Midpeninsula Regional
Open Space District

R-24-34
Meeting 24-07
March 13, 2024

AGENDA ITEM 6

AGENDA ITEM

Human-Mountain Lion Interaction Study and Management Plan Annual Update (Year 3)

GENERAL MANAGER'S RECOMMENDATION

Receive a presentation and provide feedback on the third 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 third 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.

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 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 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; 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 third 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 from a total of 28 unique individuals since the project began, 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 three, the Puma Project treated two individual mountain lions using implementable and humane behavioral modification protocols that were developed during year two 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 four to estimate mountain lion densities throughout the study area. The Puma Project currently has calculated home range estimates from GPS location data for (30) collared mountain lions in the Santa Cruz Mountains (see Attachment 1).

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.

FISCAL IMPACT

None

PRIOR 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). The second annual project update was provided on February 2, 2022 (R-23-25, 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 Four of the study, with the potential to expand into Year Five if needed. The Puma Project will continue the behavioral modification portion of the study through Year Four and into Year Five if needed. Years Four and Five will focus on data analysis and the creation of a site-specific human-mountain lion interaction management plan. A project update will be provided to the Board annually.

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 may also be published in peer-reviewed scientific journals to more broadly contribute toward the current understanding of mountain lion behavior in relation to human activity.

Attachments:
1. Annual Report

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2023

Human-Mountain Lion Interaction Study Annual Progress Report

YEAR 3

THE SANTA CRUZ PUMA PROJECT

Human-Mountain Lion Interaction Study
Annual Progress Report 2023, Year 3
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 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 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 2023:
The following document is an annual progress report compiled by the Santa Cruz Puma Project (SCPP) that describes research related activities conducted during the 2023 calendar year as part of the Human-Mountain Lion Interaction Study. During the third year of this project SCPP focused on both data collection and preliminary 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 28 unique individuals since the project began. In 2023, SCPP collared 10 adults and 11 kittens from four unique litters, gathering behavioral data as well as demographic data related to survival and reproduction. During year three, 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. Finally, SCPP is studying the efficacy of deterrents in reducing human-mountain lion interactions using a behavioral modification protocol developed in year one of the project. In 2023, SCPP treated two additional individuals following this protocol. This work is ongoing and will continue into year four of the project. The third year of research activities resulted in a more complete dataset and preliminary data analyses 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

i. In year three, SCPP successfully captured and collared 21 mountain lions. This included six previously uncollared adults, four collared adults in need of replacement collars and eleven kittens from four unique litters. Five of these adult mountain lions have territories overlapping District properties, and three mountain lions (124M, 145F, 146M) overlap with top priority sites (RSA, Fremont Older or Picchetti Ranch Open Space Preserves). Two of the four litters monitored in 2023 occurred on District properties. 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. 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 28 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 into year four of this project, SCPP will continue to capture mountain lions and collect fine-scale movement data. 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 three 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 and three, 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 2023, SCPP trained 13 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 15 interns on this project and will continue training and mentoring students over the next two years. To date, over 108,000 RSA grid camera photos and over 627,000 RSA trail camera photos have been tagged, spanning over 178 weeks of deployments. These images were filtered using a 30-minute temporal threshold to establish independence for records of the same species at each camera site, resulting in over 53,000 independent records and 21 unique species classifications. Currently processed data includes 136 independent records of mountain lions recorded at 13 unique camera stations in RSA. These data offer valuable insight into mountain lion activity patterns and space use and have been used to inform mountain lion trapping efforts and will inform a better understand mountain lion behaviors in RSA as they relate to human recreation activity.

During year four, spatial capture recapture analyses (Royle et al., 2014) will be used 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. Preliminary results from these models will be available at the end of year four.

The collection, processing and analysis of camera trap images is ongoing and will continue over the next two years. 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). Analyses related to correcting estimates of recreation intensity will begin in year four.

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 will estimate home range sizes and compared space use patterns across individuals. This will include 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 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 117.0 km^2 and 48.6 km^2 respectively. Statistically, the sex-specific mean MCP home range sizes of males and females do not significantly differ across individuals with home ranges that overlap District preserves and those that persist in other parts of the Santa Cruz Mountains. Males with territories overlapping District preserves have a mean 95% MCP of 113.9km^2, while males outside of District preserves average 119.6km^2. Females overlapping District preserves have a mean 95% MCP of 37.9 km^2, while females outside of District preserves average 58.1km^2. Figure 1 represents a map of the MCP home range estimates for all collared mountain lions monitored during 2023. Figure 2 shows the distribution of home range estimates for male and female mountain lions overlapping and outside of District preserves.

Moving into year four, SCPP will continue collaring and collecting movement data on mountain lions both within and outside District lands. SCPP is currently characterizing mountain lion home range behavior 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). LoCoH home range estimates will be complete for the current dataset by spring 2024 and the home range estimates described above will be updated accordingly. Over the next two years, SCPP will continue to update LoCoH home range estimates to reflect additional data inputs and perform further analyses 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. SCPP is using Strava to investigate the relationship between mountain lion habitat use and human recreational activity. During year two, 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. In 2023, SCPP incorporated 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.

To date, 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 2018-2023. This provides a relative measure of recreation intensity for every trail in the study area at multiple temporal scales, ranging from one hour to one year. SCPP then linked these data to observed mountain lion GPS locations at multiple spatial scales and quantified their exposure to human disturbance. During year three, SCPP incorporated these dynamic metrics of human presence into integrated step selection analyses (iSSA) that will help describe how mountain lions respond to outdoor recreation at various spatial and temporal scales (Avgar et al., 2016). While the development of these models is ongoing, SCPP expects to finalize results in the beginning of year four and incorporate them into a manuscript for publication later this year. Results from these models will help inform the creation of the final, site-specific human-mountain lion interaction management plan at the end of year five.

ii. Using the Strava data 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. 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. During years two and three, SCPP 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). Moving into year four, SCPP will continue processing camera data for these calibrations and incorporate human activity data from RSA cameras. Following the creation of LoCoH home range estimates (Objective 2), SCPP will quantify the exposure of each mountain lion to outdoor recreation and assess its effect on individual movement behavior using iSSA (Objective 3.i.). This work will begin in year four and preliminary results will be ready by the end of year four.

iii. 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 four of the study as more tagged camera data becomes available.

iv. Hypotheses related to the influence of mountain lion age on responses to human activity will begin during year four of the study. SCPP has successfully collared 28 unique mountain lions over the first three years of the project, providing an adequate dataset to begin preliminary analysis. During year four, SCPP will begin answering questions related to the influence of age on mountain lion behavior. SCPP will continue to capture and collar mountain lions over the next two years to improve sample size for this analysis.

v. 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 will be available during year four. SCPP expects to begin analyses related to the probability of human-mountain lion encounters across the study area at the

end of year four when mountain lion abundance and outdoor recreation intensity estimates are more well developed.

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 2023, SCPP successfully exposed two collared mountain lions to 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. Female mountain lion 114F was treated on March 6, 2023 in Sierra Azul Open Space Preserve. Female mountain lion 129F was treated on March 23, 2023 on private land adjacent to Sierra Azul (with permission from property owners). 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. These paintballs are water-soluble and non-toxic and will wash off of marked mountain lions over time. 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 the collars are recovered. To-date, five individuals have been treated following this protocol and three collars have been recovered.

SCPP will continue behavioral modification work during year four 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 and aims to treat at least 10 individuals prior to data analysis. 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 expects to treat an additional three to five individuals and begin preliminary data analyses during year four. 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.

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. During year four, SCPP will work closely with CalFire and other land management agencies to identify and map fuel breaks that were created and maintained within the last five years. Fuel break data from San Mateo County has been collected and SCPP are currently collecting data for Santa Clara and Santa Cruz counties. The mapping of all

shaded fuel breaks across the study area over the last five years is expected to be complete in by spring 2024. SCPP will use these maps to analyze movement data from collared mountain lions to test how they respond to already established fuel breaks. 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:

1. Recent work published by members of SCPP and collaborators found that exposure to housing density plays a significant role in adult female survival (Nisi et al., 2023). This results in source-sink dynamics across the Santa Cruz Mountains, where mountain lions living in more developed areas face lower annual survival rates. Nisi et al., 2023 found that over 40% of the Santa Cruz Mountains are considered sink areas, with population growth rates <1. Furthermore, Nisi et al., 2023 found that habitat selection may be an inadequate metric of habitat quality, highlighting the need to think critically about how we evaluate mountain lion habitat and the relationships between individual movement decisions and population dynamics. Figure 3 is a figure taken from Nisi et al., 2023 that shows spatially explicit estimates of population growth rates across the Santa Cruz Mountains. While District preserves are not explicitly highlighted, results from this work make clear the importance of undeveloped open spaces in supporting higher rates of adult female survival and providing critical source habitat that sustains regional population growth.

   SCPP researchers also contributed to a recent statewide study of human-caused mountain lion mortality. This work, published in Proceedings of the National Academy of Sciences (PNAS), found human-caused mortality is additive to natural mortality, further reducing population-level survival rates of mountain lions across the state (Benson et al., 2023). This suggests that the mortality risk mountain lions face near intermediate levels of human development can greatly contribute to reductions in population growth rates.

   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.

Management recommendations:

1. Management recommendations will be provided upon further data collection and analyses and later incorporated into a final management plan at the end of year five.

Conclusions and next steps:

During the third year of the Human-Mountain Lion Interaction Study, SCPP successfully collared 21 mountain lions, including six previously uncollared adults and 11 kittens from four distinct litters. SCPP continues to actively collect data on mountain lion space use and human recreational activity and incorporate these data into animal movement models, which will be finalized later this year. SCPP also successfully treated two additional mountain lions following our behavioral modification protocol, increasing our sample size to five treatment events. As we move into year four of the project, SCPP will continue collaring mountain lions, collecting data on mountain lion movement and human recreational activity and performing behavioral modification work. However, in year four SCPP will transition into more active development of data analyses and the preparation of results. SCPP will finalize analyses of mountain lion habitat selection and movement behavior and the effects of human recreation activity on each. These results will be incorporated into a manuscript and submitted for publication later this year. This data will also contribute to our final human-mountain lion interaction management plan. The 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. 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	63.2km^2
	115F	12/23/2020	2yrs	RSA, Montebello, Foothills, Los Trancos, Windy Hill, Coal Creek	35.0km^2
	25F	1/8/2021	10yrs	NA	39.4km^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	63.2km^2
	25F	5/3/2022 (re-collar)	11yrs	NA	39.4km^2
	94F	5/23/2022	5yrs	Sierra Azul, Bear Creek Redwoods, St. Joseph's Hill	56.7km^2
	127F	9/14/2022	5yrs	NA	29.4km^2
	128M	9/20/2022	2.5yrs	Skyline Ridge, Russian Ridge, Long Ridge, Montebello	53.6km^2
	129F	11/14/2022	3.5yrs	Sierra Azul	36.0km^2
	130M	11/18/2022	4yrs	NA	109.3km^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	109.3km^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

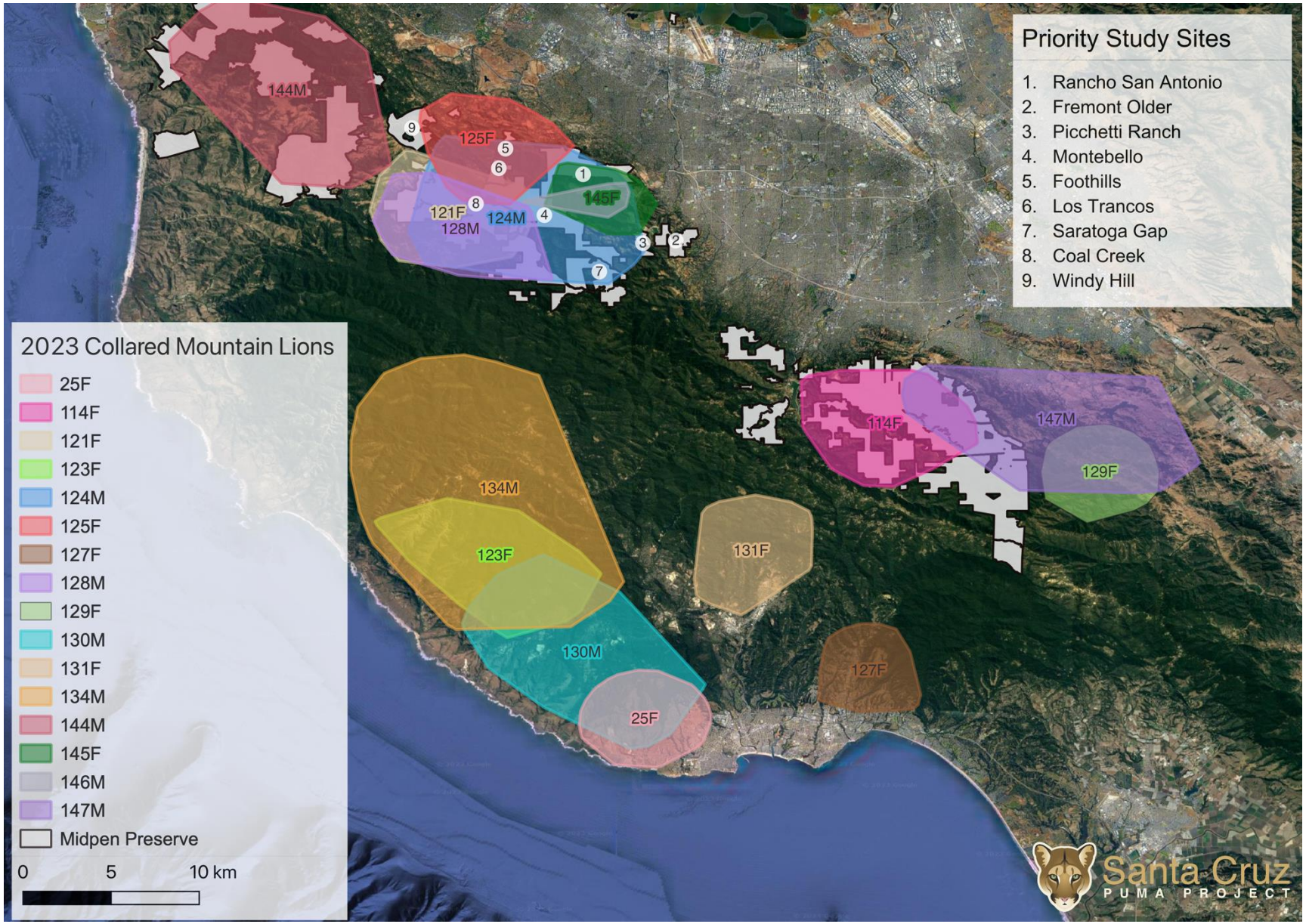

Figure 1: 95% minimum convex polygon (MCP) home range estimates for all adult mountain lions monitored during 2023.

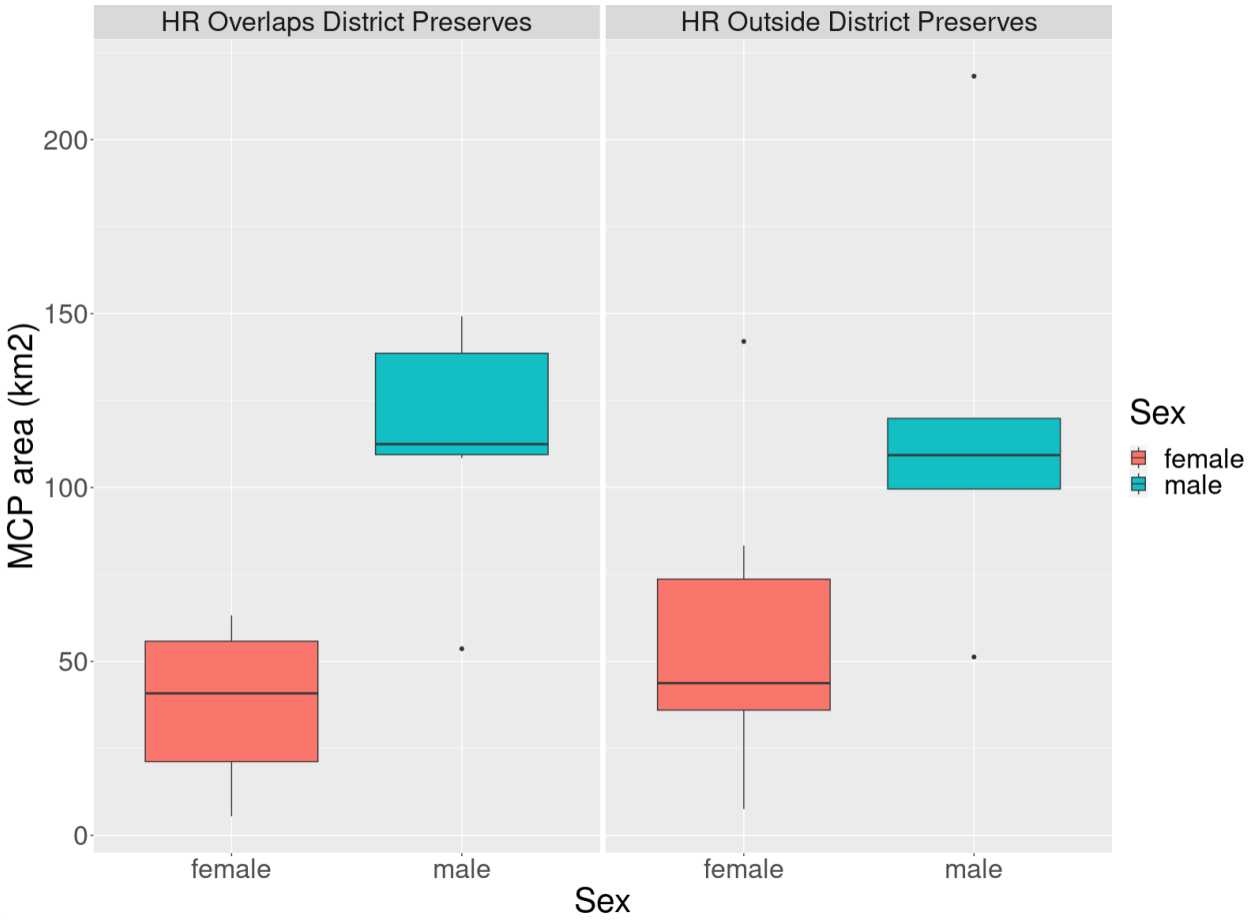

Figure 2: Boxplot representation of MCP home range estimates for male and female adult mountain lions within and outside of District preserves. Data includes 28 individuals collared between November 2020 and December 2023. While males and females do differ in home range size, preliminary results suggest there is no statistically significant differences within sexes between individuals utilizing District preserves and those in other parts of the study area.

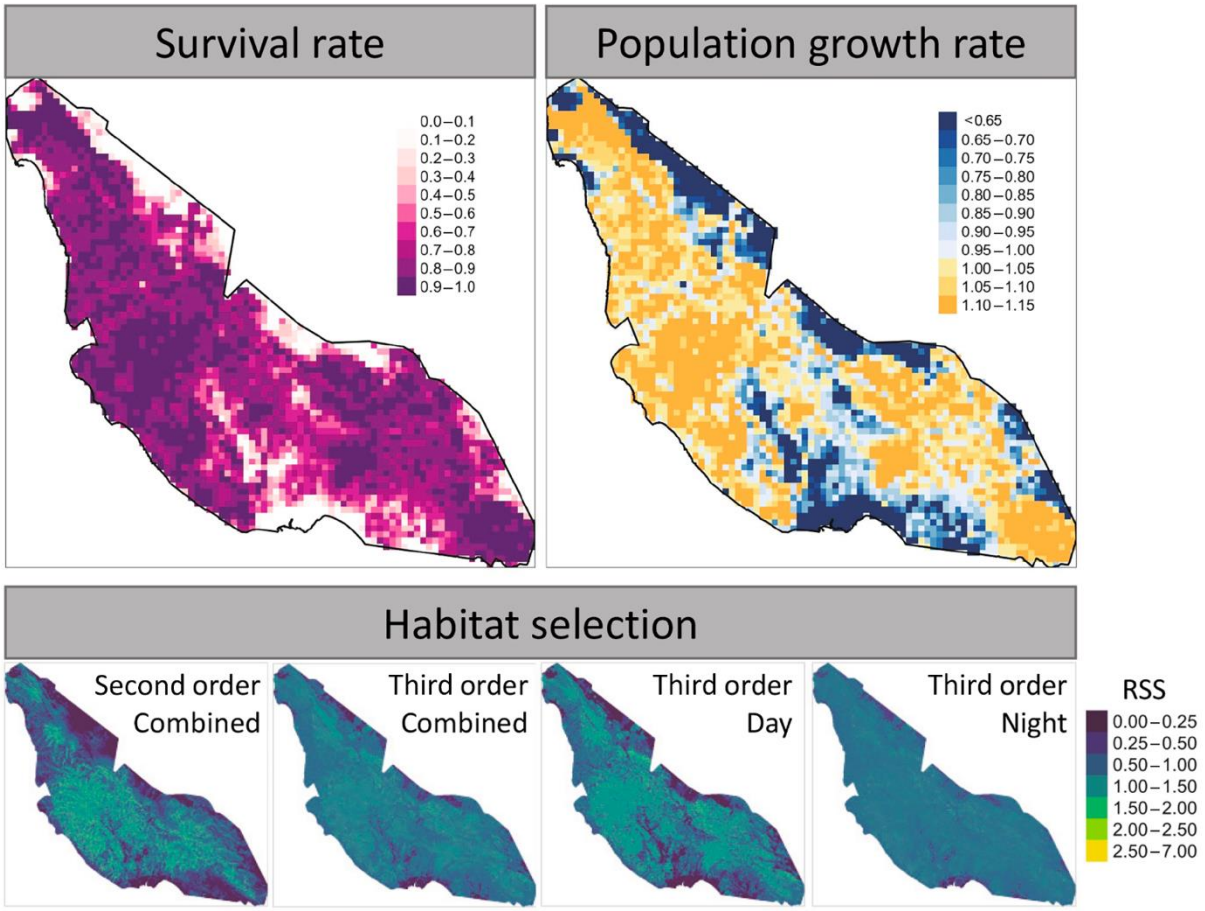

FIGURE 3 Puma population processes and habitat selection patterns in the Santa Cruz Mountains. The top left panel shows estimated adult female puma survival rates and the top right panel shows corresponding estimated puma population growth rates (λ) across the study area. The bottom row shows relative selection strength (RSS) across the study area, at the second and third orders of selection. Combined models were models that included both daytime and nighttime puma locations, while day and night models included only locations from that respective time of day. Third order daytime selection was most predictive of predicted population growth rate across the study area.

Figure 3: Figure published in Nisi et al., 2023 representing population processes and habitat selection patterns in the Santa Cruz Mountains.

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