Evaluating Ecological Conservation Gaps Across a Proposed Sentinel Landscape

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Signature Page

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The Group Project is required of all students in the Master of Environmental Science and Management (MESM) Program. The project is a year-long activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Group Project Final Report is authored by MESM students and has been reviewed and approved by:

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Acronym Glossary

AUC	Area under the curve
BPG	Biogeographic population group
CDFW	California Department of Fish and Wildlife
CRLF	California red-legged frog
CWHR	California Wildlife Habitat Relationship
DEM	Digital elevation model
DOD	Department of Defense
DOI	Department of Interior
DPS	Distinct population segment
FEMA	Federal Emergency Management Agency
GAP	Gap Analysis Project
LPNF	Los Padres National Forest
MaxEnt	Maximum Entropy
NGO	Non-governmental organization
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
SCC	Southern central coast
SLP	Sentinel Landscape Partnership
SWAMP	Surface Water Ambient Monitoring Program
VSL	Vandenberg Sentinel Landscape
VSLP	Vandenberg Sentinel Landscape Partnership
VSFB	Vandenberg Space Force Base
WVC	Wildlife vehicle collisions
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USFS	United States Forest Service
USGS	United States Geological Survey

1. Project Overview

1.1 Background and Significance

California's Southern Central Coast (SCC) region, located within the California Floristic Province, is renowned for its unique ecological and cultural significance (Calsbeek et al., 2003). As one of the world's rare Mediterranean ecosystems, it supports a broad diversity of life and serves as a vital connection to the cultural and spiritual heritage of Indigenous communities (Rick & Erlandson, 2019). This globally recognized biodiversity hotspot is home to rare and endemic species that thrive in its distinct biogeographic setting, underscoring the region's ecological importance (Habel et al., 2019; Myers et al., 2000). Beyond its rich biodiversity, the SCC also contains the last remaining stretch of undeveloped coastline in Southern California, providing a sanctuary for coastal species. This highlights its role as a quality habitat for special-status species with limited ranges and high conservation concern. Additionally, the SCC sits at the intersection of four ecoregions, creating a dynamic range of habitats that sustain species diversity and connectivity (ICF, 2023).

However, the ecological integrity of this region is threatened by development, agriculture, and recreation, creating complex and often conflicting management challenges. Climate change compounds these issues with rising temperatures, shifting precipitation patterns, and sea-level rise placing additional stress on natural systems (Reside et al., 2018). Furthermore, increasing activity at Vandenberg Space Force Base (VSFB), including expanded operations and infrastructure development, further complicates conservation efforts (Schultz, 2014; VSFB, 2024). Significant obstacles to conservation project implementation hinder active management of critical habitats and diminish the region's resilience to these threats. This conservation planning-implementation gap underscores the urgent need for coordinated conservation actions to effectively address these challenges (Keeley et al., 2018; Knight et al., 2008).

Efforts to bridge the planning-implementation gap must address diverse management challenges while fostering synergies among the various partners invested in the region. These partners include federal and state agencies, local governments, conservation organizations, Indigenous communities, private landowners, and VSFB. Aligning the priorities and actions of these stakeholders requires a collaborative and adaptive approach that accounts for the region's complex social, cultural, and ecological dynamics. The proposed Vandenberg Sentinel Landscape (VSL), achieved through the Sentinel Landscapes Partnership program, offers a collaborative solution to these challenges. Securing the VSL designation would provide resources to address competing land use needs through coordinated planning and management. Specifically, the VSL could bridge the conservation planning-implementation gap by fostering collaboration, pooling expertise, providing funding, and aligning priorities. These efforts would address the region's diverse needs while enhancing the long-term health and resilience of the SCC.

1.2 The Vandenberg Sentinel Landscape Partnership

The Sentinel Landscapes Partnership (SLP) offers a unique framework to balance the conservation of natural resources, the preservation of working lands, and the support of national defense priorities. Each designated Sentinel Landscape is centered around a military installation and includes areas where large-scale conservation efforts can align with the needs of the U.S. Department of Agriculture (USDA), Department of Defense (DOD), Department of the Interior (DOI), and Federal Emergency Management Agency (FEMA) (Sentinel Landscapes, 2025a). The program's mission is to strengthen military readiness, conserve natural resources, bolster agricultural and timber economies, expand public access to outdoor recreation, and enhance resilience to climate change (Figure 1-1). The partnership accomplishes these goals by connecting federal agencies, state and local governments, non-governmental organizations, and interested landowners and managers within designated Sentinel Landscapes to achieve landscape-level outcomes.

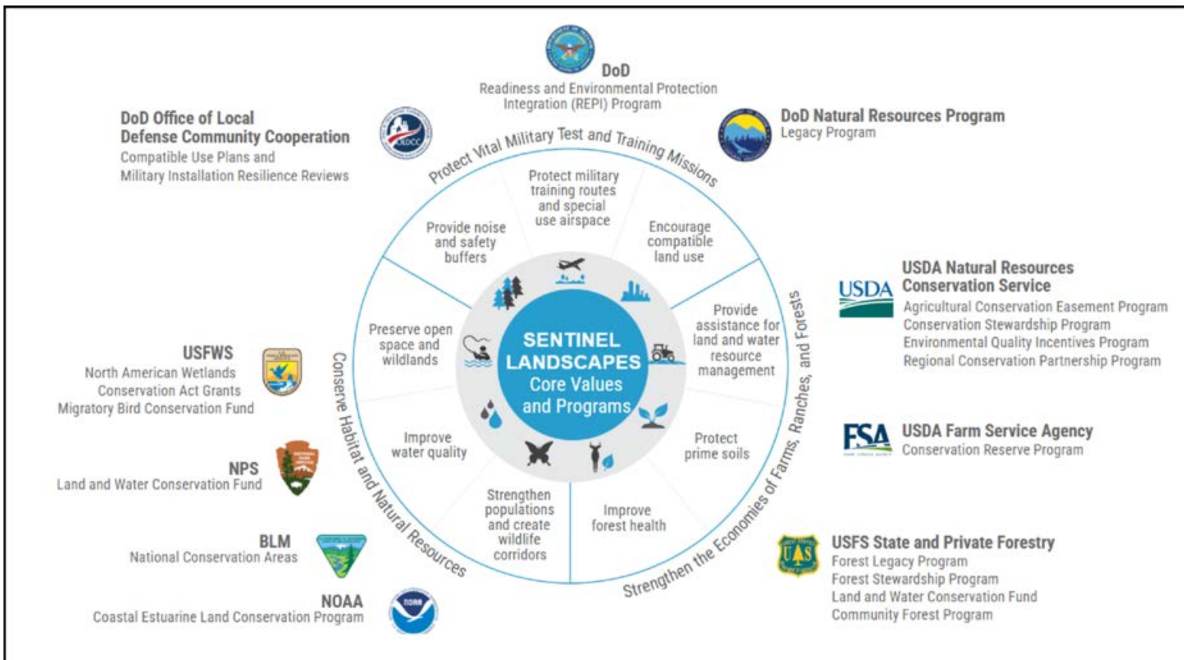

Figure 1-1. Federal Programs Active in Sentinel Landscapes. Source: Sentinel Landscapes, 2025b.

LegacyWorks Group is a non-profit consulting organization specializing in collaborative, community-driven initiatives for landscape-level conservation. Since 2022, LegacyWorks Group has led strategic planning for each of the designated Sentinel Landscapes, supporting the establishment of the Fort Huachuca and Northwest Florida Sentinel Landscapes. Building on this expertise, LegacyWorks Central Coast California is advocating for the designation of a Sentinel Landscape surrounding Vandenberg Space Force Base, which would encompass the majority of Santa Barbara County (Figure 1-2). The proposed VSL aims to protect critical natural land buffers around VSFB, conserve the region's unique biodiversity, and enhance regional resilience to climate change.

The VSL designation would mark a transformative step for conservation in the region, fostering collaboration among federal, state, and local partners to address shared conservation and defense priorities. By leveraging funding matches with federal programs like the Readiness and Environmental Protection Integration program, the VSL could unlock significant funding to protect critical habitats, promote sustainable working lands, and ensure adequate buffer zones for launch activities. This designation would also create a unique opportunity to bridge the conservation-implementation gap by appointing a dedicated Sentinel Landscape Coordinator, who would facilitate collaboration among partners, streamline resource allocation, and drive progress toward landscape-level goals. LegacyWorks Group is working alongside prominent local conservation organizations, including The Nature Conservancy, Gaviota Coast Conservancy, and Coastal Ranches Conservancy, to achieve these objectives.

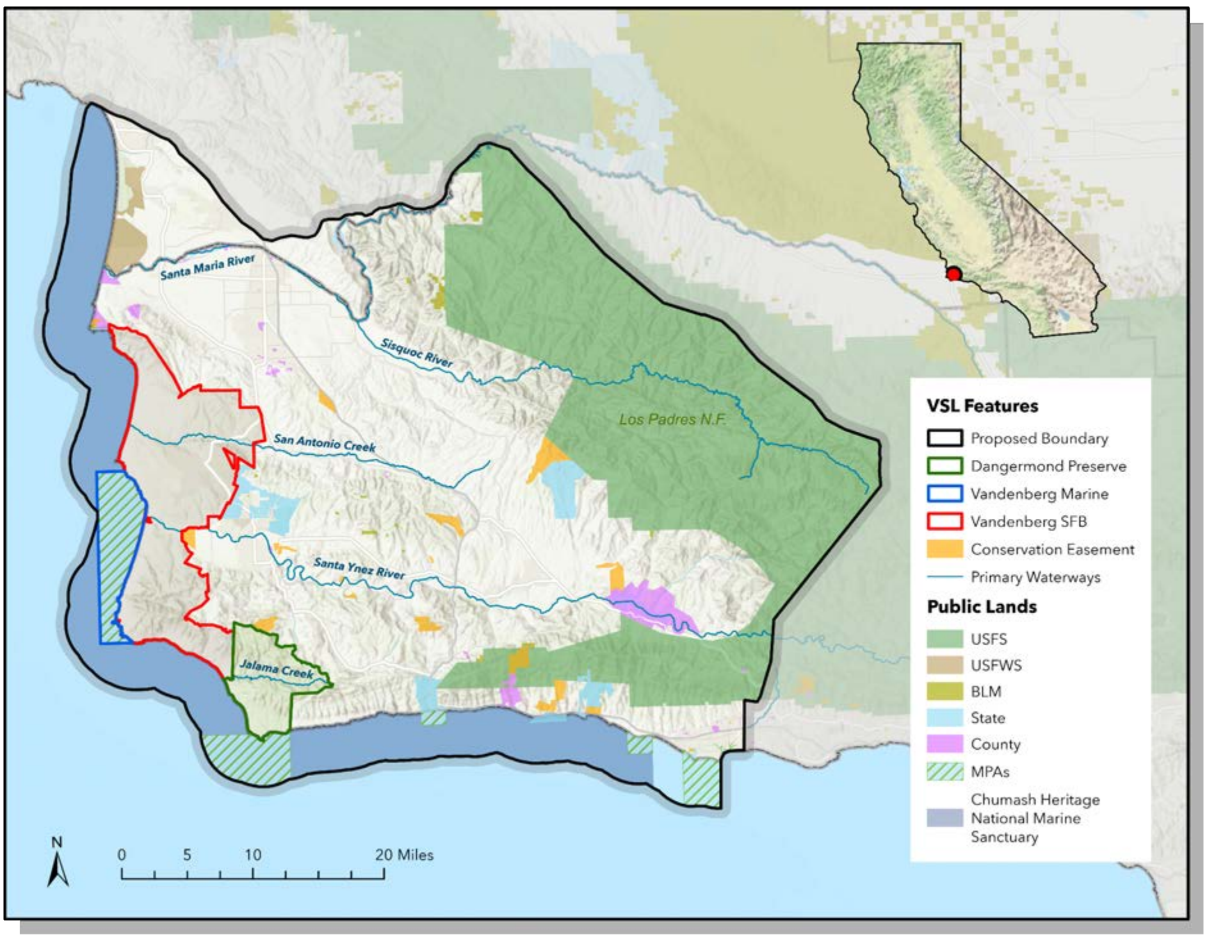

Figure 1-2. Proposed Vandenberg Sentinel Landscapes Boundary. The designation boundary is anchored by Vandenberg Space Force Base, outlined in red, and features federal and state public lands and protected areas.

A competitive Sentinel Landscape Partnership (SLP) application requires a clear and compelling framework that aligns the region's unique priorities with the broader goals of the SLP program. The application must include a Landscape Needs Statement that articulates the critical environmental, military, and community challenges the proposed landscape aims to address. This statement should emphasize the need to safeguard VSFB from incompatible development, conserve the SCC region's globally significant biodiversity, and build resilience to climate impacts. According to the 2026 Sentinel Landscape Designation Cycle Proposal Guidance (Sentinel Landscapes, 2025a), a successful proposal must:

1. Demonstrate a well-established network of partners, including federal agencies (USDA, DOD, DOI, and FEMA), state agencies, local governments, non-profits, and private landowners. The proposal should provide a documented history of ongoing collaboration among these partners and explain how each will contribute to specific actions that support the partnership's goals.

2. Define a clear sentinel landscape boundary with identified priority areas, backed by scientific and strategic rationale. The boundary should reflect ecological, operational, and community priorities, illustrating the interconnectedness of the area's natural resources, defense activities, and regional resilience efforts.

1.3 Objectives

Our project aimed to support a competitive application for the proposed VSL through the following objectives:

1. Identify the conservation priorities and implementation barriers faced by partners of the proposed Vandenberg Sentinel Landscape.

2. Recommend priority conservation areas to incorporate in the Vandenberg Sentinel Landscape application.

1.4 Report Overview

The following three chapters address our two project objectives. Chapter 2 uses qualitative methods to assess VSL partner priorities, identifying key themes and areas of interest. In Chapter 3, we focus on freshwater systems, identifying opportunities to advance Southern Steelhead Trout recovery. Chapter 4 shifts to terrestrial systems, where we conduct a multi-species connectivity analysis to identify critical areas for wildlife movement. Each chapter includes a description of the data and methods used, followed by an interpretation of the results. Finally, Chapter 5 summarizes our findings and provides recommendations for priority areas and projects to guide conservation planning within the proposed VSL.

2. Partner Priorities

2.1 Introduction

Engaging partners in conservation planning is essential for developing effective and sustainable strategies. Projects are more likely to succeed when they address local ecological and social needs while aligning with organizational priorities, capacity, and available funding (Jarvis et al., 2015). Involving local partners fosters a collaborative network to identify and implement achievable goals (Knight et al., 2008). Structured interviews with practitioners and experts help define conservation priorities, uncover implementation barriers, and establish clear, landscape-level objectives. This collaborative approach ensures initiatives are grounded in local knowledge and responsive to diverse stakeholder needs. In this study, we conducted and analyzed interviews with prospective VSL partners to inform the development of an SLP designation. These partners—experts in terrestrial wildlife, freshwater systems, natural resource management, private lands management, agriculture, policy, and Indigenous knowledge—provided valuable insights into regional priorities, implementation challenges, and collaboration opportunities. Their perspectives serve as the foundation for the next phases of our project. The interviews serve as the foundation for the next chapters of our project.

2.2 Methods

Design

Our research employed a mixed-methods approach to develop data-driven theories through iterative collection and analysis (Charmaz, 2006). This approach informed the creation of our semi-structured interview protocol. The study was approved by the Office of Human Subjects Research under protocol #1-24-0410.

Initial partner outreach began with a list of 33 VSL contacts provided by LegacyWorks Group. Each potential participant received a project introduction and VSL primer, with clear communication that participation was voluntary and that they could withdraw at any time. The sample included representatives from both the public and private sectors. Additional participants were identified through snowball sampling. Detailed participant and organizational information are provided in Appendix A.

Data Collection

Interviews were conducted via Zoom between July 1st and August 28th, 2024. Each 30-minute session was recorded and transcribed verbatim. Participants received the interview questions in advance and provided written consent via email, followed by verbal confirmation at the start of the interview. Most participants agreed to full identification, while some preferred organizational-level identification or anonymity.

The semi-structured interview consisted of five sections: Introduction, Personal Background, Broad Trends, Project Examples, and Success Metrics (Appendix B). The Introduction provided a brief project overview, addressed participant questions, obtained verbal consent, and confirmed their preferred level of identification. The Personal Background section explored each interviewee's area of expertise by asking about their experience in the conservation field. The Broad Trends section focused on priorities, revealing criteria considered and barriers encountered when implementing conservation projects. The Project Examples section allowed partners to share details of specific conservation projects and the motivations behind them. Finally, in the Success Metrics section, partners were asked to reflect on their vision for a successful Vandenberg Sentinel Landscape Partnership (VSLP) and what metrics would indicate that conservation efforts were having a positive impact. Throughout the interview, we maintained an open structure, allowing for follow-up questions tailored to each participant's expertise.

Data Analysis

Our analysis utilized both grounded theory and sentiment analysis to extract thematic insights and emotional responses from partner interviews.

Thematic Coding

Grounded theory is a systematic methodology that develops theories and hypotheses through iterative data collection and analysis. This approach enables the discovery of emergent themes and patterns in the data, rather than relying on predetermined hypotheses (Charmaz, 2006). We created a hierarchical coding structure, beginning with broad themes (parent codes) such as "biodiversity metrics," and refining them into more specific sub-themes (child codes) like "wildlife connectivity" and "species richness" (Saldaña, 2013). Using NVivo software, we assigned interview text segments to both parent codes and emergent child codes, uncovering the major themes discussed.

Sentiment Analysis

Sentiment analysis quantifies the attitudes and emotional tone of interviews from transcripts, adding a valuable dimension to our qualitative analysis that complements thematic coding. We extracted transcripts from a compiled PDF using the 'pdftools' package in R (Ooms, 2025) and structured the text by interview.

For text preparation, we tokenized the data using the 'tidytext' package (Silge, 2016), breaking it into words while removing standard English stop words (e.g., "and," "but"), interviewee/interviewer names, and filler words to retain only meaningful content. We then performed a sentiment analysis using the AFINN lexicon, which assigns scores from -5 (highly negative) to 5 (highly positive) (Nielsen, 2011). Tokenized words were matched to the AFINN lexicon, and sentiment scores were aggregated to quantify sentiment distributions. This analysis revealed partner attitudes toward conservation in the region.

2.3 Results

Of the 33 initially identified partners, 21 individuals representing 19 organizations participated in interviews, as some organizations had two representatives with different areas of focus. The 19 organizations included 13 non-governmental organizations (NGOs), five government bodies, and one private entity. The interviews covered a range of topics based on participants' expertise: eight focused on terrestrial wildlife, four on aquatic systems, four on agriculture, three on cultural issues, and two on climate change.

Thematic Coding

Conservation Criteria & Indicators

The top conservation criteria and indicators identified were habitat intactness (37 references) and biodiversity metrics (28) (Appendix C-1). Within the habitat intactness theme, sub-themes emphasized the importance of contiguous undeveloped habitat and landscape connectivity. Commonly cited biodiversity metrics included species persistence under climate change, habitat heterogeneity, and wildlife connectivity. Other key themes included special-status species, ecological resilience, and social metrics.

Priority Conservation Areas

The most frequently mentioned priority area by VSL partners was the Gaviota Coast (53 references) (Appendix C-1). Within this region, key focal areas included the Jack and Laura Dangermond Preserve, Point Conception, and Arroyo Hondo. Watersheds were also identified as a major priority within the proposed VSL (25 references) (Appendix C-1), with specific mentions of the Jalama and Gaviota Creek watersheds. Other important water bodies highlighted by partners included the Santa Maria and Santa Ynez rivers. Additionally, VSFB emerged as a key focus area in the discussions.

Implementation Barriers

Implementation barriers were primarily attributed to four key challenges: political barriers (118 references), funding deficiencies (99), resource deficiencies (64), and collaboration barriers (58) (Appendix C-1). Political barriers included land ownership conflicts, specific legislative or program requirements, and delays in the permitting process. Funding deficiencies were most often linked to a lack of investment, limited personnel capacity for grant applications, and the time-consuming nature of securing funding. Resource deficiencies were primarily associated with insufficient personnel capacity for project implementation. Collaboration barriers involved a lack of understanding, coordination, and trust between groups.

Example Projects

The most frequently referenced projects were biodiversity preservation (90 references), water resources management (68), natural and working lands conservation (64), fire and fuels management (41), and listed species recovery (29) (Appendix C-1). Within biodiversity preservation, top projects included wildlife connectivity, barrier removal, and fish passage enhancement. In water resources management, key projects focused on water quality improvement, flow maintenance, and restoration. Natural and working lands conservation efforts primarily centered on conservation easements and climate-smart agriculture. Fire and fuels management projects involved cultural burns, fuels reduction, and wildfire resilience planning. Recovery projects for listed species emphasized steelhead trout and western snowy plovers as top species of concern.

Motivations

The primary motivation for the projects was preserving biodiversity (111 references) (Appendix C-1). This included key themes such as wildlife connectivity, habitat restoration, fish passage enhancement, and protection of listed species. Other notable motivations included climate resilience, regulatory compliance and mitigation, recreational benefits, fostering partnerships, water resource management, funding opportunities, equitable tribal engagement, and the preservation of private lands.

Measures of Success

While responses to the success measures question varied widely, four key themes emerged as most prominent: collaborative partnerships (69 references), community-oriented success metrics (29), increased biodiversity (21), and increased project completion efficiency (16) (Appendix C-1). Within the collaborative partnerships theme, cross-boundary collaboration was the most frequently mentioned measure of success, followed by VSFB's involvement in off-base projects, reciprocal support, and streamlined knowledge sharing. Community-oriented success metrics focused on improved public engagement and education, as well as the incorporation of community feedback. Increased biodiversity was defined by the area of protected lands, habitat connectivity, habitat restoration efforts, and listed species recovery.

Sentiment Analysis

The sentiment analysis of the interviews yielded an overall mean sentiment score of 0.8, indicating a generally positive tone across all responses (Figure 2-1). A closer inspection revealed a bimodal distribution, suggesting two distinct sentiment trends within the data. Notably, this pattern appeared in nearly every interview, with sentiment varying based on the specific topics discussed (Appendix D).

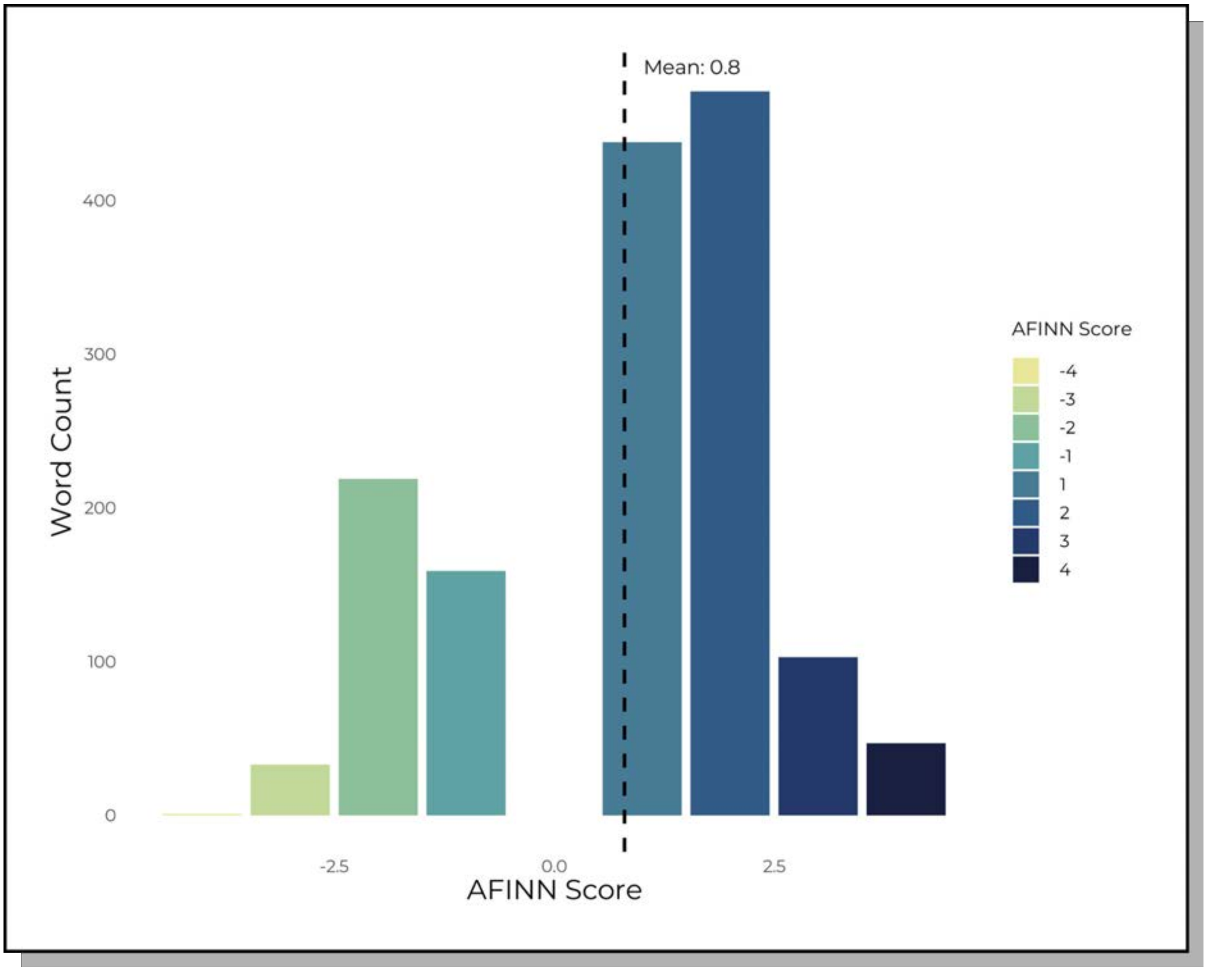

Figure 2-1. Aggregated Sentiment Analysis Scores Across Interviews. Distribution of AFINN lexicon scores for the interview data. Negative scores indicate negative sentiment, while positive scores indicate positive sentiment. The mean sentiment score (0.8) is marked as a dashed black line.

2.4 Discussion

Our thematic coding analysis provided key insights into partner priorities, implementation challenges, and the broader conservation landscape within the proposed VSL. By identifying recurring themes and analyzing sentiment, we gained a deeper understanding of how conservation practitioners view opportunities and barriers in the region.

Partner Priorities and Alignment

Our results show a strong consensus among partners on the importance of preserving biodiversity, with habitat intactness, wildlife connectivity, habitat restoration, and special-status species emerging as dominant themes. These findings underscore the significance of landscape-scale connectivity, particularly in areas like Gaviota Creek, Santa Maria River, and Santa Ynez River, where fish passage and barrier removal were commonly cited as conservation priorities. While preserving biodiversity was the most frequently mentioned motivation, other factors such as climate resiliency, regulatory compliance, mitigation, and private land preservation highlight the multifaceted nature of conservation goals. Future planning efforts should focus on integrating these priorities to maximize partner buy-in and achieve multi-benefit conservation outcomes.

Implementation Challenges

Partners consistently identified political barriers and funding limitations as major obstacles to conservation implementation. Concerns about permitting delays and land ownership conflicts highlight the potential for policy advocacy and regulatory streamlining to facilitate conservation action. Funding constraints were also identified as a significant challenge, particularly for sustaining long-term monitoring programs and maintaining sufficient personnel capacity. These findings suggest that conservation efforts could benefit from collaborative funding approaches, such as public-private partnerships, and that fostering cross-boundary relationships could help address trust and coordination barriers.

Enhancing Collaboration in the VSLP

The Gaviota Coast and the region's watersheds were identified as priority conservation areas within the partnership. However, many interviewees were hesitant to share specific project details, likely due to confidentiality requirements or organizational discretion. This highlights the need for continued partner engagement and trust-building efforts as the VSLP progresses. Thematic coding also revealed a variety of conservation metrics and indicators used by different organizations, including habitat intactness, biodiversity metrics, and social metrics. Recognizing these differences can enhance collaboration and improve the effectiveness of initiatives within the Sentinel Landscapes framework.

The sentiment analysis further emphasizes the complexity of partner perspectives, revealing a bimodal distribution with both positive and neutral to slightly negative sentiments. We interpreted positive sentiment as support for regional conservation initiatives, indicating strong potential for collaboration. In contrast, more neutral or negative sentiments may reflect concerns about specific land management strategies, regulatory policies, or potential impacts on local communities. These differing viewpoints underscore the importance of ongoing partner engagement and clear communication. By proactively addressing concerns and fostering transparency, the VSLP can strengthen partner buy-in and enhance the long-term success of regional conservation efforts.

Limitations

Our participant sample mainly consisted of conservation professionals from NGOs, which limited the representation of certain partners. Despite our intention for broad participation, time constraints and scheduling difficulties—coupled with our client's ongoing efforts to engage agencies such as NOAA, USFS, and tribal representatives—restricted our ability to include these perspectives in the interviews. As a result, our findings may not fully capture regional conservation priorities.

Thematic coding faced methodological limitations, particularly regarding potential researcher bias in grounded theory interpretation. Our group's conservation backgrounds could have influenced how we analyzed and categorized the data. For sentiment analysis, a key limitation is our reliance on a predefined lexicon that classifies words as either positive or negative. Certain words, such as "fire" or "concern," may be categorized as negative in sentiment lexicons, but in context, they could convey a positive or constructive tone. For example, these terms might reflect thoughtful consideration, beneficial conservation practices, or highlight areas for improvement, which would not necessarily indicate negative sentiment. Consequently, the analysis may have misclassified some words or phrases, potentially skewing the sentiment distribution and limiting the precision of our findings.

2.5 Conclusion

From our partner interviews, we identified key themes across all categories, including political barriers (118 references), biodiversity preservation (111), biodiversity preservation projects (90), collaborative partnerships (69), and the Gaviota Coast (53). Steelhead trout recovery and wildlife connectivity emerged as prominent sub-themes across multiple categories, highlighting the primary conservation concerns of our partners. These findings directly informed our approach to the second objective of this project: recommending priority conservation areas for the Vandenberg Sentinel Landscapes (VSL) application.

Given the lack of perspectives from tribal communities and private landowners, we recommend expanding engagement with these groups to develop a more comprehensive understanding of regional conservation needs. Incorporating diverse land management practices and traditional ecological knowledge will enhance the effectiveness of the VSL. Moving forward, efforts should focus on relationship-building with these groups to ensure that a broad range of perspectives are represented. Since our initial interviews, LegacyWorks Group has made progress by expanding the partnership to include NOAA and the USFS, thus strengthening the coalition and broadening the expertise and resources available for conservation efforts in the region.

3. Southern Steelhead Trout Recovery

3.1 Introduction

Partner interviews identified Southern steelhead trout recovery as a top conservation priority within the proposed VSL. Native to Southern California, Southern steelhead trout (*Oncorhynchus mykiss*) represents a distinct population segment (DPS) of steelhead trout adapted to the region's warmer climate and intermittent stream systems. Historically, this species ranged along California's South Coast from San Luis Obispo to San Diego counties, though the primary anadromous-producing watersheds are now concentrated north of the Santa Monica Mountains (National Marine Fisheries Service, 2012); Figure 3-1). The anadromous form of Southern steelhead spawns in freshwater streams and depends on marine resources for growth and maturation (Kendall et al., 2015). Therefore, maintaining access to both freshwater and marine environments is essential for sustaining the species' life cycle and genetic diversity.

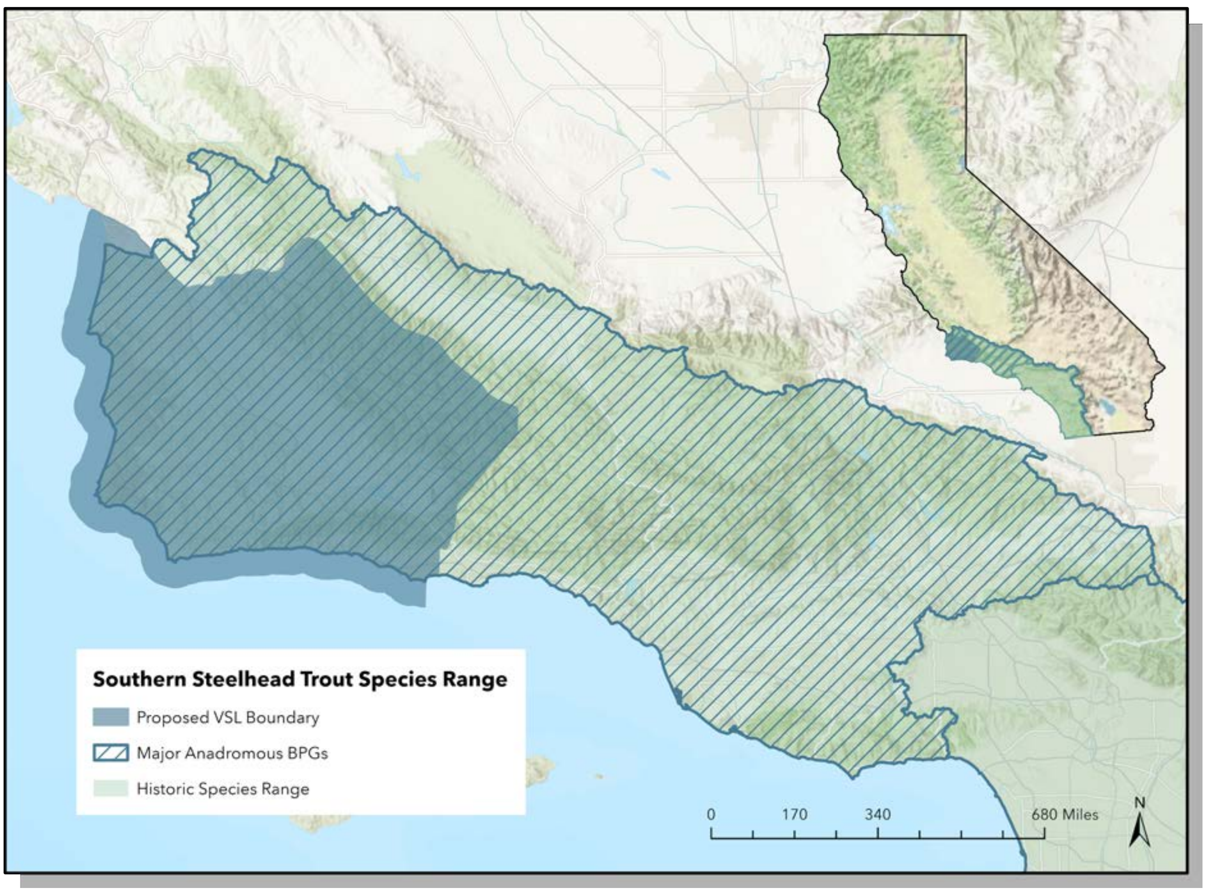

Figure 3-1. Southern Steelhead Trout Species Range. The historic species range of Southern steelhead is shaded in green. Critical watersheds that produce anadromous fish are delineated by the hashed polygon. The proposed VSL is shaded in blue.

Significance of Southern Steelhead

Southern steelhead holds cultural, environmental, and political significance. Historically, steelhead were vital to the Chumash diet and supported the spiritual and physical health of indigenous communities (NOAA, 2019; Weiner et al., 2016). As a keystone species, Southern steelhead play a critical role in both freshwater and marine ecosystems (Nguyen, 2020). By migrating between rivers and the sea, they transport nutrients that enhance the productivity of aquatic food webs (Munshaw et al., 2013). Additionally, Southern steelhead serve as an indicator species, with their population health reflecting the overall condition of aquatic ecosystems and habitat quality. Although they have adapted to variable stream conditions, urbanization and climate change have pushed them to their tolerance limits, leading to their federal protection as an endangered species under the Endangered Species Act in 1997.

Threats to Southern Steelhead

Human activities and environmental changes threaten Southern steelhead. Physical barriers such as dams, roads, and urbanization fragment habitat and restrict fish passage, disrupting migration (Weigel et al., 2013). The loss of riparian vegetation raises water temperatures, while agricultural and urban runoff introduce pollutants that degrade habitat quality (Fuller et al., 2022). Water extraction for agriculture and industry lowers streamflows, reducing available refugia, especially in summer (Grantham et al., 2012). Climate change further intensifies these threats, with rising temperatures exceeding thermal thresholds, prolonged droughts drying streams, and altered precipitation patterns causing flooding that displaces juveniles and eggs (Mohseni et al., 2003; Sloat & Osterback, 2013; Wade et al., 2013). Shifts in ocean temperatures also impact prey availability. These cumulative stressors underscore the urgent need for conservation action.

Advancing Southern Steelhead Trout Recovery in the Proposed VSL

Current efforts to conserve Southern steelhead focus on restoring access to key watersheds where they can spawn and grow. Most anadromous-producing watersheds lie north of the Santa Monica Mountains, where the proposed VSL would be designated. Primary recovery actions include removing barriers and improving habitat quality. Multiple VSL partners emphasized the need to enhance fish passage and restore freshwater habitat to support species recovery. Effectively prioritizing recovery projects requires identifying suitable steelhead habitat. However, conducting comprehensive field surveys across the entire region is often infeasible due to resource constraints, making habitat suitability modeling a necessary tool for locating potential recovery sites. Given the challenges steelhead face during the summer months, ensuring sufficient suitable habitat for over-summering survival is critical. Therefore, we tested the feasibility of assessing Southern steelhead over-summering habitat suitability to identify priority areas within the VSL for species recovery projects.

3.2 Methods

Assessing Southern steelhead over-summering habitat suitability requires data on steelhead presence and key environmental factors that indicate habitat quality. Table 3-1 provides a summary of all data used in this analysis.

Table 3-1. Data Sources for Southern Steelhead Suitability Analysis.

Data	Source	Description
Steelhead Presence	California Department of Fish and Wildlife	Field-surveyed observations of Southern Steelhead in Santa Barbara and Ventura Counties from 2018-2020
Steelhead Biogeographic Population Group (BPG) - Southern California Coast	National Marine Fisheries Service (NMFS)	Historic range of Southern Steelhead DPS
California Streams	California Department of Fish and Wildlife	Location of all California streams in National Hydrography Dataset scaled to 1:24k
Stream Temperature	California Department of Fish and Wildlife	Long-term field-measured stream temperature of select Santa Barbara streams from 2018-2020
Stream Temperature	CA Water Board SWAMP Program	Long-term field-measured stream temperatures of select Santa Barbara and Ventura County streams from 2018-2020
Stream Flow	United States Geological Survey	Long-term field-measured stream flow (cubic feet per second) from USGS stations in Southern California Counties (Kern, Los Angeles, Riverside, Santa Ana, Santa Barbara, San Diego, Ventura) from 2018-2023
Digital Elevation Model (DEM)	United States Geological Survey	Elevation and slope of terrain in the Santa Barbara region set at 30 m resolution

Tabular Data Processing

Species Occurrence

Species occurrence data for Southern Steelhead Trout (*Oncorhynchus mykiss*) was obtained from California Department of Fish and Wildlife (CDFW). This dataset was compiled through survey efforts across numerous water bodies and provides a foundation for understanding the species' distribution in Southern California. To ensure relevance and accuracy, we filtered occurrences in R to include only observations recorded between 2018 and 2023. Only living occurrences were retained to focus on viable populations. Because steelhead occurrences are highly concentrated in a few streams, we did not filter the dataset to the summer months, as doing so would have limited our analysis to four small streams (Arroyo Hondo, Gaviota, Mission, and Rattlesnake Creeks) with incomplete environmental data. These filtering steps produced a refined dataset that captures the recent spatial and temporal trends in steelhead populations across the study area.

Environmental Parameters

Stream Temperature

Stream temperature is a key environmental parameter influencing the habitat suitability of Southern steelhead. Elevated water temperatures can exceed the species' thermal tolerance, particularly in summer, affecting growth, survival, and reproduction. To assess these impacts, we obtained stream temperature data from CDFW and California Water Board Surface Water Ambient Monitoring Program (SWAMP).

Data processing in R involved filtering both datasets to match the temporal data coverage of the species occurrence dataset (2018-2023). After aggregating the datasets, we developed a linear regression model to predict missing or uncertain temperature values based on known relationships between environmental factors and stream temperature. We selected linear regression for its ability to model the relationship between stream temperature and key environmental predictors—such as air temperature, streamflow, and riparian cover—which have been well-documented in previous research (Mohseni et al., 1998). The resulting temperature layer serves as a foundation for identifying areas with suitable thermal conditions for steelhead during critical life stages.

Streamflow

Streamflow is another key determinant of Southern steelhead habitat suitability. We obtained streamflow data from USGS, which provides live measurements at 15-minute intervals across the United States. In R, we filtered the data to include only measurements from 2018 to 2023 for relevant counties, including Santa Barbara, Ventura, and Los Angeles. To ensure accuracy and reliability, we selected only high-quality records that were labeled “approved for publication.” Mean summer streamflow values were then calculated for each monitoring site to capture seasonal variations critical for steelhead survival. These metrics were integrated into the habitat suitability model to assess whether sufficient flows are available during the species’ most vulnerable periods.

Spatial Data Processing

Major anadromous-producing watersheds (Conception Coast, Monte Arido, Santa Monica Mountains BPGs) were clipped from the California NHD stream dataset, using a 100 m riparian buffer for environmental parameter interpolation (Li et al., 2009; Moerke & Lamberti, 2006).

In ArcGIS Pro, we interpolated the summarized stream temperature and flow data to generate broader stream segments for assessing habitat suitability. We applied Inverse Distance Weighting, which assumes that areas closer to the monitoring site will have stream temperature or flow values similar to those measured at the site (Khouni et al., 2021). This process produced two 30 m resolution rasters for interpolated stream temperature and streamflow, expanding spatial data coverage to include unmonitored stream segments.

Stream elevation, slope, and aspect are also critical factors for determining suitable habitat and were incorporated into the suitability model to enhance its accuracy (Kim et al., 2020). Higher elevation environments tend to have cooler waters, and steeper stream gradients promote higher velocities (McGill et al., 2024). Using the 30 m resolution digital elevation model, we calculated stream elevation, slope, and aspect for the riparian zone within the study area.

Habitat Suitability Analysis Using MaxEnt

We conducted our suitability model for Southern steelhead over-summering habitat using the Maximum Entropy (MaxEnt) Wallace Application in R. MaxEnt is a machine learning algorithm that evaluates the relationship between species presence and environmental factors to predict suitable habitat. Adapting methods used by NMFS to evaluate Southern steelhead habitat suitability in 2006, we combined 6,490 fish presence records with environmental covariates to create our model (Boughton & Goslin, 2006). Like NMFS, we included data on stream temperature, streamflow, and stream gradient (Boughton & Goslin, 2006). Considering the influence of elevation and aspect on habitat quality, we also incorporated these additional parameters.

To ensure predictions were constrained to streams with environmental data, we set the background modeling extent to match the streams raster used to produce the raster stack. To train our model and minimize spatial bias, we generated 40,000 background points which were spatially partitioned using a checkerboard 2 (k=4) design. This method allocates 75% of the points for model training and 25% for model validation. We assessed model performance using the area under the curve (AUC) value, with AUC > 0.7 indicating a well-performing model (Wang et al., 2022).

3.3 Results

Significant data gaps limited our ability to conduct an accurate Southern steelhead over-summering habitat suitability analysis for the region. While data on elevation, slope, and aspect were available for all streams in the region, information on streamflow and stream temperature were limited. Despite approximately 1,000 stream gages existing across California (California State Water Resources Control Board, 2022), only 38 USGS stream gages were actively collecting long-term streamflow data within the major anadromous-producing watersheds. Similarly, only 47 long-term CDFW and SWAMP stream temperature monitoring sites were established, despite many potential monitoring locations. These severe data limitations restricted the number of streams included in our suitability modeling.

Streams with sufficient data include San Antonio Creek, Santa Ynez River, Atascadero Creek, Mission Creek, Ventura River, and Santa Paula Creek (Figure 3-2). These streams have complete datasets for all environmental parameters required for modeling. In contrast, streams with insufficient data include Cuyama River, Jalama Creek, Sisquoc River, and others (Figure 3-2). Missing data in these streams primarily pertains to streamflow or stream temperature, either due to lack of public availability or because the data was never collected. Additionally, sections of the Santa Maria River and several lower watershed streams (Gaviota Creek, Arroyo Hondo, Refugio Creek, and others), had no data on streamflow or temperature. These areas are also designated as critical habitat for special-status species, such as endangered steelhead (Figure 3-2).

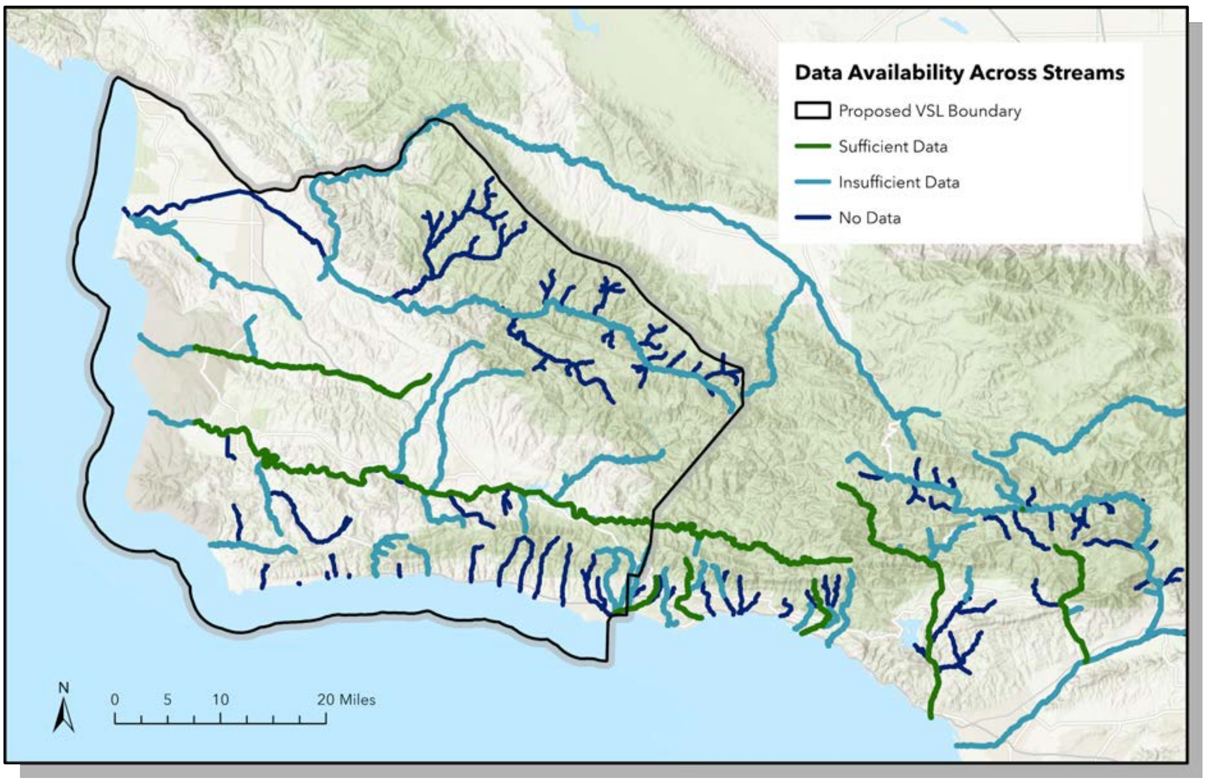

Figure 3-2. **Data Availability Across Streams.** Green streams have complete datasets for all environmental parameters. Blue streams are missing data on streamflow or stream temperature. Dark blue streams lack streamflow and stream temperature data, and are designated Southern steelhead trout critical habitat.

3.4 Discussion

Recommendations

These findings highlight the need for increased monitoring and data sharing to support decision-making in the region. Many streams lacked sufficient long-term streamflow and stream temperature to facilitate spatial analyses that inform prioritization of Southern steelhead Trout recovery efforts. Data scarcity could be addressed through a VSL partnership that fosters communication and collaboration to improve data sharing and monitoring capacity. Priority watersheds for increased monitoring include the Gaviota Creek, Jalama Creek, and Santa Maria River watersheds, which were also identified as priority conservation areas by VSL partners in our interviews (Figure 3-2). Efforts to establish or repair monitoring stations can help address the spatial and temporal monitoring gaps that often hinder comprehensive stream habitat assessments.

Limitations

Data constraints limited a thorough habitat suitability assessment to identify priority areas for steelhead recovery projects. Even with sufficient data to model suitability, this approach to recovery planning still has limitations. Stream hydrogeology, adjacent land-uses, fish biology, and climate change all impact Southern steelhead, but were excluded from the prior habitat suitability analyses (Boughton & Goslin, 2006). Cold springs, deep pools, and groundwater seeps introduce cold water and provide thermal refugia for steelhead in the summer months (Alessio et al., 2023). However, the locations of these features have not been thoroughly mapped, preventing their inclusion in the habitat suitability analysis.

Accounting for Agricultural Impacts

In the Santa Maria River, intensive agriculture has increased pesticide and sediment toxicity in streams, reducing macroinvertebrate densities (Anderson et al., 2006). Fine sediment deposition from agriculture also reduces prey availability and impairs juvenile steelhead growth and survival (Suttle et al., 2004). However, long-term water quality data and the locations of high pesticide and sediment deposition are not widely available. Increasing monitoring efforts for these parameters would help identify priority areas for promoting agricultural practices that reduce runoff and minimize habitat degradation.

Accounting for Fish Biology

Fish movement patterns and prey availability influence fish presence and persistence but often are not accounted for in habitat suitability models. While models can help identify areas to focus steelhead recovery efforts, it is equally important to ground-truth model outputs (Nagai et al., 2020; Shinskie et al., 2023). Field surveys of fish, prey, and redd presence in predicted suitable habitats are crucial to confirming the accuracy of model outputs. Furthermore, evaluating fish movement patterns is essential to understanding whether fish can access suitable habitat after restoration or barrier removals. Additional monitoring before implementation would help confirm the biological and logistical feasibility of proposed recovery projects.

Accounting for Climate Change

Integrating climate change projections into our model could enhance its ability to predict future habitat suitability for Southern steelhead. Rising air temperatures, increasing wildfire frequency, prolonged droughts, and intensified precipitation variability may alter the availability and quality of suitable habitat. Higher air temperatures increase stream temperatures, which can negatively impact steelhead persistence in streams (Mohseni et al., 1998, 2003). Wildfires burn away stabilizing vegetation and harden soil surfaces, weakening soil structure and increasing erosion (Jumps et al., 2022). This destabilization of streambanks results in the introduction of excess nutrients, toxic contaminants, and fine sediments which degrade water and spawning habitat quality for steelhead (Suttle et al., 2004; Verkaik et al., 2013). Shifting precipitation patterns and increasing drought prevalence affect streamflows and velocities, altering habitat suitability. Incorporating fine-resolution climate projections into habitat suitability models would allow for more accurate predictions of future steelhead distributions, ultimately improving conservation planning and prioritization efforts.

Importance of Long-term Monitoring

Long-term datasets of steelhead presence, activity, and stream habitat are necessary to conduct and validate spatial analyses that inform recovery action. Data limitations in freshwater ecosystems were repeatedly acknowledged as obstacles to conducting spatial analyses in previous studies (Boughton & Goslin, 2006; Spina & Tormey, 2000; Warrick et al., 2015). Overall, our work highlights the need for increased monitoring in the region. Improved data availability will enable an updated understanding of where suitable habitat is located, how threats impact suitable habitat, and which areas should be prioritized within the proposed VSL.

3.5 Conclusion

Limited data prevented an accurate over-summering habitat suitability analysis but revealed the need for increased regional stream habitat quality monitoring to inform Southern steelhead trout recovery planning. This can be achieved through a VSL partnership, as VSL partners are committed to collaboration to achieve shared goals, such as Southern steelhead recovery. Increased data sharing and monitoring would help close the data gaps prevalent in freshwater ecosystems. Therefore, we conclude the following:

- A VSL partnership would be highly beneficial to increase data sharing and monitoring capacity to close regional freshwater data gaps and advance steelhead recovery.
- Stream quality monitoring should be prioritized for streams in the Gaviota, Jalama, and Santa Maria watersheds, as these areas currently lack data and were identified by VSL partners as important conservation areas.
- Research documenting the influence and locations of groundwater seeps, pesticide runoff, sedimentation, and fish activity is necessary to inform where suitable habitat exists, how threats impact suitable habitat, and which recovery projects (e.g., habitat restoration, barrier removal, or sediment control) should be prioritized.

4. Wildlife Connectivity

4.1 Introduction

From interviews with VSL partners, we identified wildlife connectivity as a top priority. To guide the management and restoration of critical wildlife pathways, we conducted an analysis to identify ways to enhance connectivity for wide-ranging carnivores, small to mid-sized mammals, and habitat specialists, including ground-foraging birds and amphibians, within the proposed VSL region.

Maintaining connected landscapes allows wildlife to move freely in search of food, mates, and suitable breeding grounds (Albert et al., 2017). Connectivity also enables species to shift their ranges in response to environmental changes (Cushman et al., 2013). However, urbanization, infrastructure development, and agricultural expansion have caused significant habitat fragmentation, disrupting wildlife movement, limiting access to resources, and altering ecological systems (Littlefield et al., 2019). Fragmentation can also isolate populations, increasing the risk of inbreeding and genetic bottlenecks, while reducing a species' ability to adapt to climate change and migrate as conditions shift (Haddad et al., 2015). Strategic, data-driven conservation planning is essential to maintaining a connected landscape. Targeted interventions, such as wildlife crossings or corridor restoration, can help maintain functional connectivity (Goldfarb, 2023). Wildlife connectivity modeling can identify critical movement corridors, heavily trafficked pinchpoints, and barriers to animal movement, providing valuable insights for prioritizing conservation efforts within the VSL boundary.

4.2 Methods

Core Area Selection

Core areas are key locations that require linkages to maintain ecological connectivity and biodiversity (Sawyer et al., 2011). For this connectivity analysis, core areas were primarily selected based on the Gap Analysis Project (GAP) designated protected areas, which represent lands with varying levels of conservation measures (United States Geological Survey, 2024; Table 4-1). Partner input was also central to the selection process, ensuring that locally significant areas and management priorities were considered. Specifically, partners emphasized the ecological importance of VSFB, leading to the inclusion of both its northern and southern sections as core areas. Other core areas, such as the Burton Mesa Ecological Reserve, Purisima Hills, and Bicknell Open Space were selected for their regional significance as critical landscape blocks, as identified by the California Essential Habitat Connectivity project (W.D. Spencer et al., 2010; Table 4-2, Figure 4-1). Neighboring core areas were consolidated into a single core. This collaborative approach ensured that core areas aligned with both ecological goals and place-based conservation priorities.

Table 4-1. USGS Gap Analysis Project Land Definitions.

GAP status code	Definition of land status
1	Areas managed for biodiversity to prevent conversion of natural land cover and maintain a natural state. Natural disturbance events can proceed or are mimicked in the management. (Ex. Wilderness Areas)
2	Areas managed for biodiversity to prevent conversion of natural land cover and maintain a natural state, but management practices can degrade natural states and natural disturbance events can be suppressed (Ex. National Wildlife Refuges)
3	Areas having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses. It also confers protection to federally listed endangered and threatened species throughout the area. (Ex. National Forests)
4	Areas with no known mandate for biodiversity protection or conversion of natural habitat. The area generally allows conversion to unnatural land cover throughout or management intent is unknown. (Ex. Agricultural lands)

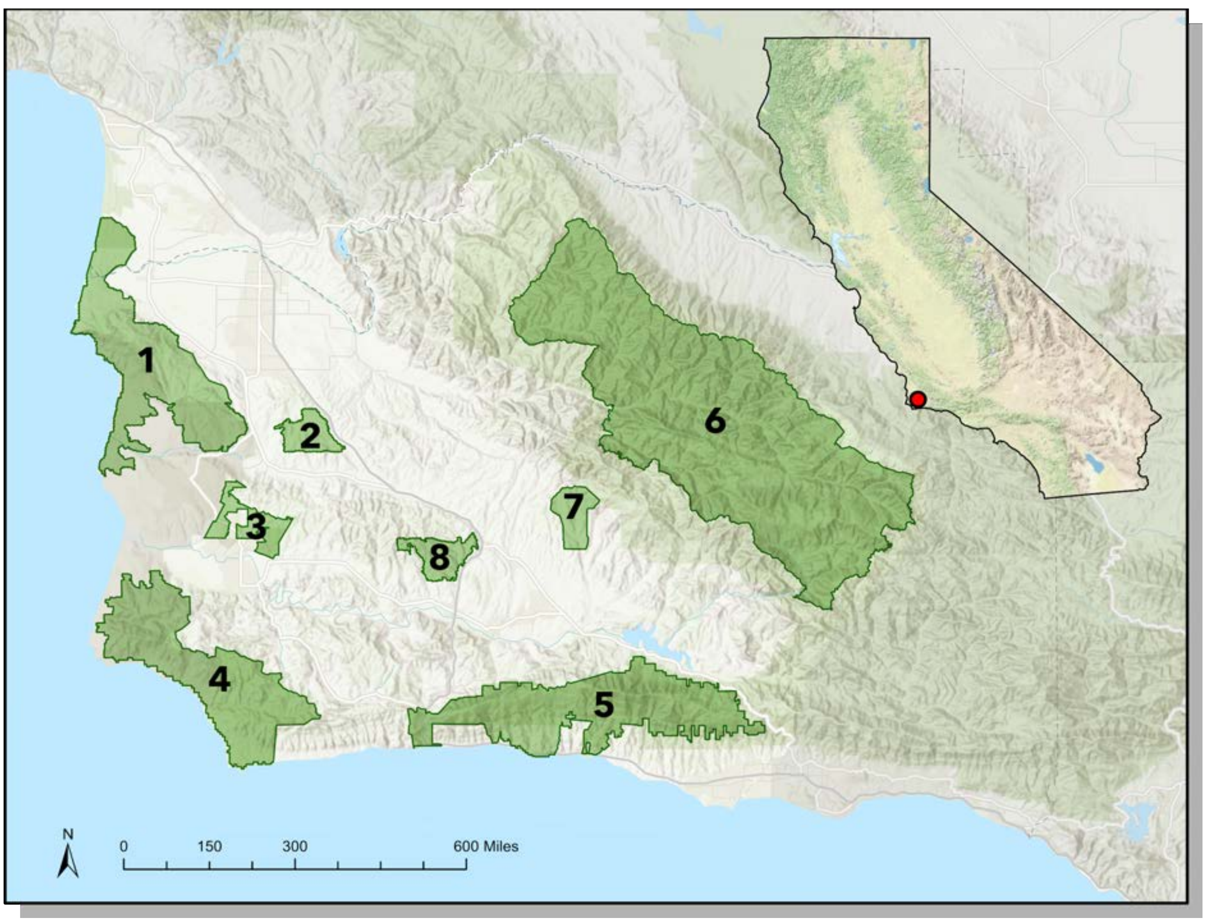

Figure 4-1. Core Areas in the Study Region. Core areas were selected based on the GAP designated protected areas and expert input. Descriptions of core areas by identification number are outlined in Table 4-2.

Table 4-2. List of Core Area Attributes. Consolidated core areas are categorized by designation type, managing unit, and GAP status code.

Core Area ID	Unit Name	Designation Type	Managing Unit	GAP Status
1	Vandenberg Space Force Base (Northern)	Military Land	Department of Defense	4
	Guadalupe Dunes County Park	Local Conservation Area	County of Santa Barbara	2
	Guadalupe-Nipomo Dunes National Wildlife Refuge	National Wildlife Refuge	U.S. Fish and Wildlife Service	2
2	Long Canyon	Conservation Easement	Land Trust for Santa Barbara	4
	Land Trust for Santa Barbara County Easement	Conservation Easement	Land Trust for Santa Barbara	4
3	Burton Mesa Ecological Reserve	State Conservation Area	California Department of Fish and Wildlife	2
	La Purisima Mission State Historic Park	State Historic or Cultural Area	California Department of Parks and Recreation	4
4	Jack and Laura Dangermond Preserve	Private Conservation	The Nature Conservancy	2
	Vandenberg Space Force Base (Southern)	Military Land	Department of Defense	4
5	Gaviota State Park	State Park Recreation	California Department of Parks and Recreation	4
	El Capitan State Beach	State Park Recreation	California Department of Parks and Recreation	4
	Arroyo Hondo Preserve	Private Conservation	Land Trust for Santa Barbara County	2
	Los Padres National Forest (LPNF)	National Forest	U.S. Forest Service	3
6	San Rafael Wilderness	Wilderness Area	U.S. Forest Service	1
7	Sedgwick Reserve	State Conservation Area	University of California	2
8	Rancho Purisima Hills	Conservation Easement	Land Trust for Santa Barbara	4

Focal Species Selection

Selecting focal species is a critical step in connectivity modeling and must consider the diversity of species' life histories and ecologies (Breckheimer et al., 2014; Meurant et al., 2018). Species exhibit different movement patterns based on their ecological needs. Passage species require expansive, connected landscapes to facilitate movement across broad spatial scales. Corridor-dwelling species depend on continuous habitat corridors to maintain population connectivity and genetic diversity over generations. Connectivity modeling must account for both movement types to ensure long-term ecosystem resilience (C. Krause & Gogol-Prokurat, 2014). Ideal focal species include umbrella species, whose habitat needs overlap with multiple species, as well as fragmentation-sensitive or special-status species that may serve as indicators of broader connectivity challenges (Breckheimer et al., 2014; Thorne et al., 2006).

Focal species were selected based on both expert consultation and established connectivity modeling criteria from the CDFW Guidance Document for Fine-Scale Connectivity Analysis and the CalTrans Gaviota Pass Highway 101 Wildlife Connectivity Assessment. (ICF, 2023; C. Krause & Gogol-Prokurat, 2014; C. M. Krause et al., 2015). The selection process prioritized species representing diverse taxonomic groups, movement behaviors, and habitat requirements, ensuring a comprehensive connectivity assessment of the biodiversity within the VSL region. Criteria included area sensitivity, barrier sensitivity, dispersal limitations, specialized habitat requirements, listed status, and ecological roles as umbrella, indicator, or flagship species (C. Krause & Gogol-Prokurat, 2014, Table 4-3).

Table 4-3. Focal Species Selection Criteria Definitions

Selection Criteria	Definition
Area sensitive	Species that occur in low density but require large areas
Barrier sensitive	Species that are specifically sensitive to road development
Umbrella	Species that are representative of a trophic group/guild, species' habitat and ecological needs are used as a proxy for broader ecosystem
Dispersal limited	Species that require seasonal migration (fine scale movement)
Habitat specialist	Species that are highly sensitive to habitat loss or fragmentation
Listed status	Species of greatest conservation need based on conservation status ranking

Based on the selection criteria outlined above, this analysis includes five focal species: mountain lion (*Puma concolor*), mule deer (*Odocoileus hemionus californicus*), black-tailed jackrabbit (*Lepus californicus*), California thrasher (*Toxostoma redivivum*), and California red-legged frog (*Rana draytonii*). The selected focal species and the rationale for their inclusion are displayed in Table 4-4. Additional information on each species' life history, justification for selection, distribution maps, habitat associations, and spatial patterns are provided in Appendix E.

Table 4-4. Focal Species for Analysis.

Taxonomic Group	Scientific Name	Common Name	Movement Type	Rationale Criteria
Mammal (Carnivore)	*Puma concolor*	Mountain lion	Passage	Area sensitive, barrier sensitive, umbrella, flagship, specially protected
Mammal (Ungulate)	*Odocoileus hemionus*	Mule deer	Passage	Barrier sensitive, dispersal limited, important prey species
Mammal (Lagomorph)	*Lepus californicus*	Black-tailed jackrabbit	Passage	Barrier sensitive, important prey species
Bird	*Toxostoma redivivum*	California thrasher	Corridor	Habitat specialist, umbrella (chaparral)
Amphibian	*Rana draytonii*	California red-legged frog	Corridor	Habitat specialist, umbrella (riparian), indicator, flagship, listed species

Passage Species Corridor Analysis

Several resistance-surface approaches are used to model species connectivity, including circuit theory, cost-weighted distance, and resistant kernels (Kumar & Cushman, 2022). Circuit theory models adapt concepts and algorithms from electrical circuit theory, treating habitat cores as nodes connected by resistors across a raster grid (Shah & McRae, 2008). The model assumes that animals are "random walkers," meaning they have no prior knowledge of the landscape they move through. Passing a current through the circuit from source to destination nodes generates current values for each cell in the landscape, representing the probability of a random walker moving through the cell (McClure et al., 2016). Higher current densities are found at "pinchpoints" where many potential paths converge in a narrow linkage area, as few alternative paths exist (McClure et al., 2016).

Cost-weighted distance modeling treats resistance to movement as a cost and calculates the cumulative ecological cost an animal incurs while moving between two habitat cores, or termini (Wade et al., 2015). From this cost surface, the model computes the least-cost path and least-cost corridor between any two termini (Wade et al., 2015). This approach assumes animals have perfect knowledge of the landscape and will select a single optimal route that minimizes movement costs (Williamson et al., 2020).

For the three passage species, we applied both cost-weighted distance and circuit theory models to identify least-cost corridors, pinchpoints, and landscape barriers to movement. The analysis covered the VSL boundary, buffered by 10 km, to include additional habitat outside the boundary.

Resistance Surface

The resistance surface forms the foundation of connectivity modeling, where land areas are assigned a resistance or "cost" value that reflects the relationship between ecological variables and the difficulty of species movement across each cell (Wade et al. 2015). This surface represents limitations to movement based on environmental conditions and species-specific ecological needs. Resistance can be derived from habitat suitability models by inverting the suitability values, with areas of high habitat suitability corresponding to low resistance, and vice versa (Poor et al., 2024).

Habitat Suitability Model

Two primary approaches for estimating habitat suitability are expert opinion-based models and statistical models. Statistical models, such as species distribution models created with MaxEnt, offer improved accuracy and reproducibility but come with tradeoffs in terms of resolution, computational feasibility, and data requirements. To model habitat suitability at a fine scale for our regional analysis, we selected an expert opinion model developed by Beier et al. (2006) for the Arizona Missing Linkages project. This project conducted a connectivity analysis for the same focal passage species in southeastern Arizona (Beier et al., 2006).

To build our habitat suitability model for the three passage species, we relied on expert estimates of species responses to four habitat factors, which were mapped at 30 m resolution:

- ***Vegetation***: Vegetation types classified by the California Wildlife Habitat Relationships System arithmetic means.
- ***Topographic position***: Pixels characterized as ridge, canyon bottom, flat/gentle slope, or steep slope using the Corridor Designer toolbox.
- ***Elevation***: USGS National Elevation Dataset digital elevation model.
- ***Roads***: Euclidean distance from primary and secondary TIGER/LINE roads.

Based on expert opinion values, we assigned scores ranging from 1 to 10 to each topographic position, elevation class, and distance from roads class. The scoring system was as follows: 1-3 represents optimal habitat, 4-5 denotes suboptimal but usable habitat, 6-7 indicates areas that may be occasionally used but cannot sustain a breeding population, and 8-10 represents strongly avoided areas (Beier et al., 2006). Due to regional differences in vegetation between these studies, we inverted and scaled CDFW California Wildlife Habitat Relationship (CWHR) suitability values to match Beier et al.'s scoring, rather than assigning values to land cover (Appendix F). The CWHR habitat classification scheme is a predictive model with expert-assigned suitability ratings for vegetation types by stage class. We then summed these layers according to their assigned factor weights, reflecting the degree to which each habitat factor influences suitability.

Resistance Calculation

Habitat suitability surfaces can be inverted to calculate resistance to movement through a linear inverse transformation, assuming a direct inverse relationship between suitability and resistance. However, this approach oversimplifies species movement behavior. In reality, species may traverse lower-quality habitats during movement periods (Keeley et al., 2016). An approach by Keeley et al. (2016) addressed this by using a negative exponential transformation function to convert habitat suitability values into resistance:

$$Resistance = 100 - 99 \times \frac{((1 - exp(-c * h))}{(1 - exp(-c))}$$

where *h* is the habitat suitability value (ranging from 0 to 1), and *c* is the scaling parameter. *C*-values closer to 1 indicate a nearly linear relationship between suitability and resistance, while increasing *c*-values create an increasingly nonlinear negative exponential function of suitability (Keeley et al., 2016; Poor et al., 2020). For consistency with previous studies and the method outlined in Jennings et al., (2020), a non-linear *c*-value of 4 was applied for all species (Wang et al., 2022).

Connectivity Modeling

We employed several tools from the ArcGIS Linkage Mapper Toolbox to model least-cost corridors, least-cost paths, pinchpoints, and landscape barriers to movement (B. McRae & Kavanagh, 2021). To maintain biological accuracy, corridors and pinchpoint linkages were truncated to fit within the species' home range size.

- ***Linkage Pathways:*** Core habitat areas and resistances were used to map corridors and least-cost paths through cost-weighted distance modeling. The resulting corridors indicate each grid cell's relative value in providing connectivity between core areas, helping identify routes that encounter more or fewer features that facilitate or impede movement.

- ***Pinchpoint Mapper:*** This tool ran Circuitscape, a computational algorithm based on circuit theory, to identify and map areas of constricted movement (pinchpoints) within the resulting corridors. Areas with higher current flow are the most critical for maintaining corridor intactness and connectivity.

- ***Barrier Mapper:*** Resistances and cost-weighted distance rasters were used to estimate reductions in movement cost if resistances values were set to 1, representing full habitat restoration. High-scoring barrier centers detected within a 1000 m moving window indicate areas where restoration or mitigation could improve connectivity.

Patch Analysis

We conducted a patch analysis for all five focal species to identify habitat patches that could support their populations as they move through corridors. This analysis evaluates the ability of habitat patches to sustain populations over time and models areas that corridor-dwelling species may rely on for movement across generations. Our approach adapted the retired habitat patch tool from the ArcGIS Corridor Designer toolbox to classify contiguous patches as either population, breeding, or other (smaller than breeding) patches, using the following definitions (C. Krause & Gogol-Prokurat, 2014; Majka et al., 2006):

- ***Population patch:*** Suitable habitat that can support at least 50 individuals and sustain the species for several decades.
- ***Breeding patch:*** Suitable habitat capable of supporting one breeding pair, or areas at least twice the size of the minimum home range but smaller than a population patch.
- ***Other patch:*** Suitable habitat smaller than a breeding patch, which can be used as stepping-stone habitat to link other patches.

We defined suitable habitat using the CDFW threshold for high habitat suitability, which is greater than or equal to 0.66 for CWHR arithmetic means. After grouping contiguous suitable habitats and classifying the patch types, we filtered the patches within the unionized corridors of passage species and assessed the dispersal distance between patches. Patches that did not meet the species' dispersal requirements were excluded, resulting in the final patch layer.

Priority Area Identification

To identify priority areas for conservation, we assessed where important pinchpoints, barriers, and habitat patches overlap with the following ecological threats:

- ***Urban growth:*** 2050 projections of urban growth areas in California.
- ***Human modification:*** A cumulative measure of the human modification of terrestrial lands from the Global Human Modification of Terrestrial Systems dataset. High and very high human modification were selected as values ≥ 0.4 on the 0-1 index scale.

- ***Fire risk:*** A measure of fuel conditions and fire potential in the ecosystem, representing the relative likelihood of severe wildfire occurring in a given area. High, very high, and extreme fire risk were selected from the five threat categories.
- ***Wildland Urban Interface:*** Areas where human development intermingles with or is adjacent to wildland vegetation. Both intermix and interface zones were selected as areas where habitat fragmentation, human-wildlife conflict, and increased wildfire risk may threaten ecological connectivity and wildlife movement.

We selected the 90th percentile of pinchpoint and barrier values across the three passage species and intersected these areas with regions with more than one threat to identify vulnerable linkage areas at highest risk. To pinpoint areas where high quality habitat is at risk, we intersected the unionized results from our patch analysis with areas under multiple threats. We then refined priority areas by considering land ownership and feasibility, protected status, and presence of critical habitat for endangered species. To account for the impact of roads on connectivity, we also assessed barriers for wildlife-vehicle collision (WVC) hotspots (Shilling, 2015).

4.3 Results

Identified priority areas were categorized based on the predominant land ownership type and the presence of critical habitat. Predominant land ownership type was assigned based on the ownership type covering over 50% of the priority area boundary. Pinchpoints and barriers lacked protected land, while habitat patches contained a small percentage of protected land. Connectivity maps for individual species are available in Appendix E.

Pinchpoints

Our analysis identified 21 top-percentile pinchpoint areas under multiple ecological threats (Figure 4-2). Of these pinchpoints, 10% are located on majority publicly owned land and provide critical habitat for special-status species as designated by the United States Fish and Wildlife Service (USFWS); 33% are on privately owned land with critical habitat; 5% are on publicly owned land without critical habitat; and 52% are on privately owned land without critical habitat.

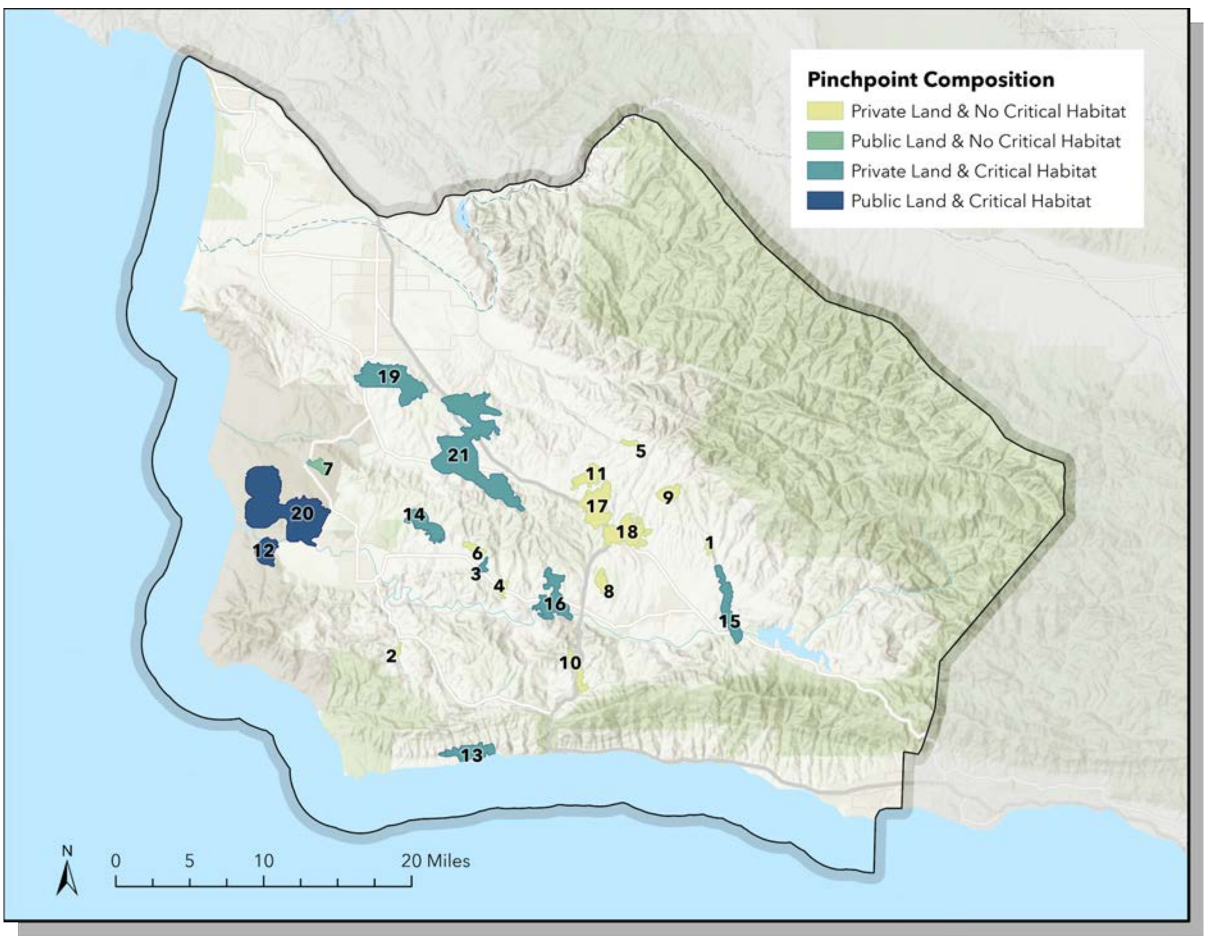

Figure 4-2. Top-Percentile Pinchpoints Under Multiple Threats. The 21 identified pinchpoints differ in majority land ownership types and presence of critical habitat. Publicly owned areas with critical habitat are located within VSFB (polygons 12 and 20).

Barriers

We identified 20 barrier areas under multiple ecological threats (Figure 4-3). Of these, 5% are located on majority publicly owned land and provide critical habitat for special-status species; 40% are on privately owned land with critical habitat; and 55% are on privately owned land without critical habitat. Upon overlaying roads, we found that 65% of identified barriers intersect with major roads and wildlife-vehicle collision hotspots, highlighting the significant challenge that roads pose to connectivity.

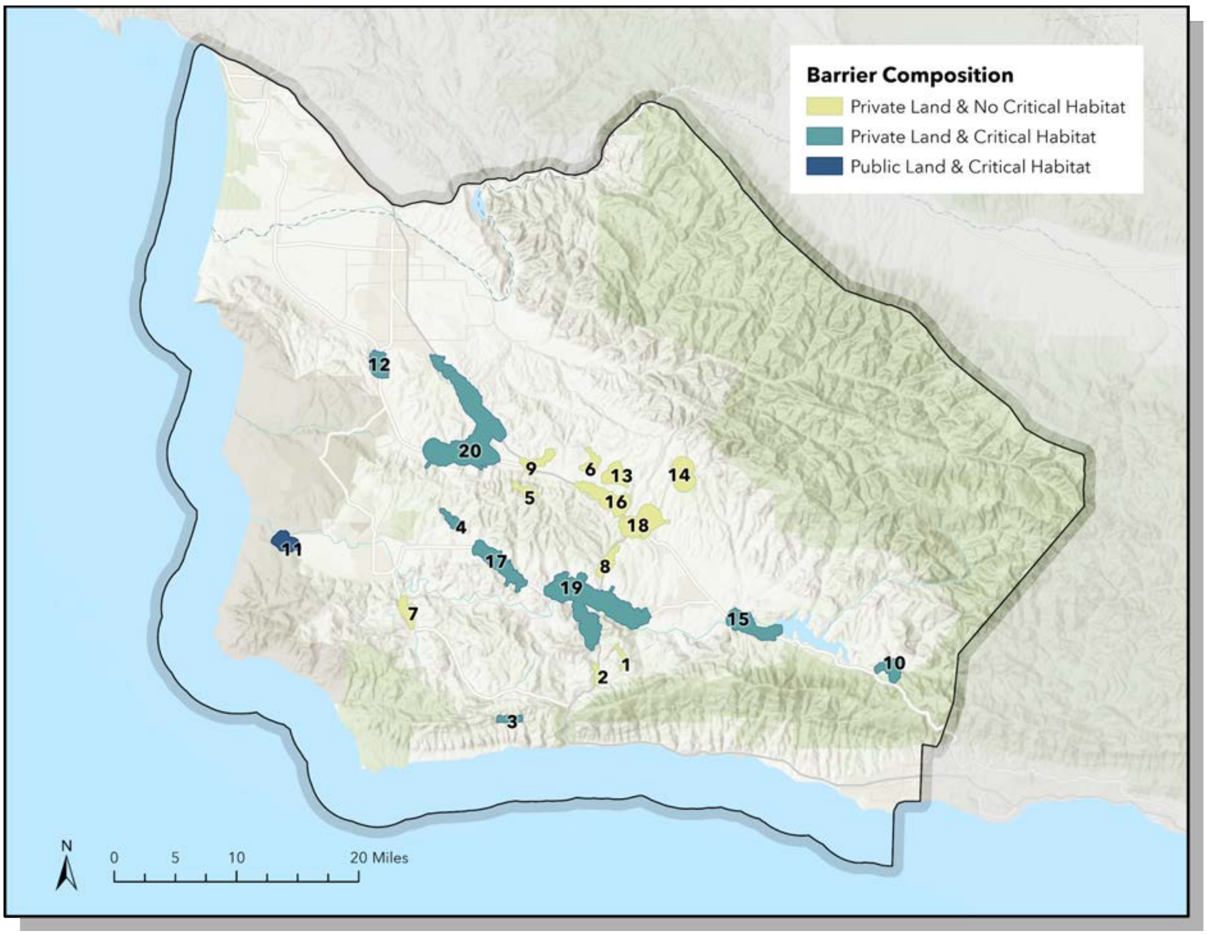

Figure 4-3. Top-Percentile Barriers Under Multiple Threats. The 20 identified barriers differ in majority land ownership types and presence of critical habitat. Publicly owned areas with critical habitat are located within VSFB (polygon 11).

Patches

From the unionized habitat patches, we identified 34 patches under multiple ecological threats (Figure 4-3). Of these patches, 24% are on majority publicly owned land and provide critical habitat for special-status species; 44% encompass privately owned land with critical habitat; 6% do not contain critical habitat and are majority publicly owned; and 26% do not contain critical habitat and are privately owned. Unlike pinchpoints and barriers, 9% of habitat patches contain some portion of protected land.

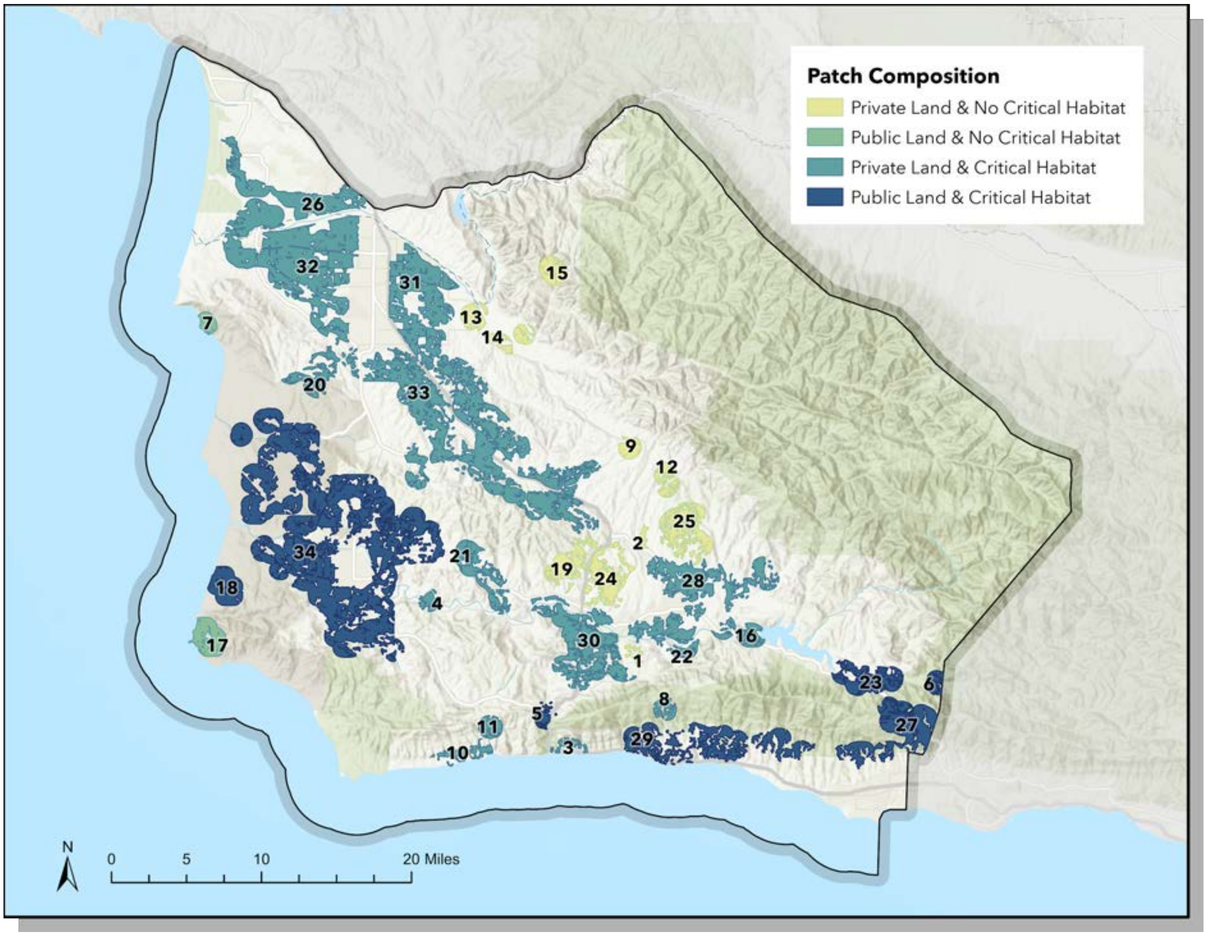

Figure 4-4. High Quality Habitat Patches Under Multiple Threats. The 34 identified habitat patches differ in land ownership types and presence of critical habitat. Publicly owned areas with critical habitat are located within VSFB (patches 18 and 34) and LPNF (patches 6, 23, 27, and 29).

4.4 Discussion

Land-Habitat Composition

The study region is a patchwork of land uses including open space, agriculture, residential, and commercial areas. Few priority areas were under a single land ownership type, except those within VSFB. Publicly owned land containing critical habitat are ideal for conservation, offering greater feasibility for implementing projects and providing potential benefits for special-status species. Effective conservation planning must consider critical habitat, as it informs protection measures, supports compliance with the Endangered Species Act, and helps mitigate habitat loss and fragmentation. Public lands, already subject to regulatory requirements, are generally more accessible for conservation than private lands, which require willing landowners to participate. The primary challenge is coordinating and collaborating across the various public agencies responsible for managing these lands. However, private lands can still offer viable conservation opportunities, depending on landowner willingness to engage in conservation activities.

Corridor Analysis

Modeled pinchpoints can serve as conservation priorities because they are locations where a relatively small loss of area could disproportionately impact important migration routes or movement needs (McRae, 2012). By identifying areas where the highest current flow values overlap with multiple ecological threats, we pinpointed regions where high traffic areas would benefit most from conservation interventions. Inspection of satellite imagery and land use data revealed that many pinchpoint areas contain agricultural or riparian buffers which may function as narrow passageways through which movement is funneled. Additionally, some pinchpoints are constrained by surrounding development, such as urban infrastructure and roads. Of the 21 priority pinchpoint areas, five contained the ideal combination of majority public land ownership and critical habitat. Possible interventions for maintaining connectivity in these areas include habitat protection and corridor enhancement, which could expand surrounding habitat and reduce bottlenecks, enabling more free movement of wildlife (Jones et al., 2015).

Modeled barrier centers are areas within linkages that most significantly impact habitat continuity. Habitat restoration and barrier removal in these areas could greatly improve structural connectivity. Barriers may result from natural landscape features (e.g., unsuitable habitat types and topography) or built obstructions (e.g., roads and dams). Of the 20 barrier areas facing multiple ecological threats, 13 intersect with major roads, highlighting the significant impact of roads on wildlife movement. This finding aligns with empirical studies documenting major highways in this region as WVC hotspots, particularly for highly mobile species such as mountain lions and mule deer, which were focal species in our study (Shilling et al., 2023). These results emphasize the potential benefits of road-based interventions, such as wildlife corridors, culverts, and fencing, to improve connectivity and mitigate WVCs.

Patch Analysis

Our patch analysis identified contiguous suitable habitats that support focal species at various levels, ranging from sustaining populations and facilitating breeding to serving as stepping-stone habitat. By intersecting these patches with multiple ecological threats, we pinpointed areas where high-quality habitats are under significant pressure. When evaluating the feasibility of conservation actions and the importance of conserving critical habitat, 24% of patches met these criteria. While 9% of patches have some level of protection, the extent of this protection is minimal compared to the total patch area. Conservation actions for these patches may include habitat restoration, land protection strategies, and mitigation of major threats such as development, roads, and land conversion. Implementing wildlife corridors and reducing human disturbances in key patches can further enhance ecological resilience and help conserve high-quality habitat.

Recommendations

Several strategies can improve wildlife connectivity. For pinchpoints, common approaches include habitat protection and restoration. Protecting surrounding habitat can prevent land conversion that would disrupt and sever bottlenecked linkages. Restoration and habitat enhancement can expand available habitat around corridors, offering alternative movement routes. To mitigate landscape barriers, particularly roads, recommended strategies involve constructing culverts, underpasses, and overpasses to allow wildlife to cross the corridor with reduced mortality risks from WVCs. Below, we present specific intervention examples for two priority areas selected for their distinct characteristics:

Pinchpoint ID #16

Pinchpoint 16, located near Buellton, is divided by Highway 246 and includes a mix of cultivated cropland to the south and herbaceous and shrub scrub habitats at its boundaries (Figure 4-5). Most of the land is privately owned, except for River View Park, a small publicly owned open space managed by the City of Buellton. A key ecological feature is the Santa Ynez River and its riparian corridors, which provide habitat for native species, including the federally endangered Southwestern willow flycatcher (*Empidonax traillii extimus*).

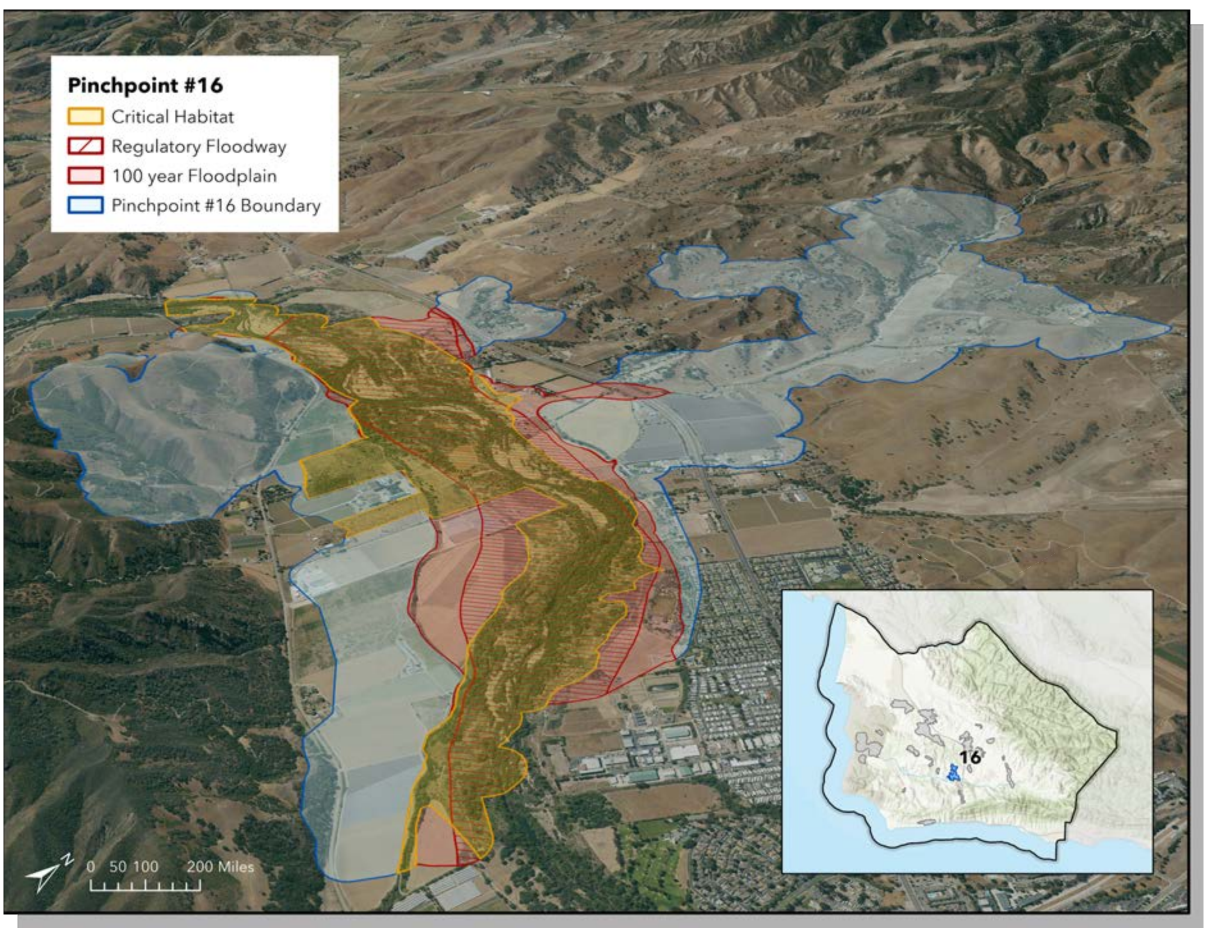

Figure 4-5. Pinchpoint 16 Features. Pinchpoint 16 is characterized by critical habitat and flood zones. The Santa Ynez River provides critical riparian habitat for the Southwestern willow flycatcher.

The area surrounding the Santa Ynez River is also within the regulatory floodway zone, including regions with a 1% annual chance of flooding (100-year floodplain). According to FEMA, these floodways must remain unobstructed to allow the free flow of floodwaters. Encroachment, especially from agriculture or infrastructure, could increase flood risks and damage riparian habitats.

Protecting and restoring riparian ecosystems is crucial for maintaining habitat connectivity and facilitating species movement. Climate-smart agriculture, such as agroforestry, can enhance soil stability, carbon sequestration, and wildlife habitat, all while supporting agricultural productivity (Muschler, 2015). In the Santa Ynez watershed, agroforestry practices like hedgerow expansion along agricultural fields can create semi-permeable corridors that facilitate species movement. These conservation buffers reduce edge effects and enhance habitat permeability, acting as vital wildlife corridors that support biodiversity across landscapes (Bentrup, 2008; Johnson & Buffler, 2008). Additionally, conservation buffers offer co-benefits such as pollinator habitat enhancement, carbon sequestration, flood mitigation, and improved water quality (Bentrup, 2008; Johnson & Buffler, 2008).

Conservation efforts should also prioritize maintaining floodway integrity and restoring riparian corridors to improve ecosystem function and climate resilience. Studies suggest that phasing out agriculture in flood-prone areas and restoring native vegetation can enhance water retention, reduce flood damage, and increase biodiversity (Opperman et al., 2010). The Yolo Bypass in the Sacramento Valley demonstrates a successful balance between flood management and ecological restoration (Sommer et al., 2001), an approach that could be applied to the Santa Ynez River.

Conservation easements have proven effective in agricultural landscapes by reducing habitat loss and preventing cropland conversion (Braza, 2017). In a long-term study of USFWS conservation easements in the Prairie Pothole Region, Braza found that lands under easements experienced 14.6% less cropland conversion than comparable unenrolled lands, demonstrating their effectiveness in protecting ecologically valuable areas while providing economic benefits to landowners. These easements offer financial incentives, reduce wind erosion and flood damage, and ensure long-term land protection. Implementing conservation easements along the Santa Ynez River could protect important habitat while allowing compatible land uses. Expanding conservation buffers through agroforestry and floodplain restoration can enhance climate resilience, biodiversity, and habitat connectivity in this pinchpoint.

Barrier ID #15

Barrier 15 is located along Highway 154 near Lake Cachuma (Figure 4-6). This area is primarily privately owned, with portions managed by the Bureau of Reclamation, and contains critical habitat for the vernal pool fairy shrimp (*Branchinecta lynchi*). The segment of Highway 154 that bisects this barrier is a documented hotspot for WVCs, though it is not currently designated as a priority wildlife barrier by CDFW. Conservation strategies such as wildlife fencing and culverts could improve connectivity by directing wildlife to designated crossing structures, reducing WVCs, and facilitating safe movement across the fragmented landscape. Similar mitigation measures have proven effective elsewhere, such as in Arizona, where fencing and culverts have enhanced habitat permeability for species like mountain lions and mule deer (Beier et al., 2006).

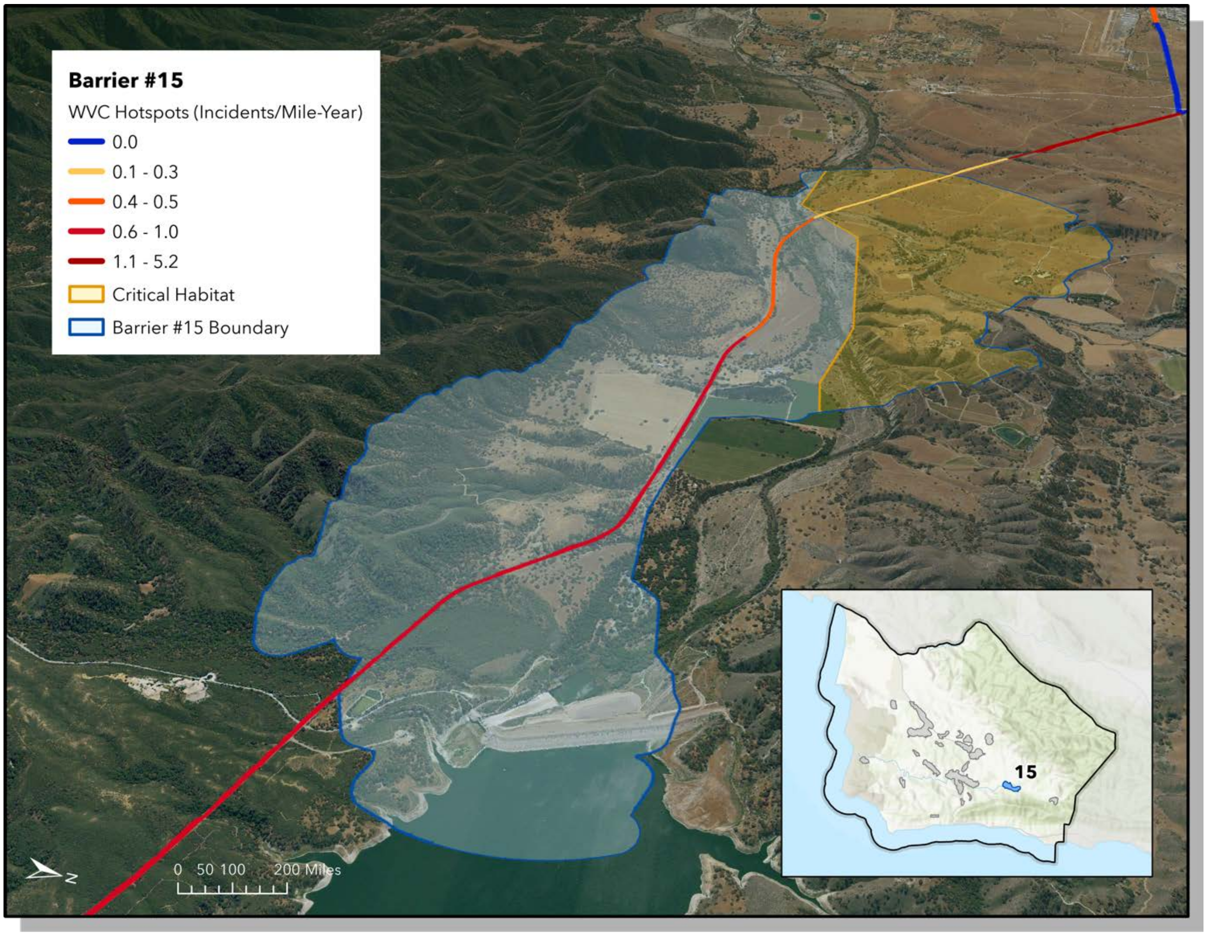

Figure 4-6. Barrier 15 Features. Barrier 15 is located along a segment of Highway 154 next to Lake Cachuma that is a hotspot for wildlife-vehicle collisions, characterized by the number of annual WVC incidents per mile. The area contains critical habitat for the federally threatened vernal pool fairy shrimp and is predominantly privately owned, with portions managed by the Bureau of Reclamation.

In addition, conservation easements and agricultural buffer zones could help maintain movement corridors across private lands, as recommended in the Columbia Plateau Ecoregion Connectivity Analysis (WHCWG, 2012). Modifying existing culverts and enhancing streamside vegetation would further improve connectivity for aquatic and semi-aquatic species (WHCWG, 2012). A combination of road mitigation, land conservation, and habitat restoration strategies will be essential for maintaining ecological integrity in these barrier zones.

A significant challenge in implementing crossing and barrier mitigation projects is the diversity of land uses and ownership. Different stakeholders, including private landowners, public agencies, and conservation groups, manage adjacent properties which can complicate coordination, funding, and permitting efforts. Therefore, engaging a diverse range of partners, facilitated by a connected VSL network, will be key to advancing connectivity barrier mitigation.

Limitations

Accounting for Climate Change

Due to data limitations and the near-term focus of this study, we did not account for future climate scenarios, which are essential for predicting shifts in habitat suitability and species movement corridors under climate change. Without integrating long-term climate trends, conservation efforts may prioritize areas that will no longer support species in the future (Reside et al., 2018). A dynamic modeling approach that incorporates the combined effects of climate change, land use alterations, and shifting disturbance regimes could enhance predictive accuracy and provide a more realistic representation of species movement and ecological dynamics in a changing climate (Franklin, 2010; Littlefield et al., 2017).

Subjectivity in Expert Opinion Models

Our resistance layer relied on an expert opinion model, which brings several limitations. The subjective nature of expert opinion can introduce variability and bias, as experts may have different experiences, perspectives, and interpretations of ecological processes (Krueger et al., 2012). Additionally, expert opinion models are often based on incomplete and imperfect data, which can increase uncertainty in model outputs (Krueger et al., 2012). As a result, expert opinion may lack the robustness of empirically based models.

Focal Species as Proxies

In our multi-species connectivity approach, we use focal species as representative umbrella species that serve as proxies for a broader diversity of species. However, it is important to note that no single species can serve as a perfect surrogate for another (Breckheimer et al., 2014). Addressing this limitation may require a more detailed understanding of the dispersal habitats of target species to identify which species are most likely to benefit from protection under another species' proxy.

Focal Species Spatial Patterns

Focal species' home range size and dispersal distance significantly influence model outputs. Species' home range size is used to estimate population and breeding patch size, as well as to define the truncated corridor widths in the connectivity analysis (C. Krause & Gogol-Prokurat, 2014). These home ranges were selected based on current research and relevant literature for each species. However, home range sizes can vary considerably depending on factors such as sex, environmental conditions, and food availability (Spencer et al., 2010). Limited research on California red-legged frog home range size led us to use the home range of the foothill yellow-legged frog (*Rana boylii*) (C. M. Krause et al., 2015).

Connectivity Modeling

The spatial configuration of core habitat areas plays a fundamental role in the formation of pinchpoints in Circuitscape models. Irregularly shaped core areas with pronounced edges tend to exaggerate pinchpoints by funneling random walkers through narrow entry points (B. H. McRae et al., 2008). This effect can create artificially high current densities (pinchpoints) near these habitat areas, which may not accurately reflect true movement patterns. Additionally, circuit models assume species movement occurs equally in all directions and follows a random pattern without prior knowledge of the landscape (B. H. McRae et al., 2008). Since many species exhibit directional biases and spatial memory, circuit theory models may lose some accuracy in predicting wildlife movement. In contrast, cost-weighted distance models assume that animals have perfect knowledge of the landscape, enabling them to traverse optimal paths of least resistance (Williamson et al., 2020). This assumption may not accurately reflect true movement patterns, especially for species with dispersal constraints or specialized habitat requirements.

4.5 Conclusion

We identified priority areas where pinchpoints, barriers, and high-quality habitat are under multiple threats. These areas can serve as key locations for interventions aimed at improving wildlife connectivity across the proposed VSL. Common restoration strategies to enhance and maintain wildlife corridors include reestablishing native vegetation and managing invasive species to improve habitat quality. Additionally, physical barriers can be mitigated by installing wildlife-friendly infrastructure such as culverts, underpasses, and overpasses, allowing safe movement across roads and other built structures.

The findings and limitations of this study present several opportunities for future research. Empirical studies are needed to assess whether the modeled corridors are actively used by focal species. This ground-truthing is often conducted by deploying GPS collars or tags on target species to track their movement patterns across the landscape. Camera traps and genetic sampling can complement collaring studies by confirming species presence in the modeled corridors and assessing whether gene flow between populations indicates successful connectivity (Calderón et al., 2024). Field surveys can further assess physical barriers, anthropogenic activity, and habitat quality not captured in the model. These surveys will also help determine the feasibility of movement in urban areas and identify which intervention strategies—such as culverts and wildlife crossings—are most appropriate to improve connectivity in identified barrier areas.

Additional modeling could further enhance this study's findings. Similar fine-scale connectivity assessments have included land facet analysis to model corridors of topographic similarity that may provide resilience to climate change (C. M. Krause et al., 2015). Incorporating climate change into conservation planning is essential to ensure that conservation efforts more realistically represent species distributions and ecological dynamics, accounting for climate threats. Moreover, adding more species to this analysis could strengthen the model by capturing a broader range of ecological requirements, movement behaviors, and habitat needs, resulting in corridors that better reflect diverse species interactions and ecosystem dynamics. The analysis should include both corridor species and passage species that represent the rich biodiversity within the VSL region.

5. Summary of Findings and Recommendations

5.1 Summary of Findings

Our project supported a VSLP application to enhance collaboration and accelerate conservation efforts in the California South Central Coast region. A VSLP can bridge the gap between conservation planning and on-the-ground implementation. Through discussions with VSL partners, we gained valuable insights into key conservation priorities and implementation challenges. Building on this information, we identified critical areas within the proposed VSL where targeted actions can be most effective.

VSL Partner Priorities and Barriers to Implementation

Our qualitative analysis identified key themes and priorities among VSL partners, with biodiversity preservation as the top concern. Partners also highlighted wildlife connectivity, habitat restoration, listed species recovery, and watershed protection as critical conservation priorities. However, significant challenges hinder implementation, including political barriers, insufficient funding, limited resources, and collaboration difficulties. Overcoming these obstacles is essential for advancing regional conservation efforts. The proposed VSLP can help bridge the gap between planning and implementation, strengthen regional collaboration, and expand funding opportunities for conservation within the VSL.

Overarching Attitudes towards VSLP

Sentiment analysis revealed a slightly positive overall outlook on the proposed VSLP, though attitudes varied among partners. This range of perspectives highlights the need for ongoing engagement and open dialogue to strengthen the VSL network. By emphasizing transparency and inclusivity, the VSLP can foster stronger partner buy-in and drive the long-term success of regional conservation efforts.

Opportunities to Advance Southern Steelhead Trout Recovery

To support habitat restoration and watershed priorities, we explored opportunities to advance Southern steelhead trout recovery. Limited data prevented a full habitat suitability analysis, highlighting the need for better stream habitat monitoring to guide recovery efforts. A VSL partnership could help close these data gaps through enhanced monitoring and data sharing.

Improving Landscape-scale Wildlife Connectivity

To support wildlife connectivity, we conducted a multi-species connectivity analysis within the proposed VSL boundary, identifying priority areas for targeted conservation. These include pinchpoints, barriers, and high-quality habitat under multiple threats. A VSL partnership could foster stronger collaboration, secure additional funding for connectivity projects, and increase the efficiency of large-scale conservation efforts across the landscape.

Final Justification for a VSLP

Our findings underscore a critical need for a VSLP in this region. Discussions with VSL partners confirmed their enthusiasm for participation and highlighted the need for greater funding and stronger collaboration. Through spatial analyses, we identified priority areas for conservation projects within the proposed VSL. Ultimately, designating a VSL in the Southern Central Coast region of California will streamline project development, bridge the conservation planning-implementation gap, and drive regional conservation efforts forward.

5.2 Recommendations for Conservation Planning and Future Research

Recommendation 1: Expand VSLP network to include more tribal and private landowner representation.

Most VSL partners are public agencies or nonprofits focused on natural resource conservation. However, to ensure diverse perspectives, greater representation from local tribes and private landowners is essential. Incorporating Indigenous knowledge into regional conservation planning can strengthen ecological stewardship and inform culturally relevant strategies. Private landowners also need stronger representation, as many key pinchpoints, barriers, and habitat patches are on private land. Notably, quality habitat, pinchpoints, and barriers are located within Hollister Ranch, a residential community set within a working cattle ranch on the Gaviota Coast. Given these findings and VSL partners' recognition of Hollister Ranch as a priority conservation area, we recommend actively engaging the Hollister Ranch Conservancy in the partnership. Effective conservation efforts will depend on the involvement of landowners and collaborative solutions that align conservation goals with their interests.

Recommendation 2: Increase monitoring and data sharing to support Southern Steelhead Trout recovery planning.

Stream temperature and flow monitoring should prioritize the Gaviota Creek, Jalama Creek, and Santa Maria watersheds to address data gaps in freshwater systems. Consistent, collaborative data collection is crucial for assessing the impacts of climate change, wildfires, and habitat degradation on species recovery. Recovery planning would also benefit from research on groundwater seeps, pesticide runoff, sedimentation, and fish activity to identify suitable habitats and inform conservation strategies. This research will help prioritize restoration, barrier removal, and sediment control projects. Enhanced data sharing, facilitated by a VSL coordinator, will strengthen collaboration, improve efficiency, and expand data availability.

Recommendation 3: Ground-truth wildlife connectivity models.

Validating modeled wildlife corridors is essential to ensure they accurately reflect wildlife movement. Field studies can confirm species presence and compare observed movement patterns with modeled routes. Ground-truthing can also identify barriers and assess habitat quality that may not be accurately represented in models. Additionally, these surveys help determine movement feasibility in urban areas and pinpoint interventions (e.g., culverts, wildlife crossings) to improve connectivity in barrier zones.

Recommendation 4: Engage partners in wildlife connectivity planning

The patchwork of mixed land and habitat composition across the study region highlights the need to engage diverse partners to improve wildlife connectivity within the proposed VSL. Wildlife movement transcends jurisdictional boundaries, and both public and private lands present opportunities and challenges for connectivity. To address these challenges, the VSL partnership must actively engage private landowners and communicate the co-benefits of conservation. Enhancing wildlife connectivity can provide multiple co-benefits, including carbon sequestration, improved water quality and soil health, and the preservation of ecosystem services that support biodiversity.

The type of intervention needed to improve wildlife connectivity depends on whether movement is constricted (i.e., a pinchpoint) or impeded by landscape features (i.e., a barrier). In constricted areas, interventions should focus on widening the movement corridor through habitat restoration or protecting private land via conservation easements. In areas where movement is blocked, often by roads, infrastructure solutions such as overpasses, underpasses, and culverts, should be implemented to facilitate safe crossings. Determining the appropriate intervention and its location is complex and requires input from multiple stakeholders to ensure the protection of critical habitat, enhancement of habitat quality, and connection of fragmented landscapes. Therefore, advancing multi-species wildlife connectivity in the proposed VSL will require regional collaboration to identify and implement the most effective strategies for connecting and conserving wildlife corridors.

Appendices

Appendix A. Table of VSL Partner Participants

Table A-1. VSL Partner Participants. The position title and affiliation of 20 interviewees representing 18 organizations are reported in this table. One interviewee preferred to remain fully anonymous.

Name	Title	Organization
[Redacted]	[Redacted]	California Department of Transportation (CalTrans)
Michael Delbar	Chief Executive Officer	California Rangeland Trust
Em Johnson, Bre Sliker	Director of Climate Resilience, Climate Projects Manager (Agriculture)	Community Environmental Council (CEC)
Brian Holguin	Consultant, Community Member for Chumash Band of Indians	[Redacted]
Doug Campbell, Candice Meneghin	Past Executive Director, Nature Conservationist	Coastal Ranches Conservancy
Stephanie Wald	Watershed Project Manager	Creek Lands Conservation
Doug Kern	Executive Director	Gaviota Coast Conservancy
Bill Leahy	Co-Director, Central Coast Region	LegacyWorks Group
Ben Halpern	Executive Director	National Center for Ecological Analysis and Synthesis
Teresa Romero	Director	Native Nations
Devin Best	Executive Director	San Luis Obispo Resource Conservation District
Garrett Wong	Climate Program Manager	Santa Barbara County
Devin Rothman	Director of Land Conservation	Santa Barbara Land Trust
Moe Gomez	Director	South Coast Habitat Restoration
Mark Reynolds	TNC Point Conception Institute Director and Lead Scientist for Jack and Laura Dangermond Preserve	The Nature Conservancy (TNC)
Emma Chow	District Conservationist	United States Department of Agriculture, Natural Resource Conservation Service (USDA NRCS)
Christina (Christie) Boser	Ecologist / Wildlife Biologist	United States Fish and Wildlife Service
Darryl York	Environmental Section Chief	Vandenberg Space Force Base

Appendix B. Partner Interview Guide

- What are the most important ecological and conservation areas in the region, and why? What criteria and indicators do you look for?
- What are the main barriers you face in implementing conservation projects in the Gaviota region?
- What are some examples of projects your organization is currently working on? What was the main motivation for pursuing these projects? What are three projects that you want to advance within the next 3-5 years?
- How should we measure success? What targets or metrics do we need to consider that will indicate that the project/actions/partnership is working or has succeeded?

Appendix C. Table of Thematic Codes

Table C-1. Thematic codes. Child codes are nested under the bolded and shaded parent codes. References refer to the number of times a specific coded segment appears within a source, while sources indicate the number of distinct interviews that contained coding for the theme.

Category	Name	References	Sources
Conservation Criteria & Indicators	**Habitat intactness**	37	10
	Habitat intactness\Contiguous undeveloped habitat	13	6
	Habitat intactness\Landscape connectivity	4	4
	Biodiversity metrics	28	12
	Biodiversity metrics\Species persistence under climate change	4	3
	Biodiversity metrics\Habitat heterogeneity	3	3
	Biodiversity metrics\Wildlife connectivity	3	3
	Biodiversity metrics\Species richness	2	2
	Special-status species	23	7
	Special-status species\Number of listed species	5	4
	Special-status species\Critical habitat	5	2
	Ecological resilience	18	7
	Ecological resilience\Resilience to drought	3	2
	Ecological resilience\Resilience to flooding	3	2
	Ecological resilience\Resilience to warming	3	2
	Social metrics	12	4
	Social metrics\Cultural significance	6	2
	Social metrics\Equity and environmental justice	2	2
	Social metrics\Socioeconomic status	1	1

Category	Name	References	Sources
Priority Conservation Areas	**Gaviota Coast**	53	13
	Gaviota Coast\Jack and Laura Dangermond Preserve	12	8
	Gaviota Coast\Point Conception	11	7
	Gaviota Coast\Arroyo Hondo Preserve	4	2
	Gaviota Coast\Hollister Ranch	3	2
	Gaviota Coast\Gaviota Creek	3	2
	Gaviota Coast\Naples	2	1
	Gaviota Coast\Gaviota State Park	1	1
	Gaviota Coast\Isla Vista	1	1
	Watersheds	25	7
	Watersheds\Jalama Watershed	6	2
	Watersheds\Gaviota Creek Watershed	5	3
	Watersheds\Main stem rivers	2	1
	Vandenberg Space Force Base	7	6
	Santa Maria River	5	2
	Coastal zones	4	3
	Santa Ynez River	4	4
	Santa Ynez Valley	4	1
	Los Padres National Forest	3	3
	Santa Maria Valley	2	2
	Chumash Marine Sanctuary	2	2
	Cuyama Valley	2	2
	Sedgwick Reserve	2	1
	More Mesa	2	1
	Guadalupe-Nipomo Dunes	2	1
	Point Sal	2	1
	Oceano Dunes State Park	1	1
	Purisima Hills	1	1
	Sisquoc River Valley	1	1
	Cat Canyon	1	1
	Elkat Canyon Resort	1	1
	Tajiguas Landfill	1	1

Category	Name	References	Sources
Implementation Barriers	**Political barriers**	118	14
	Political barriers\Land ownership conflict	21	11
	Political barriers\Specific legislation or program requirements	10	3
	Political barriers\Permitting process delays	8	5
	Political barriers\Lack of accountability and enforcement	7	2
	Political barriers\Political opposition to conservation action	6	4
	Political barriers\Carbon market access	6	1
	Political barriers\Lack of regulations	5	3
	Political barriers\Lack of public support	4	3
	Funding deficiencies	99	14
	Funding deficiencies\Lack of investment	25	12
	Funding deficiencies\Personnel capacity to apply for funding	17	8
	Funding deficiencies\Time-intensive funding process	12	7
	Funding deficiencies\Grant specificity	4	4
	Resource deficiencies	64	10
	Resource deficiencies\Personnel capacity to implement projects	29	10
	Resource deficiencies\Unique species and ecosystem requirements	3	1
	Resource deficiencies\Resource limitation for long-term projects	2	1
	Collaboration barriers	58	10
	Collaboration barriers\Lack of understanding between groups	10	6
	Collaboration barriers\Lack of coordination between groups	9	5
	Collaboration barriers\Lack of willingness to participate	6	3
	Collaboration barriers\Lack of trust between groups	6	3
	Collaboration barriers\Lack of knowledge of opportunities	3	2
	Development pressures	22	3
	Development pressures\Urban sprawl	6	3
	Development pressures\Intensive agriculture	2	1
	Development pressures\Transportation infrastructure	2	1
	Development pressures\Zoning regulations	2	1

Category	Name	References	Sources
Example Projects	**Biodiversity preservation project**	90	11
	Biodiversity preservation project\Wildlife connectivity and barrier removal	41	11
	Biodiversity preservation project\Fish passage enhancement and barrier removal	21	5
	Biodiversity preservation project\Pollinator conservation	4	3
	Water resources management project	68	11
	Water resources management project\Water quality improvement	9	5
	Water resources management project\Environmental flow maintenance	6	3
	Water resources management project\Watershed restoration	6	4
	Water resources management project\Groundwater recharge	6	3
	Water resources management project\Water conservation	5	4
	Water resources management project\Water use efficiency improvement	5	3
	Water resources management project\Estuary enhancement	3	2
	Water resources management project\Purchase water rights	1	1
	Water resources management project\Sedimentation prevention	1	1
	Natural and working lands conservation project	64	12
	Natural and working lands conservation project\Conservation easement	24	8
	Natural and working lands conservation project\Climate-smart agriculture	14	7
	Natural and working lands conservation project\Land use litigation	6	1
	Fire and fuels management project	41	8
	Fire and fuels management project\Cultural burning	8	4
	Fire and fuels management project\Wildfire resilience planning	5	4
	Fire and fuels management project\Fuels reduction	5	4
	Fire and fuels management project\Prescribed burning	4	3
	Fire and fuels management project\Prescribed grazing	1	1

Category	Name	References	Sources
Example Projects	**Listed species recovery project**	29	7
	Listed species recovery project\Steelhead recovery	9	4
	Listed species recovery project\Snowy plover habitat recovery	4	2
	Listed species recovery project\Least Bell's Vireo recovery	2	1
	Listed species recovery project\California red-legged frog recovery	1	1
	Listed species recovery project\California tiger salamander recovery	1	1
	Habitat restoration project	21	6
	Habitat restoration project\Riparian habitat restoration	7	3
	Habitat restoration project\Invasive species removal	6	3
	Habitat restoration project\Wetland restoration	1	1
	Climate adaptation and mitigation project	17	6
	Climate adaptation and mitigation project\Carbon sequestration	8	3
	Climate adaptation and mitigation project\Disaster response	2	1
	Climate adaptation and mitigation project\Emissions reduction	2	1
	Climate adaptation and mitigation project\Climate adaptation policy	1	1
	Climate adaptation and mitigation project\Wildfire resilience	1	1
	Recreational benefit project	14	6
	Recreational benefit project\Open space access	9	4
	Recreational benefit project\Public beach access	2	2
Motivations	**Preserving biodiversity**	111	17
	Preserving biodiversity\Wildlife connectivity	28	10
	Preserving biodiversity\Habitat restoration	12	8
	Preserving biodiversity\Fish passage enhancement	10	4
	Preserving biodiversity\Listed species protection	8	7
	Preserving biodiversity\Invasive species management	4	3
	Climate resiliency	32	7
	Climate resiliency\Climate resilient ecosystems	5	4
	Climate resiliency\Climate-smart agriculture	4	3

Category	Name	References	Sources
Motivations	Climate resiliency\Green communities	3	3
	Climate resiliency\Emissions reduction	3	2
	Climate resiliency\Soil health	2	2
	Regulatory compliance and mitigation	21	5
	Regulatory compliance and mitigation\Endangered Species Act	5	3
	Regulatory compliance and mitigation\Clean Water Act	2	2
	Regulatory compliance and mitigation\California Environmental Quality Act	1	1
	Regulatory compliance and mitigation\Clean Air Act	1	1
	Regulatory compliance and mitigation\Farm Bill	1	1
	Regulatory compliance and mitigation\National Environmental Policy Act	1	1
	Regulatory compliance and mitigation\Sustainable Groundwater Management Act	1	1
	Recreational benefit	21	5
	Recreational benefit\Open space access	7	3
	Recreational benefit\Public beach access	5	3
	Fostering partnerships	20	10
	Water resources	15	7
	Water resources\Groundwater recharge	5	3
	Water resources\Water quality improvement	4	3
	Water resources\Water use sustainability	3	3
	Water resources\Watershed restoration	1	1
	Equitable tribal engagement	13	4
	Equitable tribal engagement\Sustainable cultural resource access	6	4
	Funding opportunity	13	4
	Private land preservation	11	8
	Meeting community needs	9	4
	Capacity building	7	3
	Natural disaster risk reduction	5	1
	Natural disaster risk reduction\Wildfire risk reduction	2	1
	Natural disaster risk reduction\Flood risk reduction	1	1

Category	Name	References	Sources
Measures of Success	**Collaborative partnerships**	69	17
	Collaborative partnerships\Cross-boundary collaboration	12	10
	Collaborative partnerships\Vandenberg collaboration on projects off-base	8	6
	Collaborative partnerships\Reciprocal support	5	4
	Collaborative partnerships\Streamlined knowledge sharing	5	3
	Collaborative partnerships\Indigenous involvement	2	2
	Community oriented success metrics	29	8
	Community oriented success metrics\Improved public engagement and education	5	3
	Community oriented success metrics\Incorporated community feedback	5	3
	Community oriented success metrics\Improved economies and social well-being	1	1
	Community oriented success metrics\Improved environmental determinants of health	1	1
	Community oriented success metrics\Integrated tribal engagement	1	1
	Community oriented success metrics\Sustainable cultural resource access	1	1
	Increased biodiversity	21	6
	Increased biodiversity\Area of protected lands	3	2
	Increased biodiversity\Habitat connectivity	3	2
	Increased biodiversity\Habitats restored	3	3
	Increased biodiversity\Listed species recovery	2	2
	Increased project completion efficiency	16	6
	Increased project completion efficiency\Funding-facilitated efficiency	2	2
	Increased project completion efficiency\Streamlined permitting processes	2	1
	Increased project completion efficiency\Streamlined project prioritization	1	1
	Increased project funding	12	6
	Increased project funding\Improved access to government funding	2	2
	Increased project funding\Equitable funding distribution	1	1

Category	Name	References	Sources
Measures of Success	Increased project funding\Improved access to grant funding	1	1
	Ecosystem resilience	7	5
	Ecosystem resilience\Amount of carbon sequestered	1	1
	Ecosystem resilience\Drought and fire resilient landscapes	1	1
	Monitoring and evaluation	6	2
	Monitoring and evaluation\Remote sensing	2	1
	Monitoring and evaluation\Carbon accounting	1	1
	Monitoring and evaluation\Field surveys	1	1

Appendix D. Sentiment Distribution Across Interviews

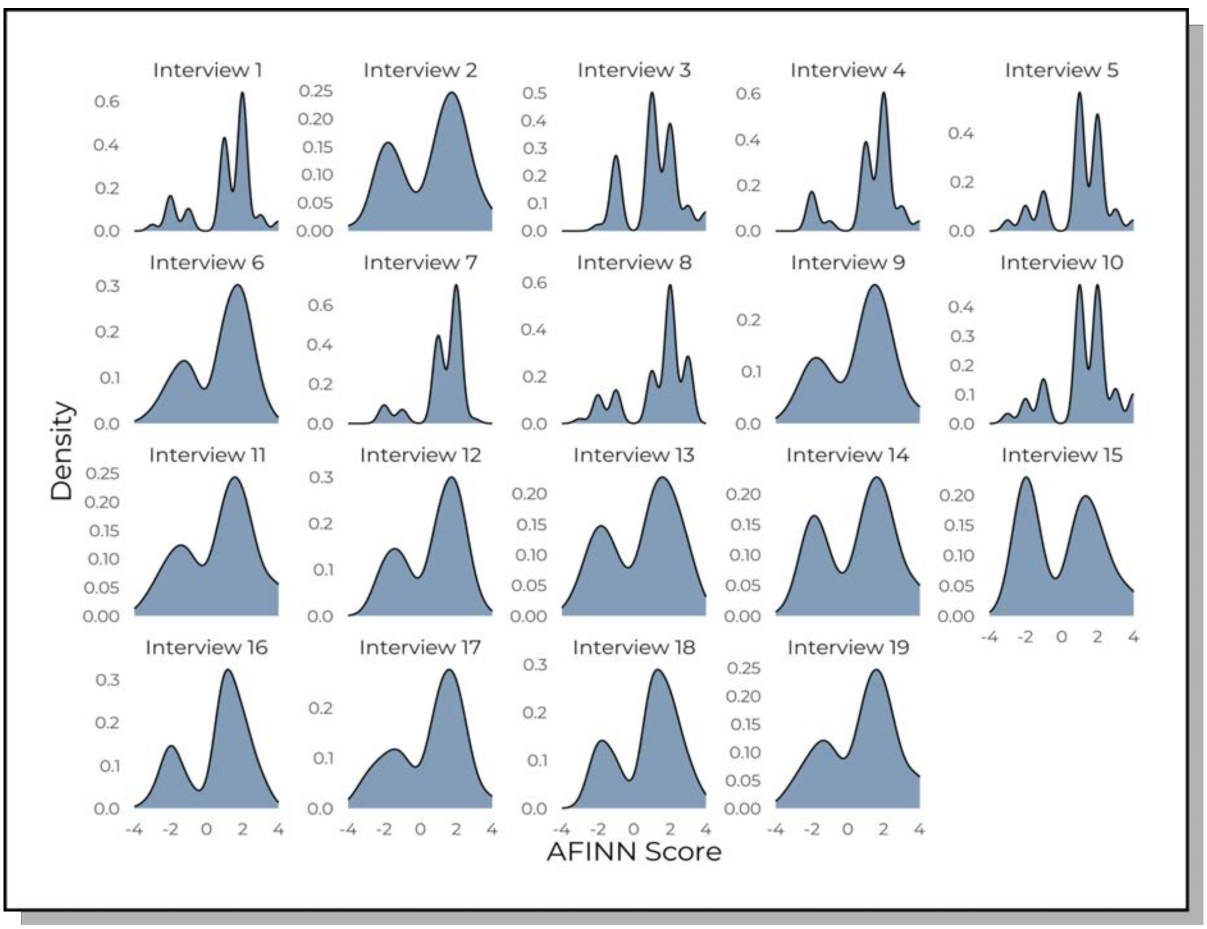

Figure D-1. Sentiment Score Distribution by Interview. The distribution of scores indicates variations in sentiment across interviews, with many exhibiting a bimodal pattern. This suggests that individual interviews contained both strongly positive and negative sentiments, highlighting the complexity of partner attitudes toward conservation in the region.

Appendix E. Species Profiles

Mountain Lion (*Puma concolor*)

Justification for Selection

Mountain lions, an apex predator and flagship species of California's central coast, require large, contiguous habitats. They typically avoid human-dominated landscapes, making them an essential umbrella species for this analysis (Thorne, 2006; Fletcher, 2022). They are highly mobile, preferring open habitats with good visibility, and are particularly sensitive to landscape fragmentation at broader spatial scales (Minor et al., 2010; ICF, 2023). Mountain lions in California are classified as a specially protected non-game species under the California Wildlife Protection Act of 1990 (Proposition 117). CDFW manages mountain lion populations due to their ecological significance and inherent value. For these reasons, mountain lions are included in this analysis as a passage species.

Photo Credit: CDFW

Figure E-1. Mountain Lion Distribution.

Distribution and Habitat Associations

The mountain lion is the second-largest wild cat in North America and has the most extensive range of any carnivore in the Western Hemisphere, spanning from southern Chile to the Yukon in Canada. In California, these adaptable predators occupy a variety of habitats, including temperate redwood forests, mixed coniferous and deciduous forests, coastal chaparral, foothills, and mountainous regions. Their presence is closely tied to the availability of native and non-native ungulates such as mule deer, elk, bighorn sheep, and feral hogs (CWHR 2008).

Spatial Patterns

Male home ranges usually are a minimum of 40 square kilometers (km^2), female home ranges usually are 8-32 km^2 (CWHR Staff, 2008b). For the corridor analysis, corridors were truncated to the home range size of 40 km^2. For the patch analysis, the minimum breeding patch size was 20,000 hectares (ha), minimum population patch size was 100,000 ha, and dispersal distance was 274 kilometers.

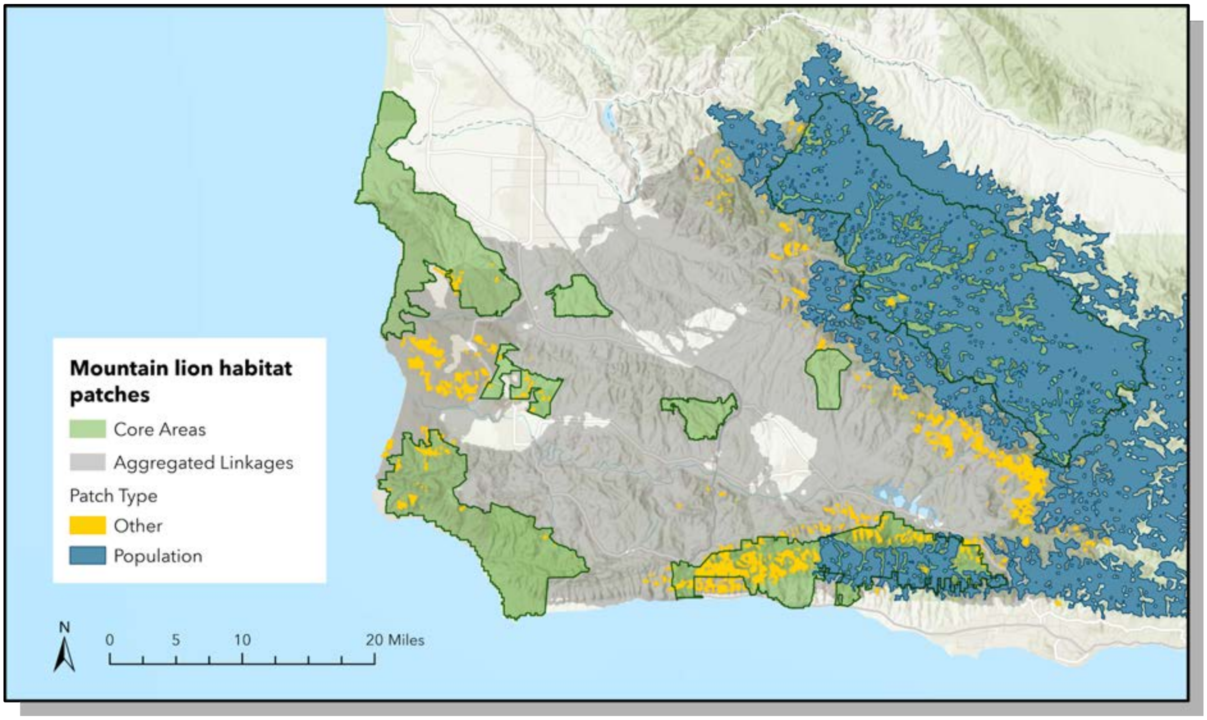

Figure E-2 Mountain Lion Habitat Patches. Population patches are concentrated in LPNF, with no identified breeding patches in the study region. Smaller patches, located adjacent to the population patch and around coastal core areas, may serve as stepping-stone habitat, facilitating movement between patches and core areas.

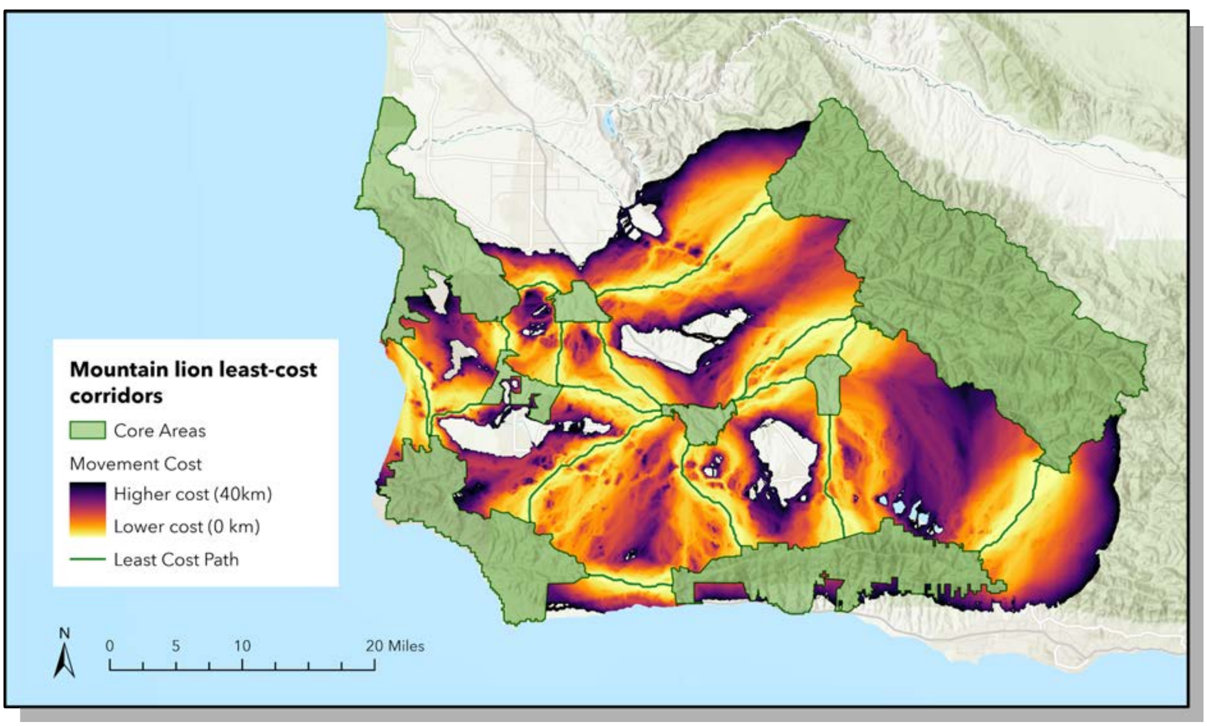

Figure E-3 Mountain Lion Least-cost Corridors. Least-cost paths follow areas within the corridor that have the lowest movement cost (shown in yellow). The widest corridors are located between LPNF and surrounding core areas, offering greater opportunities for movement.

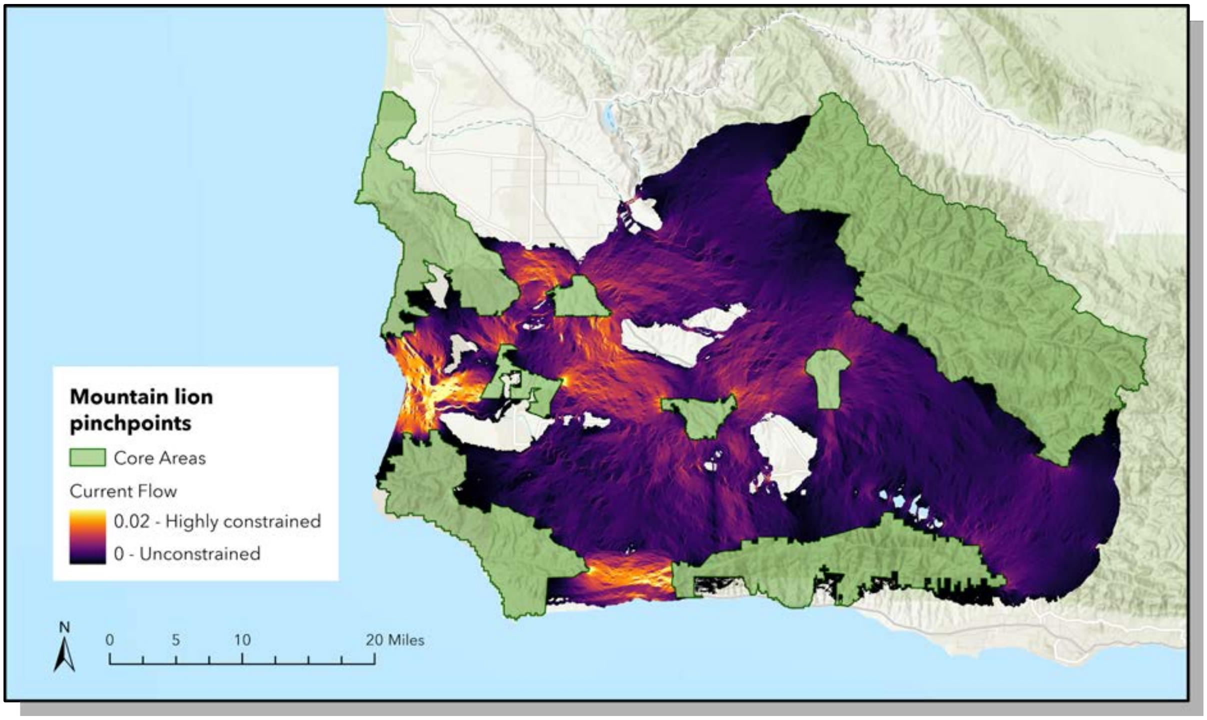

Figure E-4 Mountain Lion Pinchpoints. High-traffic areas constraining movement are located between the Dangermond Preserve and the Santa Ynez Mountains, as well as between VSFB core areas. While wider corridors provide alternative movement routes, these paths deviate from the least-cost path.

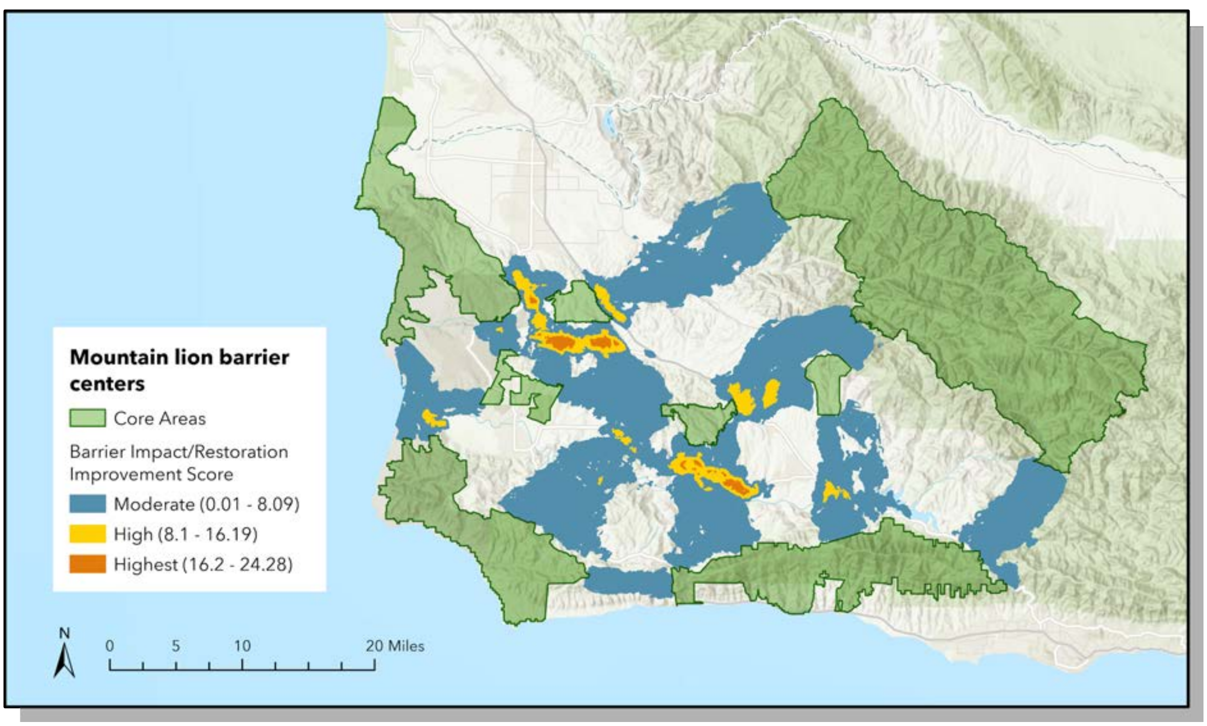

Figure E-5 Mountain Lion Barrier Centers. High barrier impact scores are concentrated around the Bicknell Open Space and Purisima Hills core areas, highlighting key landscape barriers to movement. Restoration efforts in these areas could improve connectivity, as most barriers intersect major roads.

Mule deer (*Odocoileus hemionus*)

Justification for Selection

Mule deer are a mid-sized species with moderate mobility, who rely on various habitats, including edge environments and open landscapes (Kie et al., 2002). Their movement patterns and habitat use make them a key representative of species that rely on medium-scale connectivity corridors. Mule deer are an ecologically and economically significant species in California, valued for wildlife viewing, recreational opportunities, and hunting. As a key prey species, they support predator populations, including mountain lions, coyotes, and, occasionally, bobcats and black bears. For these reasons, the mule deer was selected as a passage species for this analysis.

Photo Credit: Mule Deer Foundation

Distribution and Habitat Associations

Mule deer are common year-round residents with a broad distribution across California. The state is home to two subspecies: the Columbia black-tailed deer (*O. h. columbianus*) and the California mule deer (*O. h. californicus*). They inhabit a wide range of ecosystems, including forests, woodlands, and brush-dominated habitats. Ideal habitat consists of a diverse mosaic of vegetation, providing a mix of herbaceous openings, dense brush, riparian corridors, and abundant edge habitat.

Figure E-6. Mule Deer Distribution.

Spatial Patterns

Typical home ranges for female mule deer range from 1-5 km². Bucks have larger home ranges and travel longer distances than doe and fawn groups (CWHR Staff, 2008b; C. M. Krause et al., 2015). Nonetheless, tremendous variation in home range-size has been reported for adult female mule deer, ranging from 0.1 to 12 km² (Kie et al., 2002). For the corridor analysis, corridors were truncated to the home range size of 7 km². For the patch analysis, minimum breeding patch size used was 100 ha; minimum population patch size was 500 ha.

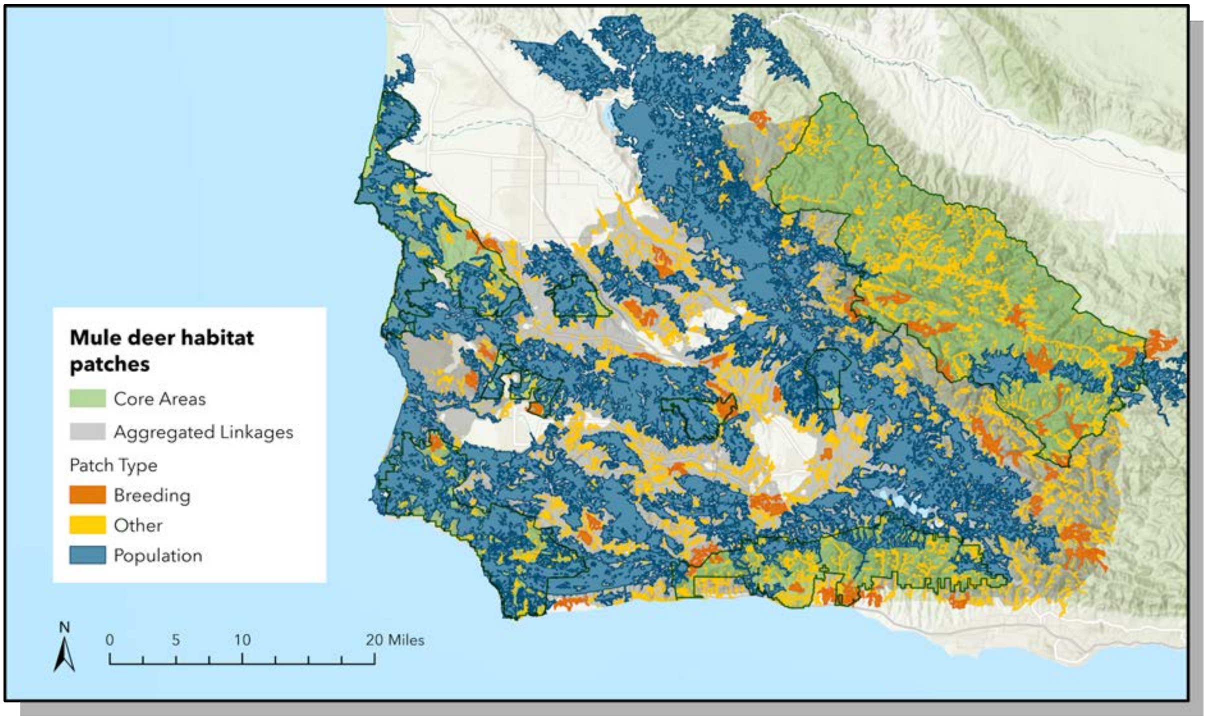

Figure E-7. Mule Deer Habitat Patches. Population patches are generally well-connected across the study region, though they are limited within LPNF. Breeding and other patches are primarily adjacent to population patches, providing potential stepping-stone and breeding habitats.

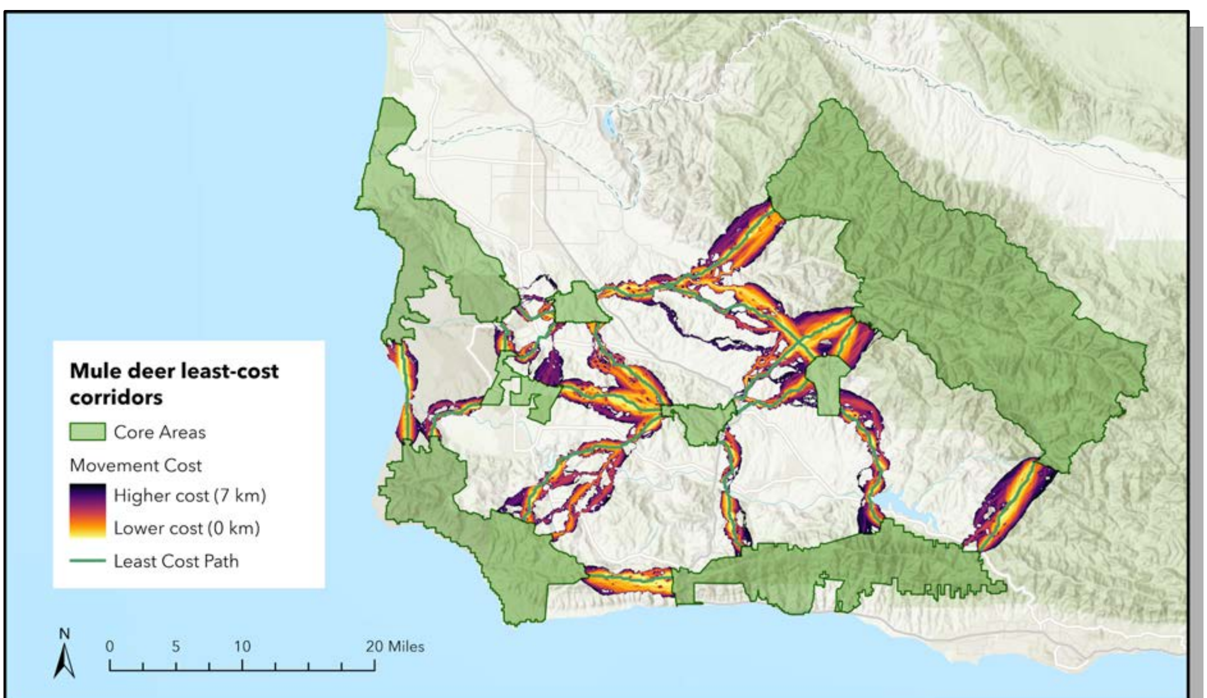

Figure E-8. Mule Deer Least-cost Corridors. Least-cost paths traverse corridor areas with the lowest movement cost (shown in yellow). The widest corridors occur between LPNF and Sedgwick Reserve, offering greater opportunities for movement in this region.

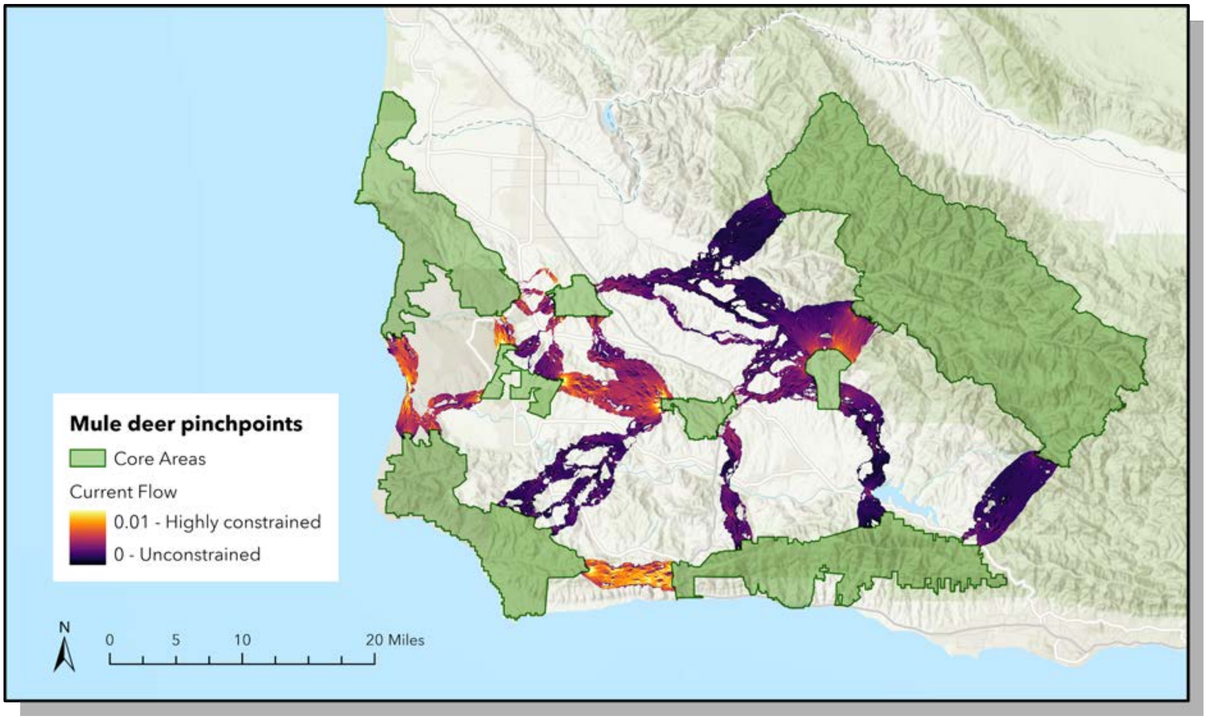

Figure E-9. Mule Deer Pinchpoints. High-traffic areas where movement is constricted are located between Dangermond Preserve and the Santa Ynez Mountains, as well as between VSFB core areas. Limited alternative movement routes in these regions highlight the vulnerability of these linkages.

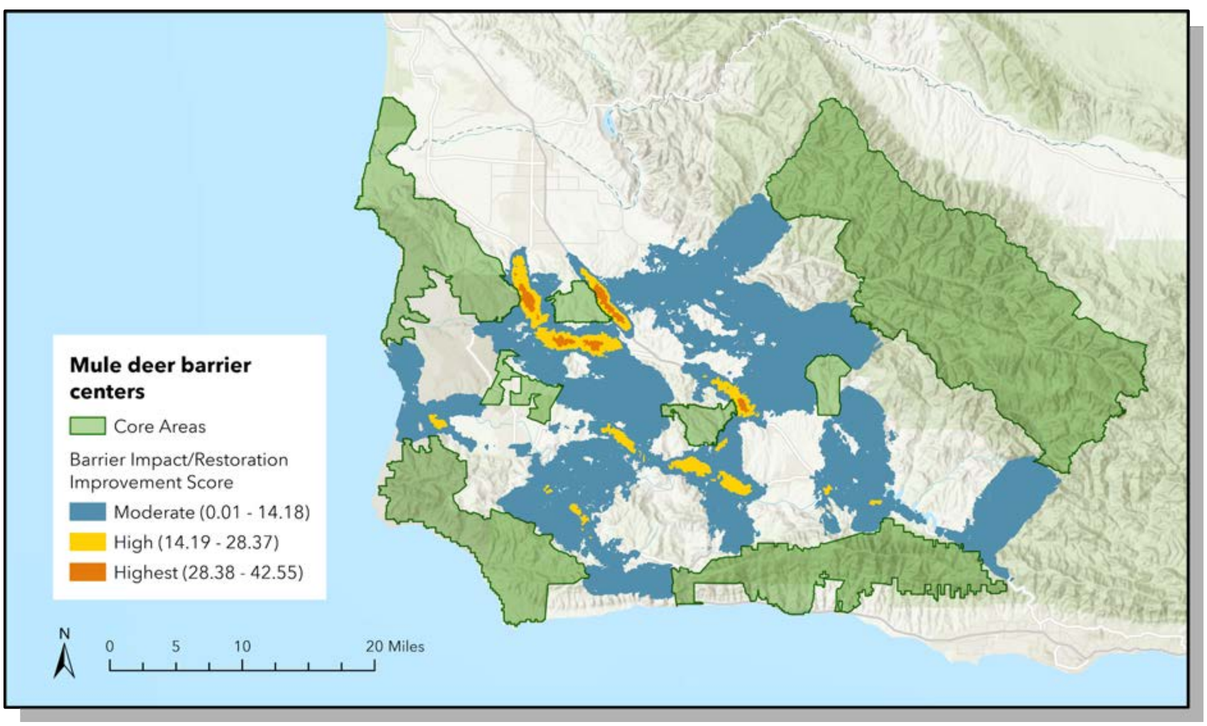

Figure E-10. Mule Deer Barrier Centers. High barrier impact scores are concentrated around the Bicknell Open Space and Purisima Hills core areas, identifying key landscape barriers to movement. Restoration efforts in these areas could enhance connectivity, as most barriers intersect major roads.

Black-tailed jackrabbit (*Lepus californicus*)

Photo Credit: Jim Harper, Wikipedia

Justification for Selection

Black-tailed jackrabbits are highly sensitive to barriers and serve as an important indicator species for habitat connectivity. Their abundance at lower elevations, reliance on open landscapes, and use of shrubs for cover make them a representative species for evaluating medium-scale habitat corridors (CWHR Staff, Polite, et al., 2008). While not a conservation concern, the black-tailed jack rabbit plays a critical ecological role as a primary prey species for many predators, including coyotes, eagles, northern harriers, barn owls, red-tailed hawks, great horned owls, rattlesnakes, and gopher snakes (CWHR Staff, Polite, et al., 2008). For these reasons, the black-tailed jackrabbit was selected as a passage species for this analysis.

Distribution and Habitat Associations

The black-tailed jackrabbit is a widespread and adaptable species, maintaining stable populations across its range. The black-tailed jackrabbit is common throughout California, except at higher elevations, thriving in herbaceous, desert-shrub, and early forest or chaparral habitats (CWHR Staff, Polite, et al., 2008). For cover, jackrabbits rely on shrubs and other vegetation for concealment from predators. They are active year-round, with peak activity occurring during dawn and dusk (crepuscular) and some daytime movement.

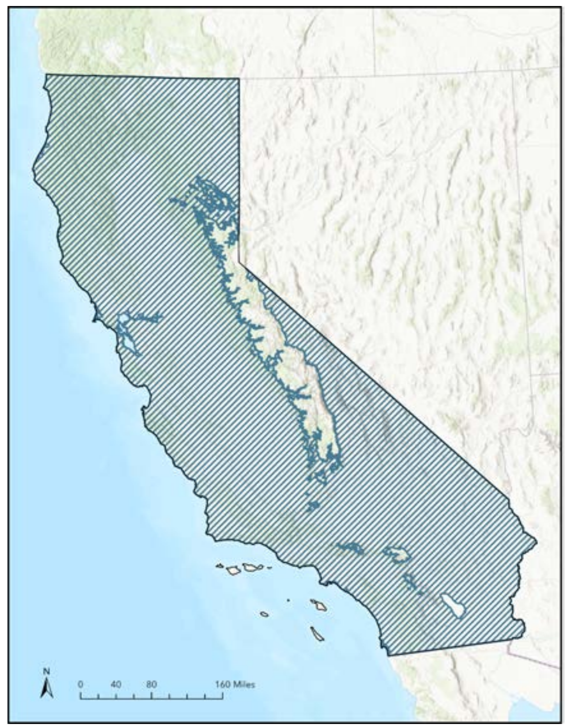

Figure E-11. Black-tailed Jackrabbit Distribution.

Spatial Patterns

Black-tailed jackrabbits maintain home ranges that vary from 4 to 79 hectares (ha), depending on habitat quality and location (CWHR Staff, Polite, et al., 2008). For the corridor analysis, corridors were truncated to the home range size of 2km. For the patch analysis, minimum breeding patch size used was 18.5 ha, minimum population patch size was 460 ha, and dispersal distance used was 1.2 kilometers (CWHR Staff, Polite, et al., 2008; C. M. Krause et al., 2015).

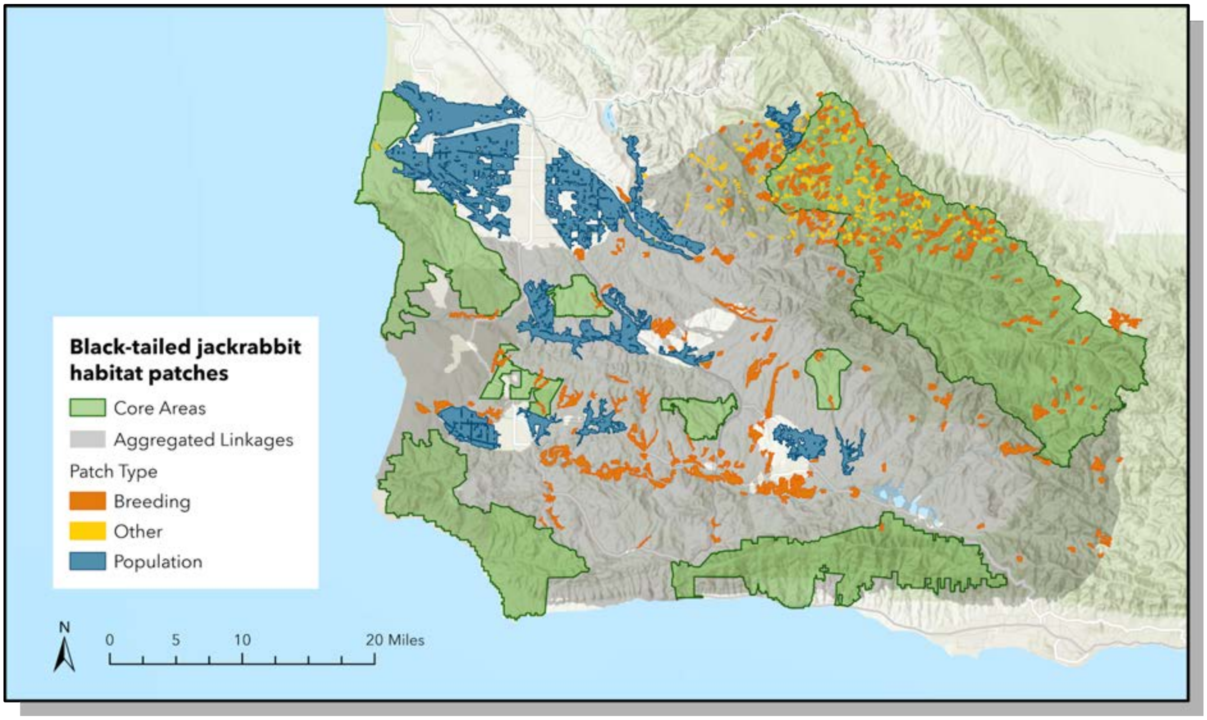

Figure E-12. Black-tailed Jackrabbit Habitat Patches. Population patches are concentrated in the northwestern corner of the study region and are not well connected. Breeding and other patches are also dispersed across the landscape, providing important stepping-stone habitat to link population patches and core areas.

Figure E-13. Black-tailed Jackrabbit Least-cost Corridors. Least-cost paths traverse areas of the corridor with the lowest movement cost (shown in yellow). Regions with wide movement pathways are located next to the southern VSFB core area and LPNF.

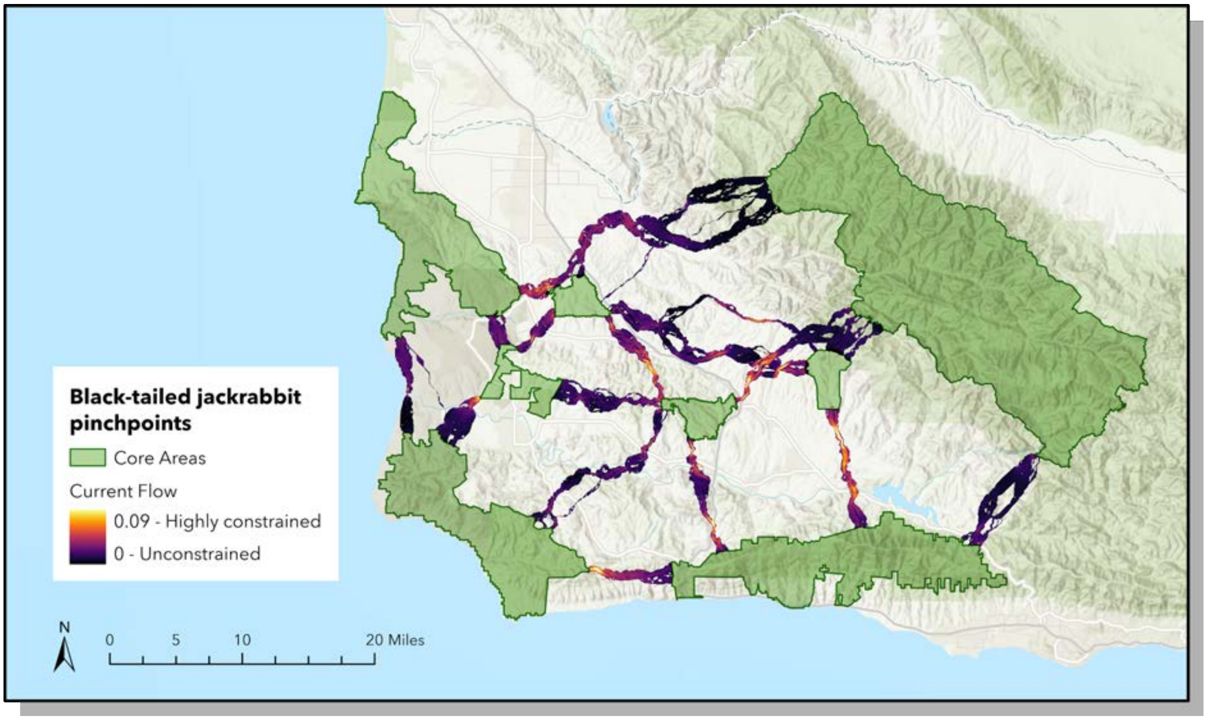

Figure E-14 Black-tailed Jackrabbit Pinchpoints. High-traffic areas where movement is constricted are located between the Santa Ynez Mountains and Sedgwick Reserve, as well as along paths from Purisima Hills. In these areas, few alternative movement routes exist, highlighting the vulnerability of these linkages.

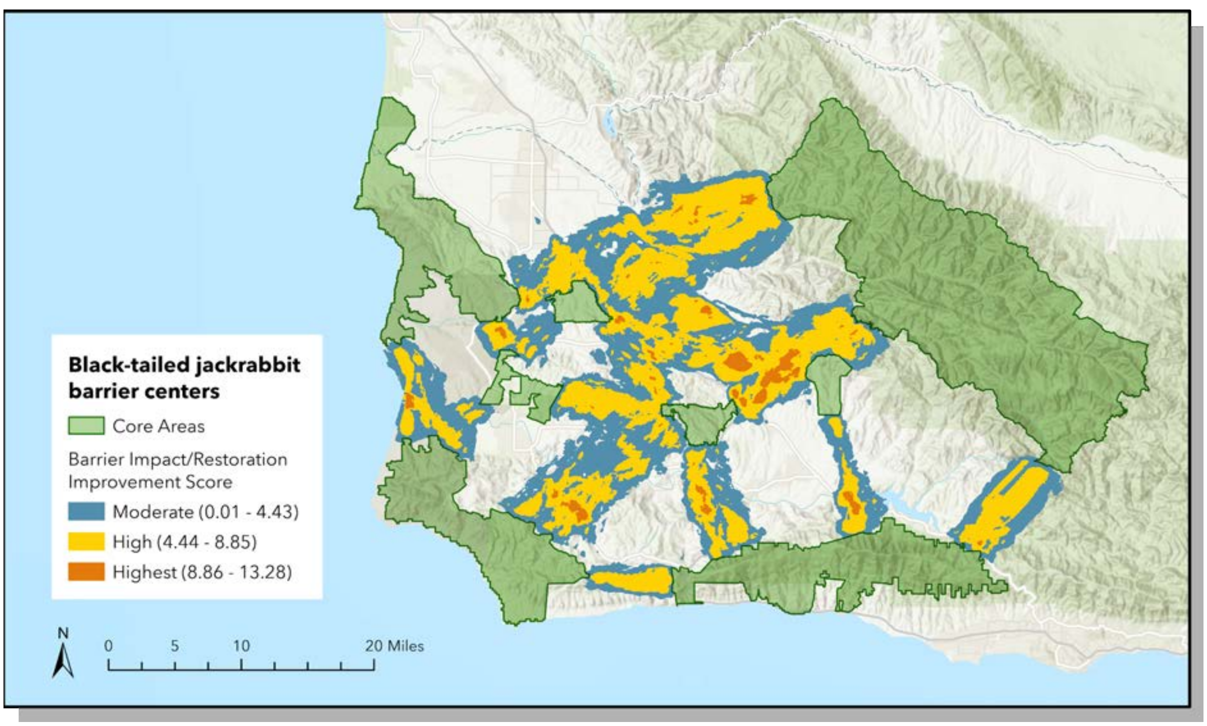

Figure E-15. Black-tailed Jackrabbit Barrier Centers. High barrier impact scores are concentrated within the species' corridors, emphasizing significant landscape barriers to movement. Restoration efforts in these areas, particularly where barriers intersect major roads, could enhance connectivity.

California thrasher (*Toxostoma redivivum*)

Justification for Selection

California thrashers are habitat specialists that are particularly sensitive to habitat loss. While not currently listed as threatened or endangered, urbanization, habitat loss, and increased wildfire frequency pose risks to their populations. Protecting large, continuous areas of undisturbed chaparral and riparian thickets is key to maintaining healthy populations. Because the thrasher relies on dense, contiguous shrubland, it serves as an indicator species for chaparral habitat connectivity and was selected as a corridor dweller species.

Photo Credit: Luke Seitz, Macaulay Library

Figure E-16. California Thrasher Distribution.

Distribution and Habitat Associations

The California thrasher is a common year-round resident of foothills and lowlands throughout California, from the Mexican border to Humboldt and Shasta Counties. This species primarily inhabits moderate to dense chaparral, as well as riparian thickets in open valley foothill habitats. Thrashers are insectivorous but also consume fruits, acorns, and seeds, foraging primarily on the ground by digging and probing in leaf litter. They require dense shrub cover for nesting and roosting and are generally non-migratory, although some local movements occur outside the breeding season (CWHR Staff, Dobkin, et al., 2008).

Spatial Patterns The home range size for California thrasher in chaparral habitat was recorded to be 1.4 hectares (CWHR Staff, Dobkin, et al., 2008). For this analysis the minimum breeding patch size used was 3 hectares; minimum population patch size was 300 hectares, and dispersal distance used was 65 hectares (CWHR Staff, Dobkin, et al., 2008; C. M. Krause et al., 2015).

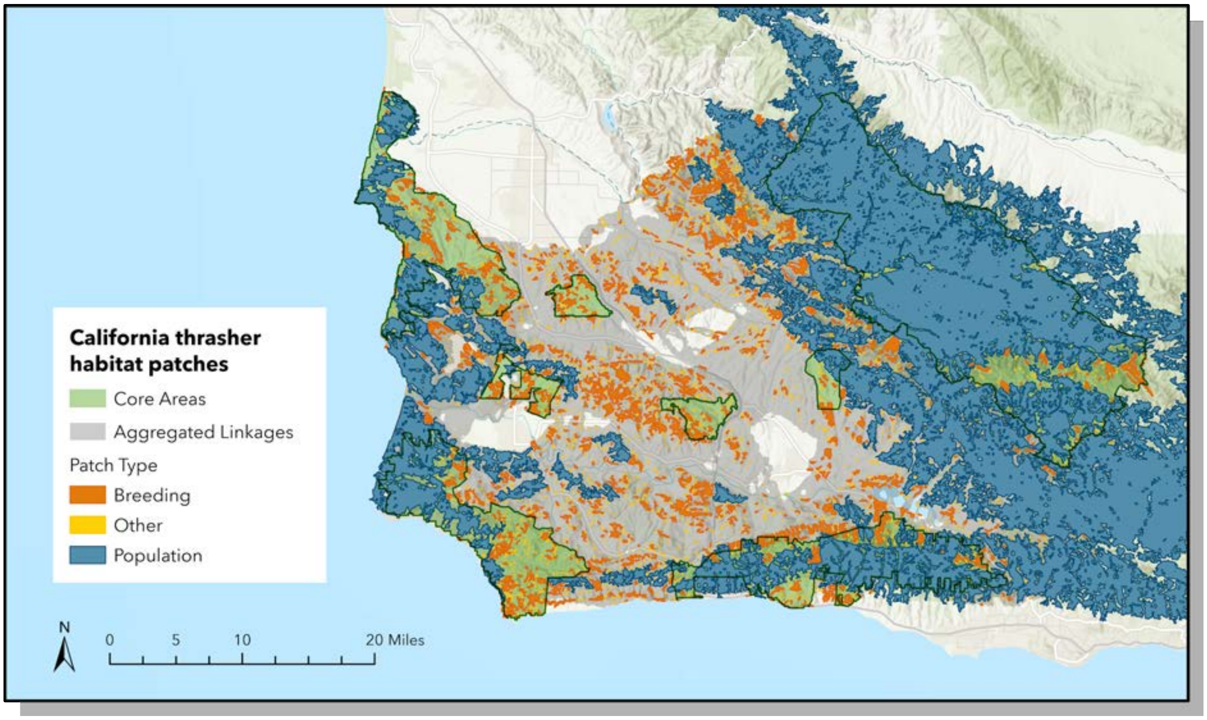

Figure E-17 California Thrasher Habitat Patches. Population patches are concentrated around LPNF and coastal core areas. Breeding and other patches are well-distributed across the landscape, serving as stepping-stone habitats that help maintain connectivity for corridor-dwelling species across generations.

California red-legged frog (*Rana draytonii)*

Justification for Selection

Listed as a threatened species under the federal Endangered Species Act, the California red-legged frog (CRLF) has experienced significant declines due to habitat loss, pollution, and the introduction of non-native predators (CWHR Staff, 2008a). CRLF was chosen as a focal corridor-dwelling species because of its dependence on permanent aquatic habitats, sensitivity to habitat fragmentation, and ecological role in riparian ecosystems as an indicator of freshwater habitat health.

Photo Credit: Zachary Cava

Distribution and Habitat Associations

CRLF occurs in coastal and low-elevation regions, with populations concentrated in the San Francisco Bay Area and San Luis Obispo and Santa Barbara counties. Its historical range extended further, but habitat loss has led to significant population declines (Kuyper, 2022). CRLF are highly aquatic, inhabiting vegetated pools in streams, marshes, lakes, and ponds. They prefer shorelines with dense emergent vegetation for cover and require permanent or near-permanent water sources for breeding and larval development. CRLF also utilize upland habitats for foraging, dispersal, and shelter (CWHR 2008).

Figure E-18. California red-legged frog Distribution & Critical Habitat. Critical habitat is indicated by the solid blue patches.

Spatial Patterns

Although there is little research on CRLF home range size, studies have shown that frogs can disperse to suitable terrestrial areas up to 3 kilometers away from breeding and non-breeding aquatic habitat (Kuyper, 2022). Suitable upland habitat includes areas that contain cover features such as dense riparian vegetation, woody debris, burrows, or anthropogenic cover. Other researchers observed that CRLF moved up to 22 m per day in the warmer, more arid habitat of Santa Barbara County (Kuyper, 2022). For this analysis, home range size used was 10 meters, minimum breeding patch size used was 1-hectare, minimum population patch size was 25 hectares, and dispersal distance used was 50 meters per day (CWHR Staff, 2008a; C. M. Krause et al., 2015).

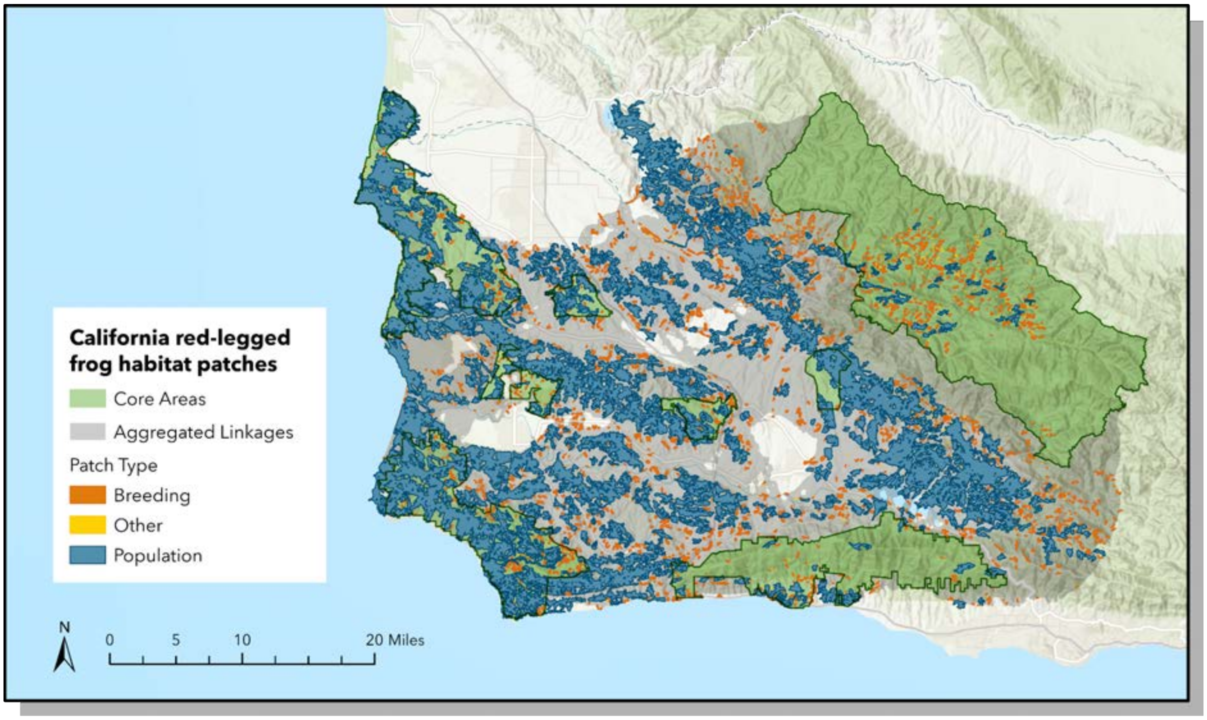

Figure E-19. California Red-legged Frog Habitat Patches. Population patches are concentrated around coastal core areas and the foothills adjacent to LPNF. Breeding and other patches are distributed near population patches and within LPNF, serving as important stepping-stone habitats that support connectivity for corridor-dwelling species across generations.

Appendix F. Resistance Value Table

Table F-1. Connectivity Analysis Resistance Values. Values are based on expert opinion from CDFW and Beier et al. (2006).

	Mountain Lion	Black-tailed Jackrabbit	Mule Deer
Factor Weight			
CWHR Vegetation	70	70	80
Elevation	0	10	0
Topography	10	10	15
Distance from Roads	20	10	5
CWHR Vegetation Suitability (Rescaled)			
Alkali Desert Scrub	10	4.6	8.56
Annual Grassland	7.03	6.04	7.66
Barren	0	0	0
Bitterbrush	6.94	2.53	5.14
Blue Oak Woodland	5.32	6.31	3.97
Blue Oak-Foothill Pine	3.79	6.31	3.97
Chamise-Redshank Chaparral	4.33	3.88	5.23
Closed-Cone Pine-Cypress	5.5	7.39	4.24
Coastal Oak Woodland	5.32	6.31	3.97
Coastal Scrub	4.78	4.06	4.06
Cropland	0	0	0
Deciduous Orchard	9.01	8.38	9.37
Desert Riparian	4.69	3.88	4.87
Desert Scrub	7.75	2.71	8.56
Desert Wash	6.76	4.24	8.02
Dryland Grain Crops	10	3.07	8.02
Estuarine	0	0	0
Eucalyptus	7.21	5.5	6.49
Evergreen Orchard	9.64	8.38	9.37
Fresh Emergent Wetland	10	10	8.02
Irrigated Grain Crops	10	3.07	8.02
Irrigated Hayfield	10	3.07	6.04
Irrigated Row and Field Crops	10	3.07	8.02
Jeffrey Pine	4.87	7.3	4.24
Juniper	4.78	4.51	4.51
Lacustrine	0	0	0
Marine	0	0	0
Mixed Chaparral	3.79	4.06	4.15
Montane Chaparral	4.24	5.41	4.06
Montane Hardwood	4.06	5.86	4.06

	Mountain Lion	Black-tailed Jackrabbit	Mule Deer
Montane Hardwood-Conifer	3.43	6.76	4.15
Montane Riparian	3.34	8.29	4.06
Pasture	9.01	3.07	6.04
Perennial Grassland	7.03	6.4	7.66
Pinyon-Juniper	4.78	5.59	4.51
Rice	10	8.83	9.64
Riverine	0	0	0
Sagebrush	7.3	2.17	6.4
Salient Emergent Wetland	0	0	0
Sierran Mixed Conifer	3.16	7.48	4.15
Urban	10	7.03	6.04
Valley Foothill Riparian	4.24	7.39	4.06
Valley Oak Woodland	5.32	6.31	3.97
Vineyard	9.01	3.07	8.02
Wet Meadow	6.04	7.66	7.48
Elevation (ft)			
Elevation range: cost		0-6000: 1 6000-8000: 4 8000-11000: 8	
Topographic Position			
Canyon Bottom	1	3	2
Flat-Gentle Slope	3	1	2
Steep Slope	3	4	4
Ridgetop	4	4	6
Distance to Roads (m)			
Distance from road range: cost	0-200: 8 200-500: 6 600-1000: 5 1000-1500: 2 1500-25000: 1	0-250: 9 250-500: 6 500-1000: 3 1000 - 25000: 1	0-250: 7 250-1000: 3 1000-25000:1

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