained by an overlap in high quality habitat and concentrated human presence (*manuscript in prep*). Moving into year 5, we plan to continue exploring the drivers of human – mountain lion encounters, specially through our estimates of mountain lion densities and more explicit estimates of human trail use.

Objective 4: Determine the efficacy of deterrents

i. 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 2024, SCPP successfully treated three collared mountain lions with behavioral modification techniques following a field protocol that was finalized in year two of the study. This protocol includes a combination of trained dogs, human voice playbacks and non-injurious projectiles. We treated male mountain lion 144M on April 16, 2024 in La Honda Creek Open Space Preserve. We treated male mountain lions 130M and 147M off District properties on May 7, 2024 and November 15, 2024, respectively. During each treatment, the mountain lion was pursued by trained hounds into a tree where it was exposed to a human voice recording, played at 80dB and marked with between one to five paintball projectiles. Mountain lion movement behavior was monitored before, during and after treatment at five-minute temporal resolution. These data are stored on each individual's GPS collar and will be analyzed when all collars are recovered. To-date, eight individuals have been treated following this protocol and six collars have been recovered.

   SCPP hopes to continue behavioral modification work during year five of the project to increase sample sizes to a total of 10-15 individuals. This increase in sample size is essential to robustly evaluate any changes in habitat selection, movement behavior and space use of each mountain lion before and after treatment. There are currently seven individuals not-yet-treated and fit with GPS collars that we aim to treat this spring, potentially bringing our total sample size to 15. This method, if successful, 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.

ii. Shaded fuel breaks 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 fuel breaks may serve dual functions, as fuel breaks for preventing fire spread and as a potential strategy to deter mountain lions from approaching or remaining in recreational areas. SCPP is working closely with Midpen, CalFire and CA State Parks to map all fuel breaks that were created and maintained within the last five years. Following the identification of all major fuel breaks, we will use habitat selection models to evaluate how mountain lions respond to these landscape features. These habitat selection models were built and tested during year 4 of the project and will be applied in year 5 when fuel break mapping is complete. 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 fuel breaks 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 fuel breaks 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 by members of SCPP and collaborators compliments the Human-Mountain Lion Interaction Study and provides important context for the findings of this study.

Greenberg et al., 2024 describes drivers of urban development into the wildland-urban interface (WUI) and highlights the relationships between affordable housing, WUI growth, and environmental impacts, including habitat fragmentation and fire risk (Greenberg et al., 2024). This work is relevant to wildlife conservation not only in the Santa Cruz Mountains, where we see rapid development of the WUI and unaffordable housing costs, but across all of California and helps connect both social and natural science research to better inform conservation objectives and sustainable development goals.

Allen et al. 2024a demonstrates the widespread impact that mountain lions have on other carnivores, affecting the activity patterns and space use of co-occurring, subordinate carnivore species (Allen, Avrin, et al., 2024). This work finds that close competitors, such as coyote, show the most of avoidance of mountain lion scrape sites following mountain lion scent marking behavior. Other carnivores, such as gray foxes, show less avoidance perhaps because they are a less likely competitor and can benefit from information left behind at mountain lion scrape sites.

Allen et al. 2024b describes intraspecific variation in mountain lion activity patterns at communication hubs, or scrape sites (Allen, Green, et al., 2024). This work finds females with kittens are more active at scrape sites during the daytime, likely to avoid the risk of dominant males. However, such activity patterns may put these individuals at greater risk of encountering humans and thus this work highlights a potential tradeoff faced by female mountain lions at a critical reproductive life stage.

Finally, through a global collaboration, **Burton et al. 2024** finds carnivores were most sensitive to changes in human activity during the COVID-19 pandemic and showed the strongest increases in nocturnality in response to high human activity (Burton et al., 2024). This work highlights the sensitivity of mountain lions and other carnivores to changes in human activity and further supports the need to study how different forms of human disturbance, such as outdoor recreation, affect carnivore behavior.

All of this work comes as coastal and southern mountain lion populations across the state are being considered for listing under California's Endangered Species Act due to lack of genetic connectivity. SCPP has been studying the effects of human disturbance and habitat fragmentation on mountain lions in the Santa Cruz Mountains and continues to monitor population dynamics, cause-specific mortality and individual behavioral responses to human disturbance. Data gathered as part of this Human-Mountain Lion Interaction Study will further contribute to our understanding of how human activity affects mountain lions, not only through the built environment but also through human

presence, which has yet to be considered in the majority of studies related to human-carnivore interactions.

Insights from other recent mountain lion publications:

i. Parsons et al. 2024 tested the efficacy of aversive conditioning on mountain lions and found that treatments with hounds were successful in increasing the flight initiation distance (FID) of mountain lions to an approaching human subject (Parsons et al., 2024). Results from control trials suggest that untreated individuals may habituate to human presence and reduce FID. This work compliments our ongoing behavioral modification work and supports the idea that using a combination of hounds, human voice, and paintball projectiles may be an effective way to reduce human-mountain lion encounters. Our work will build on Parsons et al. 2024 by evaluating habitat selection with respect to anthropogenic features following treatment, rather than FID alone.

ii. In contrast to the work of Parsons et al. 2024, Winter et al. 2024 conducted a CA state-wide evaluation of using hounds to deter mountain lions and found that hounds had no effect on a mountain lions' likelihood of return to the treatment site. This work relied on data following mountain lion captures, rather than targeted behavioral modification treatments. Therefore, although there was no support for using hounds to deter mountain lions, we feel our ongoing work is still an important test of behavioral modification as it does not include the potentially confounding effects of anesthesia and incorporates not only hounds, but also auditory and physical deterrents into the treatment.

iii. Bolas et al. 2025 also offers complimentary results to our ongoing work related to recreation impacts on mountain lion movement. While this work did not evaluate changes in habitat selection, Bolas et al. 2025 found mountain lions in high recreation areas become more nocturnal, adjusting their activity patterns to avoid human presence (Bolas et al., 2025). In combination with our results, this work offers a more complete understanding of how human presence affects mountain lion ecology in multi-use landscapes.

Management recommendations:

i. We are excited to share our results regarding the impacts of recreation on mountain lion habitat selection and movement behavior. We found evidence that mountain lions strongly avoid outdoor recreation, and thus increasing the extent and intensity of recreational trail use will likely have a negative impact on functional mountain lion habitat. However, we also found evidence of fine-scale behavioral plasticity as mountain lions relax their avoidance of recreation areas at night. Thus, maintaining both space and time with limited recreation activity within recreational landscapes is likely an important strategy to maintain mountain lion habitat, even within high human-use areas.

ii. We also found evidence of habituation, as mountain lions exposed to high levels of recreation activity show a relaxed avoidance of recreation. Despite evidence of habituation, we found no support for habituation leading to increased conflict with people. Therefore, our results suggest habituated movement may not always be cause for concern. We are excited to pair these results with our behavioral modification work to

evaluate the efficacy of behavioral modification treatments in reversing habituated behavior and maintaining fear of human presence in mountain lions, particularly those exposed to high levels of recreation.

iii. Further management recommendations will be provided upon the competition of all data collection and analyses. These recommendations will be incorporated into a final management plan at the end of the project.

Conclusions and next steps:

During the forth year of the Human-Mountain Lion Interaction Study, SCPP successfully collared 16 mountain lions, including eight previously uncollared adults and three kittens from two distinct litters. SCPP continues to actively collect data on mountain lion space use and human recreational activity and is finalizing a manuscript that incorporates outdoor recreation metrics into models of mountain lion movement. SCPP successfully treated three additional mountain lions following our behavioral modification protocol, increasing our sample size to eight treatment events. As we move into year five of the project, SCPP will continue collaring mountain lions, collecting data on mountain lion movement and human recreational activity and performing behavioral modification work. While fieldwork during year 5 of the project was not initially anticipated, SCPP is requesting a six-month project extension and budget supplement to support additional fieldwork and increase sample sizes, particularly related to behavioral modification treatments. This extension will ensure sufficient data collection to robustly address all objectives of this project. During the final year of this project, SCPP will finalize all analyses and incorporate results into peer-reviewed publications and a human-mountain lion management plan. The management plan will provide actionable strategies for minimizing human-mountain lion conflict, such as preserve access modifications, education and outreach, habitat modifications along trails or mountain lion behavioral modifications. The 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	51.3km^2
	114F	12/22/2020	3yrs	Sierra Azul, St. Joseph's Hill, Russian Ridge	69.7km^2
	115F	12/23/2020	2yrs	RSA, Montebello, Foothills, Los Trancos, Windy Hill, Coal Creek	35.0km^2
	25F	1/8/2021	10yrs	NA	39.6km^2
	116M	2/21/2021	2.5yrs	Sierra Azul, St. Joseph's Hill, Bear Creek Redwoods	147.3km^2
	117M	3/29/2021	2yrs	Sierra Azul, El Sereno	NA
	118M	4/11/2021	7yrs	RSA, Montebello, Saratoga Gap, El Sereno, Felton Station, Picchetti Ranch, Fremont Older, Foothills, Bear Creek Redwoods, Los Trancos	149.2km^2
	119M	5/24/2021	5wks (109F litter)	NA	NA
	120M	5/24/2021	5wks (109F litter)	NA	NA
	121F	10/21/2021	3yrs	Russian Ridge, Skyline Ridge, Long Ridge, Montebello, Saratoga Gap, Coal Creek	55.5km^2
	122M	11/17/2021	1.5yrs	NA	NA
	123F	12/1/2021	2yrs	NA	73.6km^2

	109F	12/6/2021	5.5yrs	NA	68.2km^2
Year 2	124M	1/28/2022	3.5yrs	Montebello, Skyline Ridge, RSA, Russian Ridge, Saratoga Gap, Long Ridge, Los Trancos, Picchetti Ranch, Foothills, Coal Creek	108.5km^2
	125F	2/7/2022	2yrs	Montebello, Windy Hill, RSA, Russian Ridge, Foothills, Skyline Ridge, Coal Creek, Los Trancos	46.7km^2
	126M	2/8/2022	10yrs	NA	NA
	60F	3/25/2022	4yrs	Long Ridge, Saratoga Gap	18.7km^2
	115F	4/6/2022 (re-collar)	3yrs	RSA, Montebello, Foothills, Los Trancos, Windy Hill, Coal Creek	35.0km^2
	121F	4/14/2022 (re-collar)	5yrs	Russian Ridge, Skyline Ridge, Long Ridge, Montebello, Saratoga Gap, Coal Creek	55.5km^2
	114F	4/28/2022 (re-collar)	5yrs	Sierra Azul, St. Joseph's Hill, Russian Ridge	69.7km^2
	25F	5/3/2022 (re-collar)	11yrs	NA	39.6km^2
	94F	5/23/2022	5yrs	Sierra Azul, Bear Creek Redwoods, St. Joseph's Hill	56.7km^2
	127F	9/14/2022	5yrs	NA	40.8km^2
	128M	9/20/2022	2.5yrs	Skyline Ridge, Russian Ridge,	53.6km^2

				Long Ridge, Montebello	
	129F	11/14/2022	3.5yrs	Sierra Azul	44.4km^2
	130M	11/18/2022	4yrs	NA	117.9km^2
Year 3	131F	1/7/2023	3.5yrs	NA	43.8km^2
	124M	1/30/2023 (re-collar)	3.5yrs	Montebello, Skyline Ridge, RSA, Russian Ridge, Saratoga Gap, Long Ridge, Los Trancos, Picchetti Ranch, Foothills, Coal Creek	108.5km^2
	123F	2/20/2023 (re-collar)	2yrs	NA	83.3km^2
	130M	4/27/2023 (re-collar)	4yrs	NA	117.9km^2
	132F	5/12/2023	4wks (114F litter)	Sierra Azul	NA
	133F	5/15/2023	4wks (114F litter)	Sierra Azul	NA
	123F	5/18/2023 (re-collar)	2.5yrs	NA	73.6km^2
	134M	6/2/2023	3.5yrs	NA	218.2km^2
	135M	7/27/2023	4wks (127F litter)	NA	NA
	136F	7/27/2023	4wks (127F litter)	NA	NA
	137F	7/27/2023	4wks (127F litter)	NA	NA
	138M	7/28/2023	4wks (121F litter)	Russian Ridge, Montebello, Skyline Ridge	NA
	139M	7/28/2023	4wks (121F litter)	Russian Ridge, Montebello, Skyline Ridge	NA
	140F	7/28/2023	4wks (121F litter)	Russian Ridge, Montebello, Skyline Ridge	NA
	141M	9/5/2023	4wks (129F litter)	NA	NA
	142F	9/5/2023	4wks (129F litter)	NA	NA

	143F	9/5/2023	4wks (129F litter)	NA	NA
	144M	10/31/2023	5.5yrs	La Honda Creek, Purisima Creek Redwoods, El Corte de Madera Creek	112.4km^2
	145F	11/2/2023	4yrs	RSA, Montebello, Picchetti Ranch	22.0km^2
	146M	11/2/2023	1.5yrs	RSA, Montebello	NA
	147M	11/14/2023	4yrs	Sierra Azul	112.5km^2
	121F	12/5/2023 (re-collar)	5yrs	Russian Ridge	
Year 4	114F	1/15/2024 (re-collar)	5yrs	Sierra Azul, St. Joseph's Hill	69.7km^2
	25F	1/25/2024 (re-collar)	10+yrs	NA	39.6km^2
	151M	3/4/2024	2yrs	Corte de Madera, Russian Ridge, Skyline Ridge, La Honda Creek, Montebello, Purisima Creek	NA
	152F	3/14/2024	3yrs	Corte de Madera, Thornewood, La Honda	NA
	154F	4/18/2024	4wks (129F litter)	NA	NA
	155M	4/18/2024	4wks (129F litter)	NA	NA
	157M	5/13/2024	5wks (145F litter)	RSA	NA
	130M	11/4/2024 (re-collar)	4yrs	NA	117.9km^2
	160F	11/13/2024	1.5yrs	Sierra Azul, St. Joseph's Hill, El Sereno	97.3km^2
	129F	11/13/2024 (re-collar)	4yrs	Sierra Azul	44.4km^2
	161F	11/20/2024	4yrs	Purisima Creek, Corte de Madera, La Honda	38.5km^2
	136F	11/26/2024	1.5yrs (127F offspring)	NA	37.7km^2

	162F	12/10/2024	2yrs	Fremont Older, El Sereno	134.6km^2
	163M	12/18/2024	5yrs	Montebello, Long Ridge	125.0km^2
	164M	12/21/2024	6yrs	Bear Creek	NA
	127F	1/8/2025 (re-collar)	7yrs	NA	40.8km^2

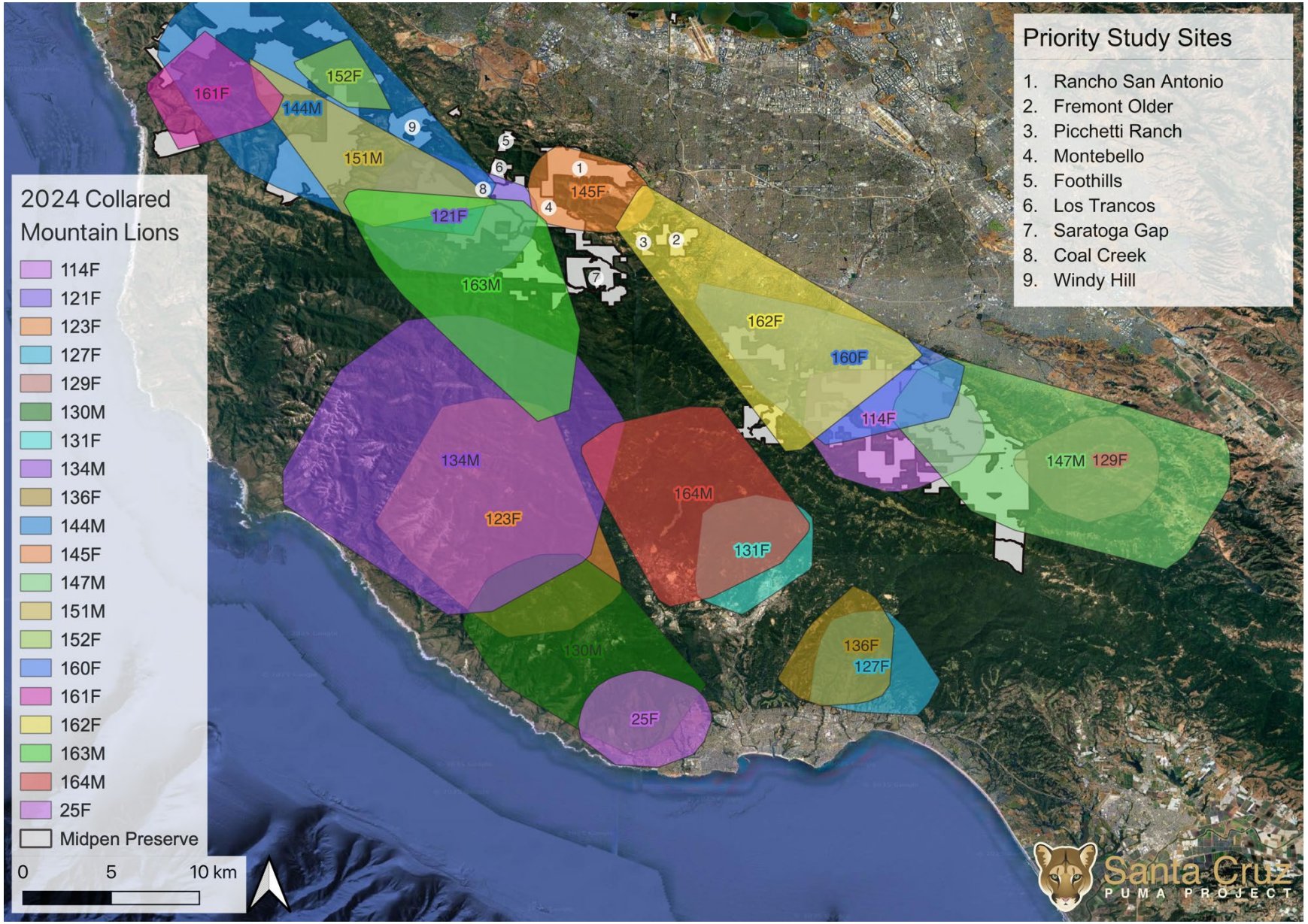

Figure 1: 95% minimum convex polygon (MCP) home range estimates for all adult mountain lions monitored during 2024.

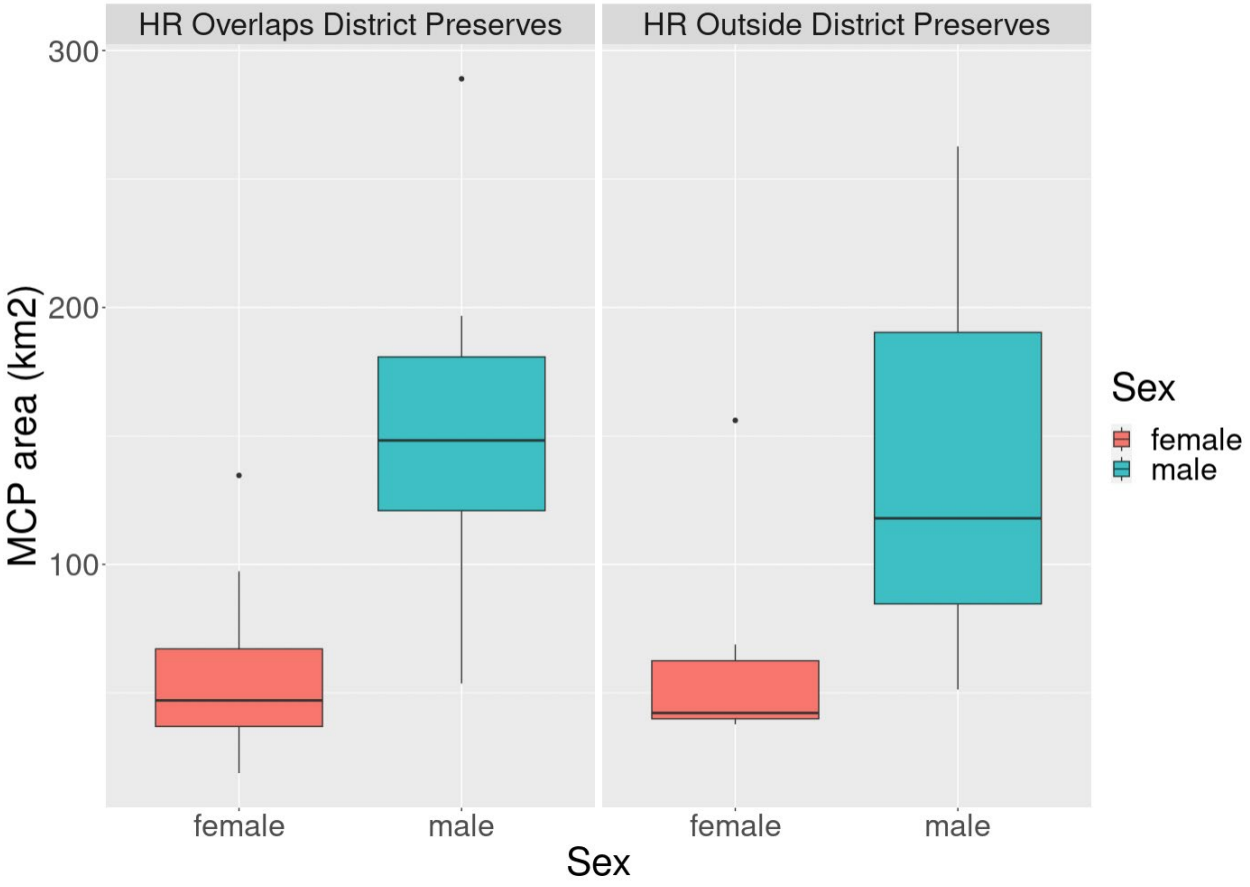

Figure 2: Boxplot representation of MCP home range estimates for male and female adult mountain lions within and outside of District preserves. Data includes 28 individuals collared between November 2020 and December 2024 with at least 30 days of GPS tracking data. While males and females do differ in home range size, preliminary results suggest there is no statistically significant differences within sexes between individuals utilizing District preserves and those in other parts of the study area.

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