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Managing Landscape Urbanization and Assessing Biodiversity of Wildlife Habitats: A Study of Bobcats in San Jose, California

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Abstract: In the rapid process of urbanization, crucial habitats for mid-sized felids such as bobcats are increasingly compromised. This study employs Geographic Information System (GIS) tools and Machine Learning to investigate the subtle impacts of urbanization on bobcat habitats. Focused on the San Jose area, our extensive geospatial analysis has developed a complex ecological model for bobcat habitats. Our findings emphasize the significant influence of factors like vegetation cover, water body distribution, road traffic volume, and intersection density on the suitability of habitats for bobcats. Specifically, we discovered that while vegetation cover typically supports habitat suitability, its proximity to busy roads significantly undermines this advantage, indicating a need for strategic urban planning that incorporates wildlife mobility. By synthesizing natural and urban elements, we offer fresh insights into urban ecosystem management and propose specific conservation tactics: identifying optimal wildlife crossings, integrating corridors with urban infrastructure, and placing fencing and signage strategically to facilitate wildlife movement safely. These measures aim to reduce road-related threats and enhance the integrity of natural habitats, strengthening bobcat conservation efforts. More than its direct implications for bobcat conservation, this study offers actionable insights for urban wildlife conservation and introduces innovative methods for assessing and mitigating the broader ecological impacts of urbanization.

Keywords: bobcat; road crossings; suitability map; landscape urbanization; biodiversity; geospatial design

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1. Introduction

Urbanization and the expansion of transportation networks significantly transform landscapes, often detrimentally affecting wildlife. In urban areas, this growth leads to the fragmentation and displacement of natural habitats, which, in turn, isolates wildlife populations and increases the risk of Wildlife–Vehicle Collisions (WVCs) in urban areas [1]. The reasons for transportation planners' often limited focus on avoiding critical habitats are complex. Traditionally, road construction prioritizes human-centric factors such as economic efficiency, traffic flow, and connecting urban centers, while environmental concerns, especially those related to wildlife habitats, are secondary [2,3]. This oversight stems partly from a lack of comprehensive environmental impact assessments and a limited understanding of habitat fragmentation's long-term ecological consequences [4]. Additionally, the urgency of infrastructural demands often leads to expedited planning processes that overlook environmental concerns [5], and a lack of collaboration between urban planners, ecologists, and conservationists exacerbates this issue [6], resulting in road networks that are efficient for humans but harmful to wildlife habitats.

These planning shortcomings have serious implications. According to one study, approximately 1 million wildlife are killed in vehicle collisions in the United States each year [7]. Roads cause not only immediate mortality but also lead to significant ecological disruptions, such as genetic isolation among wildlife populations [8]. As habitats are fragmented by roads, these populations become segmented, leading to reduced genetic diversity and increased vulnerability to various environmental threats [9].

Focusing on the bobcat (*Lynx rufus*) in the San Jose region, we see the direct consequences. San Jose's unique urban dynamics, typical of many rapidly developing urban centers in North America, provide a pertinent example of urban expansion impacting native wildlife habitats. Bobcats, native to this region and requiring extensive home ranges, are particularly vulnerable to urban encroachment and habitat fragmentation [10]. These creatures serve as ecological linchpins in the San Jose area, playing a crucial role in maintaining the balance of the local ecosystem. As apex predators, bobcats help regulate the populations of smaller mammals and rodents, preventing overpopulation and its associated ecological imbalances [11,12]. This predation is essential for controlling the spread of diseases and maintaining a healthy and diverse ecosystem. Furthermore, their presence is indicative of a thriving natural habitat, signifying a well-functioning ecosystem [13]. Therefore, the preservation of bobcats is not only essential for their own species' survival but is also integral to maintaining the overall health and balance of San Jose's urban environment, reflecting the interdependence of all species within this ecosystem.

To protect wildlife and enhance road safety, it is crucial to identify and implement suitable locations for wildlife crossings [14,15]. This challenge intertwines the welfare of both wildlife and humans, marking a pivotal moment in the development of San Jose's urban landscape [16]. The urgency of this task is highlighted by the high incidence of roadkill, which not only affects local ecosystems but also has global implications. Bobcats, as apex predators, are essential for maintaining the balance of the food chain, and their loss can lead to significant ecosystem disruptions. By strategically placing wildlife crossings, we can reduce these incidents, thus preserving the ecological integrity and biodiversity of the area [17]. Moreover, this approach addresses a broader concern: the impact of infrastructure development on wildlife [18]. Accurately evaluating and predicting wildlife crossing points is vital for mitigating habitat fragmentation and ensuring ecological connectivity, both locally and globally.

Moreover, the study of bobcat crossings is not confined to its immediate implications for this specific species. It stands as a prototypical example for addressing similar issues involving a multitude of wildlife species and urban infrastructure. Lessons learned from studying bobcats can be applied to inform the conservation efforts of other wildlife, ensuring that urban environments remain hospitable for diverse and resilient ecosystems [19]. In this way, the research on bobcat crossings in San Jose transcends its immediate context and contributes to a broader understanding of how urbanization impacts wildlife and ecosystems [19]. It underscores the urgent need for innovative solutions that balance the imperatives of urban development with the preservation of biodiversity and ecological integrity.

This article aims to illuminate the path towards harmonious coexistence between urban development and wildlife conservation, offering practical insights and solutions. We explore innovative urban planning approaches that integrate wildlife conservation, such as designing and implementing wildlife corridors and crossings specifically tailored for bobcats. By reducing wildlife–vehicle collisions, these solutions help preserve bobcat populations and maintain ecological balance. This study provides a blueprint for cities globally to navigate the challenges of urban expansion while safeguarding their natural habitats and the species that inhabit them.

2. Literature Review

2.1. Biodiversity Conservation

Bobcats are not merely inhabitants of the San Jose urban ecosystem, they serve as apex predators that maintain prey balance and contribute to the region's ecological balance [20]. As apex predators, bobcats traditionally regulate the populations of smaller mammals, which, in turn, affect vegetation and other wildlife species [21,22]. This cascading effect ripples through the food web, maintains biodiversity and checks species overpopulation. However, urban challenges in San Jose, this regulatory role of bobcats faces challenges. Despite their presence, many prey populations remain overabundant due to factors unique to urban settings. These include altered landscapes, availability of anthropogenic food sources, and reduced predation effectiveness in these modified habitats [23]. This phenomenon, often referred to in literature as the "predation paradox," indicates that the ecological role of apex predators like bobcats is more complex in urban areas than previously understood [24]. Furthermore, they contribute to the process of seed dispersal, an often-overlooked ecological service [25]. By consuming prey, bobcats inadvertently ingest seeds that can be carried to new areas, aiding in the distribution of plant species [26]. This not only promotes genetic diversity within plant populations but also bolsters the overall resilience of the ecosystem.

2.2. Genetic Connectivity

Urbanization has fragmented San Jose's bobcat habitats, leading to genetic isolation and potential biodiversity loss. Genetic diversity is crucial for disease resistance and adaptability to environmental change [9]. Establishing wildlife crossings is essential for maintaining genetic flow and bobcat population viability. Genetic diversity is the substrate for natural selection, enabling adaptation to environmental shifts [27]. Urban encroachment impedes connectivity and reduces the genetic variance of migrants, potentially diminishing the bobcats' adaptive capacity [28]. Furthermore, reduced genetic diversity can erode the adaptive potential of bobcat populations [29]. As environmental pressures mount, this genetic diversity is paramount for species survival [30]. Without it, populations become increasingly vulnerable to unforeseen challenges.

2.3. Road Safety

The intersection of bobcats and roadways in the San Jose region presents a significant challenge for both wildlife and human commuters. Wildlife–Vehicle Collisions (WVCs) present substantial challenges, encompassing property damage, personal injuries, and fatalities [31]. Property damage often involves significant costs for vehicle repair and impacts insurance premiums [32]. Injuries to drivers and passengers can range from minor to severe, requiring medical attention and possibly leading to long-term health consequences. Most critically, these collisions can result in fatalities, underscoring the serious risk they pose to the life of humans and wildlife [33]. The impacts of these collisions extend beyond the individual bobcats involved. Each incident contributes to the overall mortality rate of the population, potentially leading to long-term declines [34,35]. Additionally, WVCs can disrupt the ecological balance by removing apex predators from the ecosystem, which can lead to cascading effects on prey populations and vegetation dynamics [21].

In regions like California, where the intersection of wildlife and urban development is a growing concern, the implementation of well-designed wildlife crossings has shown promising results for species like bobcats [36]. For instance, in areas such as near Los Angeles and other parts of California, specifically designed overpasses and underpasses have been constructed to facilitate the safe movement of wildlife across busy roadways [37,38]. These structures have been strategically placed considering the natural movement patterns of wildlife, thereby minimizing their exposure to traffic and reducing the likelihood of collisions.

The results from these wildlife crossings have been encouraging. Monitoring studies have shown a significant decrease in wildlife–vehicle collisions in areas where these crossings are present [39]. Furthermore, they have contributed to maintaining genetic diversity within wildlife populations by allowing for greater movement and interaction among separate groups [38]. Therefore, the establishment of wildlife crossings is a practical measure that goes beyond conservation. It enhances public safety by reducing wildlife-related traffic incidents and plays a pivotal role in balancing urban development with the preservation of wildlife populations. The success of these crossings in California serves as a model for other regions facing similar challenges, ultimately paving the way for a safer coexistence between humans and wildlife in urban landscapes.

2.4. Urban Ecology

San Jose represents a microcosm of urban sprawl, mirroring the challenges that wildlife faces in rapidly urbanizing regions worldwide. The study of bobcat crossings stands as a prototypical example for addressing similar issues involving other wildlife species and urban infrastructure. It offers invaluable insights into the domain of urban ecology and wildlife conservation amidst the relentless tide of urbanization [40]. Understanding how bobcats adapt to this changing environment provides invaluable insights into the broader field of urban ecology. Their behavior, movements, and interactions with human infrastructure serve as a lens through which we can better comprehend the challenges and opportunities presented by urbanization [41].

2.5. Interdisciplinary Collaboration

This research necessitates a collaborative effort across various disciplines, uniting ecologists, urban planners, transport authorities, and conservationists to address the challenges at the interface of urban development and wildlife conservation. It emphasizes the intrinsic value of interdisciplinary cooperation in crafting solutions that consider both human and wildlife requirements while informing policy and planning decisions [42]. This interdisciplinary approach recognizes that the issues at hand are multifaceted and interconnected. Ecologists contribute insights into wildlife ecology and habitat needs, while urban planners provide expertise in infrastructure design [43]. Transport authorities bring vital data on traffic dynamics and engineering, and conservationists anchor the work in ethical and conservation policy [44]. Such cross-disciplinary collaboration yields comprehensive strategies that are sensitive to ecological and human demands [45]. This inclusive approach not only bolsters conservation efficacy but also enriches policy making with a broader grasp of the underlying complexities [46].

Moreover, incorporating varied perspectives leads to sustainable urban development strategies that embed wildlife conservation into urban planning, promoting a more harmonious and resilient cityscape [47]. This study, through an interdisciplinary lens, evaluates potential bobcat crossing sites within San Jose's urban matrix.

Two primary research questions guide this research: 1. What are the major factors impacting bobcats' living habitat? We assumed that the primary factors affecting bobcat habitat in San Jose, California are urban development, the amount of road traffic, and the presence of natural features such as vegetation and water sources. 2. How do these factors influence bobcats' ability to cross infrastructure in San Jose, California? We hypothesize in this regard that the above factors, particularly road traffic and urban infrastructure, will lead to habitat fragmentation and an increase in roadkill incidents, which will affect the movement patterns of bobcats and the connectivity of their populations. Through the integration of geospatial analysis and ecological modeling, this research aims to provide practical solutions that not only conserve bobcat populations but also contribute to the broader understanding of wildlife–urban interface management.

3. Materials and Methods

3.1. Study Site

The study delineates a 30 km radius (approximately 18.64 miles) from the Calero Reservoir as its focal area, located 20 km (about 12.43 miles) from downtown San Jose, CA. The Calero Reservoir, a crucial hydrological feature for the region, supports the surrounding ecosystems with ample water resources. Figure 1 illustrates several designated wildlife preserves within the study site, including the North Coyote Valley Conservation Area, Tulare Hill Ecological Preserve, and Basking Ridge Conservation Area—integral to the region's biological diversity. The area boasts a rich ecological mosaic of forests, grasslands, and watersheds, providing habitats conducive to a variety of wildlife species, including several protected ones. In recent years, a surge in roadkill events has been observed, particularly at the confluence of Highway 101 and Monterey Road (refer to Figure 1), with significant repercussions for human safety, bobcat populations, and the broader ecosystem integrity.

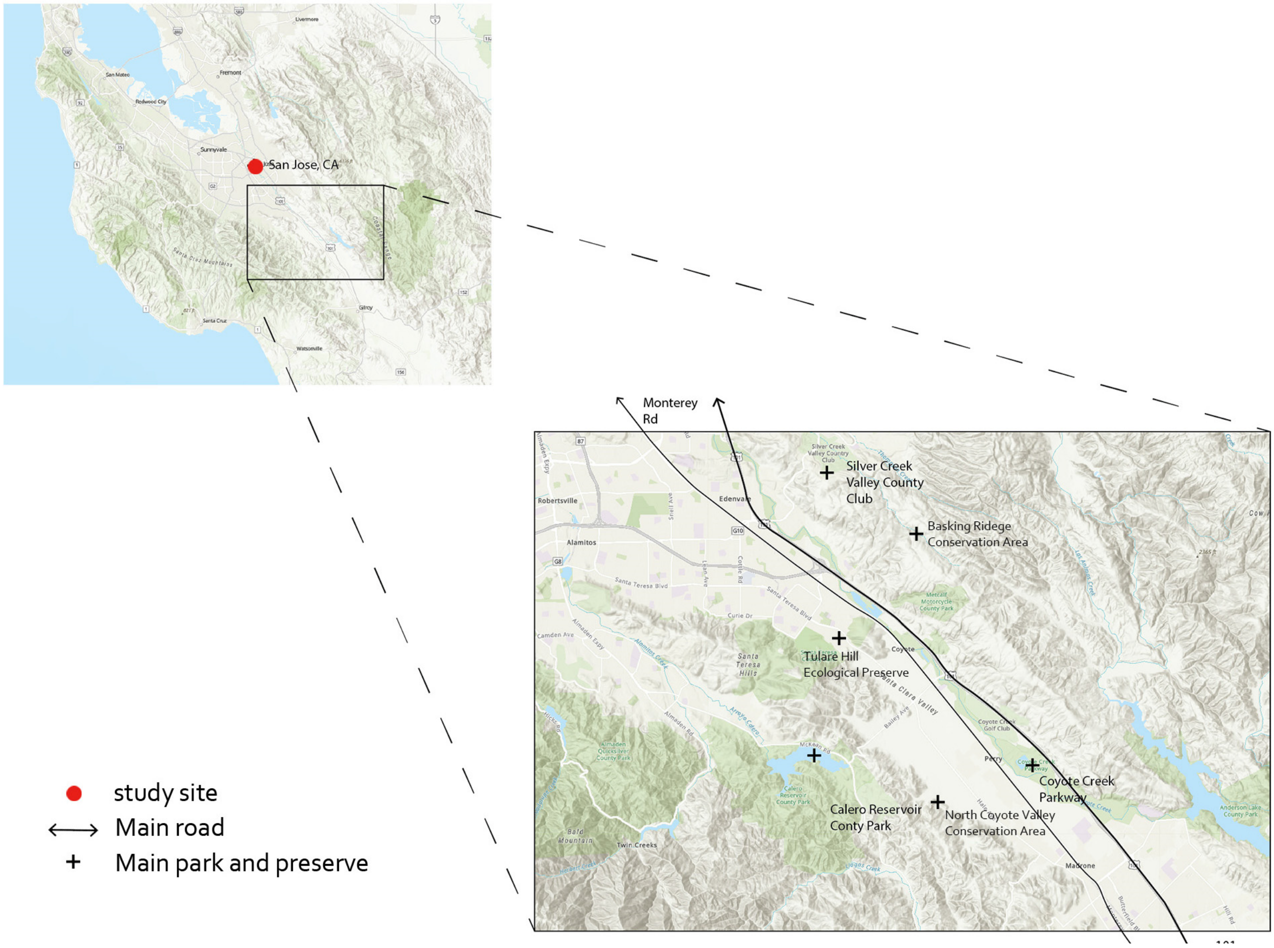

Figure 1. Bobcat Habitats and Infrastructure Crossways in the Calero Reservoir Vicinity, San Jose, California.

3.2. Data Sources and Scoring

This study conducted a literature review to identify key factors influencing the optimal locations for bobcat crossings. Articles published between 2019 and 2023 were sourced from the Web of Science database using keywords such as "Bobcat Crossing", "Habitat", "Living Condition", and "Infrastructure". The five-year period was selected to reflect recent developments in infrastructure and their effects on wildlife habitats. A dataset of 100–200 articles was curated to balance comprehensiveness with manageability, ensuring an in-depth analysis without sacrificing the breadth of the review. Within this dataset, 118 articles met the review criteria.

The research then extracted and quantified key factors from these articles, assessing word frequency in the abstracts to derive a weighted scoring system. These factors were categorized into six domains impacting bobcat habitats: "Vegetation Coverage", "Distance to Stream", "Vehicle Traffic Volume", "Bobcat Movement Pattern", and "Bobcat Roadkill Spots". This methodical approach informed the creation of a bespoke analytical framework, going beyond a mere synthesis of existing knowledge. Table 1 presents a comparative analysis of these factors, detailing associated keywords, frequency, and cumulative weight. The synthesis of factor analysis and weighting provides a novel contribution to the field by quantifying each factor's influence. Subsequent sections will delve deeper into these factors to assess their relevance to the siting of bobcat crossings.

Table 1. Key Factors for Bobcat Crossings.

Key Factors	Keywords	Frequency	Sum Weight
Vegetation Coverage	Open Water (Aquatic)	20	23.9%
	Developed Land	18	
	Riparian Forest and Shrub	15	
	Woodland	13	
	Grasslands	10	
	Wetland	8	
	Irrigated Agriculture	8	
Distance to Stream	Stream Length	25	19.6%
	Drainage Distance	14	
	Channel Network	12	
	Watershed	12	
	Stream Usage	10	
	Stream Segment	8	
	Riparian Zone	8	
Vehicle Traffic Volume	Average Daily Traffic (ADT)	15	15.7%
	Vehicle Flow	14	
	Road Usage	12	
	Vehicle Flow Analysis	12	
	Peak Hour Traffic	12	
Bobcat Movement Pattern	Bobcat Tracking	24	26.8%
	Bobcat GPS Telemetry	22	
	Bobcat Habitat Selection	20	
	Bobcat Migration	17	
	Bobcat GPS Collar Data	15	
	Bobcat Movement Ecology Studies	13	

Table 1. *Cont.*

Key Factors	Keywords	Frequency	Sum Weight
Bobcat Roadkill	Roadkill Hotspots	12	14.0%
	Wildlife Mortality Locations	11	
	Roadway Animal Incidents	10	
	Roadkill Mapping	10	
	Wildlife–Vehicle Conflict Zones	8	
	Animal–Vehicle Collision Sites	7	

Table 2 offers a comprehensive overview of the data employed in this project, incorporating information on vegetation coverage, water system characteristics, vehicle traffic volume, bobcat movement position points, and incidents of bobcat roadkill. All data were processed in the WGS 1984 coordinate reference system. The table provides granular details for each dataset, such as resolution, application, year of reference, and the originating source of the data.

Table 2. Data Sources.

Data	Reference Year	Resolution	Usage	Data Source
Vegetation Coverage Data	2023	Vector	Reclassification of Vegetation	The national Map. Gov
Water System Data	2023	Vector	Abstracting the Distance from Water	The national Map. Gov
Vehicle Traffic Volume	2023	Vector	Visualizing the Traffic Data	The national Map. Gov
Bobcat Movement Position Point Data	2023	Vector	Visualizing the Bobcat Movement Pattern	MOVEBANK
Bobcat Roadkill Data	2023	Vector	Extracting Space Distribution of Bobcat Roadkill	MOVEBANK

3.3. Data Analysis Criteria of Habitat Suitability Modeling (HSM)

This study employed Habitat Suitability Modeling (HSM) to develop a model for habitat suitability. HSM is considered the practical application of the ecological niche concept, utilizing environmental variables to predict the presence or abundance of species throughout the research area [48]. The research also harnessed the logic of the Landscape Planner's Toolkit, integrating Geographic Information Systems (GISs) to collect and process visual data such as Data Evaluation Parameters (DEPs) [49].

We categorized each factor into five equidistant values based on their impact on bobcat crossings, ranging from S1-Highest suitability (5 pts) to S5-Lowest suitability (1 pt); this division of Habitat Suitability Index (HSI) values into five equidistant levels facilitates easier comparison and contrast among the suitability of different habitats [50]. Our evaluation of the five values and their impact on bobcat crossings drew upon key insights extracted from the literature review, a method whose efficacy in assessing habitat suitability has been well documented.

HSM development integrates species occurrence with environmental data, employing statistical algorithms to analyze the relationship between these environmental factors and species occurrences, thereby predicting the probability of suitable habitats across the landscape [51]. In our analysis, the analysis incorporated key factors from Section 3.2 to ascertain the most crucial species occurrence data and environmental data. Subsequently, assigning habitat suitability using the Ordered Weighted Averaging (OWA) method [52]. The weighted key factors were then transformed into spatial distribution maps using OWA values, enabling spatial analysis within GIS. This approach has a strong precedent in current applications [53].

For the impact factors that cannot find the evidence for suitability score, this research applied the "Equal Interval" classification method [54]. In "Equal Interval" classification, each class occupies an equal interval along the number line. They are found by determining the range of the data [55]. The range is then divided by the number of classes, which gives the common difference. The class limits are established by starting at the lowest value and adding the common difference to obtain the upper limits of the first class, adding the common difference to this to obtain the limit of the second class, until the upper limit of the data is reached [56].

Finally, we overlaid all factors with different weights based on the word frequency, in ArcGIS Pro, then generated potential crossing locations where bobcats are likely to attempt to crossroads. Weighted overlay is a technique in GIS-based multi-criteria decision analysis that assigns weights and combines various thematic layers to create a comprehensive suitability map, widely used in habitat suitability modeling, land use planning, and site selection studies [57]. These areas represent critical points for wildlife connectivity. The formula of the weighted overlay method is shown below:

$$weightedoverlay = \sum_{i=1}^{n} C_i \times W_n \tag{1}$$

where C_i is each criterion (i) that has been reclassified, and W_n is the number of data (n) that were weighted.

3.3.1. Kernel Density

This study employs Kernel Density Analysis (KDA) as a pivotal ecological analytical method to evaluate bobcat habitats. Within the extensive realms of geospatial analysis, geography, and ecology, Kernel Density Analysis has proven to be a highly prevalent model, extensively applied for detecting ecological corridors [58–60], identifying biodiversity hotspots [61,62], and assessing potential conflict areas [63,64]. The methodology involves calculating the density of point features surrounding each output grid cell, contingent upon specified bandwidth and a chosen kernel function [65]. In this project, the KDA mechanism can be demonstrated as follows (2):

$$K_{(x)} = \frac{1}{nh2} \sum\nolimits_{i=1}^{n} K\left(\frac{x - x_i}{h}\right) \tag{2}$$

where for each habitat category, (n) represents the total number of locations that are suitable as bobcat's habitats, ($x - x_i$) represent the individual samples of habitat locations, (h) is the bandwidth (search radius of each habitat), and (K) is the kernel function, typically a Gaussian function.

In this project, Kernel Density Analysis (KDA) is initially employed to transform bobcat observation points into a continuous density surface [66]. Leveraging the spatial features of the density values derived from this continuous surface, polygons representing bobcat active regions are extracted, potentially indicative of their hunting grounds, habitats, or migration routes, drawing upon insights from prior reviews. The choice of bandwidth and kernel function among various parameters significantly impacts the accuracy of corridor estimation. With a very large bandwidth, the detection result fails to reflect the variability in data, whilst a very narrow bandwidth leads to noises [67]. Kernel function impacts how an individual sample is spread and weighted across the density surface. Herein, this study employs 1609.344 (1 mile) as bandwidth and Gaussian function as kernel function for its mathematical simplicity and statistical interpretability.

When considering the impact of roads on wildlife, by analyzing the activity density of bobcats and the location of roads, it is possible to determine where road infrastructure has the greatest impact on bobcats. This information is crucial for wildlife management and conservation planning, as it can guide how to design and place wildlife corridors or other mitigation measures.

3.3.2. Euclidean Distance

Euclidean distance serves as a metric to quantify the spatial relationship with bobcat habitats. Typically employed in prior studies to assess habitat isolation [68,69] and ecological importance evaluation [70,71], this metric calculates the shortest straight-line distance between points, providing a straightforward measure of spatial separation [65]. Equation (3) is the mathematical representation:

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \tag{3}$$

where (d) represents the distance between two points, which are points within study range and habitats, respectively, with (x_1, y_1) and (x_2, y_2) as the coordinates of these points. Herein, the calculation involves determining the distances from each pixel in the study area to the nearest bobcat-active points, considering key resources like water sources and food supply as indicated by prior reviews. Subsequently, varied weight values are assigned to these resources on the map, contributing to the creation of a weighted suitability raster based on pre-calculated Euclidean distances.

This method serves as a valuable tool for unraveling the spatial relationship between bobcats and their environment. It offers a straightforward means of assessing the spatial characteristics of animal habitats and identifying potential suitable areas. The analysis proves advantageous in swiftly pinpointing regions where bobcats can readily access resources, while also highlighting areas that may pose challenges due to difficulties in resource acquisition [35]. Through the overlay and calculation of Euclidean distances, researchers gain insights into animal behavioral patterns and ecological needs. This understanding, in turn, informs the development of effective wildlife management and conservation strategies.

4. Results

4.1. Vegetation Coverage (Sum Weight: 23.9%)

This study employed the Kernel Density method to process Vegetation Coverage data. Kernel Density Analysis uses kernel functions (such as the Gaussian kernel) to interpolate data points, forming a continuous density surface, thus accurately capturing variations in vegetation coverage on a small spatial scale. Bobcats prefer complex natural vegetation structures [17] and their presence is often associated with open water bodies, developed open spaces, grasslands/herbaceous and shrub/shrub habitats [72]. Forest-type land has a significant impact on the relative abundance of bobcats [73]. Although current research has analyzed the habitat types preferred by bobcats and their characteristics, there is not yet a clear and unified consensus on the preference order of these habitats. Therefore, in this study, we employed a method based on word frequency analysis to count habitat-related keywords mentioned in the literature under the "Vegetation Coverage" category, which are relevant to suitable locations for bobcat crossings. This method aims to quantify the relative importance of different land types for bobcats. Specifically, we classified these keywords into five levels using the Equal Interval method, assigning suitability scores from 5 (highest importance) to 1 (lowest importance) based on their significance, see Table 3.

Table 3. Suitability Ratings for Vegetation Coverage.

Keywords for Vegetation Coverage	Suitability Level	Current Value (Based on Word Frequency from Table 1)	Reclassified Value
Open Water (Aquatic)	S5—Highest Suitability	18.6–20	5 pts
Developed Land	S4—Higher Suitability	15.0–18.6	4 pts
Riparian Forest and Shrub	S3—Moderate Suitability	12.8–15.2	3 pts
Grassland; Woodland	S2—Lower Suitability	10.0–12.8	2 pts
Wetland; Irrigated Agriculture	S1—Lowest Suitability	8–10.0	1 pt

4.2. Distance to Stream (Weight: 19.6%)

In this study, the Euclidean Distance Analysis method was used to assess the Distance to Stream, a crucial factor in determining the suitability of habitats for bobcats. This method calculates the straight-line distance from each point within the study area to the nearest water stream, providing a clear quantification of the spatial relationship between water sources and bobcat habitats. Proximity to water sources is crucial for bobcats as these areas typically offer a richer food supply, including prey species attracted to water bodies. Additionally, water sources often support a variety of vegetation, providing necessary cover for bobcats for hunting and protection.

In urban environments, bobcats have been found to prefer areas around creeks and water channels [74], likely due to these areas offering a more favorable microclimate and more secluded environment compared to the more exposed urban landscapes [75]. Furthermore, water sources are essential for the hydration of bobcats, especially in urban areas where natural water sources may be scarce. Therefore, proximity to water is a significant factor in their movement and territory selection [76].

Consequently, areas closer to water sources are deemed more suitable for bobcat habitats. However, current research lacks specific studies on the precise distance between suitable bobcat habitats and water sources. To address this, our study applied the Equal Interval method to divide the distance from each point in the study area to the nearest stream into five levels, reflecting varying degrees of habitat suitability based on proximity to water sources. As shown in Table 3, this scoring system was developed based on a comprehensive review of bobcat behavioral patterns and ecological needs, assigning values from 5 (closest) to 1 (farthest) based on the reclassification of these levels according to their distance, as shown in Table 4.

Table 4. Suitability Ratings for Distance to Stream.

Distance to Stream	Suitability Level	Current Value (Based on Distance to Stream)	Reclassified Value
Very Close	S5—Highest Suitability	0–50 m	5 pts
Close	S4—Higher Suitability	50–100 m	4 pts
Moderate	S3—Moderate Suitability	100–150 m	3 pts
Far	S2—Lower Suitability	150–200 m	2 pts
Very Far	S1—Lowest Suitability	Above 250 m	1 pt

4.3. Traffic Volume (Weight: 15.7%)

This study utilized Kernel Density to analyze Traffic Volume data. Kernel Density reveals the spatial distribution characteristics of traffic by identifying areas of high traffic density.

Research has shown that bobcats exhibit avoidance behavior towards road areas and show the least overlap in their range within road-related habitats [77]. Bobcats are also particularly sensitive to traffic noise and vehicle lights [78]. Thus, areas with high traffic volume are not preferred habitats for bobcats. Using the Equal Interval method, this study classified the relative distances to high traffic volume areas. Based on proximity to these areas, from farthest to nearest, we assigned suitability scores from 5 to 1 to these locations, as shown in Table 5.

Table 5. Suitability Ratings for Traffic Volume.

Traffic Volume	Suitability Level	Average ADT per Day (Quantity of Vehicles)	Reclassified Value
Very low	S5—Highest Suitability	0–50,000	5 pts
Low	S4—Higher Suitability	50,000–110,000	4 pts
Moderate	S3—Moderate Suitability	110,000–370,000	3 pts
High	S2—Lower Suitability	370,000–920,000	2 pts
Very High	S1—Lowest Suitability	Above 920,000	1 pt

4.4. Bobcat Movement Patterns (Weight: 26.8%)

This study utilized the Kernel Density method to analyze data on Bobcat Movement Patterns. Kernel Density Analysis allowed us to visualize key areas and pathways of bobcat activity, such as frequently crossed locations or primary activity zones, aiding in understanding the spatial distribution of bobcats' behavioral habits and ecological needs. Using bobcat movement monitoring data from MOVEBANK in 2023, we produced maps of bobcat activity ranges and understood the intensity of activities within these areas. The Equal Interval method was applied to classify bobcat activity density into five different levels. For detailed categorization, refer to Table 5; these were assigned scores from 5 (highest density) to 1 (lowest density) based on the density gradient, see Table 6.

Table 6. Suitability Ratings for Movement Patterns.

The Density of Movement Patterns	Suitability Level	Crossing Times per Square Miles in 2023	Reclassified Value
Very High	S5—Highest Suitability	25,600–113,000	5 pts
High	S4—Higher Suitability	8460–25,600	4 pts
Moderate	S3—Moderate Suitability	2220–8460	3 pts
Low	S2—Lower Suitability	500–2220	2 pts
Very Low	S1—Lowest Suitability	0–500	1 pt

4.5. Bobcat Roadkill (Weight: 14.0%)

This study employs the Kernel Density method to analyze Bobcat Roadkill events. Kernel Density Analysis reveals the spatial clustering characteristics of bobcat roadkill incidents. By generating continuous density maps, this method clearly depicts the concentration trends of roadkill events in specific areas. The risk of road mortality for bobcats is significantly influenced by traffic levels [79], and roadkill incidents impact the activity and population of bobcats [80]. Increased traffic leads to an increased likelihood of vehicle encounters with wildlife [81]. As traffic volumes increase, the likelihood of bobcats crossing the roadway and being struck by vehicles as a result increases. Busy roads can disrupt roadways and can affect the habitats of mammalian predators (especially felines) by forcing these animals to cross roads more frequently to access different parts of their territories [82]. This increase in crossing behavior increases the risk of road traffic accidents. Therefore, based on bobcat roadkill data from MOVEBANK in 2023, our study applied the Equal Interval method to categorize the distances in high bobcat roadkill density areas into five levels, forming a continuous distance gradient. Each level is assigned a suitability score from 1 to 5 based on the relative distance from high-density roadkill areas. For detailed categorization, refer to Table 6; this grading method, by quantifying the frequency of bobcat roadkill events, reveals the spatial distribution patterns of habitat suitability affected by this factor, see Table 7.

Table 7. Suitability Ratings for Bobcat Roadkill.

The Density of Bobcat Roadkill	Suitability Level	Roadkill per Square Miles in 2023	Reclassified Value
Very low	S5—Highest Suitability	0.001–0.011	5 pts
Low	S4—Higher Suitability	0.012–0.053	4 pts
Moderate	S3—Moderate Suitability	0.054–0.214	3 pts
High	S2—Lower Suitability	0.215–0.836	2 pts
Very High	S1—Lowest Suitability	0.837–3.234	1 pt

4.6. Habitat Suitability Modeling (HSM)

The vector data obtained from Section 4.2 to 4.6 were processed by multiplying each factor's score by its corresponding weight and then summing them to obtain a composite score for each location. This reflects the contribution of each factor to land suitability. A visualized composite score map was then generated, summarizing the weighted sums [83]. Highly suitable habitats are represented in green, while the least suitable are in red.

In the San Jose region, our Habitat Suitability Modeling (HSM) integrated various ecological factors to reveal that the most conducive environments for bobcats, depicted as verdant zones on the composite maps, are predominantly located on the outskirts of urban development. These areas, in proximity to conservation zones such as Basking Ridge and Metcalf Motorcycle County Park, benefit from reduced human encroachment and roadkill risk due to their distance from major highways. Conversely, areas adjacent to and south of these highways, portrayed in shades of orange and yellow, manifest lower habitat suitability, with the least suitable regions, marked in red, located within densely urbanized areas. This pattern corroborates previous findings by Riley et al. [13], underscoring the detrimental effects of urban land use and adjacent road infrastructure on bobcat habitat viability.

Cross-layer analysis of Figure 2 elucidates the differential impact of various factors on habitat suitability. While urban regions and their associated roads demonstrate reduced suitability, this is contrasted by the lower scores in areas adjacent to the North Coyote Valley Conservation Area, despite their remote location from urban centers. Here, the widespread and uniform distribution of rivers correlates with increased habitat suitability, enhancing as one moves away from tributaries. Traffic dynamics further complicate suitability; the northwest regions near urban centers, with higher traffic volumes, signify lower suitability, aligning with infrastructure hotspots, particularly at intersections. However, the lowest roadkill map scores are concentrated along major thoroughfares, such as Highway 101 and Monterey Road, challenging conventional wisdom which posits that increased traffic and more lanes amplify mortality rates for bobcats [35].

An unexpected revelation from our study is the spatial congruence between areas of high habitat suitability and regions with frequent roadkill incidents, an intuitive contradiction that suggests ideal habitats might also present heightened risks for traffic-related fatalities. The habitat suitability map (Figure 2) positions primary bobcat territories at the city's periphery, correlating with areas of dense vegetation typical of conservation lands, parks, golf courses, and undeveloped tracts. The optimal habitats, situated between South San Jose and Metcalf Motorcycle Park, are dissected by major roadways. Although these roads provide a degree of suitability, they coincide significantly with roadkill hotspots when juxtaposed with individual maps. This observation compels a further discourse and consideration of roadkill intersections, especially where road planning and construction bisect suitable bobcat environments, potentially leading to a high frequency of roadkill events. The synthesis of these findings suggests a need for a multifaceted approach to urban development in San Jose, to better accommodate the needs of local wildlife, including bobcats. Specific management actions and recommendations will be detailed in the discussion section.

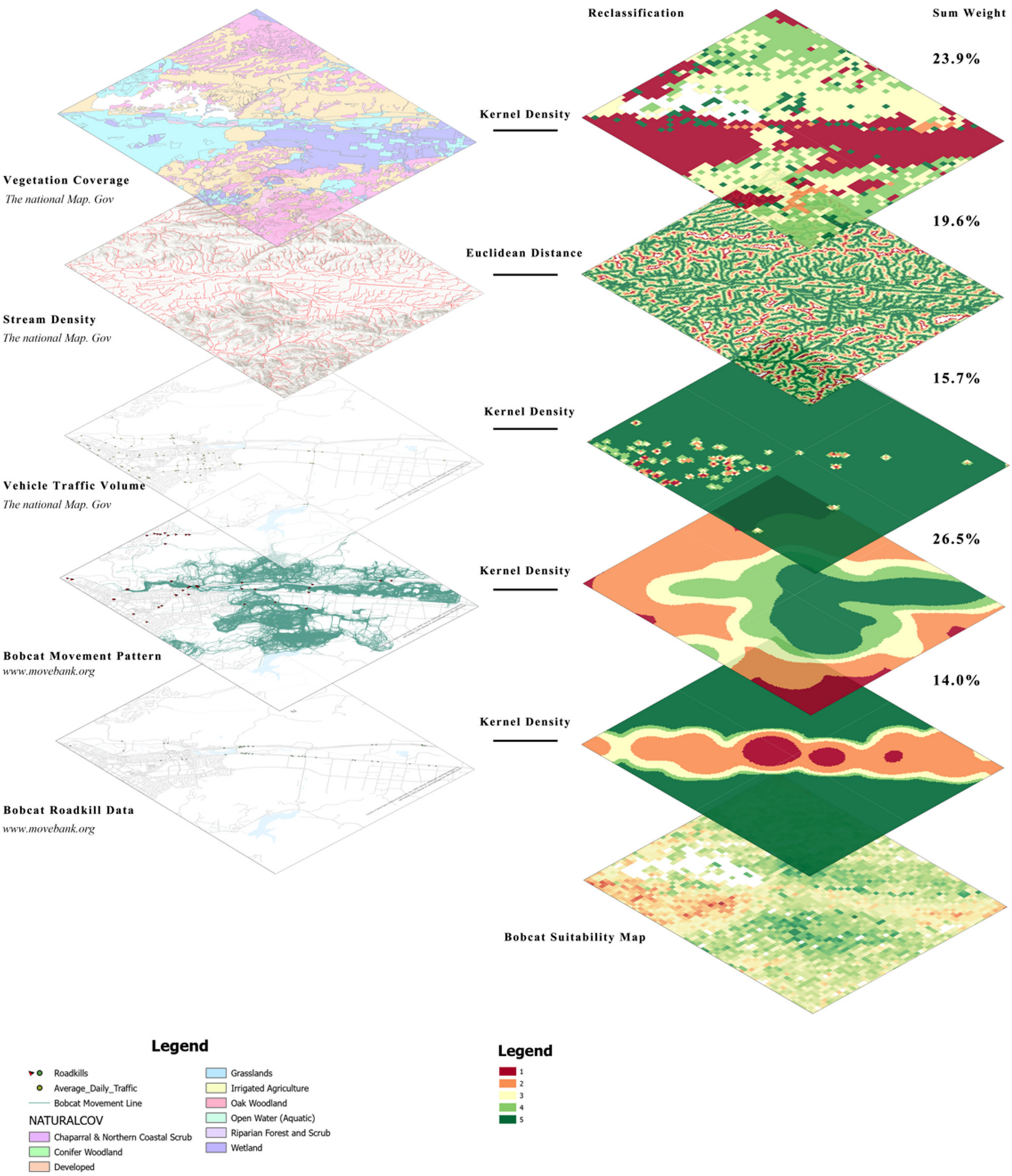

Figure 2. Comprehensive Habitat Suitability Analysis for Bobcats in San Jose, California: Integrating Vegetation Coverage, Stream Density, Traffic Volume, Bobcat Movement Patterns and roadkill dates, 2023.

5. Discussion

In this study, we explored the impact of human activities on bobcat habitat selection and suitability. Our analysis of the San Jose region, encompassing conservation areas such as Basking Ridge Conservation Area, Tulare Hill Ecological Preserve, and North Coyote Valley Conservation Area, indicated that major roads, including Highways 101 and 85, and urban land use, including the land between Highways 101 and 85, the silver leaf, and the town along the Monterey Road, called the Los Paseos significantly negatively impacted bobcat habitat suitability. These have led to habitat fragmentation and reduced connectivity within these suburban and natural landscape. Major roadways notably disrupt ecological continuity, severely disrupting the ecological environment and intensifying roadkill incidents, thereby restricting bobcat movement. Ruell et al. [28] also highlighted the negative impacts of roads on habitat connectivity.

Comparing the different layers, from Figure 2, we find that the interactions between various factors may influence suitability by affecting bobcat behavior. In our analysis, comparing the influence of roadkill incidents and traffic volume on habitat suitability, we found that while the general patterns of habitat suitability associated with roadkill incidents broadly align with those of traffic volume, the areas of highest impact for each do not overlap. Specifically, these factors differentially affect bobcat behaviors such as movement patterns, territorial range, and crossing frequency, with peak areas for roadkill incidents suggesting a higher risk to bobcats in certain regions [84], while traffic volume peak areas may correspond to areas with restricted bobcat movements due to noise and continuous vehicle presence. The occurrence of roadkill incidents is not concentrated at the peaks of traffic flow but aligns more with the suitability in the movement patterns of bobcats. Firstly, it is evident that the cause of roadkill incidents is not just heavy traffic flow, but the result of the interaction between traffic flow and bobcat movement patterns. Additionally, comparing the bobcat movement maps with layers of vegetation, streams, land use, etc., we can see some patterns similar to bobcat activities. Areas rich in vegetation and far from urban areas show higher suitability and activity density. This also reflects to some extent that natural environmental factors like vegetation are attractors of bobcat activity. This observation also underscores the significance of natural environmental factors as determinants of bobcat activity, evident from the bobcat movement maps. The patterns depicted in these maps show a clear correlation between areas of dense vegetation and increased bobcat activity [85]. Particularly, these areas, typically remote from urban settings, are not only characterized by higher habitat suitability but also by a greater density of bobcat activities. For example, areas such as Metcalf Motorcycle County Park and the portion southwest of the two preserves and the area between South San Jose have more dark green patches on the Suitability Map, demonstrating better suitability for bobcats. This is also an area where bobcat activity patterns are more intense (Figure 3). At the same time, however, the fragmental distribution of vegetation has led to more frequent travelling of bobcats on roads in this area, as seen in the illustration of bobcat movement patterns, even on roads, where their movement trajectories cross roads and connect the two reserves (Figure 2). This suggests that, aside from traffic flow, the natural landscape features, such as vegetation cover, significantly influence bobcat movements, attract their presence, and contribute to habitat preference, offering essential resources and sheltered breeding locations [85]. Vegetation cover is an important factor in bobcat habitat selection, providing them with necessary food sources and secluded breeding grounds [86].

Moreover, our analysis in Figure 3 revealed a dichotomy in the attractiveness of vegetation cover for bobcats. While areas rich in vegetation are highly appealing to bobcats, their proximity to transportation infrastructure increases the risk of roadkill. This finding is supported by Schmidt et al. [87], who indicated that bobcats near roads have a higher risk of roadkill. Cain [88] also observed an increased likelihood of roadkill for medium-sized carnivores in highly suitable habitats along roadways.

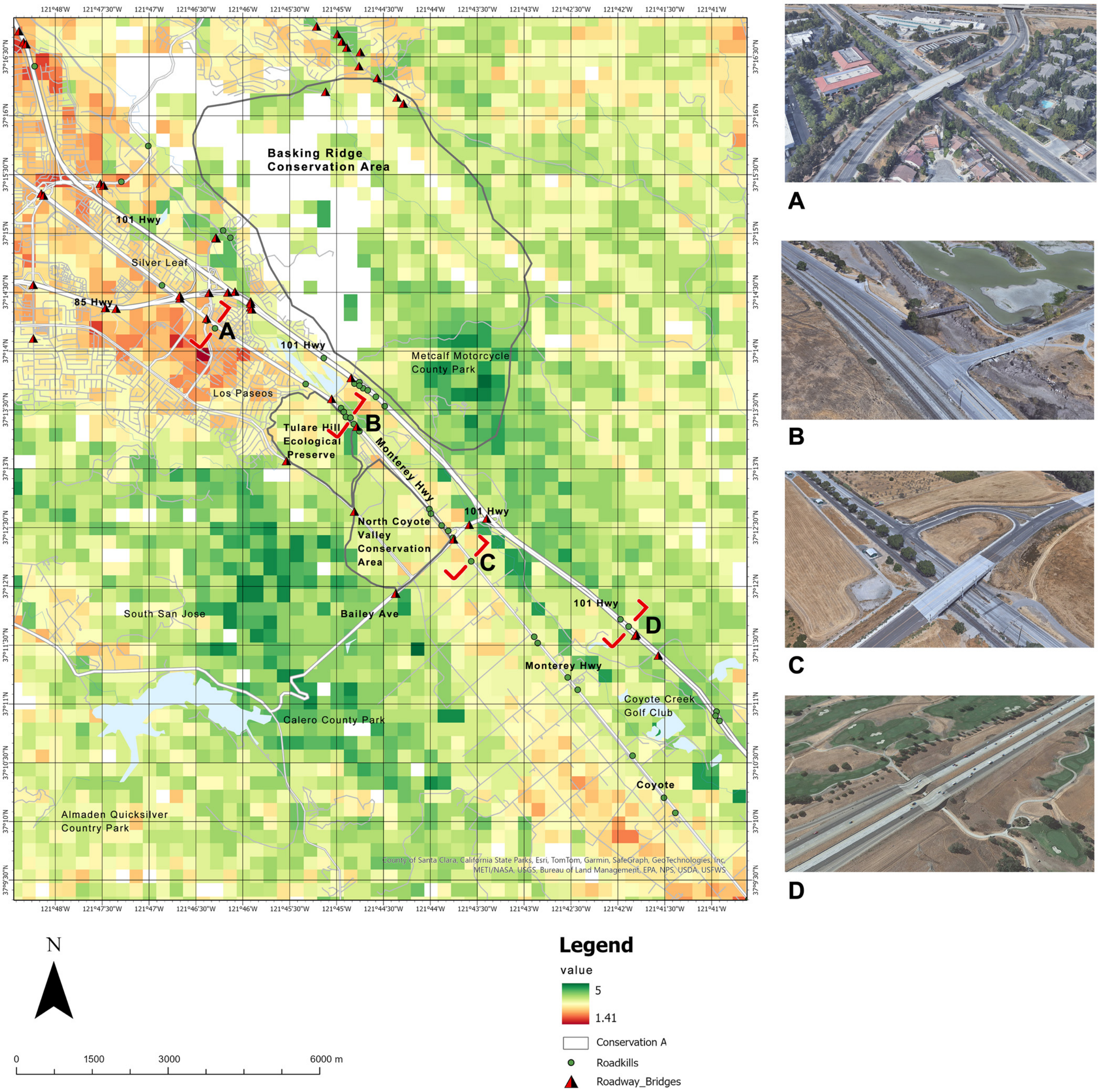

Figure 3. Overlay analysis of habitat suitability maps with infrastructure and conservation areas (**A**–**D**) are representative road sections that we selected for detailed analysis (Photos Source: Google Earth, 2023).

Overall, our research emphasizes that although areas with rich vegetation offer higher suitability for bobcats, road traffic infrastructure and roadkill phenomena significantly diminish this suitability. Some studies have also shown that predators, such as bobcats, tend to cross primary and secondary roads within their range of habitat. An increase in the density of primary and secondary roads results in more bobcats crossing and a greater risk of roadkill injury [84], due to their movement pattern. This is consistent with Serieys et al. [17], who found that bobcats prefer densely vegetated coniferous forests as habitats. However, abundant vegetation does not always equate to high suitability scores. Overlapping analysis (Figure 2) showed that roadkill incidents primarily occur on main roads, highly overlapping with areas frequently traversed by bobcats. This might be due to vegetation density providing cover but also potentially attracting bobcat activity, thereby increasing the risk of roadkill [89]. Our study indicates that in addition to considering the individual impact of various factors in habitat suitability assessments, the interplay and potential negative effects of these factors must also be considered. Therefore, future research should aim to adjust and optimize the suitability assessment system to more comprehensively reflect the complex relationships between environmental factors. Especially in assessing habitat suitability, it is crucial to consider not only the independent effects of environmental factors but also how these factors interact and affect the behavior and survival of wildlife. Moreover, our study underscores the need for conservation strategies, particularly in urban and suburban areas. When planning and managing natural reserves, the potential negative impacts of roads and urban land use on wildlife habitats should be fully considered. For instance, increasing ecological corridors and wildlife crossings can reduce roadkill incidents and enhance habitat connectivity. Additionally, raising public awareness about wildlife conservation, particularly among residents in urban and suburban areas, can help reduce disturbances to wildlife habitats. To delve deeper into bobcat habitat suitability analysis, we selected four areas (Figure 3) for case studies, comparing, learning, and applying our findings by overlaying suitability maps and roadkill points to analyze key points in depth.

Figure 3 shows that Segment A, being close to the town, has the lowest suitability score. Despite some vegetation, it is primarily urban greenery and close to houses. Segment B, near a water source, has vegetation only on the northeast side and is traversed by a flyover across the main road, resulting in good suitability. Segment C, with open views and belt-like vegetation on both sides, also crossed by a flyover, has slightly lower suitability compared to B. Segment D, farthest from the urban area, with broad views and some vegetation, also shows good suitability in the image. In conclusion, it is found that the suitability of different sections varies due to the different environmental landscapes in their surroundings. However, the same feature is that the habitat suitability is lower in the crossings where there is no advantage of natural resources such as vegetation and water. Whereas the abundance of favorable natural conditions and appropriate tunnel treatments will increase the suitability of the intersection location. In addition, the closer to the urban landscape, the lower suitability even though there are high quality vegetation and corridor bridge. For details, the comparison of the four sections reveals that areas with vegetation on both sides or near a water source have higher suitability, as clearly demonstrated by B and C. Additionally, in similar road environments, the comparison between B and C indicates that more abundant and favorable natural factors lead to higher suitability. This suggests that increasing vegetation around roads and in poorer corridors could be considered to reduce roadkill. Therefore, following this, we will conduct case studies and research based on the characteristics of different intersections (Figure 4), exploring measures to enhance suitability in the area.

Section A is characterized by a complex interplay of transportation networks and natural environments. In such areas, the challenge lies in bobcats potentially wandering into high-risk roadkill zones due to the blurred boundaries between roads, human settlements, and natural habitats. Based on Section 1-1 in Figure 4, railways may become their pathways, with animals using these linear structures for movement [90]. The common approach to mitigate threats from trains to mammals is to install fences along railway lines, preventing wildlife from entering the railway area. Fences, typically made of metal or wood and sufficiently high to deter target species, are proposed by [91]. However, fencing can restrict wildlife migration and habitat use, leading to habitat fragmentation and disruption of population genetic flow [57]. They also involve high construction and maintenance costs, requiring regular monitoring and repair. To address this, Spanowicz et al. [92] collected roadkill data in Canada and Brazil and designed an adaptive fencing plan, prioritizing high-risk areas to increase connectivity and reduce costs. Additionally, the authors of [93] developed a warning device that alerts animals as trains approach, enhancing their attention and facilitating learning. Moreover, for Section A, where roads are flanked by rich vegetation and central medians covered with dense plants, management measures including regular trimming and clearing roadside vegetation have been proven effective in reducing roadkill incidents for various carnivores [94–96]. Different species respond variably to the height and density of vegetation in road medians, influencing their road-crossing behavior [96]. However, more research is needed on the impact of road medians on bobcat crossing behaviors to achieve integrated vegetation management around these areas. For such sections, physical barriers like higher fences in high-risk areas along railways and roads can prevent bobcats from entering these zones. Additionally, comprehensive measures like managing road vegetation can effectively reduce animal roadkill incidents. Roadway A is characterized by its complex transportation network intertwined with the natural environment. The challenge with this type of area is that bobcats may stray into areas of high roadkill risk because the boundaries between the road, habitat, and natural environment are not obvious. Railroads may become their walking paths because typically there is sparse vegetation on both sides of the railroad, and animals may use these linear structures as a pathway for movement [90]. For such sections, for both sides of the railroad and roadway, physical separation, such as higher fences, can be added to prevent bobcats from straying into the area. And planting more native vegetation to increase cover to reduce the tendency of bobcats to cross railroads.

Section B is the area where roadkill incidents occur most frequently (Figure 3). It bisects a region highly suitable for bobcats, separating the reserve from a water source on the other side. There is a direct positive correlation between the risk of road mortality for carnivores and the presence of water bodies [97]. The proximity to water sources (Section 2-2 in Figure 4) may lead bobcats to prefer these areas as crossing points, being both drinking spots and hunting grounds, and increasing potential conflicts with human activities. For such fragmented and divided habitats, in addition to establishing wildlife crossings, it is also advisable to set up wildlife monitoring systems near these critical water sources, intervening when necessary. Through spatial overlay analysis of factors affecting bobcat survival and habitat suitability, we recognize the importance of establishing wildlife corridors along highway edges near highly suitable habitats. Further assessments can utilize spatial capture–recapture models to estimate bobcat densities in urban environments [74]. This will help to precisely identify bobcat activity hotspots. Moreover, studies like Reed et al. [11] show that combining expert experience models with empirical models simulating landscape connectivity can effectively identify crucial ecological corridors for medium-sized carnivores like bobcats. Data collected on wildlife activity and roadkill statistics are crucial in determining optimal locations for road crossing structures. Research indicates that wildlife underpasses not built based on such data have significantly lower usage efficiency compared to those planned and constructed with relevant data [98]. Section B is the area where roadkill occurs most frequently. Section B divides the area of high bobcat suitability and separates the reserve from the water source on the other side. The proximity to water sources may cause bobcats to prefer crossing at watering points and hunting areas. In addition, these areas may also be places where human activities are more concentrated, which increases the likelihood of bobcat conflicts with human. For such sections where suitable habitat is divided and fragmented, in addition to establishing animal passages, wildlife monitoring systems can be set up near these critical water sources and humans intervene when necessary.

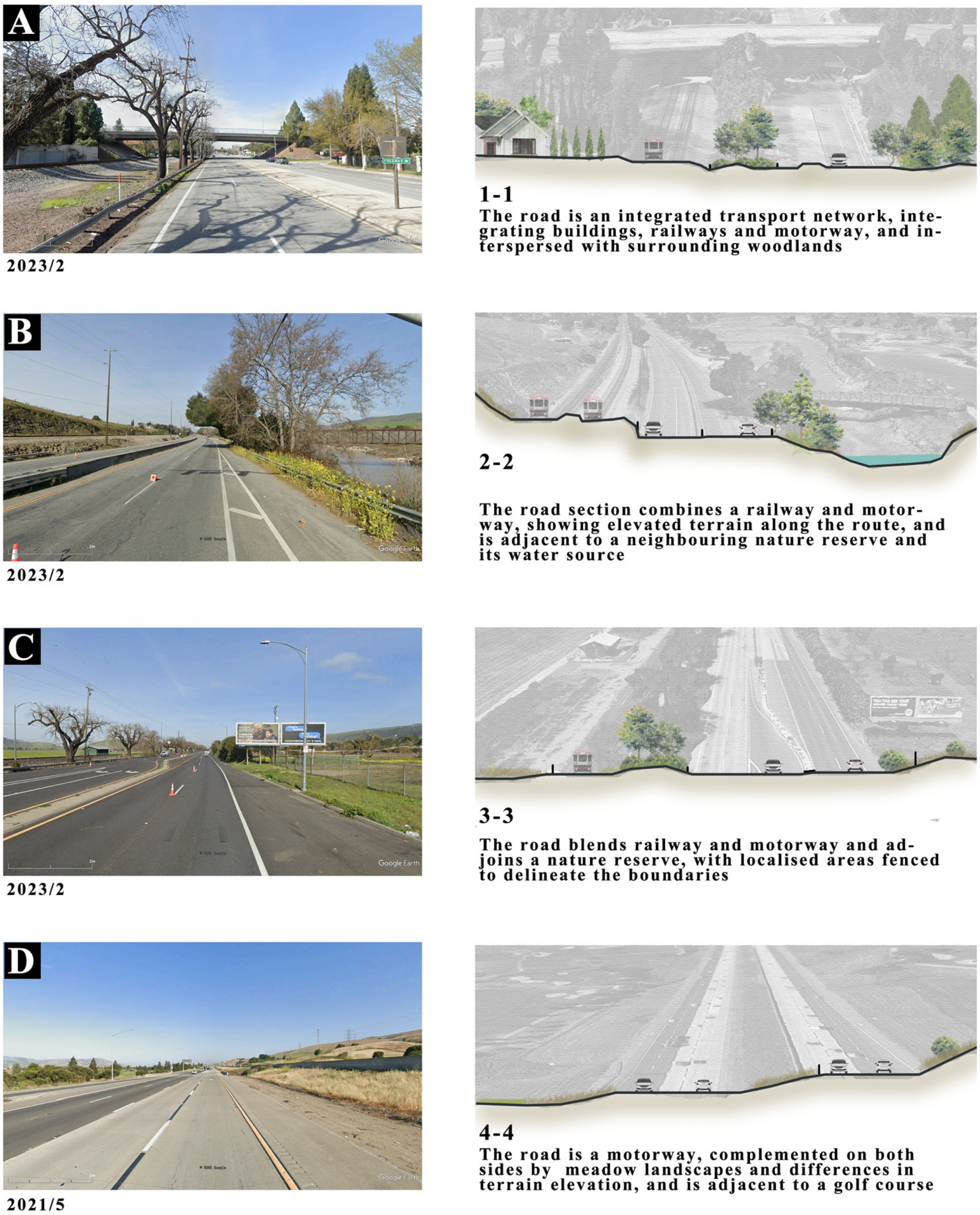

Figure 4. Representative Road Sections with Roadkill Records (**A**–**D**) are representative road sections that we selected for detailed analysis (Source: Google Earth, 2023).

Section C is characterized by its integration of rail and car lanes, adjacent to a nature reserve (Section 3-3 in Figure 4). The fences here somewhat delineate the boundaries between wildlife and human activities. However, bobcats and other wildlife adapt their behaviors to avoid human activities and habitat fragmentation [99]. The partial fencing along one side of Section C may not prevent bobcats from crossing to the other side of the road. Studies indicate a higher incidence of roadkill at fence ends than in fenced or unfenced sections, suggesting fences should be continuous or sufficiently long to encourage the use of crossing structures rather than movement around fence ends [100]. Besides barriers, wildlife underpasses or highway crossings should be added to ensure bobcat safety. In addition to passages and fencing, the habitat variables related to forests, crucial for bobcats as emphasized by Woolf et al. [73], should be considered. When designing and constructing such ecological infrastructure, efforts should be made to simulate and preserve key features of the bobcat's natural habitat, like vegetation type and density, and prey availability.

Overpasses and underpasses should be surrounded by ample vegetation resembling the adjacent habitat, avoiding elements that could startle or hinder wildlife [101]. In Section C, considering the impact of large man-made structures like billboards and streetlights on bobcat use of crossing facilities should be included in the design of ecological infrastructure. Moreover, given the proximity to a nature reserve, competition and interactions with other feline species may affect bobcat distribution [102]. In planning reserves and wildlife corridors, this competition should be accounted for by planning resources such as food, water, and shelter to minimize direct competition between species for the same resources. Section C is characterized by its blend of railway and motorway and its proximity to the nature reserve. Fencing here demarcates the boundary between wildlife and human activity to some extent; however, bobcats and other wildlife adjust their behaviors to avoid human activity and habitat fragmentation [99]. Fencing around Section C that only partially encloses an area on one side may not prevent bobcats from abandoning their crossings to the other side of the road. Further measures, such as wildlife crossings or bridges, may be needed subsequently to ensure the safety of bobcats.

Section D, with its expansive meadow landscapes and significant topographical elevation differences (Section 4-4 in Figure 4), provides bobcats with open vistas and abundant hunting grounds. This might also make them more prone to approaching human activity areas, such as nearby golf courses. While some studies suggest golf courses in urban landscapes can serve as refuges for wildlife, offering various habitats [103,104], associated factors like roads fragmenting habitats, extensive grasslands, and human activity presence may increase road mortality risks for species like bobcats. Previous research indicates that bobcat collision areas are characterized by smaller, fewer habitat patches, and larger, more isolated grassland patches [105]. In a simulation study on Deer–Vehicle Collisions (DVCs), researchers found that reducing speed limits and roadside clearings are powerful mitigation tools to decrease DVC numbers [106]. Although there is no similar simulation study on bobcat roadkill probability and vehicle speed, setting specific road signs and locally reducing speed on fast cross-city highways could be an effective and cost-efficient solution to mitigate roadkill incidents.

In conclusion, to reduce roadkill incidents, establishing crossing zones, such as wildlife underpasses or overpasses, along with barriers to prevent animal crossings, is a feasible approach [107]. Furthermore, studies have shown that carnivores prefer large, open overpasses [36,108,109]. Therefore, we recommend incorporating fences and wildlife passages into highway upgrade plans. Installing barriers along highways near reserves and other highly suitable habitats can reduce the likelihood of wildlife like bobcats entering roadways. Additionally, wildlife bridges can help bobcats cross, minimizing fragmentation of suitable habitats on either side of the highway.

In the practical implementation of these conservation measures, it is essential to tailor the design and placement of wildlife crossings and barriers based on the specific behavioral patterns and habitat requirements of bobcats. This entails conducting detailed studies of bobcat movement patterns, preferred habitats, and road-crossing behaviors. Such data can inform the strategic placement of wildlife overpasses and underpasses, ensuring these structures are located at key points where bobcats are most likely to cross roads. Additionally, the design of these crossings should mimic the natural environment to encourage usage by bobcats [110] incorporating elements like native vegetation and ensuring an appropriate scale and layout. Barrier installations along roadways should be carefully planned to minimize habitat fragmentation while effectively deterring bobcats from entering high-risk road areas [111]. Collaborative efforts with local authorities and communities are also vital in implementing traffic calming measures, such as speed limit reductions in areas with high wildlife activity, to further mitigate the risk of roadkill [35]. In summary, a comprehensive and data-driven approach, considering the unique ecological characteristics of bobcats, is crucial to effectively implement these measures and enhance the safety and connectivity of bobcat habitats.

6. Limitations

While our study presents a comprehensive assessment of suitable locations for bobcat crossings in the San Jose region, several inherent limitations should be acknowledged. First, our study focuses on the last 5 years of data for San Jose, which means that direct extrapolations to other areas may not be entirely applicable due to differences in ecological, topographical, temporal, and urban characteristics. The reliance on observational data and historical records, although valuable, may not fully capture the nuances of recent urban developments or transient bobcat populations. The criteria employed to determine crossing suitability, grounded in current knowledge, might require updates as new research emerges or bobcat behaviors evolve. Our predictive models, despite their robustness, operate under certain assumptions and may not capture the intricate web of all ecological, behavioral, and infrastructural factors. Moreover, we did not delve deeply into potential shifts in human commuting patterns, which could significantly influence the effectiveness of proposed crossings as San Jose's urban landscape evolves. Lastly, the long-term success of these proposed crossings in mitigating wildlife–vehicle collisions and bolstering bobcat genetic diversity remains to be validated. As such, while our findings shed light on urban bobcat challenges and potential interventions, they should be interpreted considering these caveats, and future research could further refine our understanding by addressing these limitations.

7. Conclusions

This study has systematically evaluated the viability of bobcat habitats in the San Jose area of California in the face of urban expansion, using established ecological and geospatial analysis methods. Our evaluation criteria are grounded in accepted habitat suitability modeling techniques, incorporating Weighted Overlay methods, Kernel Density Analysis, and Euclidean Distance Analysis [67,112,113]. These are not new inventions but rather a reintegration of proven methods, customized to address the unique challenges that bobcats face in urban environments. Our findings underscore the adverse impacts of urban growth and transportation infrastructure on habitat fragmentation, increasing the likelihood of roadkill and compromising the ecological integrity of conservation areas. The evidence points to an urgent need for implementing wildlife crossings to facilitate the coexistence of urban development and wildlife habitats.

Through the application of geospatial design and ecological modeling, we have pinpointed key potential bobcat activity zones and high-risk locations for roadkill incidents. This provides urban planners and wildlife managers with a strategic methodological framework to effectively integrate wildlife conservation and road safety in urban fringe regions, emphasizing the importance of preserving biodiversity and maintaining genetic connectivity in rapidly urbanizing landscapes. Crucially, our study brings to light the profound influence of human activities on bobcat habitat selection and suitability. By considering ecological factors, geospatial data, and human activities in tandem, we gain a deeper understanding of wildlife habitat needs, laying a scientific foundation for formulating effective conservation strategies.

The bobcat, as an indicator species, plays a pivotal role in mirroring the health of the ecosystem. Its sensitivity to habitat alterations and fragmentation serves as a critical indicator of the impacts of urbanization on wildlife. By focusing conservation efforts on the bobcat, our work not only tends to their survival but also supports biodiversity at large, in line with global initiatives like the Convention on Biological Diversity (CBD) and the United Nations' Sustainable Development Goals pertaining to life on land (SDG 15) [114,115]. This study, therefore, not only addresses local ecological challenges but also contributes to global biodiversity conservation efforts, marking the interconnectivity of urban ecology, transportation planning, and wildlife management. By addressing the needs of bobcats, a key indicator species, our study acts as a barometer for the success of urban planning and conservation initiatives, ensuring a balanced ecosystem in the San Jose region.

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