California Gnatcatcher Corridor Study
Evaluation of the Northern Connector
Through the Wildlife Corridor Planning Zone
in the City of Oceanside, CA

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(CAGN Corridor Study Northern Connector 2024)

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Preserve Calavera
Coastal North San Diego County

Protecting, enhancing, and restoring the natural resources of coastal North San Diego County

Produced by:

Ecological Conservation and Management
& Resilient Transitions

Contact:

Tito A. Marchant, Principal Ecologist: Tito@ecologicalcm.com

Scott Rothberg, Ph.D., Senior Spatial Ecologist

Isabella Santarsieri, M.S., Senior Wildlife Biologist

Steve Steele, Senior Plant Ecologist

Ecological Conservation & Management
Holistic Habitat Specialists

RESILIENT TRANSITIONS

Executive Summary

The CAGN Corridor Study Northern Connector 2024 is a project designed to evaluate the Northern Connector through the Wildlife Corridor Planning Zone (WCPZ) in Oceanside, California (CA), specifically for the benefit of the California Gnatcatcher (*Polioptila californica*) (CAGN). This study was conducted by Ecological Conservation and Management, Inc. (ECM), with mapping and analysis support from Resilient Transitions (RT) and with funding from Preserve Calavera. The primary objective of this work is to assess the quality of existing habitat and the connectivity of available open space in the Northern Connector of the WCPZ and make recommendations on priority areas for habitat restoration and enhancement, conservation, public and private engagement, and other intervention strategies in the Northern Connector.

The results of our CAGN Suitability Model show areas of existing high-quality habitat among a background of medium quality habitat, low quality habitat, and developed land uses. The combination of our CAGN Suitability Model and our CAGN Optimal Corridor model identified that multiple parcels present opportunities for stepping-stones of connectivity, but several stepping-stones identified in previous research in the WCPZ were not properly analyzed and are in a degraded condition. While slope and other land characteristics will limit what restoration action can occur on individual parcels, multiple parcels contain areas where restoration of Diegan coastal sage scrub (DCSS) and native grassland plant communities may lead to significant functional improvement of the corridor. Our results also confirm and add to previous conclusions reached regarding the ability for the CAGN corridors to persist across SR-76. Bottlenecks, steep slopes and potential barriers are present at these key crossing locations, but enhancement opportunities exist and are identified to potentially improve the viability of the corridors at these locations. Our analysis suggests that movement across the SR-76 will be unlikely, or seldom, given the many obstacles that exist along this highway and adjacent roads. But from a gene flow perspective, the crossing of one individual per generation might be sufficient to maintain genetic diversity at the metapopulation level in coastal areas of north county San Diego. However, the steppingstone approach that is envisioned for this region will allow individuals to move west to east, using existing and potentially restored habitat. We provide recommendations for the three focused parcels under consideration. Additional analysis will be necessary to evaluate other parcels within the CAGN Corridor Study Northern Connector to evaluate their potential to serve as part of the steppingstone plan and what kind of management actions would be needed to function as such.

This final report provides an overview of study design, an account of our field work, an integrated methodology and results for the GIS work performed, an inventory of priority parcels and recommended intervention actions, a discussion section providing key insights from our study, and recommended next steps for an expanded study.

1.1 Introduction and Project Understanding

The federally threatened coastal California Gnatcatcher (*Polioptila californica*) is a year-round resident of coastal sage scrub habitats in Southern California (CA). The California Gnatcatcher (CAGN) breed from March– August, raising multiple broods in favorable years, but they also suffer from high over-winter mortality and relatively short lifespans compared to other passerines (Clark, K.B., et al, 2023; Atwood and Bontrager 2020). As an obligate insectivore with a high metabolism, CAGN must continue to forage through the annual dry period despite likely declining food availability (Clark, K.B., et al, 2023). Therefore, foraging efficiency is crucial for maintaining enough caloric food intake to compensate for energy expenditures. Indeed, mortality has been found to be greatest during the fall and winter period, with periods of cold temperatures and wet weather resulting in population declines at monitored sites (Clark, K.B., et al, 2023; Atwood et al. 1998, Erickson and Miner 1998). Campbell et al. (1998) report that CAGN's seasonally shift their habitat use from CSS to riparian and willow scrub, primarily from May to November when CSS plants are dry, dormant, and brown.

CAGN not only shifts habitat temporally, but also spatially. The distance of dispersal is still widely unknown, but a mark-resight study reported dispersal of up to 14 km (Vandergast et al. 2019). It is also known that CAGN will disperse through urban areas (Bailey & Mock 1998), and that fledglings dispersing from natal territories disperse over longer distances (Preston et al., 1998, Atwood & Bontrager 2001; Vandergast et al., 2019). Hence, regarding CAGN it is important that habitat restoration efforts focus on understanding connectivity of patches of CSS, native grassland, and proximal riparian habitat, as well as the urban/open space interface, as multiple habitat corridors facilitate species movement from one core site to other stepping-stone sites (Bowler 2000). Moreover, Vandergast et al., concluded that connectivity may help support long term persistence under current conservation and management strategies.

While the Multiple Habitat Conservation Plan (MHCP) was adopted by San Diego Association of Governments (SANDAG) in 2003, few cities have fully incorporated MHCP objectives into their comprehensive plans, and little to no progress has been made since regarding connecting wildlife corridors to specifically benefit the CAGN despite widespread support from stakeholders. Preserve Calavera seeks to better understand and evaluate constraints and impediments on successful CAGN movement through the study area. With an up-to-date evaluation in hand and in conjunction with engagement with the surrounding urban community, we believe that successfully restoring, adequately monitoring and evaluating the response of CAGN to site(s)-specific restoration efforts is critical to the conservation of this species.

The distribution and local abundance of wildlife is usually related to time and space. It is therefore important to differentiate between a wildlife corridor that is primarily designed for improving and facilitating gene flow at a metapopulation scale, and one that is primarily designed to allow greater movement of individuals within a population and among some populations. These two objectives can be overlapping and synergistic, but metapopulation gene flow on one hand, and individual movement across an urban-wildland landscape on the other, will occur at different time and geographical scales. Movement important for management include: Dispersal, Migration, and Home Range (Michael Morrison, 2009). Resources agencies (USFWS & CDFW) envisioned a steppingstone approach to link patches of native habitat to promote movement of CAGN individuals. Our analysis therefore, focuses on improving movement of individuals that occupy the urban-wildland landscape.

1.2 Project Significance

Preserve Calavera is a non-profit conservation organization whose mission is to preserve, protect and enhance the natural resources of coastal north San Diego County. As part of that mission, Preserve Calavera is committed to supporting effective regional and local wildlife movement corridors.

The MHCP is the framework for conservation for the seven cities of coastal north San Diego County, including Oceanside. The MHCP identifies areas of core habitat and connecting wildlife corridor linkages. This plan and the associated Draft Oceanside Subarea Habitat Conservation Plan (SAP) define the major north/south regional wildlife movement corridor through Oceanside. This regional corridor relies on movement across stepping-stones in the area described as the Wildlife Corridor Planning Zone (WCPZ) that connects core habitat in Carlsbad with core habitat on Camp Pendleton. Existing development at the time these plans were being prepared did not support land connections that would be needed for terrestrial species movement. Consequently, the corridor was primarily designed to support movement of the CAGN. The biological studies done to support these plans were completed over twenty years ago. Since then, substantial development has occurred, or is soon to occur, within the WCPZ.

The failure to adopt the SAP and on-going development has led to increasing concerns about the viability of a local connector within the regional movement corridor. It is expected that a separate project to review the entire corridor within the City of Oceanside will be included as part of the update of the City's General Plan currently underway.* This project is one of several related efforts intended to improve the function of the regional corridor, considering current conditions.

This project is significant for CAGN conservation as it aims to enhance habitat connectivity within the WCPZ, facilitating movement between core habitat stepping-stones. Successful implementation of this project will contribute to the long-term persistence of CAGN populations by improving our understanding of existing habitat quality and connectivity and what effect management actions could have on future quality of connectivity in the connector.

1.3 Project Overview

The CAGN Corridor Study Northern Connector 2024 is a project designed to evaluate the Northern Connector through the WCPZ in Oceanside, CA, specifically for the benefit of the CAGN. The primary objective of this work is to assess the quality of existing habitat and the connectivity of available open space in the Northern Connector of the WCPZ. The sub-objectives of this work include:

1. Evaluate the existing habitat condition for CAGN on a selection of key parcels within the study area;
2. Evaluate the impediments to successful movement between parcels within the study area of the CAGN corridor;
3. Evaluate the specific constraints to successful crossing of State Road 76 (SR-76) and Mission Avenue;
4. Provide recommendations on priority areas for habitat restoration and enhancement, conservation, public and private engagement, and other intervention strategies in the Northern Connector.

**At the time of this study, the City of Oceanside was actively engaging with the public on a comprehensive General Plan Update. Historic SAP references are included in this analysis, however, inclusion of the spatial components of the draft General Plan and concurrent draft Environmental Impact Report (DEIR) were outside of the scope of this study for integration.*

The project team outlined three tasks in our scope of work as a comprehensive approach to assessing and understanding the connectivity of the CAGN wildlife corridor in the study area.

Task One involved reviewing existing data on CAGN locations, dispersal, and movement within the WCPZ. This included analyzing municipal and county planning documents, E-bird and CNDDB datasets, and other priority existing data from relevant agencies and organizations. Resilient Transitions collaborated with the broader project team to define spatial data gaps and collect additional spatial data needed for a successful wildlife corridor evaluation in the study area. The outcome of this task was crucial for establishing a comprehensive understanding of the current state of the CAGN wildlife corridor. A fundamental part of Task One was a series of site reconnaissance by three ecologists of key parcels within the study area. The field work gathered data on current habitat conditions, plants and wildlife, as well as other key parameters that are necessary to inform the models to be developed in Tasks Two and Three.

Task Two focused on the development of a CAGN suitability model to delineate low, medium, and high existing habitat suitability within the study area. This involved developing and evaluating potential input datasets and transforming input datasets into a final suitability model through an iterative analysis process. Subsequently we evaluate high, medium, and low suitability areas for intervention options, considering different constraints and restoration opportunities.

The final task, Task Three, focused on the development of a CAGN wildlife corridor model. This involved performing a blended Optimal Corridor Connections Analysis and Least Cost Corridor Analysis using the suitability model produced in Task Two as a cost surface. The results of Task Three provided insight into how CAGN traverse the landscape of suitable and unsuitable habitat in the study area. The results of Task Three highlight strong and weak connections between stepping-stones in the corridor and offers additional insight into recommendations for corrective actions to enhance corridor connectivity.

1.4 Study Area

This study is located within the WCPZ in Oceanside, California (Figure 1). The study area described as the Northern Connector (Figure 2), is the portion of the WCPZ that extends from El Camino Real westerly to Canyon Drive, and from Mesa Drive northerly to SR-76, then to San Luis Rey River, and extending Northwesterly to the approximate terminus of Wala Drive, and Northeasterly to the intersection of San Luis Rey River Trail and Pala Drive.

We also specify an analysis extent. The geographical coverage of the analysis extent encompasses the study area; it also expands slightly South and East, and expands greatly North. The purpose of the analysis extent is twofold. First, the analysis extent allows our analyst to have uninterrupted, full coverage of the study area for all geographical processing. This is an important setting as it removes spurious calculation errors that are a common occurrence along the perimeter cells of rasters during raster-based processing in Task Two and Task Three. Second, by expanding the northern section of the analysis extent the analyst was able to evaluate CAGN habitat suitability input variable values in undeveloped open space North of Oceanside in Camp Pendleton. In many ways this region served as a reference area during intermediate processing. The analysis extent is illustrated in Figure 1 and is referenced in all figures in Section 2.3.2.

There are several key parcels and corridor crossing locations that are the foci of the scope of this study (Figure 1). In reference to Oceanside SAP Figure 3-8, the key parcels are 4, 5, 6, or alternatively APN's, 1603001200 (4), 1461621800 (5), 1605112400 (5), 1461402200 (6). The key crossing locations for SR-76 are in the vicinity of SR-76 and Canyon Drive, and in the vicinity of SR-76 and between Mission Avenue and El Camino Real. These key crossing locations were originally identified for evaluation by Preserve Calavera as viable due to the potential for line of sight by CAGN despite the development of the surrounding land and the multi-faceted barrier created by the transit corridor.

Specific attention was given to the interpretation of results for these key areas. Please see the Appendix For cross reference information for other parcels in the study area.

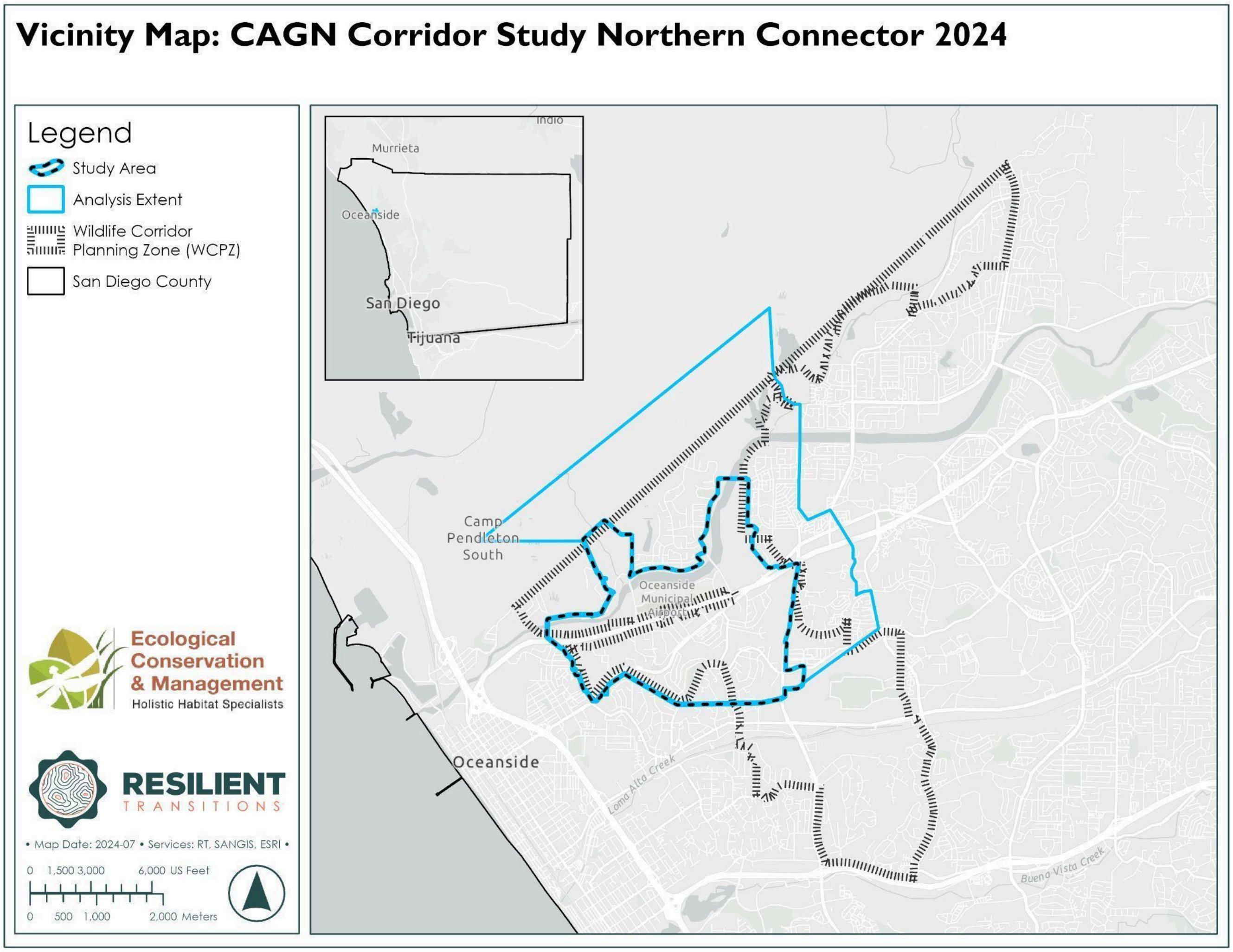


Figure 1: Vicinity map. This study is located within the Northern portion of the WCPZ. The analysis extent is a slightly larger area capturing a greater portion of open space in the Camp Pendleton area.

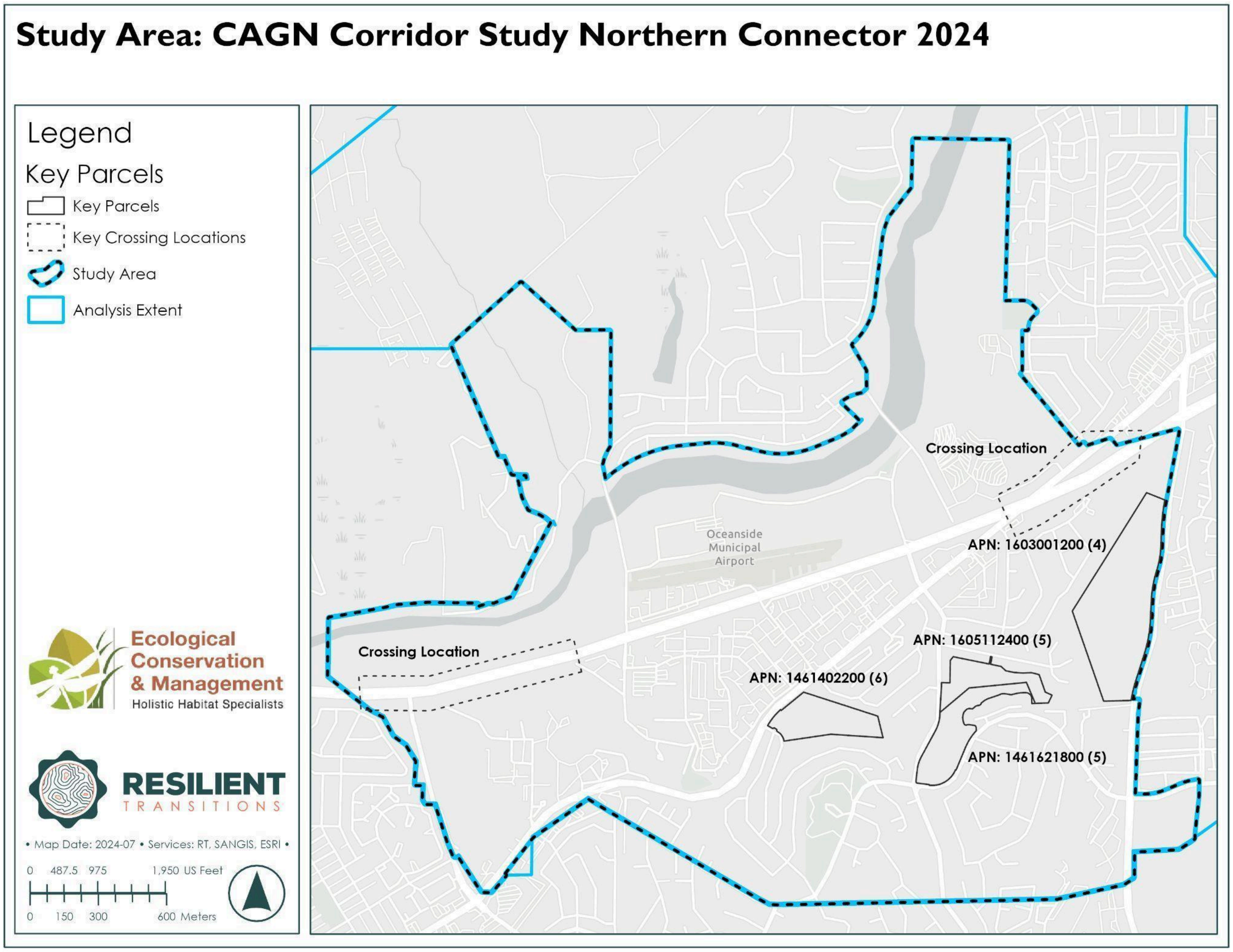


Figure 2: Study Area. Key parcels and key crossing locations that are the focus of this analysis are indicated within the study area.

2.1 Integrated Methodology and Results

We present a cohesive narrative of the methodology and results to provide transparency in the decision-making process involved in our fieldwork and in the model development for this project. The primary software for model development and evaluation was ArcGIS Pro 3.3.0 (ESRI 2024).

2.2 Field Data Collection and Review (Task One)

After completing a review of relevant literature, three ecologists conducted a site reconnaissance to gather data on current habitat conditions, plant and wildlife presence, and other key parameters. This fieldwork provided essential information to inform the habitat suitability models and corridor models.

Biologists visited parcels 4, 5 and 6 to conduct vegetation surveys using ESRI's Field Maps. The team delineated polygons of data down to the alliance level. Data included general plant communities such as Diegan Coastal Sage Scrub or Non-native Grassland, and where appropriate, noted plant species dominance such as Baccharis Dominated Diegan Coastal Sage Scrub. The nuances in plant communities are important factors when considering what is suitable habitat for CAGN breeding or foraging. Once rough polygons were outlined in Field Maps, the team used ArcGIS Pro to assign unique attributes to polygons and smooth out edges to create a seamless matrix of habitat types across parcels 4, 5 and 6. Field reconnaissance did not include ground-truthing of vegetation mapping outside of these key parcels. For more information on the integration of field data into the modeling process, see Appendix 6.1. In addition to vegetation surveying, whenever the team encountered a CAGN, the location and age/sex class of the observation was recorded in Field Maps for reference.

2.3 CAGN Habitat Suitability Model Development (Task Two)

2.3.1 CAGN Habitat Suitability Model Overview

The team developed a habitat suitability model to delineate low, medium, and high existing CAGN habitat suitability within the study area (CAGN Suitability Model). In ArcGIS Pro, the *Suitability Modeler* package is a tool that provides an interactive, exploratory environment for creating and evaluating suitability models (ESRI 2024). In practice, this tool integrates the process of reclassification, transformation, and model testing into one convenient workspace.

The CAGN Suitability Model was created through an iterative suitability analysis process. This process begins with developing high resolution input datasets, followed by reclassification of the base values of input datasets, followed by transforming input datasets to the same scale, then performing a weighted overlay to produce a suitability model, and ultimately iterating the process to develop a high

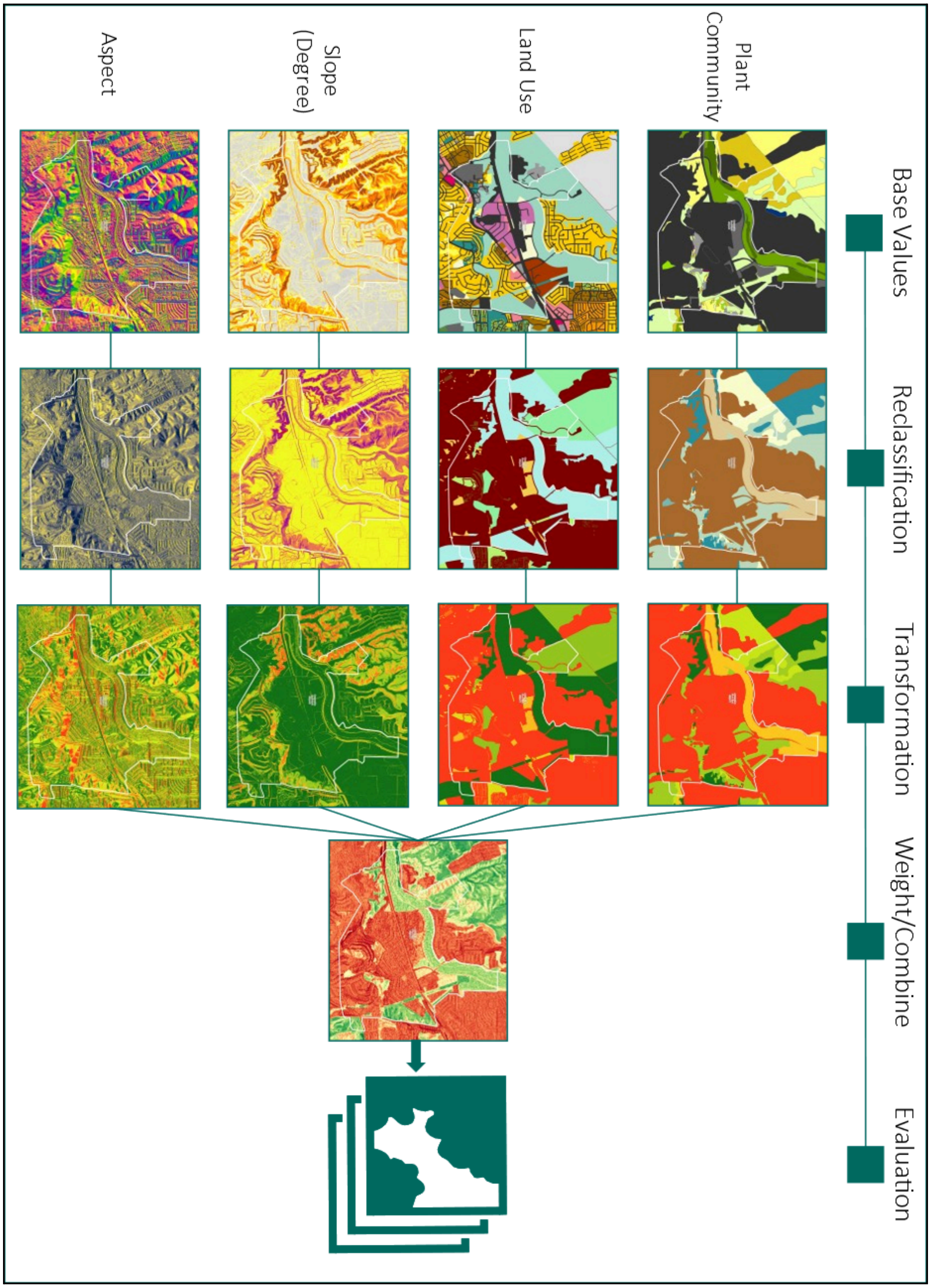


Figure 3: Suitability Modeling Process Overview

performing final model. The CAGN Suitability Model is produced on a scale of 1-10, with 1 (red) representing low suitability and 10 (green) representing high suitability. Figure 3 outlines this process. In the following sections we document the CAGN Suitability Model development process. The two sections of this process that are addressed at length are the input dataset transformation process and the iterative process of selecting the highest performing final model.

2.3.2 Input Dataset Creation, Reclassification, and Transformation

We sourced spatial input datasets from the City of Oceanside, SANGIS, CALFIRE, USGS, ESRI, PRISM climate group, and custom-built datasets based on Task One field surveys. All locally derived polygon datasets were originally projected in NAD 1983 StatePlane California VI FIPS 0406 (US Feet) and any externally derived raster datasets were projected in WGS 1984 Web Mercator (auxiliary sphere). During the reclassification phase, all raster inputs and final raster outputs were projected to a common scale in WGS 1984 Web Mercator (auxiliary sphere) with a WGS 1984 geographic coordinate system. Any feature class datasets and other input datasets were transformed into rasters at 1 m by 1 m cell sizes. The final CAGN Suitability Model was produced at a 10 m x 10 m cell size.

The initial variables and variable weights for consideration included the following:

- Plant Community Type* (25%)
- Land Use* (20%)
- Slope (Slope Degrees)* (15%)
- Aspect (Slope Direction)* (15%)
- Elevation (10%)
- Fire History (5%)
- Proximity to Water (5%)
- Climate Variable (Precipitation and Temperature) (5%)

Only those variables with an asterisk (*) were included in the final model. As a result, the base model weights for the first iteration of the CAGN Suitability Model were adjusted to:

- Plant Community Type* (30%)
- Land Use* (30%)
- Slope (Slope Degrees)* (20%)
- Aspect (Slope Direction)* (20%)

In Appendix 6.1 we provide a technical appendix to document the reclassification and transformation process. We include observational notes, maps, figures, and tables to document the reclassification and transformation process, and for the variables that were ultimately excluded from this analysis, we provide maps and tables to substantiate the decision to remove these variables from the model.

2.3.3 Suitability Model Evaluation

Model Criteria Weights Overview

The team developed a habitat suitability model to delineate low, medium, and high existing CAGN habitat suitability within the study area. Once the input variables were transformed to a common scale of 1 to 10, the iterative weighted overlay could begin. A weighted overlay analysis, also referred to as a weighted sum analysis, evaluates the analysis extent one cell at a time. For each cell, each variable is multiplied by a specified criteria weight percentage, then summed together with each of the other weighted variables. With the common scale of 1 to 10 for input variables, this style of weighted overlay produces an output suitability raster surface with a range of 1 to 10, low to high.

The final model was created through an iterative analysis process, modifying weights applied to input variables to combine separate, weighted input rasters into a final suitability model raster. We determined the highest performing model using a blend of qualitative sensitivity analysis, validation against field surveys and historic observations, and evaluation of consistency with study objectives. Our experience has shown that this cumulative process regularly requires double loop learning rather than single loop learning alone; said alternatively, this cumulative process regularly requires the team to collaborate and revisit the classification and transformation scheme for individual variables to apply modifications, rather than comparing model iterations and modifying variable weights alone.

The first step is to produce a control model with uniform variable weights, and in this study that resulted in four input variables set to an equal criteria weight of 25%. The next step is to produce a base model with informed variable weights as specified in Section 2.3.2.

In Appendix 6.2 we present a technical appendix to document the model criteria weights decision making process. In total we completed 17 iterations of the model before finalizing the highest performing model. In Appendix 6.2 we limit the presentation to an abbreviated description of the first two rounds of iterations followed by more thorough documentation and supporting figures of the final round of iterations (3_0 - 3_6). We have also included documentation for the k-means clustering algorithm that was used to inform the symbology of the final model.

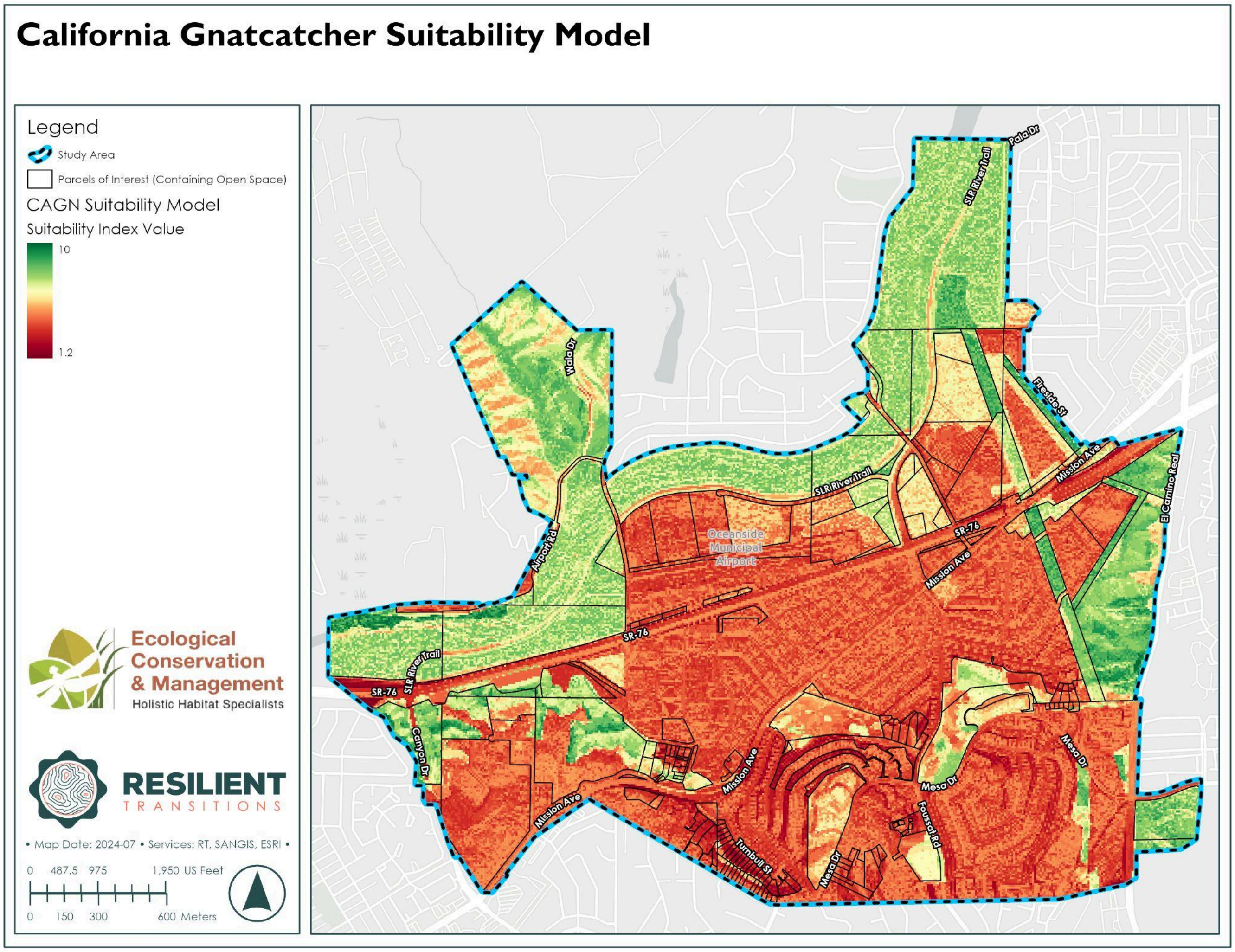


Figure 4: CAGN Suitability Model. Model represents the highest performing model and is represented using symbology based on a K-means clustering algorithm.

2.3.4 CAGN Suitability Model Results

Interpretation of Model Processing and Evaluation

Of the four variables that were included in this analysis, Plant Community Type ultimately accounted for the most weight at 30%, followed by Land Use at 27.5%, followed by Slope at 22.5%, and Aspect at 20%. The binned cell counts of the transformation values in the analysis extent demonstrate the individual composition of the four input variables, and a comparison of these individual binned values to the histogram of cell values of the final model (3_6) highlights a few takeaways. Regarding the individual composition, the Plant Community Type variable and the Land Use variable are distributed as expected, with a large portion of the study area classified as non-native, disturbed, or developed habitat. These areas are visually distinguished in the final model, and they appear in the distribution of cell values in the final model as the tall peaks of binned suitability index values between 3.2 and 4.1. Given that the analysis extent includes the San Luis Rey River, a selection of conserved lands, and several stepping-stones of remnant open space, it was also expected that these two variables would classify a sizable proportion of the landscape as high transformed value cells (values between 7-10).

A unique outcome of our results was the influence of the other two variables, Slope and Aspect, on the final suitability index scores. The histogram of cell values of the final model is overall a normal distribution rather than a bimodal distribution. Throughout the iteration process the models oscillated between normal and bimodal before returning to normal. Within the final normal distribution, there appears to be a secondary distribution about the upper first standard deviation, approximately between 6.2 and 9.0. The binned cell counts of the transformation values for Aspect between values of 6 and 10 (meaning between East-South-West facing slopes) contributed strongly to this secondary distribution. If we key in on the parcels containing open space, we see that the final combination of variable weights satisfactorily highlighted the aspects preferred by CAGN while muting the portions of those parcels with steep slopes. Yet, across the entire study area our model inadvertently highlights how urbanization of a landscape with historically variable terrain creates a landscape with fixed slopes and preferred aspects. Generally, these slopes and aspects are the road grades, residential and commercial development pads, and preferred residential home orientations that make up the Oceanside community in our study area. The outcome of placing weights >20% on these two variables in our final model inadvertently contributed to developed areas scoring closer to 3.0 to 5.0, rather than 1.0 to 3.0. This is one of the reasons why a K-means clustering algorithm approach was used to represent the final CAGN Habitat Suitability symbology, though we acknowledge it does introduce some visual bias.

Our expectation was to include 8 or 9 different input variables into our CAGN Suitability Model, yet our final model included only four input variables. After review, it was determined that the remaining variables demonstrated little to no variation across the study area and would have had negligible, if not detrimental effects to the final suitability model. These variables with no variation would have reduced model performance by introducing noise rather than allowing the model to evaluate the underlying relationships of or between the included variables. In future expanded work in the WCPZ it would be beneficial to introduce the variables described in 2.3.2 to capture more variation in the biotic and abiotic conditions that would influence CAGN habitat preference.

Utilization of CAGN Suitability Model Results

The final CAGN Suitability Model was utilized in multiple ways. First, locations with high and medium high suitability values were used to confirm and identify parcels with CAGN habitat. These areas are starting points for intervention where habitat restoration could expand upon the foundation of existing habitat. These parcels were differentiated from those medium and low suitability parcels where alternative intervention strategies may be more promising due to constraints and risks. These parcel-specific findings and recommendations are explored in greater detail in Section 3.0.

Second, the CAGN Suitability Model was directly utilized in Task Three to develop and evaluate the CAGN Northern Connector optimal corridor connections. How the suitability model was repurposed for Task Three is explained in greater detail in Section 2.4.

2.4 CAGN Optimal Corridor Connections Model Development (Task Three)

The team developed a CAGN wildlife corridor model to explore the current conditions of connectivity within the study area of the Northern Connector (CAGN Optimal Corridor Northern Connector or CAGN Optimal Corridor) and to develop recommendations for corrective actions to enhance corridor connectivity. In ArcGIS Pro, the *Optimal Corridor Connections Analysis* tool and the *Least Cost Corridor* tool are two tools that provide deeper understanding of the strength and weakness of connectivity between multiple locations (ESRI 2024). In practice, the blend of these two tools allows researchers to conceptualize the preferred use of the landscape by wildlife, visualize the presence of bottlenecks, and develop inferences on how stepping-stones compose a wildlife corridor.

In theory, these cost distance analysis tools allow a user to input a cost distance raster surface and a direction raster surface and compute the least-cost pathway from one location to another location. Rather than using a simple Euclidean distance calculation (straight-line distance) to predict wildlife movement through cells of a raster from one location to another location, a user can develop a cost distance raster that applies a cost to move through each cell. Then, the accumulative cost between the locations can be used to identify the optimal path. Historically, the legacy tool, *Least Cost Path*, was capable of producing an output of a narrow polyline or one-cell wide path between two locations of interest. By blending *Optimal Corridor Connections Analysis* tool and the new *Least Cost Corridor* tool, we were able to identify both the optimal travel pathway for a gnatcatcher through the different parts of the Northern connector but expand our inference to visualize how the gnatcatcher corridor width varies as the rate the actual accumulated cost vary (ESRI 2024). It is important to keep in mind that the word Optimal in the context of the results of this analysis refers to the optimal travel route and in some instances the concentration of multiple modeled routes, not as an attribute distinguishing the degree of viability of modeled corridors connections.

In Task Three, we leveraged the final CAGN Suitability Model to serve as the input cost distance raster for our analysis. First, we inverted the CAGN Suitability Model, thereby converting the scale of 1 (low suitability) to 10 (high suitability) to indicate 10 (highest cost to traversal) to 1 (least cost to traversal). This enabled the model to identify the least cost pathways through the Northern Connector. Second, we selected multiple locations on the periphery of the study area to serve as our source and destination locations. This enabled the model to simulate CAGN dispersal through the Northern Connector. To produce a resulting corridor that is more informative than a fixed-width buffer around the optimal path, our analyst explored thresholds between 1%-10%. Ultimately, we applied a percent cost threshold of 3% (or 97th percentile) to produce the CAGN Optimal Corridor Northern Connector.

We present the CAGN Optimal Corridor Northern Connector for visual interpretation and provide an interpretive description to explore our results and provide context. We also present location specific inferences identified by the optimal corridor in the key findings of Section 3.1, 3.2, and 3.3.

2.5 Interpretive Description of the CAGN Optimal Corridor Results

The CAGN Optimal Corridor illustrates the present-day visual interpretation of gnatcatcher habitat connectivity within the Northern Connector (Figure 5). Overall, between the Northeast, Southeast, Southwest, and Northwest regions of the study area there are four corridors, with 5 primary linkages and a few secondary linkages. The primary linkages are discernable as the dark blue arteries illustrating optimal or core pathways within the corridor. The handful of secondary linkages can be seen as light blue-green or faint yellow accessory connections that either appear as part of the swath of a primary corridor or as distinct, separate, minor linkages. We explore each of these individually in greater detail.

Beginning in the Northeast and described clockwise, the CAGN Optimal Corridor has a wide corridor trunk within APN 1580103100 (The topmost parcel in the Northeast). The trunk flows South along the East side of San Luis Rey River to the patch of Non-native Grassland on the southern edge of the parcel. At this point the corridor diverges, and moving Southeast, the corridor continues along the utility corridor before splitting into two separate primary linkages South of Mission Basin Groundwater Purification Facility. The main branch of the model continues along the central utility corridor (North-South Central Utility Corridor), and the second branch moves East then Southeast tracing another utility corridor parallel to Fireside Street along the edge of the residential development (North-South Eastern Utility Corridor). We designate the central branch from the second branch due to the larger width of the central utility corridor. The wider width of this utility corridor produces a wider overall branch. In modeling terms this equates to dozens of single-cells-wide optimal pathways of similar, low costs to traversal spread across the main branch whereas the second branch has a narrower, denser overlap of single-cell wide pathway options. Both branches experience a bottleneck at SR-76, although the North-South Central Utility Corridor branch remains wider and the secondary North-South Eastern Utility Corridor branch fractures into several alternative optimal paths with overall higher accumulated costs to traversal (See Section 3.2 for more details about SR-76 Crossing Locations).

The utility corridor branches reconnect within parcel APN 1603001200, highlighting the value added to the overall corridor of this large, open space parcel. The North-South Eastern Utility Corridor branch navigates through portions of the CAGN Suitability Model associated with high to medium-high suitability plant communities, with some avoidance of low suitability plant communities and areas with steep slopes that would increase the cost to traversal. The large area in this parcel identified with multiple optimal corridor value pathways is associated with existing DCSS in parcel 1603001200.

The East-West corridor from El Camino Real to Canyon Drive shows the greatest challenge to CAGN connectivity (East-West Mission Ave Corridor). This can be seen by the narrow width of the optimal pathways, the braid of optimal pathways within parcels containing open space, and by the spread of sub-optimal secondary linkages attempting to seek alternative low-cost paths across this network of open space stepping stones. From a modeling perspective this indicates convergence of least cost pathways to a specific, limited subset of movement options. The secondary linkages that are present in the East-West Mission Ave Corridor demonstrate an attempt to balance cost to traversal with distance

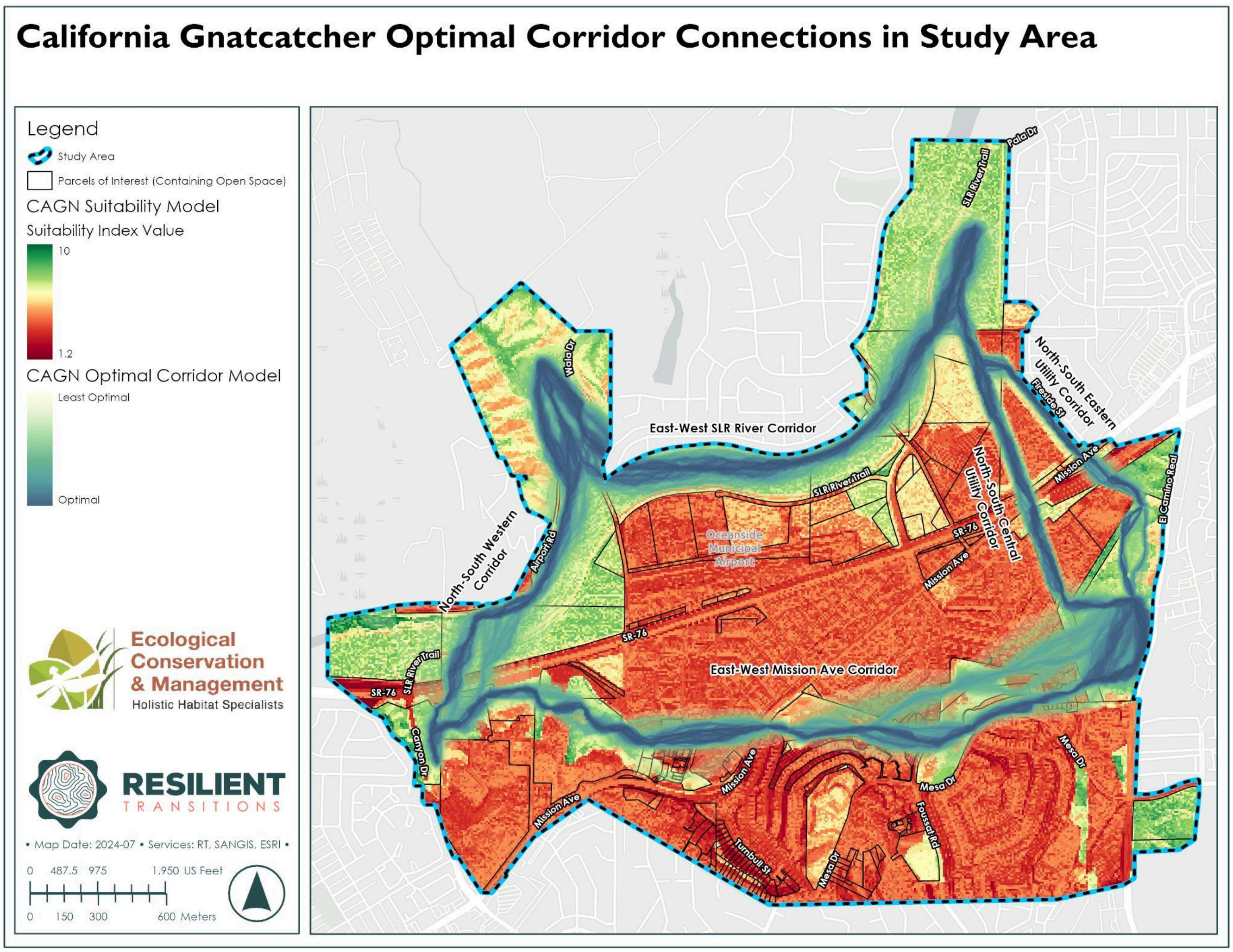


Figure 5: Overlay of CAGN Suitability Model and CAGN Optimal Corridor in the Northern Connector of the WCPZ.

to traversal. From a wildlife management perspective, this highlights a repeating sequence of tight bottlenecking of the corridor through the residential neighborhoods followed by spread into open space parcels that serve as stepping stones. In the East-West Mission Ave Corridor movement of CAGN through residential neighborhoods may occur but will be limited by the line of sight during traversal and by the presence of suitable habitat capable of supporting CAGN movement.

Near SR-76 and Canyon Drive the East-West Mission Ave Corridor bottlenecks before crossing SR-76. This convergence is mostly associated with low suitability, steep slopes and less suitable aspects. The primary linkage is seen crossing SR-76, but a secondary linkage is also seen running parallel to the primary linkage (North-South Western Corridor) (See Section 3.2 for more details about SR-76 Crossing Locations).

The primary linkage of the North-South Western Corridor, moving North across SR-76 and then Northeast, shows favoritism in the model for a path which traverses through the thin line of Diegan Coastal Sage Scrub and Southern Riparian Woodland along the North side of San Luis Rey River corridor rather than the Southern Arroyo Willow Riparian Forest. This trend continues North paralleling Airport Road. Here, the spread of the North-South Western Corridor linkage blends with the spread of the East-West SLR River Corridor linkage. This spread aligns with the medium-high to high suitability scoring region characterized by gentle slopes, Diegan Coastal Sage Scrub and Non-native Grassland plant communities, and areas with south facing aspects. This spread also can be seen avoiding the regions with higher cost to traversal located on the West side of the valley that contain steep slopes and low suitability aspects as well as regions on the East side of the valley that contain low suitability residential development.

Last, the East-West SLR River Corridor primary linkage of the model traces the San Luis Rey River corridor; The optimal pathways in this linkage braid widely before tapering as the river turns North. The braiding is associated with multiple, individual least cost pathways attempting various options to reach the East-West strip of Southern Riparian Woodland on the North side of the river and then tapering into a dense, narrow band of overlapping optimal paths where the North bank of the river has produced a embankment of South-facing slopes. In the last North-South stretch the East-West SLR River Corridor recrosses San Luis Rey River in an attempt to reach the plot of Nonnative Grassland in parcel 1580103100.

3.1 Evaluation of CAGN Movement within the Northern Connector

The CAGN Optimal Corridor is a representation of CAGN habitat connectivity within the Northern Connector. This wildlife corridor model clearly illustrates the value that parcels containing open space provide to wildlife as much as it illustrates the establishment of stepping stones and the impediments to movement that are concomitantly caused by urban development design.

A unique output of this model is the braiding of alternative optimal pathways within parcels containing open space. In Parcel 1580103100 and 1603001200, the braiding of alternative paths showcases the preferential movement between cells with high to medium high suitability scores and the relative conduction of travel paths through certain areas. This was the desired outcome of building a corridor model which is capable of producing hundreds of alternative travel paths rather than a model which is only capable of producing a single polyline value or least cost path. This model illustrates that not all open space is equal in terms of its contribution to CAGN habitat. Avoidance of steep slopes and preferences for specific plant communities are highlighted by the braiding of the model.

The two North-South Eastern Utility Corridors are great examples that demonstrate the need and effect of using the 97th percentile of the optimal corridor connections output. In these areas we see that this limit correctly restricts the model. Here, the model limit processes out pathways through mostly unsuitable cells that would misrepresent the caliber and quality of the present day corridor. In these same areas the use of the 97th percentile limit also created the possibility to see where small-scale narrow choke points are present. The knowledge gained from the comparison of the total width of the corridor against the small-scale bottlenecks at the SR-76 crossings is invaluable for comparing intervention alternatives to improve the success of CAGN dispersal through the Northern Connector.

A second unique output of this model is the presence of secondary linkages. The secondary linkages appear in both North-South corridors as well as the East-West Mission Ave Corridor through the residential communities on the South side of SR-76. Each of the secondary linkages run parallel to primary linkages. In certain instances, such as the wide crossing area over SR-76 West of Canyon Drive, we are likely viewing a single, wide corridor crossing area. In other instances, such as the primary linkage and secondary linkages between parcels 1603001200, 1605112400, 1461402200, we interpret that the model is demonstrating a portion of the corridor where a core pathway is moving through mostly suitable CAGN habitat areas, and several alternative, shorter pathways through a mixture of suitable and sometimes unsuitable habitat areas. The key difference here is in the length of the pathways. The core pathways are often the *least cost* pathways because even though the geographic length of the pathway may be long, the accumulated cost-per-cell of traversing through high suitability cells is a low total cost. The alternative pathways are often the *geographically shorter* pathway, and in these instances the accumulated cost-per-cell of traversing through low suitability cells would be expected to lead to a high total cost, but the quantity of cells traversed is lower, resulting in low total cost. We present an alternative perspective of the CAGN Optimal Corridor in Figure 6 overlaid over imagery and with no transparency to demonstrate the full width of the 97th percentile of data.

Figure 6: Artistic interpretation of the CAGN Optimal Corridor with no transparency. This variant of the model illustrates how secondary linkages potentially create a framework for gnatcatcher movement through regions of the study with reduced suitability.

3.2 Evaluation of Constraints to Crossing SR-76 and other Transit Corridors

The CAGN Optimal Corridor model clearly illustrates three locations with the greatest likelihood for CAGN to successfully cross SR-76. Our scope of work assumed two crossing locations, one in the vicinity of SR-76 and Canyon Drive, and one in the vicinity of SR-76 and between Mission Avenue and El Camino Real. The three crossing locations identified in the CAGN Optimal Corridor model align with this assumption, but specifically highlight SR-76 crossing locations: (1) The North-South Eastern Utility Corridor. From the intersection of Ocean Pointe Road and Mission Avenue extending East 50 meters (165 feet), (2) The North-South Central Utility Corridor. From the intersection of Mission Ave extending East 70 meters (230 feet) from the East bound Mission Avenue and Frontier Drive Bus Stop (ID: 22558), and (3) The North-South Western Corridor. From Canyon Drive extending East 320 meters (1,050 feet).

In this section we present three ‘bird-eye’ perspective renderings of the CAGN Optimal Corridor to provide an immersive vantage point and to help readers feel as if they are physically present within the scene as we explore these crossing locations (Figure 7, 8, 9).

On the East side of the study area, our modeling identified SR-76 and Mission Avenue as the crossing location with the largest modeled corridor width. However, there are multiple real world logistical challenges for gnatcatchers at this crossing location. First and foremost, over the last ~20 years the City of Oceanside has a history of an active project slated for development on the North side of SR-76 and on both sides of the North-South Central Utility Corridor.. This development will eventually have considerable deleterious impacts to the long-term viable use of this corridor by gnatcatchers, though some efforts have been documented to mitigate this impact (Mock and Spencer 2007). The second complication is the presence of other underground utilities in this utility corridor, specifically gas and water lines, which will influence the long-term management of vegetation along the corridor. The third complication is the overpass of SR-76 over Mission Avenue. Our modeling effort was informed by available GIS resources at the time of analysis, but the multi-dimensional reality of this crossing location is a conflict between the positive available line of sight from one side of SR-76 to the other side, and the negative influence of a two level, 60 meter (197 feet) wide transit corridor on CAGN movement. The uncertain future of the quality of habitat present on the North side of SR-76 and the probability of successful, routine use limits the potential of this section of the corridor. It is uncertain whether over time CAGN will be able to traverse this corridor.

The secondary corridor linkage at the intersection of Ocean Pointe Road and Mission Avenue extending East is a promising crossing location of SR-76. There are three bottlenecks present along the North-South Eastern Utility Corridor. The first is the junction on the South side of Mission Basin Groundwater Purification Facility. The CAGN Suitability Model highlights the distinct patches of low, medium, and high suitability habitat distributed around this junction. The second bottleneck is between the utility corridor along the backside of the residential homes along Fireside Street and the intersection of Mission Avenue. Here the linear strips of low, medium, and high suitability habitat funnel the corridor through a 50 meter (165 feet) wide strip of suitable habitat. The third bottleneck is at the complex transit corridor containing Mission Avenue and SR-76. Compared to the other utility corridor, this junction of Mission Avenue and SR-76 has no overpass. Instead, as seen in the ‘birds-eye’ visuals, SR-76 is raised, with the North-facing slopes lined with Eucalyptus and other mixed non-native ground cover, and the South-facing slopes lined with non-native grassland. The transit corridor where Mission Avenue and SR-76 run parallel is classified in our model with some of the lowest suitability index scores due to the presence of low suitability vegetation and transit land uses. Throughout this secondary linkage the presence of non-native vegetation is expected to impose a large negative influence on the ability of the corridor to support CAGN movement. The bottleneck effect of this intersection is of concern, however vegetation management throughout this linkage could greatly improve the functionality of the corridor for gnatcatchers. For example, the current linkage is constrained to a 50 meter (165 feet) wide strip. Although the models indicate this as suitable habitat, it is likely far from suitable. Collaboration with the managers of this utility corridor and community engagement with the residents along Fireside Street could theoretically improve CAGN habitat along this corridor, expanding the width to potentially 150 meters (495 feet). Similar conclusions were reached in the study of the Pavillion project (Mock and Spencer 2007).

On the West side of the study area, our modeling attributed the area from Canyon Drive extending East as the crossing location with the largest modeled corridor width. The North-South Western Corridor in this location has a large spread, with both a primary corridor linkage and a secondary linkage visible. The corridor spans the width of the gap between the Oceanbreeze Village Townhomes and Condos and SR-76 and two distinct roadside embankments. These two roadside embankments are characterized by North facing steep slopes greater than 30 degrees. As a result, the CAGN Suitability model attributed the roadside embankments with low suitability scores. This created a funneling effect in the CAGN Optimal Corridor model, wherein the model attempted to remain in Diegan Coastal Sage Scrub habitat while avoiding steep slopes and the residential development at the top of the bluffs. In this intersection, the corridor stems from the East-West Mission Ave Corridor between the Rosicrucian Fellowship and SR-76. Once at SR-76, there is good line of sight across the highway to the East-West SLR River corridor. While the model highlights preference for the crossing location at the primary linkage closer to Canyon Drive this entire span is likely one large corridor crossing location. It is expected that intervention in the form of vegetation management on both sides of the highway could improve the functionality of the corridor for gnatcatchers.

In comparing the North-South corridor crossing locations across SR-76 on the West side and the East side of the study area, our results indicate that the corridor on the East side along El Camino Real (the North-South Eastern Utility Corridor) would be the only viable regional corridor from the Northern Connector southward. The presence of development radiating outward from the intersection of Canyon Drive and Mission Drive has reduced the availability of open space further South on the West side of the study area. Nevertheless, the presence of protected open space North of San Luis Rey River, the presence of the river corridor, the presence of green utility corridors, and the presence of public and private stepping-stones within the residential communities are promising of the viability of circular movement of California gnatcatchers in the Northern connector and beyond.

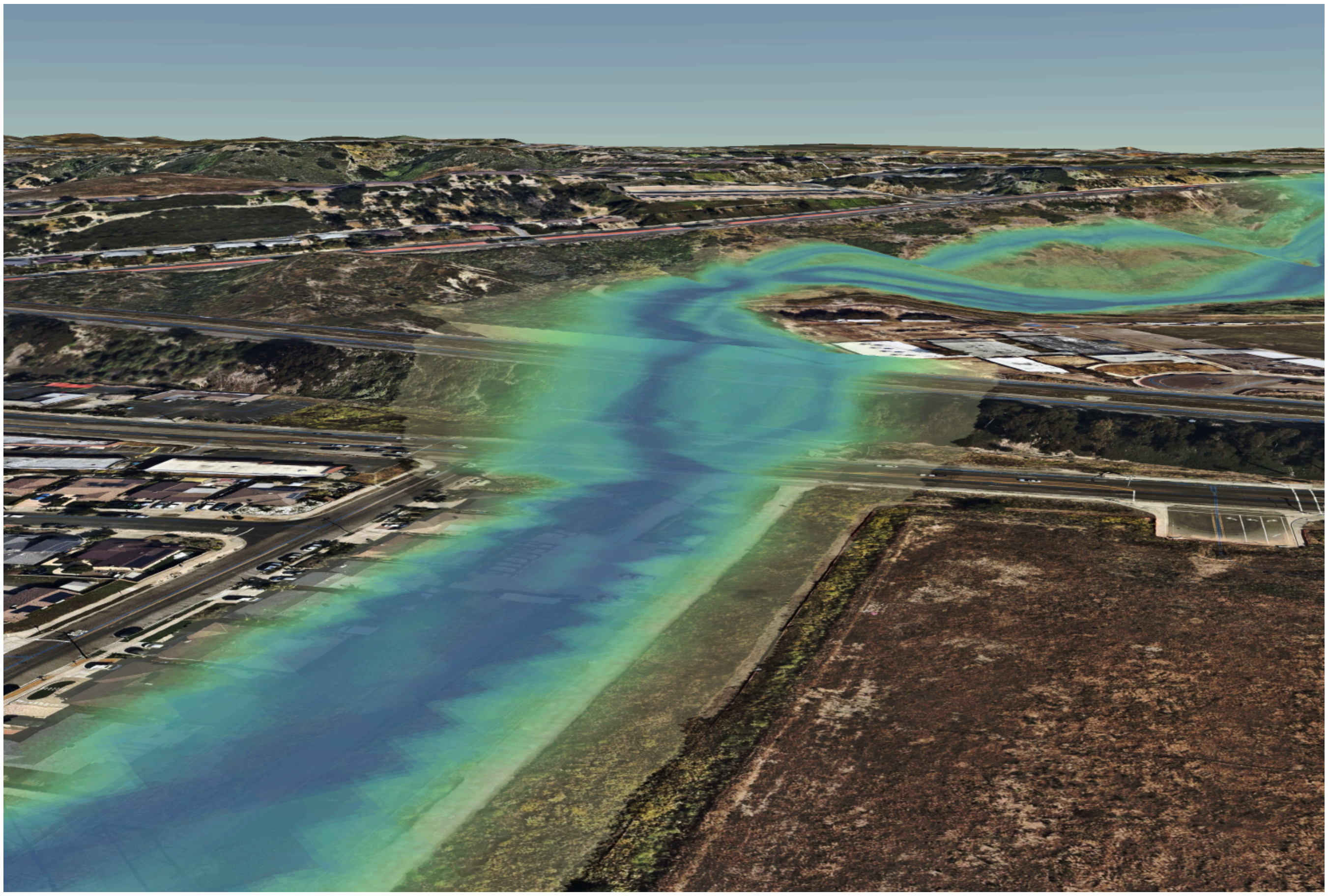


Figure 7: CAGN Optimal Corridor Crossing location. (1) The North-South Eastern Utility Corridor. From the intersection of Ocean Pointe Road and Mission Avenue extending East 50 meters (165 feet). This ‘bird-eye’ perspective rendering is from a North to South vantage point.

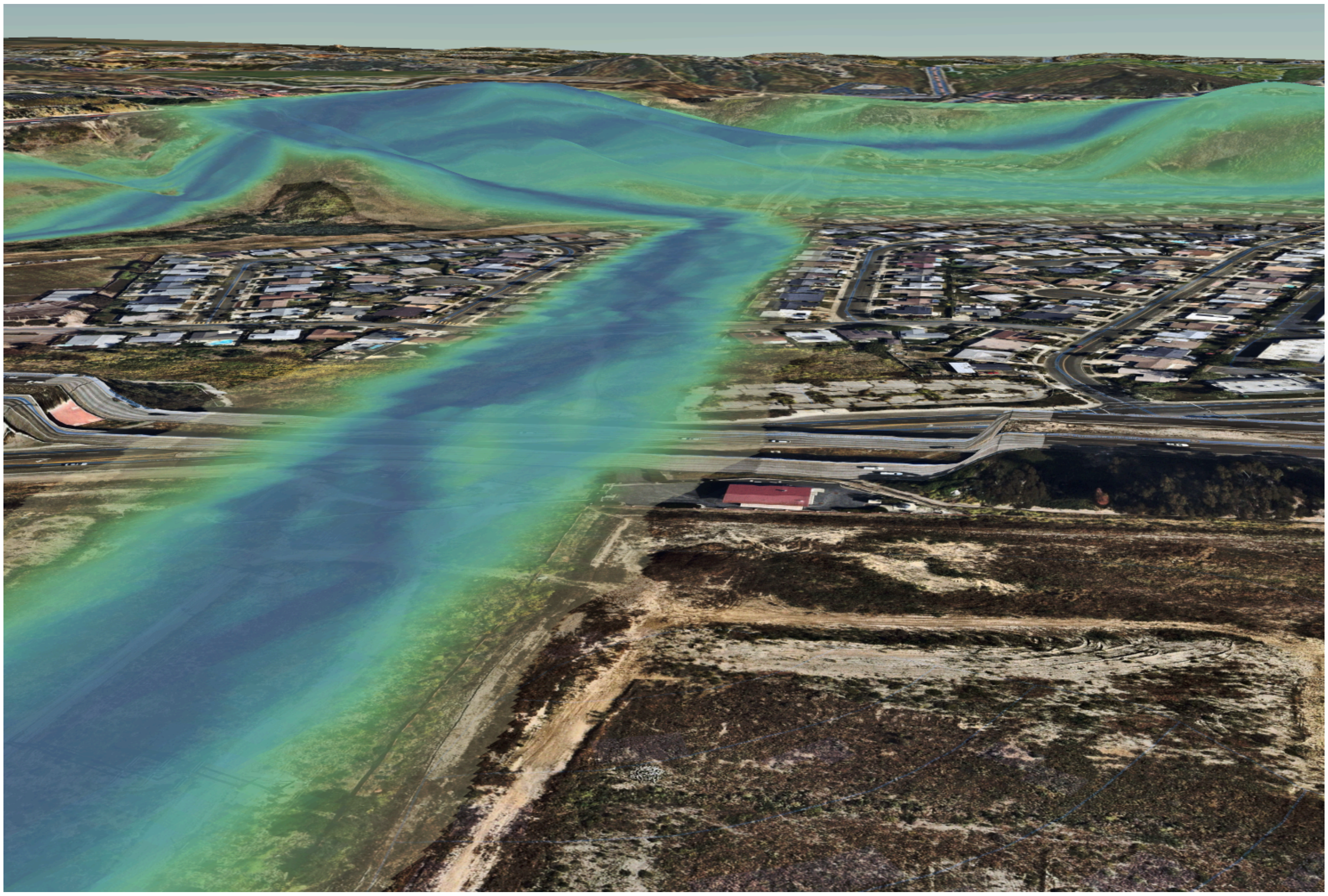


Figure 8: CAGN Optimal Corridor Crossing location. (2) The North-South Central Utility Corridor. The intersection of Mission Ave extending East 70 meters (230 feet) from the East bound Mission Avenue and Frontier Drive Bus Stop (ID: 22558). This ‘bird-eye’ perspective rendering is from a North to South vantage point. In reality, SR-76 continues as an overpass over Mission Avenue.

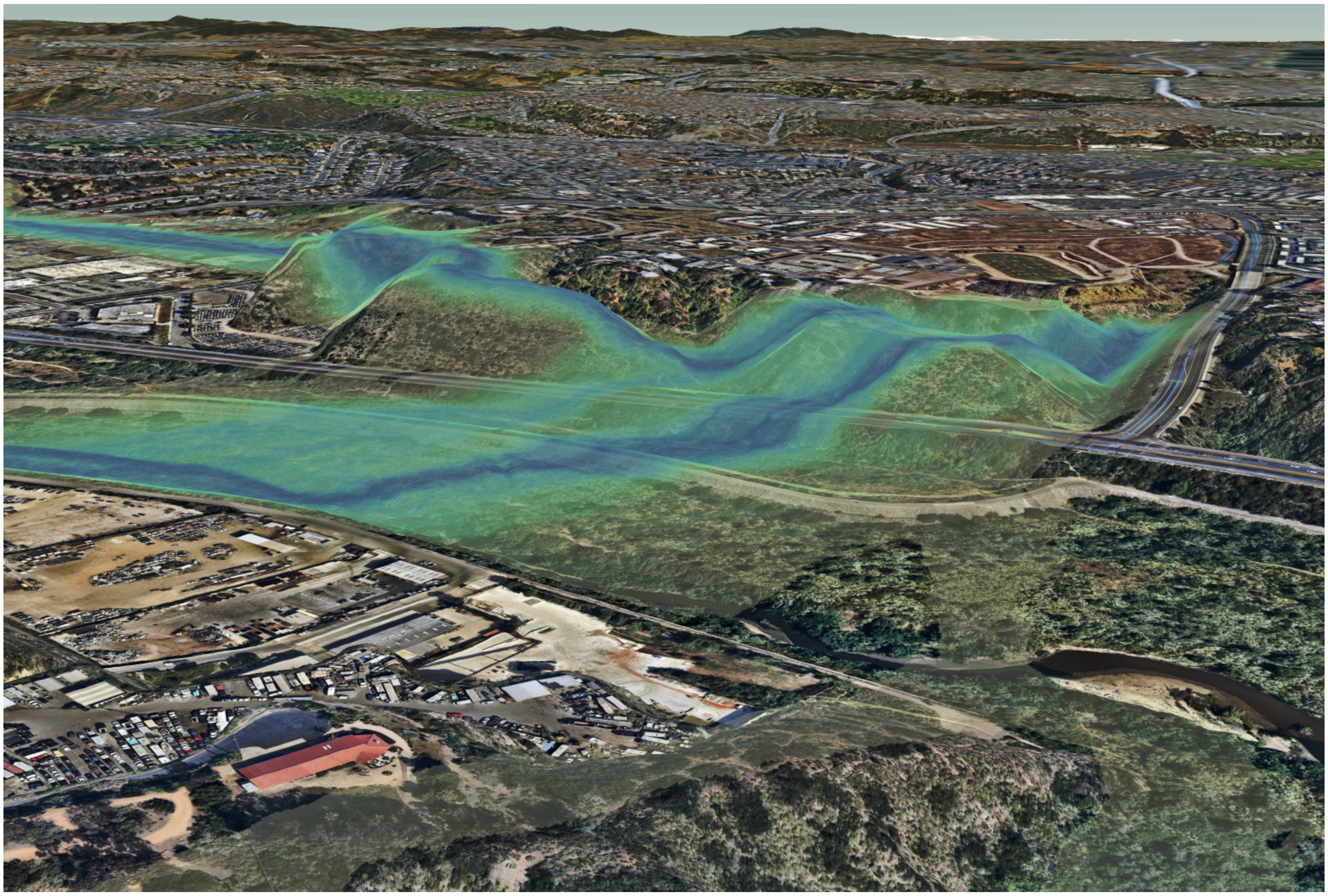


Figure 9: CAGN Optimal Corridor Crossing location. (3) The North-South Western Utility Corridor. From Canyon Drive extending East 320 meters (1,050 feet). This 'bird-eye' perspective rendering is from a Northwest to Southeast vantage point.

3.3 Evaluation of Key Parcels in Study Area

Our scope of work included an evaluation of existing habitat conditions and an exploration of restoration potential on a selection of key parcels within the study area, specifically 1603001200 (4), 1461621800 (5), 1605112400 (5), 1461402200 (6). For each of the key parcels we performed site surveys, evaluated the current plant communities present on site, reviewed the suitability model results for the site, identified and removed any areas that would be inaccessible or otherwise unavailable for restoration, and developed a restoration plan for the remaining area, if applicable. Table 1 summarizes this evaluation and the prioritization of restoration in the study area. This approach allowed us to quantify per parcel the Existing DCSS, the Existing + Restored DCSS potential, and illustrate what the future plant community conditions would look like in a restored state.

As expected, the CAGN Suitability Model identified the greatest quantity of existing CAGN habitat on parcel 1603001200 (Area 4). The CAGN Optimal Corridor illustrates how this parcel serves as a hub in the Northern Connector, providing breeding, foraging, and dispersal habitat and is the highest priority in the study area for restoration or enhancement.

Priority Areas for CAGN Habitat Restoration or Enhancement							
APN	Revised Priority	Table 3-4 Reference Priority	Existing DCSS (Acres)	Existing + Restored DCSS[1,2] (Acres)	Other Vegetation Present[1,2] (Type: Acres)	Ownership	Estimated Total Restoration Cost
1603001200	1	4	20.76	31.24	DCSS-B: 5.44 NNG: 3.58 SRW: 0.20 NNV: 6.90 EUC: 0.16	Public	Approx. 10 acres $500,000[3]
1461621800	2	5	0.61	12.54	NG: 0.09 DCSS-B: 0.81 NNG: 8.48 NNV: 3.45	Private	Approx. 2 acres $150,000 to $200,000[4]
1605112400	**3**	**5**	1.64	7.24	NG: 0.50 DCSS-B: 0.34 NNG: 3.61 NNV: 1.99 EUC: 1.28	**Private**	**No restoration effort is recommended. Maintain as open space.**
1461402200	**4**	**6**	**1.27**	**13.91**	**NG: 0.12 DCSS-B: 0.52 NNG: 0.04 NNV: 12.6 EUC: 0.56**	**Private**	**No restoration effort is recommended. Maintain as open space.**

[1] DCSS = Diegan Coastal Sage Scrub, DCSS-B: Diegan Coastal Sage Scrub Baccharis-dominated, NG: Native Grassland, NNG: Non-native Grassland, NNV: Non-native Vegetation, SRW: Southern Riparian Woodland, EUC: Eucalyptus Woodland.

[2] These sites contain steep slopes and other inaccessible areas. The acreage estimates included in the Existing + Restored DCSS category and the Other Vegetation Present category have been reduced to describe the acreage available for habitat management.

[3] This estimated cost includes implementation and three to five years of maintenance and monitoring. It assumes the restoration of nesting and foraging habitat for the CAGN.

[4] This estimated cost includes implementation and three to five years of maintenance and monitoring. It assumes the restoration of CAGN foraging and dispersal habitat.

Table 1: Priority Areas for CAGN Habitat Restoration or Enhancement

3.3.1 Evaluation of Area 4 - Vista Del Valle (Parcel 1603001200)

As expected from existing information including occupancy by CAGN onsite, the CAGN Suitability Model identified the greatest quantity of existing habitat on parcel 1603001200 (aka Parcel 4). Below we include the detailed vegetation mapping effort conducted by ECM. The Diegan Coastal Sage Scrub habitat present onsite occurs on the West-Norwest facing, gentle slope of the site in association with Native Grassland. Approximately, 10 acres of nonnative vegetation and nonnative grassland also occur onsite. These 10 acres make up the most valuable area for CAGN habitat including additional nesting and foraging habitat. Access, an important determinant on restoration overall costs, is good with a trail on the lower-west side of the site along the power lines, which can be used by trucks and other small equipment, such as ATV and a small trailer to haul container plants and tools, as well as a small bobcat for digging planting holes. Water connection could potentially be found at the nearby Pablo Tac School of the Arts elementary school. Additionally, nearby hydrants could be used as a temporary water connection.

Because of the likely large nonnative seedbank, it is recommended that all habitat restoration is done with container plantings. This allows for a more effective weed control either with mechanical or chemical methods. It is also recommended that both, pre- and post-emergent herbicides are used for weed control. A drip irrigation system should be used to provide supplemental watering if rainfall is not sufficient during the first two years of growth. A drip system minimizes watering of weeds, conserves water, and promotes the development of a deep root system, which will result in higher survival of containers, faster rate of growth, and bigger and stronger plants. The best, long-term strategy for weed control is to “shade out” them by creating a close canopy of native shrubs in the shortest amount of time. With proper maintenance, monitoring and adaptive management, it is possible to attain 100% native plant canopy in three-to-four years.

The species palette should include those that are known to grow well from container planting conditions and that are the primary species for nesting and foraging habitat of the CAGN. These species would include California sage (*Artemisia californica*), California buckwheat (*Eriogonum fasciculatum*), California coast sunflower (*Encelia californica*), bush monkey flower (*Diplacus aurantiacus*), and Blue elderberry (*Sambucus mexicanus*). Because of the high cover of nonnative species within the polygons identified for restoration, it is recommended a high plant density: between 600 to 800 plants per acre. Depending on slope and access, it is also recommended that planting holes be excavated with a small bulldozer equipped with a 9–12-inch auger. Using this method, plants will be able to grow deeper and larger root systems in less time. In addition, using drip irrigation will increase water percolation in auger-excavated holes. A four-to-six-inch mulch layer should be applied in the basins of each container for better moisture retention, be it from rainfall or supplemental watering. A thick mulch layer will also help with weed control by suppressing weeds germination and providing a buffer when herbicide is applied around each container.

In general, no native plant seeds should be used in restoration efforts where the land has been under anthropogenic disturbances and has a large nonnative seedbank. Using seeds as a means to restore a disturbed area is very costly, has low probability of success, and will take many more years to reach the desired objectives.

While Area A may not support additional breeding pairs, the restoration of these 10 acres will provide significantly more resources for existing pairs and individuals as well as improving their fitness. It is therefore recommended that CAGN surveys are conducted before a final restoration plan is developed to determine baseline conditions. These surveys should be conducted post restoration to assess the response of CAGN and other selected wildlife to restoration efforts.

Vista Del Valle was known to host several rare and sensitive plant species. Therefore, Preserve Calavera commissioned ECM to conduct a comprehensive rare plant survey this spring in part to assist in determining potential future coastal sage scrub restoration on the parcel. This botanical survey was led by Fred M. Roberts who was assisted by ECM's ecologists Stevie Steele and Tito A. Marchant. A separate report will be submitted with detailed recommendations for the conservation and restoration of these unique habitats. Because of the significance of our findings, we include our preliminary assessment below.

The Vista Del Valle parcel includes about 65 acres of natural open space. The status of rare plants on the parcel appears to have been relatively unexplored prior to examination by the San Diego Inspect and Manage Group (IMG) in 2018. The IMG group focused on specific federally listed species, namely San Diego ambrosia (*Ambrosia pumila*) and thread-leaved brodiaea (*Brodiaea filifolia*).

The southern two-thirds of the site have several rare plant species, largely due to the presence of heavy clay soils. This section is dominated by a mosaic of coastal sage scrub, non-native annual grassland, relatively extensive and intact perennial native grassland, and scattered eroded clay-soil exposures. The northern third of the parcel appears to consist of more loamy soils and is dominated by dense non-native annual grassland and mustard. Rare plant species, with the possible exception of thread-leaved brodiaea, are not anticipated to occur in the north but ongoing surveys may prove otherwise (thread-leaved brodiaea has just reached its most detectable full flowering condition).

A total of nine rare plants represented by 44 rare plant features (either point features or extended polygons) have thus far been found. The rare plants includes the federally listed endangered San Diego ambrosia [13 sites recorded], the federally listed thread-leaved brodiaea [2 locations], the California Rare Plant Rank 1B plant, Blochman's dudleya (*Dudleya blochmaniae* subsp. *blochmaniae*)[5 locations], the California Rare Plant Rank 2B plant, chaparral ragwort (*Senecio aphanactis*)[3 locations], the California Rare Plant Rank 4 plants western dichondra (*Dichondra occidentalis*) [2 locations], Palmer's grappling hook (*Harpagonella palmeri*) [13 locations], California boxthorn (*Lycium californicum*)[1 site], and small-flowered microseris (*Microseris douglasii* subsp. *platycarpha*) [4 locations], and the California Rare Plant Rank 3 plant, vernal barley (*Hordeum intercedens*)[1 site].

Especially noteworthy among these is Blochman's dudleya, which is quite scarce south of Camp Pendleton in San Diego County and primarily known about Carlsbad and Oceanside with historic locations south to the border. Chaparral ragwort is extremely rare in Southern California overall, with only four collections between Los Angeles, Orange, and San Diego Counties over the last 25 years (all four were in San Diego County).

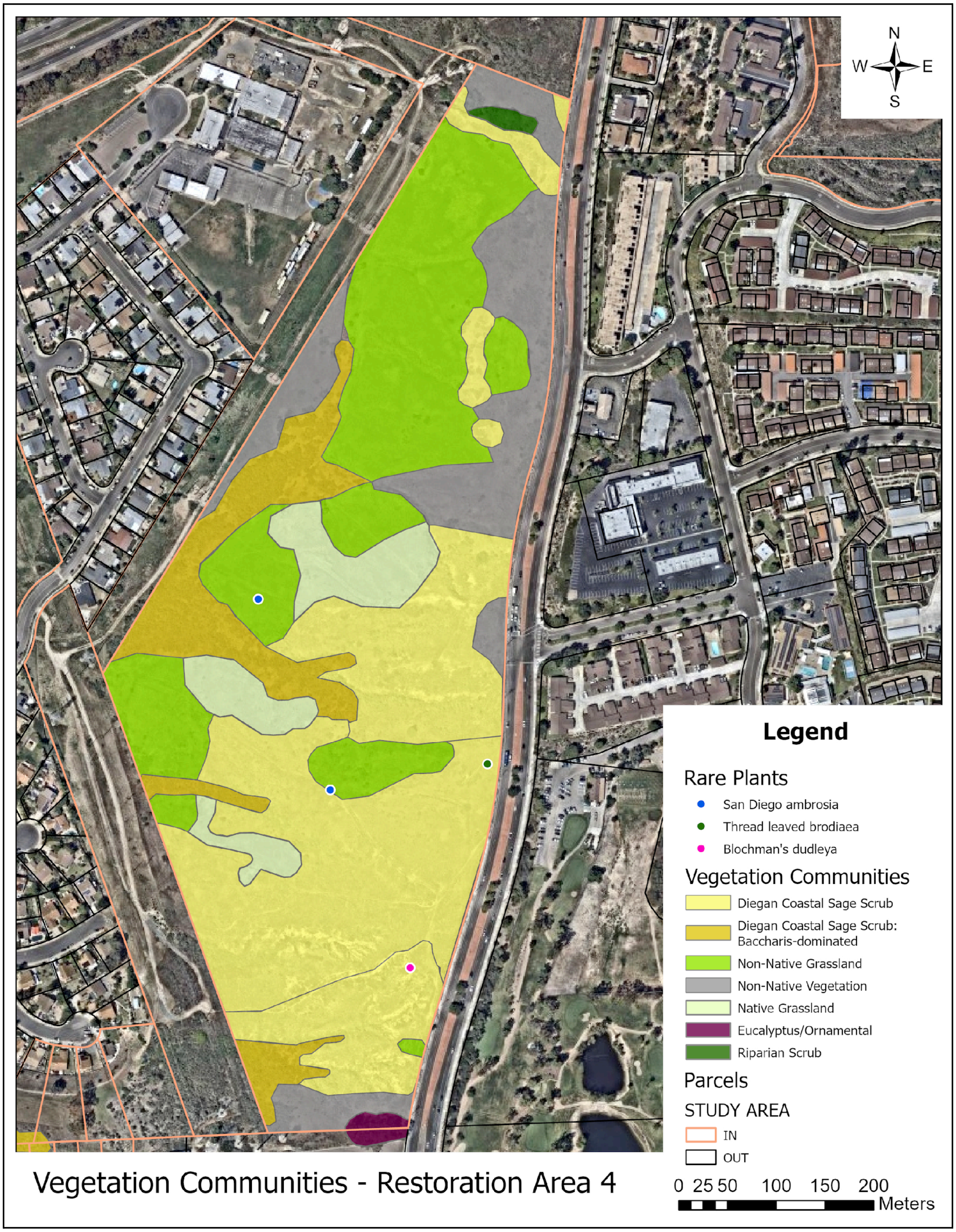
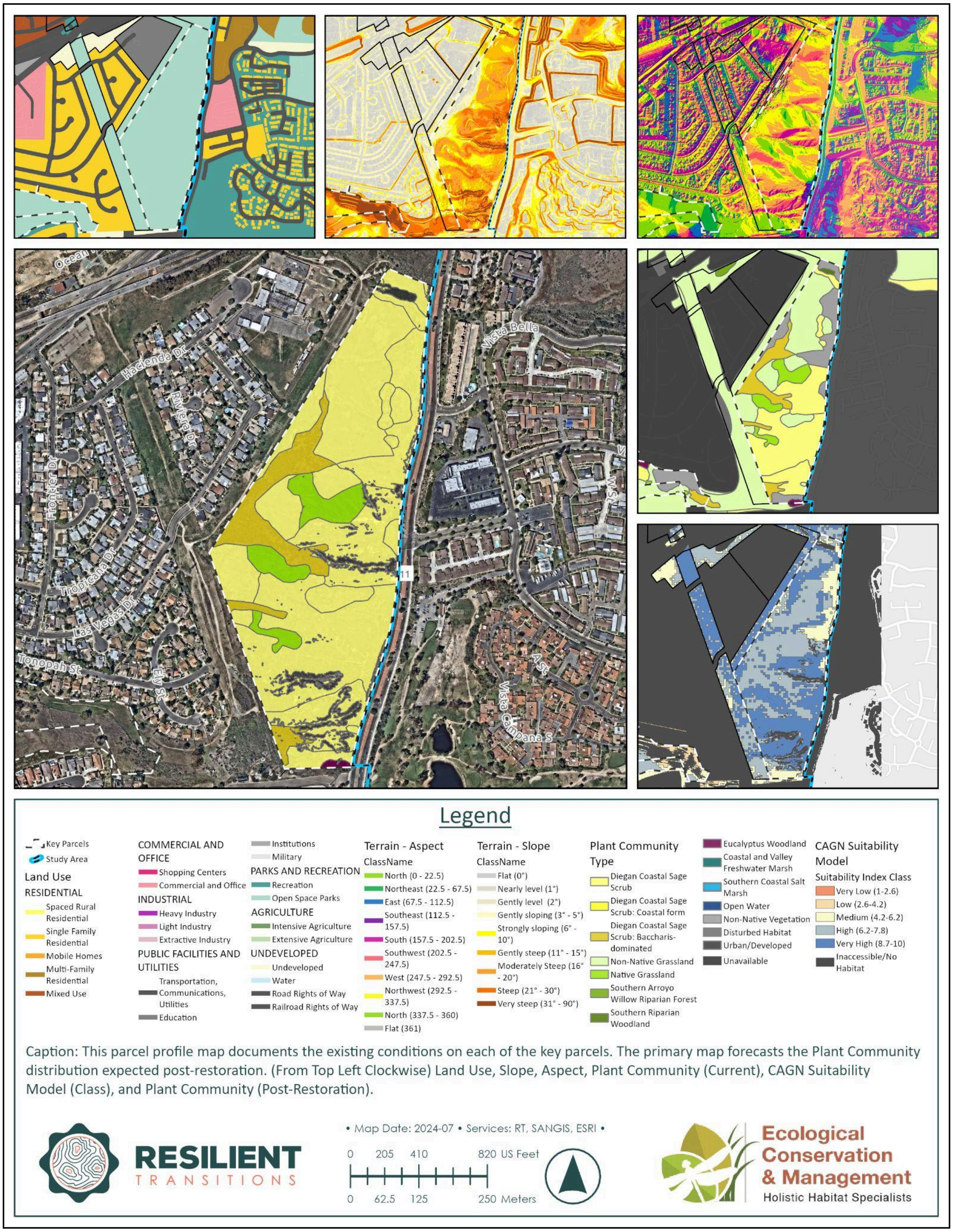


Figure 10: Area 4 - Parcel 1603001200 - Enlarged Vegetation Communities map.



Caption: This parcel profile map documents the existing conditions on each of the key parcels. The primary map forecasts the Plant Community distribution expected post-restoration. (From Top Left Clockwise) Land Use, Slope, Aspect, Plant Community (Current), CAGN Suitability Model (Class), and Plant Community (Post-Restoration).

Figure 11: Area 4 - Parcel 1603001200 - Comprehensive parcel summary.

3.3.2 Evaluation of Area 5 (Parcel 1461621800 + 1605112400)

This area is composed of two parcels; 1461621800 + 1605112400. The southern parcel (1461621800) holds more value and has a higher priority for CAGN habitat restoration because of the presence of a few DCSS patches that could be expanded to provide greater foraging and dispersal for the CAGN. The model accurately predicted areas where slopes steeper than of CAGN preferences have lower priorities for restoration. Because of this and the urban encroachment around Area 5, access is limited and difficult, making it more laborious to bring containers to their planting locations and the actual planting and maintenance activities. In addition, a water access has not been identified at this moment. Therefore, a limited restoration effort is recommended covering a total area of about two acres.

A combination of active (i.e. including planting) and passive (weed control without planting) restoration efforts is recommended. Planting should focus in the areas surrounding the existing patches of native habitats and using the same species suggested for Area 4, at similar planting densities. It is also recommended not to include native plant seeds in the restoration efforts. Passive restoration is recommended for the areas surrounding the active restoration to allow for natural colonization by native species. The goal of this approach is that over time, these patches of native habitat will expand and provide higher-quality foraging and dispersal habitat for CAGN.

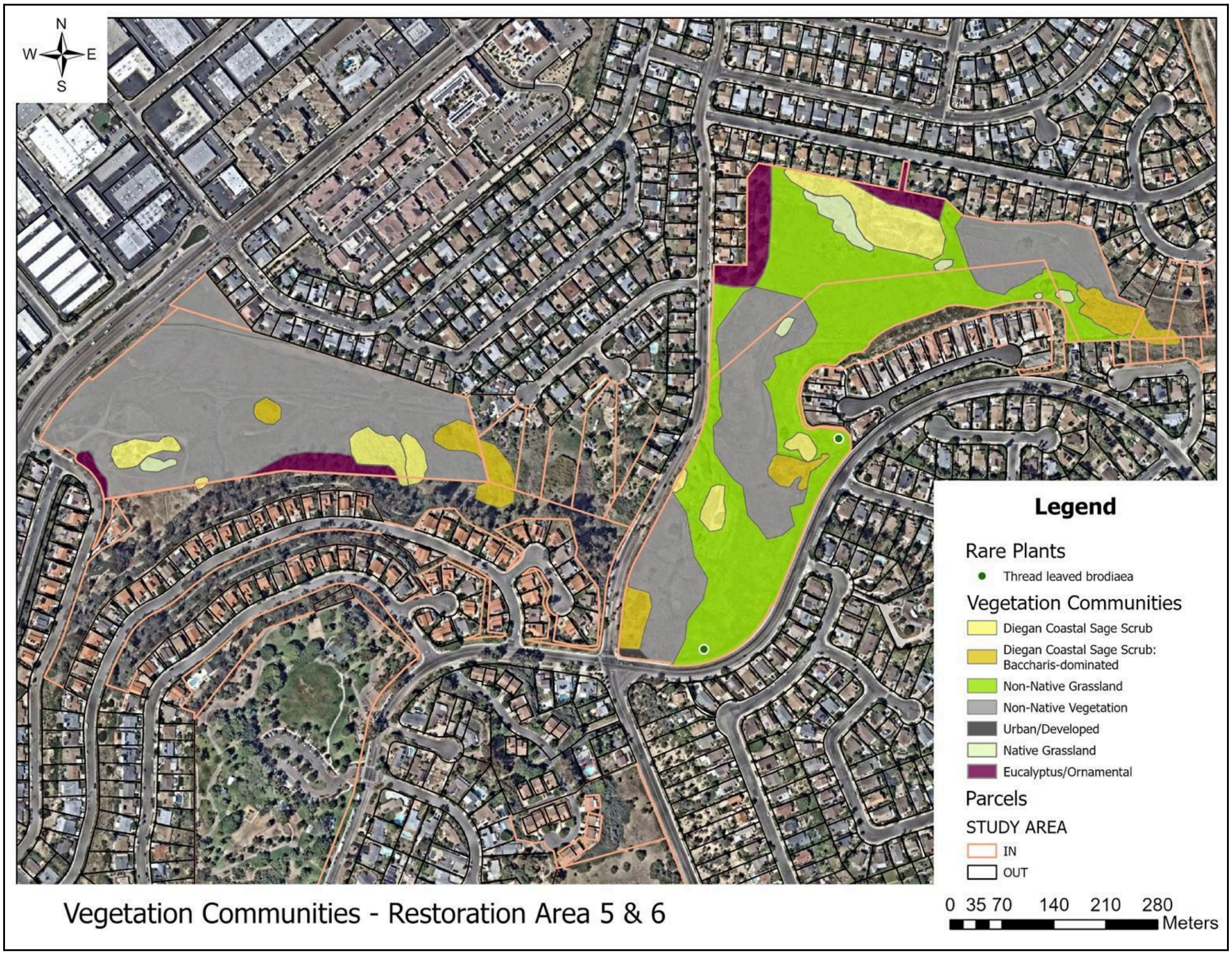
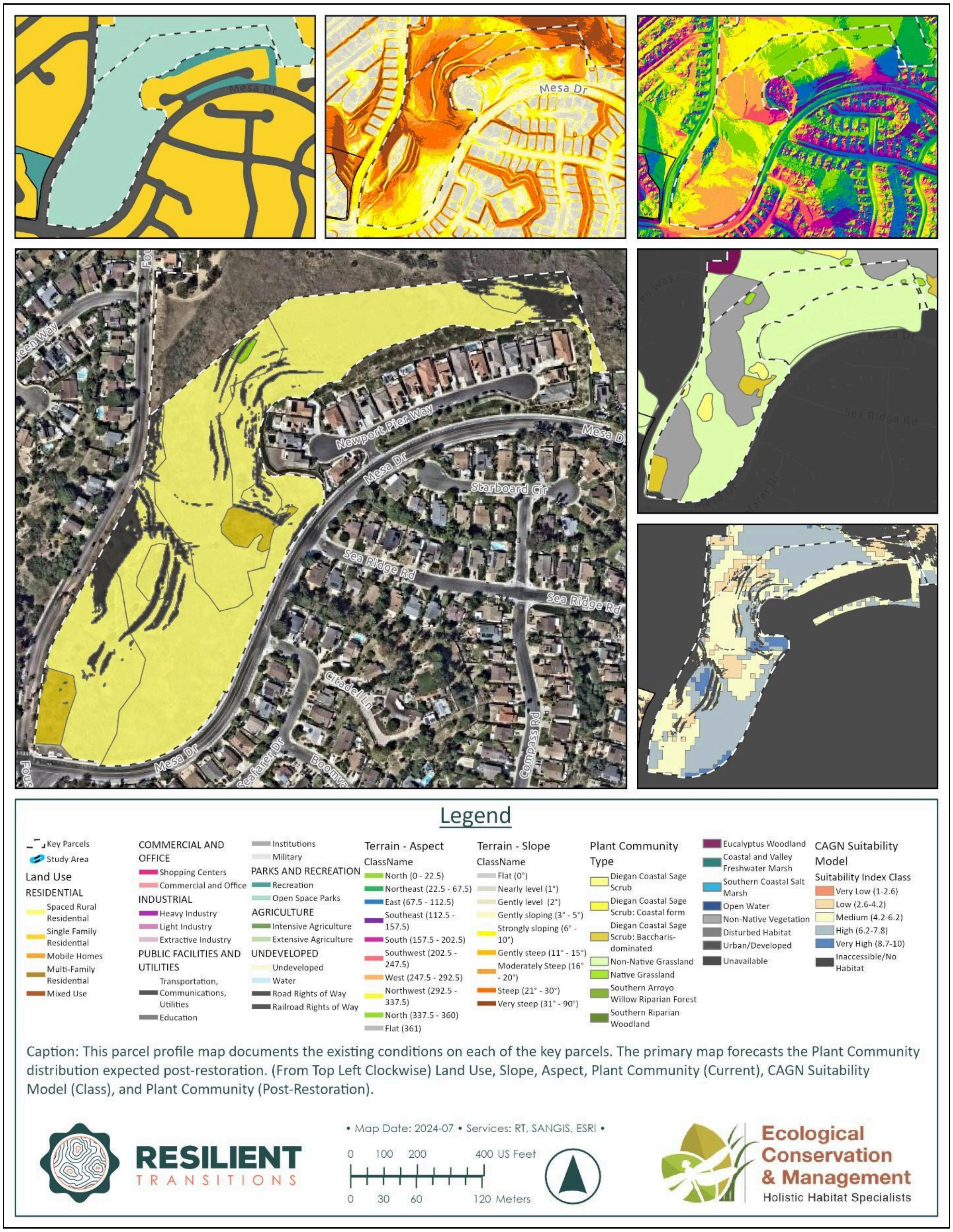
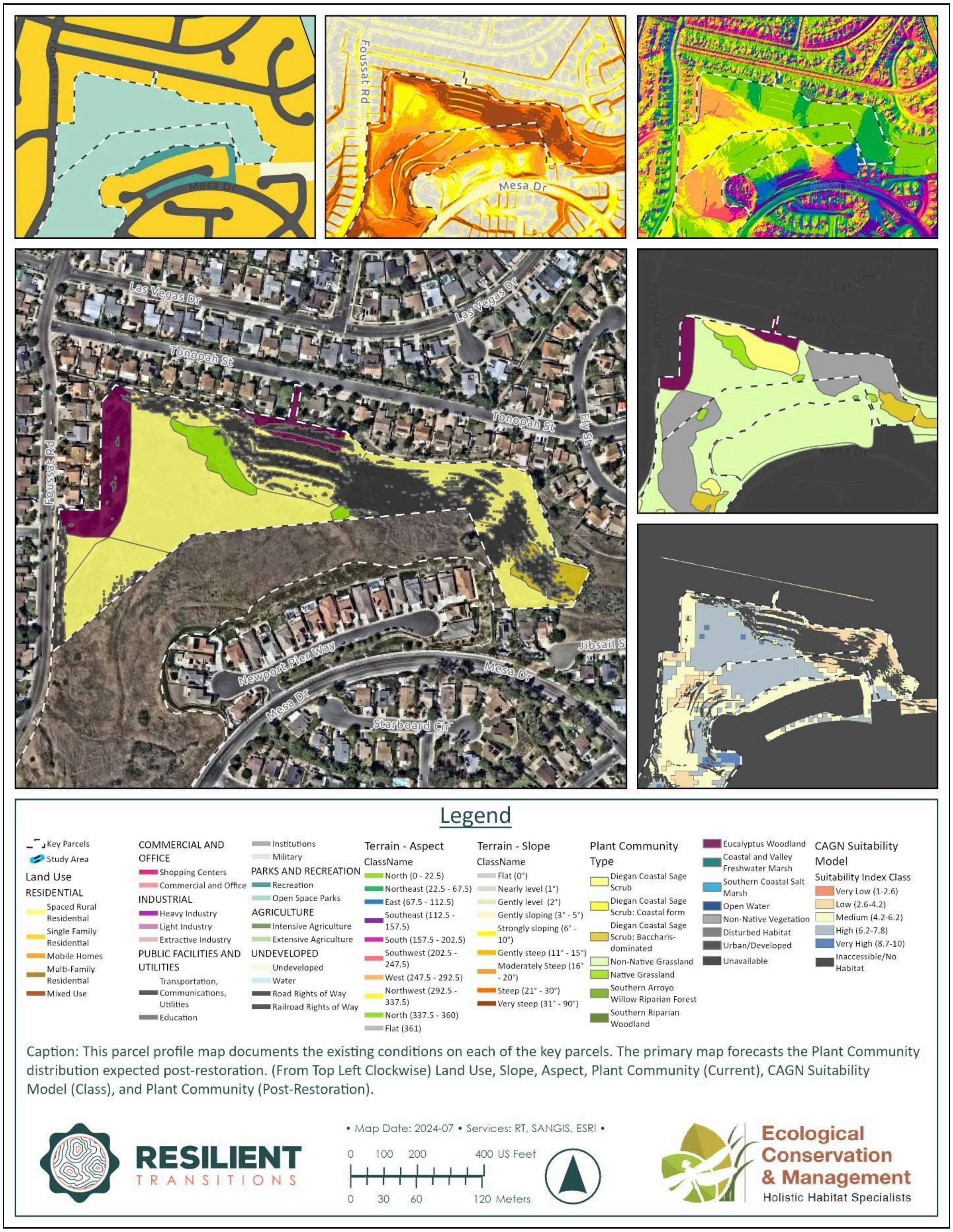


Figure 12: Area 5 and 6 - Parcels 1461621800 + 1605112400 and Parcel 1461402200 - Enlarged Vegetation Communities map.



Caption: This parcel profile map documents the existing conditions on each of the key parcels. The primary map forecasts the Plant Community distribution expected post-restoration. (From Top Left Clockwise) Land Use, Slope, Aspect, Plant Community (Current), CAGN Suitability Model (Class), and Plant Community (Post-Restoration).

Figure 13: Area 5 - Parcel 1461621800 - Comprehensive parcel summary.

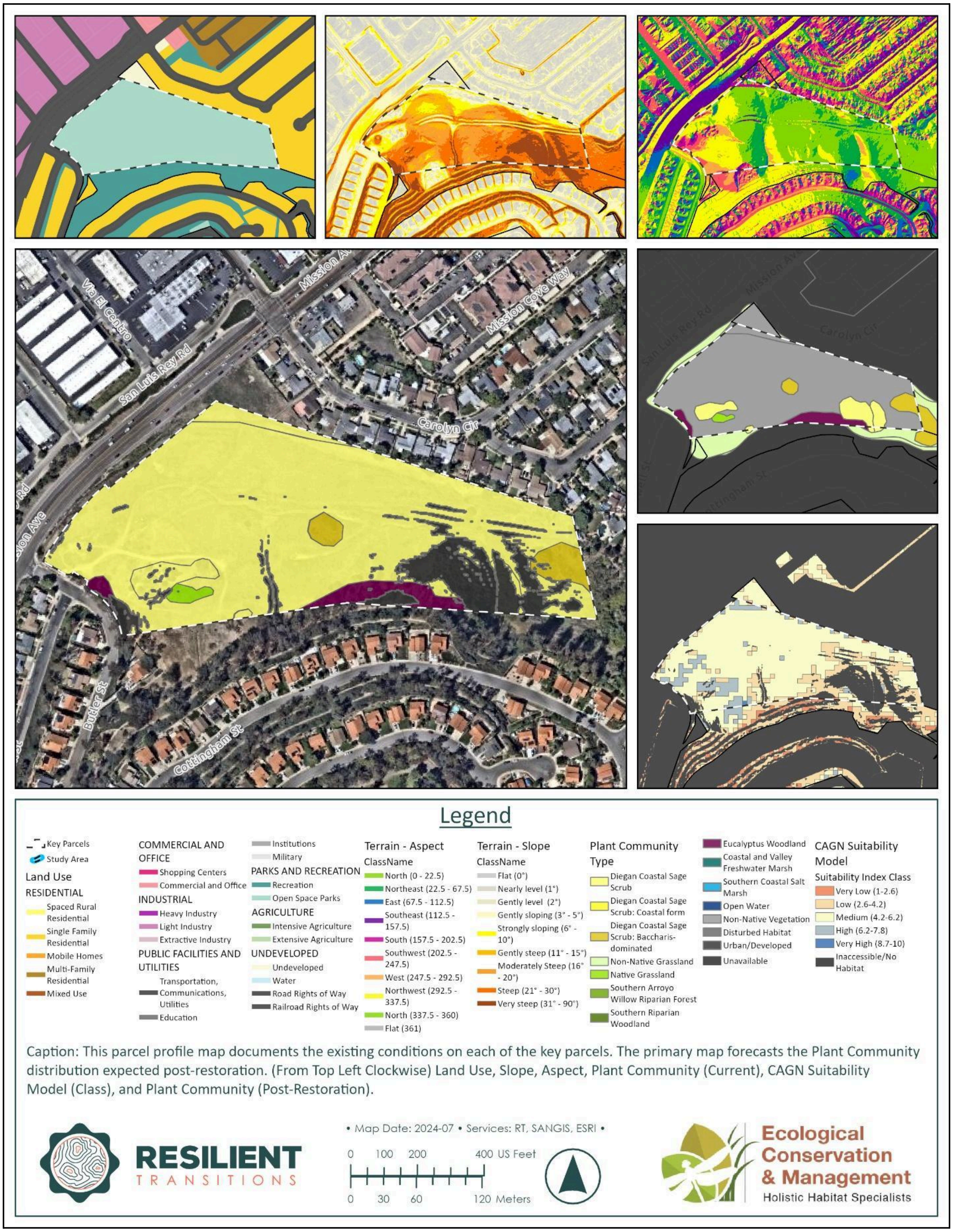


Caption: This parcel profile map documents the existing conditions on each of the key parcels. The primary map forecasts the Plant Community distribution expected post-restoration. (From Top Left Clockwise) Land Use, Slope, Aspect, Plant Community (Current), CAGN Suitability Model (Class), and Plant Community (Post-Restoration).

Figure 14: Area 5 - Parcel 1605112400 - Comprehensive parcel summary.

3.3.3 Evaluation of Area 6 (Parcel 1461402200)

Approximately, over 80 percent of Area 6 is dominated by non-native vegetation, including mustard species, fennel, annual grass species, and acacia and several other ornamental species that have spread from the surrounding urban area. This parcel is also more isolated from other native habitats, has steep slopes, and poor access. Therefore, we do not recommend any restoration work to occur at this parcel. Once other parcels within the Northern Corridor are evaluated, this parcel's value can be reassessed.



Caption: This parcel profile map documents the existing conditions on each of the key parcels. The primary map forecasts the Plant Community distribution expected post-restoration. (From Top Left Clockwise) Land Use, Slope, Aspect, Plant Community (Current), CAGN Suitability Model (Class), and Plant Community (Post-Restoration).

Figure 15: Area 6 - Parcel 1461402200 - Comprehensive parcel summary.

3.4 Evaluation of Other Parcels Containing Open Space

The scope of work for this study was limited to a thorough evaluation of only three key parcels and key crossing locations where intervention and action is critical to the long-term viability of the corridor. With that said, the results of this analysis permit us to make preliminary and broader recommendations.

Of the +1,600 parcels within the broader study area, we identified 353 parcels containing open space during the initial development of the CAGN Suitability Model. After producing the CAGN Suitability Model, we reduced this number to 174 parcels of interest. With the results of the CAGN Suitability Model and the CAGN Optimal Corridor model we can further reduce the parcels of interest down to 51 parcels (including the three key areas: 4, 5, & 6 already discussed) where intervention would have a meaningful impact. We have attributed these parcels with broad classifiers including:

- Corridor Community Engagement
- Passive Management
- Restoration and Active Management

Many of these privately held parcels are eligible for what we would describe as, “Corridor Community Engagement.” These parcels not only provide additional open space benefit to gnatcatchers, but also support plants and wildlife in the vicinity of the CAGN Optimal Corridor. Where possible, conversations with landowners can go a long way to foster awareness and potentially create opportunities for passive open space management. Open space management is not limited to restoration, as habitat enhancement can have favorable results for habitat connectivity. For homeowners, education and advocacy of other best management practice recommendations can reduce edge effects, such as: reducing light pollution, reducing pesticide use and other actions that support pollinators, and creating wildlife-supporting structures that provide cover, food, water, and space for migrating wildlife.

A few of these parcels are publicly held, and it is likely that habitat management plans are already in place. Engagement with the managing agencies could shed light on what barriers to restoration implementation exist and lead to the discovery of what funding opportunities are available to expedite restoration action.

From a regional planning perspective, our results substantiate the need for proactive engagement with the City of Oceanside. The wildlife corridors of the WCPZ and the transportation and development corridors of the City of Oceanside are at an inflection point, where timely action and decision-making will influence the trajectory of sustainability along Mission Avenue and SR-76. Our results indicate that the steppingstone of the North-South corridor along El Camino Real and Mission Avenue and the steppingstone of the East-West corridor along Mission Avenue are already in a fragmented state.

Further dissipation and attrition of the steppingstone and the narrow areas of open space that connect them is possible and likely without proactive management to correct the course of degradation. The CAGN Suitability Model identifies opportunity areas to improve the existing condition of CAGN habitat in the Northern Connector, and the CAGN Optimal Corridor model illustrates how the presence of high quality habitat supports improved connectivity.

We acknowledged in Section 1.2 that during the time of this study the City of Oceanside was in the middle of a General Plan Update. The 'Community Forum: Oceanside GPU Phase 2' asked the public "What do you consider to be the most significant ways to support long-term sustainability at the local level?" The two highest responses were, "Preservation of open space, natural habitat, and other natural resources" and "Limiting urban sprawl and promoting efficient land use." And yet, the City's proposed Smart and Sustainable Corridors Plan (SCCP) identifies three Specific Planning Areas, one of which is Mission Avenue, and all three of which bisect the WCPZ (https://onwardoceanside.com/smart-sustainable-corridors-plan). The SCCP will facilitate infill and redevelopment along Mission Avenue. The challenge is that without appropriate accommodation of open space and active land management of the remaining open space, the functional value of the East-West wildlife corridor will further degrade.

The City of Oceanside is an essential figure in ensuring the long-term viability of gnatcatcher connectivity within the Northern Connector. The City's proactive involvement and strategic planning, particularly through its upcoming General Plan, SCCP, routine development project appraisal services, and as a land manager of many key parcels in the WCPZ, are critical to balancing development with the preservation of ecological functionality. The SCCP's focus on Mission Avenue offers a unique opportunity to integrate infill and redevelopment with the conservation of open space, which is an essential part of maintaining and enhancing the East-West wildlife corridor. By aligning the City's development goals with functional conservation goals the City can play a pivotal role in halting further fragmentation and degradation of the corridor. Alignment of these goals would support both urban sustainability and the ecological health of open space. Proactive engagement with the City and its stakeholders will be crucial in steering this balance and ensuring that urban growth does not come at the expense of critical wildlife corridors.

3.5 Project Conclusions

The primary objective of this work was to assess the quality of existing habitat and the connectivity of available open space, primarily in the three areas previously identified in the Northern Connector of the WCPZ. We expanded our analysis to other parcels with this plan to provide context and to demonstrate the utility of our approach. To support this assessment we pursued three sub-objectives.

3.5.1 Sub-Objective One

In Section 2.3 and 3.3 we evaluated the existing habitat condition for CAGN on a selection of key parcels within the study area (Sub-Objective One). The CAGN Suitability Model developed in Section 2.3 provided us with a temporal reference point, classifying the study area as it exists today into areas with high, medium, and low suitability scores. The spectrum of high to low suitability paints a distinctive picture of the study area. Our expectation was to see a contrast between residential-commercial-industrial land uses and open space land uses. This contrast is present, but more striking is the presence of patches of high suitability scoring areas against a backdrop of medium-high and medium suitability scoring areas within open space land uses themselves. Likewise, it was unique to see how other factors like open space land use type, steep slopes, and north-facing aspects contributed to lower suitability scores, very likely associated with lower quality existing habitat conditions.

For the key parcels, we converted the continuous suitability spectrum into distinct classes to assist with existing habitat evaluation and restoration decision making, as seen in Figure 11, 13, 14, and 15. We classified high suitability scores as those cells with suitability index values greater than 6.2, medium suitability scores as those cells with suitability index values greater than 4.2, and low suitability scores as those cells with a suitability index value less than 4.2. As expected, the majority of high and medium suitability CAGN habitat is located North of SR-76 in the vicinity of the San Luis Rey River corridor. Sub-Objective One sought to learn more about the existing habitat condition South of SR-76, and we are able to conclude that the majority of high and medium suitability CAGN habitat is located in the vicinity of El Camino Real and of Canyon Drive.

In Section 3.3 we keyed in on a selection of parcels located within the primarily residential corridor of the study area. Large parcels of remnant open space with functional potential are still present in this section of the corridor, but our results show that many of these parcels exist in a state of low and medium CAGN habitat suitability and are generally neglected in terms of active land management for the benefit of wildlife. Specifically, Parcel 1603001200 (Area 4) was identified as having the highest quantity of existing DCSS at more than 20 acres, and the greatest potential for expansion of habitat up to more than 31 acres. This is consistent with previous research emphasizing the importance of large, contiguous patches of high-quality habitat for CAGN survival. In contrast, Parcels 1461621800, 1605112400, and 1461402200 had far less quantities of existing suitable habitat primarily due to urban encroachment and, observationally, a lack of active land management. We recognize that steep slopes pose a financial and logistical challenge to comprehensive restoration in these areas, but limited habitat enhancement and passive restoration efforts would improve the current existing habitat condition. The results of this analysis suggest that targeted restoration in Parcel 1603001200, including the use of container plantings and weed control, as recommended in Section 3.3, could significantly enhance habitat quality, facilitate CAGN movement, and potentially support a larger local CAGN population.

The accuracy of the results on existing habitat conditions could be improved by expanding the coverage of vegetation surveys from only the key parcels to every parcel of open space in the study area. Plant Community Type accounted for 30% of the model weight. In Figure 4 we see how the model benefited from the higher resolution data derived from the detailed vegetation survey completed in 2024. For all other areas the most recent vegetation surveys were completed -at best- 10 years ago. Investment in vegetation surveys and improving the resolution of the Plant Community Type dataset would be particularly valuable along both utility corridors on the East side of the study area, in the vicinity of both SR-76 crossing locations, within the residential neighborhoods near Buddy Todd Park (along Mesa Drive) and the open space along Foussat Road, and within the publicly owned open space in the vicinity of the San Luis Rey River.

3.5.2 Sub-Objective Two

In Sections 2.4, 2.5, and 3.1 we evaluated the impediments to successful movement between parcels within the study area of the CAGN corridor (Sub-Objective Two). In Section 2.4 and 2.5 we provided an interpretive description of the CAGN Optimal Corridor model. We prefaced that the term optimal can be misleading. The model seeks to find connectivity, and what we visually represent are hundreds of most likely travel routes of varying cost to CAGN movement. The sometimes dispersed and sometimes narrow concentration of optimal connections highlights areas of the WCPZ where conductance between patches of CAGN habitat is highest and where it is lowest. The darker blue coloration indicated lower cost ‘optimal’ connections and the lighter yellow coloration indicated higher cost ‘less optimal’ connections. The interpretation of the permeability of the landscape to the movement of CAGN led us to several conclusions.

Overall, the CAGN Optimal Corridor model helped us to identify probable movement zones for CAGN, where the combination of land conservation and active land management should be prioritized. Conversely, the CAGN Optimal Corridor model highlighted critical connectivity issues, particularly (1) through the utility corridors on the East side of the study area and (2) in the East-West corridor from El Camino Real to Canyon Drive. In both instances we observed narrow widths of optimal pathways, indicating the presence of bottlenecks to CAGN movement. These results are in line with previous research which noted that fragmented landscapes can severely limit genetic flow and movement for CAGN. Gene flow is important at the metapopulation level to minimize the chances of a genetic bottleneck. But gene flow within populations is also important to preserve the genetic diversity found among individuals at this scale. The steppingstone approach is best for accomplishing this latter goal.

In Section 3.1 we evaluated movement in the Northern Connector. The results suggest that along the two utility corridors, management action which improves the vegetation to a state that is more conductive to the movement of bird species would improve connectivity and reduce the risk of habitat fragmentation. Expansion of the study area South along El Camino Real to El Corazon and Northeast and Northwest would certainly help us draw broader conclusions about CAGN connectivity throughout the WCPZ.

Regarding the East-West corridor through stepping stones in the residential area south of SR-76, the variation in the model results is an indication that the viability of this section is impaired relative to the strong connectivity found on the North side of SR-76. Here, the model alternates between areas with narrow bottlenecking of optimal paths and areas with a wide spread of alternative paths. This insight supports our conclusion to recommend that Area 4 and parts of Area 5 are targeted for immediate restoration or enhancement as they are the most likely to support North-South movement through the WCPZ along El Camino Real.

Nevertheless, in the East-West corridor the secondary linkages between stepping-stones highlights the value that different forms of intervention could bring to the corridor in the long-term. In particular, conservation and active land management of other steppingstone patches could have a large impact on the strength of the corridor. The presence of other, less optimal pathways through residential neighborhoods and between steppingstones also signifies that community engagement could have a large impact on the strength of the corridor, especially engagement that promotes the use of a diverse landscaping including native plant species to support wildlife.

3.5.2 Sub-Objective Three

In Section 3.2, we evaluated the specific constraints to successful crossing of State Road 76 (SR-76) and Mission Avenue (Sub-Objective Three). The SR-76 transportation corridor acts as a major barrier to CAGN movement. The analysis identified this transportation corridor as a band of low suitability along its entire width. Our results identified three key crossing locations, with the crossing at SR-76 and Canyon Drive showing the most promise due to its larger corridor width. However, this location also faces significant challenges, such as steep slopes that limit suitable habitat on the South side of SR-76, significant urban development South along Canyon Drive that limits dispersal potential, and urban encroachment along the West-East corridor that likely limits CAGN movement. This is consistent with previous research which emphasizes the detrimental effects of infrastructure on CAGN dispersal.

To address the constraints posed at each of the three SR-76 crossing locations, our study suggests targeted intervention. Enhancement of the quality of habitat on both sides of these crossings with native plants that provide forage and cover would increase the likelihood of successful navigation through the landscape and across the transportation corridor. The viability of the N-S Central Utility

Corridor is compromised by pending development on the North side of SR-76. Habitat restoration, where not constrained by pending development design nor underground and aboveground utilities, could allow infrequent dispersal of CAGN, but vegetation surveys would need to be performed on this corridor to correct the model's interpretation of viability in this corridor. The viability of the N-S Eastern Utility Corridor is more promising. We conclude that a reliable dispersal corridor could be designed for this corridor, but such a corridor would need to be greatly enhanced both in terms of habitat width and in terms of habit quality, but vegetation surveys would need to be performed on this corridor to model the post-restoration potential variability of this corridor route.

We recognize that utility managers and other land managers of the parcels referenced herein and that compose these crossing locations will have other objectives to meet. In particular vegetation management for wildfire mitigation and willingness to intentionally provide habitat to host a listed species will likely limit engagement with utility managers and developers. Yet opportunities also exist. Community engagement and collaboration with managers and developers could lead to a better understanding of their current resource management plans. Common ground may be present where changes could reduce the influence of edge effects or improve existing habitat conditions at these pinch points and improve the ecological conductivity of the land for gnatcatchers and wildlife overall. In the absence of true consideration of alternative development configurations and land management changes it should be anticipated that regional connectivity of gnatcatcher metapopulations within the stepping-stone corridor will become impaired or disconnected.

3.5.4 Sub-Objective Four

In Sections 3.3 and 3.4 we provided recommendations on priority areas for habitat restoration and enhancement, conservation, public and private engagement, and other intervention strategies in the Northern Connector (Sub-Objective Four). Through our analysis, we identified 51 parcels where targeted interventions could improve habitat quality and connectivity for CAGN.

One of the most critical recommendations involves the active restoration of Parcel 1603001200, which was identified as a key hub for CAGN movement, both North-South and East-West. Our proposal includes using high-density container plantings of native species such as *Artemisia californica* and *Eriogonum fasciculatum*, as detailed in Section 3.3.1. These species have been shown to support CAGN foraging and nesting and their establishment in degraded areas could significantly increase the habitat's carrying capacity. Furthermore, using container plants -rather than taking more aggressive actions that might disturb and then activate the seed bank- would help jump start the succession of shrubs while outcompeting the existing non-native grasses and other undesirable species.

Additionally, passive management strategies are recommended for parcels where active restoration may not be feasible due to access limitations or high restoration costs. For example, in Parcels

1461621800 and 1605112400, a combination of selective planting around existing patches of DCSS and ongoing weed control could gradually enhance habitat quality without the need for extensive intervention. This strategy aligns with our adaptive management framework which advocates for flexible, site-specific approaches to conservation in dynamic landscapes.

Furthermore, the engagement of local communities and private landowners in conservation efforts is critical to the long-term success of these strategies. In Section 3.4, we emphasized the importance of education and outreach to foster stewardship among landowners whose properties lie within or adjacent to identified corridors. Initiatives such as reducing light pollution, minimizing pesticide use, and promoting the planting of native species can have significant cumulative effects on improving habitat quality and reducing edge effects, which are known to impact CAGN movement and survival.

Also in Section 3.4, we emphasize the need to engage with the City of Oceanside. The City is an essential figure and serves roles as the arbiter of community development and the land manager of many key parcels in the WCPZ. Our results highlight the current fragmented status of the corridor, and how without active management and preservation of open spaces, further degradation is likely. The SCCP's focus on Mission Avenue and other redevelopment areas within the WCPZ offers a unique opportunity for the City to align its development goals with the preservation of ecological functionality. In doing so, the City has the opportunity to play a vital role in maintaining and enhancing wildlife connectivity and balancing urban growth with environmental sustainability.

Finally, our study suggests that public agencies, advocacy groups, and private stakeholders should collaborate to secure funding for the implementation of these recommendations. We limited our restoration recommendations based on limited resources and immediate feasibility, but additional funding could provide sufficient resources to achieve broader restoration targets. Habitat restoration grants and community-based conservation programs could provide the necessary support to ensure that the identified priority areas are managed effectively in the face of an uncertain future. This multi-faceted approach, combining active restoration, passive management, and community engagement, is essential for enhancing the resilience of the Northern Connector and supporting the long-term viability of CAGN populations throughout the WCPZ.

4.1 Limitations

Limitations in geospatial analytics are common, and in this analysis, we encountered several limitations during the input dataset development phase. It was unfortunate that we discovered several datasets intended for inclusion in the suitability model experienced little to no variation within the analysis extent. Specifically we expected Elevation, Fire History, and Climate and Precipitation to be included and improve how well this model characterized the habitat need of gnatcatchers. Even though Elevation was excluded from the model, we included an additional map showing the original classification and transformation scheme in Appendix 6.1 to document the justification for exclusion. In Appendix 6.1 we see that the Elevation ranged from 0-128 meters (420 ft). Previous CAGN research identified ranges of elevation usage and elevation avoidance, but our study area only contained values for the top three elevation classes (0-30 meters (10), 30-100 meters (9), and 100-200 meters (8)). If we assigned the weight expected for elevation (10%) to this transformed dataset, we would have seen a contribution to the CAGN Suitability Score from elevation alone ranging from 0.8 to 1.0. This close-to-uniform coverage would have inhibited the model rather than improved the model. We included the excluded variables in the Appendix to facilitate their consideration in future expanded studies in the WCPZ.

In other instances, such as with the Land Use dataset, assembling geospatial data proved to be a complicated endeavor. SANGIS is a wonderful repository of geospatial data, and the coordination between the various Development Services, Utilities, and other departments of participating cities in San Diego County typically produces well refined datasets. The GIS Division of the City of Oceanside has a well-maintained inventory of geospatial information, but for this analysis the disconnect between certain datasets, such as the Softline and Hardline Preserves and SANGIS's preserved open space layers and the accessibility to the Development Services Active Projects layer, led to a substantial amount of revision needed to produce a Land Use dataset that closely matches the current land use in the study area. GIS data from the City of Oceanside, particularly the Softline and Hardline Preserves and the Active Projects layer are limited in their accuracy. The results could be improved by greater transparency of geospatial data for active and planned development projects from the City of Oceanside. These datasets were cross referenced within the study area and minor modifications were made to improve the utility value these layers provide to the model. Correcting this limitation exhausted the time available to perform quantitative evaluations of pre-restoration suitability modeling and corridor modeling and scenario planning for post-restoration suitability modeling and post-restoration corridor modeling.

We use language like illustration, representation, and interpretation because we recognize that in any model of wildlife corridors there is model uncertainty. The corridor model focused on CAGN movement potential and stepping-stones within the study area, therefore all the corridor connections are internally facing and do not illustrate connectivity further North to Camp Pendleton nor further South along El Camino Real to El Corazon. Further, the corridor model requires locations of interest to serve as sources and destinations. This can cause some bias within large stepping-stones where we know through field surveys that large portions of the parcel could serve as CAGN breeding and foraging habitat. This limits the interpretation of the results to a better understanding of inter-parcel connections like Dispersal rather than intra-parcel inferences on CAGN foraging. Last, we had several secondary linkages that demonstrate least-cost path corridor modeling shortcomings related to the differences between optimal paths that show preference for shortest path and optimal paths that show preferences for lowest cost cells. Both aspects of these optimal paths are informative, but it required additional modeling time to determine a percentile threshold that maintained a balance.

Lastly, without focused CAGN surveys throughout the study area, it is not possible to adequately ascertain the accuracy of the models. We believe that surveys are critical to test the validity of models, to make adjustments to inputs, and to refine the conclusions reached. Research has shown that CAGN are exposed to many different abiotic and biotic conditions throughout their range, from Ventura to northern Baja California, and from the coast to inland valleys. Therefore, locally collected data on their preferences are necessary to develop more refined habitat suitability and movement models at the scale of the WCPZ study area.

4.2 Next Steps

Among the important lessons our team learned from Phase I was that the WCPZ Working Group has a shared interest in updating Table 3-5, Priority Areas for Habitat Restoration or Enhancement [in the WCPZ] (City of Oceanside Subarea Plan 2010).

This initial study served its role to create actionable opportunities on key parcels, key crossing locations, and to identify parcels where alternative intervention opportunities exist. The secondary purpose of this study was to serve as a pilot for the WCPZ at large. Over the course of several meetings with the WCPZ Working Group we identified a shared interest in updating Table 3-5, Priority Areas for Habitat Restoration or Enhancement [in the WCPZ] (City of Oceanside Subarea Plan 2010). Through this work we were able to demonstrate a method to update the current and future condition acreage numbers as well as the priorities of parcels in the table. With a tangible method in hand, we expect the next step in Phase II of this work will be to expand coverage to a few additional previously identified parcels in the WCPZ.

The modeling component of this expansion is relatively straightforward. After expanding the study area to include a few select new key parcels, we plan to improve upon our method in Phase II by making a renewed effort to successfully complete a pre- and post-restoration comparison of the suitability model and the corridor model. If sufficient resources are available, it would be highly valuable to integrate two or three scenarios of infill development within the Mission Avenue corridor to see how alternative development scenarios limit or improve corridor connectivity.

We also demonstrated that detailed vegetation and habitat mapping is crucial to properly inform the model. Diegan Coastal Sage Scrub was an acceptable category for this initial investigation but we recognize that it is too broad of a category. Sub-associations and species dominance affect the type and quality of CAGN habitat and integrating this level of plant community information could improve the model. Lastly, we believe that CAGN surveys over the entire area are necessary and therefore we recommend they be included. There has not been a comprehensive CAGN survey in the region. What we have are isolated surveys over many years. At this moment, we do not know the current locations, relative population density, and nesting territories for this species. If conducted as part of Phase II, a detailed vegetation mapping coupled with focused surveys for CAGN will significantly improve model predictions, conclusions and recommendations for restoration efforts across the steppingstone planning zone. A better understanding of dispersal patterns of CAGN within the study area will help elucidate not only the area where they occupy a majority part of their lives but also the areas they must travel through to reach areas of seasonal use.

Lastly, once priority parcels for restoration have been identified, it is recommended that a restoration plan is developed for each parcel using an adaptive management framework. This plan should include plant palettes, detailed planting methods, vegetation and wildlife monitoring including for CAGN presence, and maintenance activities. The restoration plan should also include GIS-based maps to guide all activities for each site and document their change over time. Monitoring of restoration activities is an essential component of determining ***what*** happened following restoration and ***why*** the changes happened (Michael Morrison, 2009).

5.1 References

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Appendices

The appendices contain supplementary information focusing on documentation of the modeling processes in Task Two and Task Three, and documentation of cross reference information for parcels beyond the key parcels that were the focus of this project. Additional materials, detailed maps, raw data, and other supplementary information are provided to Preserve Calavera separately.

6.1 Detailed Input Dataset Creation, Reclassification, and Transformation

In Appendix 6.1 we provide a technical appendix to document the reclassification and transformation process. We include observational notes, maps, figures, and tables to document the reclassification and transformation process, and for the variables that were ultimately excluded from this analysis, we provide maps and tables to substantiate the decision to remove these variables from the model.

*Plant Community Type**

Model Base Weight: 30%

Variable Development: The input dataset for this variable is derived from Holland 2008, Holland-Oberbauer 2012, and from plant community surveys of key parcels in 2024. The datasets were appended together to create full coverage within the study area and where overlap occurred priority was given to the most recent survey data. The classification scheme was developed using existing research and was fine tuned based on field experience and collaboration within the project team. The classification scheme places preference on existing Diegan Coastal Sage Scrub (DCSS) which supports CAGN breeding/nesting, CAGN foraging, and CAGN dispersal. Secondary preference is assigned to Native Grassland, Non-native Grassland, and Baccharis-dominated DCSS which support CAGN breeding/nesting, CAGN foraging, and CAGN dispersal at a reduced capacity, especially when these communities are present with patches of DCSS. Riparian plant communities are assigned lower values, representing marginally suitable habitat or un-preferred habitat that still support CAGN movement and dispersal. Last, low quality plant community classes are assigned low values, representing un-preferred habitat that is highly restrictive to CAGN movement.

Reclassification and Transformation Scheme	
Classification	**Transformed Value**
Eucalyptus Woodland/Non-Native Vegetation/Urban/Developed/Disturbed Habitat/Open Water	**1**
Coastal and Valley Freshwater Marsh/Southern Coastal Salt Marsh	**2**
Southern Riparian Woodland/Southern Arroyo Willow Riparian Forest	**4**
Diegan Coastal Sage Scrub: Baccharis-dominated	**6**
Non-Native Grassland	**7**
Native Grassland	**8**
Diegan Coastal Sage Scrub/Diegan Coastal Sage Scrub: Coastal form	**10**

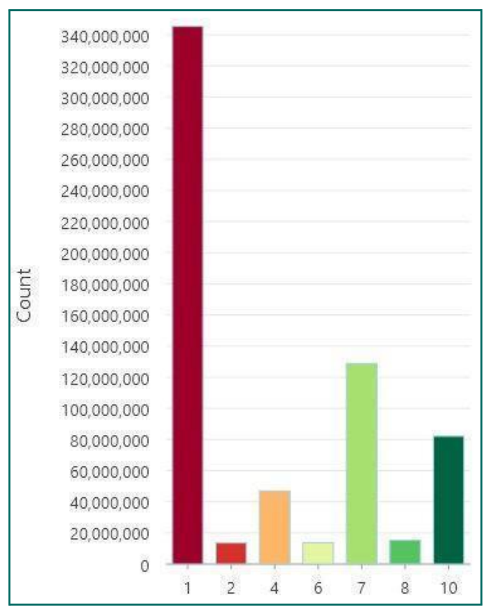
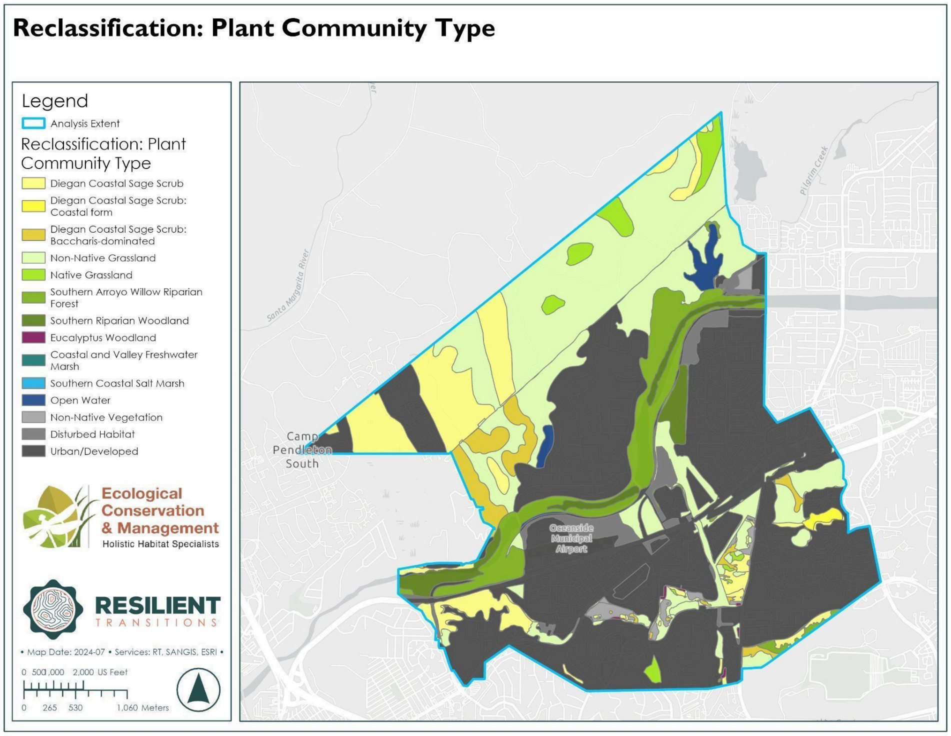
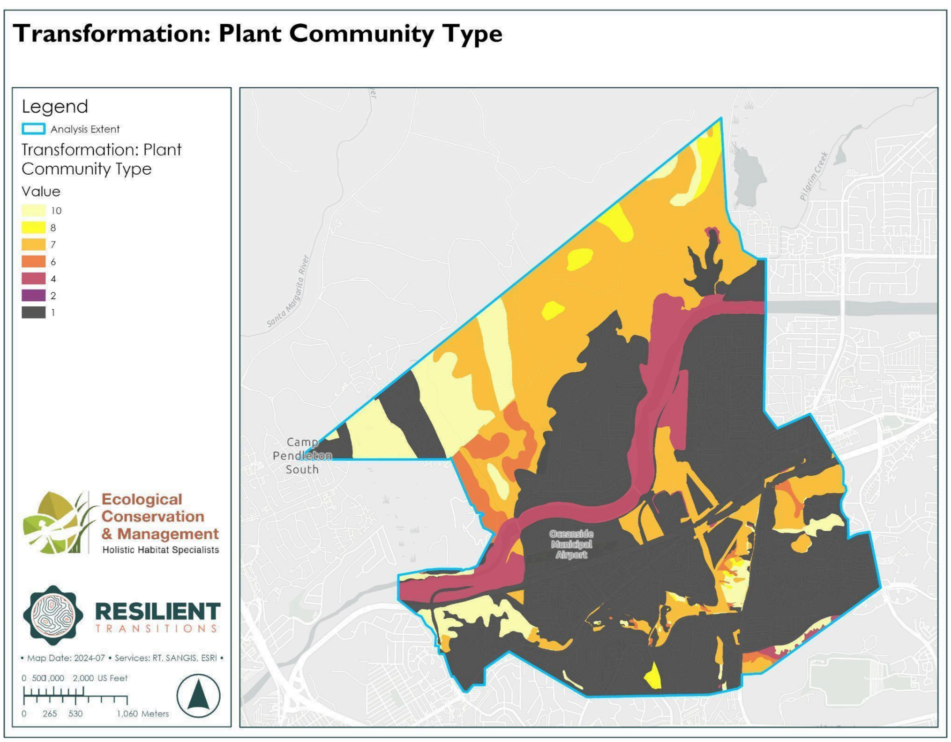


Table 6.1. Reclassification and Transformation scheme for Plant Community Type. The transformation figure on the right illustrates the count of cells that are binned in each of the final transformed value classes.

<u>Visualization of Reclassification and Transformation Scheme</u>:





*Land Use**

Model Base Weight: 25%

Variable Development: The input dataset for this variable is derived from the 2023 Land Use of San Diego County as the base layer, with subsequent augmentation using 1) Roads of San Diego County, 2) Softline and Hardline Conserved Land Use of City of Oceanside, and (3) Active Projects of City of Oceanside (as of May 2024). Where modification of the base layer was required, lu-codes were updated to proximate codes in the Land Use dataset. The classification scheme places the highest value on known conserved open spaces (e.g. federally protected land, state protected land, county protected land, or locally protected hardline preserves), with the second highest value placed on semi-protected open space (e.g. other federally protected land in use, other open space parks, or locally protected softline preserves). The scheme progressively tapers lower through three classes of green space and other movement-facilitating open spaces down to urban green space. Last, all urban and heavily developed uses are transformed to a value of 1.

Reclassification and Transformation Scheme	
Classification	**Transformed Value**
Residential/Industrial/Commercial/ Transit/Utilities	**1**
Urban Green Space	**2**
Other Open Space	**4**
Agriculture and Green Space	**6**
Open Space Semi-Protected (Softline)	**8**
Open Space Protected (Hardline)	**10**

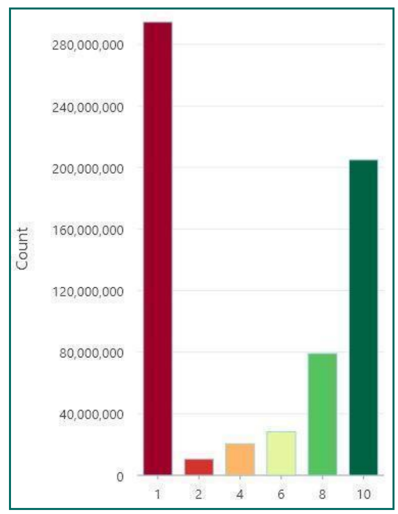


Table 6.2. Reclassification and Transformation scheme for Land Use. The transformation figure on the right illustrates the count of cells that are binned in each of the final transformed value classes.

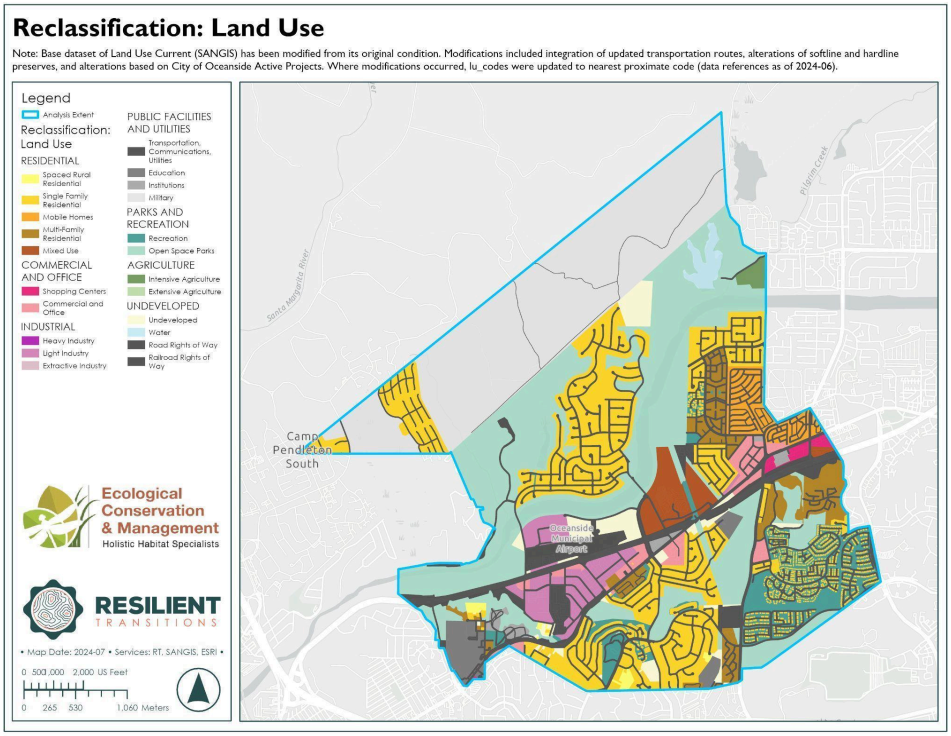
Classification of Adapted SANDAG Land Use Codes:

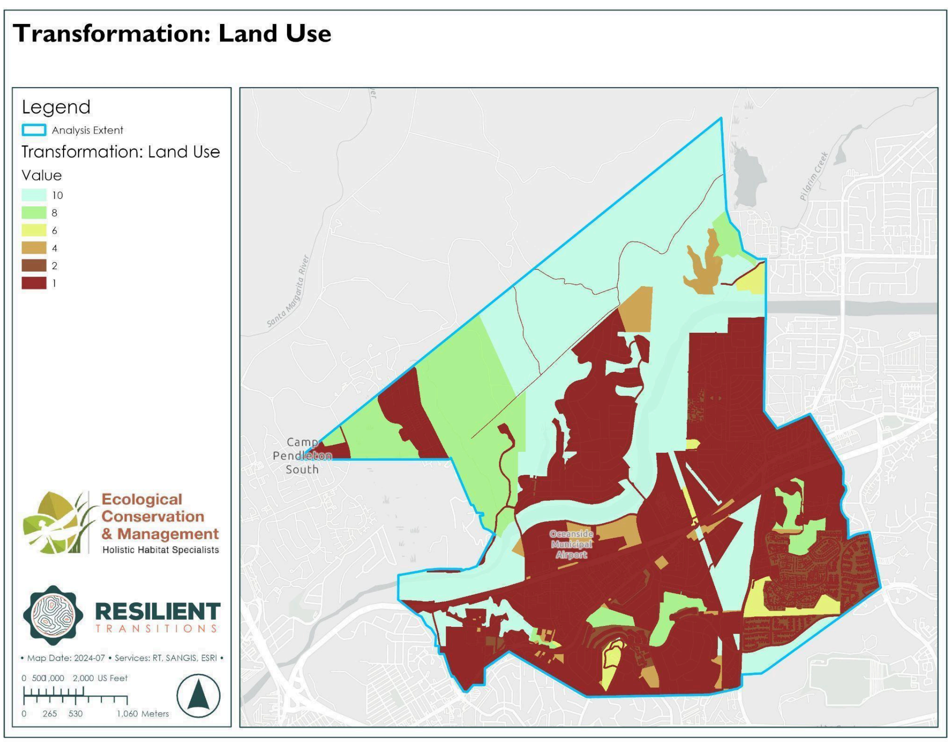
Land Use Code Classification Table		
CLASSIFICATION	**LUCODE**	**DESCRIPTION**
Residential/Industrial/Commercial	**1000**	**Spaced Rural Residential**
/Transit/Utilities	**1100**	**Single Family Residential**
	1110	**Single Family Detached**
	1120	**Single Family Multiple-Units**
	1190	**Single Family Residential Without Units**
	1200	**Multi-Family Residential**
	1290	**Multi-Family Residential Without Units**
	1300	**Mobile Home Park**
	1404	**Monastery**
	1409	**Other Group Quarters Facility**
	1500	**Commercial**
	1500	**Commercial and Office**
	1501	**Hotel/Motel (Low-Rise)**
	1502	**Hotel/Motel (High-Rise)**
	1503	**Resort**
	2100	**Light Industry**
	2101	**Industrial Park**
	2103	**Light Industry - General**
	2104	**Warehousing**
	2105	**Public Storage**
	2301	**Junkyard/Dump/Landfill**
	4103	**General Aviation Airport**
	4111	**Rail Station/Transit Center**
	4112	**Freeway**
	4113	**Communications and Utilities**
	4114	**Parking Lot - Surface**
	4115	**Parking Lot - Structure**
	4116	**Park and Ride Lot**
	4117	**Railroad Right of Way**
	4118	**Road Right of Way**
	4119	**Other Transportation**
	5003	**Community Shopping Center**
	5004	**Neighborhood Shopping Center**
	5005	**Specialty Commercial**
	5006	**Automobile Dealership**
	5007	**Arterial Commercial**
	5008	**Service Station**
	5009	**Other Retail Trade and Strip Commercial**
	6002	**Office (Low-Rise)**
	6003	**Government Office/Civic Center**

	6100	Institutions
	6101	Cemetery
	6102	Religious Facility
	6103	Library
	6104	Post Office
	6105	Fire/Police Station
	6108	Mission
	6109	Other Public Services
	6502	Hospital - General
	6509	Other Health Care
	6701	Military Use
	6803	Junior College
	6803	Other Commercial Industrial
	6804	Senior High School
	6805	Junior High School or Middle School
	6806	Elementary School
	6807	School District Office
	6809	Other School
	9700	Mixed Use
Urban Green Space	7606	Landscape Open Space
	7601	Park - Active
	7607	Residential Recreation
Other Open Space	9101	Vacant and Undeveloped Land
	9201	Bay or Lagoon
	9202	Lake/Reservoir/Large Pond
	9500	Undeveloped
Agriculture and Green Space	7200	Recreation
	7201	Tourist Attraction
	7203	Landscape Open Space
	7204	Golf Course
	7205	Golf Course Clubhouse
	7207	Marina
	7209	Casino
	7210	Other Recreation - High
	7601	Park - Active
	7604	Beach - Active
	8002	Intensive Agriculture
	8003	Field Crops
Open Space Semi-Protected (Softline)	6702	Military Training - Developable
	7600	Open Space - Developable
Open Space Protected (Hardline)	6702	Military Training
	7603	Open Space Park or Preserve
	7609	Undevelopable Natural Area

*A selection of code descriptions have been modified for application in this project.

<u>Visualization of Reclassification and Transformation Scheme</u>:





*Slope (Degrees)**

Model Base Weight: 20%

Variable Development: The input dataset for this variable is derived from the dynamic World Elevation Terrain service (ESRI 2024). The classification scheme emphasizes the gentle slopes and midrange slopes preferred by CAGN in marginalized landscapes. The scheme tapers off exponentially for slopes greater than 22 degrees (i.e. slopes greater than 40 %). It is noted that 83 degrees is the maximum value detected in our analysis extent.

Reclassification and Transformation Scheme	
Classification (Value Range) (Degree)	**Transformed Value**
(0 – 5)	**10**
(5 – 10)	**9**
(10 – 22)	**7**
(22 – 30)	**4**
(30 – 45)	**2**
(45 – 90)	**1**
(–)	**NODATA**

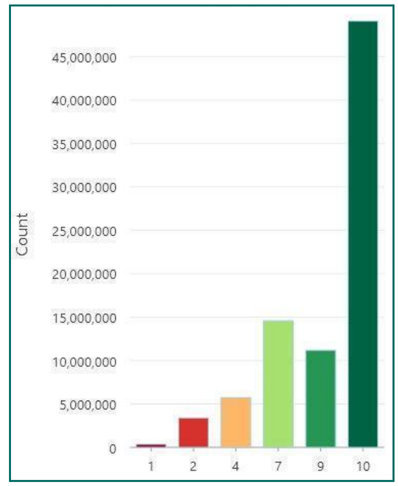
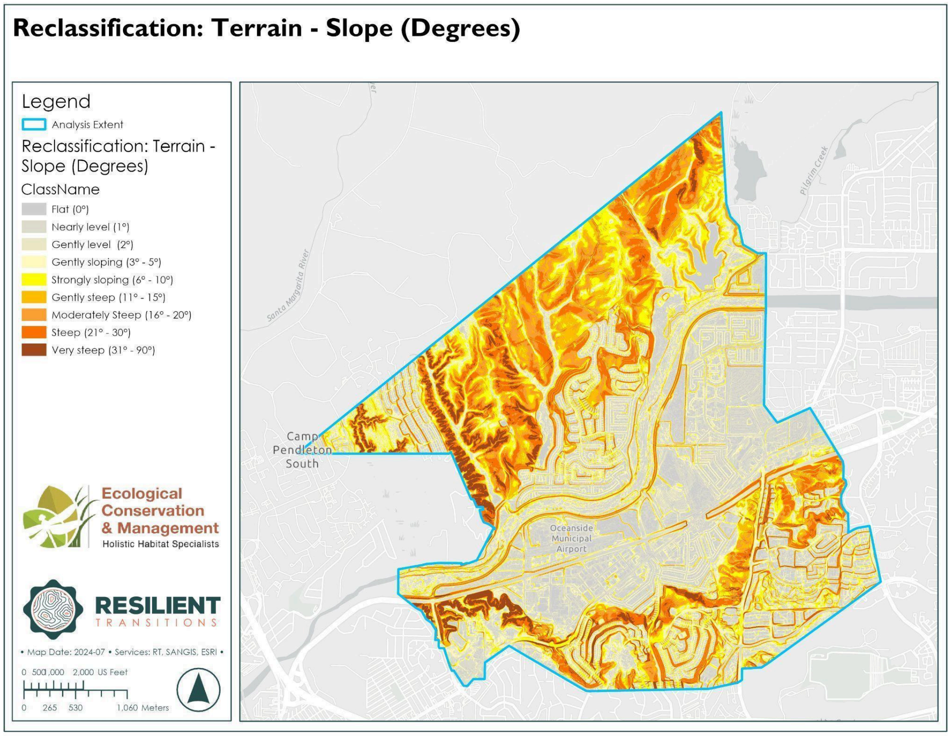
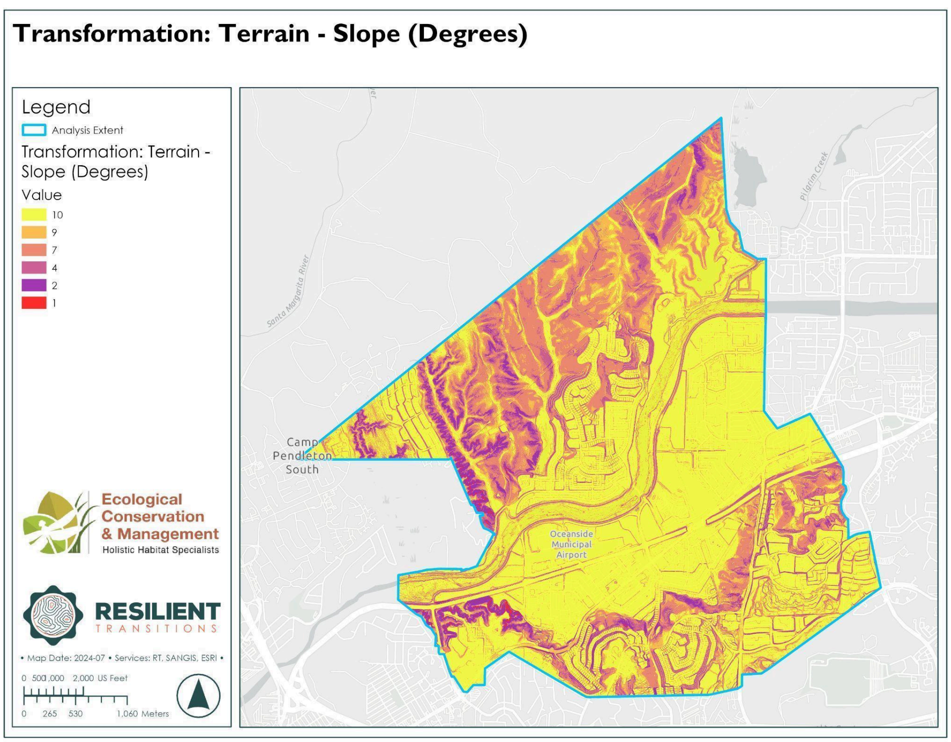


Table 6.3. Reclassification and Transformation scheme for Slope (Degrees). The transformation figure on the right illustrates the count of cells that are binned in each of the final transformed value classes.

Visualization of Reclassification and Transformation Scheme:





*Aspect (Slope Direction) **

Model Base Weight: 20%

Variable Development: The input dataset for this variable is derived from the dynamic World Elevation Terrain service (ESRI 2024). The classification scheme emphasizes South-facing aspects, which typically receive higher sunlight exposure and therefore more suitable vegetation growth and warmer microclimates. Southwesterly- and Southeasterly-facing slopes are also transformed to very suitable values. East- and West-facing slopes are attributed with moderately suitable values given their balanced sunlight exposure. Northwest-, Northeast-, and North-facing slopes are attributed with lower transformed values due to minimal sunlight exposure and cooler temperatures.

Reclassification and Transformation Scheme	
Classification (Value Range) (Radian)	**Transformed Value**
North (0 - 22.5)	**2**
Northeast (22.5 - 67.5)	**4**
East (67.5 - 112.5)	**6**
Southeast (112.5 - 157.5)	**9**
South (157.5 - 202.5)	**10**
Southwest (202.5 - 247.5)	**9**
West (247.5 - 292.5)	**6**
Northwest (292.5 - 337.5)	**4**
North (337.5 - 360)	**2**
NODATA	**NODATA**

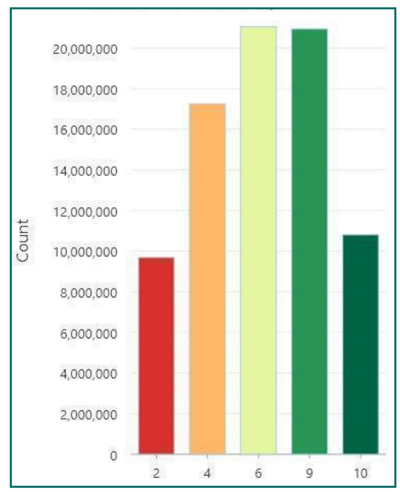
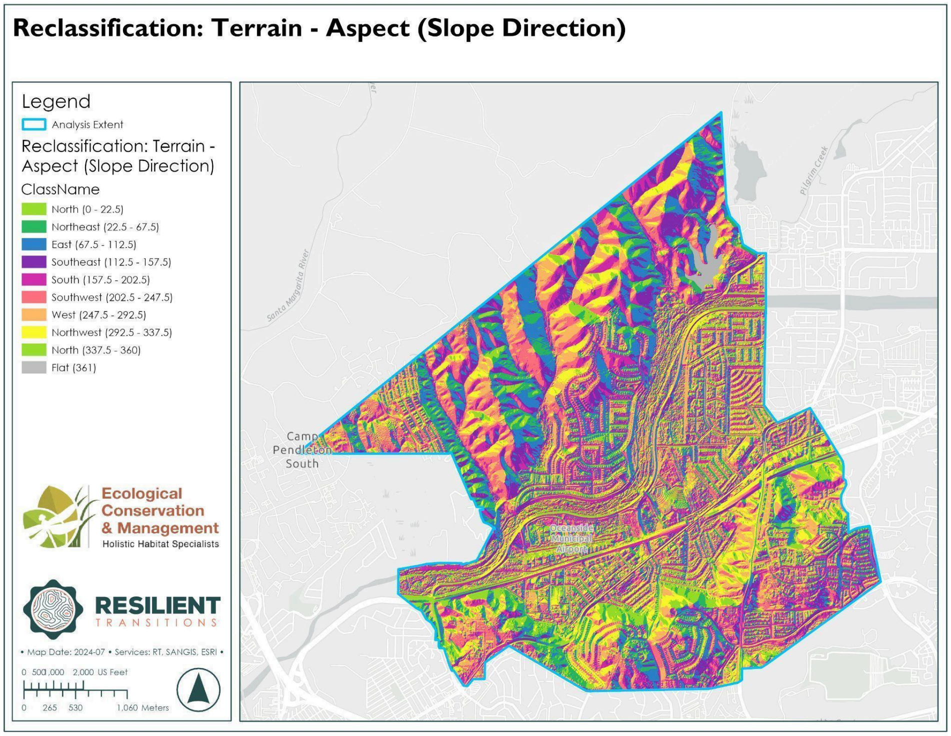
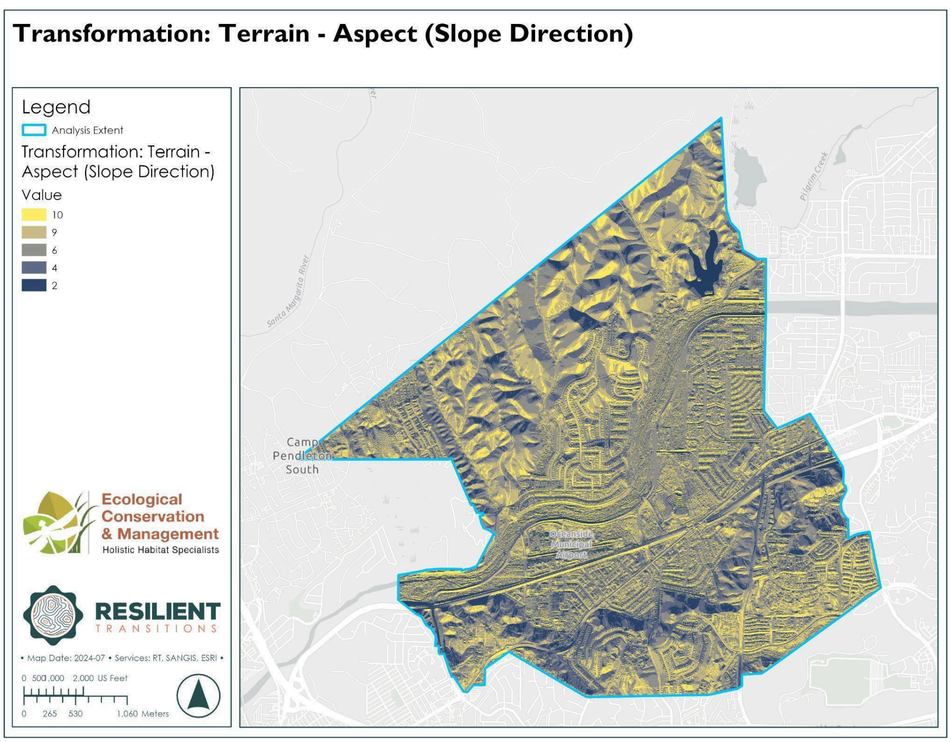


Table 6.4. Reclassification and Transformation scheme for Aspect (Slope Direction). The transformation figure on the right illustrates the count of cells that are binned in each of the final transformed value classes.

<u>Visualization of Reclassification and Transformation Scheme</u>:





Elevation

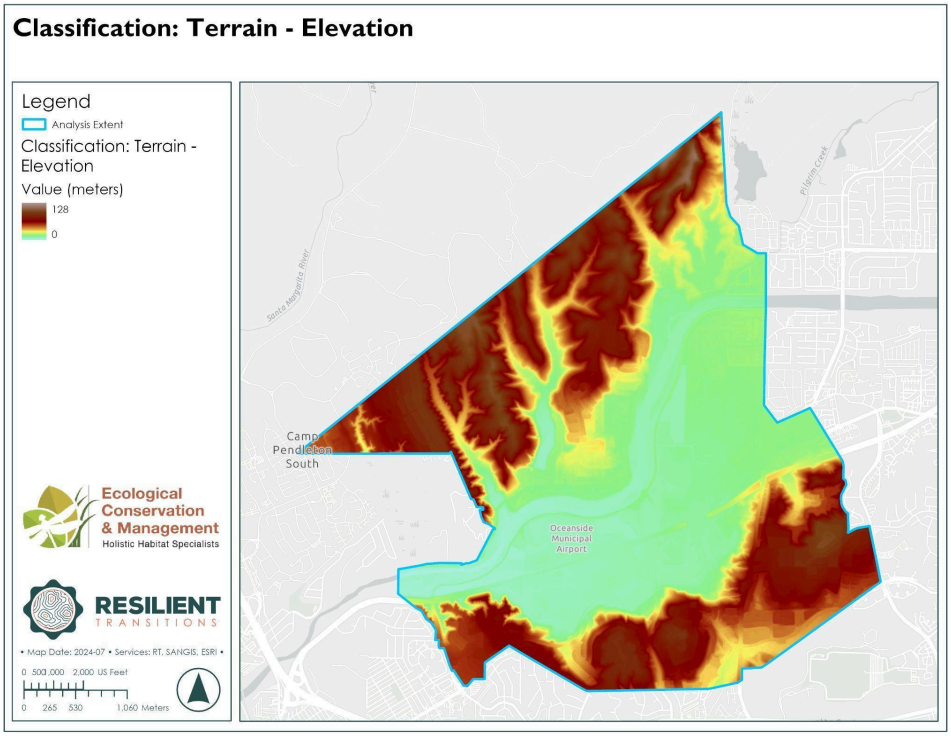
Model Base Weight: Excluded

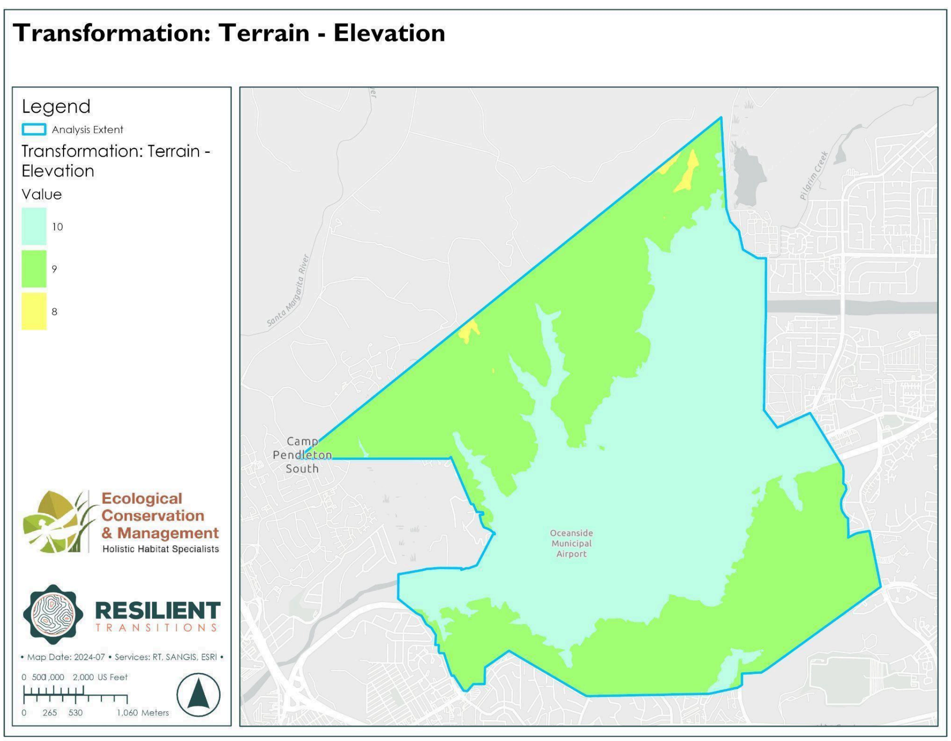
Variable Development: The input dataset for this variable is derived from the dynamic World Elevation Terrain service (ESRI 2024). We originally included this variable based on the literature review and we developed the following classification scheme. However, upon review our preliminary result revealed that 90 meters was the maximum elevation recorded within the study area, with 128 meters occurring in our analysis extent in the vicinity of Camp Pendleton.

Proposed Classification Scheme:

- 10: 0-30 meters (100 feet)
- 9: 30-100 meters (330 feet)
- 8: 100-200 meters (655 feet)
- 6: 200-300 meters (985 feet)
- 1: Above 300 meters (+985 feet)

Visualization of Reclassification and Transformation Scheme:





Proximity to Water

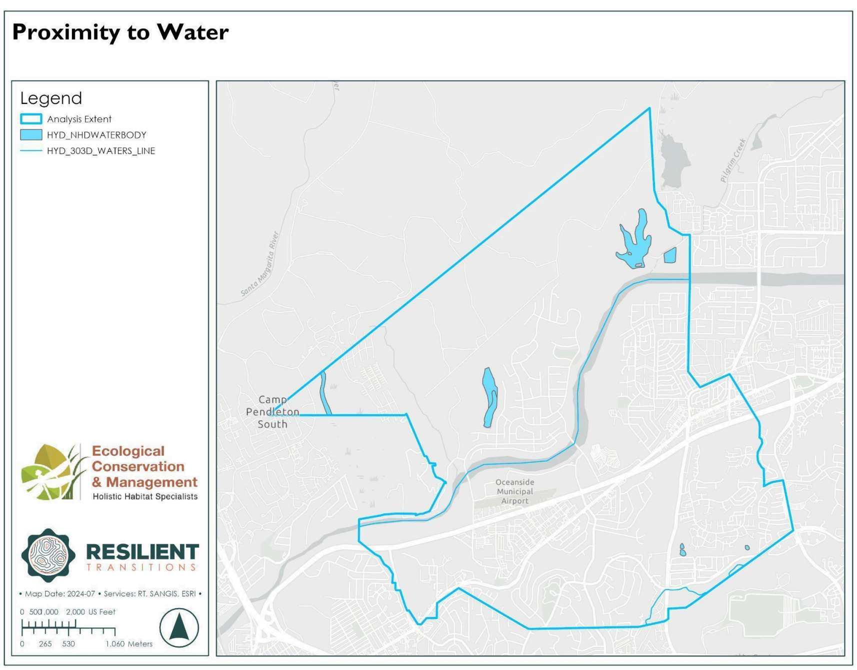
<u>Model Base Weight</u>: <u>Excluded</u>

<u>Variable Development</u>: The input dataset for this variable is derived from the National Hydrography Dataset and is sourced from SANGIS. We originally included this variable based on the literature review and we developed the following classification scheme. Our research indicated that proximity to water is important because it provides for riparian scrub and woodland plant communities that can be important to CAGN, especially as the green fringe near water bodies typically sustains during the hot summer months when preferred habitat is dormant. However, other literature substantiates that most water intake by CAGN is sourced from rain drops, dew on leaves, or intaken through their diet. This, combined with sufficient plant community data introduced to the model by the *Plant Community Type* variable, led us to eliminate this variable.

<u>Proposed Classification Scheme</u>:

- 10: 0-25 feet
- 9: 25-100 feet
- 6: 100-300 feet
- 4: 300-1000 feet
- 1: Greater than 1000 feet

<u>Visualization of Reclassification and Transformation Scheme</u>:



Fire History

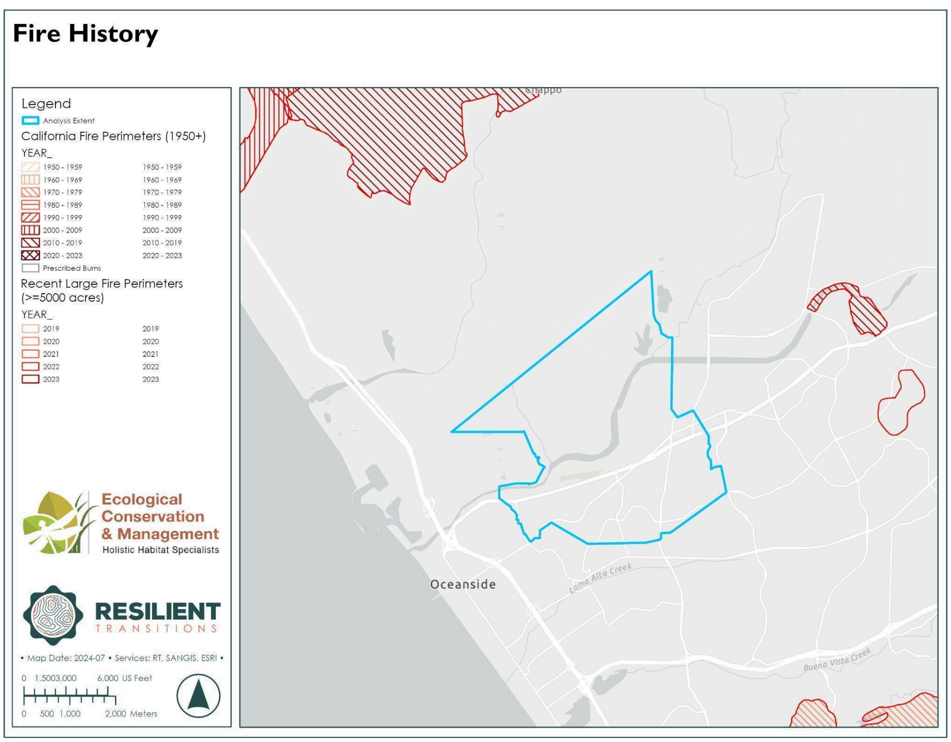
<u>Model Base Weight</u>: <u>Excluded</u>

<u>Variable Development</u>: The input dataset for this variable is derived from CALFIRE. Research suggests that fire history is a relevant input for CAGN habitat suitability model development because of the influence fire has on the successional stages of DCSS. We developed the following classification scheme for this variable. However, upon review of the preliminary results we identified that there have been zero fires from 1950-Present day within the analysis extent.

<u>Proposed Classification Scheme</u>:

- 10: Areas unburned in the past 10+ years
- 9: Areas unburned in the past 5-10 years
- 7: Areas unburned in the past 3-5 years
- 4: Areas burned 2-3 years ago
- 1: Areas burned 2 or less years ago

<u>Visualization of Reclassification and Transformation Scheme</u>:

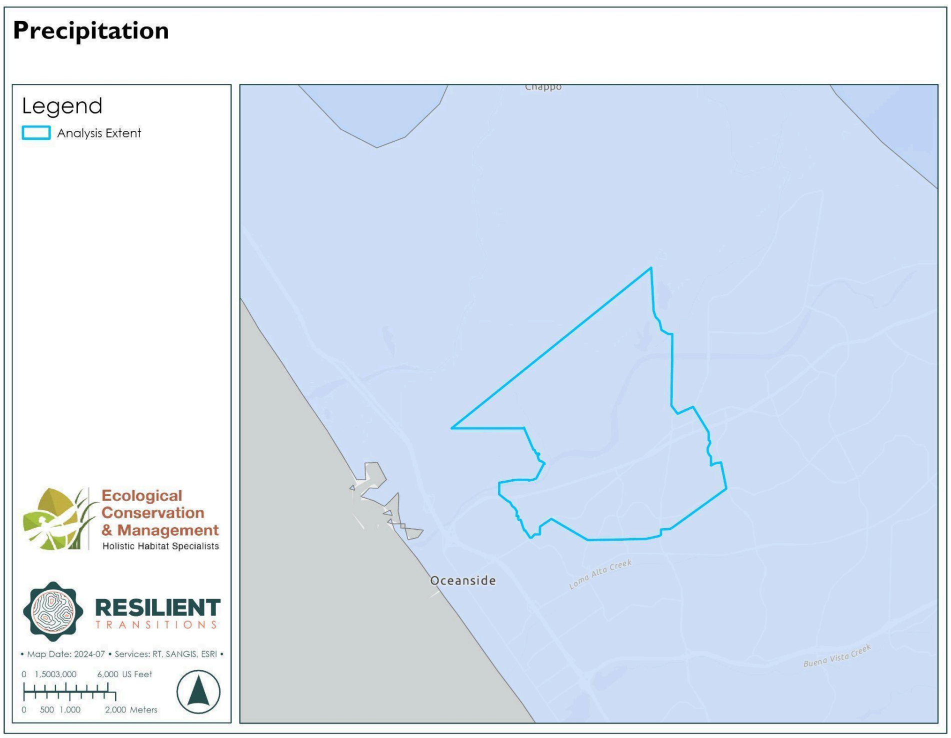


Climate Variables (Temperature and Precipitation)

Model Base Weight: Excluded

Variable Development: The input dataset for this variable as illustrated is sourced from the County of San Diego 30-year continuous precipitation record. This dataset was further cross referenced against the PRISM Climate Group at Oregon State University. However, upon review of the preliminary results for temperature and precipitation, we identified that there is little to no variation in precipitation nor temperature in our study area. Among the issues for this variable is that the most readily available weather station is at Oceanside Municipal Airport, the center of our study area. Alternatively, the PRISM dataset could be leveraged in a future, more comprehensive study over a larger geographic area.

Visualization of Reclassification and Transformation Scheme:



6.2 Detailed Model Criteria Weights Determination and Documentation of CAGN Suitability Model Symbology Documentation

In Appendix 6.2 we present a technical appendix to document the model criteria weights decision making process. In total we completed 17 iterations of the model before finalizing the highest performing model. In Appendix 6.2 we limit the presentation to a description of the first two rounds of iterations followed by more thorough documentation and supporting figures of the final round of iterations (3_0 - 3_6). We have also included documentation for the k-means clustering algorithm that was used to inform the symbology of the CAGN Suitability Model.

In total we performed 17 iterations of the model before finalizing the highest performing model. During the first 4 iterations (1_0-1_3) our analyst identified a selection of classification errors within the Land Use variable. We applied double loop learning to correct the erroneous codes, and then proceeded with the second round of iterations. During the second round of iterations (2_0-2_5) we identified issues with the Plant Community Type variable and the Slope variable which required us to revisit the transformed values and make adjustments. The Slope variable serves as an example. For Slopes, in the Variable Development description we intentionally included language for marginalized landscapes. Our research had identified slope preferences within CAGN habitat; however much of the stepping-stones that make up the Northern Connector are remnant pieces of land that have been spared from past development. One of the reasons for this is the presence of moderate to steep slopes within the coastal bluff system. Our field surveys and past CAGN monitoring survey corroborate that CAGN persist in this marginalized landscape. This manifested during the second round of iterations, and we elected to increase the transformed values for the classes of 10-22 degrees and 22-30 degrees to those final values listed in the reclassification and transformation scheme.

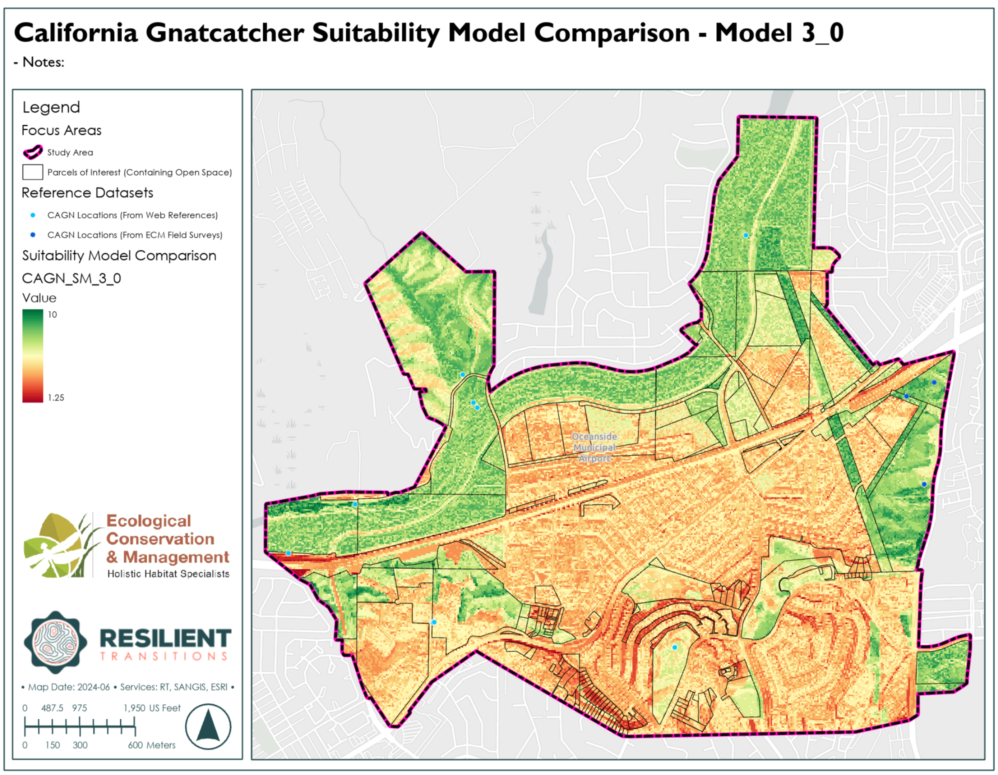
Next, we present the final round of iterations (3_0-3_6). Because qualitative habitat suitability model development is prone to subjective decision making, for each iteration, we have included the criteria weights used as well as the observational notes that led to changes and subsequent iterations. The CAGN Suitability Model iterations shown are produced on a scale of 1-10, with 1 (red) representing low suitability and 10 (green) representing high suitability.

Iteration Comparison: 3_0

1. Control model with uniform (equal) variable weights

Criteria Weights	
Plant Communities	25
Land Use	25
Slope	25
Aspect	25

2. Observational Notes:
    a. Histogram follows a bell curve: High quantity of medium values
    b. Higher slope and aspect weights lead to higher suitability index values in urbanized areas; This adds to the greater quantity of medium 'suitable habitat' detections.

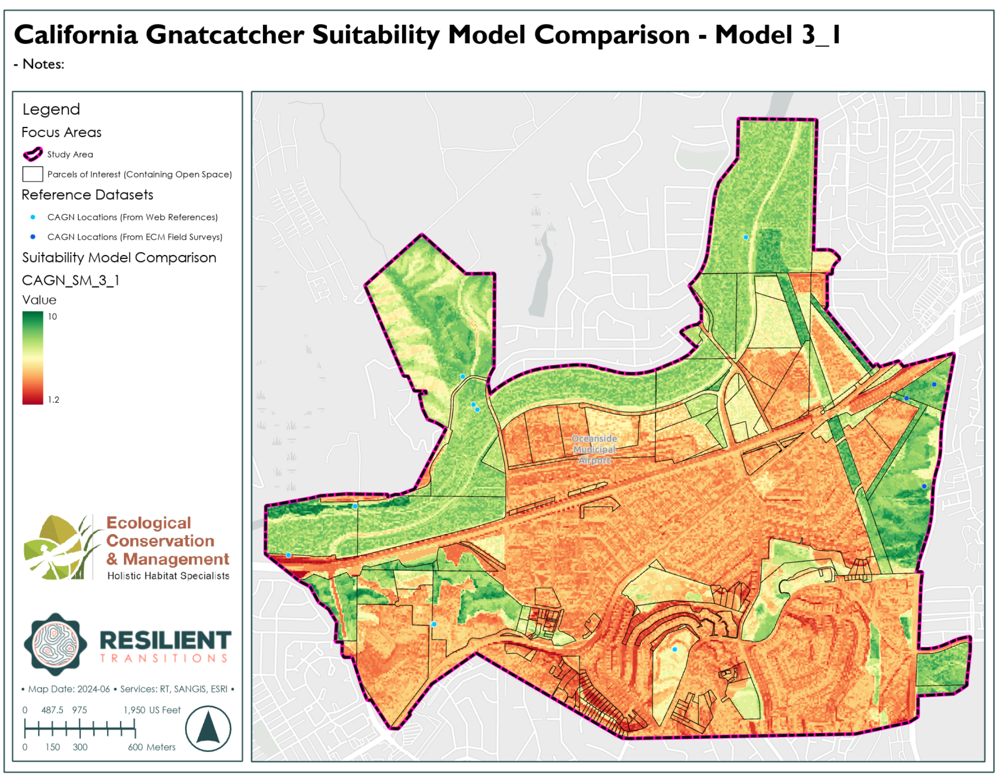


Iteration Comparison: 3_1 to 3_0

1. 3_1 model with informed variable weights (Base Model)

Criteria Weights	
Plant Communities	30
Land Use	30
Slope	20
Aspect	20

2. Observational Notes:
    a. Bimodal distribution is beginning to develop.
    b. Values in residential areas decrease
    c. High suitability values on urban recreational areas decrease
    d. Near SR-76/N Canyon Dr/Poplar Rd, the influence of steep slope values has diminished, leading to an increase in suitability score for steep slopes.
    e. Near SR-76/N Canyon Dr/Poplar Rd, influence of Aspect value is accurately defining higher suitability areas versus less suitable areas.

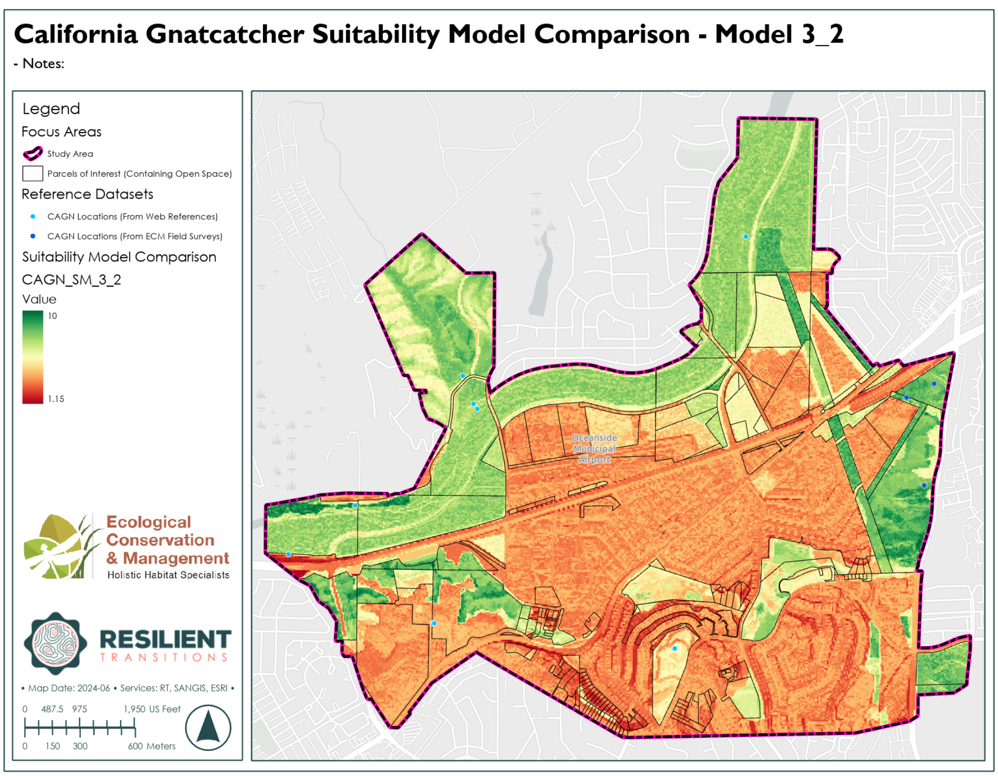


Iteration Comparison: 3_2 to 3_1

1. 3_2 model with informed variable weights

Criteria Weights	
Plant Communities	32.5
Land Use	32.5
Slope	20
Aspect	15

2. Observational Notes:
   a. Bimodal distribution converts to a flattened bell curve, but spread about the curve remains in two prominent peaks on either side of the mean.
   b. Values in residential areas continue to decrease, values in open space areas continue to increase. This is partially due to emphasis on Plant Community and Land Use categories, but also related to decrease in Aspect values.
   c. Decrease in Aspect value leads to more homogenized suitability values in open space areas (this is more pronounced than the increased influence of Plant Community and Land Use variables in the same area).

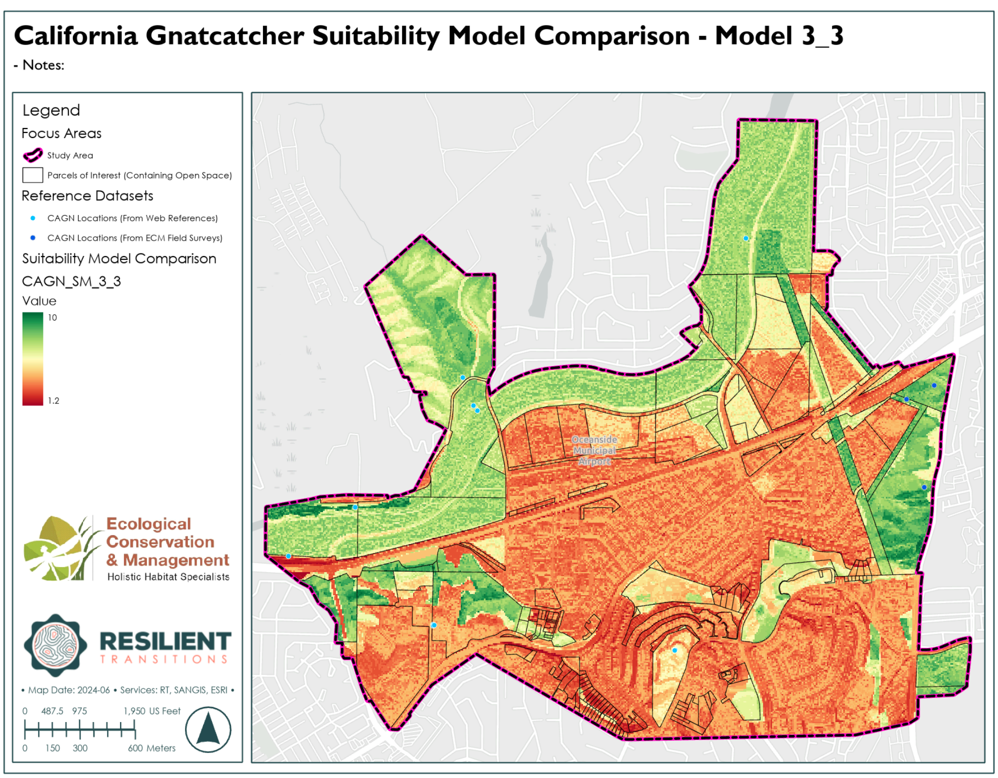


Iteration Comparison: 3_3 to 3_2

1. 3_3 model with informed variable weights

Criteria Weights	
Plant Communities	**32.5**
Land Use	**32.5**
Slope	**15**
Aspect	**20**

2. Observation Notes:
   a. This model iteration is included/intended to illustrate the tradeoff between high Slope weight and high Aspect weight.
      i. Ultimately, this is a comparison for why Slope=20/Aspect=15 as seen in Model 3_2 was chosen instead of Slope=15/Aspect=20.
   b. Similar Normal distribution to previous model.
   c. Values in 3_3 see an expected increase in the suitability score in locations with a favorable Aspect, but the trade-off for a decrease in the suitability of Slope representation is perhaps not worth it. This circumstance is highlighted well on the slopes straddling Canyon Dr near SR-76.

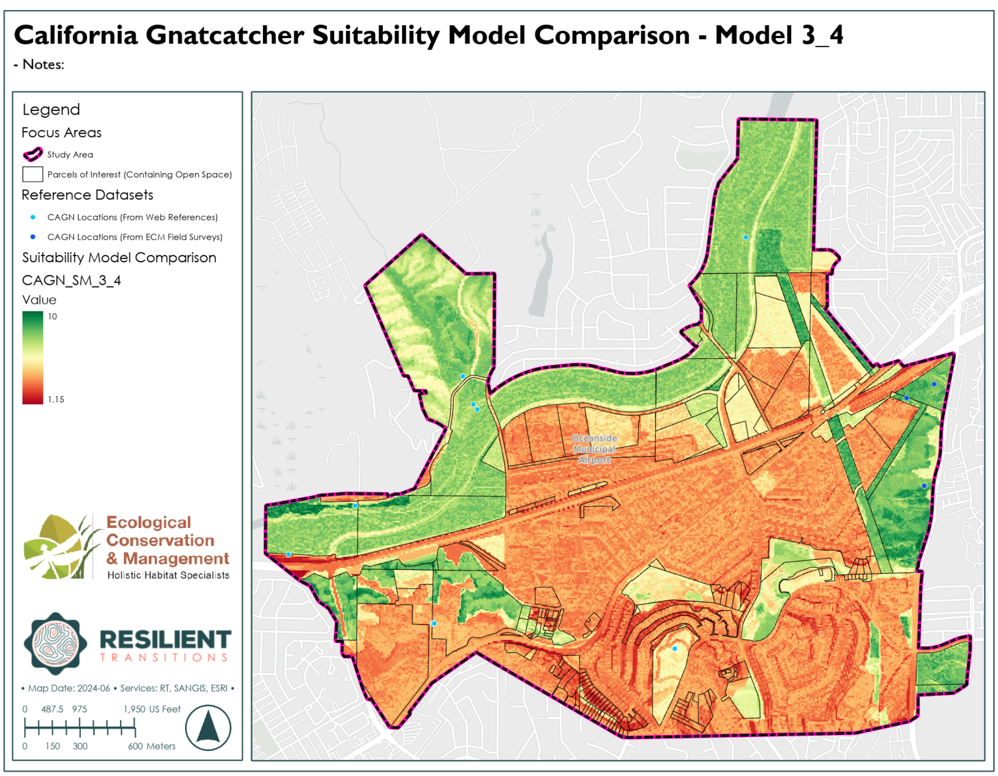


Iteration Comparison: 3_4 to 3_2

1. 3_4 model with informed variable weights

Criteria Weights	
Plant Communities	30
Land Use	35
Slope	20
Aspect	15

2. Observational Notes:
   a. Normal distribution with a flattened curve. Spread about the curve remains in two prominent peaks on either side of the mean. An almost uniform change across urbanized areas and open space areas.
   b. In parcels where patches of suitable habitat are intermixed with patches of unsuitable habitat, this model increases the amount of medium suitability scores by increasing the value of patches that previously were identified as unsuitable. The suitable habitat patches remain almost constant.
   c. Because the uniform change here is related to an increase in Land Use weight, we expect that the effect of this change in our parcels is less informative than a modification to Slope or Aspect weight could be.

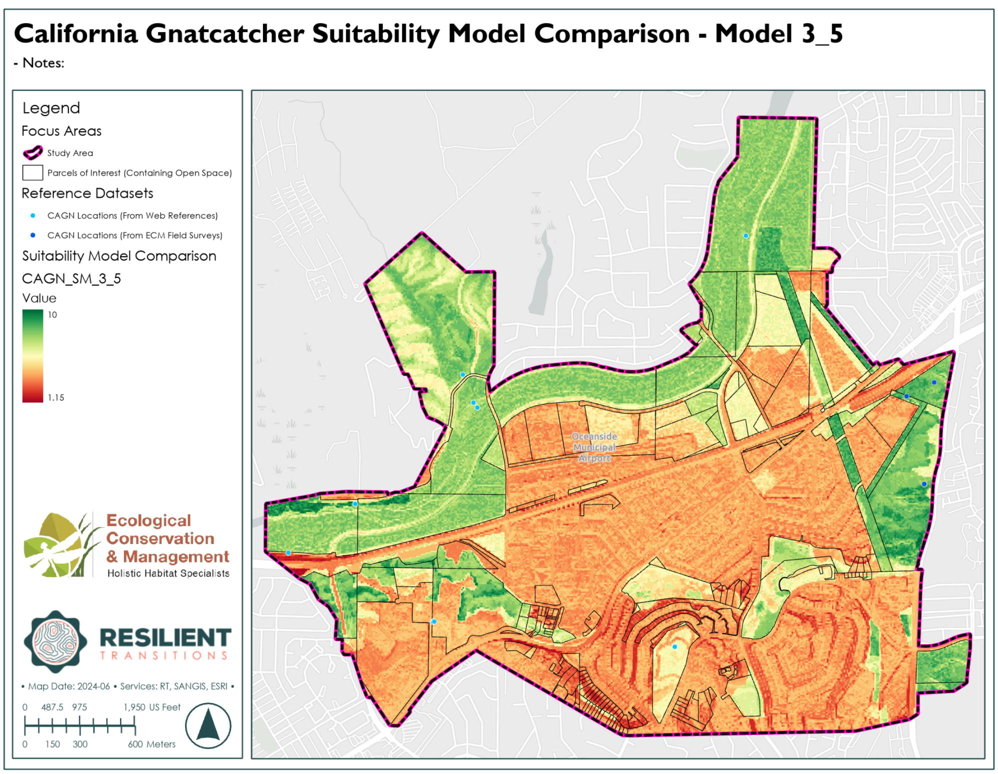


Iteration Comparison: 3_5 to 3_2

1. 3_5 model with informed variable weights

Criteria Weights	
Plant Communities	30
Land Use	32.5
Slope	22.5
Aspect	15

2. Observation Notes:
    a. Normal distribution with a flattened curve. Spread about the curve remains in two prominent peaks on either side of the mean. Two peaks shift right on the x-axis.
    b. Related to (a) above, it is assumed that the decrease emphasis on Land use as well as the increased emphasis on Slope uniformly improves the score of urbanized areas and has a less significant influence on open space areas.
    c. Increase in Slope value improves differentiation between suitable habitat and unsuitable habitat in open space areas (the boundaries are more clearly defined within a parcel).

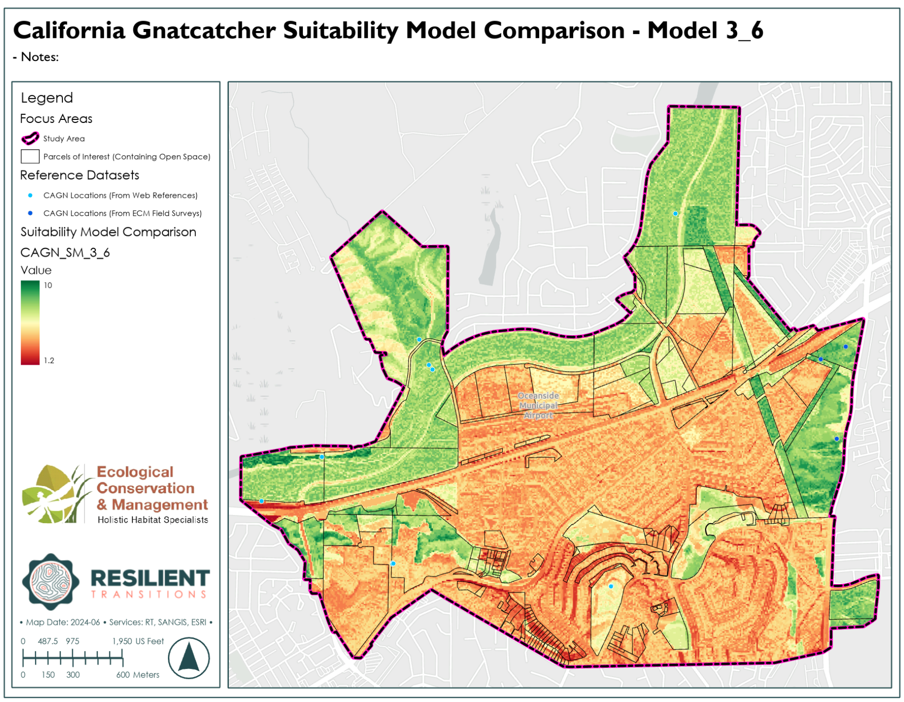


Iteration Comparison: 3_6 to 3_5

1. 3_6 model with informed variable weights

Criteria Weights	
Plant Communities	30
Land Use	27.5
Slope	22.5
Aspect	20

2. Observation Notes:
   a. Normal distribution with a flattened curve. Spread about the curve remains in two prominent peaks on either side of the mean, but distribution changes significantly.
      i. In the high suitability peak, the two high value bins reduce, and the values shift to normalize the high end of the bell curve. In the low suitability peak, values redistribute, with a large increase in the 4.8 bin, and separation forming between the 3.5 bin and 4.1 bin.
   b. Increases in the Slope and Aspect value again lead to an overall increase in the score of cells within urbanized areas. This appears to be an unintended consequence.
   c. Increase in the Slope and Aspect result in greater differentiation of suitable habitat and unsuitable habitat areas within open space parcels. Here, unsuitable areas in general are emphasized. The scores in areas with known suitable vegetation become more variable, with those in more suitable Aspect and more suitable Slope becoming pronounced.



Reinterpretation of Symbology for Final CAGN Habitat Suitability Model

This section regarding reinterpretation of final CAGN habitat suitability model symbology is included to mitigate the subjective influence of decision making on the final symbology. Throughout the iterative process we identified the value-added for increasing Slope and Aspect criteria weights, and the unintended consequence of increasing the overall suitability score of developed areas. Rather than representing the final model with a uniform spectrum of red to yellow to green, we instead applied a K-means cluster algorithm to inform the decision of final symbology. A K-means clustering algorithm identified three clusters of suitability, which were used to define a total of five suitability classes within our scale of 1 to 10. We adjusted the symbology for the final suitability model accordingly to better capture this final distribution of value clusters, and to improve the visual distinction between parcels containing suitable habitat for CAGN and those regions of the study area with unsuitable habitat.

The K-means clustering algorithm produced the following classes:

- Very Low Suitability: Values less than 2.265
- Low Suitability: Values between 2.265 and 4.245
- Medium Suitability: Values between 4.245 and 6.20
- High Suitability: Values between 6.20 and 7.80
- Very High Suitability: Values greater than 7.80

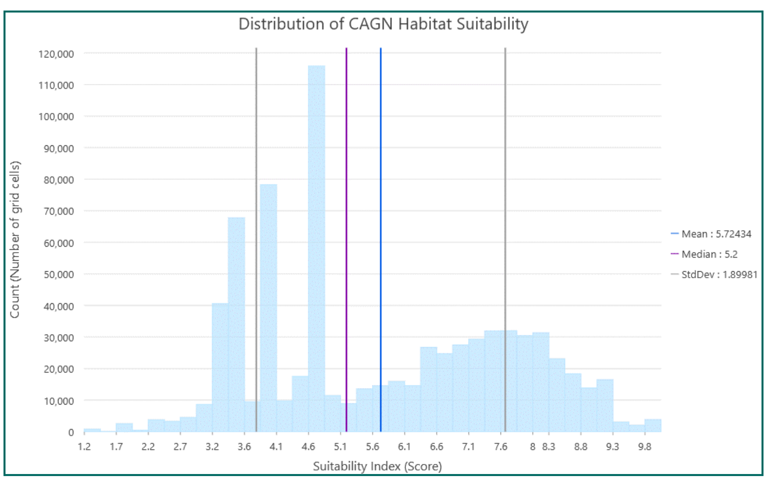


Figure 6.5 Histogram of Final Suitability Model (version 3_6). Minimum 1.2. Maximum 10. Mean 5.26. Std Dev 1.74. Median 4.625. Skewness 0.403. Kurtosis 2.043.

The initial symbology and final symbology are presented for visual comparison.

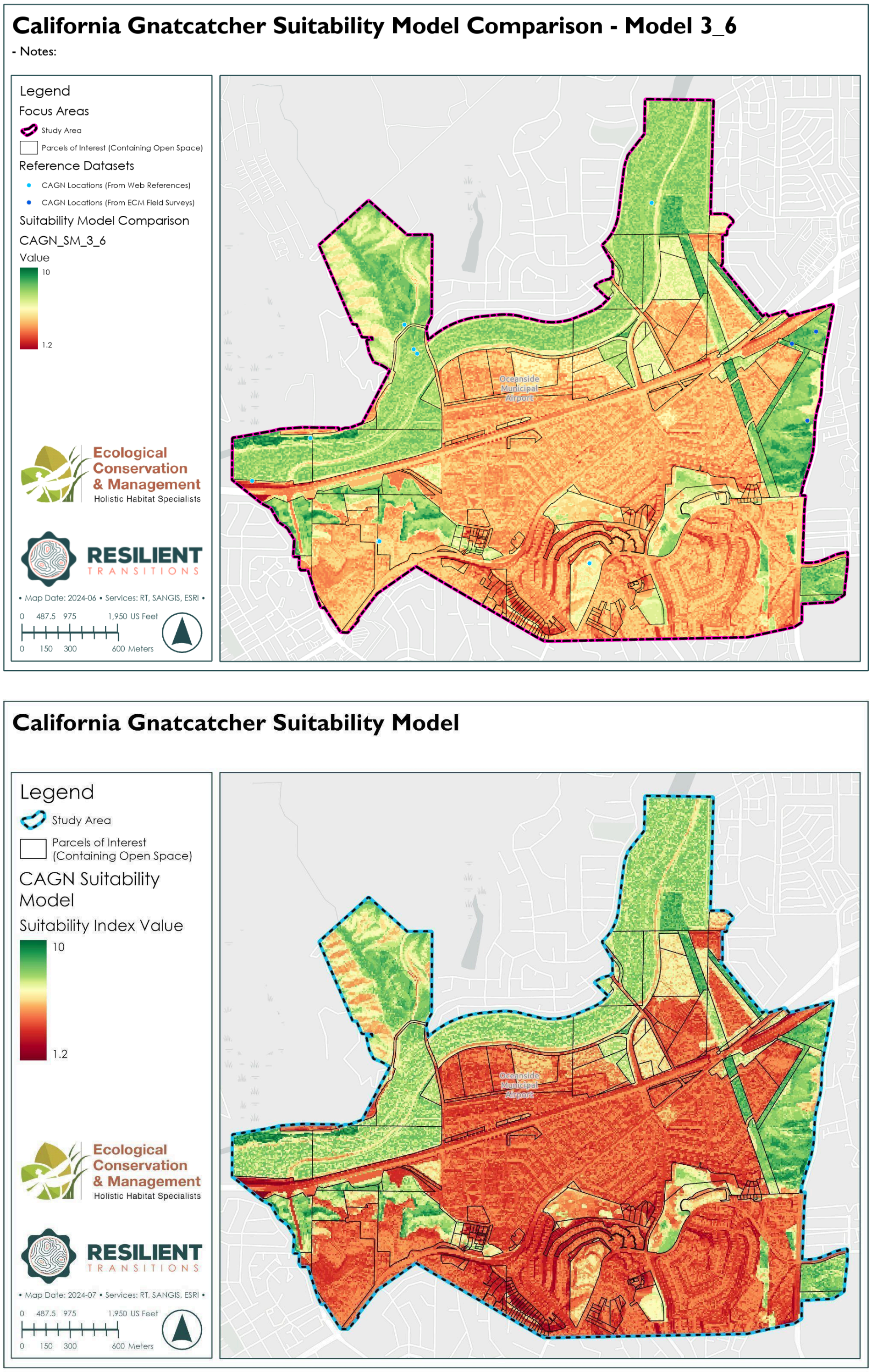


Figure 6.6. Visual Comparison of the unadjusted initial Model 3_6 symbology (top) and the informed final CAGN Suitability Model symbology (bottom). The initial symbology uses a simple green to red symbology whereas the final symbology is informed based on a k-means cluster algorithm.