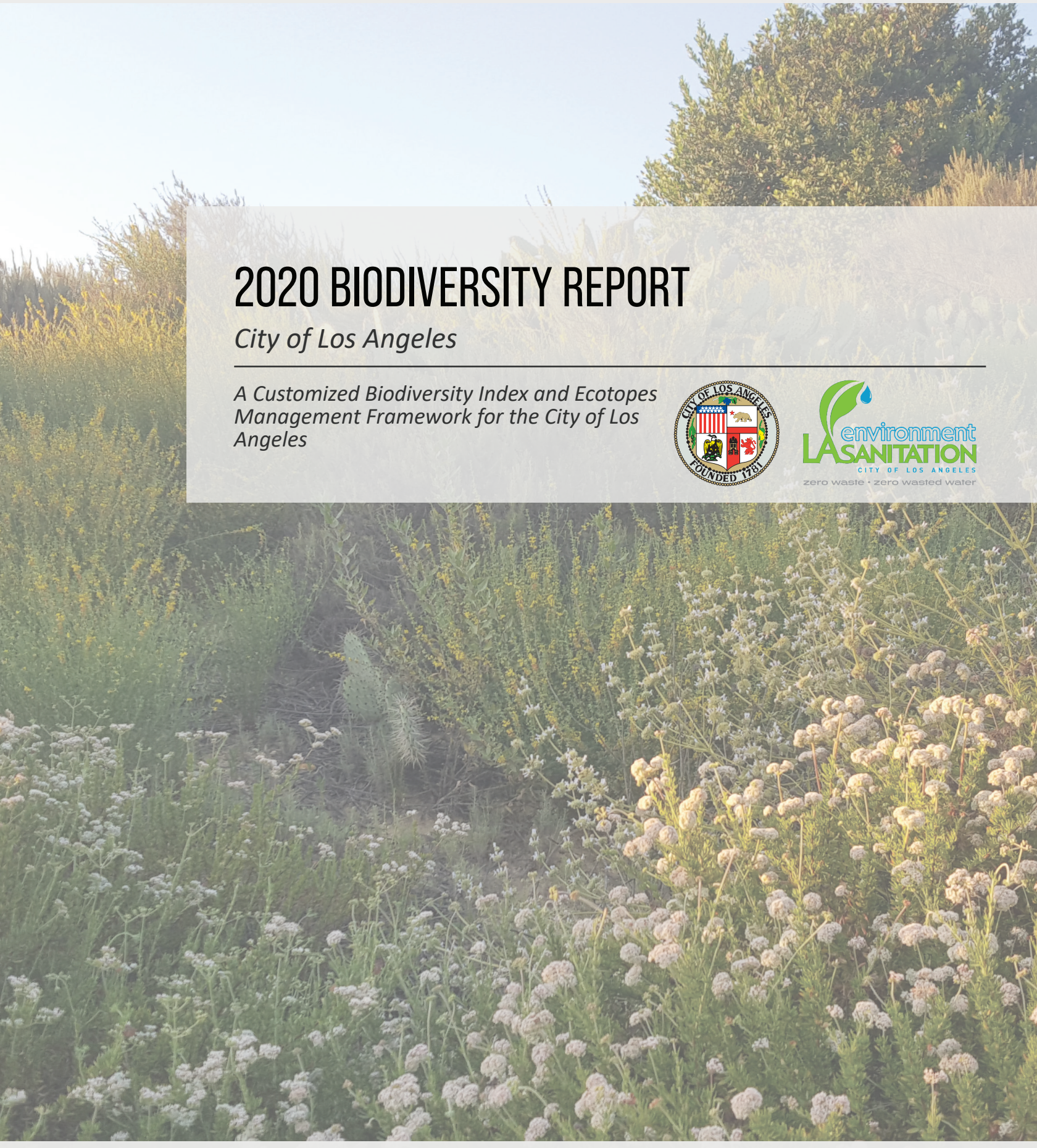

2020 BIODIVERSITY REPORT

City of Los Angeles

A Customized Biodiversity Index and Ecotopes Management Framework for the City of Los Angeles

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cover photo: coastal sage scrub restoration, Coyote Hills ecotope

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FOREWORD

LA Sanitation and Environment (LASAN) is proud to present the 2020 Biodiversity Report. We were very excited to tackle this project when Mayor Garcetti and the City Council requested that our Department lead the City's biodiversity efforts. Biodiversity in Los Angeles is globally significant and is a source of great pride for Angelenos. Biodiversity is also central to the sustainability and resilience of the City. Virtually every City Department has a role in protecting and enhancing biodiversity. I am pleased to see the program make strides to provide long-term protection and enhancement of the biodiversity within the City of Los Angeles.

At LASAN, biodiversity has come to mean something essential. LASAN's mission is to protect public health and the environment, and biodiversity is a true denominator of many, if not all, of LASAN's efforts toward this mission. This is because biodiversity health is one of the highest indicators of environmental quality – and of the health of any and all ecosystems. If we achieve this goal, and have biodiversity and healthy ecosystems in the City, then it is a sign that infrastructure is well integrated with built, natural, and social systems. We believe that there is a direct nexus between all of the work we do at LASAN and the health of our urban biodiversity in Los Angeles.

This report presents the framework for an LA-specific Biodiversity Index that will be used to measure the health of the urban ecosystem in Los Angeles. The LA Biodiversity Index is an extremely powerful tool and will help the City as a whole measure progress on environmental initiatives. Measuring the Index and institutionalizing biodiversity in City practices and policies will also help the City of LA meet an important goal set forth in LA's Green New Deal - "no-net loss" of biodiversity. It will also ensure that environmental and social justice are addressed, providing access to nature for all Angelenos. Every back- and front-yard, every open space, no matter how large or small it is, every greenway, every park and every parkway, every school ground, and definitely every waterway and every waterbody of our beautiful City is an open opportunity to enrich our urban biodiversity. Each one of these spaces is a component of an ecotope in the web of our urban ecosystem.

As the Director and General Manager of LASAN, I am thrilled that this project has provided LASAN the opportunity to work with respected scholars, professional experts, stakeholders, and other City Departments to gain important information and insight on LA's biodiversity. Through these efforts, the City has risen to the forefront of urban biodiversity research and laid the groundwork for leading-edge stewardship. LASAN is honored to continue advancing the vital topic of biodiversity for the benefit of the public and the environment. This work will be a reference for City policies as they develop for years to come.

After reading this report, we hope that you too recognize the nexus between your daily life and biodiversity.

Enrique C. Zaldivar, P.E.
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ACKNOWLEDGEMENTS

This report was prepared by the LASAN Biodiversity Team under the direction of Dr. Mas Dojiri, Assistant General Manager and Chief Scientist. LASAN team members Melinda Bartlett, Michelle Barton, Isaac Brown, Deborah Deets, Peggy Nguyen, and Doug Walters (Chief Sustainability Officer) were integral in shaping this document and informing the process. A special thank you to Stephanie Gee and Vincent Tran (LASAN) who assisted with mapping and modeling efforts.

This process was informed by Isaac Brown's doctoral research at the UCLA Institute of the Environment and Sustainability. Guidance was provided by Isaac Brown's doctoral committee members, which included Dr. Richard Ambrose, Dr. Thomas Gillespie, Dr. Mark Gold (currently California Natural Resources Agency), and Dr. Eric Strauss of Loyola Marymount University. Additional contributors from UCLA include: Dan Cooper, Dr. Ryan Harrigan, Dr. Casandra Rauser, Elizabeth Reid-Wainscoat, and Dr. Brad Schaffer.

Thank you to Mayor Eric Garcetti and LA City Councilmember Paul Koretz of Council District 5 (CD 5) for providing outstanding leadership in the field of urban biodiversity. CD 5, and in particular, Andy Shrader, provided vision and helped LASAN convene an outstanding Expert Council that contributed so much of their knowledge, time, and leadership toward this report and effort as a whole. Thank you to Liz Crosson, who has been a great advocate for biodiversity in the Mayor's Office.

Thank you to all Biodiversity Expert Council members who provided guidance on this effort. We'd also like to thank the City of Los Angeles Interdepartmental Biodiversity Team, which will be integral in measuring the LA Biodiversity Index moving forward. In particular, we'd like to extend a thank you to the Expert Council and Interdepartmental Team members who participated in the September 2018 LA Biodiversity Index workshop.

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EXECUTIVE SUMMARY

Acmon blue butterfly - *Icaricia acmon (Photo: Isaac Brown)*

EXECUTIVE SUMMARY

Los Angeles Sanitation and Environment (LASAN) is pleased to share the 2020 Los Angeles Biodiversity Report, the second such report produced on behalf of the City of Los Angeles (LA). This document builds upon the action items and concepts identified in the 2018 Biodiversity Report, which documented measurement of the Singapore Index on Cities' Biodiversity for Los Angeles, and contained recommendations for a customized LA City Biodiversity. This report presents 1) the resulting LA City Biodiversity Index, 2) the "ecotopes" spatial management framework, and 3) an approach for measuring urban habitat quality and connectivity in Los Angeles. It also includes a number of biodiversity case studies that serve as emerging models for biodiversity stewardship in Los Angeles.

Urban areas in cities worldwide are emerging as a new frontier for nature stewardship. While the State of California has long been a global leader in managing threatened and endangered species, the City of Los Angeles only recently embarked on a more comprehensive approach to biodiversity. On May 10, 2017, the LA City Council adopted the Biodiversity Motion introduced by Councilmember Paul Koretz of Council District 5 (Motion 25A, Council File No. 15-0499). The motion directed LASAN to develop a customized biodiversity index for the City of LA that would focus on conservation and access to nature and biodiversity in urban areas. The Biodiversity Motion coincides with the City's official goal of no-net biodiversity loss put forth in the 2015 Sustainable City pLAn, in LA's Green New Deal (2019 pLAn), and in biodiversity measures included in the City's General Plan (see Appendix A for full list of General Plan policies). In addition, the actions outlined in the motion will help the City achieve other important equity goals set forth in the Green New Deal, most notably the goal to improve the raw scores of CalEnviroScreen indicators of LA communities in the top 10% of scores by 50% by 2035. Together, the Green New Deal goals and Biodiversity Motion suggest that biodiversity in LA shall not only be protected, but that access to it should be equitable to maximize benefits and support urban resilience and livability.

This document is intended for City staff, science experts, and the general public. While the information presented in this document is somewhat technical in nature, the LASAN biodiversity team believes it is important for all residents of the City – particularly landscapers, planners, teachers, and students - to understand that biodiversity in Los Angeles is precious and that we can and must all take steps to protect, preserve, and enhance it in our gardens, schools, workplaces, and public areas.

LA CITY BIODIVERSITY INDEX - QUANTIFYING BIODIVERSITY PROTECTION AND ENHANCEMENT

In 2017, the LASAN Biodiversity team convened a transdisciplinary group of scholars, practitioners, and City staff to measure an established urban biodiversity index, the Singapore Index on Cities' Biodiversity, to provide a baseline measurement of biodiversity. The process also served as a starting point for creating a customized index for Los Angeles. Chapter 1 of this report shares the LA City Biodiversity Index and a proposed strategy for measurement and long-term application. The LA Biodiversity Index is tailored specifically to the Los Angeles context and is designed to monitor progress toward the no-net loss target. The LA City Biodiversity Index was crafted with the guidance of project stakeholders and an Expert Council of local practitioners, non-governmental organizations (NGOs), scholars, and City staff. It is intended to be institutionalized within municipal environmental management practices as a central tool in implementing a future LA Biodiversity Policy and guiding long-term management and monitoring of biodiversity stewardship. It includes three core themes of urban biodiversity: conservation of native biodiversity, social justice aspects of biodiversity, with a focus on equity, and governance and management activities (see Table E-1). As Los Angeles is home to a huge variety of native species, many of which are endemic to the region, the focus of the index, and particularly that of the first theme, is preserving and protecting native species. To an extent, the ecosystem services and value that non-native or introduced species provide is captured in the second theme, but the Expert Council and project team felt strongly that the index as a whole should focus on native species. The three themes are divided into eight indicators:

1.1 HABITAT QUALITY - Estimates the value of all landscapes in the City, including urban landscapes and natural areas, as potential habitats for native species.

1.2 INDICATOR SPECIES - Assesses the presence and distribution of species that are indicators of broader biodiversity.

1.3 THREATS TO BIODIVERSITY - Assesses the human-caused threats to native biodiversity from urbanization/land use, artificial night light, changes in wildfire frequency due to climate change, pollution, and invasive species.

2.1 ACCESS TO BIODIVERSITY - Assesses equity of access to nature, biodiversity, tree canopy, and landscapes.

2.2 EDUCATION - Evaluates educational programs and access to natural areas, biodiversity, and vegetated space on school campuses.

2.3 COMMUNITY ACTION - Evaluates biodiversity stewardship and engagement activities by members of the public.

3.1 GOVERNANCE - Evaluates City governance structure and policies with implications for biodiversity.

3.2 MANAGEMENT - Evaluates City management activities with implications for biodiversity emphasizing on-the-ground stewardship, management of invasive species, and management of threatened and endangered species.

The LASAN Biodiversity Team believes that these eight indicators are integral to the stewardship of biodiversity in the City of Los Angeles. The hope is that the metrics and indicators in the LA Biodiversity Index will capture a snapshot of the biodiversity actions taken by the City, engaged residents, educators, stakeholders. Further, the LASAN Biodiversity Team hopes that the design of the index will inspire City employees, policy-makers, and members of the public to take actions necessary to improve the scores of individual indicators and make progress on conservation efforts.

The LA City Biodiversity Index will be measured every three years, with major milestone measurements at 10-year intervals. The LASAN Biodiversity Team will perform index measurements with assistance from the Expert Council. LASAN's Biodiver-

Table E-1: City of Los Angeles Biodiversity Index

Theme	Indicator CODE	Indicators	Metric CODE	Metrics
1. Native Species Protection & Enhancement	1.1	Habitat Quality	1.1a	1.1a: % Natural Areas
			1.1b	Habitat Quality of Urban Landscapes & Open Space
			1.1c	Habitat Quality of Streams
			1.1d	Connectivity of Natural Areas
			1.1e	Connectivity of Urban Landscapes & Open Space
			1.1f	Connectivity of Streams and Riparian Areas
	1.2	Indicator Species	1.2a	% Open Space with Charismatic Umbrella Species
			1.2b	Native Species Presence in Urban Areas
			1.2c	Species of Conservation Conern Gained or Lost
	1.3	Threats to Native Biodiversity	1.3a	Urban Edge Effects on Natural Areas
			1.3b	Presence & Spread of Invasive Plants
			1.3c	Wildfire Frequency Departure from Natural
2. Social Equity Considerations & Biodiversity	2.1	Access to Biodiversity	2.1a	Access to Natural Areas
			2.1b	Neighborhood Landscape/Tree Canopy Footprint
	2.2	Education	2.2a	School (K-12) Biodiversity Topics
			2.2b	Off-Campus Biodiversity Educational Visits
			2.2c	Campus Nature Education Gardens/Areas
	2.3	Community Action	2.3a	Community Scientist Activities and App Utilization
			2.3b	# Certified Biodiversity-Friendly Areas
3. Governance & Management of Biodiversity	3.1	Governance	3.1a	Biodiversity Vision/Action Plan
			3.1b	% Departments with Biodiversity Programs & Policies
	3.2	Management	3.2a	% Protected Natural Areas
			3.2b	Protected Natural Areas Management and Monitoring
			3.2c	Management of Invasive Species & Pests
			3.2d	Management of Threatened, Endangered, & Species of Concern

sity Team will also coordinate with the Expert Council to refine methodologies, as needed, for new metrics (i.e., metrics not included in the Singapore Index). LASAN will publish the final metrics, along with detailed methodology, and benchmark and monitoring scoring thresholds after the first measurement of the LA Index is complete. It is anticipated that at that time, LASAN will release a report, similar to the 2018 Biodiversity Report, that contains individual metric scores, detailed methodology, and management implications and recommendations for all 25 metrics.

In the future, the LA Biodiversity Index composite score, as well as the scores of individual metrics, will provide a succinct update to elected officials and key decision makers about the progress being made on biodiversity issues. Scores can be used to direct actions and funding at the City level to ensure that sufficient progress is being made towards the no-net loss and social goals. Scores can also be used to encourage stakeholders and members of the general public to engage with biodiversity issues and take personal actions like becoming community scientists and uploading photos of biodiversity to iNaturalist or certifying their gardens as wildlife habitat.

While many of the indicators can be measured using existing data, additional data is needed to provide a full measurement of the proposed LA City Biodiversity Index. In order to advance biodiversity concepts, and increase the protection of native species, additional data, research, and funding is needed. Continued collaboration with outside academics, non-profits, and experts on biodiversity-related topics will be needed to gather important data (e.g., observations of indicator species) or to fill existing data/knowledge gaps (e.g., creating comprehensive, dynamic databases of school campus gardens/habitats). Further, funding will be necessary to expand biodiversity research, fill data gaps, and conduct relevant studies. There is substantial interest in the topic of urban biodiversity and new funding streams are emerging. City budget items that protect and enhance biodiversity, expand equitable access to natural resources, and increase the capacity of local government to inventory and manage existing biodiversity should be prioritized. In addition, State and Federal grants to support biodiversity work in the City of Los Angeles should be pursued.

ECOTOPES - BIODIVERSITY AND URBAN ECOSYSTEM MANAGEMENT UNITS AND DATABASE

In 2018, each indicator in the Singapore Index was measured City-wide. However, with over 300,000 acres (121,000 hectares) of extremely diverse ecological conditions, the Expert Council felt a mechanism was needed to better account for the distribution and variation of biodiversity across the City. To address this, the LASAN Biodiversity Team created a framework of ecological subregions called ecotopes. Ecotopes combine landform, microclimate, and biotic characteristics, key building blocks of biodiversity, to divide the city into discrete spatial units. These discrete units are well-suited for measuring and reporting on biodiversity matters, and will help tailor actions to specific areas of the City. Ecotopes are also envisioned as future management units to address biodiversity and related urban ecosystem stewardship topics of ecosystem services, pollution, and ecological hazards. Habitat conservation, restoration, and connectivity planning should be assessed within individual ecotopes to better inform City-wide and regional conservation work. The ecotopes framework will be integrated with the LA Biodiversity Index, and many metrics will be assessed by ecotope. The ecotopes framework is accompanied by a high-resolution dataset of environmental factors relevant to biodiversity stewardship and site-level decision making. The dataset will be made available to practitioners and the public at-large to support management decisions (e.g., urban landscape design for biodiversity) and to maximize site urban ecosystem services (e.g., stormwater management, urban heat island reduction, and sea level rise). Chapter 2 summarizes the theoretical basis and methods for selecting and partitioning 17 subregional ecotopes within the City of Los Angeles and 10 additional related ecotopes within neighboring areas (see Figure E-1). Detailed descriptions and maps for each ecotope are included in Appendix B.

MEASURING URBAN HABITAT QUALITY AND CONNECTIVITY IN LOS ANGELES

Chapter 3 presents measurement methods, results, and stewardship implications associated with two key indicators of the LA Biodiversity Index: habitat quality and connectivity. While habitat connectivity is often mentioned as a key tool for conserving urban biodiversity, spatially explicit measurements of connectivity are often lacking for cities. This chapter presents an application of leading edge modeling techniques to provide a quantitative, spatial valuation of urban habitat quality for the City of Los Angeles and surrounding areas, and connectivity modeling for native biodiversity in the Elysian Valley that can serve as a pilot approach for addressing connectivity more broadly across the City. The results have implications for both urban habitat conservation and equitable access to urban nature, two key objectives of the Biodiversity Motion and no-net loss biodiversity target. The maps also provide a roadmap for incorporating biodiversity stewardship considerations into urban and landscape design, planning, and management. Researchers, policymakers, and stakeholders can use the maps to identify areas of the City that would benefit the most from conservation actions and use them to implement meaningful changes to increase habitat quality and connectivity.

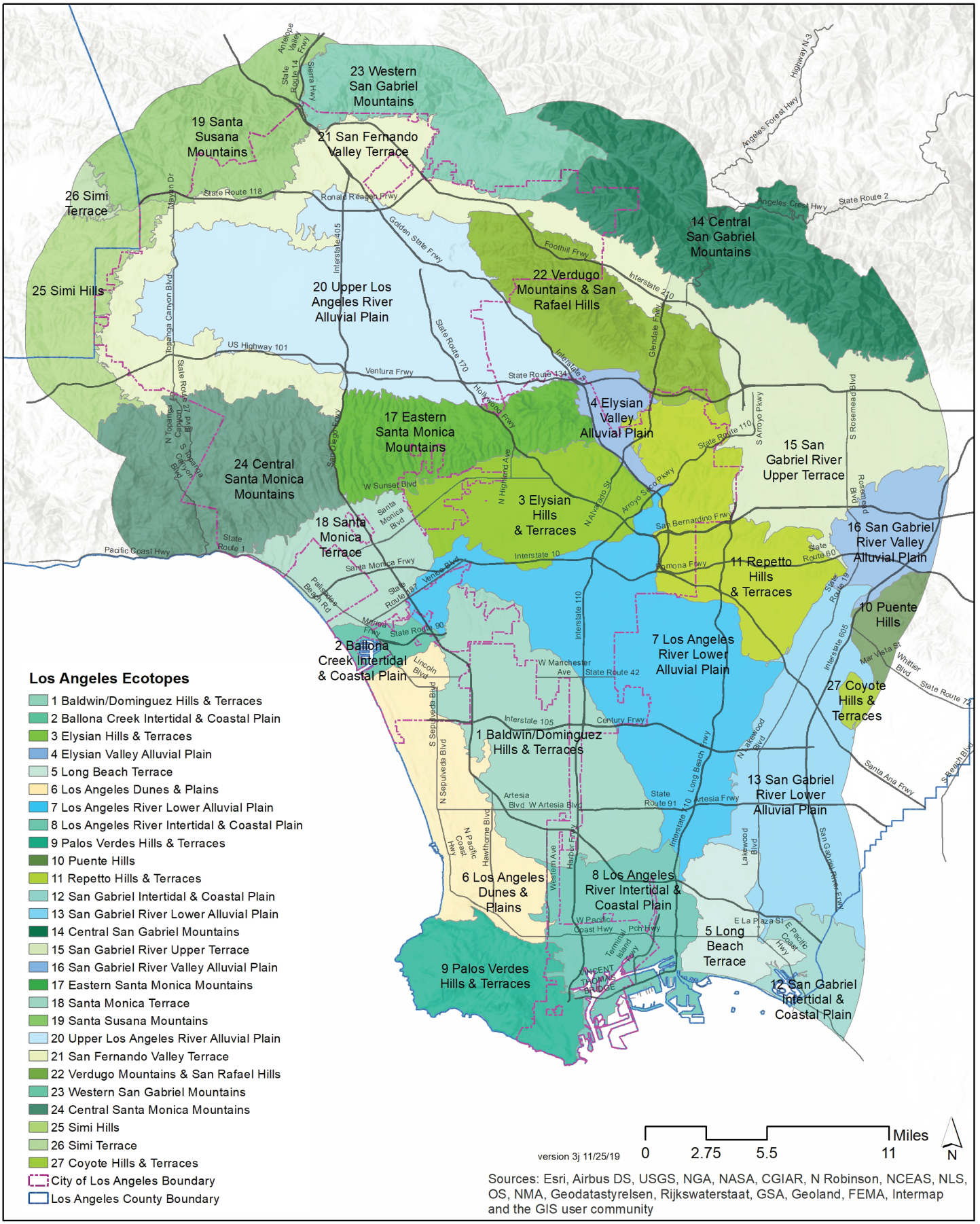


Figure E-1: Los Angeles Ecotopes

URBAN BIODIVERSITY CASE STUDIES

The final chapter, Chapter 4, includes a series of case studies that demonstrate how the concepts of biodiversity protection and enhancement are changing the way we manage and steward nature in City projects. These include:

CASE STUDY 1: A biodiversity stewardship pilot project at the neighborhood-scale led by the Greater Wilshire Neighborhood Council in conjunction with the National Wildlife Federation;

CASE STUDY 2: The Wildlife Pilot Study project in the Eastern Santa Monica Mountains led by the Department of City Planning;

CASE STUDY 3: Biodiversity considerations in the G2/Taylor Yard park design project along the LA River by the Bureau of Engineering;

CASE STUDY 4: Incorporation of biodiversity considerations into a water quality project at MacArthur Park led by LASAN;

CASE STUDY 5: A native fish passage project within the LA River led by the Bureau of Engineering and Mayor's Office with support from the consulting firm, Stillwater Sciences;

CASE STUDY 6: A research study that used historic records to develop a map of hypothesized natural vegetation in the Los Angeles River Watershed.

These projects provide early examples of how the concepts of biodiversity protection and enhancement are reshaping the way projects are being crafted in the City of LA and the increased benefits they are providing for both nature and neighborhoods. They also demonstrate the potential and need for the analytic tools presented in this report, and others, to guide and measure protection and enhancement of biodiversity in LA.

SUMMARY AND NEXT STEPS

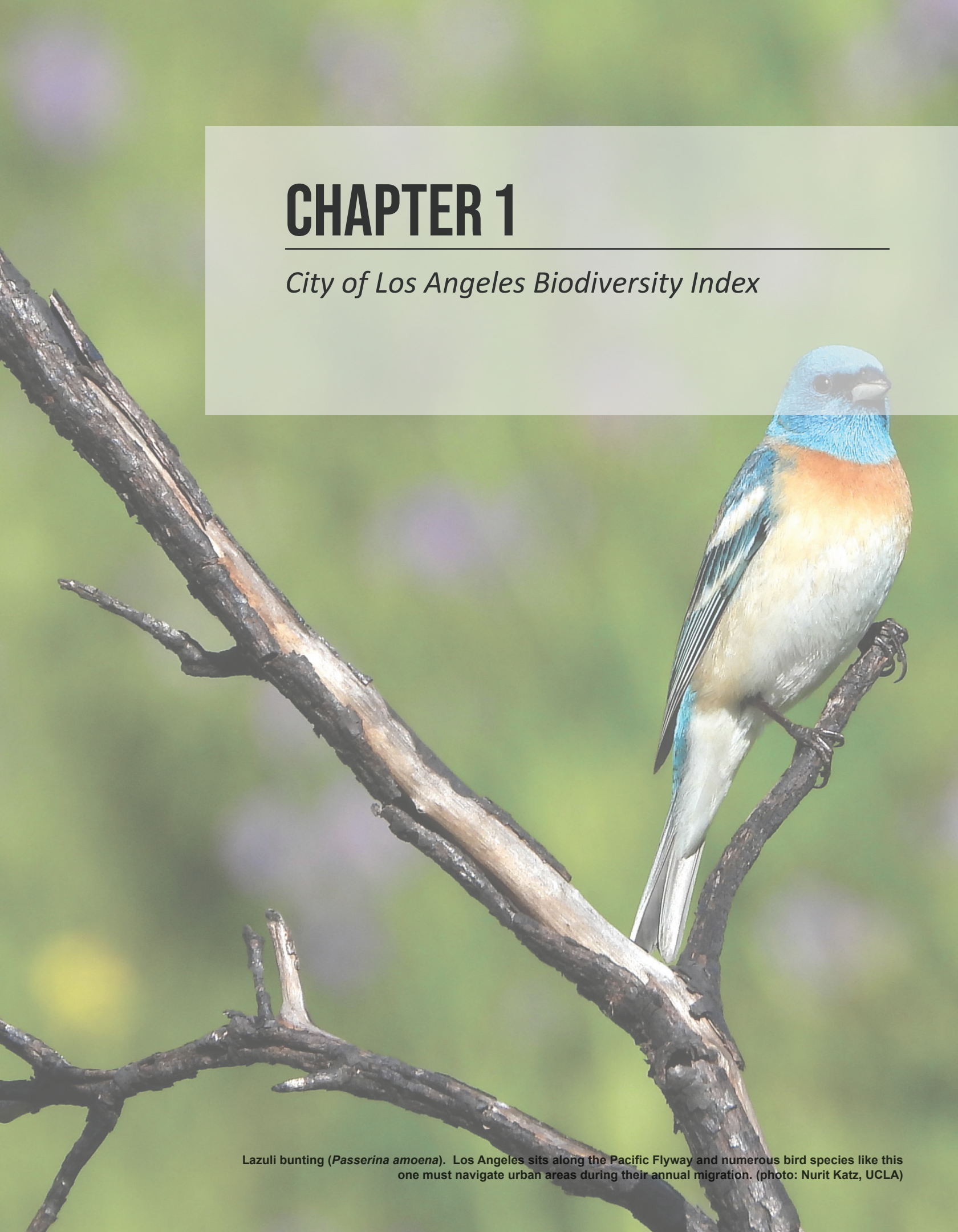
Change in cities is often rapid, and the potential to protect and enhance urban biodiversity is immense. Cities like LA are just beginning to formally address urban ecology comprehensively, and rapid expansion of stewardship is necessary to accommodate urgent climate-driven changes to urban ecosystems. Along with stewardship of ecosystem services, ecological hazards, and pollution, biodiversity stewardship is central to cities' ability to provide urban forest cooling benefits, accommodate changing flood regimes, maintain equitable nature access, and conserve species within fragmented urban landscapes. The City's biodiversity work is regenerative, aiming not only to prevent further loss of species, but to improve ecological integrity conditions through specific human activities and actions.

The LA City Biodiversity Index and ecotopes framework are two key tools to help LA gauge progress and guide stewardship toward no-net loss of biodiversity and urban ecosystem health. They also support the development of a comprehensive biodiversity policy and additional site-level decision support tools that are important next steps for this effort. By using these tools as the basis for an effective urban biodiversity stewardship program, LA will not only support achieving resilience and sustainability in the face of the climate crisis, but will leverage ecology and biodiversity to support the next generation of urban enrichment.

In the future, the City's efforts to protect biodiversity will be enhanced dramatically through meaningful collaboration with regional, state, and federal agencies that work on biodiversity issues, including, but not limited to, Los Angeles County, the California Department of Fish & Wildlife, the U.S. Department of Fish & Wildlife, the National Marine Fisheries Service, the U.S. Army Corps of Engineers, and the Regional Water Quality Control Board. Broader regional or statewide biodiversity efforts and action plans are essential to ensure funding and meaningful implementation of biodiversity conservation efforts.

CHAPTER 1

City of Los Angeles Biodiversity Index



Lazuli bunting (***Passerina amoena***). Los Angeles sits along the Pacific Flyway and numerous bird species like this one must navigate urban areas during their annual migration. (photo: Nurit Katz, UCLA)

CHAPTER 1: CITY OF LOS ANGELES BIODIVERSITY INDEX

INTRODUCTION

Cities worldwide are expanding efforts to protect and enhance urban biodiversity and there are now over 250 municipalities with urban biodiversity plans or reports (Urban Biodiversity Hub, 2019). These efforts are urgently needed considering recent studies estimating that over one million species are threatened with extinction, many within decades, as a result of climate change, pollution, and urban expansion (IPBES, 2019). Biodiversity is also increasingly viewed as a social equity concern in cities like Los Angeles where many communities lack access to nature and the benefits it provides within their neighborhoods. Thus, conservation of native biodiversity and equitable access to nature are two central components of many emerging urban biodiversity strategies.

Los Angeles lies within a designated "global biodiversity hotspot," one of only 36 in the world. This designation means that biodiversity is both highly concentrated and highly threatened in LA. Cities in biodiversity hotspots often have high numbers of legally protected species, but also high rates of extirpation. The City of Los Angeles is home to more than 37 plant and animal species listed as threatened or endangered, and an unknown number of species that have been extirpated within its boundary (City of Los Angeles, 2006). Biodiversity in these urban hotspots is often disconnected into fragmented habitat patches of insufficient size to ensure viable populations or ecosystem processes (see Figure 4-1.) Climate change and continued urban growth, through both infill development and expansion of cities into adjacent lands, will place increasing pressure on these remaining habitats.

While cities across California have long been global leaders in protecting threatened and endangered species, Los Angeles only recently embarked on a more comprehensive approach to biodiversity when the Los Angeles City Council passed the May 10th, 2017, Biodiversity Motion CF#15-0499 (the Motion), authored by City Councilmember Paul Koretz. The Motion directed Los Angeles Sanitation and Environment (LASAN) to work with other relevant City departments to develop a customized biodiversity index focused on conservation and access to biodiversity. The motion was in line with Mayor Eric Garcetti's 2015 Sustainable pLAn goal of no-net biodiversity loss. In addition, the motion would help the City achieve other important social equity goals set forth in the Green New Deal, most notably improving the raw scores of CalEnviroScreen indicators in LA communities in the top 10% by 50% by 2035. It is an accepted best practice in many cities worldwide to address such specific environmental performance targets by creating scientifically defensible and verifiable tools to measure target achievement. Indices are one approach to measuring performance of broad topics, such as biodiversity, and are useful for tracking comprehensive change over time, monitoring the results of diverse policy actions, and improving scientific understanding of environmental processes addressed. However, to successfully create and implement an index within a large city, buy-in from local environmental leaders and stakeholders is essential. Public outreach and education on biodiversity in general, and on the LA City Biodiversity Index, will be key to success.

The Motion directed LASAN to model the biodiversity index after the internationally established biodiversity index, the Singapore Index on Cities' Biodiversity. The Singapore Index is a tool to help cities address biodiversity in comprehensive and quantifiable ways, and to support urban biodiversity research and decision making. The LASAN team chose to measure the established Singapore Index on Cities' Biodiversity (Singapore Index) in 2017 as a first step toward consensus around the customized LA Biodiversity Index (see 2018 City of LA Biodiversity Report).

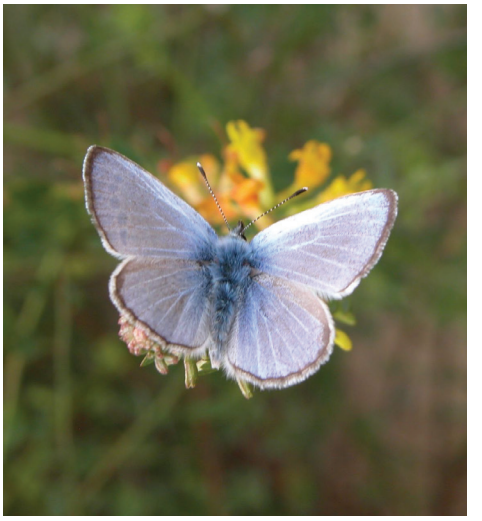
This chapter presents a summary of the initial Singapore Index measurement process and considerations that inform the LA Biodiversity Index. It concludes with the proposed LA Biodiversity Index, preliminary indicator measurement methods for the Index, and an application strategy. To ensure the effectiveness, defensibility, and applicability of the Index, the process was strategically collaborative, including local stakeholders, scholars, professionals, and end users, in addition to published literature, to inform the Index format. Such "transdisciplinary" processes can lead to highly effective integration of new and existing actionable science in applied project contexts.

The Los Angeles City Biodiversity Index is designed to measure indicators, such as threats to native biodiversity, that will demonstrate progress toward the no-net loss target and provide a framework for a future LA Biodiversity Action Plan and Policy. Due to the tailoring of many of the indicators around local biodiversity performance targets, laws and policies, dataset availability and characteristics, and ecological conditions, the Index is most directly applicable in and around the City of Los Angeles and Los Angeles County, and in cities across California with relatively minor modifications for local context.

Ridgway's rail - *Rallus obsoletus* (Photo: © Jesse Rorabaugh https://www.inaturalist.org/photos/2899643)

San Diego horned lizard - *Phrynosoma coronatum* (photo: by Isaac Brown)

Southern California steelhead - *Oncorhynchus mykiss* (photo: Mike Weir)



Palos Verdes blue - *Glaucopsyche lygdamus ssp. palosverdesensis* (photo: © Travis Longcore) http://www.inaturalist.org/photos/729282

Coastal California gnatcatcher - *Polioptila californica californica* (Photo:© Jon Sullivan https://www.inaturalist.org/observations/3813868)

Mountain lion P-64 - *Puma concolor* (photo: National Park Service)

Burrowing owl - *Athene cunicularia* (photo: Smithsonian Institute)

Yellow-billed cuckoo - *Coccyzus americanus* (photo: Tom Vezo)

Red-legged frog - *Rana draytonii* (Photo: © Ken-ichi Ueda https://www.inaturalist.org/photos/23031186)

Two-striped garter snake – *Thamnophis hammondii* (Photo: © Chris Brown https://www.inaturalist.org/photos/32474031)

Figure 1-1: Example fauna of conservation concern associated with the City of Los Angeles.

Application within other Mediterranean regions, and beyond, would require increasing amounts of tailoring for context. However, the LA Biodiversity Index, and the associated implementation process presented here, provides a valuable framework for creating a customized Index for any city worldwide.

SCORING THE SINGAPORE INDEX

In 2017, the LASAN team chose to measure and score an existing biodiversity index, the Singapore Index on Cities' Biodiversity, as a first step toward accomplishing the goals set forth in the Motion. The team felt that measuring the Singapore Index would serve three important strategic purposes, including: "1) helping stakeholders and local experts begin a dialog around indicators for City biodiversity; 2) providing an initial measurement based on an established index that can be used to summarize LA biodiversity early in the process and can be used as a point of comparison between LA and other cities; and 3) determining appropriate indicators, datasets, and identifying key management issues unique to LA that can be incorporated into a customized index for the City" (LA Sanitation and Environment, 2018). To initiate the process, and ensure that it was both defensible and applicable, the project team, together with Los Angeles Councilmember Paul Koretz's team at Council District 5, convened three advisory groups: 1) an open Stakeholder Group of interested community members, non-governmental organizations (NGOs), regulatory agency staff, etc.; 2) an Interdepartmental Biodiversity Team of City staff who represent potential key decision makers whose actions may shape index performance over time and may provide data necessary for measurement; and 3) an invitation-only Expert Council of local scholars and practitioners to measure the Singapore Index, provide recommendations for the customized LA Index, and oversee LA Index development. The overall results of the Singapore Index measurement process, and recommendations for the LA Biodiversity Index, are presented in the 2018 City of Los Angeles Biodiversity Report.

Recommendations for improvement in the LA City Biodiversity Index include a variety of considerations including on-the-ground stewardship opportunities and observations, data availability and measurement feasibility, and frontiers in urban biodiversity research being addressed at major research institutions in LA including California State University Los Angeles (Cal State LA), Loyola Marymount University (LMU), the University of California Los Angeles (UCLA), and the University of Southern California (USC). Together, the recommendations demonstrate the diverse perspectives of the working groups and the benefits of a transdisciplinary process toward shaping an actionable index and actionable science. Considering recommendations from the Expert Council and insights gained from relevant literature, the following general recommendations for modifications to the Singapore Index have been incorporated into the customized LA Biodiversity Index. *Please note that the design and scoring of the Singapore Index itself is currently in the process of being revised to account for several of the recommendations put forth by global stakeholders, including the City of Los Angeles*.

1) ACCOUNT FOR THE DISTRIBUTION AND ABUNDANCE OF BIODIVERSITY ACROSS THE CITY. The Singapore Index is designed to measure biodiversity of an entire city. Indicators of species richness are emphasized and measured in a non-spatial way. Therefore, the species-based indicators (Indicators 3-8) generally emphasize species richness within the city's highest quality, and most diverse natural areas (i.e., richness in just a few high quality large natural areas is driving the scores for the entire city). Local extinctions or restorations within smaller natural areas, changes in abundance or distribution of relatively common native species across the city, or distribution of biodiversity near urban areas with limited access to natural areas are not well accounted for.

2) SCORING STRATEGY SHOULD BE SENSITIVE TO REASONABLE THRESHOLDS FOR CHANGE. As written, many of the Singapore Index indicator scores are not likely to change over time considering potential trends in stewardship or impacts. For instance, Singapore Index Indicator 1, Proportion of Natural Areas, assigns the following scores: 0 points: <1%, 1 point: 1-6.9%, 2 points: 7-13.9%, 3 points: 14-20%, 4 points > 20%. Hypothetically, if LA were to contain 17% natural areas it would receive a score of three for Singapore Index Indicator 1, a reasonable score on the 0-4 point scale. Since the threshold between scores of 2 and 3 is 14%, LA could lose 3%, as much as 9,000 acres (3,600 hectares) of natural areas before falling to a score of 2, yet far smaller amounts of loss would be viewed as unacceptable. Therefore, tailoring score thresholds based on local potential rates, or tolerance, of change, or shifting to an ordinal instead of numeric scoring system that tracks positive, neutral, or negative trends, allows scoring to be more sensitive to meaningful rates of change.

3) INCORPORATE NORMALIZED VALUES AND PERCENTAGES. Several of the Singapore Index scores rely on specific numbers of species, acreages, events, etc. to differentiate scores. For example, 68 native bird species within a city (Indicator 3), or >71 "biodiversity projects" (Indicator 16) achieve a top score of 4 points. Given the ecological diversity and size of LA, it easily exceeds both of these score thresholds and will score 4 for these indicators for the foreseeable future,

regardless of stewardship or other drivers of change. Normalizing score thresholds relative to contextual benchmarks, such as basing scores for Singapore Index Indicator 3 on the percentage of native bird species that were historically present in cities prior to urbanization, instead of the total number of species, is emphasized in the LA Index (e.g., 75% of regional native birds are found in urban areas = score 3, etc.). In this way, cities with naturally lower regional bird species richness could still achieve top scores, and score thresholds have more potential to serve as indicators of change over time for cities with much higher bird richness.

4) TAILOR THE INDEX TO LA-SPECIFIC CONTEXT. Los Angeles, like other cities, has unique biodiversity priorities based on local ecology, regulatory context, conservation values, and/or environmental justice context, etc. For some Singapore Index Indicators, the City felt the methodology could be updated to better align with local priorities and available data sources. As science has advanced since the inception of the Singapore Index ten years ago, Los Angeles also has access to data and monitoring systems that are more effective than those called for in the Singapore Index. Tailoring indicators, methods, scoring approaches, scoring thresholds, and application strategies to the local context will increase the Index's effectiveness, applicability, and utility as a long-term stewardship tool. For example, indicator 2.1a, Access to Natural Areas, was modified from Singapore Index Indicator 13 to better account for equitable access to natural areas, as incorporating equity into the index is a local priority. However, such tailoring may make comparison of performance between cities, especially in different regions, more difficult. Please note that neither the Singapore Index nor the LA Index were developed specifically for city-to-city comparisons, rather they were developed for self-monitoring.

5) IMPROVE APPLICABILITY OF INDICATORS IN LOCAL-SCALE DECISION MAKING AND MAKE THEM MORE SPATIALLY EXPLICIT. Effective indicators are typically spatially explicit, scalable, quantifiable, and are often tailored to local context. Many of the drivers of change for urban biodiversity are the result of decisions at the parcel or neighborhood-scale, such as landscape architectural design, landscape maintenance practices, or urban design impacting the pattern of landscapes and open space. Crafting indicators in a way that allows them to be mapped in a spatially explicit way at high resolutions makes them more applicable for local-scale decisions, in addition to their broader-scale, city-wide monitoring value.

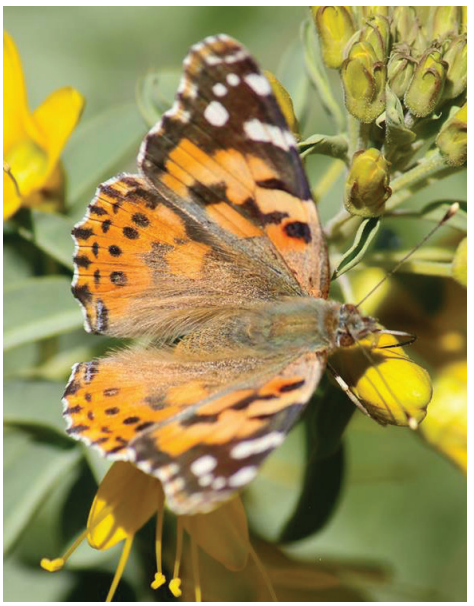
6) IMPROVE MEASUREMENTS THAT ADDRESS PROVISIONING OF ECOSYSTEM SERVICES. The Singapore Index includes two indicators, #11 - water quality from pervious surfaces and #12 - cooling/carbon from tree canopy that emphasize regulating ecosystem services. These are just two examples of the numerous regulating, provisioning, and other ecosystem service categories provided by urban ecosystems and biodiversity. Including only two indicators is insufficient to address such a broad topic. Additionally, including scores for ecosystem services that do not differentiate between native and non-native biodiversity sources dilutes the index scoring from the focus on native biodiversity conservation and access, the primary objectives of the LA Biodiversity Motion. For LA, the project team recommends creating a separate index dedicated specifically to regulating and provisioning ecosystem services considering both native and non-native biodiversity. However, the "cultural" ecosystem services of native biodiversity (e.g., educational value, physical and mental health value, etc.) were included in the LA Biodiversity Index because these types of ecosystem services specifically address issues and benefits of equitable access to native biodiversity, a key objective of LA's Biodiversity Motion.

DEFINING URBAN BIODIVERSITY

Strong definitions are also essential to creating applicable environmental indicator frameworks. While scholars may be familiar with specific technical definitions for biodiversity, the term is not well understood among urban decision makers or the public. The following definition of "urban biodiversity" is an important foundation for the LA Biodiversity Index.

FOR THE CITY OF LOS ANGELES, BIODIVERSITY IS

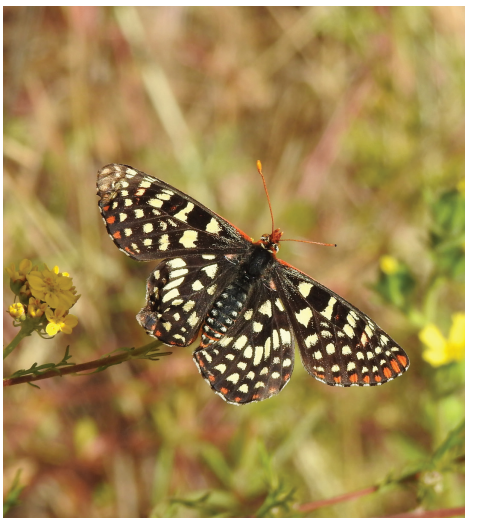
the flora, fauna, and ecosystems that enrich and sustain natural and urban areas



Painted lady butterfly - *Vanessa cardui* (Photo: Mike Miller)

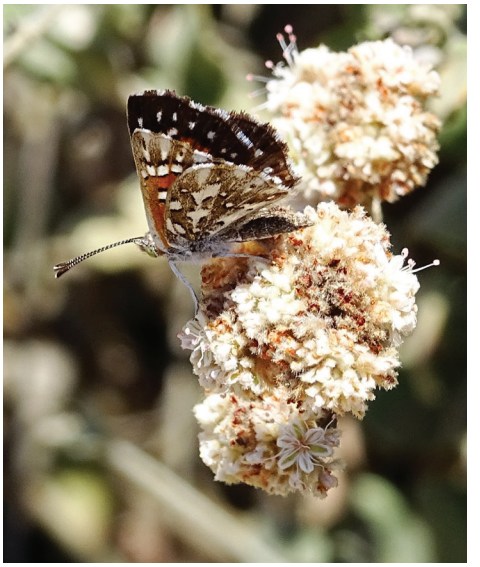
Gray buckeye - *Junonia coenia* ssp. *grisea* (Photo: © Jennifer Arrow https://www.inaturalist.org/photos/53746428)

Sara orangetip - *Anthrocharis sara* (Photo: © Dan Horowitz https://www.inaturalist.org/observations/40116526)



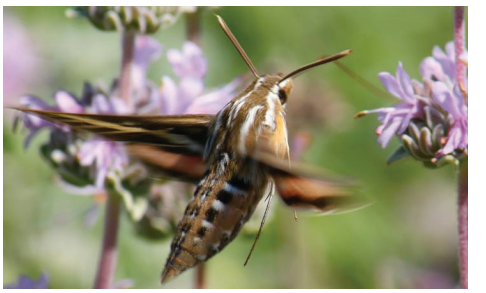
Variable checkerspot butterfly - *Euphydryas chalcedona* (Photo: © Andy Kleinhesselink) https://www.inaturalist.org/photos/39962390

Gray hairstreak - *Strymon milinus* (Photo: © Andy Kleinhesselink https://www.inaturalist.org/observations/9861196)



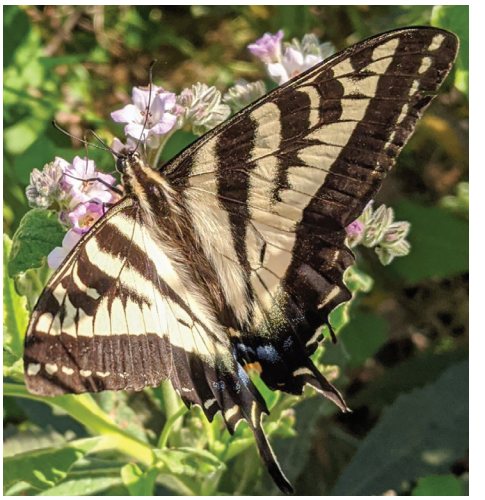
Behr's metalmark - *Apodemia virgulti* (Photo: © Jesse Rorabaugh https://www.inaturalist.org/photos/2243648)

Marine blue butterfly - *Leptotes marina* (Photo: Isaac Brown)



White-lined sphinx moth - *Hyles lineata* (Photo: Mike Miller)

Monarch caterpillar - *Danaus plexippus* - As monarch caterpillars feed exclusively on milkweed, presence of native species, like narrow-leaved milkweed (shown), are critical for survival of the species. (Photo: © Patt Farris https://www.inaturalist.org/photos/7623321)



Pale swallowtail - *Papilio eurymedon* (© jlmackey) https://www.inaturalist.org/photos/71259668

Figure 1-2: Examples of common and rare butterfly and moth species in Los Angeles. Butterflies, in general, are an excellent "indicator" taxonomic group to support measurement of the abundance and distribution of biodiversity across Los Angeles because they are relatively easy to identify, photograph, and record on iNaturalist by non-experts. Many butterfly species are also habitat specialists, making them good indicators of habitat quality, type, and, potentially, pattern. Observations on iNaturalist are a key tool to support LA Biodiversity Index Indicator 1.2b, Native Species Presence in Urban Areas, discussed in Table 1-1.

Terms in the definition have been carefully selected to encompass the multiple objectives of the Biodiversity Motion, including conservation of native wildlife and the habitats they require. Emphasis on both "natural" and "urban" areas is intended to suggest that stewardship addresses the entire spectrum of land use intensity associated with the City, including the most natural, the most urban, and the developed open space, agricultural, or semi-rural areas that often act as an interface between the two. The idea of "sustaining" the City is meant to account for the goal of enhancing ecosystem services provided by both native and non-native biodiversity, particularly as they support the resilience of the City to climate change. The term "enriching" addresses enhancing access to biodiversity and the diverse benefits it can provide. While equitable access, educational, and health benefits are important for social justice and the sustainability of cities, "enrichment" suggests striving for higher levels of biodiversity than the more utilitarian goal of "sustainability," such as protecting nature for nature's sake, celebrating biodiversity in public art, or in implementing urban design and architectural "placemaking" that draws from local ecological cues. While many problematic non-native and invasive species are also present in cities, and the term "biodiversity" typically implies species of conservation value, some non-native species can provide ecosystem services. Therefore, the definition intentionally emphasizes only the species that are considered beneficial, whether they are native or non-native (i.e., non-invasive).

A PROPOSED LOS ANGELES CITY BIODIVERSITY INDEX

Following production of the 2018 City of LA Biodiversity Report, LASAN began crafting the LA Biodiversity Index. The process was driven by Expert Council recommendations and by Isaac Brown's doctoral research at the UCLA Institute of the Environment and Sustainability. Through subsequent Expert Council meetings and review, the Index was refined to respond to the opinions of these experts, many of whom represent local decision makers, researchers studying local biodiversity, and end users of the Index. As a basis for measurement methods, and potential future collaboration and integration, the Index also considered other biodiversity measurements currently being developed for LA, including the UCLA Sustainable Los Angeles County Grand Challenge and Los Angeles County Biodiversity Atlas, and the Natural History Museum of LA County and the Nature Conservancy's Biodiversity Analysis in LA (BAILA). These activities and associated tools provided important precedents for methods and data to support index design and measurement.

Orienting the LA Biodiversity Index around the local decision-making processes, available or desired datasets, and parallel efforts was an essential step toward creating an index sensitive to meaningful physical changes in local biodiversity. In an urban context, meaningful changes are those where decisions around land stewardship, or other land use actions, can drive urban biodiversity enhancement or degradation. External environmental drivers, such as climate change, can also produce meaningful changes, albeit often indirectly and on different scales.

Table E-1 (see page 9) provides the overall LA Biodiversity Index framework organized within a hierarchy of themes, indicators, and metrics. Most generally, "themes" represent overarching categories of indicators, similar to the "Core Components" provided in the Singapore Index, but are adjusted to address the main objectives of the Biodiversity Motion. The three themes of the LA Index are conservation of native biodiversity, social aspects of biodiversity, with a focus on equity, and governance and management activities. Indicators are more specific topics within each theme and are measured with two to six "metrics" that include specific quantitative or qualitative measurements.

The general measurement approach for each metric, relevant datasets and data gaps, and the relationship of each metric to the Singapore Index improvement recommendations discussed above, are provided in Table 1-1. Measurement of metrics 1.1b and 1.1e (Habitat Quality and Connectivity of Urban Landscapes & Open Space) is the focus of Chapter 3. Specific measurement and scoring details for other LA Biodiversity Index metrics are preliminary and will be finalized during future Index measurement. However, the overall structure of the proposed Index, selected indicators and metrics, preliminary methods, and scoring have been well-vetted with the Expert Council and are considered complete and should be the focus of the initial measurement. A weighting approach is proposed later in this Chapter and should be "calibrated" through consensus with the Expert Council during the Index measurement process. The remaining discussion in this Chapter will address the application strategy for the LA Biodiversity Index.

Table 1-1: LA City Biodiversity Index and Preliminary Methods

Indicator/Metric	Description	Relationship to Singapore Index Indicator(s) (Retained, Modified, or New)	Preliminary Methods	Preliminary Benchmark Score (every 10 years)	Preliminary Monitoring Score (every 3 years)
1.1 Habitat Quality: Estimates the value of all landscapes, including urban and natural areas, in the City as habitat for native species.					
1.1a: % Natural Areas	This indicator relies on satellite remote sensing and iNaturalist observations of native plant species to map native vegetation that are considered "natural areas". Natural areas are the highest quality habitats for native species in the City and represent a useful spatial unit for management.	RETAINED from Singapore Index. Loss of natural areas is an obvious impact to biodiversity and easily understood by both laypeople and experts.	See Singapore Index Methods described in 2018 LA Biodiversity Report Appendix B, Indicator #1. Natural area classification categories will include: natural areas, degraded natural areas, non-native grasses, non-native shrubs and trees, urban/developed, urban related bare soil, agriculture, and water as other classifications (e.g., non-native shrubs and trees) provide ecosystem services. Measure city-wide, by ecotope, and/or other study area of interest.	0 points: <1% natural areas	-2 points (significantly negative): evidence of major net reduction due to land development/land conversion projects
				1 point: 1-5%	-1 point (negative): evidence of a net reduction
				2 points: 5-10%	0 points (neutral): no change
				3 points: 10-30%	1 point (positive): evidence of a net addition
				4 points: 30-50%	2 points (significantly positive): evidence of major net addition due to significant ecological restoration projects
				5 points: >50% natural area	
1.1b: Habitat Quality of Urban Landscapes & Open Space	This indicator estimates the quality of all landscapes and waterbodies in the City, at a 10-foot grid resolution, to provide habitat for native biodiversity in general. It considers both the structural quality of vegetation or water features, and the size of the broader landscape patch within which the pixel falls. Larger patches are assumed to provide higher habitat value than smaller patches. Measuring the habitat value of all areas of the City, including urban landscapes, provides a useful tool for habitat protection and enhancement from local-site to City-wide scales. This metric can also help identify areas that currently lack biodiversity in support of enhancement prioritization.	NEW indicator not accounted for in the Singapore Index. Except for natural areas, the Singapore Index does not evaluate other landscapes for habitat value in a spatially explicit way. This new indicator provides a location-specific value for all landscapes in the City that is useful for planning, design, and management at the local scale, including measurement of benefits or impacts of landscape change.	*See Chapter 3 in Brown (2019) for detailed methods.* Measure city-wide, by ecotope, and/or other study area of interest. *(*note that methods described in Brown 2019 should be modified to add 1 additional point of value to streams/drainages/water features, whether above ground or piped, that flow through parks and open space to differentiate their restoration opportunity potential vs. those that do not occur in parks & open space).*	0 points: area of interest weighted average score = 0	-2 points (significantly negative): More than 1% reduction in weighted area score
				1 point: area of interest weighted average score = 1	-1 point (negative): >0-1% reduction in weighted area score
				2 points: area of interest weighted average score = 2	0 points (neutral): no change in weighted area score
				3 points: area of interest weighted average score = 3	1 point (positive): >0-1% increase in weighted area score
				4 points: area of interest weighted average score = 4	2 points (significantly positive): More than 1% increase in weighted area score
				5 points: area of interest weighted average score = 5	
1.1c: Habitat Quality of Streams	This indicator estimates the habitat quality of streams in the City. As freshwater systems are some of the most altered and threatened habitat types in the City, there is value in separately assessing the quality of these habitats.	NEW indicator not accounted for in the Singapore Index. Except for natural areas, the Singapore Index does not evaluate other landscapes for habitat value in a spatially explicit way. This new indicator provides a location-specific value for streams and rivers in the City that is useful for planning, design, and management at the local scale.	This metric will rely on existing data from the California Stream Condition Index (CSCI). The CSCI is a statewide scoring tool that assesses the health of freshwater streams. The CSCI distills complex biological and environmental data to individual scores that range from approximately 0.1 -1.4, with higher scores indicating better habitat quality. Scores can be interpolated so that entire stream networks have predicted scores. Data can be averaged over time period of interst (e.g., 10 years, 3 years). As the CSCI only has four scoring thresholds, the highest scores will incorporate other data from the Algal Index of Biotic Integrity for Streams into final methodology and/or iNaturalist on presence of native amphibians and fish. Specific methods and scoring need additional refinement.	0 points: average CSCI for the City <0.62 (very likely altered)	-2 points (significantly negative): >10% overall reduction in average CSCI score between baseline year and assessment year
				1 point: average CSCI for the City 0.63-0.79 (likely altered)	-1 point (negative): 2-10% overall reduction in average CSCI score between baseline and assessment
				2 points: average CSCI for the City 0.80-0.91 (possibly altered)	0 points (neutral): no significant change in overall CSCI score (-2 to 2% change in average CSCI score)
				3 points: average CSCI for the City >0.92 (likely intact)	1 point (positive): 2-10% overall increase in average CSCI score between baseline and assessment
				4 points: average CSCI for the City >0.92 (likely intact) and ASCI > 10th percentile	2 points (significantly positive): >10% overall increase in average CSCI score between baseline and assessment
				5 points: average CSCI for the City >0.92 (likely intact) and ASCI > 30th percentile	

Indicator/Metric	Description	Relationship to Singapore Index Indicator(s) (Retained, Modified, or New)	Preliminary Methods	Preliminary Benchmark Score (every 10 years)	Preliminary Monitoring Score (every 3 years)
1.1d: Connectivity of Natural Areas	Measures contiguousness of natural areas not considering other landscape types' contributions to connectivity. Utilizes "effective mesh size", which is a widely used indicator that provides a broad-scale, non-spatial measure of connectivity.	RETAINED from Singapore Index. This metric is most sensitive for measuring changes to connectivity for sensitive species that prefer large natural areas as habitat. Natural areas with limited connectivity, or opportunities for new connectivity, will be most sensitive to change.	See Singapore Index Methods described in 2018 LA Biodiversity Report Appendix B, Indicator #2. Measure city-wide, by ecotope, and/or other study area of interest. *(*Consider adjusting score thresholds based on effective mesh size scenario of complete connectivity of all major natural areas - i.e., maximum possible mesh size of existing natural areas if connected.)*	0 points: Effective mesh size <200 ha	-2 points (significantly negative): More than 2% reduction in effective mesh size
				1 point: Effective mesh size 200-500 ha	-1 point (negative): >0-2% reduction in effective mesh size
				2 points: Effective mesh size 501-1000	0 points (neutral): no change in effective mesh size
				3 points: Effective mesh size 1001-1500	1 point (positive): >0-2% increase in effective mesh size
				4 points: Effective mesh size 1500-2000	2 points (significantly positive): More than 2% increase in effective mesh size
				5 points: Effective mesh size >2000	
1.1e: Connectivity of Urban Landscapes & Open Space	Measures general connectivity of all landscape types, including both natural areas and non-native landscapes, spatially, at a 10-foot grid resolution. This indicator will be most sensitive to changes in connectivity for common urban biodiversity, especially in dense urban areas with limited open space or landscape. Spatial mapping of connectivity can provide a useful tool for habitat protection and enhancement by identifying key connectivity "pinch points" that may be sensitive to loss, or may benefit from connectivity enhancement. This metric can also help identify opportunity areas to enhance connectivity to improve access to biodiversity in underserved areas.	NEW indicator not accounted for in the Singapore Index. The Singapore Index measures connectivity of natural areas only, and in a non-spatial way. This indicator expands the measurement to account for connectivity of all landscapes. Many wildlife species move through both native and non-native landscapes, especially in Los Angeles where migratory species must traverse large areas of contiguous urban development.	*See Brown (2019) Chapter 3 for detailed methods.* Measure city-wide, by ecotope, and/or other study area of interest. *(*refinement of model inputs/outputs and scoring strategy is needed).*	0 points: weighted average pixel connectivity score lower than 15% for area of interest	-2 points (significantly negative): More than 2% reduction in weighted average score
				1 point: weighted average pixel connectivity score 16%-30% for area of interest	-1 point (negative): >0-2% reduction in weighted average score
				2 points: weighted average pixel connectivity score 31%-45% for area of interest	0 points (neutral): no change in weighted average score
				3 points: weighted average pixel connectivity score 46%-60% for area of interest	1 point (positive): >0-2% increase in weighted average score
				4 points: weighted average pixel connectivity score 61%-75% for area of interest	2 points (significantly positive): More than 2% increase in weighted average score
				5 points: weighted average pixel connectivity score upper 75% for area of interest	
1.1f: Connectivity of Streams and Riparian Areas	Measures general connectivity of streams and riparian areas. Like metric 1.1e, this metric will be sensitive to changes in connectivity for common urban biodiversity, especially in dense urban areas. Spatial mapping of connectivity along streams can provide a useful tool for habitat protection and enhancement by identifying stream/river segments that would benefit from restoration and enhancement.	NEW indicator not accounted for in the Singapore Index. The Singapore Index measures connectivity of natural areas only, and in a non-spatial way. This indicator expands the measurement to account for connectivity of streams and rivers. Many wildlife species utilize riparian corridors and freshwater features to traverse the City.	This metric will use metric 1.1c, Habitat Quality of Streams and Water Features, as the starting point. Stream features will be buffered and analysis will be performed in Omniscape. The methodology still needs to be refined, but will be similar to that emplyed for metric 1.1e.	0 points: weighted average pixel connectivity score lower than 15% for area of interest	-2 points (significantly negative): More than 2% reduction in weighted average score
				1 point: weighted average pixel connectivity score 16%-30% for area of interest	-1 point (negative): >0-2% reduction in weighted average score
				2 points: weighted average pixel connectivity score 31%-45% for area of interest	0 points (neutral): no change in weighted average score
				3 points: weighted average pixel connectivity score 46%-60% for area of interest	1 point (positive): >0-2% increase in weighted average score
				4 points: weighted average pixel connectivity score 61%-75% for area of interest	2 points (significantly positive): More than 2% increase in weighted average score
				5 points: weighted average pixel connectivity score upper 75% for area of interest	

Indicator/Metric	Description	Relationship to Singapore Index Indicator(s) (Retained, Modified, or New)	Preliminary Methods	Preliminary Benchmark Score (every 10 years)	Preliminary Monitoring Score (every 3 years)
1.2 Indicator Species: Assesses presence and distribution of species that are indicators of broader biodiversity.					
1.2a: % Open Space with Charismatic Umbrella Species	This indicator will provide a spatially explicit indication of biodiversity of large natural areas. Selected umbrella species are "avoider" species (i.e., species that don't venture far from large natural areas), such as foxes, bobcats, black-tailed deer, bear, California quail, or mountain lions that indicate the overall biodiversity status of large open space areas because their presence generally means that the space possesses a broad suite of habitat quality and connectivity functions, is of sufficient size, and has relatively limited urban edge effects. Additionally, changes to charismatic wildlife species, as opposed to more nuanced habitat quality metrics per indicator 1.1, are easier to grasp by laypeople, and thus, are useful for raising awareness and facilitating beneficial change.	MODIFIED from Singapore Index Indicators 3-8: Large mammals are easier to monitor than total species richness, as is required in related Singapore Index Indicators 3-8, since their presence can be easily tracked with trailcams. Indicators 3-8 also only measure species richness city-wide and do not provide an indication of quality of individual natural areas. Monitoring change in total species richness within each large natural area independently would be prohibitive, whereas umbrella species are both monitorable and are defensible indicators of overall species richness.	First, a list of target charismatic umbrella species must be determined with input from local experts. Inventory of existing observation data, new monitoring, and/or expert opinion on habitat suitability of large natural areas will be necessary to establish presence of these species. Richness of charismatic umbrella species and changes to presence within each large natural area form the basis for scoring. Consider individuals/unit area and % of open space with species as potential measurement units.	0 points: TBD % or individuals/unit area of charismatic umbrella species present within area of interest.	-2 points (significantly negative): loss of 1 or more umbrella species from area of interest
				1 point: TBD % or individuals/unit area of charismatic umbrella species present within area of interest.	-1 point (negative): reduction in population size of 1 or more umbrella species from area of interest
				2 points: TBD % or individuals/unit area of charismatic umbrella species present within area of interest.	0 points (neutral): no change
				3 points: TBD % or individuals/unit area of charismatic umbrella species present within area of interest.	1 point (positive): increase in population size of 1 or more umbrella species from area of interest
				4 points: TBD % or individuals/unit area of charismatic umbrella species present within area of interest.	2 points (significantly positive): gain of 1 or more umbrella species in area of interest
				5 points: TBD % or individuals/unit area of charismatic umbrella species present within area of interest.	
1.2b: Native Species Presence in Urban Areas	Common native wildlife species exhibit varying levels of urban tolerance from the wildland interface to the urban core and may provide a useful spatial indicator of distribution of biodiversity in urban areas. Tolerance and presence of resident and migratory species within 1/4-mile grid based on iNaturalist observations will provide a spatially explicit indication of distribution of overall biodiversity across all urban areas. Changes to the native species may result from changes to urban design or landscape strategies, making this metric useful for measuring the impacts or benefits of urban stewardship activities on biodiversity. For example, planned enhancements to the Los Angeles River may result in expansion of less urban-tolerant species into the urban core. Conversely, increasing infill development may result in reductions in presence of less tolerant species if such activities are not offset with increased habitat within the 1/4-mile pixel.	MODIFIED from Singapore Index Indicators 3-8: Indicators 3-8 in the Singapore Index will be sensitive to non-spatial changes in relatively rare or extirpated species sensitive to being gained or lost City-wide. This information has limited application in stewardship beyond management of those specific species and locations where they may be lost or gained. Assessing the distribution of sensitive plant and animal indicator species is a more effective approach for measuring changes to native biodiversity in general, especially in urban areas where local gains or losses of relatively common biodiversity are likely. The modifications will also better address the social equity objectives of the Biodiversity Motion.	All species of native fauna present in datasets (iNaturalist, CNDDB, eBird, eButterfly) to be ranked on a scale of 1-5 based on typical level of urban tolerance exhibited by the species based on expert opinion. Explore potential sources for aquatic data (e.g., Surface Water Ambient Monitoring Program (SWAMP)). Categories envisioned include very urban tolerant, urban tolerant, suburban tolerant, wildland interface, or natural-areas dependent species. Highest scoring observation within each 1/4 mile pixel determines the pixel score. As community science data is opportunistic, and may not always accurately represent the species present in a particular location, a minimum of two observations will be required for each species to be counted. Additional means of screening iNaturalist data, such as occupancy modeling, or detecting species (e.g., camera traps, tracks, etc.) will be explored. Indicator will require an expert body to agree on level of urban tolerance score and it may not be possible to rank all species.	0 points: area of interest weighted average score = 0 (no indicator species observed)	-2 points (significantly negative): More than 1 point reduction in weighted average tolerance class
				1 point: area of interest weighted average score = 1 (very urban tolerant species observed)	-1 point (negative): reduction in weighted average tolerance class
				2 points: area of interest weighted average score = 2 (urban tolerant species observed)	0 points (neutral): no change
				3 points: area of interest weighted average score = 3 (suburban tolerant species observed).	1 point (positive): increase in weighted average tolerance class
				4 points: area of interest weighted average score = 4 (edge species observed).	2 points (significantly positive): More than 1 point increase in weighted average tolerance class
				5 points: area of interest weighted average score = 5 (natural areas-dependent species observed).	

Indicator/Metric	Description	Relationship to Singapore Index Indicator(s) (Retained, Modified, or New)	Preliminary Methods	Preliminary Benchmark Score (every 10 years)	Preliminary Monitoring Score (every 3 years)
1.2c: Species of Conservation Concern Gained or Lost	This indicator tracks changes to sensitive species in each City-designated Ecotope (See Chapter 2). This indicator will likely focus on CDFW Species of Special Concern, but could include other categories of species protected under the Federal Endangered Species Act, California Endangered Species Act, and other local policies that have been, or are nearly, extirpated from the City, or are sensitive to climate change. Loss or recovery of protected flora and fauna is a major indicator of alignment with the goals of the Endangered Species Act. Further extirpation of other species from the City is an indication of overall biodiversity change, as are changes to climate-sensitive species, many of which may occur near City mountain tops or coastlines, which are areas especially sensitive to temperature change or sea level rise.	MODIFIED from Singapore Index Indicators 3-8: This indicator is similar in application value of the original Singapore Indicators 3-8, but focuses exclusively on sensitive, regulated, and/or rare species, i.e., species that are likely to change, as opposed to total species richness. However, in addition to a city-wide measurement of change, it will also track presence of species within each of the City's 17 Ecotopes (see Chapter 2). Specific locations of sensitive species will not be identified due to concerns for species protection.	(Applicable in California only) Prepare baseline (existing condition) measurement of past and current species presence within each Ecotope based on expert opinion and/or recorded observations/suitability modeling in the California Natural Diversity Database (CNDDB), CALSCAPE/Calflora, other dataset of State or Federally threatened, endangered, or species of concern, or other sensitivity designation if applicable (i.e., "sensitive species"). Future measurements will rely on establishment of new monitoring programs for these species within Ecotopes.	0 points: no sensitive species remain within ecotope	-2 points (significantly negative): net loss of 1 or more species
				1 point: 1-10% of suitable sensitive species still present	-1 point (negative): reduction in population of one species
				2 points: 10-25% of suitable sensitive species still present	0 points (neutral): no change
				3 points: 25-50% of suitable sensitive species still present	1 point (positive): increase in population of one species
				4 points: 50-99% of suitable sensitive species still present	2 points (significantly positive): net gain of more than one species
				5 points: 100% of suitable sensitive species still present	
1.3 Threats to Native Biodiversity: Assesses human-caused threats to native biodiversity from land use and invasive species.					
1.3a: Urban Edge Effects on Natural Areas	This metric accounts for the impact of adjacent land uses on biodiversity by measuring night lighting within 1/2 mile of natural areas. Edge effects are an important and challenging aspect of natural areas management. Adjacent land uses may be designed to mitigate these impacts, and changes to this metric suggests whether measures are actively being implemented.	NEW indicator not accounted for in the Singapore Index. Accounts for the impact of adjacent land uses on natural areas using light pollution, which is regularly measured and studied by local scholars. This spatially explicit information can inform stewardship in specific natural areas and adjacent neighborhoods.	Step 1: Identify natural areas per indicator 1.1a. Step 2: Buffer natural areas by 1/2 mile. Step 3: Extract night lighting measurements per dataset recommended by Travis Longcore @ UCLA using raw dataset pixel resolution. Step 4: monitor change in night lighting over time within 1/2 mile natural area buffer.	0 points: night lighting highest 95% of score range	-2 points (significantly negative): >1% reduction in darkness
				1 point: night lighting upper 95% to 50% of score range	-1 point (negative): 0-1% reduction in darkness
				2 points: night lighting lower 49% to 35% of score range	0 points (neutral): no change
				3 points: night lighting lower 34% to 25% of score range	1 points (positive): 0-1% gain in darkness
				4 points: night lighting lower 24% to 15% of score range	2 points (significantly positive): >1% gain in darkness
				5 points: night lighting lowest 15% of score range	
1.3b: Presence & Spread of Invasive Plants	Invasive plants are a major threat to native biodiversity and ecosystem services. Spatial monitoring of invasive plant species is somewhat limited, as is management. This indicator tracks presence, rate of spread, and level of threat for invasive plant species in USGS Quadrangles (7.5 x 7.5 miles) as monitored by the California Invasive Plant Council (CalIPC). While this indicator may not be sensitive to specific management activities or sites, it does provide a general indicator of direction of the threat and helps support awareness.	MODIFIED from Singapore Index Indicator 10. The Singapore Index simply tracks the presence of invasive plant species. The proposed approach improves upon that by using readily available local information from CalIPC, including level of threat and general extent of each species within the City. However, USGS Quads are relatively coarse in scale, and more locally-specific information is needed in the future.	(Applicable in California only) California Invasive Plant Council (CalIPC) dataset extracted for the City. CalIPC tracks presence of invasive plant species within USGS Quads (7.5 x 7.5 miles) in California. The system also assigns a level of threat for each species. Methods will incorporate both presence and level of threat into scoring. Likely approach will assess percentile level of spread/threat exposure of each quad within the City. As USGS Quads are coarse, ground truthing should be employed as feasible. Could also consider incorporating data in the eCRAM database for riparian/wetland areas.	0 points: highest 95% of score range for USGS quad (or weighted average of quads within area of interest)	-2 points (significantly negative): net increase in species presence AND level of threat
				1 point: upper 95% to 50% of score range for USGS quad (or weighted average of quads within area of interest)	-1 point (negative): net increase in species presence OR level of threat
				2 points: lower 49% to 35% of score range for USGS quad (or weighted average of quads within area of interest)	0 points (neutral): no change
				3 points: lower 34% to 25% of score range for USGS quad (or weighted average of quads within area of interest)	1 point (positive): net decrease in species presence OR level of threat
				4 points: lower 24% to 15% of score range for USGS quad (or weighted average of quads within area of interest)	2 points (significantly positive): net decrease in species presence AND level of threat
				5 points: lowest 15% of score range for USGS quad (or weighted average of quads within area of interest)	

Indicator/Metric	Description	Relationship to Singapore Index Indicator(s) (Retained, Modified, or New)	Preliminary Methods	Preliminary Benchmark Score (every 10 years)	Preliminary Monitoring Score (every 3 years)
1.3c: Wildfire Frequency Departure from Natural	Fire is an important natural disturbance process driving biodiversity change in Los Angeles. Natural fire frequencies have been disrupted by local human activities and likely climate change. Generally, for natural vegetation types dominant in the City of Los Angeles, lands that burn more frequently than every 20 years result in degradation of biodiversity. This indicator will measure the spatial extent of lands exposed to elevated fire frequency.	NEW indicator not accounted for in the Singapore Index. Wildfire is an important natural process in many Mediterranean and seasonally dry landscapes. Such locally specific biodiversity considerations are not well-accommodated in the Singapore Index.	Wildfire history is well monitored by scholars and CalFIRE. This metric will use Fire Return Interval Departure data available for the South Coast Region from the USFS (https://www.fs.usda.gov/detail/r5/landmanagement/gis/?cid=STELPRDB5327836) to map the Percent Fire Return Interval Departure (PFRID). The FRID dataset uses presettlement fire regime data and CalFIRE's fire perimeter (FRAP) database to compare historical and current fire regimes for 28 different vegetation types (e.g., coastal sage scrubs). The resulting data is broken into six condition classes (CCs) that indicate the direction and magnitude of fire frequency: CC -3, CC -2, CC -1, CC 1, CC2, and CC 3, with negative scores indicating overburning and positive scores indicating underburning. THE PFRID can be calculated for the entire City or for individual ecotopes. Further refinement of scoring thresholds may be needed.	0 points: majority of areas (>50%) assessed at severe risk of overburning (CC -3) or underburning (CC 3). Less than 10% of PFRID scores exhibit low departure scores (CC -1 or CC 1).	-2 points (significantly negative): the severity of PFRID scores is increasing for the majority (>50%) of the area.
				1 point: area assessed at high risk of overburning or underburning. Less than 10% of PFRID scores are considered low departure (CC -1 or CC 1).	-1 point (negative): the severity of PFRID scores is increasing moderately. Increased PFRID scores observed for <50% of the area.
				2 points: area assessed at moderate to high risk of overburning or underburning. Less than 25% of PFRID scores are considered low departure (e.g., CC -1 or CC 1).	0 points (neutral): no major change in PFRID scores.
				3 points: area assessed at moderate to limited risk of over or underburning. More than 50% of PFRID scores are low (CC -1 or CC 1) and less than 10% of PFRID scores are severe (CC -3 or CC 3).	1 point (positive): the severity of PFRID scores is decreasing. Decreased PFRID scores observed for <50% of the area.
				4 points: majority of area assessed at limited risk of over or underburning. More than 75% of PFRID scores are low (CC -1 or CC 1).	2 points (significantly positive): the severity of PFRID scores is decreasing for the majority (>50%) of the area.
				5 points: entirety of area assessed at limited risk of over or underburning. All PFRID scores are netrual or low (CC -1 or CC 1).	
2.1 Access to Biodiversity: Assesses equity of access to nature, biodiversity, and landscapes.					
2.1a: Access to Natural Areas	Many urban areas lack access to natural areas. Addressing this social equity concern is a priority of the Biodiversity Motion. This metric assesses access and distribution of natural areas to determine underserved areas. Neighborhoods within 1/2 mile of substantial, publicly accessible natural areas or constructed habitats will be considered accessible. The metric will help to prioritize neighborhoods that lack access for restoration or other biodiversity activities.	MODIFIED from Singapore Index Indicator 13. Singapore Index Indicator 13 measures total area of publicly accessible natural areas. However, it does not account for their distribution in a spatially explicit way. This modification better accounts for social equity implications of access and suggests optimal locations for improving access.	Measure total area of accessible natural areas and other open space with relatively high biodiversity value, including small natural areas within urban areas, and the population within and beyond 0.5 miles from these areas. Conduct network analysis based on 0.5 mile walkability model (TPL ParkScore Model), or simple 0.5 mile buffer and estimate population within walking distance. Assess equity of accessible natural areas. Another option could be to rasterize and buffer pixels of residential or school land uses instead of using a population based unit that will rely on cencus blocks with irregular shapes that make spatial measurements somewhat problematic. Relevant datasets include: California Protected Areas, Conservation Easement Databases, Trust for Public Land ParkScore, Recreation and Parks Department Data, Census Data.	0 points: < 25% of population within 1/2 mile of open space (optional spatial metric: natural area beyond 1/2 mile of residential or school land use)	-2 points (significantly negative): More than 1% reduction in accessible population (or area weighted average score if spatial metrics used)
				1 point: 25%-40% of population within 1/2 mile of open space	-1 point (negative): >0-1% reduction in accessible population (or area weighted average score if spatial metrics used)
				2 point: 40.1% - 55% of population within 1/2 mile of open space	0 points (neutral): no change
				3 points: 55.1 % - 70% of population within 1/2 mile of open space	1 point (positive): >0-1% increase in accessible population (or area weighted average score if spatial metrics used)
				4 points: 70.1% - 85% of population within 1/2 mile of open space	2 points (significantly positive): More than 1% increase in accessible population (or area weighted average score if spatial metrics used)
				5 points: > 85% of population within 1/2 mile of open space (optional spatial metric: natural area within 1/4 mile of residential or school land use)	

Indicator/Metric	Description	Relationship to Singapore Index Indicator(s) (Retained, Modified, or New)	Preliminary Methods	Preliminary Benchmark Score (every 10 years)	Preliminary Monitoring Score (every 3 years)
2.1b: Neighborhood Landscape/Tree Canopy Footprint	Urban biodiversity is also present in other landscapes and parks, in addition to natural areas. This indicator will determine levels of landscape and open space present in neighborhoods at a 1/8-mile grid resolution. This data can support urban design, planning, and other project efforts to maintain adequate levels of landscape and tree canopy in neighborhoods.	Modified from Singapore Index Indicator 12. The proposed metric re-orients Singapore Index Indicator 12 to consider tree canopy and landscape as an indicator of access to native and non-native biodiversity in built-up urban areas, instead of tree canopy alone as an indicator of urban cooling/carbon benefits. Indicators of regulating ecosystem services have been removed from the LA Biodiversity Index because they are not central to the species conservation and access concerns contained in the Biodiversity Motion.	Measure average landscape/canopy % cover per 1/8 mile pixel using 2016 LA County Tree Canopy/Landcover dataset based on LARIAC. Measure weighted average score for pixels within area of interest (e.g., City, Ecotope, Neighborhood, or other area of interest)	0 points: landscape/canopy footprint < 5%	-2 points (significantly negative): More than 1% reduction in landscape/tree canopy
				1 point: landscape/canopy footprint 5-10%	-1 point (negative): >0-1% reduction in landscape/tree canopy
				2 points: landscape/canopy footprint 10-20%	0 points (neutral): no change
				3 points: landscape/canopy footprint 20%-30%	1 point (positive): >0-1% increase in landscape/tree canopy
				4 points: landscape/canopy footprint 30%-40%	2 points (significantly positive): More than 1% increase in landscape/tree canopy
				5 points: landscape/canopy footprint >40%	
2.2 Education: Evaluates educational programs and access to nature, biodiversity, and vegetated space on school campuses.					
2.2a: Schools (K-12) Biodiversity Topics	Measures the exposure of students to local and global biodiversity topics through school curricula.	MODIFIED from Singapore Index Indicator 22. Since general biodiversity elements are required in the California curricula, the new approach addresses curricula emphasis on local vs. global biodiversity, and depth of coursework relative to State biodiversity learning standards.	Measure the level of biodiversity/nature/ecology education included in the school curriculum. Measure weighted average score across all schools and/or accounting for size of student population per school. Average score across all schools, weighted by student population per school, provides the overall score for the area of interest.	0 points: out of State of California compliance on biodiversity-related topics at designated grades (classroom instruction at designated grades meets the Performance Expectation)	-2 points (significantly negative): reduction in achieving basic State of California compliance
				1 point: at State of California compliance on biodiversity-related topics at designated grades (classroom instruction at designated grades meets the Performance Expectation)	-1 point (negative): reduction in activities above basic State of CA compliance
				2 points: at State of California compliance on biodiversity-related topics across a grade-band (classroom instruction at all grades in a grade band collectively build towards the ability to meet the Performance Expectation)	0 points (neutral): no change
				3 points: above State of California compliance on biodiversity-related topics that involve local biodiversity investigations and explanations	1 point (positive): policies or pilots that direct schools to exceed basic State of CA compliance
				4 points: above State of California compliance on biodiversity-related topics that involve local and advanced biodiversity investigations and explanations by understanding local problems and beginning to plan for action	2 points (significantly positive): implementation of activities above basic State of CA compliance
				5 points: above State of California compliance on biodiversity-related topics that involve local and advanced biodiversity investigations and explanations and engaging in action projects (with local organizations when possible) that work to solve local problems (with local-to-global problem solving in high school).	

Indicator/Metric	Description	Relationship to Singapore Index Indicator(s) (Retained, Modified, or New)	Preliminary Methods	Preliminary Benchmark Score (every 10 years)	Preliminary Monitoring Score (every 3 years)
2.2b: Off-Campus Biodiversity Educational Visits	Measures the first-hand exposure that students get to global and local biodiversity through visits to natural areas or nature centers.	RETAINED from Singapore Index.	See Singapore Index methods for Indicator 14 from the 2018 City of LA Biodiversity Report and Appendix B. Scoring could be updated to consider quality and frequency of the off-campus visits. Purposeful visits should be encouraged to occur annually in individual grade-bands.	0 points: < 0.25 formal education visits/student/year	-2 points (significantly negative): reduction in off-campus educational programs
				1 points: 0.26 - 0.5 formal education visits/student/year	-1 point (negative): reduction in formal visits/student/year (i.e., reduction of program reach/quality)
				2 points: 0.51 - 1.0 formal education visits/students/year	0 points (neutral): no change
				3 points: 1.01 - 1.5 formal education visits/student/year	1 point (positive): increase in formal visits/student/year (i.e., increase of program reach/quality)
				4 points: 1.51 - 2.0 formal education visits/student/year	2 points (significantly positive): increase in off-campus educational programs
				5 points: > 2.0 formal education visits/student/year	
2.2c: Campus Nature Education Gardens/Areas	Measures biodiversity education value of school campuses and parks based on % of parks/campuses with formal habitat area. Providing biodiversity on-campus allows for direct, regular contact and hands-on learning experiences.	NEW indicator not accounted for in Singapore Index. This indicator aligns with local interest at schools and in neighborhoods to provide campus/park habitats, an important contextual feature in Los Angeles not accounted for in the Singapore Index.	Assess campus presence of habitat/garden space. Work with the LAUSD Sustainability Team and partner organizations like the National Wildlife Federation, Enrich LA, and Captain Planet to quantify the percentage of school campuses in the City of Los Angeles thave have campus gardens and assess associated programming. Assess access to garden space/equity.	0 points: less than 50% of schools have a living schoolyard area	-2 points (significantly negative): removal of natural area or constructed habitat
				1 points: 50-75% of schools have a living schoolyard area	-1 point (negative): reduction in program quality
				2 points: 75%+ of schools have a living schoolyard area, and a majority of gardens (50%+) have programming elements (e.g., community partnership, biodiversity curriculum, community access, NWF (or other) certification)	0 points (neutral): no change
				3 points: 75%+ of schools have a living schoolyard area, and all gardens have at least ONE programming element (e.g., community partnership, biodiversity curriculum, community access, NWF (or other) certification)	1 point (positive): improvement in program quality
				4 points: 80%+ of schools have a living schoolyard area, and all gardens have at least TWO programming element (e.g., community partnership, biodiversity curriculum, community access, NWF (or other) certification)	2 points (significantly positive): construction/restoration of natural area/habitat
				5 points: 80%+ of schools have a living schoolyard area, and all gardens have at least THREE programming element (e.g., community partnership, biodiversity curriculum, community access, NWF (or other) certification)	

Indicator/Metric	Description	Relationship to Singapore Index Indicator(s) (Retained, Modified, or New)	Preliminary Methods	Preliminary Benchmark Score (every 10 years)	Preliminary Monitoring Score (every 3 years)
2.3 Community Action: Evaluates biodiversity stewardship and engagement activities by members of the public.					
2.3a: Community Scientist Activities and App Utilization	Tracks public engagement with biodiversity in a way that is easy to monitor using active users and observations in iNaturalist, eBird, or similar apps within LA. The metric also aligns with the goals of the Sustainable pLAn. This metric also emphasizes activities that support data collection that are used in other metrics.	NEW indicator not accounted for in Singapore Index. The Singapore Index does not account for pubic behavior related to biodiversity. App utilization is a convenient way to gain insight into public behavior.	Measurement is based on the annual number of observations that occur within the City boundary. Total number of resident app users may also be accounted for. The proposed numbers of observations scores at right are preliminary and should be refined based on the total number of observations in the baseline year (e.g., 2019) relative to the total population in the City in that year.	0 points: < baseline year annual observations, adjusted for population change	-2 points (significantly negative): More than 10% reduction in annual observations from previous monitoring measurement
				1 point: <20% above baseline year annual observations, adjusted for population change	-1 point (negative): 0-10% reduction in annual observations from previous monitoring measurement
				2 points: 20%-50% above baseline year annual observations, adjusted for population change	0 points (neutral): no change
				3 points: 50%-100% above baseline year annual observations, adjusted for population change	1 point (positive): 0-10% increase in annual observations from previous monitoring measurement
				4 points: 100%-500% above baseline year annual observations, adjusted for population change	2 points (significantly positive): >10% increase in annual observations from previous monitoring measurement
				5 points: >500% above baseline year annual observations, adjusted for population change	
2.3b: # Certified Biodiversity-Friendly Areas	Tracks the number of certified landscape stewardship activities that support biodiversity on public or private parcels. Includes National Wildlife Federation Community Habitat Certifications, Audubon Certified Golf Courses, or similar programs.	NEW indicator not accounted for in Singapore Index. The Singapore Index does not account for such certification systems. Certification systems administered by non-profits provide a convenient way to evaluate stewardship activities and can be effective promotional tools for biodiversity.	Work with certification program entities to determine # of certifications and annual change (e.g., NWF Community Habitat Certification, Audubon Certified Golf Courses, or similar programs).	0 points: < benchmark-year certifications or NWF Community Habitat equivalent points	-2 points (significantly negative): More than 10% reduction in annual certifications or points from previous monitoring measurement
				1 point: <20% above benchmark year certifications or NWF Community Habitat equivalent points	-1 point (negative): 0-10% reduction in annual certifications or points from previous monitoring measurement
				2 points: 20%-50% above benchmark year certifications or NWF Community Habitat equivalent points	0 points (neutral): no change
				3 points: 50%-100% above benchmark year certifications	1 point (positive): 0-10% increase in certifications or points from previous monitoring measurement
				4 points: 100%-500% above benchmark year certifications or NWF Community Habitat equivalent points	2 points (significantly positive): >10% increase in annual certifications or points from previous monitoring measurement
				5 points: >500% above benchmark year certifications or NWF Community Habitat equivalent points	
3.1 Governance: Evaluates City governance structure and policies.					
3.1a: Biodiversity Vision/Action Plan	Measures the existence and breadth of formal planning documents produced by the City to address biodiversity.	MODIFIED from Singapore Index Indicator 17. This indicator adjusts the Singapore Index thresholds to account for compliance of plans with local initiatives, in addition to Convention of Biological Diversity (CBD) initiatives.	Modified from Singapore Index - see Singapore Index methods for Indicator 17 from the 2018 City of LA Biodiversity Report and Appendix B and refine/modify methods as necessary.	0 points: no Biodiversity Vision Plan or Action Plan	-2 points (significantly negative): No planning/visioning documents planned
				1 points: Biodiverisity Vision Plan, no Action Plan	-1 point (negative): No activity on planning/visioning documents
				2 points: Biodiversity Vision Plan + Action Plan	0 points (neutral): Planning/visioning documents planned
				3 points: "" plus 1-5 local initiatives that are measurable and achievable	1 point (positive): Planning/visioning documents in progress
				4 points: "' plus 5-10 local initiatives that are measurable and achievable	2 points (significantly positive): Planning/visioning documents completed
				5 points: "' plus >10 local initiatives that are measurable and achievable	

Indicator/Metric	Description	Relationship to Singapore Index Indicator(s) (Retained, Modified, or New)	Preliminary Methods	Preliminary Benchmark Score (every 10 years)	Preliminary Monitoring Score (every 3 years)
3.1b: % Departments with Biodiversity Programs, Policies	Measures specific initiatives and policies related to biodiversity within departments at the City of Los Angeles.	MODIFIED from Singapore Index Indicators 15, 16, and 18. Singapore Index Indicator 15, related to budget for biodiversity, was too difficult to quantify since biodiversity is often a secondary benefit of many City-funded projects (e.g., water quality, regulatory compliance, etc.). Isolating costs specifically associated with biodiversity was challenging. Similarly, quantifying specific projects or institutions across the City (i.e., beyond the City's control), per Indicators 16 and 18, was challenging. Tracking existence of specific biodiversity programs and policies within departments is believed to be a more targeted approach toward the relevant City governance activities.	Modified from Singapore Index - see Singapore Index methods for Indicators 15, 16, and 18 from the 2018 City of LA Biodiversity Report and Appendix B and refine/modify methods as necessary.	0 points: < 20%	-2 points (significantly negative): No departments with biodiversity programs or policies
				1 point: 20 - 35%	-1 point (negative): 1 or less departments with biodiversity programs or policies
				2 points: 35 - 50%	0 points (neutral): no change
				3 points: 50 - 65%	1 point (positive): 1 or more departments developing biodiversity programs/policies
				4 points: 65 - 85%	2 points (significantly positive): Multiple departments developing biodiversity policies/programs
				5 points: > 85%	
3.2 Management: Evaluates City management activities emphasizing on-the-ground stewardship.					
3.2a: % Protected Natural Areas	Measures the proportion of natural areas (identified in metric 1.1a) that receive formal protection as dedicated parks, open space, or easements.	MODIFIED from Singapore Index Indicator 9. Score thresholds were adjusted to reflect more appropriate percentages that have potential to demonstrate meaningful change over time in LA.	Using methods from Singapore Index Indicator 9 and natural areas classification in Indicator 1 as the basis, measure the area of Natural Areas that fall within protected lands identified in the California Protected Areas, Conservation Areas databases, and/or other protected lands. Currently, 12.2% of City is Protected Natural Area and 20.5% of the City is Natural Area, therefore, baseline = ~60% of natural areas are protected and forms the lower threshold for performance scoring. (*would also be beneficial to account for level of protection since some protections have minimal "teeth").	0 points: < 60%	-2 points (significantly negative): any reduction in protected areas
				1 point: 60 – 65%	-1 point (negative): any weakening of protections
				2 points: 65 – 70%	0 points (neutral): no change
				3 points: 70% – 80%	1 point (positive): 0-1% increase in protected natural areas
				4 points: 80% – 90%	2 points (significantly positive): >1% increase in protected natural areas
				5 points: >90%	
3.2b: Protected Natural Areas Management and Monitoring	Assesses the level of physical-on-the-ground stewardship being applied in natural areas based on person-hours per acre per year.	NEW indicator not accounted for in Singapore Index. Accounts for the level of stewardship occurring within natural areas. Supplements 1.1a and 3.2a, which only evaluate existence or protected status of natural areas.	Measurement of this indicator will require evaluation of practices by LA Rec & Parks and other entities engaged in managing natural areas portions of parks and other protected areas. Differentiating hours worked on natural areas management vs. non-natural areas management activities will be necessary (*person-hours per acre natural area per year may also be considered as a metric for quantification).	0 points: no management program	-2 points (significantly negative): any reduction in stewardship activities and staff/volunteers
				1 point: critical management activities only	-1 point (negative): any reduction in stewardship activities
				2 points: volunteers or equivalent hours to 1 dedicated staff per >100 acres	0 points (neutral): no change
				3 points: equivalent hours to 1 dedicated staff per 100 acres	1 point (positive): increase in stewardship activities
				4 points: equivalent hours to 1 dedicated staff per 50 acres	2 points (significantly positive): increase in stewardship activities and staff/volunteers
				5 points: equivalent hours to 1 dedicated staff per 25 acres	

Indicator/Metric	Description	Relationship to Singapore Index Indicator(s) (Retained, Modified, or New)	Preliminary Methods	Preliminary Benchmark Score (every 10 years)	Preliminary Monitoring Score (every 3 years)
3.2c: Management of Invasive Species & Pests	Assesses level of management activities being implemented including: inventory, control of spread policies, management plan, area managed, etc.	NEW indicator not accounted for in Singapore Index. Accounts for the level of stewardship related to management of invasive species or pests. Supplements indicator 1.3b which only evaluates the presence and threat of invasive plant species.	Measurement of this indicator will require evaluation of practices and policies related to invasive species within the area of interest. Smaller-scale activities within individual protected areas, or by non-governmental agencies, could also be integrated into scoring on a protected area-by-protected area basis.	0 points: no inventory of Invasive Species	-2 points (significantly negative): No invasive species monitoring/management activities being implemented by City
				1 point: inventory of Invasive Species	-1 point (negative): NA
				2 points: inventory and monitoring of Invasive Species	0 points (neutral): Invasive species monitoring/management planned, but no activity toward implementation
				3 points: above + Invasive species policy that prohibits the sale of invasive plants and bans second generation rodenticide.	1 point (positive): Invasive species monitoring/management being implemented
				4 points: above + integrated pest management (IPM) for Invasive Species	2 points (significantly positive): Funded invasive species monitoring/management programs
				5 points: above + IPM for Invasive Species, Management Plan to prevent future invasions	
3.2d: Management of Threatened, Endangered, & Species of Concern	City's contribution toward protection and recovery of Threatened & Endangered Species and compliance with the State of California Endangered Species Act. Monitors level of planning for categories of species toward protection and recovery.	MODIFIED from Singapore Index Indicators 15, 16, and 18. A portion of the budget and initiatives quantified for Singapore Index Indicators 15, 16, and 18 are related to compliance with State and Federal laws related to biodiversity. 3.2d accounts for level of City compliance with State and Federal Laws related to biodiversity, specifically, which provides a more direct indication of the effectiveness of related City funding and initiatives.	Review policies, planning, and monitoring of species of conservation concern. Smaller-scale activities within individual protected areas or by non-governmental agencies could also be integrated into scoring on a protected area-by-protected area basis.	0 points: no inventory of Species of Concern in the City	-2 points (significantly negative): loss of an existing sensitive species from the City
				1 point: inventory of Species of Concern in the City	-1 point (negative): new sensitive species currently present in the City is listed
				2 points: inventory and monitoring of Species of Concern in the City	0 points (neutral): no change
				3 points: mitigation plan for impacts Species of Concern in the City	1 point (positive): increase in area of habitat for species of concern in City
				4 points: no-net-loss plan for Species of Concern in the City	2 points (significantly positive): species of concern not presently known to be in the City are observed
				5 points: adopted recovery plan for Species of Concern in the City	

Each LA Biodiversity Index metric is measured and scored on a 5-point scale. The term "score threshold" refers to the real-world quantitative measurements that differentiate each point score within a metric. An example of scores and score thresholds for metric 1.1a is provided in Table 1-2. The 5-point scale is similar to the 4-point scale used in the Singapore Index; however, the additional point allows for more specificity with little additional complexity.

The proposed scoring system also accommodates the long-term LA Index measurement schedule envisioned by the City. An important critique of the Singapore Index was that scores for many of the indicators are unlikely to change due to the large range often represented within each score threshold. The LA Index overcomes this in two ways. First, major measurements, listed as "benchmark scores" in Table 1-2, of the LA Index are planned at relatively long 10-year intervals starting in 2020 or 2021. Benchmark scoring requires specific, quantitative measurements of physical biodiversity, such as total acreage of natural areas, spatial distribution of umbrella species, etc., that will determine whether quantitative objectives are achieved. The 2030 benchmark score will be vital in understanding progress on the no-net loss goal. Such detailed and large-scale measurements often rely on data collection activities that are costly to perform frequently, such as vegetation classification and mapping that has not been completed City-wide in nearly 20 years. Further, the City does not have the funding or staffing necessary to complete measurements of underlying data (e.g., updating vegetation mapping) at this time and will continue to rely on publicly available information. While some indicators can certainly be measured more frequently if data allows, or if conservation concerns are urgent, the 10-year time interval will allow enough time to fund and complete more complex data analyses to support measurement. The 10-year timeframe will likely be sufficient to track positive or negative changes for individual biodiversity metrics.

Second, each metric in the LA Index also includes a "monitoring score" measured every three-years using an ordinal value system. The three-year measurement cycle corresponds with the LA Region Imagery Acquisition Consortium (LARIAC) remote sensing schedule that is central to measuring many of the spatially explicit metrics. The ordinal system is oriented around the qualitative direction of change, positive, neutral, or negative, rather than specific quantitative measurements. This was the approach taken for the precedent San Francisco Public Utilities Triple Bottom Line Tool indicator system (SFPUC 2015). Qualitative monitoring measurements will be less data-intensive and less precise than the 10-year benchmark measurements, reducing measurement costs and time. Still, they will effectively identify and communicate progress toward more specific, long-term quantitative targets. For example, if a metric is consistently monitored as negative, or significantly negative, every three years, then the metric is clearly not on track to achieve longer term quantitative targets, such as the no-net loss and social equity targets. This qualitative information suggests that policies need to be adjusted if quantitative targets are to be achieved. In certain cases, more frequent monitoring and reporting of benchmark and monitoring scores to policymakers may also be warranted. Figure 1-3 is a conceptual representation of potential monitoring and benchmark score reporting approach for the LA Biodiversity Index Native Biodiversity Theme over the 2020-2030 10-year time frame.

A weighting system that accounts for the difference in importance of metrics has also been incorporated and is represented in Figure 1-4. Weighting will be refined during index measurement based on priorities of stakeholders and the Expert Council. Total scores for each of the three biodiversity themes for benchmark-year measurements will be adjusted to a 100-point score for each theme. In this way, the index normalizes overall biodiversity performance across the three priority themes so end users can better evaluate biodiversity stewardship decisions within and between each theme independently. Employing a 100-point scoring system will make communicating results to stakeholders and the public at large simpler. Hundred-point scales are similar to scholastic grading systems and can be translated to letter grades, as is currently done for the Heal the Bay's Beach Report Card (Heal the Bay, 2019).

Table 1-2: Example benchmark and monitoring scoring thresholds for metric 1.1a. Two interrelated scoring approaches improve sensitivity of the index to change and reduce complexity of measurement methods over the course of long-term application.

Indicator/Metric	Preliminary Benchmark Score (every 10 years)	Preliminary Monitoring Score (every 3 years)
1.1a: % Natural Areas	0 points: <1% natural areas	-2 points (significantly negative): evidence of major net reduction due to land development/land conversion projects
	1 point: 1-5%	-1 point (negative): evidence of a net reduction
	2 points: 5-10%	0 points (neutral): no change
	3 points: 10-30%	1 point (positive): evidence of a net addition
	4 points: 30-50%	2 points (significantly positive): evidence of major net addition due to significant ecological restoration projects
	5 points: >50% natural area	

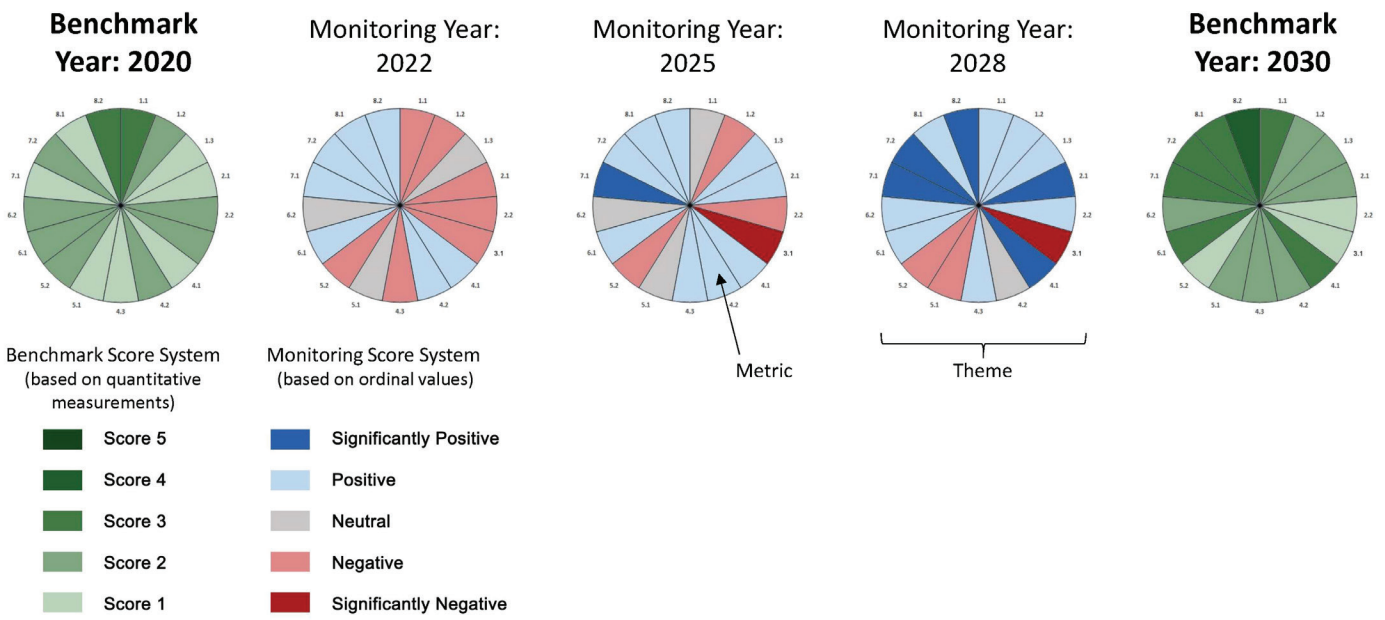


Figure 1-3: Conceptual representation of 10 -year Index reporting for the Native Biodiversity Theme. Comparison of color change within pie charts allows for simple visual communication of the overall index performance trend over multiple planned measurement years. Each pie piece is color-coded to represent an individual metric score. The 10-year benchmark scores require detailed quantitative measurements and darker green represents higher levels of biodiversity. Monitoring year metrics are measured using more simple methods to determine ordinal direction of change every three years to indicate whether stewardship activities are on track to achieve longer-term quantitative targets.

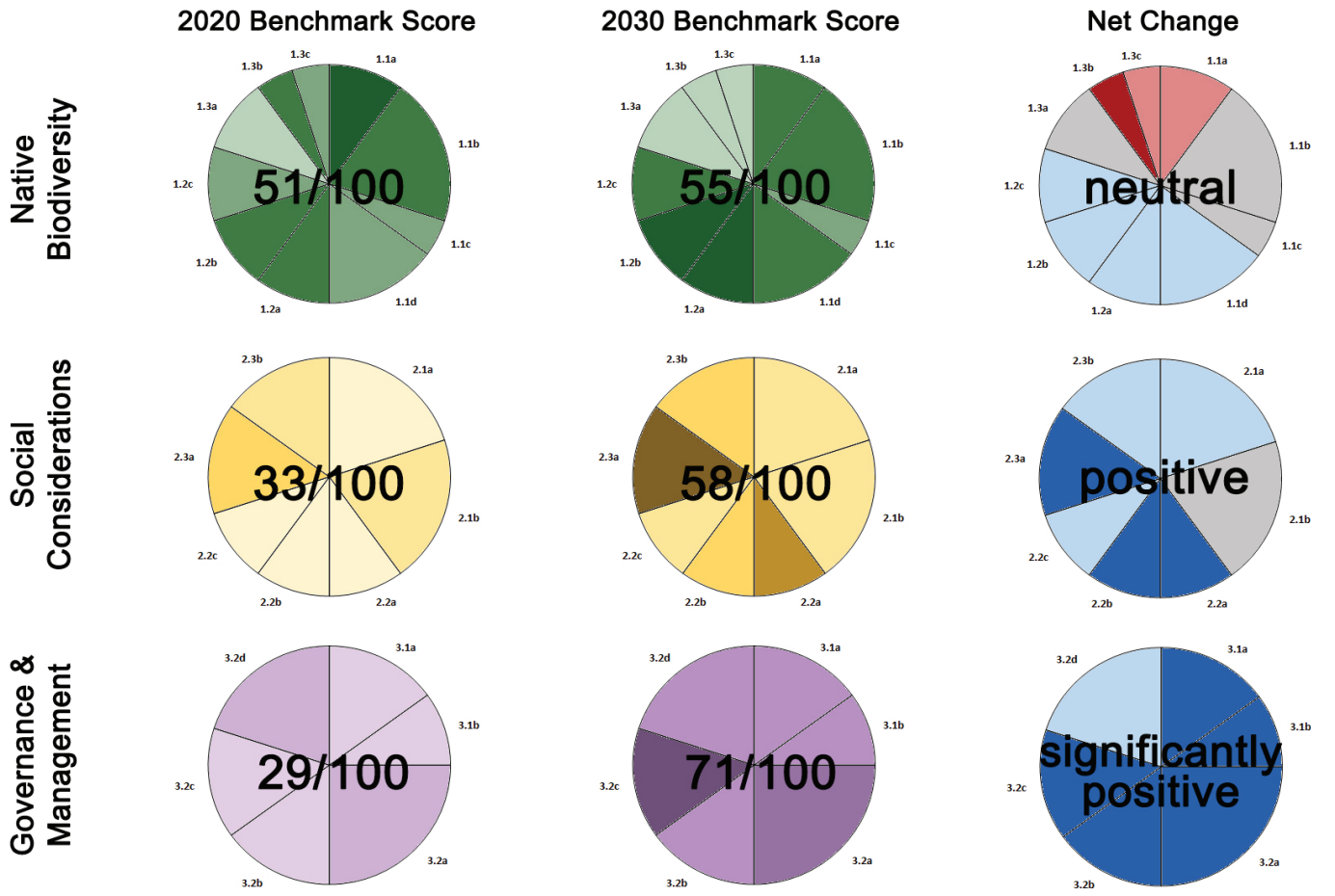


Figure 1-4: Conceptual Index reporting for the 2030 benchmark year. Weighted metric scores are denoted by sizes and colors of pie slices within each of the three themes. Total weighted scores for the 2020 and 2030 benchmark years overlay the charts. Ordinal change between 2020 and 2030 is presented at right. The conceptual results represent a scenario where management and social stewardship actions are aggressively pursued to achieve no-net loss in the native biodiversity theme, a likely scenario considering the significant conservation challenges due to climate change and urban growth.

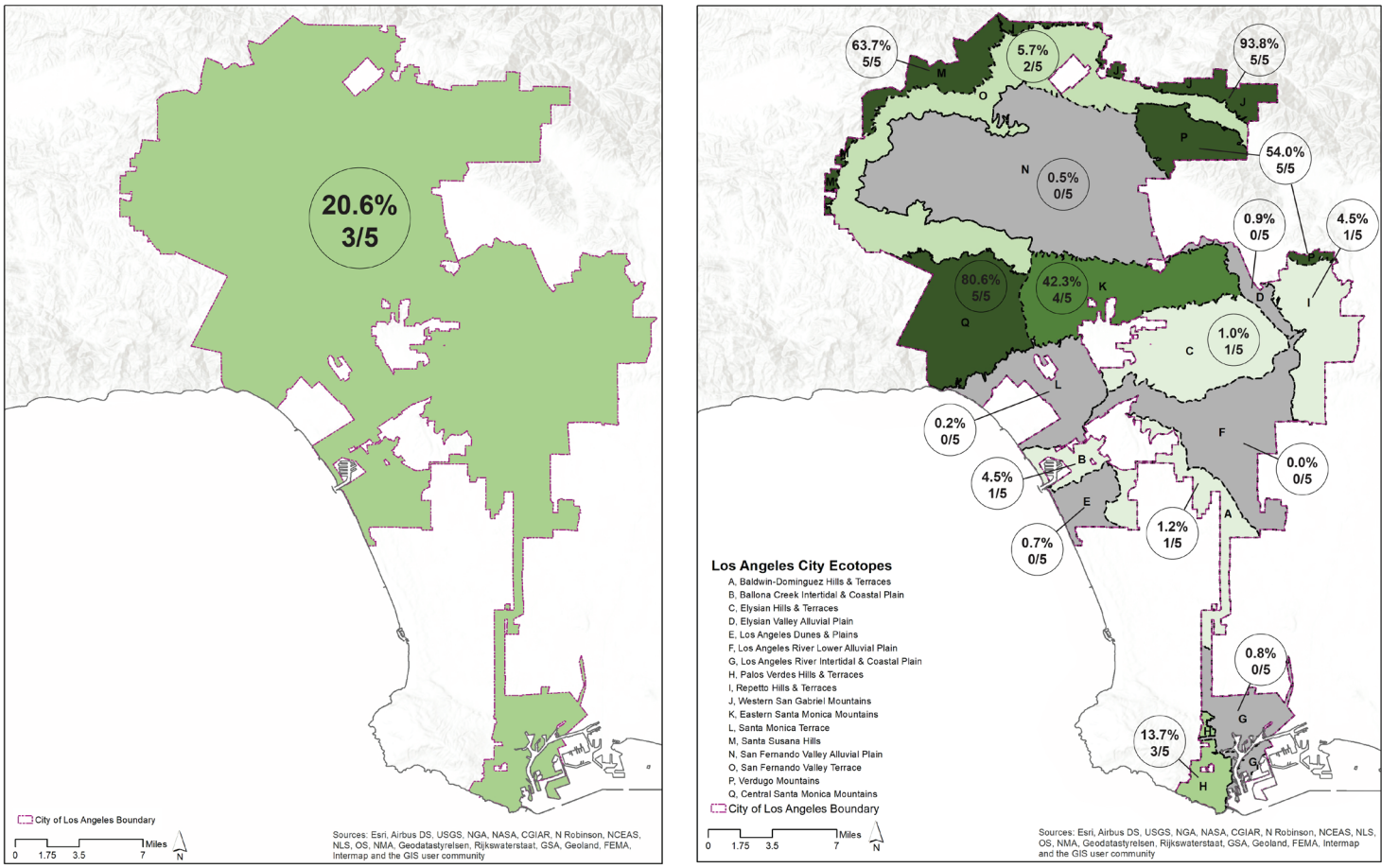


Figure 1-5: City-wide LA City Biodiversity Index score for Indicator 1.1a % Natural Areas using the Singapore Index methodology (left); and, scores for each Ecotope unit that falls within the City boundary (right). Ecotopes are described in detail in Chapter 2 and are used to better account for the distribution of biodiversity across the City in the LA City Index. Using the Singapore Index, results for this indicator are reported on a City-wide basis only (20.6% or Score of 3 for the entire City) providing less spatially explicit detail and utility in local management decisions.

A final component of the measurement strategy is the use of the "Ecotopes" framework to better account for the distribution of biodiversity across the City. Ecotopes are subregional-scale spatial units composed of unique combinations of landform, microclimate, and biotic features. They represent important "building blocks" of environmental conditions that shape native biodiversity. The ecotopes approach is fully presented in Chapter 2. Indicators within Theme 1, Native Species Protection and Enhancement, will be measured for each ecotope associated with the City of Los Angeles, in addition to City-wide measurement. Maintaining or improving scores for Theme 1 within every ecotope would demonstrate comprehensive distribution of biodiversity protection and enhancement across the City, a key recommendation by the Expert Council and component of a more defensible no-net loss strategy. Additional ecotope delineations to account for distribution of biodiversity related to social indicators in Theme 2 may also be produced in the future. Figure 1-5 presents scores for Indicator 1.1a for ecotopes that fall within the City boundary.

LA BIODIVERSITY INDEX DISCUSSION

Unlike indicator frameworks often produced within scholarly circles that are highly insightful, but with arguably more limited implementation value (e.g., Termorshuizen et al. 2007 or Rodríguez-Loinaz et al. 2015), this process has had implementation and institutionalization in City governance as its primary objectives. These objectives, and the supporting transdisciplinary collaborative process, has placed the LA Biodiversity Index in a strong position to achieve successful, long-term application. Ahern (2013) referred to such transdisciplinary processes as the *modus operandi* for sustainable and resilient urban planning and design. We also recommend that other cities consider crafting customized biodiversity indices tailored to their local context, and consider this process, including the role of the Singapore Index, as a model framework.

Since many of the indicators in the LA Biodiversity Index are spatially explicit and high resolution, dissemination as map data to aid in local decision making has also been a key objective. Sharing these maps and datasets via the City of LA's open

data platforms is anticipated to aid in decision making at individual project sites and across multiple City departments and disciplines that shape biodiversity in Los Angeles. The LA Index also draws from other City datasets to produce indicator measurements, including the County's tri-annual Light Detection and Ranging (LiDAR) remote sensing, Los Angeles Region Imagery Acquisition Consortium (LARIAC). This 3-year schedule, along with the Mayor's Sustainability pLAn 3-year update schedule, was a key consideration in the plan to report the LA Biodiversity Index at 3-year intervals. The long-term measurement strategy may also allow partial automation of indicator measurements in the future, possibly using the ArcGIS model builder tool integrated with regularly measured datasets like LARIAC, to save time and ensure replicability of measurement methods. Such integration and institutionalization, and potential automation, of local data gathering, performance measurement, and dissemination to aid local decision making could become a model for smart and ecological cities of the future.

The proposed plan for long-term measurement is not without its challenges. Effective measurement of the Index will often rely on outside research institutions to provide data to support ongoing measurement, so ongoing transdisciplinary collaboration and supporting funding for data collection could be necessary. Refinements to methods, and potentially entire indicators, may also be necessary as datasets are improved or topics of concern evolve. Emerging higher resolution vegetation mapping may make spatial comparison of change with older, more coarse-resolution datasets difficult. Environmental DNA (eDNA), an emerging technique that can improve detection of species, may eventually replace reliance on visual observations methods and could result in major alterations of data format and improved spatial coverage. These changes in data quality may be less of a concern with the more general three-year ordinal measurements that only require detection of direction of change. However, measuring more detailed, quantitative 10-year benchmark measurements with consistent methods will be necessary for comparison over time. One solution may be to measure the current benchmark year using both the previous and new measurement approaches so that differences with past measurements can be reconciled and future measurements can be aligned with the latest best practices.

To maximize the value of the LA Biodiversity Index to support positive biodiversity change, it must also support local-scale decision making. While the high resolution of many indicators supports application across geographic scales, individual projects at the parcel-scale often have access to much more detailed information on existing or planned environmental conditions, and they have the potential to craft stewardship activities at a much more detailed level. To accommodate this, the City of LA has also supported the development of a Site Biodiversity Index (SBI). The SBI is being used to evaluate biodiversity benefits of alternative design plans for a new park along the Los Angeles River (see Case Study 3 in Chapter 4). LASAN envisions that the SBI, or a similar tool, could become a key tool for assessing opportunities for biodiversity enhancement, stewardship, or mitigation for specific land development and stewardship projects. The SBI indicators are aligned with LA Biodiversity Index indicators, and results for sites may be integrated into City-wide LA Biodiversity Index measurements, providing more precise quantification of all projects administered through City Departments and better tracking of City-wide biodiversity change. Together, these tools may enhance comprehensive decision support and measurement of City Biodiversity goals across scales.

LA BIODIVERSITY INDEX SUMMARY

Environmental challenges of climate change, urban growth, and achieving social equity present complex, rapidly evolving challenges to stewardship of native biodiversity in cities. Strategic, quantitative approaches to measuring environmental performance are essential to support goals, such as stemming biodiversity loss in Los Angeles. To be successful, these approaches must be actionable and compelling to support effective local decision-making and stewardship. Quantification of performance is also often integral to securing and administering funding. The robust transdisciplinary process presented here, including applying the Singapore Index as a path to a customized biodiversity index for LA, has proven highly effective thus far. Such processes and tools provide a useful model as other cities seek to expand their institutional capacity to enrich and sustain urban biodiversity.

NEXT STEPS

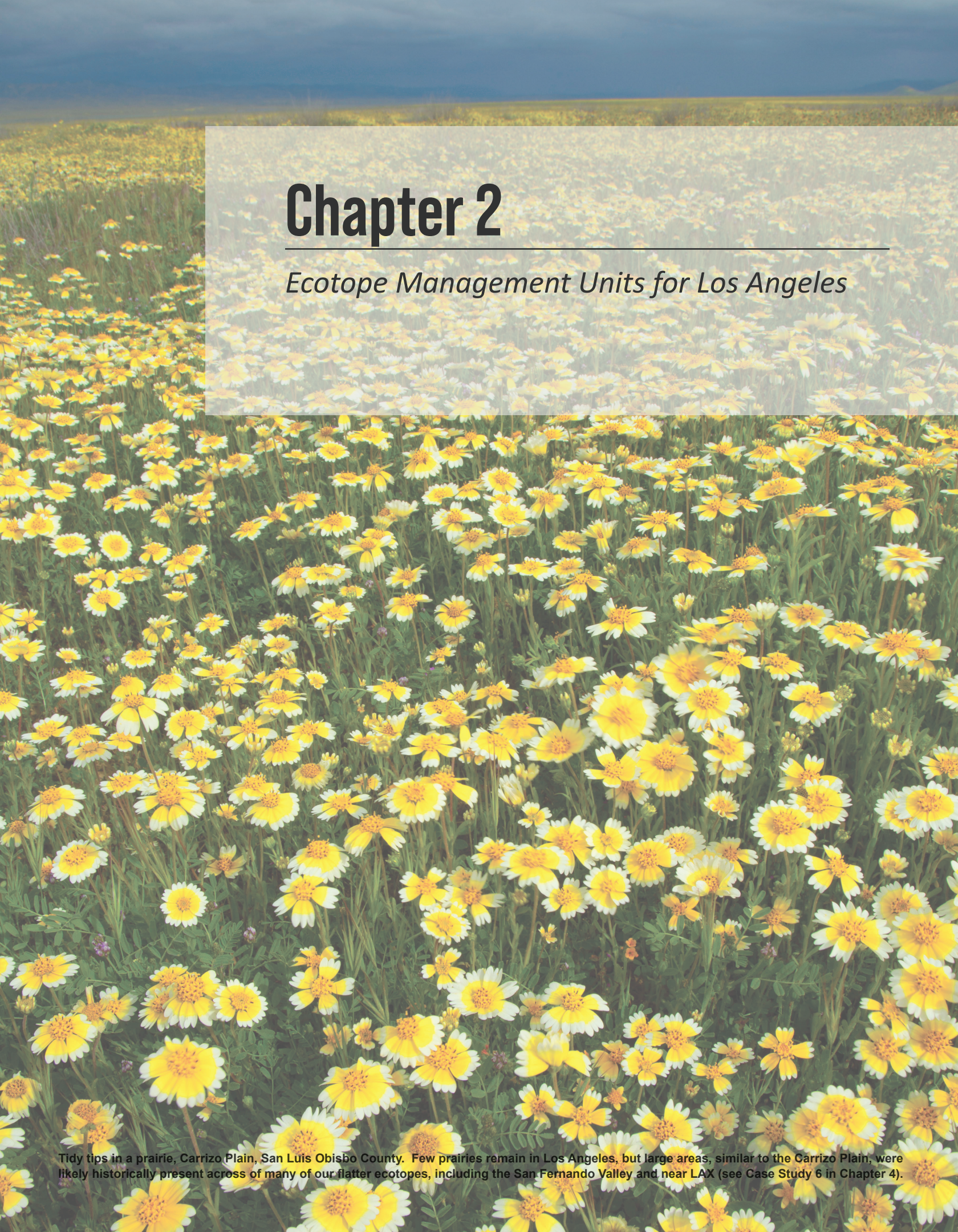
This chapter presents the framework for the brand-new LA Biodiversity Index. Table 1-1 provides the framework that the LASAN Biodiversity Team will use to perform the first measurement of the LA Index. At this time, the LASAN Biodiversity Team is working to perform preliminary measurements on all 25 metrics. Some metrics, such as 1.1b Habitat Quality of Urban Landscapes & Open Space (see Chapter 3) have already been measured. Many others have preliminary scores. However, many of the brand new metrics (i.e., metrics not accounted for in the Singapore Index) require additional research and refinement. The LASAN Biodiversity Team will work with members of the Interdepartmental Biodiversity Team and the Bio-

diversity Expert Council to refine and finalize methods as needed, making appropriate changes based on available datasets. LASAN will work with the Interdepartmental Biodiversity Team and the Biodiversity Expert Council to finalize individual metric scores.

LASAN will publish the detailed methodology and benchmark and monitoring scoring thresholds after the first measurement of the LA Biodiversity Index is complete. The resulting report will be similar to the 2018 Biodiversity Report and contain the overall index score for the City as well as individual metric scores, detailed methodology, maps, graphics, and management implications and recommendations for all 25 metrics. The overall score, and scores for individual metrics, can be used to assess progress on biodiversity initiatives, reveal shortcomings, and highlight data gaps. The management implications and recommendation sections will be particularly valuable as they will provide guidance to City practitioners and interested stakeholders about actions that can be taken to ensure that nature continues to thrive in the City of Los Angeles (e.g., encouraging habitat in building courtyards, on rooftops, etc.). LASAN also plans to include actionable items in a Biodiversity Action Plan that will outline implementation strategies and best practices.

Chapter 2

Ecotope Management Units for Los Angeles



Tidy tips in a prairie, Carrizo Plain, San Luis Obisbo County. Few prairies remain in Los Angeles, but large areas, similar to the Carrizo Plain, were likely historically present across of many of our flatter ecotopes, including the San Fernando Valley and near LAX (see Case Study 6 in Chapter 4).

CHAPTER 2: LOS ANGELES ECOTOPES FRAMEWORK

INTRODUCTION

This chapter presents the process and results of creating urban ecological subregions, or ecotopes, for Los Angeles. As we begin to manage cities more like ecosystems, differentiating urban landscape regions based on environmental conditions and stewardship objectives of interest can serve as an extremely useful management tool. A key challenge identified during the measurement of the Singapore Index on Cities' Biodiversity for Los Angeles (Chapter 1) is that LA is so large and environmentally diverse that the Singapore Index provided results that were often too general to be useful for supporting pressing management or research questions. Providing more spatially explicit information on the distribution of biodiversity across the City was a recurring recommendation by Expert Council members during the Singapore Index measurement process. The Ecotopes framework partitions the City and surrounding areas into a hierarchy of subregional-scale spatial units to measure the biodiversity index in a more localized way while still considering overall City performance.

We envision ecotopes as a spatial framework to comprehensively manage urban ecosystems. Ecotopes will serve as future management units to address biodiversity and related urban ecosystem stewardship topics of ecosystem services, pollution, climate change, and ecological hazards. As the City of Los Angeles is vast, with varied environmental conditions, City-wide strategies to address climate change and ecological hazards may lack the specificity to create meaningful change. As ecotopes have similar environmental conditions, they can be managed as individual units. Specific management activities to address risks can be tailored to individual ecotopes (or even the five general ecotope categories). To assist planning and management efforts, the framework is accompanied by a high-resolution dataset of environmental factors relevant to biodiversity stewardship and site-level decision making. The dataset can be used by City Planners, Landscape Architects, and Biologists, to support management decisions, as described above, inform landscape design for biodiversity, and maximize onsite urban ecosystem services, such as stormwater management.

In the future, the team envisions partitioning subregional ecotopes into finer neighborhood-scale ecotopes to provide more detailed information to support increasingly localized ecological and biodiversity decisions related to infrastructure design, landscape architecture, park and natural areas stewardship, habitat connectivity, urban planning, or similar site-management activities. Previous studies have demonstrated the usefulness of such a hierarchical framework for natural land ecosystem management (e.g., McNab et al. 2007, Cleland et al. 2009), but this is the first time such mapping has been applied in an urban environment. While we present highly detailed contextual information relevant to differentiating ecotopes for Los Angeles, the approach and considerations presented in this chapter provide a roadmap for application in cities worldwide.

ECOTOPES BACKGROUND

Partitioning large, complex land areas into multiple spatial management units is a common strategy used in urban and environmental planning. Such spatial units often comprise relatively homogeneous areas of analogous environmental properties relevant to management concerns at the scale of interest. Often, however, such units are based on jurisdictional boundaries with little relevance to environmental conditions. This was a concern that led the Jepson Flora Project (2019) to move from a county-based system for managing and researching the California Floristic Province to units defined by natural feature boundaries in their "geographic subdivisions" system. Additionally, in habitat conservation planning such landscape units may be used to ensure that reserve networks adequately conserve biodiversity by protecting habitats and connectivity within and between regional units (e.g., Bay Area Conservation Lands Network 2.0). Watersheds are a similar type of natural unit often preferred for managing large-scale water quality objectives.

This effort aims to integrate urban planning and ecological objectives to create urban subregional units, or "ecotopes," for the purposes of managing the Los Angeles urban ecosystem. Comprehensive urban ecosystem management generally addresses themes encompassing biodiversity conservation, ecological hazards, pollution, or ecosystem services. While the term "ecotope" has been used in a variety of ways within the field of ecology for more than a century, the term emerged within the local dialogue around LA City biodiversity to describe subregional-scale landscape units. Ecotopes, in this study, refer to *urban subregional-scale three-dimensional landscape units ranging in size from 1,000's to 10,000's of acres (400's to 4,000's of hectares) that contain similar landform, microclimate, and natural vegetation characteristics.* Modeled from current best practices applied for more rural lands, these units are delimited based on key natural features within the City rather than jurisdictional boundaries.

In addition to providing contextual information to support site to regional-scale ecological decisions, such comprehensive, ecosystem-based tools are useful because they communicate interrelationships and foster synergies between multiple disciplines involved in urban environmental management (e.g., biology, hydrology, geology, air quality, public health, social ecology, urban design, etc.), which is key for achieving higher levels of urban ecological sustainability while saving time and cost. By addressing these synergies and cross-disciplinary interrelationships, ecotopes provide an overarching framework for comprehensive ecosystem measurement, planning, and stewardship for the City, in addition to supporting more specific efforts such as urban biodiversity, water quality, or urban forestry.

OVERVIEW OF SPATIAL UNITS

Determining the primary ecological characteristics to use as the basis for partitioning spatial units is the first step in mapping ecosystems, or ecotopes. A common approach is to characterize ecosystems based on combinations of atmospheric, physiographic, and biotic factors at multiple scales (e.g., Barnes et al. 1982, Barnes et al. 1998, Hjort et al. 2015). The United States Forest Service's (USFS) Ecological Subregions of the United States, or ECOMAP, is a well-developed system that considers such a framework (see Figure 2-1) (ECOMAP 2007, McNab et al. 2007). Another precedent is the UC Berkeley Jepson Herbarium's "geographic subdivisions" of the California Floristic Province, which characterizes the distribution of biota based on topography, climate, and vegetation. However, methods and descriptions provided for each subdivision reveal an approach that appears to be mostly based on vegetation structure. While the Jepson geographic subdivisions serve as a spatial framework for botanical research and inventory, the purpose of the USFS ECOMAP system is broader and informs the USFS's overall organization and a wide variety of ecosystem management activities. Thus, ECOMAP represents the type of comprehensive ecosystem management-oriented framework the LASAN Biodiversity Team intends for Los Angeles ecotopes and is the starting point and methodological benchmark for partitioning finer-scale ecotopes.

NESTED HIERARCHY APPROACH

A key feature of the ECOMAP system, and similar land mapping efforts, is the partitioning of units at multiple scales within nested hierarchy to address management topics at various relevant scales of interest, and to integrate management across scales. ECOMAP partitions range from the broadest-scale, "Domains," which are more relevant to national scale activities, to the finest-scale, "Subsections," which are more relevant to regional-scale activities (see Figure 2-2). The system suggests additional finer-scale partitions that are not included in the national dataset, but have been mapped for many of the individual natural forest units. It is this next level of resolution, what the USFS calls the "Landtype Associations," that is the focus of the ecotopes analysis. This unit is more appropriately called an "urban subregion" in this project context.

Urban subregions are often referenced when implementing broad city policies, such as general plans, large scale infrastructure planning such as transit or water systems, or managing ecological processes such as urban heat islands or coastal zones subject to sea level rise, etc. Urban subregions, or "subareas," are also common in urban conservation planning in

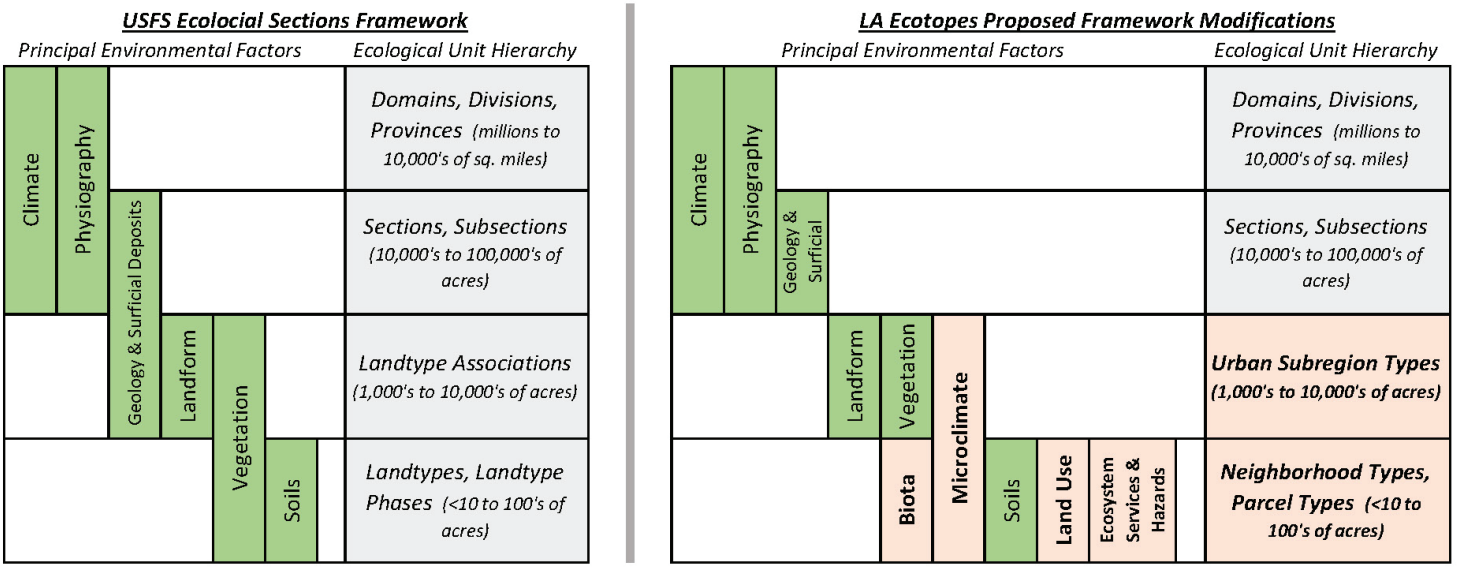


Figure 2-1: Comparison of USFS ECOMAP and LA Ecotopes frameworks. (Left) USFS ECOMAP system based on Cleland, Keys, and McNab (2009) and McNab et al. (2007). (Right) Modifications for LA Ecotopes are indicated in orange, maintained components are in gray or green.

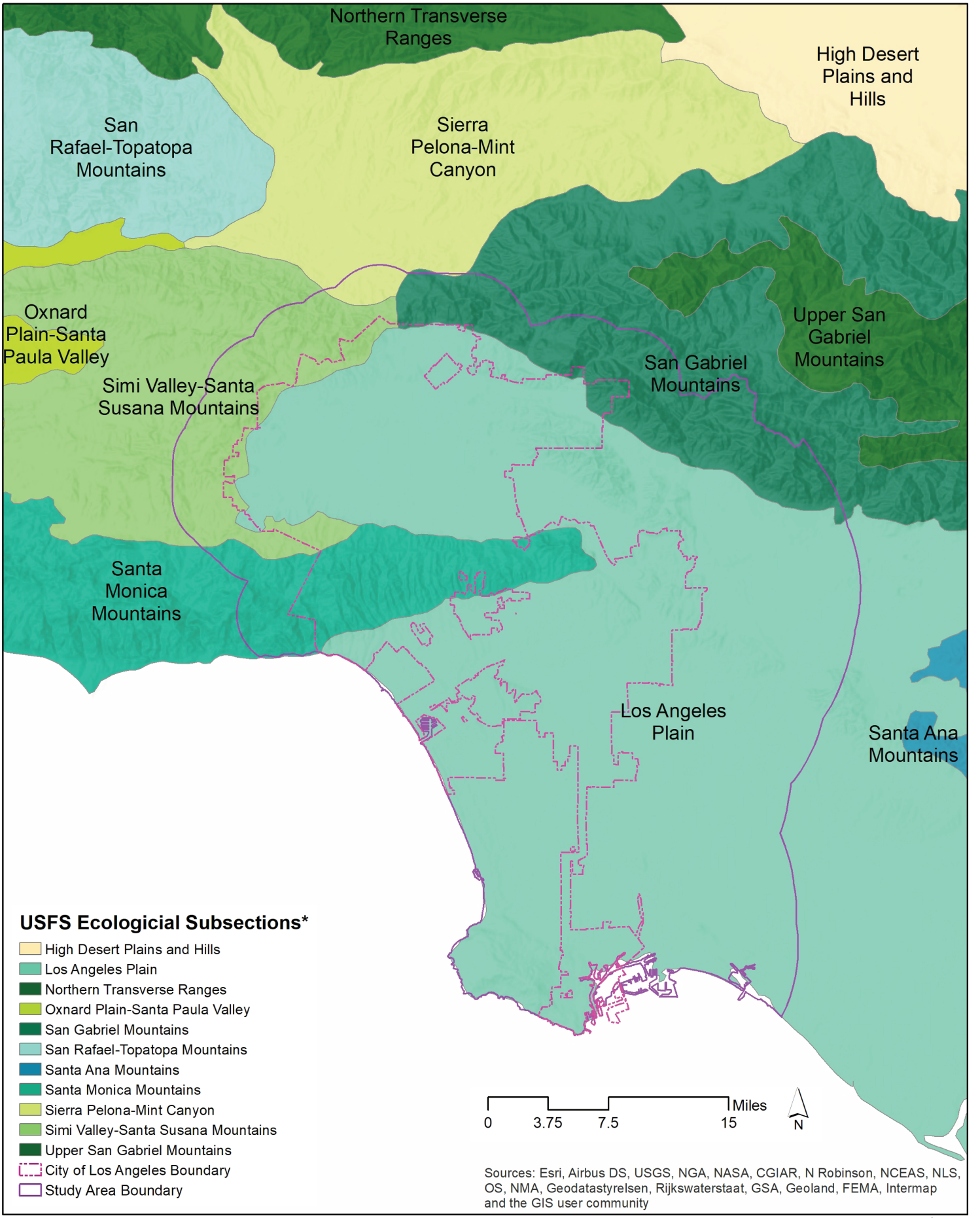


Figure 2-2:2007 USDA Forest Service Ecological Subsections (McNab et al. 2007)

Southern California, such as the Rancho Palos Verdes Natural Communities Conservation Plan (CDFW 2018). Subregional units also serve as a bridge in the hierarchy, and are a necessary step, toward crafting ecotope units at the finer neighborhood, or local-scale. The local-scale has been described as key for creating actionable science to support decisions that are dominant drivers of urban ecological change such as parcel-level activities, infrastructure, or landscape design (Opdam et al. 2013, Kaczorowska et al. 2016, Kremer et al. 2016).

METHODS

The process of determining ecotopes requires selecting and mapping relevant factors as the basis for differentiating and delimiting ecotope units (i.e., partitioning). Partitioning relatively homogeneous management units is often driven by particular management or research questions, and in cities, partitions may be driven by built, social, or natural features. In selecting factors, it is also necessary to determine which factors are relevant at the scale of interest and which may be more appropriate at finer or broader scales. Data resolution and availability are also important considerations, and it should be noted that this analysis relies on existing data to the greatest extent possible. General methods for delimiting ecotopes are described below and more detailed methods describing the theoretical underpinnings for the selection of factors, datasets, and discussion for how factors were combined to characterize ecotopes is presented in Brown (2019), Chapter 2. Appendix B provides more detailed characterizations and maps for the 27 ecotopes in the City of Los Angeles and surrounding areas, including methods and rationale for selecting the overall study area boundary.

PRINCIPAL ENVIRONMENTAL FACTORS

In line with the USFS system, the principal environmental factors of natural atmospheric (microclimate - see Figure 2-3), landform (see Figure 2-4), and native vegetation factors (see Figure 2-5) were used to differentiate and delimit Los Angeles ecotopes. For additional maps that show the three principal environmental factors for a single ecotope, see Figures 2-10, 2-11, and 2-16 respectively. Natural vegetation characteristics are a key factor driving biodiversity and ecosystems. Abiotic characteristics of the earth's surface, including climate and geophysical conditions, sometimes referred to as "geodiversity," are also integral and influence patterns of habitat suitability and landscape processes, such as climate change adaptation of ecosystems, exposure to disturbance events, or species movement (Anderson et al., 2014, Hjort et al. 2015).

Cities, like Los Angeles, have urban ecosystems that are defined by a combination of built, social, and natural characteristics. Factors such as urban zoning, building form, the distribution of disadvantaged communities, and/or pollution patterns are significant influences on urban ecosystems. However, the purpose of this hierarchical approach is to effectively manage complexity and consider all related factors that drive urban ecology and biodiversity at the most relevant scales. Consequently, social and built factors were carefully considered as potential drivers of subregional ecotope partitions, but were determined to be most appropriately considered as principal environmental factors in future neighborhood-scale ecotopes. Figure 2-1 outlines principal environmental factors for the USFS Ecological Sections ECOMAP Framework, and the modifications that were made for Los Angeles Ecotopes. Principal environmental factors envisioned for the neighborhood and finer scales are also presented in Figure 2-1, but are not delimited in this current effort.

ESRI ArcMap GIS software was used to delimit and analyze ecotopes. As was done for the USFS Ecomaps system, classification of ecotopes relied on expert judgment and interpretation of principal environmental factors maps to determine the general combinations of conditions that are most appropriate to differentiate ecotope zones at the subregional-scale, with relatively obvious environmental features used to delineate boundaries (e.g., boundary between well-sorted, undeveloped alluvial soils on flat slopes and adjacent terraces with well-developed soil profiles and steeper slopes). The spatial composition of principal environmental factors within each ecotope was measured by converting principal environmental factor shapefiles to a 30-meter raster grid, extracting pixels for each ecotope, and summarizing the results in Microsoft Excel. As with USFS Ecomaps and the Jepson geographic subdivisions, regionalization of ecotopes did not involve a statistical analysis and there was no weighting of factors. Instead, differences in combinations of microclimate and landform factors were clearly apparent, such as the broad alluvial plains within coastal microclimates of the lower LA River and the broad alluvial plains in the more continental climate of the San Fernando Valley. The varying combinations of principal environmental factors that differentiate each ecotope are characterized in Brown (2019). Quantitative analysis of the spatial coverage of each principal environmental factor served primarily as a confirmation that the types of landforms, vegetation, or microclimates present were appropriate for the ecotope. Anomalies were investigated to refine boundary locations and certain areas were reclassified. Generally, ecotope boundary locations follow Natural Resource Conservation Services' SSURGO Soil Type Unit boundaries, with some boundaries modified based on topography (see Landform subsection discussion below). The following section discusses each of the principal environmental factors (PEF) in more detail.

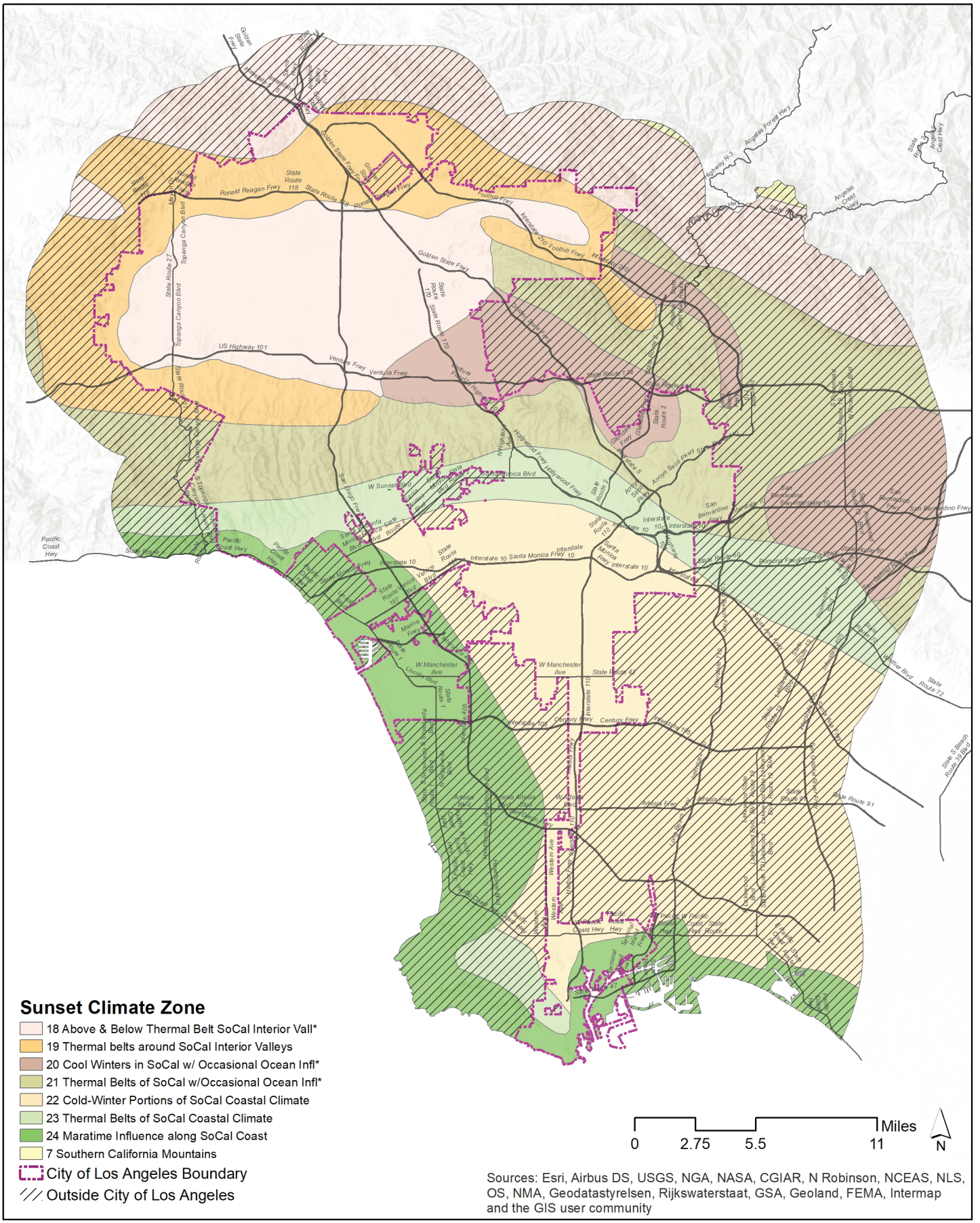


Figure 2-3: Principal Environmental Factor 1: Los Angeles Microclimates.

PRINCIPAL ENVIRONMENTAL FACTOR 1: MICROCLIMATE

As the source of energy and moisture, climate is the primary natural driver of ecosystem characteristics. In the Los Angeles region, climatic characteristics are relatively fine grained due to the complex interaction of ocean and continental weather influences, and topography. The region's position mid-latitude along the Pacific Ocean moderates microclimates near the coast resulting in a relatively long growing season and reduced summer heat extremes. More interior and high elevation areas are exposed to freezing and frost conditions in winter, with inland valleys exposed to prolonged desert-like heat extremes in summer. A unique microclimate feature of the Los Angeles region is its "thermal belts" with temperatures and humidities favorable to support unique Mediterranean species, some with subtropical origins, including citrus fruits, palms, and endemic native species such as the Engelmann Oak. Like many cities, Los Angeles also exhibits a strong urban heat island effect, which is a measure of the increase in temperatures in urban areas relative to an assumed natural condition. Some have called the phenomenon in Los Angeles an "urban heat archipelago," since the effect is strongest in interior valley areas and weakest along the coast, mainly due to interactions between urban-generated heat and patterns of cooling sea breezes (Taha 2017).

Sunset Climate Zones were produced to specifically serve the gardening industry, and while the original methods of delineation could not be acquired, the system is largely drawn from on-the-ground experiences of gardeners and farmers over decades (Figure 2-3) (Sunset Magazine 2017). The result is the most detailed available map considering multiple climate factors that drive environmental suitability for biota at the subregional-scale. Like the similar Koppen Climate system, Sunset considers maximum and minimum temperatures and precipitation patterns. Sunset also adds consideration of historic frequency of extreme hot or cold events, which are key drivers of long-term horticultural suitability and distribution of natural biota. Infrequent natural disturbance events, such as 100-year floods, droughts, wildfires, or pest outbreaks, are also important drivers of ecosystem change and should be factored into long-term environmental planning. In addition to temperature, the Sunset Climate Zones also consider latitude, elevation, ocean influence, continental air influence, and the presence of mountains, hills, and valleys. Therefore, the Sunset system is the most robust available in terms of differentiating factors and was chosen as the preferred microclimate principal environmental factor dataset.

PRINCIPAL ENVIRONMENTAL FACTOR 2: LANDFORM

Landform is a key feature for defining smaller divisions of ecosystems. A landform's slope, soils, and elevation influence an ecosystem's microclimate and surface hydrology at finer scales, which in turn influences vegetation, biodiversity, and disturbance process (e.g., such as wildfire or land use), making landform characteristics optimal features for defining finer-scale ecosystems. While microclimate considerations relied on an existing system, the Sunset Climate Zones, some data processing was required to produce the landform map. The Natural Resource Conservation Service's (NRCS) Soil Survey Geographic Database (SSURGO) soils dataset was the starting point for the ecotopes landform classification. SSURGO included landform classifications for most soil units within the study area. Where SSURGO landforms designation for soil units was missing, or naming was inconsistent, those polygons were evaluated and reclassified in ArcGIS by the LASAN Biodiversity Team. Classifications considered a variety of factors including soil type, slope %, elevation, slope position, surface hydrology, sea level rise projections, and surrounding landforms. Ultimately, ecotope landforms were reclassified into 8 categories with the following general characteristics and are mapped in Figures 2-4 and 2-11:

1. ALLUVIAL & COASTAL PLAINS: Historic or active floodplains or coastal plains with average slopes less than 2% and mixed soil types with minimally developed soil profiles.

2. ALLUVIAL FANS & TERRACES: Alluvial fans and other terrain exposed to historic, or ongoing, alluvial processes, including net deposition of alluvial material, generally near the foot of hills or mountains. Average slopes generally ranging from 3-8% often with coarse, well-drained soils.

3. TERRACES & ARROYOS: Terrain exhibiting average slopes generally less than 8%. Historically, terraces were shaped by alluvial or ocean processes, but natural land movement had eliminated these exposures prior to land development. Terrace landforms are often interspersed with small valleys or arroyos that channel drainage.

4. SAND DUNES, PLAINS, & COASTAL STRAND: Areas classified as dunes or strand in the NRCS SSURGO dataset, and adjacent areas with sandy soils.

5. HISTORIC INTERTIDAL: Flat terrain with elevations less than 20' (6 meters) above sea level, and projected to be subject to future marine and riparian flooding associated with 1-meter of sea level rise.

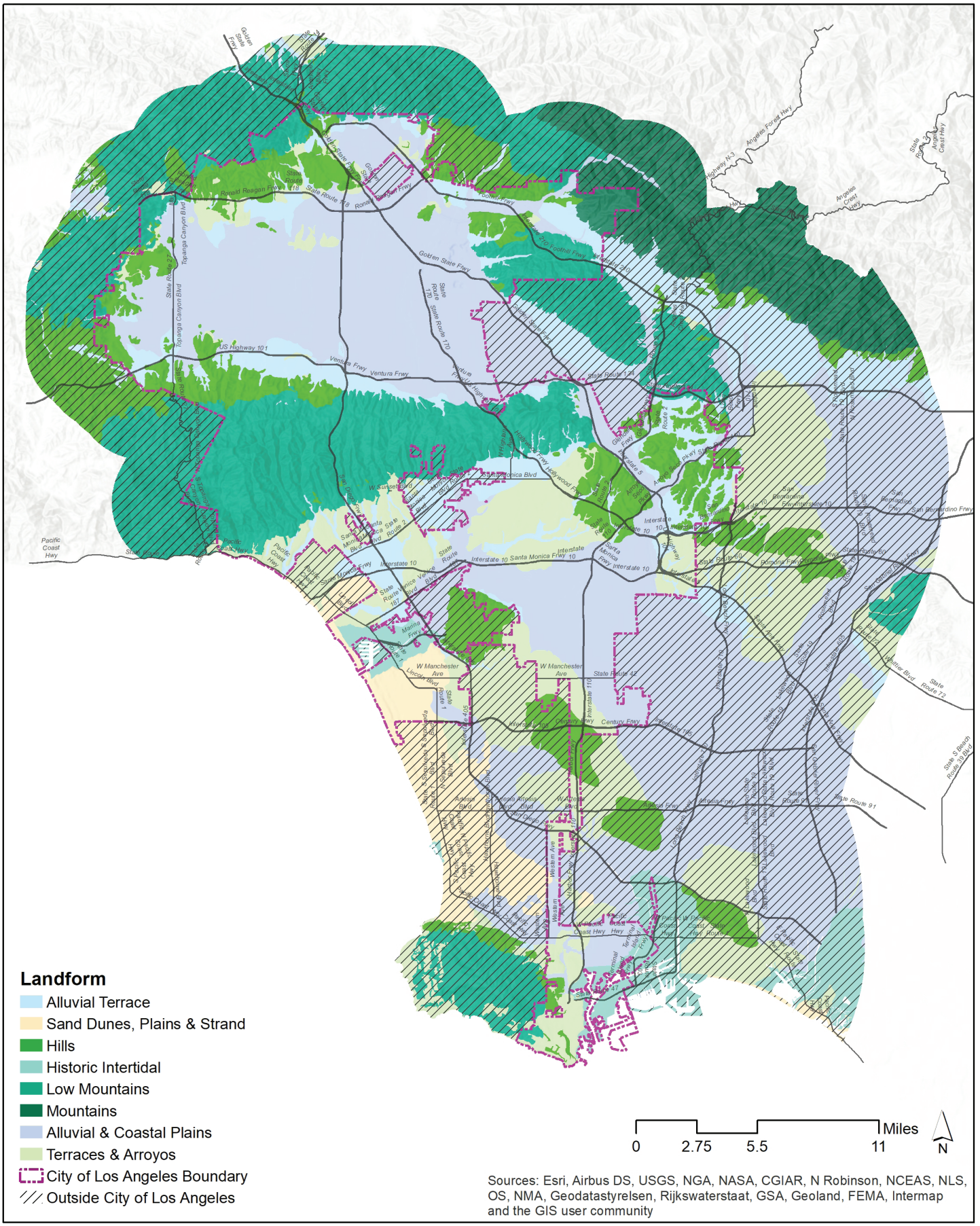


Figure 2-4: Principal Environmental Factor 2: Los Angeles Landforms.

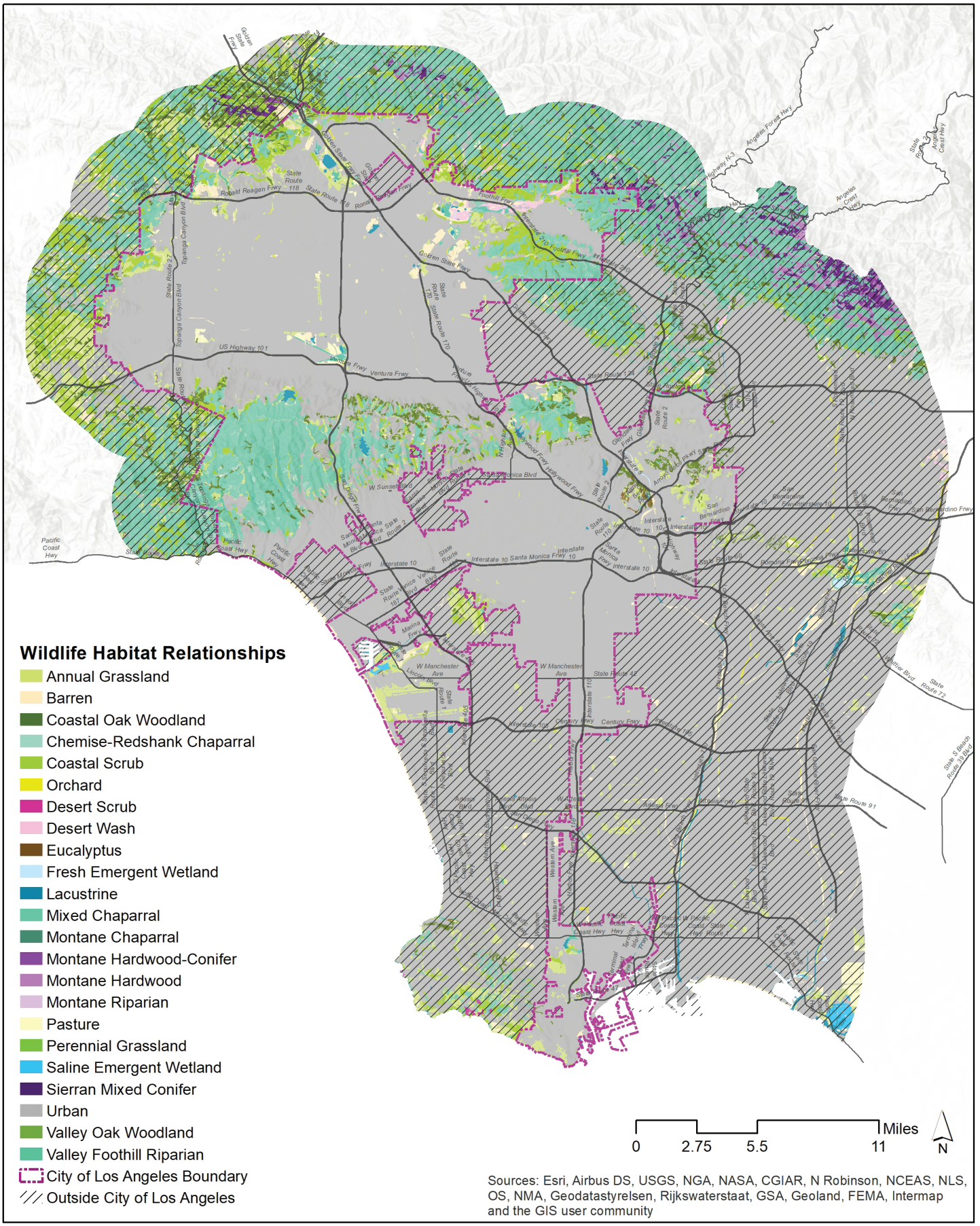


Figure 2-5: Principal Environmental Factor 3 - CALVEG Wildlife Habitat Relationships (WHR).

6. HILLS: Terrain exhibiting slopes generally greater than 8% with less than 1,000' (300 meters) in total elevation change from adjacent landform to peak elevation.

7. LOW MOUNTAINS: Terrain exhibiting slopes generally greater than 8% and exhibiting more than 1,000' in elevation change from peak to foot of slope, and peak elevation below 4,000' (1,200 meters) above sea level.

8. MOUNTAINS: Terrain exhibiting slopes mostly greater than 8% with peaks rising to greater than 4,000' above sea level.

PRINCIPAL ENVIRONMENTAL FACTOR 3: NATIVE VEGETATION

Native vegetation is the final component considered for defining urban subregional ecotopes for Los Angeles. Since much of the study area is heavily urbanized, many ecotopes only include small patches of intact native vegetation. However, the differences in the types of native vegetation remaining in these remnant patches reflect underlying environmental variation that provides additional justification for differentiating ecotopes. The CALVEG dataset provides detailed vegetation mapping from which remnant native vegetation can be distinguished from other vegetation (CALVEG 2004). The ability to classify native and non-native vegetation was useful in delineating ecotopes and is important to the assessment of metric 1.1a, % Natural Areas. CALVEG also uses USFS ECOMAP units as the overarching framework for regional data organization, and therefore, is well aligned with our finer scale ecotopes that also follow the ECOMAP methodology.

Two vegetation classifications are referenced within CALVEG, "vegetation alliances," the most detailed classification that emphasizes species composition, and "wildlife habitat relationships" (WHR), which emphasizes vegetation structure characteristics. The WHR classification is mapped in Figure 2-5, and is most similar to the vegetation structure considerations in the Jepson geographic subdivision classifications, which were based on Kuchler's (1977) "The Map of the Natural Vegetation of California." Vegetation Alliances are mapped for each ecotope in Appendix B. Acreage of each CALVEG vegetation alliance and WHR type within each ecotope was measured and relevant results are discussed in the detailed ecotope descriptions in Brown, 2019. Quantitative breakdowns of CALVEG classifications for each ecotope are also provided in Brown, 2019.

While remnant native vegetation serves as a differentiating factor, composition present in remnant patches is not a comprehensive characterization of native vegetation for the ecotope. Additional vegetation types were certainly historically present, or may be restored. General discussion of potential historic native vegetation is included in ecotope summaries in Appendix B, but is also a key area of further study for many highly urbanized ecotopes. The lack of complete vegetation data should not be viewed as a limitation in differentiating ecotopes, however, since abiotic microclimate and landform factors alone have been shown to effectively represent potential plant species and biodiversity suitability for the purposes of conservation planning (see Beier et al. 2015; Beier, Hunter, & Anderson 2015).

ECOTOPES RESULTS

The 27 ecotopes shown in Figure 2-6 were characterized for the City of Los Angeles and surrounding areas. Individual ecotopes range in size from 1,000's to 10,000's of acres (400's - 4,000's hectares), or equivalent in size to "landtype associations" units within the USFS Ecomap Hierarchy. Each ecotope includes unique combinations of landform, microclimate, and vegetation principal environmental factors, plus additional environmental factors, such as elevation, slope, aspect, ecological hazards, sea level rise, historic vegetation, and others, all of which are described in Brown (2019). Dominant landforms and SSURGO soil units were the primary factor used to delineate ecotope boundaries and are also incorporated into the ecotope naming system (e.g., Hills & Terraces, Dunes & Plains, Lower Alluvial Plain, etc.). Names combine major named features that are commonly identifiable by many Angelenos (e.g., Los Angeles River, Dominguez Hills, Ballona Creek, etc.).

The following describes how general categories of ecotopes were differentiated (see Figure 2-7). Appendix B includes specific ecological characterization, boundary considerations, mapping of principal and additional environmental factors, and discussion of stewardship implications for each of the 27 ecotopes analyzed. As an example, Ecotope 4 is also included at the end of this chapter.

A. ALLUVIAL PLAIN ECOTOPES (ECOTOPES 4, 7, 13, 16, 20)

Alluvial plain ecotopes were generally subject to historic broad-scale alluvial processes such as sedimentation, erosion, and flooding associated with large streams, rivers, drainages, and groundwater. These very flat and broad landforms have

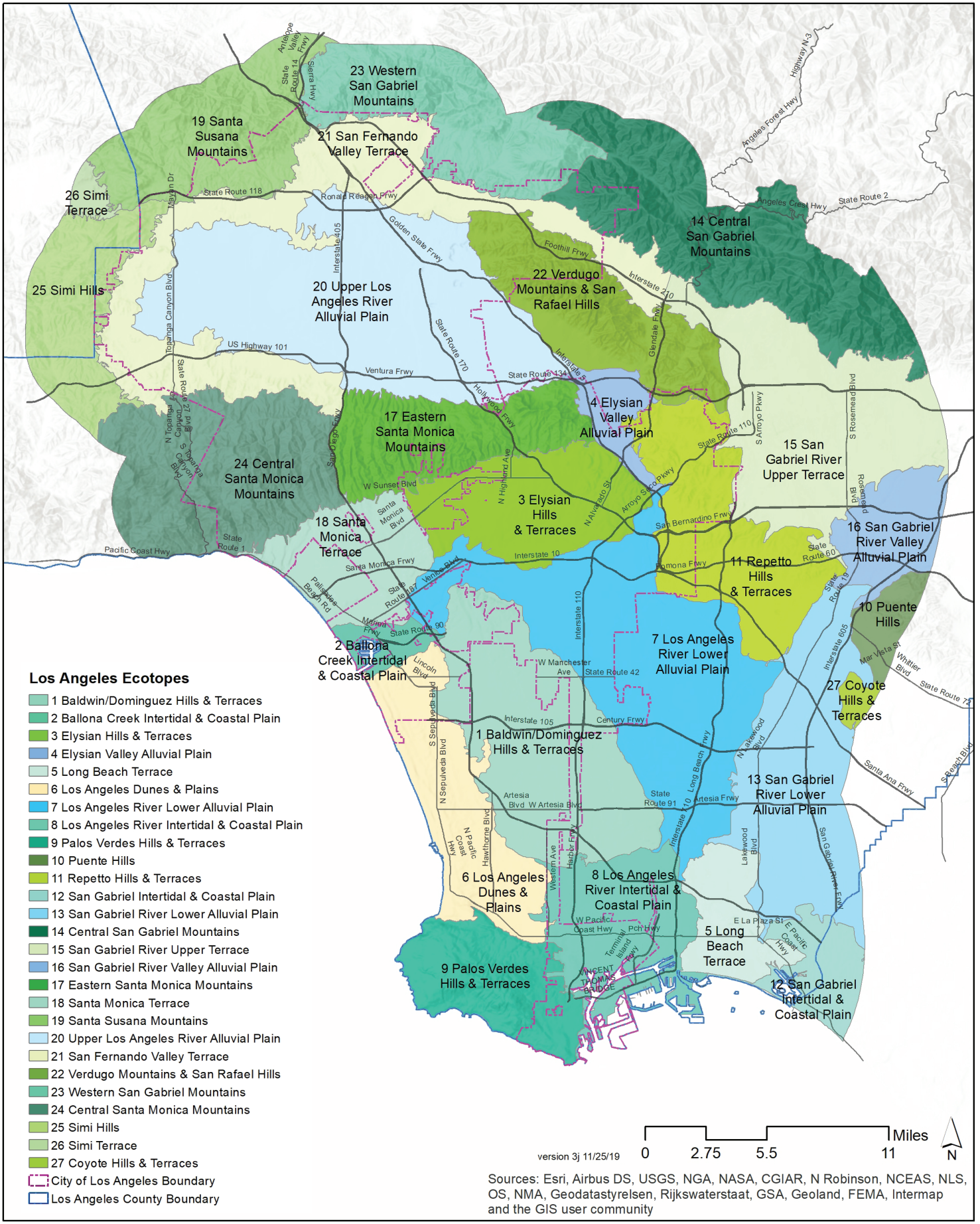


Figure 2-6: Los Angeles Subregional-Scale Ecotopes

distinctive, poorly developed alluvial soils and generally low slopes less than 2%. Much of the area of these ecotopes was subject to historic catastrophic flooding prior to the enactment of flood control measures, and some areas are still subject to flooding. Due to increased flood control and flat terrain, the alluvial plains have been subject to extensive development over the past century. Natural ecosystems have mostly been eliminated except for areas with exceptionally high groundwater such as the Whittier Narrows and portions of the LA River in the Elysian Valley. Historically, alluvial plain ecotopes would have included riparian, woodland, or marsh vegetation near stream channels, wetlands, or areas of high groundwater, and very dry scrub or herbaceous grasslands or prairies on higher ground (see Stein et al. 2007 and Dark et al. 2011). Many endemic and rare species of high conservation concern have been extirpated from these ecotopes, and restoration of this nearly lost segment of biodiversity is a priority of many local projects including the US Army Corps of Engineers Los Angeles River Ecosystem Restoration Project (see USACE 2013).

Alluvial plains within the Los Angeles River watershed were also differentiated from each other by microclimates and watersheds. Within the Los Angeles River watershed, the lower Los Angeles River Alluvial plain is exposed to coastal microclimate conditions, the San Fernando Valley Alluvial Plain is exposed to more continental influence, and the Elysian Valley Alluvial Plain exhibits a transitional microclimate. The Elysian Valley alluvial plain also exhibits uniquely high ground water conditions and somewhat more "canyon-like" terrain where the LA River passes between the Santa Monica Mountains and the Repetto Hills. A similar pattern along the San Gabriel River also provides the basis for differentiating the alluvial plain ecotopes within that watershed.

B. COASTAL PLAINS AND INTERTIDAL ECOTOPES (ECOTOPES 2, 8, 12)

Like the alluvial plains, coastal plains are also very flat ecotopes with movement of ocean and terrestrial surface water as the historic dominant shaping process. These ecotopes occur near river mouths of the Los Angeles and San Gabriel Rivers, and Ballona Creek at less than 40' (12 meters) in elevation above sea level. All are dominated by similar coastal microclimate conditions. They are the historic locations of extensive estuaries and brackish wetlands interspersed with higher terrain including small dunes or low coastal terraces. These ecotopes are subject to both riparian flooding and sea level rise, and modeling of projected sea level rise, combined with projected riparian flooding impacts in year 2100, was considered when delimiting boundaries (Barnard et al. 2018).

Remnants of large saltwater and brackish wetlands near the Ballona Creek and San Gabriel River mouths remain, but have been severely altered. Many hydrologic and natural ecological processes have been radically altered within the watersheds due to flood engineering, management of sediment transport, and adjacent land uses. Large portions of these ecotopes have also been converted to residential and commercial land uses. Almost the entire Los Angeles River coastal plain ecotope has been converted to industrial and port land uses, with lesser amounts of residential and commercial uses. Remaining historic vegetation includes a mix of salt and freshwater wetland, and riparian vegetation. Pockets of dune vegetation also remain, and prairies similar to those described by Mattoni and Longcore (1997) may have been historically present on flatter, seasonally dry terrain.

C. DUNES AND PRAIRIES ECOTOPE (ECOTOPE 6)

The Los Angeles Dunes and Prairie ecotope lies to the south of the Ballona Wetlands and includes SSURGO soils types reflecting sand and/or are characterized as dune landforms. Topography across the ecotope also strongly reflects dunes with their characteristic undulating dune and swale form to the west and gradually flattens into a broad plain to the east that was once home to notable prairie ecosystems. The dunes and prairies were characterized by Mattoni and Longcore (1997), and this delineation mostly follows theirs. This ecotope has been largely developed, except for the El Segundo Dunes area near LAX Airport, which contains many rare species of the highest conservation concern. Sandy soils and relatively low-density residential development across much of the ecotope provide opportunities for rainwater infiltration and native plant landscapes that may support urban habitat for endemic protected species such as the El Segundo Blue butterfly (*Euphilotes battoides allyni)*.

D. MOUNTAINS AND HILL ECOTOPES (ECOTOPES 10, 14, 17, 19, 22, 23, 24, 25)

Most mountain and hill ecotopes within the study area exhibit mostly steep slopes greater than 12% across their entire extent except along valley bottoms. Ecotopes named as "hills" exhibit around 1,000' or less in elevation change from the foot of the slope to the highest elevations within the ecotope. Most mountain ecotopes exhibit more than 1,000' in elevation change and peak elevations below 4,000' above sea level. The Central San Gabriel Mountains Ecotope is an exception

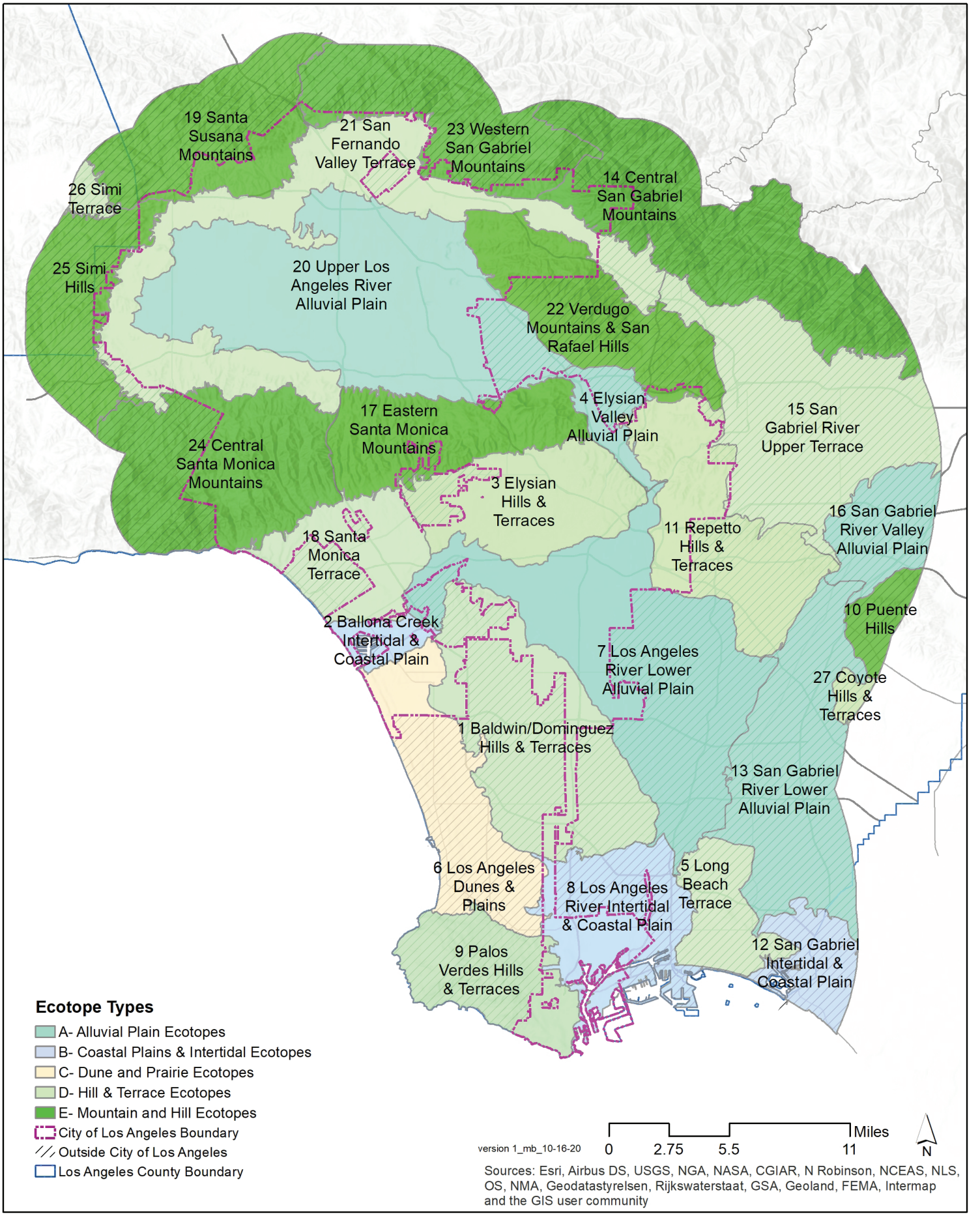


Figure 2-7: Ecotope Types

and rises to nearly 7,000' (2,100 meters) in elevation above sea level. Frequent subfreezing temperatures in winter support montane vegetation types in these ecotypes. The rugged and steep terrain that dominates these ecotopes has reduced development pressure and large portions of the San Gabriel Mountains are protected National Forest. Despite the rugged terrain, areas under private ownership have experienced intensive development, such as the Eastern Santa Monica Mountains where development of extremely steep terrain is common.

Mountain and Hill ecotopes are dominated by native vegetation including oak woodlands, chaparral, and coastal sage scrub vegetation, with riparian woodlands present in valley bottoms. Seminatural wildfire regimes also persist here due to the rugged terrain and extensive fire-adapted native vegetation is present; however, extent, intensity, and frequency of wildfires have been altered due to human activity and climate change leading to vegetation change.

In the mountains, snow is common in winter above 4,000 feet and coniferous woodlands are present at higher elevations and on northerly aspects. Drier low-elevation hills, such as the Simi Hills, are dominated by non-native annual grasslands. Lower portions of both hills and low mountains often include thermal belts with unique plant species. Coastal sage scrub vegetation also becomes more prevalent at lower elevations and drier sites. Native biota is often present within large protected and unprotected natural areas and increasing development pressure is reducing habitat connectivity critical to the resilience of many of these natural areas. Consequently, several habitat connectivity planning projects are underway here, including in the Eastern Santa Monica Mountains, the Simi Hills, and the Puente Hills.

E. HILLS & TERRACES ECOTOPES (1, 3, 5, 9, 11, 15, 18, 21, 26, 27)

The final category of ecotopes are the hills and terraces ecotopes. These ecotopes generally occur within broad transition zones between mountains and alluvial or coastal plains, and are dominated by thermal belt microclimates. Several of these ecotopes exhibit moderately sloping terrain with a single dominant aspect and are interspersed with small hills, mesas, valleys, and arroyos, such as the Santa Monica Terrace or the San Gabriel River Upper Terrace. Valleys or arroyos historically contained smaller creeks and seasonally dry washes that are tributaries to the larger Los Angeles or San Gabriel Rivers, but most have been channelized or piped into concrete flood control structures. Some of these ecotopes may also include relatively small ranges of hills such as the Baldwin, Elysian, Coyote, or Repetto Hills. Hill and terrace ecotopes may also include substantial areas of other landforms, such as small alluvial plains from creeks, such as the Dominguez Wash or Arroyo Seco, or areas of dunes, such as in the Santa Monica Terrace or LA River Intertidal and Coastal Plain, that were too small to differentiate as independent subregional-scale ecotopes.

Due to their low slopes and more limited flood hazards, hill and terrace ecotopes are also extensively developed. Limited remnant native vegetation occurs in small patches on steeper slopes or in parks that often includes oak woodlands and coastal sage scrub alliances. Strategies for protecting and enhancing connectivity between remnant patches is also a key conservation opportunity within these ecotopes.

EXAMPLE ECOTOPE DESCRIPTION

The following pages present a detailed description of Ecotope 4, the Elysian Valley Alluvial Plain. This is one of the 27 ecotopes that have been differentiated for the study area, and is the focus of extensive current ecological decision making associated with the LA River revitalization efforts (see Case Studies 3 & 5 in Chapter 4). Following the description, 15 maps are included that provide detailed environmental information about the ecotope. The following maps are included:

- Figure 2-9 Ecotope Context Map
- Figure 2-10 Microclimate
- Figure 2-11 Landform
- Figure 2-12 Elevation
- Figure 2-13 Aspect
- Figure 2-14 Slope Percent
- Figure 2-15 Drainage
- Figure 2-16 CALVEG Vegetation Alliances
- Figure 2-17 Hypothesized Potential Natural Vegetation
- Figure 2-18 Urban Habitat Quality
- Figure 2-19 Natural Areas Classification
- Figure 2-20 CalEnviroScreen Pollution Percentile
- Figure 2-21 CalEnviroScreen Population Percentile
- Figure 2-22 Ecological Hazards
- Figure 2-23 Land Use

Descriptions and maps for all 27 Ecotopes are found in the 2020 City of LA Biodiversity Report Appendix B. A discussion of the application of ecotopes in Los Angeles biodiversity stewardship follows the example ecotope maps.

Collared annual lupine - *Lupinus truncatus* (Photo: © Jeff Goddard) https://www.inaturalist.org/photos/62922845

Goldenstar - *Bloomeria crocea* (Photo: © J Kurylo) https://www.inaturalist.org/photos/62348912

Pacific foxtail (unconfirmed) - *Alopecurus saccatus* (Photo: © sweiser) https://www.inaturalist.org/photos/37187269

Purple owl's-clover - *Castilleja exserta* (© Lee R. BenVau) https://www.inaturalist.org/photos/56258852

Nodding needle grass - *Nassella cernua* (Photo: © James Bailey) http://www.inaturalist.org/photos/3488107

California poppy - *Eschscholzia californica* (Photo: Michelle Rogalski)

California goldfields - *Lasthenia californica* (Photo: Isaac Brown)

Tidy tips - *Layia platyglossa* (Photo: Isaac Brown)

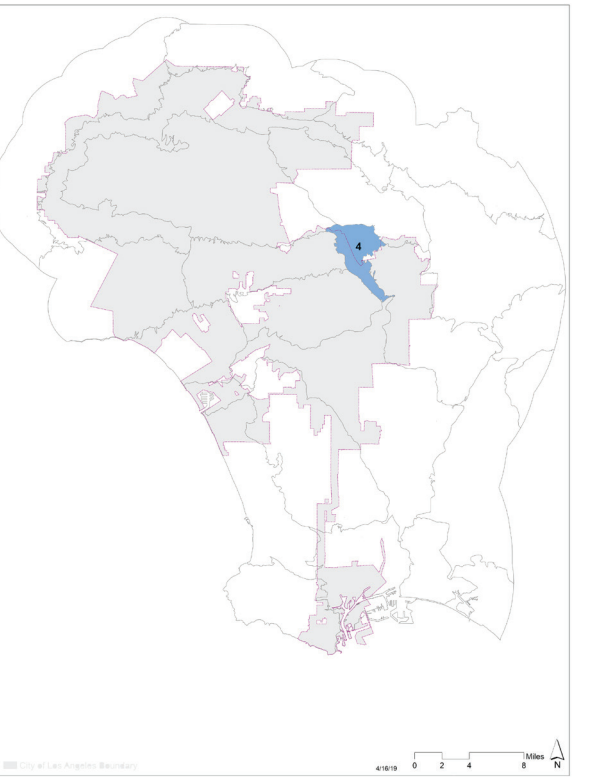
Lemmon's canarygrass - *Phalaris lemmonii* (unconfirmed) (© jrebman) https://www.inaturalist.org/photos/35161731

Fringed linanthus - *Linanthus dianthiflorus* (Photo: © Jeff S) https://www.inaturalist.org/photos/57960332?size=original

Figure 2-8: Native wildflowers and grasses of Los Angeles's coastal grasslands, prairies, and meadows. These species were selected from the literature review by Mattoni and Longcore (1997) of historical observations covering portions of Ecotopes 1, 2, 6, 8, and 18.

ECOTOPE 4: ELYSIAN VALLEY ALLUVIAL PLAIN

(Partially within the City of Los Angeles)



LANDFORM

The Elysian Valley comprises relatively flat alluvial landforms driven by historic natural alluvial processes of the LA River and tributaries. Sometimes referred to as the "Glendale Narrows," this was one reach of the LA River below the San Gabriel Mountains that historically exhibited substantial year-round flow due to geology that kept groundwater at the surface. Today, the reach still maintains year-round flow, but most originates as wastewater discharges from water reclamation plants at Glendale and the Sepulveda Basin. Natural hydrology has been severely altered due to flood control along the channel and in the broader watershed. Historically, the naturally meandering LA River, Verdugo Wash, and other smaller tributary streams resulted in braided floodplains flanked by upland stream terraces throughout the valley. These historical features are well mapped by Dr. Travis Longcore and others in Nature Conservancy (2016). Historically, groundwater, lush vegetation, and potentially afternoon shading from the adjacent Elysian Hills and Eastern Santa Monica Mountains, kept this reach of the river relatively cool throughout the year, which helped support historic steelhead trout and other native fish populations in the watershed.

MICROCLIMATE

This ecotope is characterized by cooler nighttime temperatures in winter that are driven by the valley cooling effect with occasional frost and hot, dry summers. Coastal fog is less frequent here in late spring and early summer than in areas of the coastal plain to the south and west. Less coastal influence also results in higher summer temperatures and the flat terrain exacerbates summer surface temperatures due to high solar loading during the heat of the day across most of the ecotope. However, urban heat island modeling by Taha (2017) showed a lower urban heat island effect here, possibly due to channeling of naturally cooler ocean breezes to the ecotope along the Santa Monica Mountains. The steep bluffs of the Elysian Hills and Santa Monica Mountains to the west may result in relatively cool conditions at the surface in spring and fall when lower sun angles result in relatively early afternoon shade reaching the valley floor, especially along the western portions of the ecotope.

VEGETATION & LANDCOVER

Natural areas comprise only 0.22% of the ecotope based on CALVEG data. These are mostly upland vegetation along boundaries of the ecotope along the Elysian Hills and Griffith Park where small areas of black walnut woodland, coastal sage scrub, and chaparral are present. Little natural riparian vegetation remains or was detected in the CALVEG mapping. The US Army Corps of Engineers (USACE, 2013) and the Nature Conservancy (2016) provide a more detailed characterization of LA River vegetation, including some higher quality riparian vegetation within the river channel. Historic vegetation and ecosystems along the LA River channel are well characterized by Dr. Travis Longcore in Nature Conservancy (2016) and included a combination of marsh, riparian woodland, and riparian sand/strand types. Adjacent upland "stream terraces" likely included oak woodlands and savannas mixed with coastal sage scrub and chaparral species. Historic accounts by the

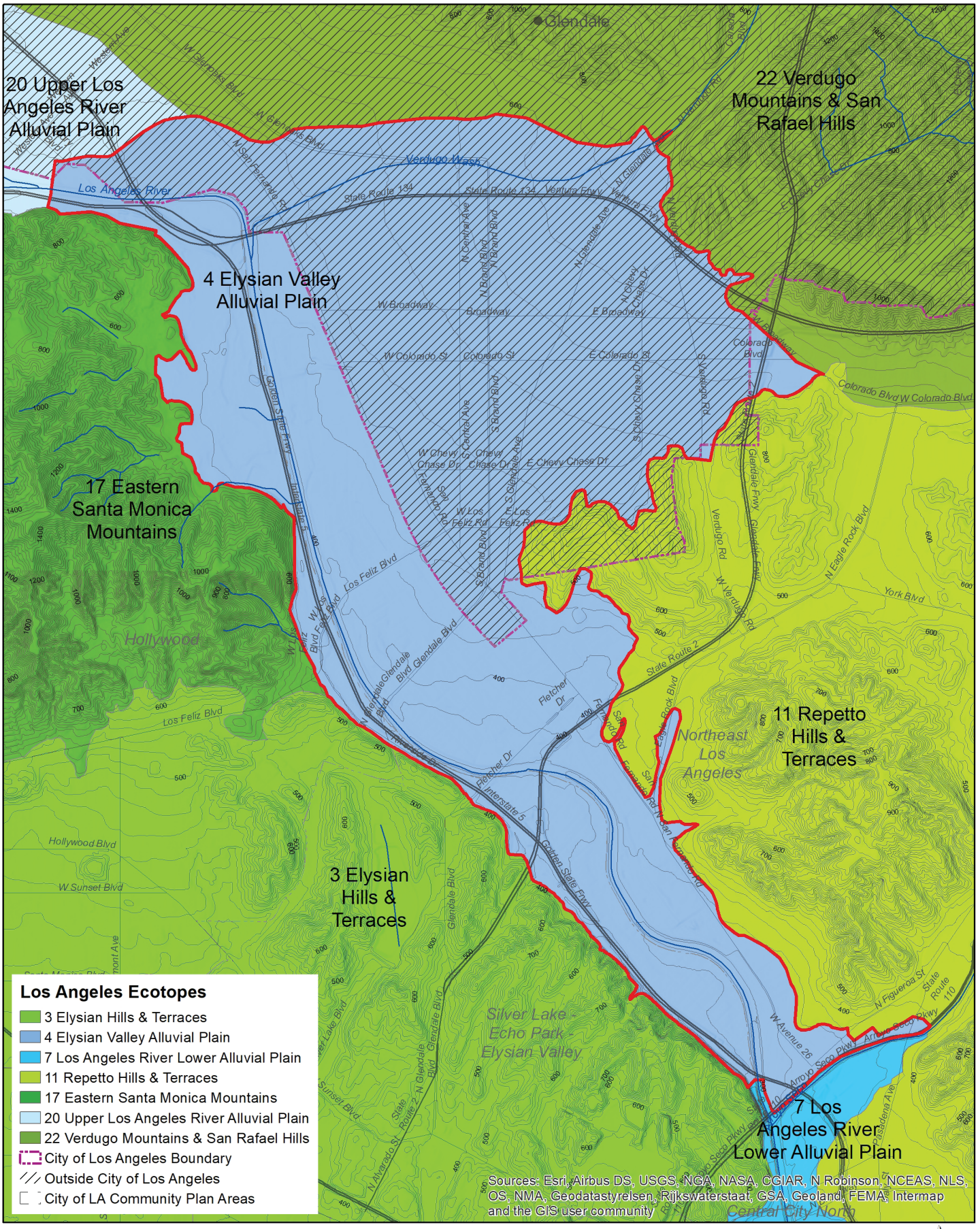


Figure 2-9: Context Map, Ecotope 4, Elysian Valley Alluvial Plain
Data source: I. Brown (2019). https://escholarship.org/uc/item/4c81w4nr

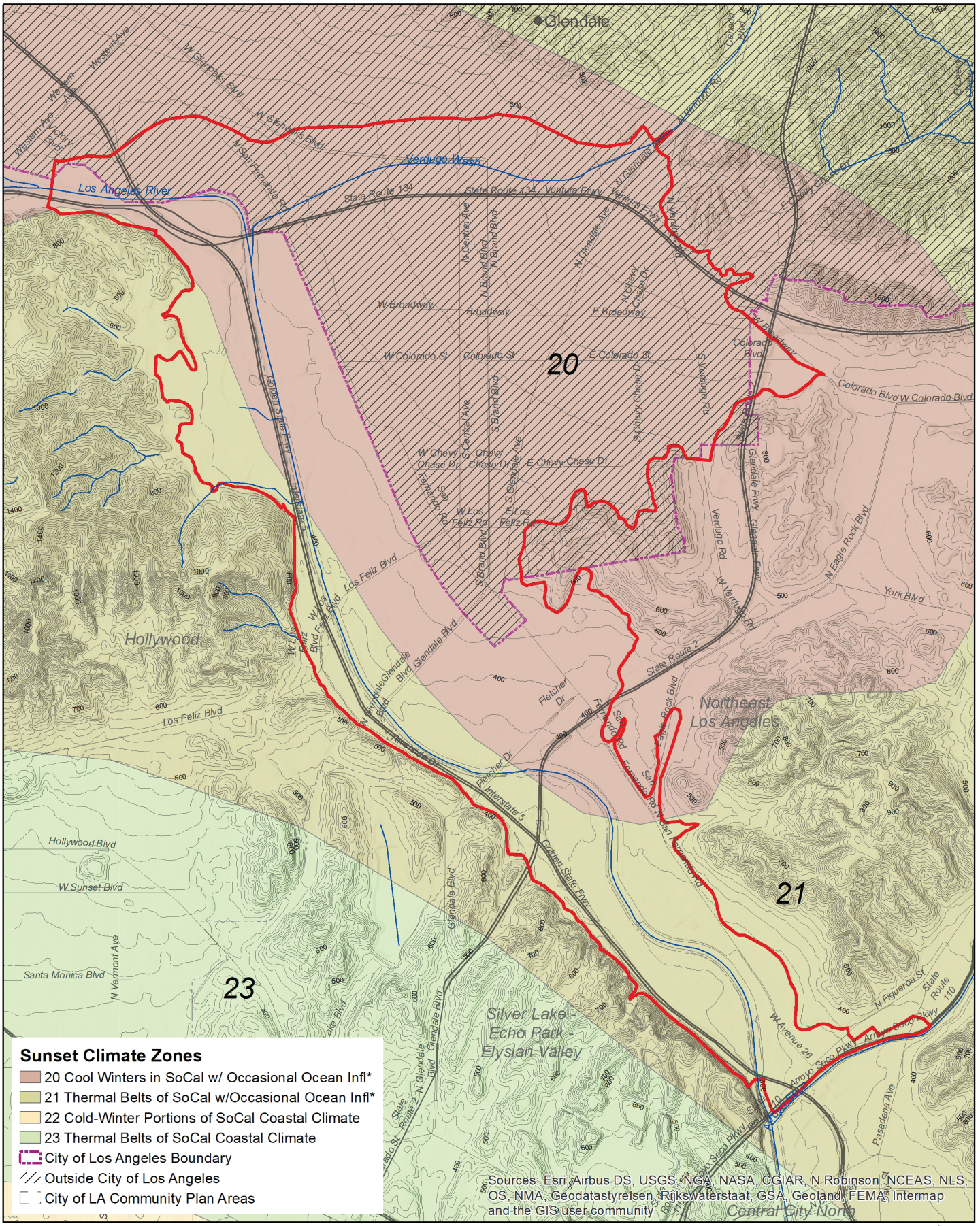


Figure 2-10: Microclimate

Data source: Sunset Magazine. http://www.sunset.com/garden/climate-zones/climate-zones-intro-us-map

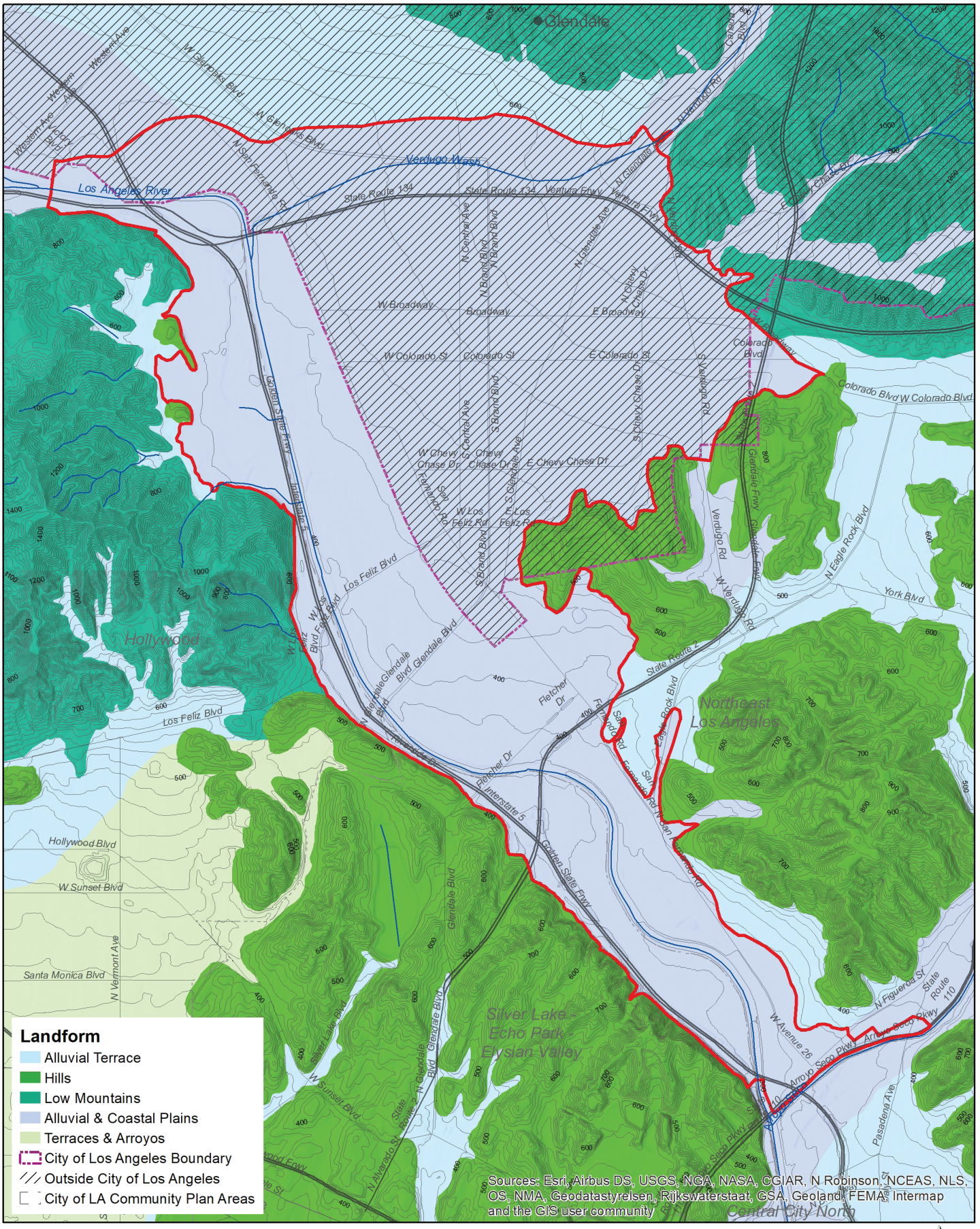


Figure 2-11: Landform
Data source: I. Brown (2019), https://escholarship.org/uc/item/4c81w4nr

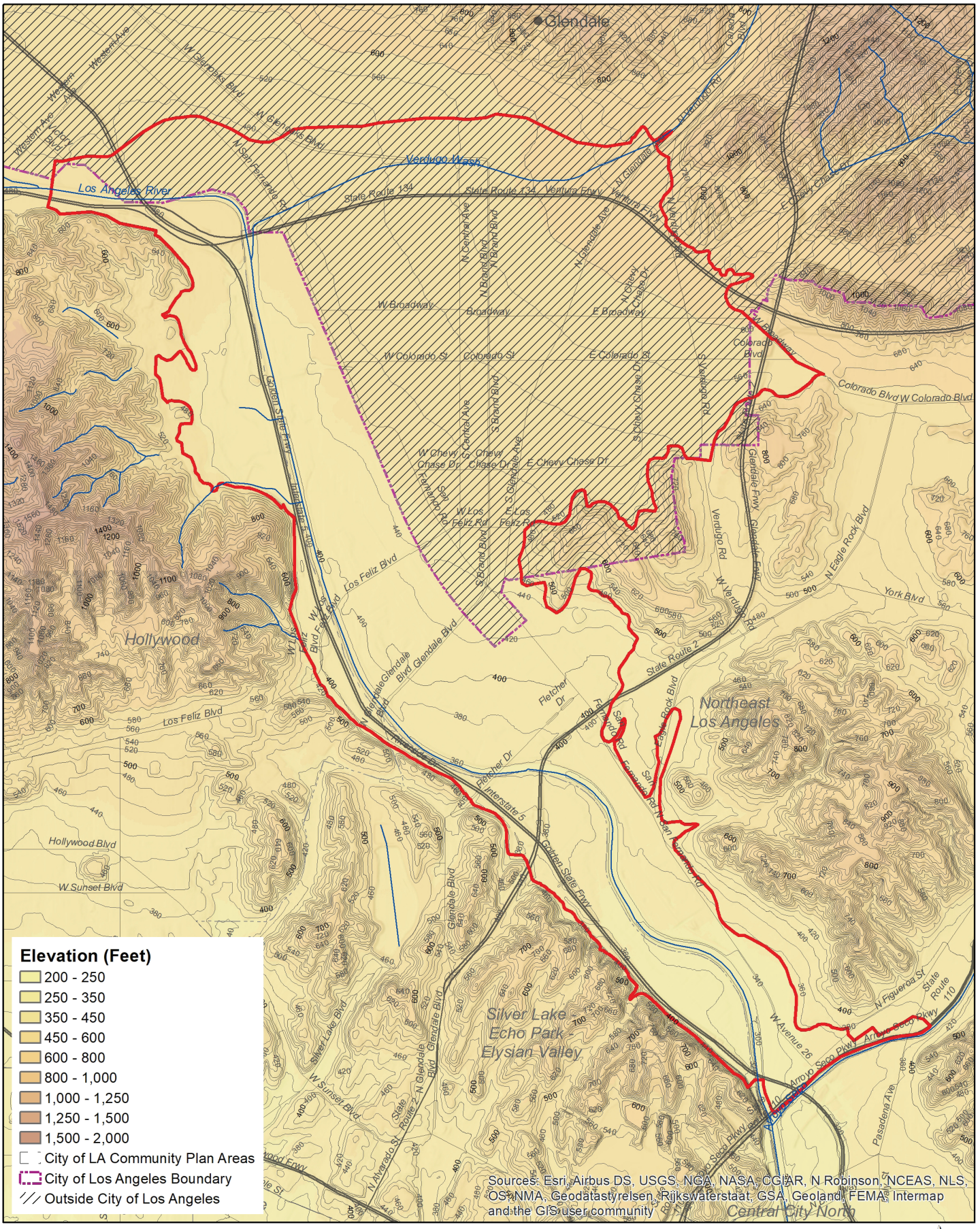


Figure 2-12: Elevation

Data source: 2006 10-foot Digital Elevation Model (DEM) – LARIAC – Public Domain. https://egis3.lacounty.gov/dataportal/2011/01/26/2006-10-foot-digital-elevation-model-dem-public-domain/

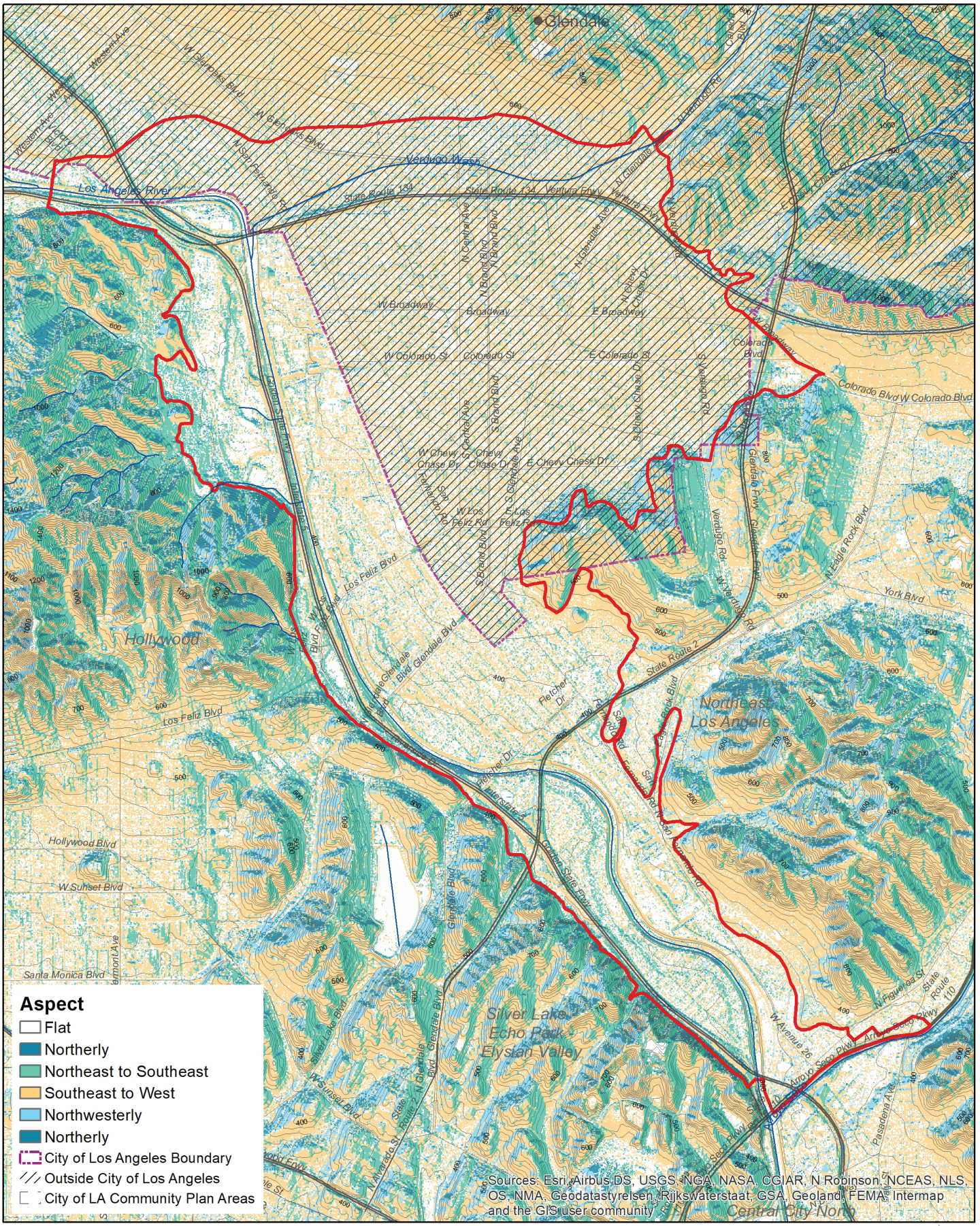


Figure 2-13: Aspect

Data source: 2006 10-foot Digital Elevation Model (DEM) – LARIAC – Public Domain. https://egis3.lacounty.gov/dataportal/2011/01/26/2006-10-foot-digital-elevation-model-dem-public-domain/

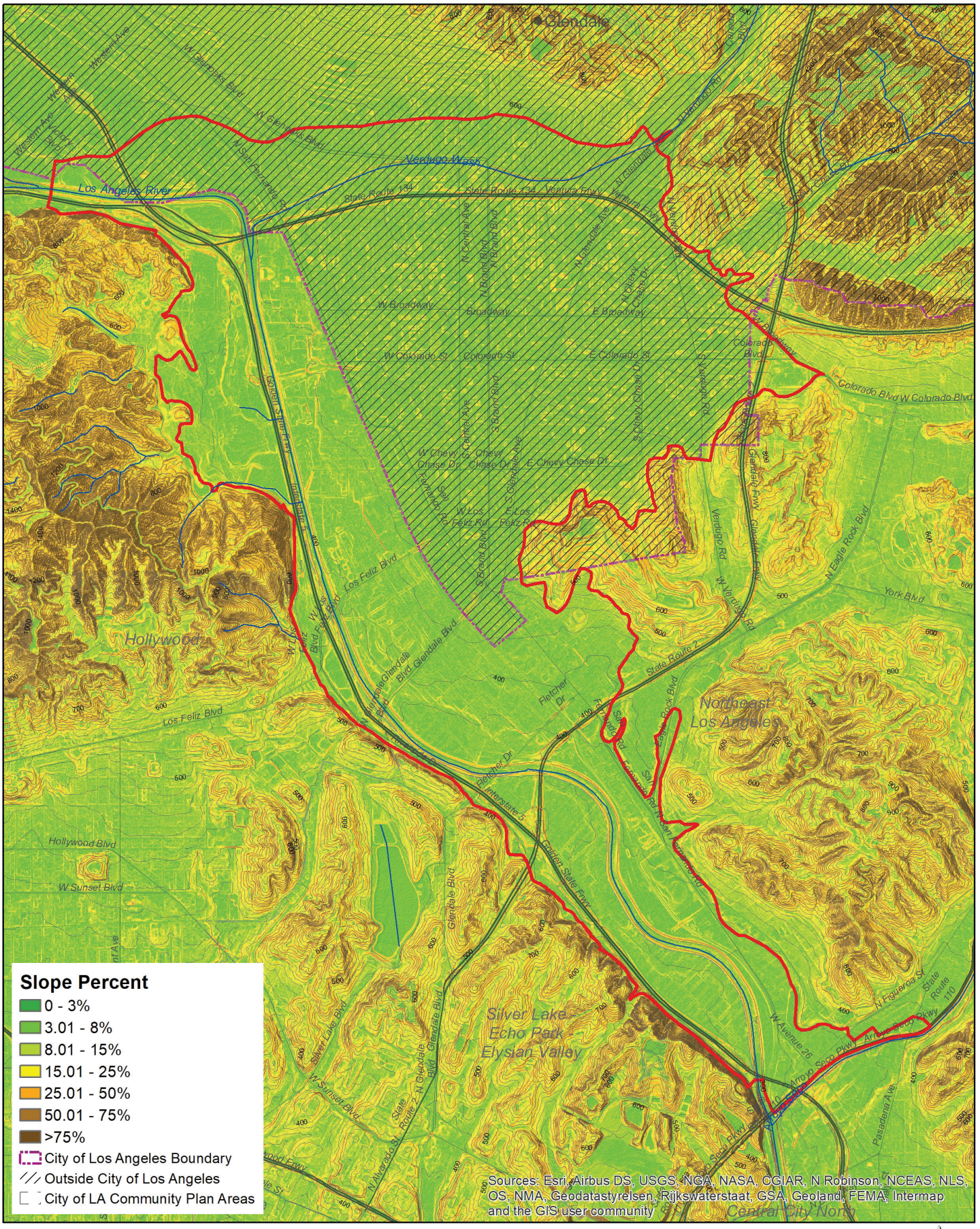


Figure 2-14: Slope Percent

Data source: 2006 10-foot Digital Elevation Model (DEM) – LARIAC – Public Domain. https://egis3.lacounty.gov/dataportal/2011/01/26/2006-10-foot-digital-elevation-model-dem-public-domain/

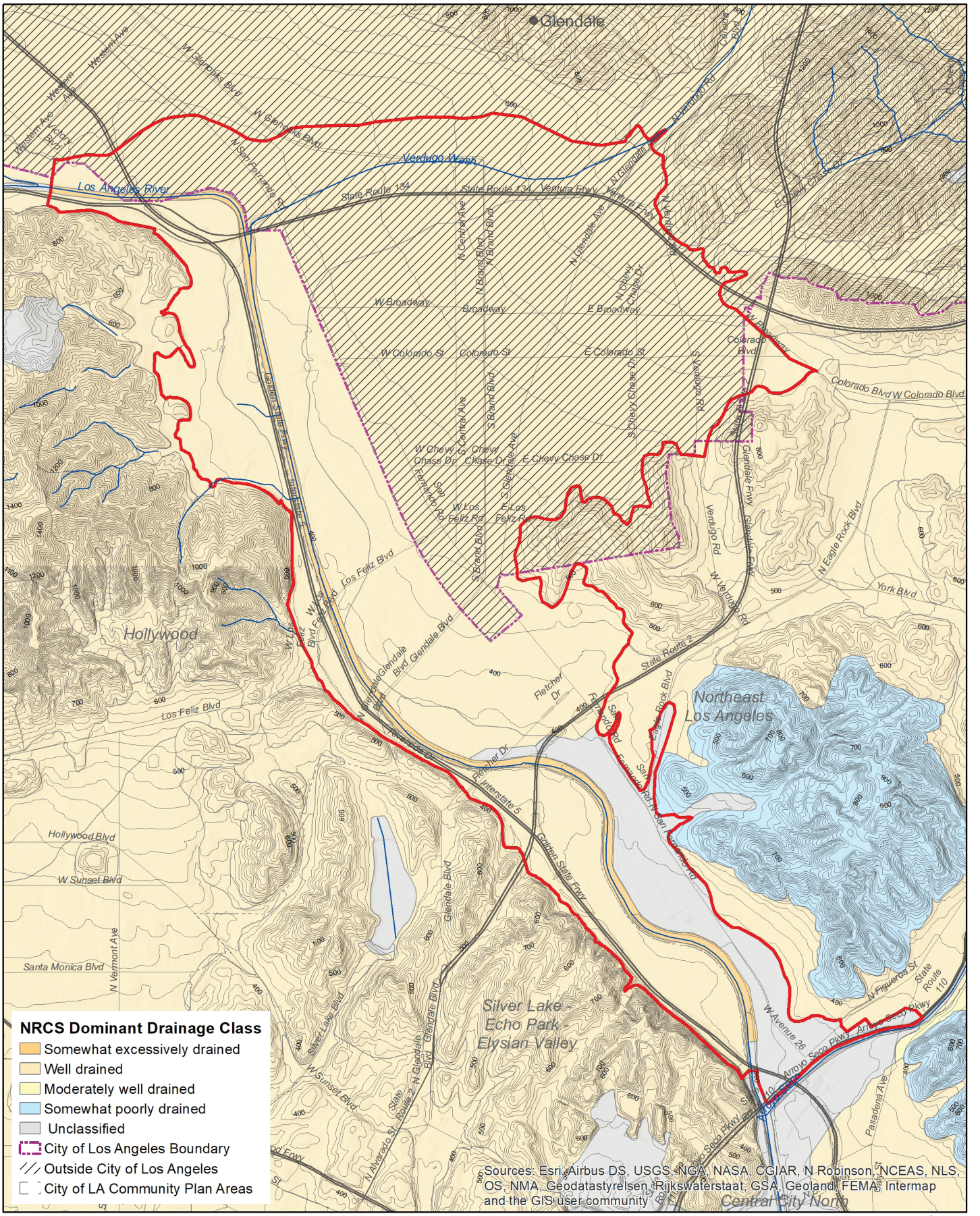


Figure 2-15: Drainage

Data source: Soil Survey Geographic (SSURGO) Database for Los Angeles County, Southeastern Part, CA; National Hydrography Dataset, U.S. Geological Survey, Reston, Virginia. 2002-2016.

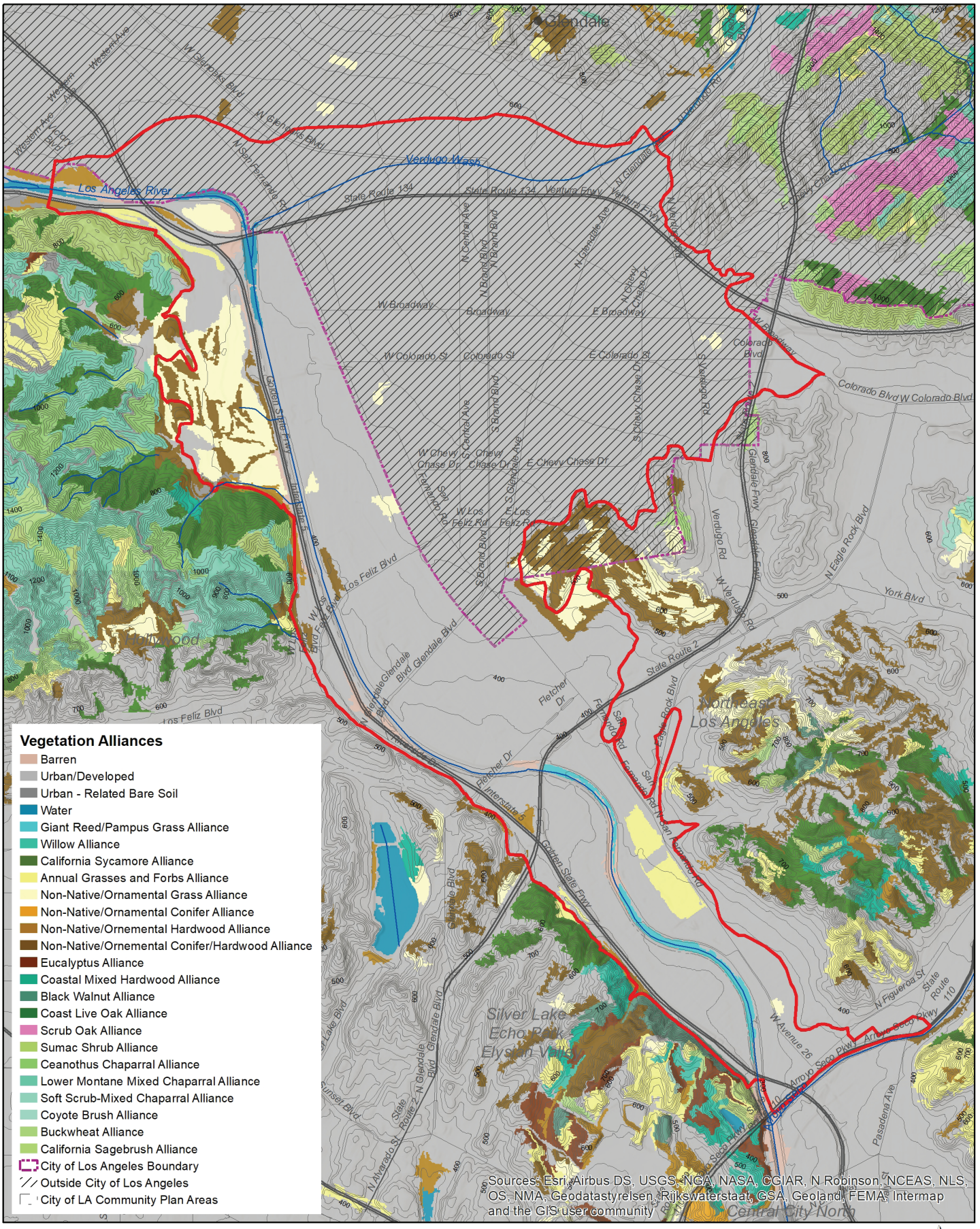


Figure 2-16: Vegetation Alliances

Data source: CALVEG. https://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192

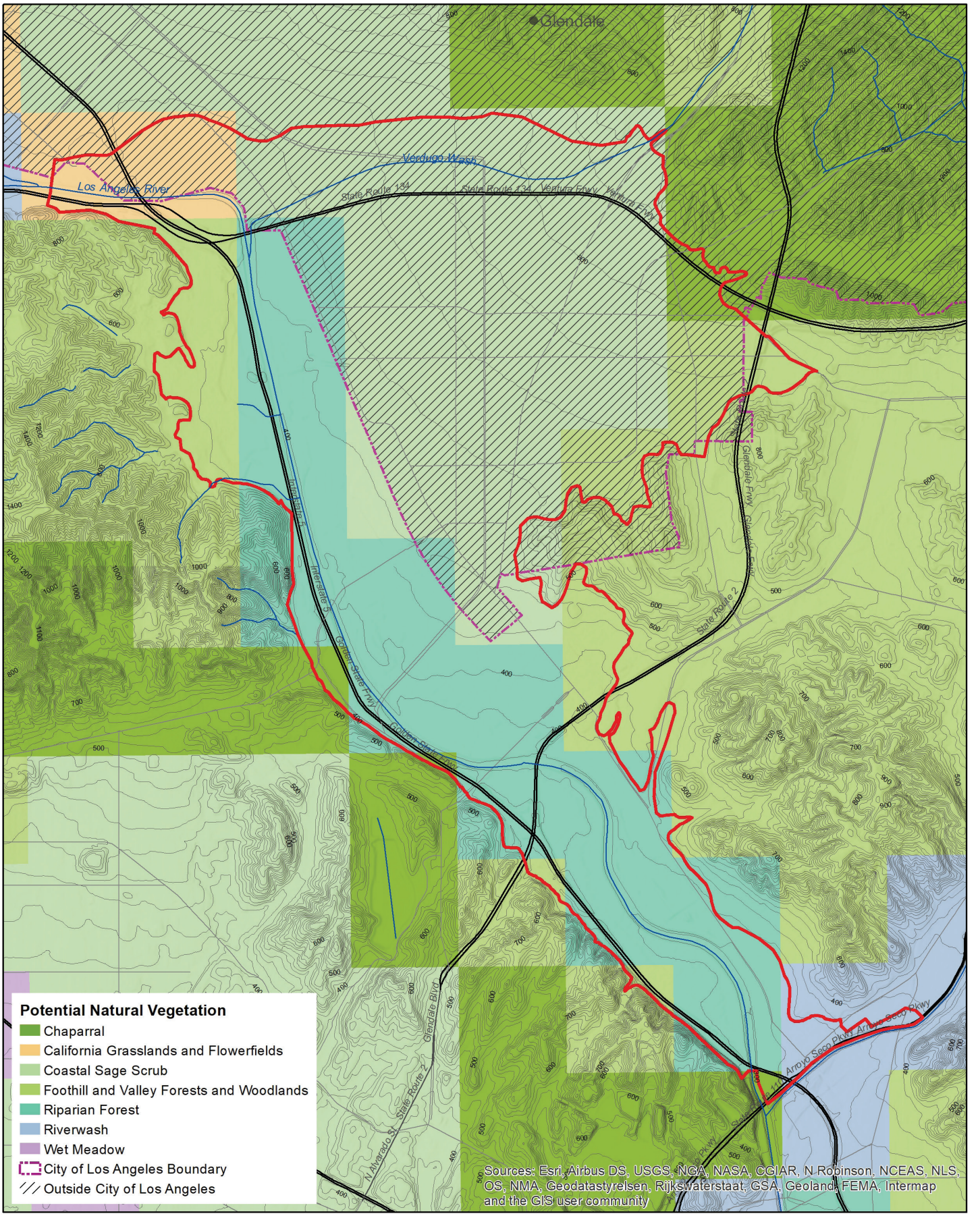


Figure 2-17: Hypothesized Potential Natural Vegetation

Data source: USC Spatial Sciences Institute/UCLA Institute of the Environment: Historical Ecology of the Los Angeles River Watershed Project.

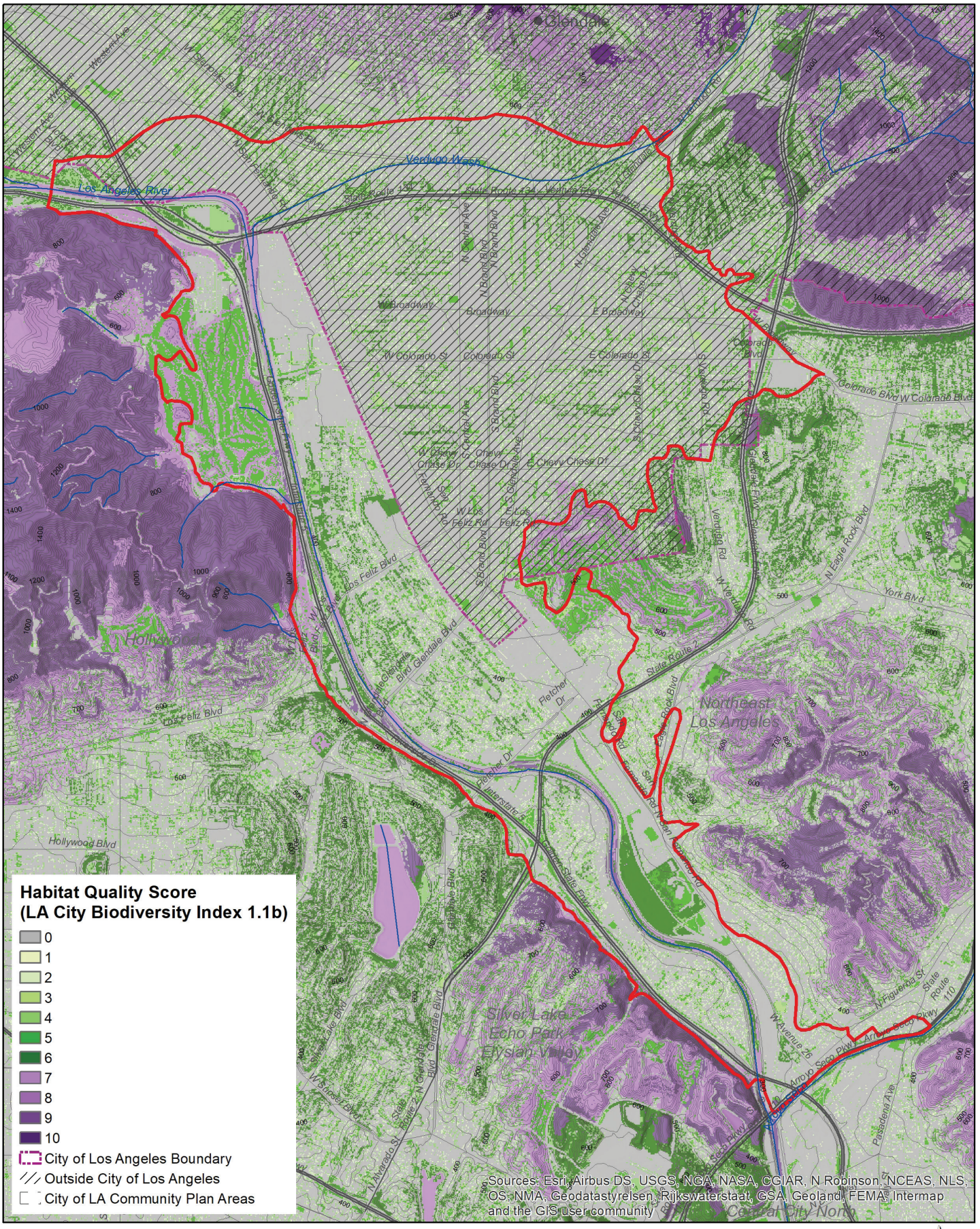


Figure 2-18: Urban Habitat Quality

See Chapter 3 for methodology used to determine Urban Habitat Quality

Data source: I. Brown (2019). https://escholarship.org/uc/item/4c81w4nr

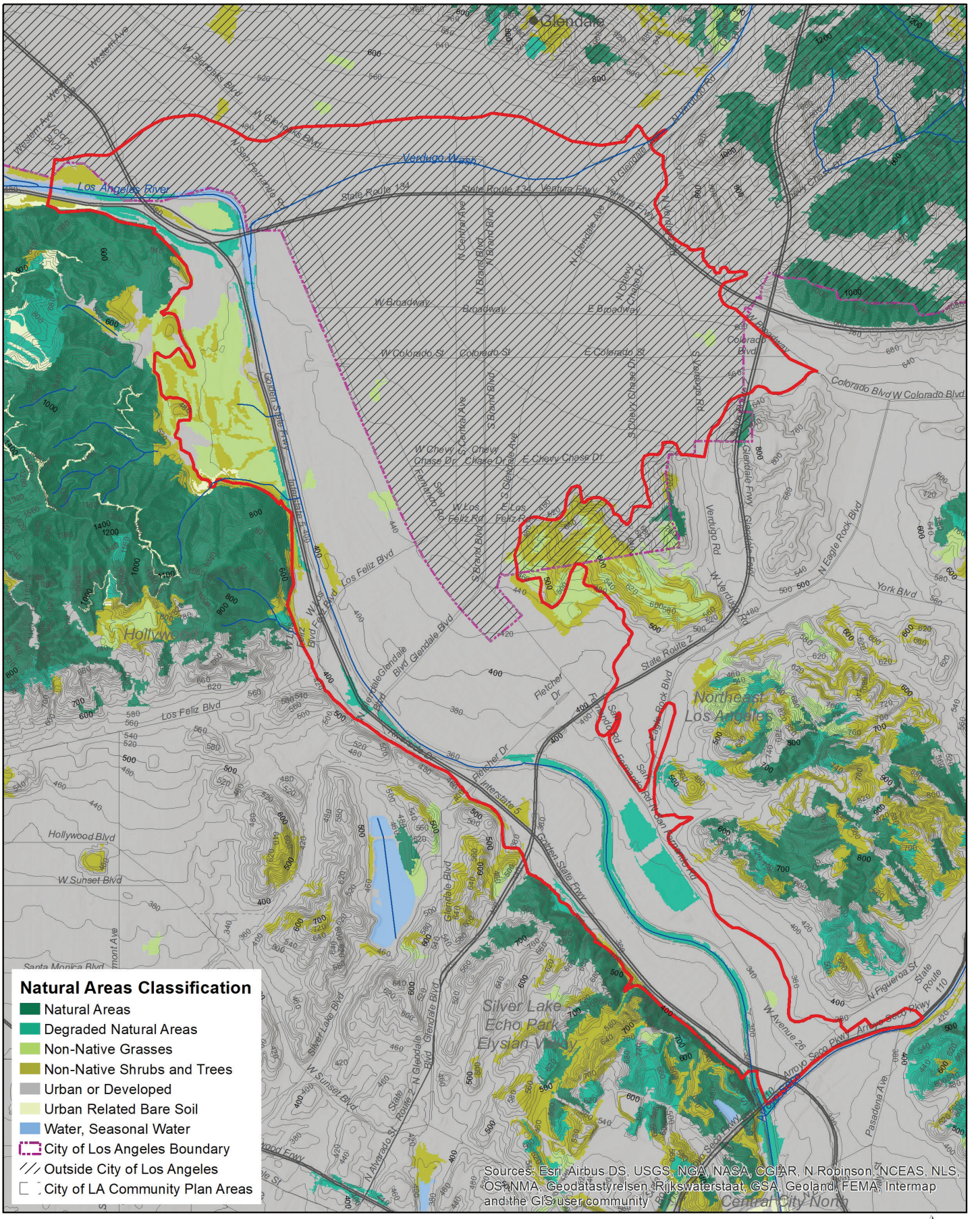


Figure 2-19: Natural Areas Classification

Data source: 2018 City of Los Angeles Biodiversity Report, Appendix B. https://www.lacitysan.org/cs/groups/public/documents/document/y250/mdi0/~edisp/cnt024943.pdf

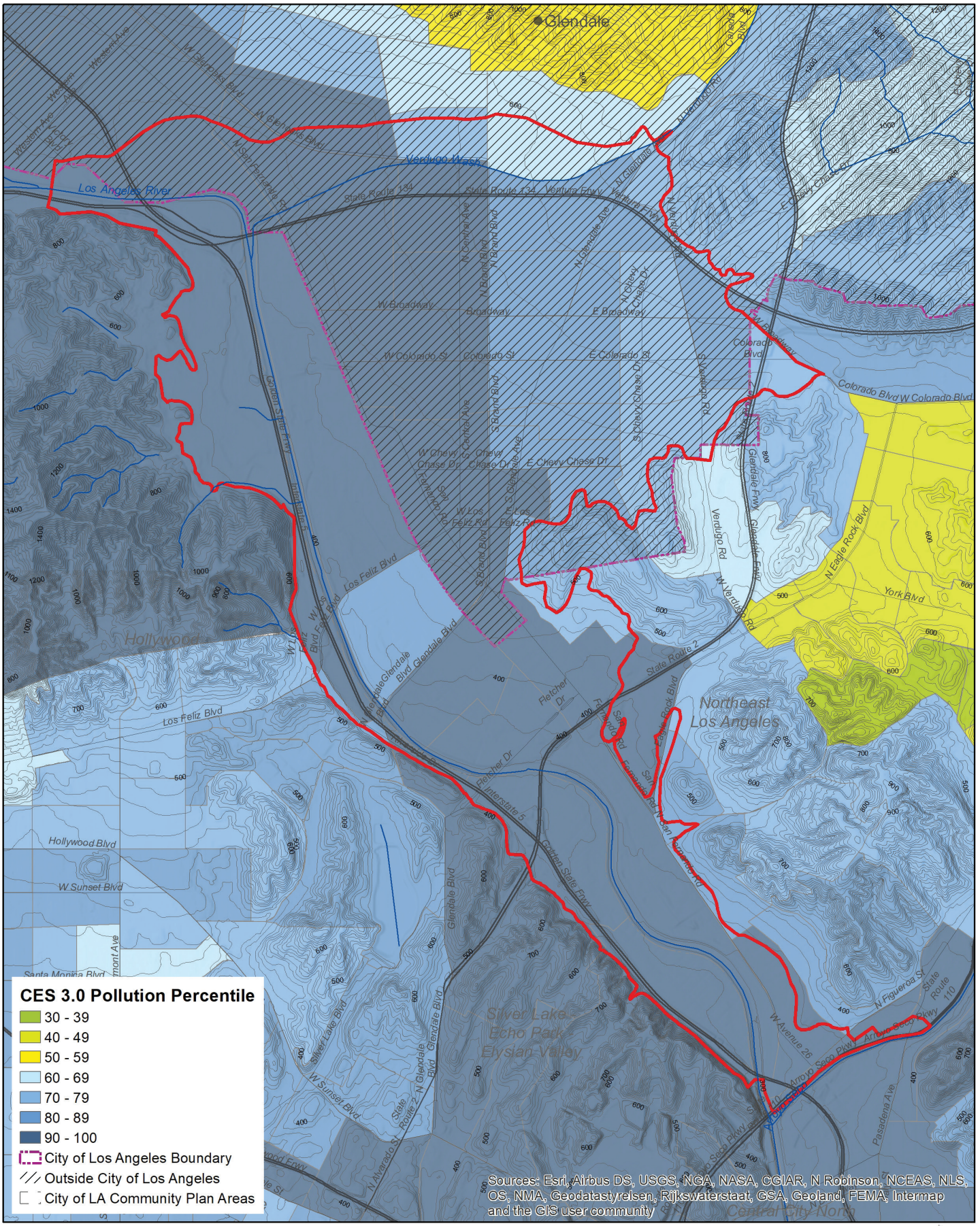


Figure 2-20: CalEnviroScreen Pollution Precentile (pollution exposure)

Data source: CalEnviroScreen 3.0. The California Office of Environmental Health Hazard Assessment (OEHHA). https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30

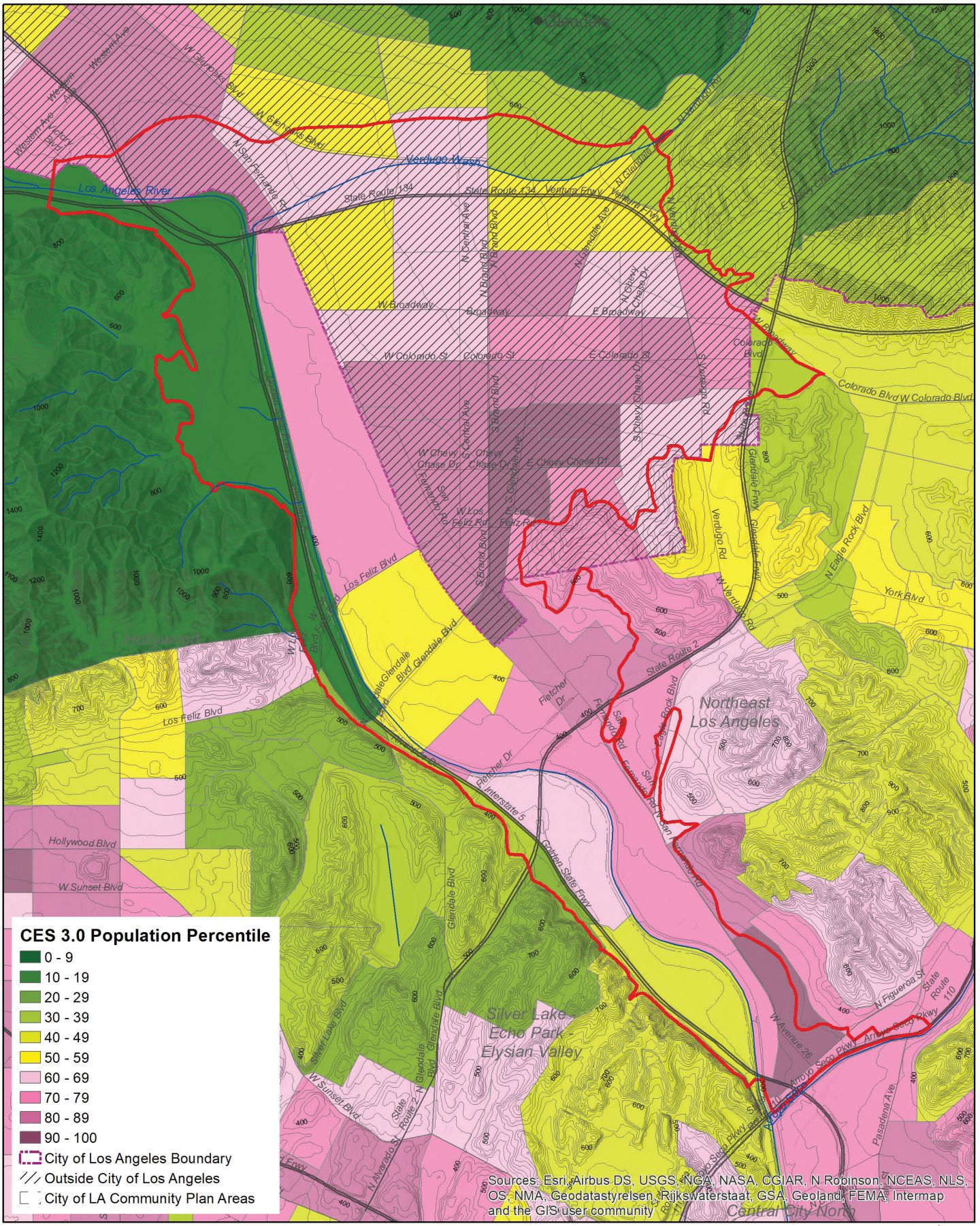


Figure 2-21: CalEnviroscreen Population Percentile (population vulnerability)

Data source: CalEnviroScreen 3.0. The California Office of Environmental Health Hazard Assessment (OEHHA). https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30

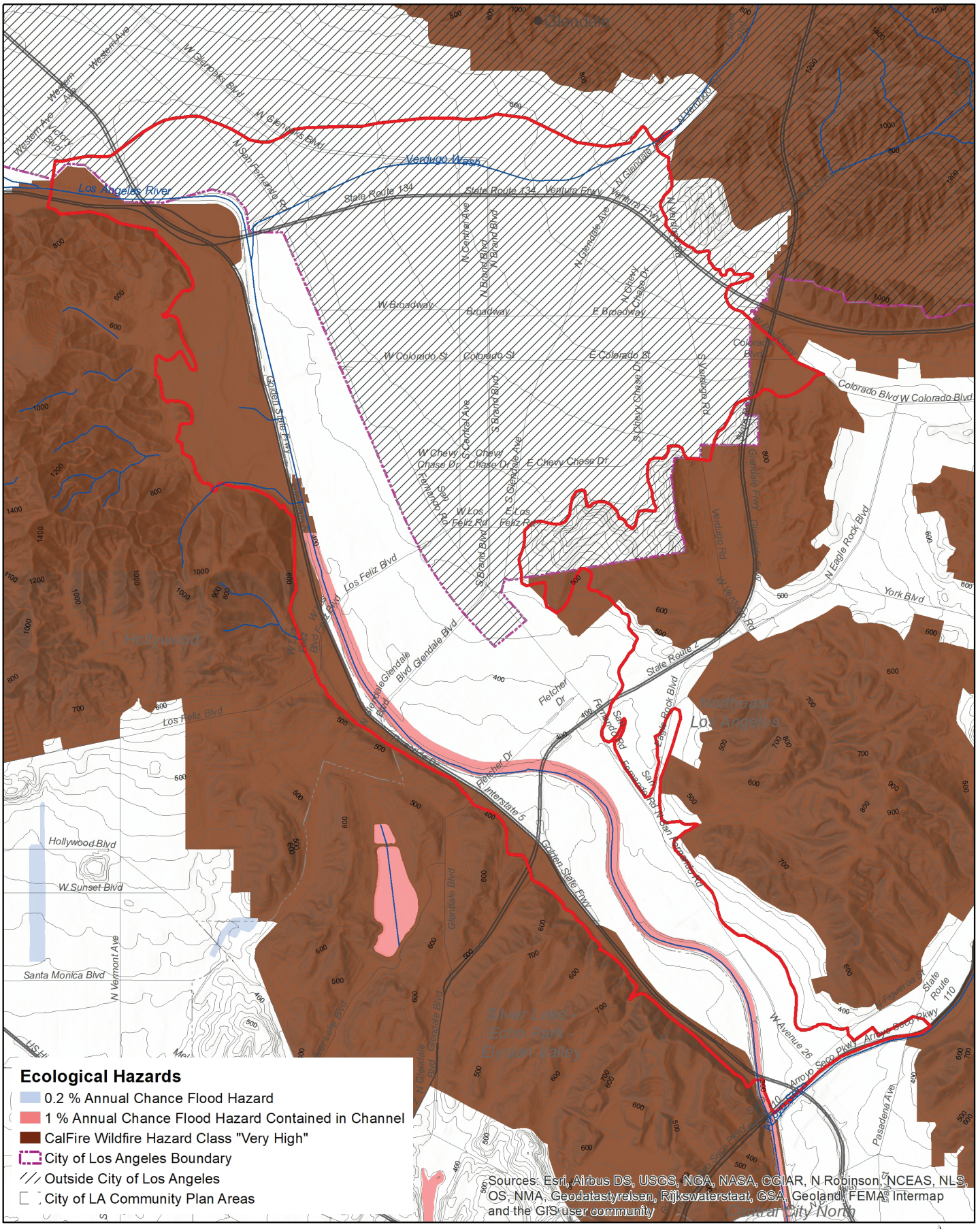


Figure 2-22: Ecological Hazards

Data sources: Coastal Storm Modeling System (CoSMoS) for Southern California, v3.0, Phase 2; Calfire Fire Hazard Severity Zone Maps; Federal Emergency Management Agency, National Flood Hazard Layer, Version 1.1.1.0, 11/01/2016.

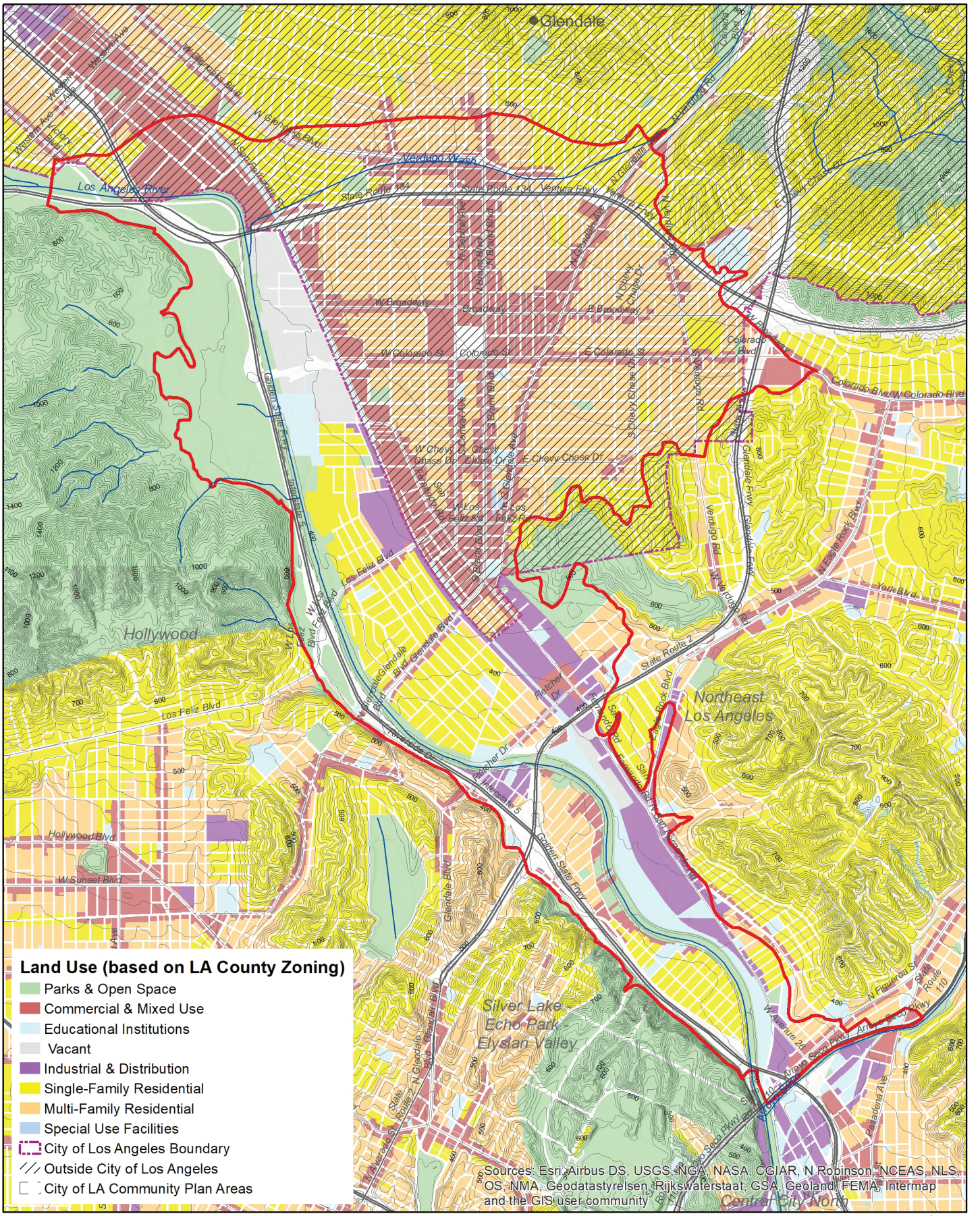


Figure 2-23: Land Use

Data source: 2008 Los Angeles County Countywide Zoning by the Southern California Association of Governments (SCAG). https://egis3.lacounty.gov/dataportal/2012/04/10/county-wide-zoning/

first Europeans to visit the area on July 30th, 1769 describe “large trees, sycamores, willows, cottonwoods, and very large live oaks.” The account also notes a “very full flowing and wide river” about 7-yards wide (Gumprecht, 2001). This flow is notable since late July is approaching the driest time of year.

ECOTOPES DISCUSSION

Ecotopes represent overarching subregional-scale ecological patterns with important implications for urban ecosystem stewardship. Like all ecosystem challenges, management must address complex interactions that cross many environmental, social, and land use disciplines and scales. While more narrowly defined environmental classifications are common, such as the NRCS SSURGO soils map, CALVEG vegetation maps, or CalEnviroScreen pollution maps, these maps are designed to be used for more specific aspects of environmental management. Ecosystem-based classifications, alternatively, are specifically designed to maximize the broadest utilization and integrate all environmental components that comprise ecosystems. Like watersheds, ecotopes provide a comprehensive spatial unit that can be useful in planning and evaluating large areas, driving policy-level decisions, and creating subregional urban ecological management plans. Ecotope maps, and the associated environmental factors maps (see Appendix B) can serve as tools to better integrate urban ecosystems and land use, benefitting people and nature (see Figure 2-23). Some examples of potential application include:

- Habitat conservation, restoration, and connectivity network planning within each ecotope as a basis for comprehensive regional biodiversity conservation;
- Management of intertidal ecotopes subject to sea level rise with implications for land use and stewardship of intertidal biodiversity;
- Management of mountain and hill ecotopes subject to wildfire, landslides, and habitat fragmentation; or,
- Stewardship of alluvial plain ecotopes that are subject to flooding and exhibit intensive development patterns with limited access to biodiversity.

An important use for ecotopes is to measure the City’s Biodiversity Index in a way that places individual locations in context and supports the protection and enhancement of biodiversity across the City in a comprehensive and resilient manner. Assessing metrics, such as 1.1a, % Natural Areas, within individual ecotopes will help distill complex, City-wide data, reveal disparities between ecotopes, and identify ecotopes that would benefit the most from direct conservation actions (see Figure 1-5).

As done with the USFS ECOMAP framework, it is a long-standing best practice in conservation planning to conserve lands within each ecological unit as a basis for comprehensive conservation of biodiversity. Conservation efforts within each ecotope may help maintain genetic diversity and protect the fundamental abiotic building blocks of biodiversity across the region. Conserving biodiversity within a comprehensive network of ecotopes should also allow biodiversity to be more resilient to the pressures of climate and land use change.

Since most urban ecosystem management decisions are executed at the parcel or neighborhood-level (i.e., the local-scale), subregional ecotopes are somewhat limited in their application in finer-scaled urban management activities (Opdam et al. 2013). As subregional boundaries may not be precise enough to inform site-level activities, creating finer, neighborhood-scale ecotopes (see Figure 2-1) could be beneficial. Boundaries at each scale are generally only appropriately precise for application at that scale

Figure 2-24: UCLA Campus Aerial Photo

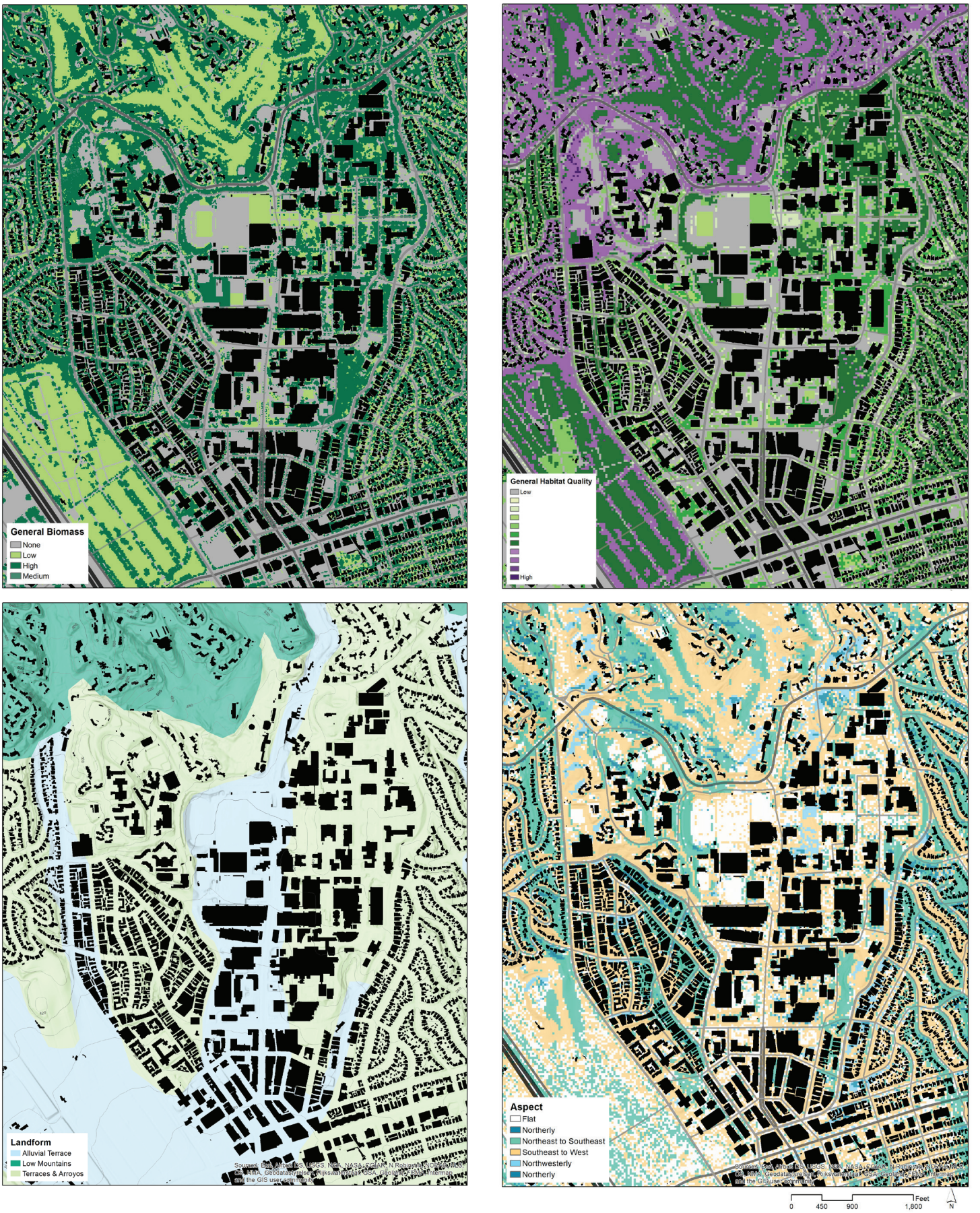


Figure 2-25: Ecotopes and the associated environmental factors maps are a useful tool for better integrating urban ecosystems and land use for the benefit of people and nature. This example for the UCLA campus modifies the traditional "figure ground" diagram, often used in urban design practice, and underlays key ecotopes layers integral to landscape, urban design, and campus masterplanning decisions related to biodiversity stewardship and ecosystem services optimization (biomass, top left; urban habitat quality, top right; landform, bottom left; and aspect, bottom right).

based on the mapping of principal environmental factors, and a hierarchical approach is necessary to address finer-scale applications. For example, the SSURGO soils map that was used as the basis for mapping ecotope boundaries is somewhat "fuzzy" and additional site-scale mapping of landforms or soils will certainly reveal more precise boundaries between neighborhood-scale ecotopes.

While the principal environmental factors and subregional units provide the overarching framework, additional maps and discussion for each ecotope in Appendix B address many "additional environmental factors." These map layers are intended to be included in a publicly available database and will be useful for understanding and communicating site-level ecological context and implications. These factors, and potentially others, are also envisioned to form the basis for partitioning neighborhood-scale ecotopes, each with their own management implications. Once complete, this database could provide a uniform and comprehensive ecological site analysis and management framework for projects anywhere in the City at site to regional scales. Uniform inventories could also streamline project analysis, review, and comparison by site managers, researchers, or governing agencies, and can form the basis for finer-grained planning and management tools such as design guidelines, landscape or restoration targets, target species lists, or site opportunities and constraints analyses.

ECOTOPES SUMMARY

The idea of creating urban ecotopes for Los Angeles emerged from the need to understand and measure biodiversity across a large and ecologically diverse land area identified during the 2018 measurement of the Singapore Index on Cities' Biodiversity. The process revealed that, at over 300,000 acres (121,000 hectares) and exhibiting over 5,000 feet (1,500 meters) in elevation change, Los Angeles was too large and complex for the Singapore Index results to be optimal for measurement or management, and that different areas of the City faced very different biodiversity management challenges. For example, in the Santa Monica Mountains a key challenge is balancing biodiversity and development at the urban-wildland interface, while in disadvantaged communities in the urban core a key issue is the current lack of access to biodiversity coupled with high exposure to pollution.

Now that the City has crafted a customized Los Angeles Biodiversity Index, the intention is to measure the index for each ecotope to provide more site-specific results and management implications, while also providing a city-wide measurement. Ecotope-specific measurements will help the City understand which ecotopes need more resources and attention in order to conserve and enhance biodiversity. In other words, results can help direct resources to ecotopes that receive low scores. Further, as most metrics in the LA City Biodiversity Index will be accompanied by a single map that clearly convey the metric results, policymakers, landscape architects, planners, and engineers should all be able to easily understand the significance of the results. In the future, management within ecotopes may also incorporate related topics of ecological hazards, pollution, and ecosystem services supporting more comprehensive urban ecosystem stewardship and decision making.

The topic of urban ecosystem management units is increasingly relevant as more cities adopt ecosystem-based goals under the umbrella of comprehensive sustainability, resilience, and climate change planning. The diverse and complex impacts of climate change on cities may be effectively viewed as ecosystem change, and the tools of ecosystem management, such as ecotopes, should be carefully considered when managing these impacts. Such an approach may be critical as cities, and specific ecotopes within them, adapt to changing ecological conditions. This may be especially true in biodiversity hotspots like Los Angeles where new levels of stewardship may be necessary to sustain entire species and ecosystem services within the urban matrix. Tools of ecosystem management hold many important lessons for cities, learned over decades of application in more rural and natural landscapes. The ecotopes approach represents one promising new example of applying these lessons to manage cities more like ecosystems to enhance biodiversity and achieve resilience.

CHAPTER 3

A Measurement of Urban Habitat Quality & Connectivity in Los Angeles

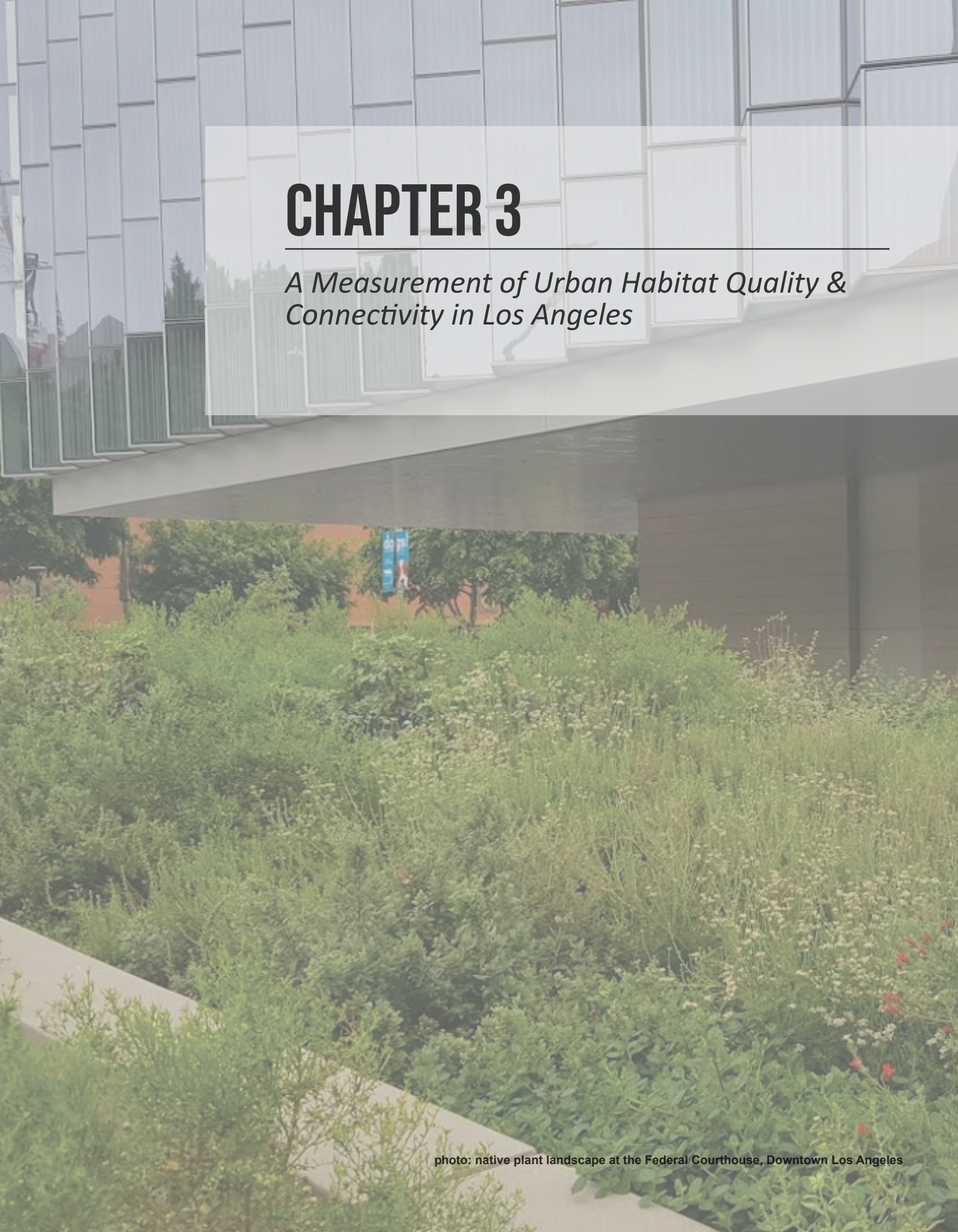


photo: native plant landscape at the Federal Courthouse, Downtown Los Angeles

CHAPTER 3 – URBAN HABITAT QUALITY AND CONNECTIVITY FOR NATIVE BIODIVERSITY

INTRODUCTION

Chapters 1 and 2 established an Index for measuring biodiversity in Los Angeles and a spatial framework of ecotopes that represent the building blocks of biodiversity and ecosystems in the City. As with the previous two chapters, the intention of Chapter 3 is to provide applied research that supports current biodiversity decision needs in Los Angeles. The focus here is to provide information that supports maintaining the quality and connectivity of urban habitat for native biodiversity, including both common and rare species, to prevent further local species loss (i.e., no-net loss). This is achieved by producing a quantitative, spatial measurement of habitat quality and connectivity that can be monitored over time via the LA Biodiversity Index Indicators 1.1b and 1.1e. It should be noted that these indicators attempt to address all native biodiversity, and habitat for threatened, endangered, or other species of conservation concern is not explicitly differentiated within these measurements at this time; however, indicators 1.2a and 1.2c in the LA Biodiversity Index are designed to address that important segment of City biodiversity.

Most past work on the topic of habitat connectivity has emphasized contiguous corridors for movement of large mammals, such as mountain lions, between large natural areas. While corridors are critical for such species, emerging approaches to connectivity are broader and account for movement of many types of species through both built and natural lands. In such cases, all landscapes and developed areas have the potential to contribute to connectivity via contiguous habitat corridors, non-contiguous habitat "stepping stones," or habitat-friendly built land uses. This approach is especially applicable in highly developed cities like Los Angeles where many common native species, such as birds or butterflies, have the potential to move broadly throughout the urban landscape if connectivity considerations are accounted for in urban and landscape design.

While habitat quality and connectivity are often discussed as goals for urban biodiversity stewardship, examples of quantitative, spatially explicit, integrated estimates are limited. This Chapter presents a high-resolution, quantitative measurement of urban habitat quality and connectivity within the Elysian Valley using the latest modeling software. The Elysian Valley is a key area for connectivity decision making in the City because it is highly urbanized, but is a key location for maintaining and enhancing connections between regional habitat cores in the Santa Monica Mountains, San Gabriel Mountains, and Verdugo Mountains, and finer-grained connectivity between urban habitat patches in the Elysian Hills, San Rafael Hills, Repetto Hills, and Puente Hills. The Elysian Valley is also a key portion of the larger Rim of the Valley connectivity initiative (see Figure 4-1) and the focus of several major LA River revitalization efforts, including the Taylor Yard Case Study (presented in Chapter 4) that may benefit from a quantitative analysis of connectivity to support decision making. Locations with the highest resulting connectivity values are potentially important for conservation and should be the focus of efforts to protect and enhance biodiversity. Additionally, areas with lower values could also be locations to enhance as habitat for common native species, such as native birds and butterflies, in support of the equitable distribution of biodiversity and natural areas throughout the City. This appears to be the first time such a measurement has been attempted within a highly urbanized context and reveals new insights into the future of urban biodiversity stewardship.

Cities are dynamic, rapidly evolving places with potential to remedy, or exacerbate, biodiversity challenges such as habitat fragmentation. Efforts to restore the LA River, increase urban forest cover, provide equitable access to nature, and improve stormwater quality through green infrastructure are all substantial, ongoing local investments. These projects, and others, have the potential to foster connectivity and improve habitat quality and resilience if optimally designed, and at potentially little additional cost. To optimize this potential, and achieve quantitative targets such as the no-net loss biodiversity strategy, cities like LA also need defensible valuation approaches to measure urban habitat quality and connectivity. Effective approaches have not yet been developed for application in urban decision making in LA, or most other cities. Therefore, the results of this effort are intended to address this research gap and support decision making in urban design, landscape architecture, infrastructure, and conservation projects within the Los Angeles urban environment.

HABITAT CONNECTIVITY BACKGROUND

Habitat quality and connectivity are important stewardship topics for cities because cities are rapidly expanding into natural lands worldwide. As a result, expanding cities are a major contributor to the accelerating global biodiversity crisis, with recent projections of 1 million or more species threatened with extinction over the coming century (IPBES 2019). Impacts

from cities, such as direct land conversion and habitat fragmentation, combined with climate change-driven species range shifts, are key drivers of species loss.

Cities also contain spatially isolated patches of habitat that are subject to loss of relatively common species due to small population sizes, adjacent urban land use pressures, or climate change. Such local loss may or may not contribute to global extinctions, but it does have an impact on local communities. In urban Los Angeles, many residents lack access to nature and biodiversity in their neighborhoods, which has been identified as a social equity injustice. The LA City Biodiversity Index assigns points for preventing local extinctions, even of relatively common native biodiversity, within urban areas in line with the City's no-net loss goal. Resilience of natural biodiversity in and around cities partially depends on maintaining connectivity through the evolving urban land uses that surround open space. In both urban and natural landscapes, habitat connectivity is increasingly seen as the preferred strategy for improving resilience of conservation areas to climate change and species loss (Heller & Zaveleta 2011).

Habitat conservation and connectivity are also especially important in LA because the City sits within a global biodiversity hotspot. Biodiversity hotspots are home to a number of species that are endemic to the region (i.e., not found elsewhere in the world). The exceptionally high geophysical diversity of landforms and microclimates, as demonstrated by the characterization of ecotopes presented in Chapter 2, is also an indicator of high biodiversity. Despite intensive development of relatively flat areas in the region, rugged mountain areas, some wetlands, and a few areas of less intensive land use maintain highly intact native biodiversity. Many of LA's important urban natural areas, such as in Griffith Park, Palos Verdes, and

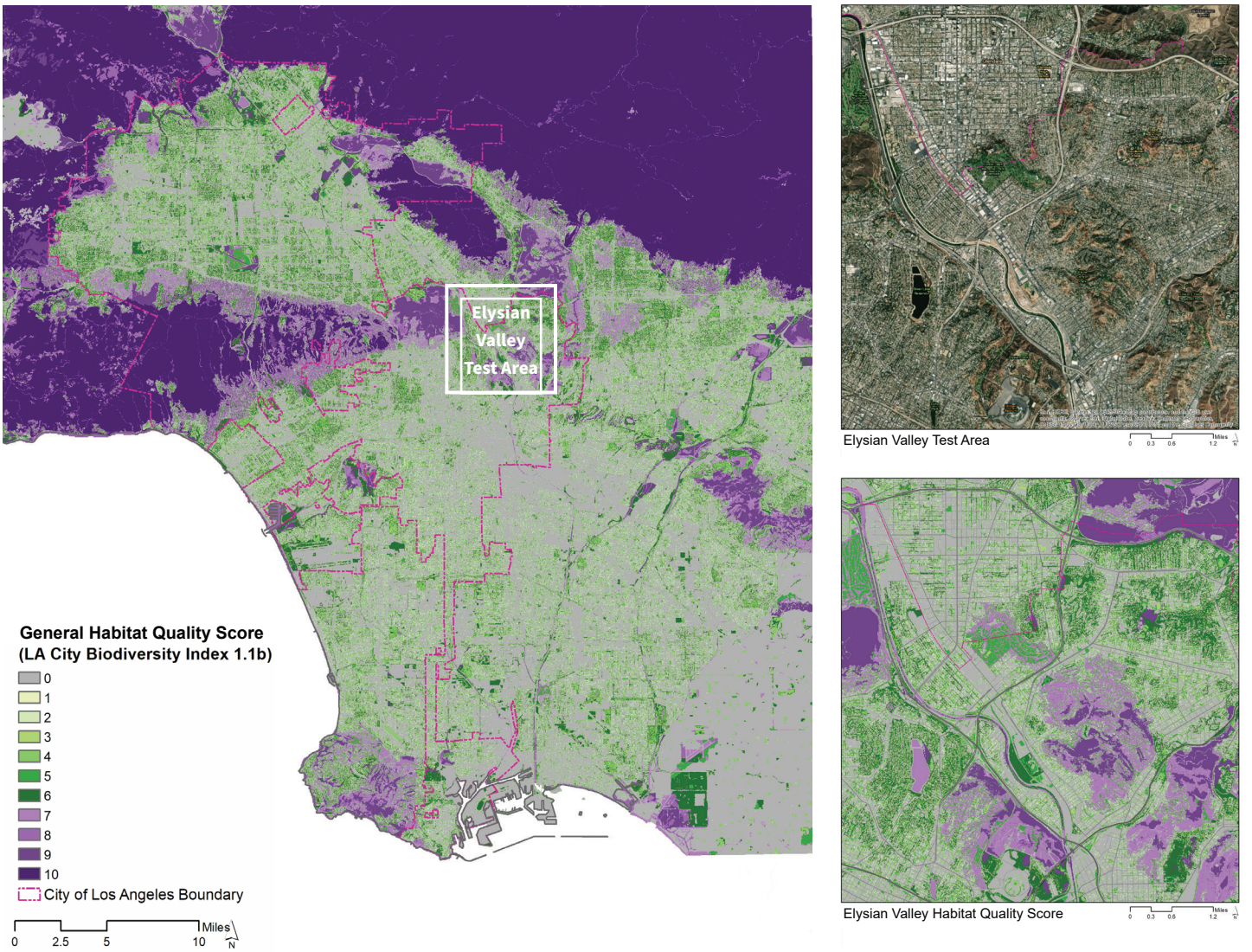


Figure 3-1: General habitat quality scores/Omniscape source values for the study area (left) and Elysian Valley (right). Such spatially explicit measurements can support decision making for protection, enhancement, and equitable distribution of biodiversity. It also provides a key component of the LA Index measurement of biodivsersity change in highly urban areas.

the Puente Hills, occur within such terrain and contain numerous rare and endemic species. These and other important urban natural areas, such as the Ballona Wetlands, Baldwin Hills, Sepulveda Basin, and the LAX dunes, exhibit limited habitat connectivity that is increasingly reduced through intensifying urban development. Measuring habitat quality and understanding connectivity patterns around these important natural areas will provide practitioners with the tools/data to enhance connections and mitigate the impacts of urbanization.

MEASURING URBAN HABITAT QUALITY

Defining habitat quality for urban biodiversity, and mapping it in a spatially explicit way, is a valuable tool for stewardship decision making and is the first step in connectivity modeling. Habitat quality is also a key indicator in the LA City Biodiversity Index, Indicator 1.1b Habitat Quality of Landscapes and Open Space. This measurement provides an estimation of habitat quality at a 10-foot resolution for City and surrounding areas based on a measure of landscape naturalness. Landscape naturalness, in terms of native vegetation presence and patch size, is assumed to provide a coarse estimate of potential suitability of habitat for native biodiversity. When combined with habitat connectivity measurements in Indicator 1.1e, a more comprehensive estimation of the value of all urban landscapes as habitat for native biodiversity is provided. This valuation reflects the methods used in The Nature Conservancy's Connecting Nature's Stage (CNS) series of studies, which also estimated habitat quality based on a measure of naturalness of landscapes. Such comprehensive measurements can be extremely useful for measuring benefits or impacts of urban land use or landscape projects, and quantifying potential mitigation to support quantitative targets for biodiversity, such as the no-net loss target.

Existing habitat quality datasets were reviewed and assessed for applicability. In California, habitat quality assessments are most frequently performed for individual species, or groups of species, of conservation concern in support of compliance with State and Federal Endangered Species Acts. Less common approaches address broader suites of species and ecosystems in comprehensive conservation planning projects such as California's Natural Communities Conservation Plans (NCCPs). While more comprehensive habitat quality assessments, such as NCCPs, are available for some subareas of the study area, only datasets with complete coverage were considered in order to provide uniform results across the study area.

A newer Combined Habitat Assessment Protocol (CHAP) is also being applied by governmental agencies in California to map overall habitat quality for multiple species in a spatially explicit way. CHAP assigns habitat value to different vegetation types considering wildlife species in the California Wildlife Habitat Relationships (CWHR) dataset (CDFW 2008). CHAP modeling has been performed across the entire study area; however, results are provided at a relatively coarse 1-acre resolution and the valuation emphasizes native wildlife species of conservation concern found mostly within high quality natural areas. Further, CHAP does not assess the quality of instream habitat. The dataset assigns very low value, with little differentiation, across urban land uses that are home to mostly common native species. Therefore, the dataset was not ideal for assessing comprehensive urban biodiversity and was not incorporated into habitat valuation considerations, but could be used to refine valuation of natural areas in the future. The Green Visions Plan for Los Angeles also used CWHR data to estimate habitat potential across urban areas for a set of target species and may be considered further in the future (Rubin, Rustigian & White 2006).

When applied at broad scales, each of the above approaches rely on remotely sensed landcover data and some level of expert judgment about the relationship between landcover and the presence of species. Our study expands upon this previous work to provide a more high-resolution, City-wide assessment of habitat quality for overall native biodiversity in both urban landscape and open space areas. Interpreted high-resolution, 6-inch aerial infrared remote sensing and LiDAR data produced for the 2016 LARIAC LA County landcover assessment was resampled to a 10-foot pixel size and was used as the base layer for assigning habitat quality values. This dataset was refined and reclassified based on additional spatial data on native vegetation from several relevant, open source datasets described below. A 10-foot resolution is small enough to detect individual trees or yards in urban areas and supports a variety of local-scale stewardship objectives, including detailed biodiversity monitoring and planning at the parcel-level, prioritizing locations for protection and enhancement in both natural and developed landscapes, or for planning public access to biodiversity.

For this assessment, two factors, structural quality of vegetation ("vegetation type quality") and landscape patch size ("patch size"), were combined into an overall habitat quality score for each pixel with a maximum potential habitat quality score of 10 points per pixel. The 2016 LA County landcover layer classifies vegetated pixels into relevant types that provided the initial basis for scoring most pixels. Non-landscape pixels, such as roads, buildings, or parking lots, were given a zero score. The CALVEG dataset was further used to refine classification of pixels as natural areas. Data on stream quality, in terms of structural character (e.g., natural bed, concrete lined, ephemeral or perennial flow, etc.) from the National Hydrologic Dataset and the LA County Department of Public Works Stormdrain System dataset, was also used to ensure that these

important habitats were fully accounted for, including locations of large culverts under roadways that provide some habitat connectivity value. Future characterization of stream quality utilizing existing data from the California Stream Condition Index and the Surface Water Ambient Water Monitoring Program will be performed for metric 1.1c. Finally, iNaturalist observations of native plant species were used to account for small urban natural areas and native plant landscapes, especially in highly urban areas. Mapped combined scores for the study area and the Elysian Valley are provided in Figure 3-1. While community science applications, like iNaturalist, are incredibly rich sources of data, it should be noted that the data is opportunistic and not always representative of the flora and fauna that exist in a particular place. Full methods for determining habitat quality scores can be found in Brown (2019) and are also included in Appendix C of this report.

A NEW APPROACH TO MODELING CONNECTIVITY

While most applied research on the topic of habitat connectivity has emphasized corridors for movement of specific species between large patches of core habitat, emerging approaches account for comprehensive movement of species throughout entire landscapes of interest (Koen et al. 2014). The Conserving Nature's Stage (CNS) series of studies by the Nature Conservancy emphasizes understanding the role of such broader connectivity of landscapes and implications of climate change in future conservation design. "Connectivity," in this case, encompasses both direct connections between major habitat cores, and also finer-grained permeability of landscapes including the configuration of smaller patches that serve as stepping stones for species movement. Connectivity also addresses the resistance of different land uses, due to various human activities and edge effects, to species movement and ecological processes.

Connectivity in these studies is modeled as a function of landscape naturalness and land use intensity, and the presumed ability of many types of species to move through them via any possible route. Likewise, "connectivity" is defined for this study as: *the degree to which an urban region, encompassing a variety of natural, semi-natural and developed landcover types, provides ecological characteristics conducive to the short and long-term movement of many types of organisms (*from McRae et al. 2016).

This study uses Omniscape software and ArcGIS to produce a high resolution, "wall-to-wall" measurement of connectivity, within the Elysian Valley of Los Angeles. Omniscape values areas as "sources" for native species within a network, such as natural areas, parks, and urban landscapes, and then measures potential connectivity for species through the network based on the assumed "resistance" of features to movement, such as intensive land use or roads. The habitat quality measurement described above, LA Biodiversity Index Metric 1.1b, Habitat Quality of Landscapes and Open Space, is used as the source layer. The Southern California Council of Governments (SCAG) 2008 Land Use layer was used as the resistance layer (full methods for defining resistance values can be found in Brown (2019) and are also included in Appendix C of this report). The results suggest the pattern of habitat quality and associated native biodiversity across the study area, and the specific areas where species may move between habitats or where movement is restricted.

Unlike most past approaches to habitat connectivity modeling designed to measure connectivity for specific target species between two large core areas of habitat, e.g., "least cost path" methods using the Circuitscape Model, Omniscape instead measures connectivity of every pixel of a study area as a potential habitat source for many types of species resulting in a "wall to wall" measure of connectivity. Thus, the Omniscape results integrate measurement of both conservation objectives, connectivity of large natural areas and connectivity of all urban landscapes, to produce a more comprehensive measurement of connectivity. The approach is applicable in the Los Angeles urban environment because native biodiversity exists at various levels throughout the urban matrix, not just in large, core natural areas. While connecting higher quality natural areas is arguably more important from a conservation perspective, any level of increase or decrease in connectivity in any location is assumed to contribute to the no-net loss biodiversity goals of the City.

Additionally, it should also be noted that such a generalized approach will not effectively estimate connectivity for many species whose movement patterns depend on specific habitat requirements, such as habitat specialists, aquatic species, or species with limited mobility. However, in line with the arguments for CNS, and fundamentals of connectivity science, modeling generalized connectivity based on landscape naturalness should provide a useful coarse filter for estimating movement of a broad segment of biodiversity.

Combined with ecotopes and other spatial indicators in the LA City Biodiversity Index, including indicators specifically oriented toward protection of threatened, endangered, and species of high conservation concern, these results support the spatial optimization of biodiversity conservation and enhancement strategies across the City. In such an optimized scenario, native biodiversity occurs throughout the City in a well-connected network of habitats whose level of quality varies depending on the habitat suitability of the space provided. In other words, most landscapes in the City can be suitable for

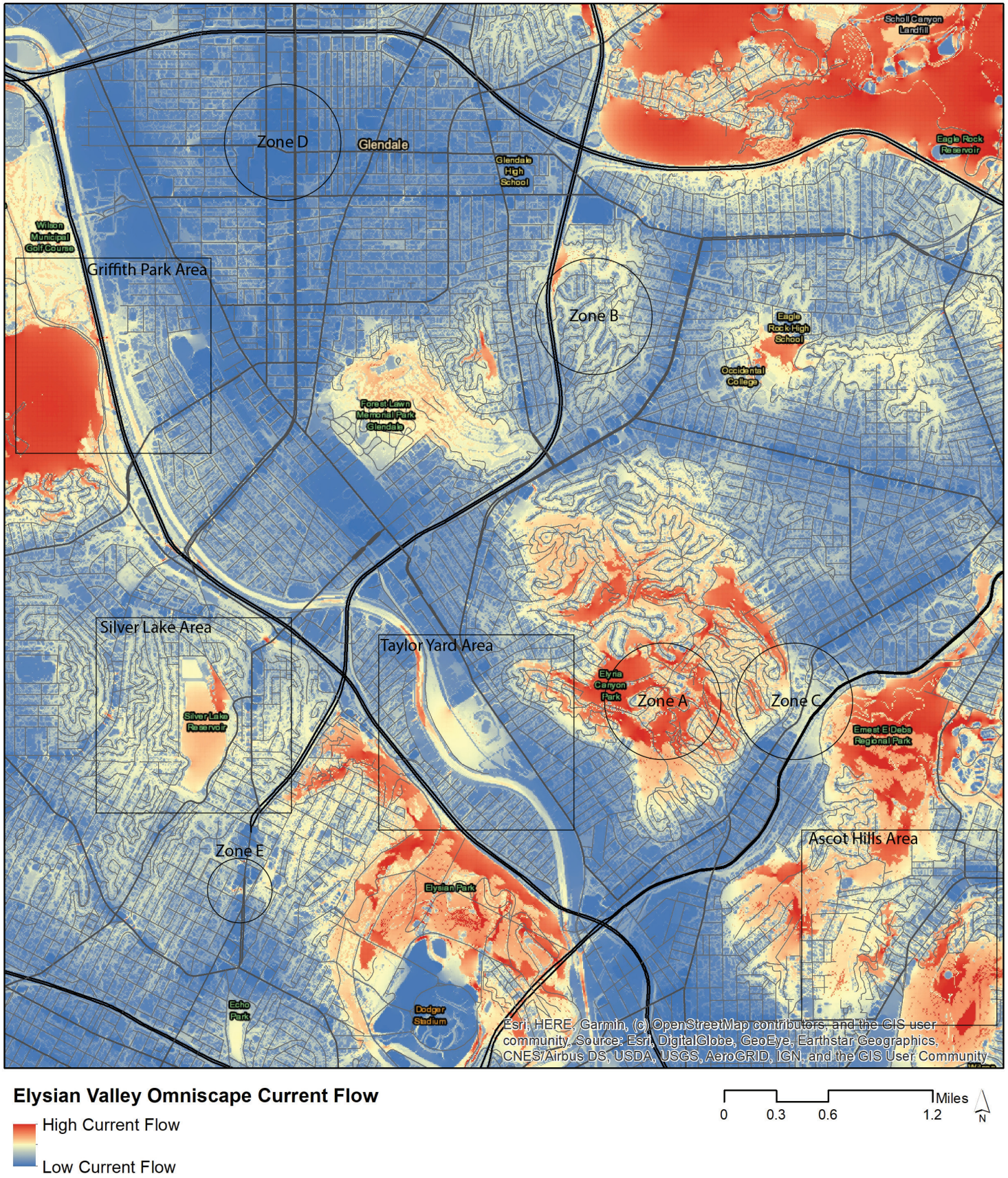
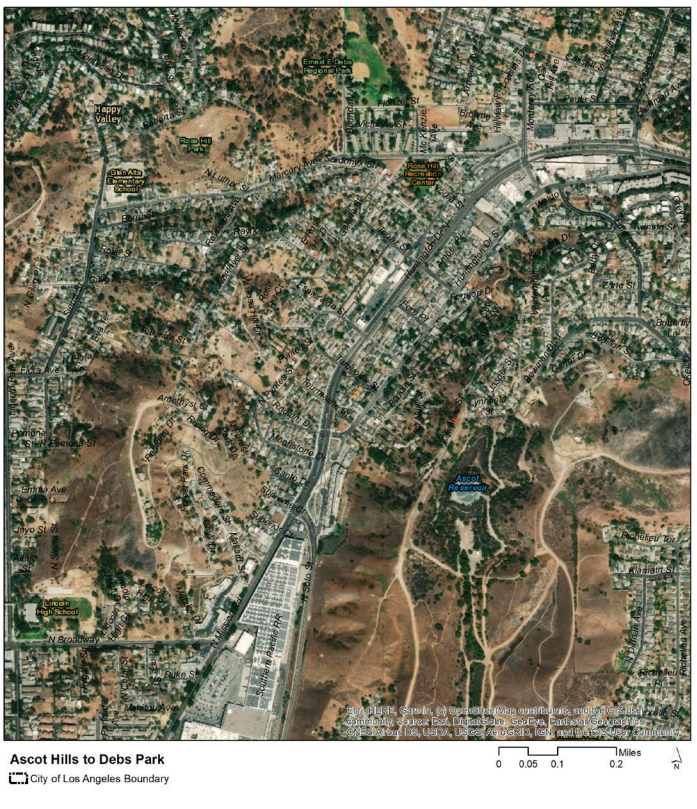
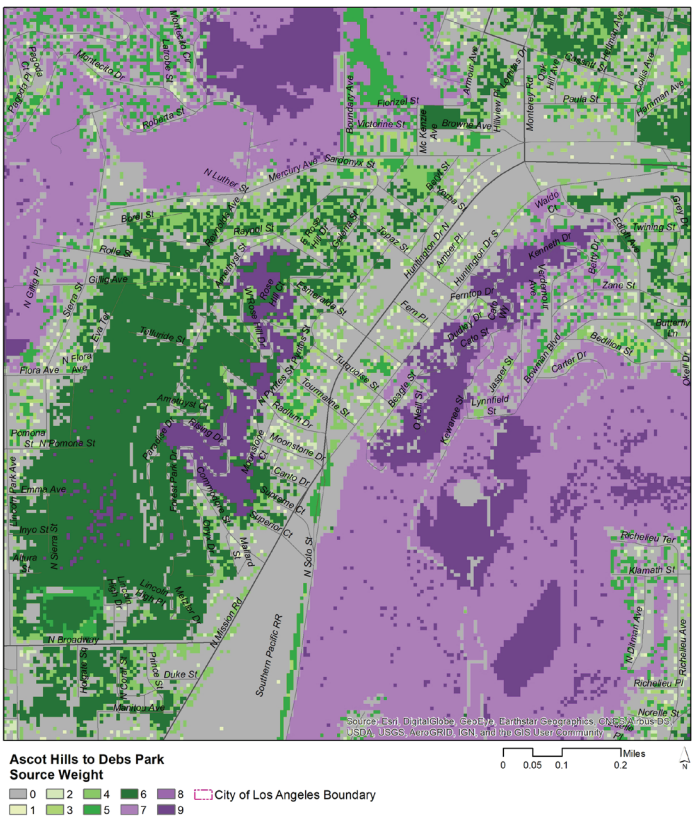
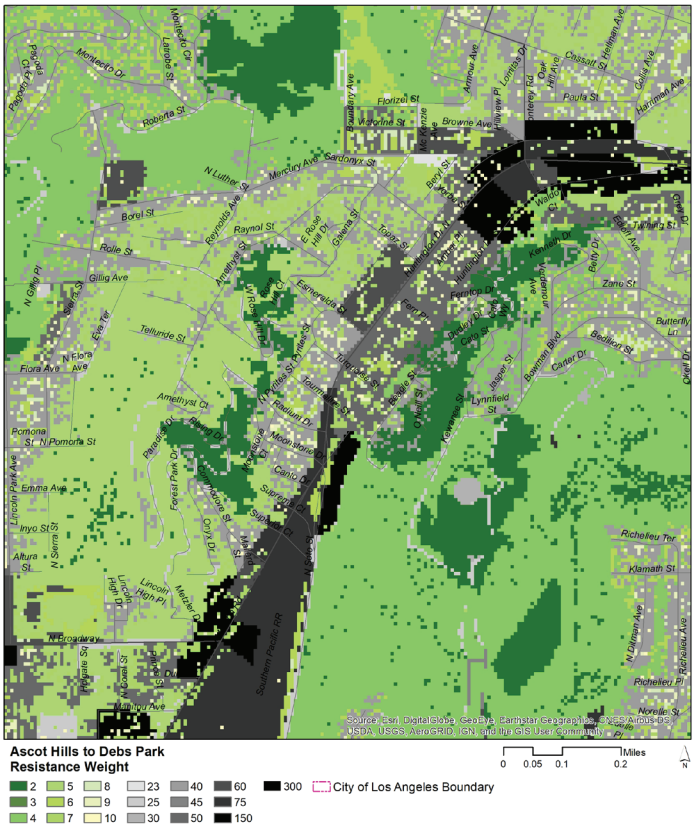


Figure 3-2: Omniscape results for the Elysian Valley test area. Current flow is an indicator of the potential for movement for many types of species through an area.







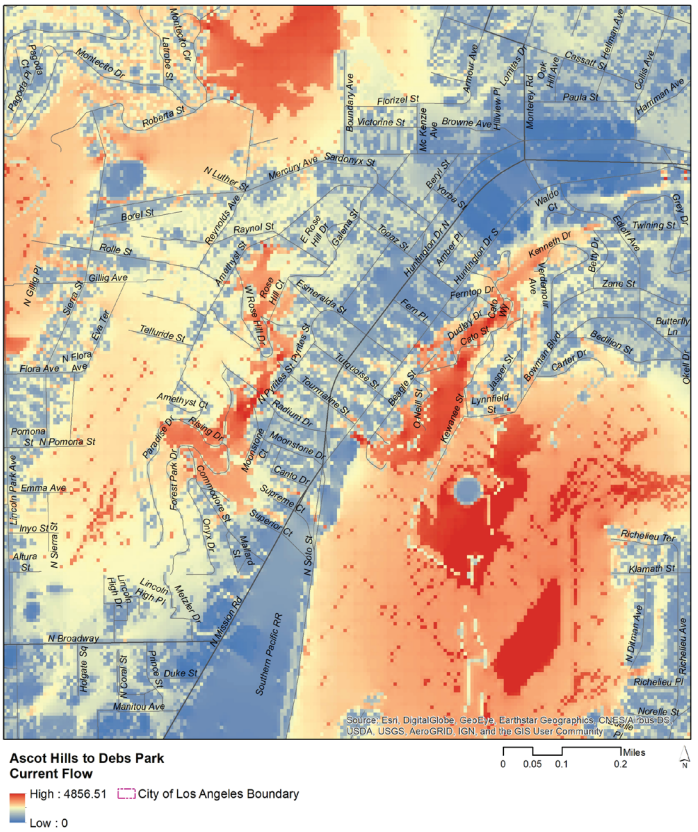


Figure 3-3: Current flow (bottom right), along with underlying source (top right) and resistance (bottom left) value maps, for an area potentially important for regional connectivity along the Repetto Hills ecotope. Multiple "corridors" of current flow through urban areas along Huntington Drive between Ascot Hills to the southeast and Debs Park to the northwest. The results suggest that these urban areas are important to maintain and enhance to provide connectivity.

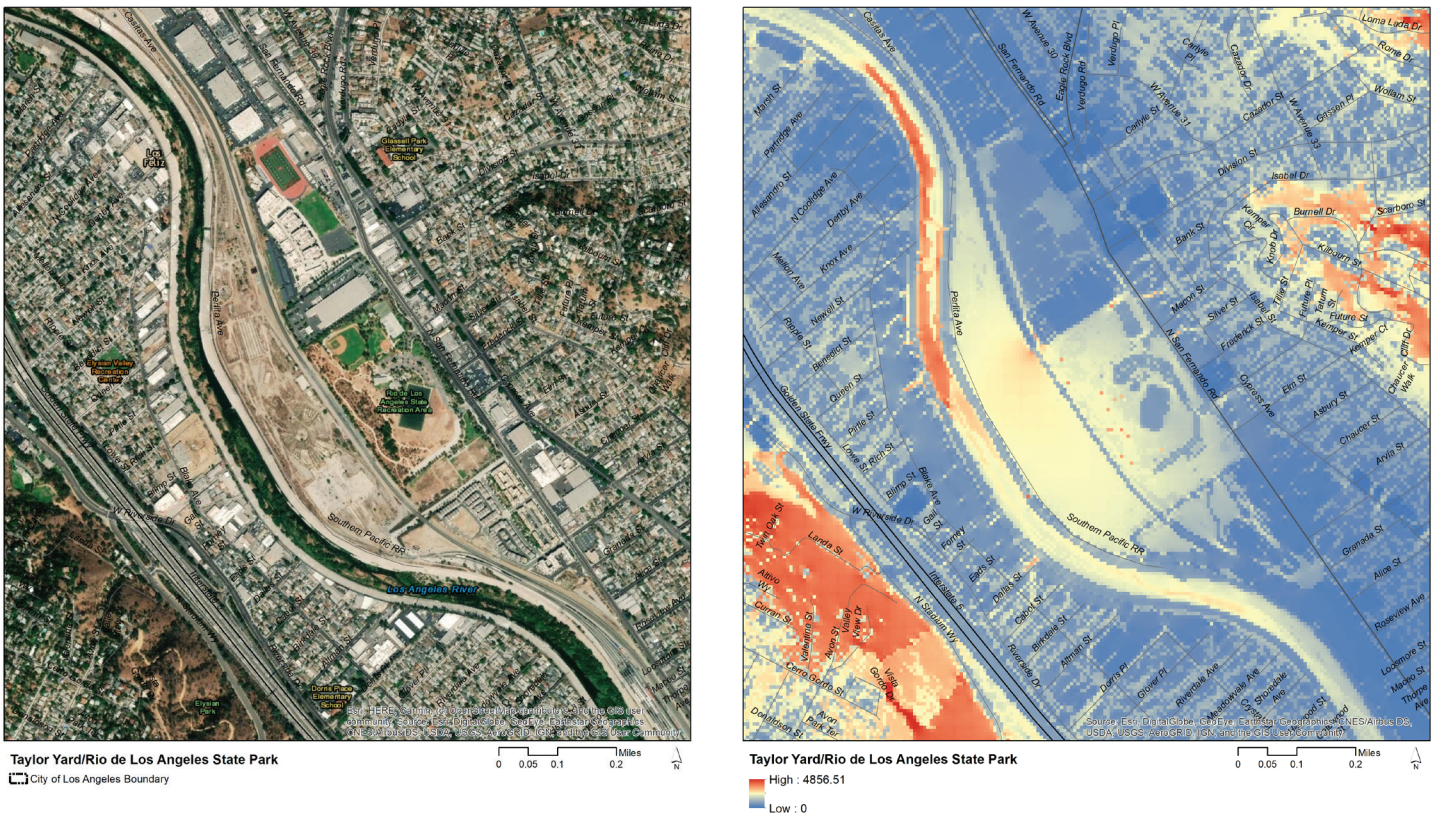


Figure 3-4: Results for the Taylor Yard area. The former Taylor Yard rail site is planned as a major new park in the LA River Revitalization project. The site demonstrates moderate connectivity value and exhibits pinch points along San Fernando Road that suggest potentially important locations for connectivity to higher quality habitats in Mount Washington to the east. Pinch points to the west across the LA River suggest potential connectivity to the Elysian Hills to the West. Clearly, strong connectivity along the River to the north and south is also supported.

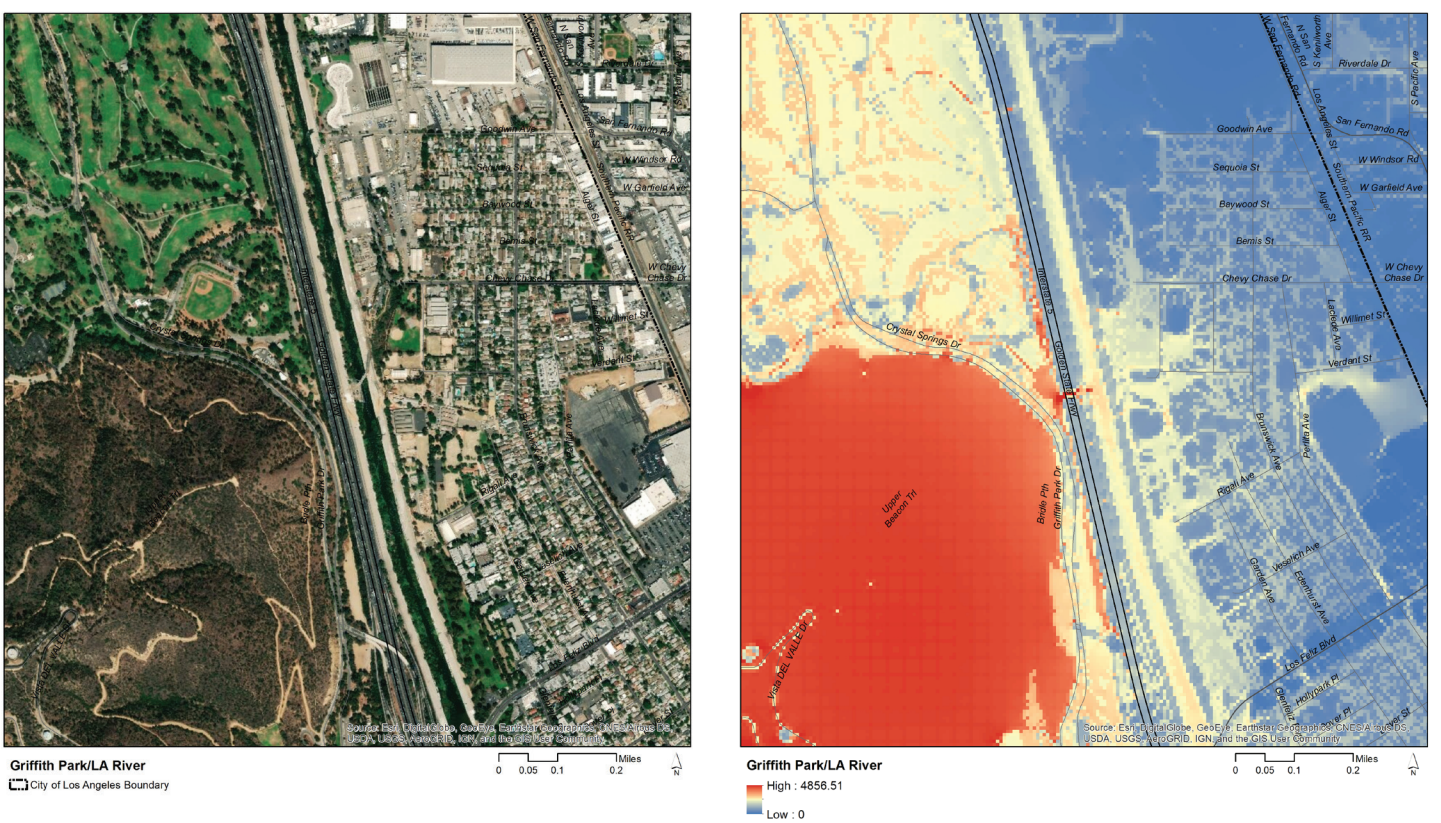


Figure 3-5: Results for Griffith Park east edge. Strong, narrow connectivity crossing the 5 freeway in the center of the image is occurring at a large box culvert for Crystal Springs Creek as it passes under the 5 Freeway connecting Griffith Park to the LA River. It is clear that this is potentially a significant connection. However, this is not a high-quality connection, or even a strong one in reality. High strength within a small area, in this case, may instead be interpreted as a lack of other quality connections between these two major habitat features as the strong current within each of them is forced through a very small, low quality corridor. It suggests the need for a better, more redundant connectivity between Griffith Park and the LA River.

Figure 3-6: Results for the Silver Lake Neighborhood. Ecological restoration and enhancement efforts are ongoing near the Silver Lake Reservoir (large red area). Diffuse moderate connectivity is evident throughout most of this high-landscape-intensity neighborhood. Hilly landforms contribute to lower development densities and patches of remnant native landscape occuring on steep slopes. Distinct connectivity pinch points are evident to the west and northeast where current (red) "punches through" high intensity, low landscape land uses along major arterial roadways in valley bottoms. These areas, and areas around them, may be important to protect and enhance connectivity.

some native biodiversity depending on the land use context. In more urban areas and developed landscapes, target species will often be more common, tolerant of urban conditions, and oriented toward increasing access to nature in neighborhoods that currently lack it. In larger natural patches or corridors, target species may be less common species that tend to avoid urban areas and are of higher conservation value in terms of sustaining populations of species at risk of extinction. LASAN suggests that an optimized urban habitat network also aligns with the natural pattern of ecotopes representing the diversity of geophysical conditions that underpin biodiversity over time. Such a pattern may support more robust and resilient native biodiversity in the City, supporting local goals for species conservation and equitable public access to nature within this global biodiversity hotspot.

PRELIMINARY CONNECTIVITY MODELING RESULTS

The basic Omniscape output is a "current flow" map representing the likelihood of potential movement of species within the area of interest (see Figure 3-2). Generally, areas of higher current flow indicate higher likelihood for movement of species through the area. As was mentioned previously, results are presented for the Elysian Valley test area. To measure City-wide connectivity, which would be a larger analysis, additional model calibration to account for longer-distance movement, are necessary; however, this local-scale mapping also partially reflects these broader-scale patterns. A City-wide measurement is a key next step. The following section describes the general results. Additional discussion of key results are included in the discussion section and in the figure captions in Figures 3-3, 3-4, 3-5, and 3-6.

Within the case study area, larger dark and light red areas of high current flow/potential species movement occur within and around high-quality natural areas since there is a relatively high amount of "source" habitat in these areas (Figure 3-2, Zone A). Generally, these areas suggest that connectivity is very high and should be protected. Other important areas of flow are large, diffuse zones of light yellowish/tan that tend to occur within more highly landscaped, low-intensity developed areas that receive relatively strong flow from nearby natural areas (Zone B). There are areas where there may be high species movement that is more diffuse compared to the more concentrated movement modeled in Zone A. Light tan areas also occur between natural areas within more intensive land uses along the lowest-resistance path between the two natural areas (Zone C). Light tan areas are areas where urban wildlife corridors, stepping stones, or land use enhancements for biodiversity may be more beneficial. Blue areas are those with high resistance values and low current flow (Zone D). Small

dark red areas, often surrounded by darker blue, or near edges of parks, represent "pinch points" where barriers to movement are producing channelized flow (Zone E). Channelized high flow can occur along corridors such as streams or rivers, but also through small corridors of relatively highly-landscaped, low intensity land uses surrounded by high-intensity land uses. These pinch points suggest specific locations to enhance or protect habitat connectivity within the broader network, or may be considered an indication of insufficient connectivity in the local area. Captions for Figures 3-3 through 3-6 discuss other model results characteristics and areas of interest around the Elysian Valley.

DISCUSSION

Omniscape analyses are useful in that they identify connectivity between all habitats in an area of interest, not just pairs of high-quality natural areas as has been common practice in past connectivity modeling. Such wall-to-wall results can serve as the basis for comprehensive connectivity planning and monitoring. This effort reveals that the Elysian Valley has islands of biodiversity surrounded by areas with limited connectivity. In order to build a more resilient City, connections between high quality habitat should be strengthened. Maximizing connectivity is important for many processes necessary for sustaining and enhancing urban biodiversity such as species dispersal, daily species movements, gene flow, recolonizing habitat patches following disturbance events, facilitating species range shifts that will accompany climate change, and increasing access to nature and biodiversity within urban neighborhoods (McRae et al. 2016).

While this modeling certainly does not reflect all important connectivity functions, it can serve as a coarse filter for identifying key locations for consideration. Areas of interest should be evaluated further, including evaluation of connectivity for specific species or ecological process of interest. The following topics are relevant to continued refinement and application of this modeling.

1. FOCUS ON THE AREAS AROUND PINCH POINTS TO MAINTAIN AND ENHANCE HABITAT CONNECTIVITY. A key product of this analysis is to identify locations where movement of species is predicted to be channelized into pinch points (Zone E, Figure 3-2). These locations can indicate key habitat connectivity routes that, if lost, may result in larger impacts to resilience of biodiversity within habitat areas they connect. They can also suggest where connectivity is limited and should be expanded, including potentially adding additional enhancements nearby to increase redundancy of connectivity. An important principle of conservation planning is that there should be at least two strong routes of connectivity connecting natural areas in case one was to fail. Thus, pinch points, and the areas around them, may be a priority for conservation and enhancement, both from a conservation perspective and to protect and enhance common native biodiversity in dense urban areas with low access to native biodiversity.

   Pinch points, or lack thereof, along major transportation corridors should be carefully evaluated. Freeways have largely eliminated direct connectivity, so pinch points may not be apparent in many areas along freeways, except at culverts as described in the Griffith Park example (Figure 3-5) or underpasses. Under or over-passes are the primary solution for solving this connectivity challenge, and two wildlife overpasses are in planning stages in LA County, including one over the 101 Freeway at Liberty Canyon and one in the Hollywood Hills. A normalized current flow map, described in Brown (2019) and McRae et al. (2016), would be useful in identifying additional optimal locations for such features.

   Many urban transit corridors are also the focus of "transit-oriented development" (TOD) and are experiencing rapid land use intensification across long, contiguous linear transects throughout the City. However, a byproduct of high density, contiguous linear corridor development is that permeability, even for highly mobile wildlife species, such as birds and insects, may be reduced or redirected. For example, the greater Wilshire corridor is an important transit corridor that runs from Downtown LA to Santa Monica, and sits along the Pacific Flyway between the Santa Monica Mountains and the nearby sensitive urban natural areas at Ballona Wetlands and the Baldwin Hills, and the Palos Verdes Peninsula and Orange County further south. The intensity of land use along this TOD corridor is expected to intensify across most of its length. Contiguous intensification, and the east-west orientation of the corridor, may further isolate these major urban natural areas, and the Pacific Flyway, to the north and south. This potential to inhibit, or alter, regional wildlife movement patterns may be an overlooked consideration, especially considering the compounding impacts of climate change on broad-scale, long term species movement and migration within the USFS Southern California Coast Ecological Section, but merits additional attention. Designating locations for less intensive development, or in some cases, promoting de-intensification, along long, contiguous TOD corridors to maintain or enhance urban wildlife movement may be warranted.

   While pinch points should be carefully evaluated if development or restoration is planned in close proximity, existing pinch points should not be seen as fixed features. Change happens rapidly in cities, and relatively minor changes in

land use and landscape in nearby neighborhoods may result in large changes in connectivity patterns, both good or bad. Land use change in the nearby network may result in shifts in current to new locations resulting in lower or higher flow in pinch points, even if the land use of the specific pixels within the pinch point does not change. New pinch points could also emerge if flow changes routes as a result of these nearby changes.

2. MODEL LONG-DISTANCE CONNECTIVITY USING A LARGER OMNISCAPE MOVING WINDOW, IN ADDITION TO LOCAL CONNECTIVITY. This modeling measured local connectivity based on a relatively small moving window of ½ mile (i.e., connectivity is measured within ½ mile from each pixel). It assumes local permeability as a measure of the ability of species to move over relatively short distances between urban habitats (local connectivity). Such local movements may be necessary to accommodate pressures of climate change on the changing location of suitable habitat within or between ecotopes, such as moving to cooler northerly aspects or toward areas with higher water availability. Local permeability may also be essential to maintaining, or enhancing, species presence in neighborhoods as surrounding urban land use continues to intensify in Los Angeles over time, as is the current trend.

   An important next step will be to rerun the analysis with a larger moving window to supplement local connectivity modeling and estimate the potential for longer-distance movement from each pixel. A long-distance moving window of at least five miles (eight km) is recommended for Los Angeles. Such long-distance modeling will add additional current flow to many areas and may result in greater emphasis on existing pinch points or corridors. It may also lead to identification of new pinch points or corridors through new dominant routes of flow that are only evident when evaluating broader patterns of connectivity.

   Such longer-distance connectivity may be relevant to species resilience in Los Angeles including movement by highly mobile species, such as mountain lions, between major natural areas, annual migrations of bird and butterfly species through Los Angeles, or potential connectivity for longer-term species movement between natural areas and major wilderness areas to the north and south within the ecoregion in the face of climate change. This longer-distance modeling also addresses connectivity between the major natural areas to the east of Los Angeles, such as Santa Fe Dam or the Whittier Narrows. These major natural areas are havens for species of conservation concern and are of interest to incorporate into a regional habitat network to reconnect isolated populations across the City. For example, connections to breeding habitats for federally endangered least Bell's vireo (*Vireo bellii pusillus*) within the Whittier Narrows along the San Gabriel River could be enhanced to foster connectivity with future planned habitat restoration planned along the LA River.

3. INTEGRATE ECOTOPE CONNECTIVITY INTO EVALUATION OF NETWORK QUALITY AND PRIORITIES. In addition to habitat quality, biodiversity is also strongly influenced by natural geophysical features, processes, and patterns, such as landform and microclimate. Such features have been aggregated into ecotopes in Chapter 2. Supplementing the connectivity modeling provided here, which is based on habitat quality in terms of vegetation quality and patch size alone, to include evaluation of connectivity of habitats within and between ecotopes could also support greater biodiversity and a more resilient habitat network (see Figure 3-7). Connectivity along stream corridors should also be integrated.

   Work by Buttrick et al. (2015) in the CNS study suggests that conservation areas with high geophysical diversity serve as a defensible "coarse filter" for biodiversity conservation at large spatial scales. Their modeling emphasizes areas with high geophysical diversity that are well connected to allow species to adapt and move in response to changing climate conditions, such as to northerly facing slopes or higher elevations due to rising temperatures. The ecotopes approach is a similar "coarse filter," but it differs in that it strives to protect portions of all fundamental abiotic features in the landscape in

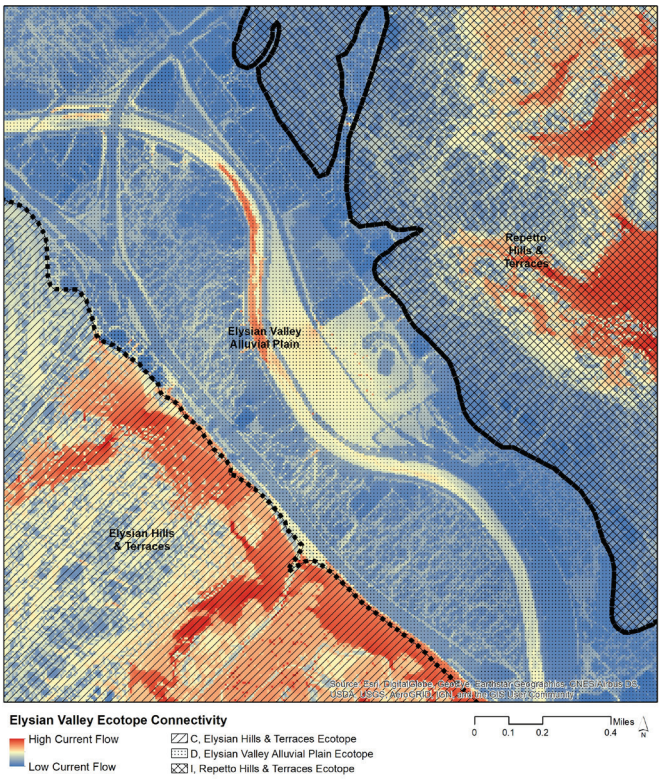


Figure 3-7: Increasing landscape connectivity within and between ecotopes would support a more natural pattern of biodiversity across Los Angeles.

line with regional conservation best practices. For example, flat, arid alluvial plains cover much of Los Angeles, and have relatively low geophysical diversity by themselves, but are nearly 100% developed and are home to some of the region's rarest ecosystems, such as vernal pools and perennial herbaceous prairies. These less geophysically diverse areas likely play a role in long-term evolution and resilience of some species at finer subregional scales. Accordingly, placing LA in a super-regional context, the entire Los Angeles region constitutes a geodiversity hotspot using Buttrick et al.'s (2015) criteria. Therefore, an ecotopes approach to preserve all aspects of nature's stage within the hotspot, including low and high geodiversity ecotopes, may maximize the biodiversity potential and intactness of the broader geodiversity hotspot.

4. MODEL CONNECTIVITY FOR INDIVIDUALS OR GROUPS OF TARGET SPECIES OR ECOSYSTEMS AND VALIDATE RESULTS USING ON-THE-GROUND MEASUREMENTS. Movement of different species can vary substantially in response to patterns of urban resistance and source conditions (e.g., Bininde et al. 2016). Further refinement of the Omniscape approach for LA may include adjusting source and resistance values for individual or groups of target species, such as species of conservation concern, local resident species, migratory species, wetland or upland species, high or low-mobility species, etc. The CHAP, WHR, and/or California Department of Fish and Wildlife BIOS database of recorded observations of species of conservation concern may be useful for calibrating source values in such an analysis. The Green Visions Plan also includes a detailed literature review of habitat requirements for relevant species in the WHR dataset and discusses implications for enhancing habitat within urban areas. This review would be useful for calibrating resistance values for specific species. On-the-ground measurements of species presence relative to modeled assumptions or results would also support refinement and validation.

   Modeling habitat suitability and connectivity for a set of target species whose presence indicates habitat high quality in more densely developed urban areas would also be useful. Many native species that are considered common, such as the California scrub jay or red-winged blackbird, are in fact rare in dense urban areas or in lower density areas with limited connectivity to larger natural areas. Presence of highly mobile "urban edge species," such as native birds or butterflies, may serve as useful indicators of habitat quality and connectivity change if their presence increases or decreases in urban neighborhoods, and thus, may provide a measure of equitable access to nature. Selecting a conspicuous species that is easy to spot and identify, such as California scrub jays or red-winged blackbirds, could allow monitoring for presence to be "crowd-sourced" through apps like iNaturalist or eBird. Areas with high connectivity and low species richness could be targeted for habitat quality enhancements to support candidate species. In the case of scrub jays, enhancing habitat would include planting native oak trees.

5. CONSIDER HOW THE PATTERN OF URBAN AREAS MAY IMPACT CLIMATE CHANGE ADAPTATION OF SPECIES WITHIN THE LOS ANGELES BIODIVERSITY HOTSPOT OVER TIME. This analysis does not include considerations of future climate or land use change that may further influence connectivity patterns or habitat suitability across the study area. As has been discussed previously, urban land use may be a critical barrier to species movement to new suitable habitats resulting from climate change. Projected regional land use change is often modeled by SCAG and others, and could be incorporated into future modeling anticipating changes to resistance and source values and the resulting routes of future current flow. Additionally, climate gradients relative to connectivity could be incorporated as was demonstrated in McRae et al. (2016). However, given the uncertainty and complexity of how climate change will impact local ecosystems, it would be beneficial to focus on maintaining the pattern of ecotopes and permeability between them as a coarse filter for the underlying geophysical diversity that provide the fundamental building blocks for potential future habitats.

6. INTEGRATE OMNISCAPE RESULTS INTO AN INDICATOR FOR THE LA CITY BIODIVERSITY INDEX. The LA City Biodiversity Index includes three habitat connectivity indicators (1.1d, 1.1e, and 1.1f). The first is borrowed from the Singapore Index and uses Fragstats to measure connectedness of natural areas based on effective mesh size. This is a useful indicator, but is not spatially explicit and does not address pinch points or the relative quality of connections. The second and third indicators are still being developed, but aim to measure connectivity of all landscapes and open space and riparian areas respectively. Determining how the Omniscape results presented here could be integrated into an indicator, per the criteria established in Chapter 1, is a key next step.

   As we measure connectivity again in the future based on updated Omniscape modeling that incorporates future changes in the underlying datasets used to calibrate resistance or source values, it will be necessary to interpret what changing results mean for connectivity in the City. Since Omniscape provides a quantitative result per pixel, it will be possible to provide a spatially explicit measure of change in connectivity for ecotopes, pinch points, City-wide, or other target areas of interest. Such quantitative data are invaluable in design and planning processes because they can be used to quantitatively establish a baseline condition, compare alternative scenarios, project future change, and quantify mitigation.

7. INTEGRATE OMNISCAPE CONNECTIVITY MODELING INTO URBAN AND SITE DESIGN DECISION MAKING. Importantly, in cases where urban or site designs show potential to impact connectivity, the modeling provided here may serve as a basis for quantitatively evaluating alternative plans. New design alternatives could be incorporated into the dataset and the Omniscape model could be rerun to evaluate implications of design scenarios. Habitat quality modeling of design scenarios for the G2/Taylor Yard project (Chapter 4, Case Study 3) based on metrics from the LA City Biodiversity Index has been completed and could be run as an initial test of such an approach. Quantitative habitat connectivity mapping may also support broader-scale planning activities such as the ongoing City of Los Angeles General Plan update, updates to the zoning codes, climate action plans, or regional open space plans (see Appendix A).

CONCLUSION

These model results demonstrate measures of habitat quality and connectivity for biodiversity within an area of interest. This is the first time that such "wall-to-wall" connectivity modeling has been demonstrated in a spatially explicit, quantitative way, at a high resolution for an urban area. The underlying habitat quality mapping, in and of itself, is also useful for measuring biodiversity, and biodiversity change, in neighborhoods. As urban projects in LA increasingly consider biodiversity benefits or impacts, habitat quality and connectivity measurements that are actionable in decision making at site to regional scales will become increasingly important for achieving the no-net loss biodiversity objective of the City.

Biodiversity in and around cities plays a role in both the global extinction crisis and the social equity crisis. As the climate changes and cities worldwide continue to expand and intensify, new approaches to integrating biodiversity will be necessary to reduce these impacts. Cities are dynamic places with great wealth and imagination. As past environmental successes have demonstrated, such as the stabilizing of the ozone hole and leadership by cities in reducing greenhouse gases, there is reason to believe that cities can tackle great environmental challenges in their backyards. Projects like the Los Angeles River Revitalization, the Department of City Planning's Wildlife Pilot Study, and the City of LA's Biodiversity Project are promising signs for the future of cities in addressing the biodiversity crisis. The topic of urban biodiversity is even expanding within the more mainstream dialog about LA land use. Urban designers or architects, who are just discovering the topic, are increasingly incorporating it into their work in Los Angeles. Given that the City is situated within a global biodiversity hotspot, if the many interrelated issues can capture the collective imagination of Angelenos, the potential for biodiversity to reshape the City and create a regenerative, post-climate future is immense. Given the City's standing as a world-influencer, the potential for urban biodiversity to gain global attention is profound. The habitat quality and connectivity data presented here adds yet another useful tool as the City of Los Angeles increasingly invests attention toward this important frontier in urban ecological stewardship.

Chapter 4

City of Los Angeles Urban Biodiversity Case Studies

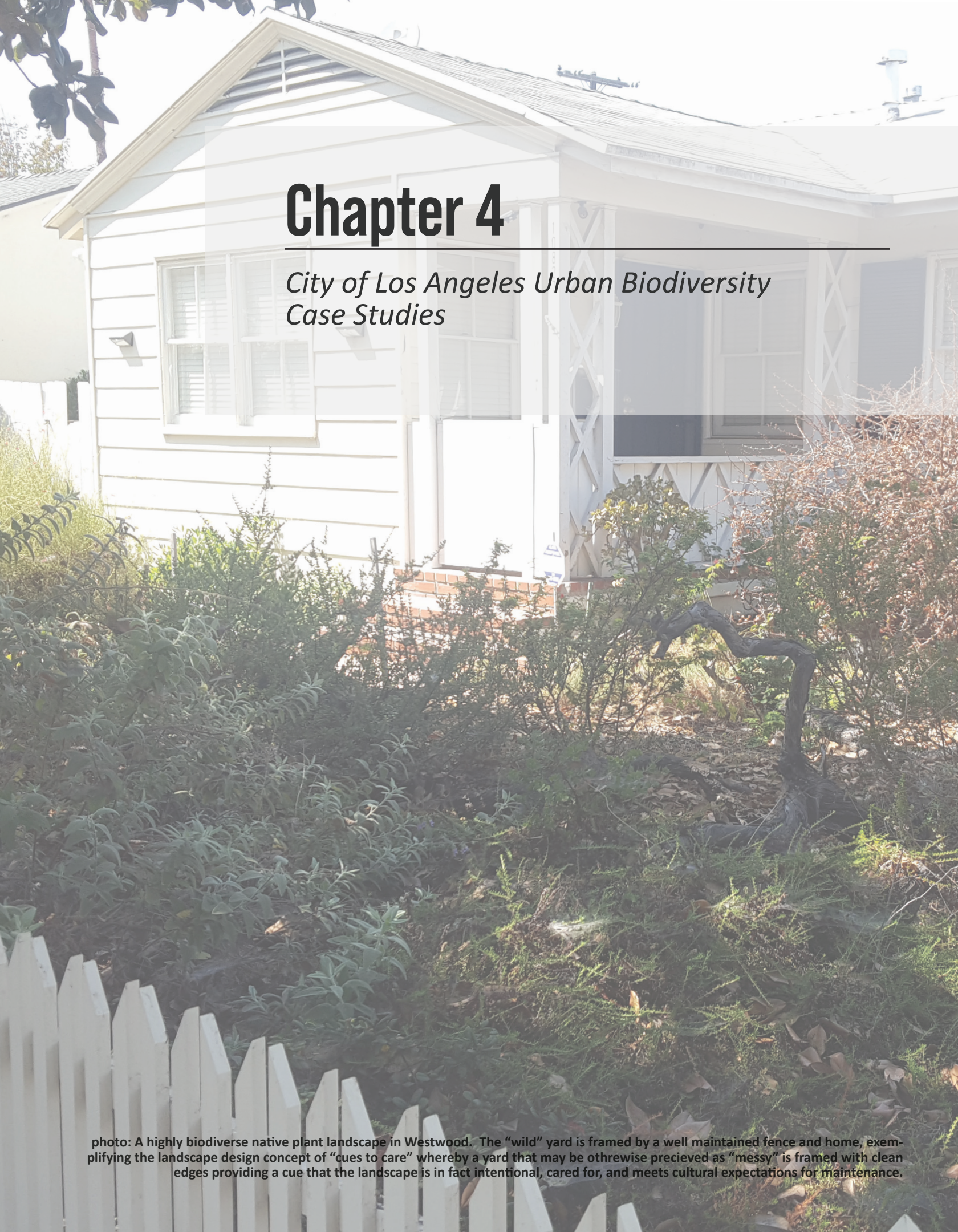


photo: A highly biodiverse native plant landscape in Westwood. The "wild" yard is framed by a well maintained fence and home, exemplifying the landscape design concept of "cues to care" whereby a yard that may be othrewise precieved as "messy" is framed with clean edges providing a cue that the landscape is in fact intentional, cared for, and meets cultural expectations for maintenance.

CHAPTER 4: BIODIVERSITY CASE STUDIES

This chapter includes a series of case study projects currently in progress that demonstrate how biodiversity is changing the way projects are conceptualized and managed in Los Angeles. More often, projects are being designed to benefit both nature and people. The following case studies provide examples of multibenefit projects that do an excellent job of taking biodiversity concerns (e.g., habitat provision, connectivity, etc.) into account.

These are just a few of the latest large-scale biodiversity projects that aim to protect biodiversity in urban areas of Los Angeles. Case studies and other substantial conservation projects and designations across Los Angeles are mapped in Figure 4.1.

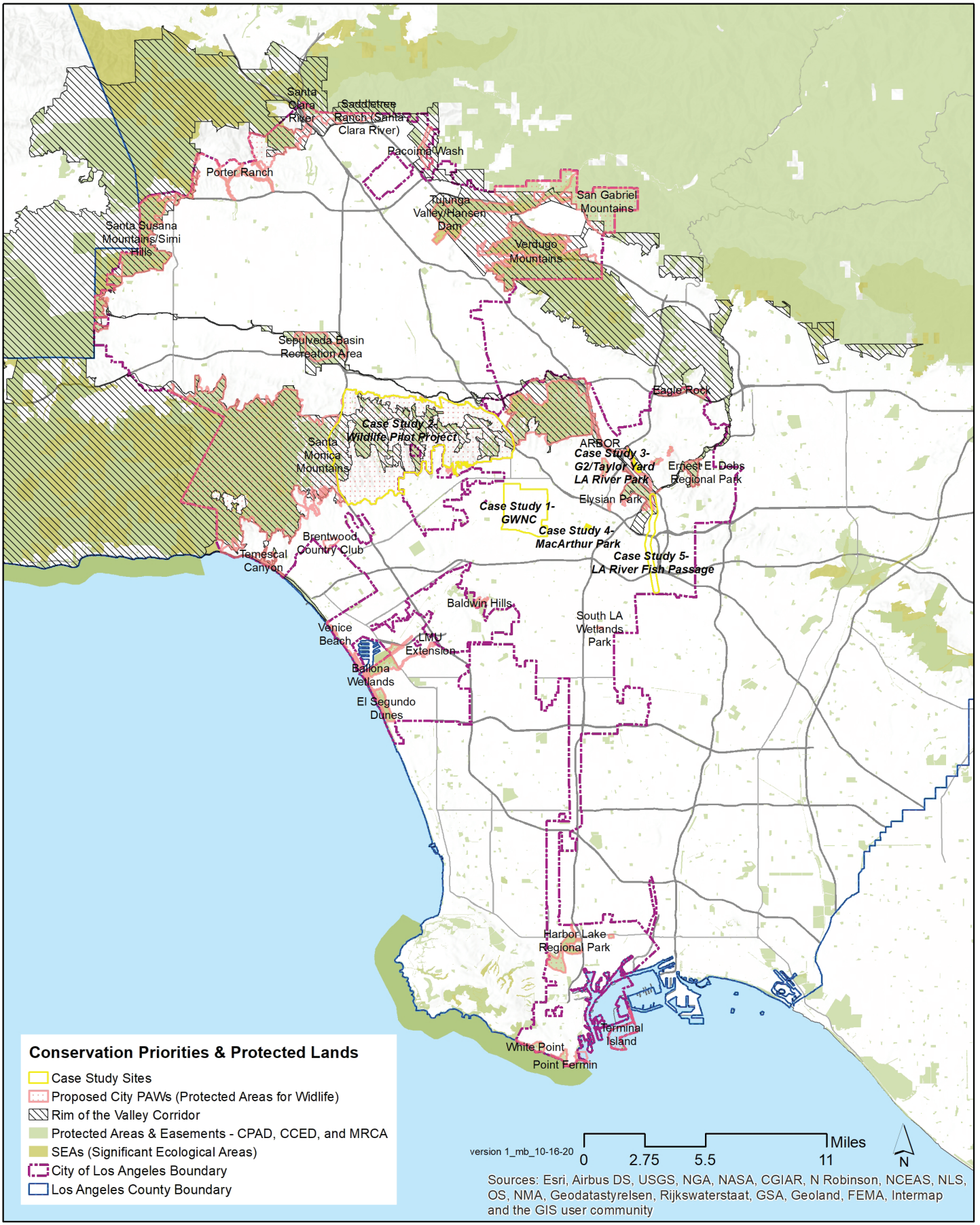


Figure 4-1: City of Los Angeles Major Biodiversity Projects

CASE STUDY 1: GREATER WILSHIRE NEIGHBORHOOD COUNCIL (GWNC) BIODIVERSITY PILOT PROJECT

The GWNC-LASAN Biodiversity Project is a pilot program to organize, engage, and encourage stakeholders in the Greater Wilshire area of Los Angeles to contribute to biodiversity science. The project aims to catalogue the biodiversity present in the Greater Wilshire area and encourage stakeholders to enhance biodiversity by certifying landscapes under the National Wildlife Federation (NWF) Certified Wildlife Habitat Program. The pilot project is being led by the Greater Wilshire Neighborhood Council (GWNC) Sustainability Committee Chair, Julie Stromberg, with assistance from member, Mary Proteau. The Greater Wilshire area is heavily urban and dense, but rich in biodiversity. The area has a robust tree canopy and several parks, which attract wildlife.

The GWNC-LASAN Biodiversity Project is a community engagement program with the goals to (1) assist LASAN in its analysis of LA's biodiversity utilizing the LA Biodiversity Index, as well as the City's biodiversity strategy and action plan; and (2) serve as precedent for a larger, similar community science program for all (99) neighborhood councils throughout the City of Los Angeles. The program officially launched on September 11, 2019, with a presentation by LASAN on the City of Los Angeles' Biodiversity Project. The year-long program will provide baseline data for a study of the biodiversity in this community. GWNC intends to repeat the program in 2-5 years to compare data and further analyze the changes and potential impacts on the biodiversity in this community.

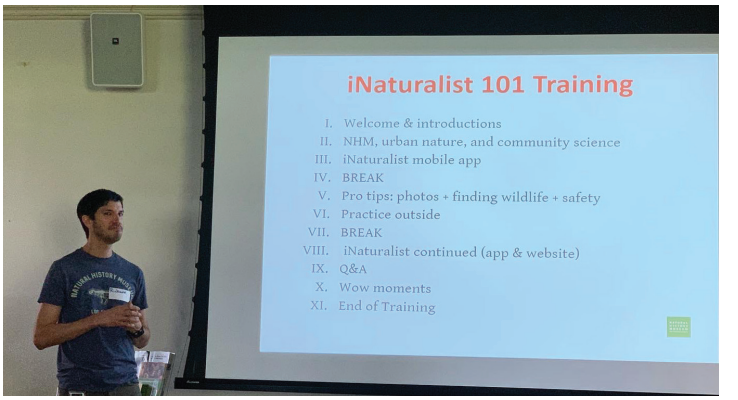
The program consists of one part of the community engagement component of LASAN's biodiversity efforts in response to Councilmember Paul Koretz's LA City Council Motion, CF#15-0499, Motion 25A. The pilot program is consistent with one of the mandates set forth in the Biodiversity Motion to develop options for community outreach and engagement. The program is enabling stakeholders to become personally invested in not only the study of LA's biodiversity, but in its preservation. Using iNaturalist (https://www.inaturalist.org/) as the cataloguing mechanism for the project, residents in the Greater Wilshire area are exploring the wonders of nature that permeate the urban landscape of their neighborhood, and Los Angeles, a global biodiversity hotspot. The program also offers an excellent opportunity to support the City's efforts in studying LA's biodiversity. The ultimate goal is for the GWNC-LASAN Biodiversity Pilot Program to serve as a strong model program for other neighborhood councils to implement throughout the City, which will enable a more expansive analysis of LA's complex and rich biodiversity. To date, several neighborhood councils have expressed interest in replicating the program and neighborhood council representatives have attended various presentations on the program.

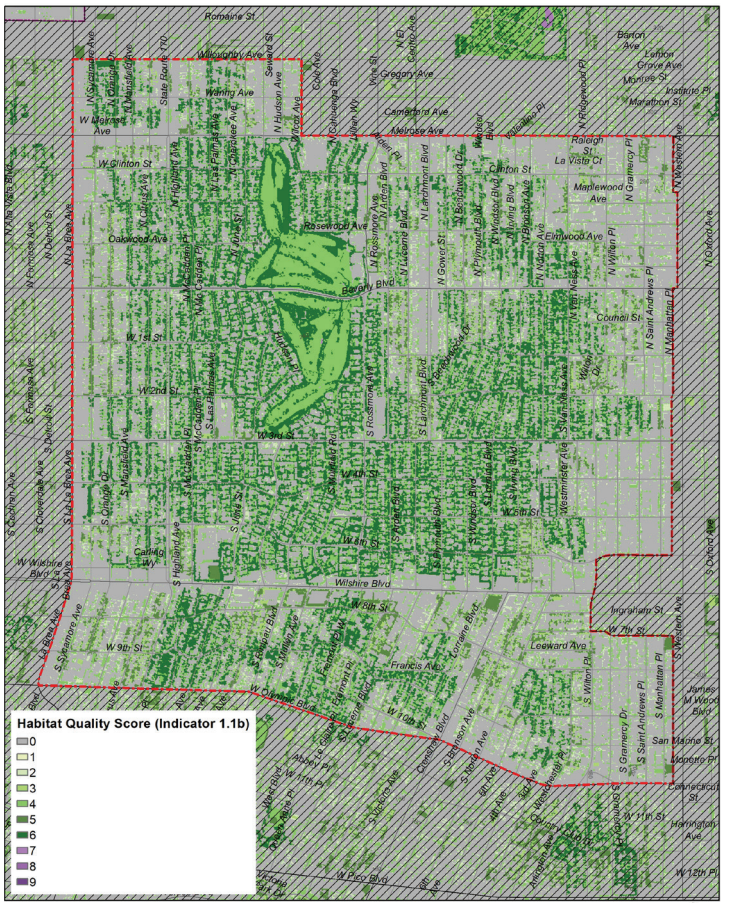
In an effort to maximize outreach for the program, the Hancock Park Garden Club (Julie Grist, President), Larchmont Buzz (Patty Lombard, Liz Fuller, and Calli Goldstein), and Los Angeles City Council Districts 4 (David Ryu) and 5 (Paul Koretz) are supporting the efforts of the GWNC-LASAN Biodiversity Project by serving as outreach partners. The LA County Natural History Museum (NHM) has also served as a de facto partner for the project with a presentation by Lila Higgins, Senior Manager of Community Science, on biodiversity and NHM LA's efforts to study Los Angeles County's biodiversity to the GWNC, and by providing training on iNaturalist to residents. The training also included a BioBlitz at a local park and library. Since the training in November 2019, over 200 individuals have contributed almost 1,000 observations to the GWNC Biodiversity Project study on iNaturalist. The goal is to have at least 1,000 contributors by September 2020.

The GWNC also launched an effort to become a National Wildlife Federation (NWF) Community Wildlife Habitat-Certified Community (https://www.nwf.org/communitywildlifehabitat), and is poised to become the first certified community in LA. The City of LA is also registered for the NWF program, so this complementary effort will nicely augment citywide efforts. Last, organizers of the GWNC performed extensive outreach to local schools to engage students in this program and are working with Los Angeles Unified School District Board Member, Nick Melvoin, to further implement the program.

CREDIT/CONTRIBUTORS

- Greater Wilshire Neighborhood Council
- LA Sanitation & Environment
- Los Angeles County Museum of Natural History
- National Wildlife Federation Community Wildlife Program





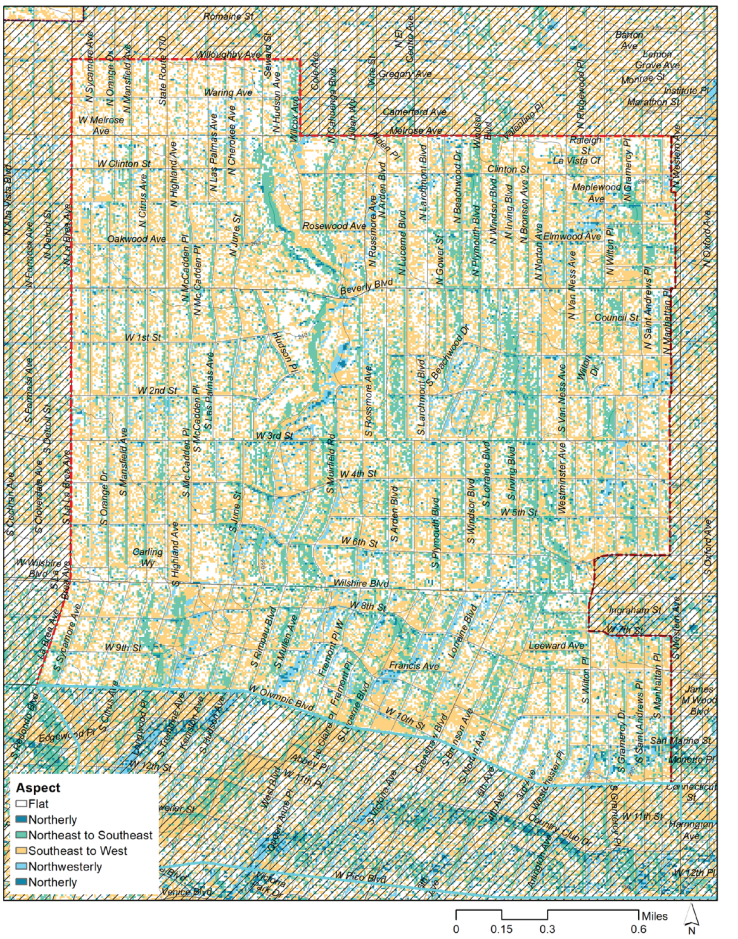


Figure 4-2: Habitat quality (bottom left- see Chapter 3 for more information) and aspect (right) maps included in the Ecotopes database. Changes to habitat quality as a result of the pilot project should be evident in coming years as iNaturalist observations of native indicator species and native plants increase and landscapes are enhanced. However, increased conversion of landscapes, or loss of tree canopy could result in a reduction of habitat quality across the neighborhood. Aspect is a key factor in site suitability for native landscape plants with implications for future presence of fauna.

CASE STUDY 2: WILDLIFE PILOT STUDY

The protection and enhancement of "natural plant and wildlife diversity, habitats, corridors and linkages" is a primary objective of the City of Los Angeles' (City) Conservation Element within the General Plan (see Appendix A). In April 2014, City Councilmember Paul Koretz introduced Motion CF-0518 to accommodate wildlife habitat and connectivity in development project approvals, which subsequently catalyzed the City Planning Department (Planning) to undertake the Wildlife Pilot Study (Study) in 2017. The Study aims to identify important areas within the City that are crucial for sustaining ecological health and biodiversity, and to create regulations and standards within these "Protected Areas for Wildlife" (PAWs) that will balance the needs of plants and animals with future development (draft PAWs are mapped in Figure 4-1).

The Study is focusing on a PAW in the eastern Santa Monica Mountains—between the 405 and 101 freeways—that is a mix of primarily low-density residential lots and large undeveloped open space. This area is being used as a pilot to create regulations and standards that will protect and enhance important natural resources, including:

- *Lakes, Streams, & Wetlands* — Lakes, streams and wetlands are a significant water source for wildlife and vegetation. They provide important watershed functions for our ecosystems.
- *Riparian Corridors* — Riparian corridors support plants and wildlife found nowhere else in the Santa Monica Mountains and are often the only source of water during the summer months for wildlife.
- *Open Space* — Parks and open spaces are important to wildlife as they serve as habitat patches and linkages for animals.
- *Ridgelines* — Ridgelines are an important feature in defining and preserving the natural settings of the Santa Monica Mountains and can serve as natural pathways for wildlife.
  Vegetation — Trees and other vegetation provide valuable habitat for breeding and feeding.

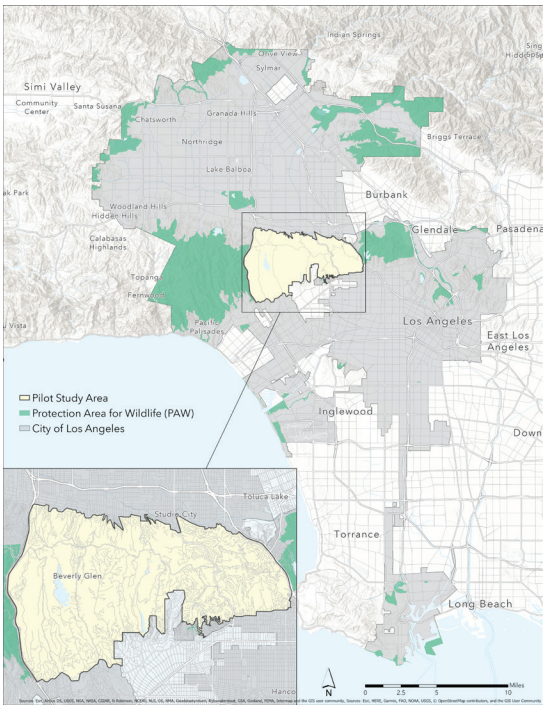
Regulations and standards being considered as part of the Study include:

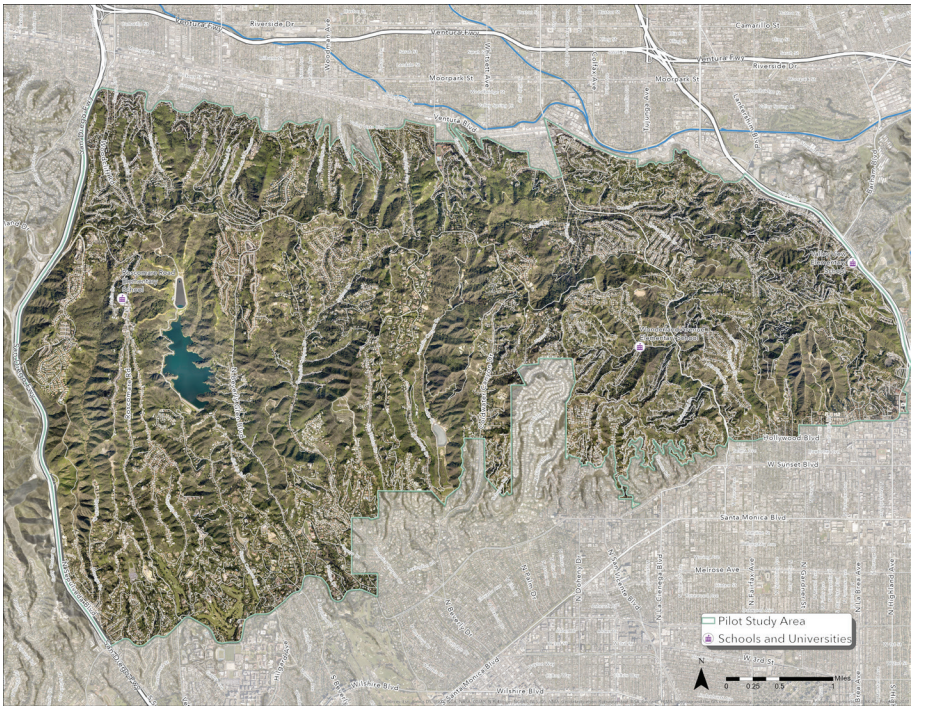
- *Buffers from Biological Resources* — Buffers and setbacks from natural resources ranging from waterways, wetlands, riparian, parks and open spaces, and ridgelines are important to providing needed space to encourage wildlife movement, healthier ecosystems, and biodiversity.
- *Fencing* — Fencing can prevent wildlife from accessing areas for foraging and breeding. However, wildlife-friendly fencing options can help wildlife move through their habitats with minimal harm and stress.
- *Landscaping* — Native and drought tolerant landscaping offer multiple benefits for biodiversity; they are water efficient, support local plant and animal habitat, and can prevent erosion and runoff.
- *Lighting* — Using the appropriate outdoor night lighting and less illumination can promote and maintain dark skies for the health and enjoyment of individuals and animals.
- *Trash Enclosures* — Wildlife can become entangled in litter or ingest plastic and paper. Encouraging secured trash enclosures will decrease human-wildlife conflicts and allow for peaceful coexistence.
- *Windows* — Non-reflective windows with screening or adhesives can reduce bird collisions and minimize disruptions in wildlife patterns and behavior.

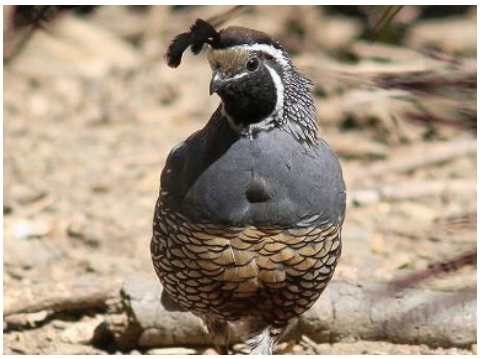
The conservation, enhancement, and connection of natural resources throughout the City will provide the foundation for maintaining biological diversity. The regulations and standards developed as part of the Wildlife Pilot Study may be expanded to other key habitat areas/PAWs within the City in the future. More information can be found at: https://planning.lacity.org/plans-policies/initiatives-policies/sustainability

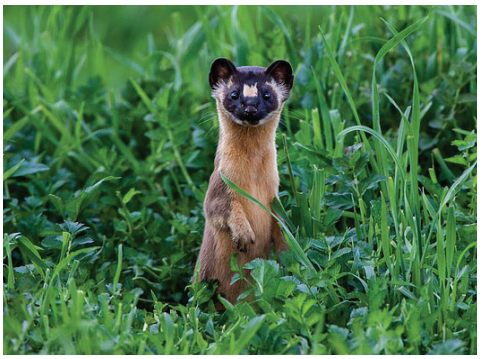
CREDIT/CONTRIBUTORS

- City of Los Angeles Department of City Planning (Lead Department)
- City of Los Angeles Council District 5
- Councilmember Paul Koretz
- ESA | Environmental Science Associates









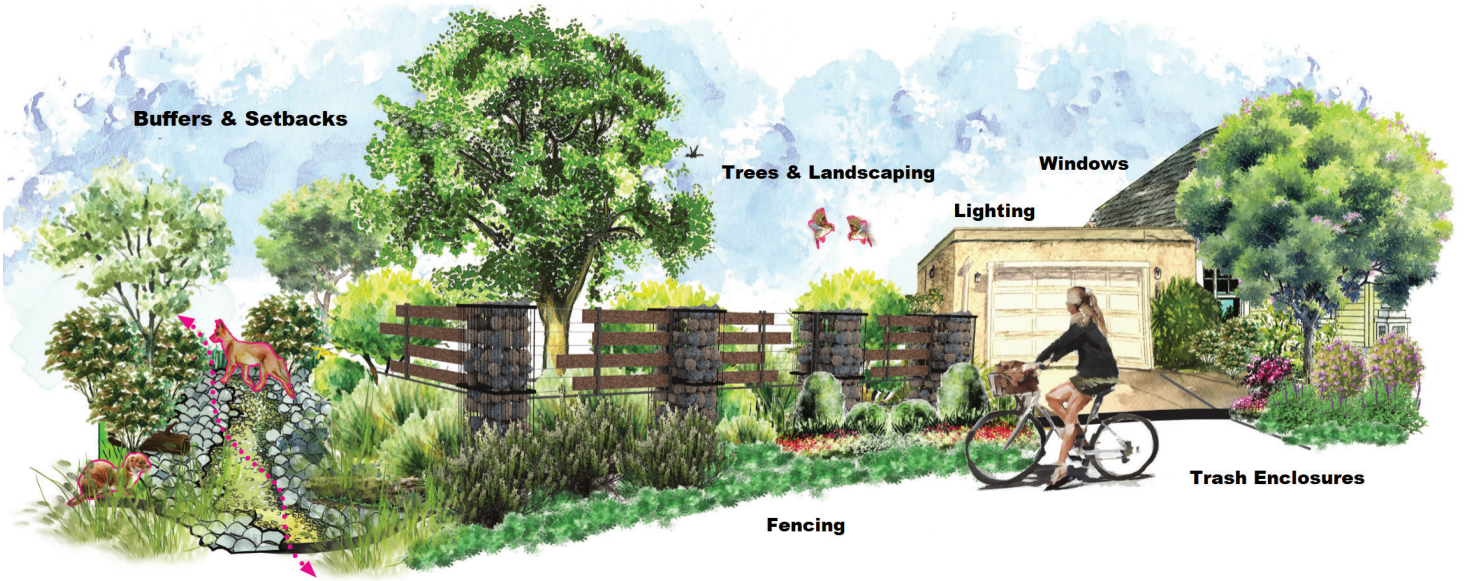


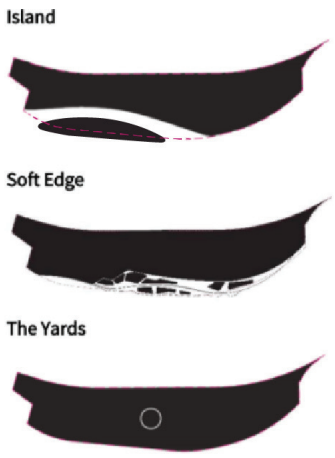
Figure 4-3: The wildlife corridor pilot area spans from the 101 freeway in the east to the 405 freeway in the west (top). California quail, © NHM Citizen Science Program, http://www.inaturalist.org/photos/5127119 (middle left); coastal whiptail, © Andrea Kreuzhage, https://www.inaturalist.org/photos/90610554; long-tailed weasel, source: John Mitchell via kpbs.org (middle right). Potential regulations and standards to protect wildlife movement and sensitive ecological features are being considered within the corridor (bottom).

CASE STUDY 3: BIODIVERSITY AT THE G2/TAYLOR YARD LOS ANGELES RIVER PARK DESIGN PROJECT

Transformation of the Taylor Yard G2 Parcel (the Project site) will help revitalize the LA River. The project will turn an abandoned former rail yard into a nature-focused open space to achieve long-standing regional priorities. The project will restore habitat value, reconnect the community to the River, protect and enhance water resources, manage flood risk, remediate the River, and provide much-needed open and recreational space in the City of Los Angeles. The transformation of this 42-acre, River-adjacent parcel will catalyze restoration of the larger River system.

The City intends to approach the Project in phases over a 10-year period as implementation and funding are approved. The Bureau of Engineering (BOE) has completed extensive preliminary technical analyses, instituted a robust community and stakeholder engagement process, and developed three site planning options for the Project.

The River mainstem is 51 miles long and was once the backbone of a vast system of riparian foothill, riverine, and freshwater marsh habitat that carried seasonal rains and subterranean flows to the coastal plain and the Pacific Ocean. Over time, increased urban development, flooding, and channelization have degraded the River ecosystem as segments have been encased in concrete banks and covered with a mostly concrete bed. As a result, plant and wildlife diversity and quality have diminished and the River has become disconnected from its floodplain and significant ecological zones. Restoration of the River is a long-standing regional priority central to larger restoration efforts such as the City's 2007 Los Angeles River Revitalization Master Plan and the 2015 United States Army Corps of Engineers' (USACE) Los Angeles River Ecosystem Restoration Integrated Feasibility Report (Ecosystem Plan).



Based on the goals and objectives of the Project, three site planning concepts were developed.

ISLAND: Creates an island to separate River flows and mimic split flow channels. Provides a significant amount of new riparian and upland habitat, per the Ecosystem Plan objectives.

SOFT EDGE: Creates a soft-edged River by cutting back the east bank and replacing it with a significant amount of new riparian and upland habitat, per the Ecosystem Plan objectives. The existing River channel would be modified to create a series of terraces.

THE YARDS: Maintains the Riverbank in its current configuration with the park developed and the existing power lines remaining in-place along the River, providing riparian and upland habitat per the Ecosystem Plan objectives within the site.

A detailed analysis of biodiversity was conducted for the G2 planning concepts utilizing a customized Site Biodiversity Index (SBI), designed specifically for this Project. The SBI for the Project uses a five-point scoring system for four different metrics measured for each 100 square-foot pixel across the Project site. This approach effectively integrates habitat considerations into the design process by identifying physical locations and features for improvement. The four metrics that were used to measure the site planning concepts are 1) habitat quality, 2) habitat variety, 3) edge effects, and 4) off-site connectivity. Across all metrics, the Island site planning option out-performs the other two concepts, as conceptually planned. The other two options could, with further detailed planning, improve.

Additional near-term priorities of the project include expanding biodiversity and ecological planning to include the adjacent State-owned G1 parcel and Rio de Los Angeles State Park as a 100-acre integrated Project.

For more information, visit https://tayloryardriverprojects.lacity.org/.

CREDIT/CONTRIBUTORS

- City of Los Angeles Bureau of Engineering (Lead Department)
- WSP
- Studio-MLA
- Isaac Brown Ecology Studio
- ECORP Consulting, Inc.

Preliminary SBI Metrics

Metric	Weight	Purpose
Habitat Quality	4	Assesses the ability of landscapes to provide habitat
Habitat Variety	3	Suitability of habitat for target species or ecosystem
Edge Effects	2	Influence of noise, light, human activity, etc.
Offsite Connectivity	1	Locations for species movement between adjacent parcels

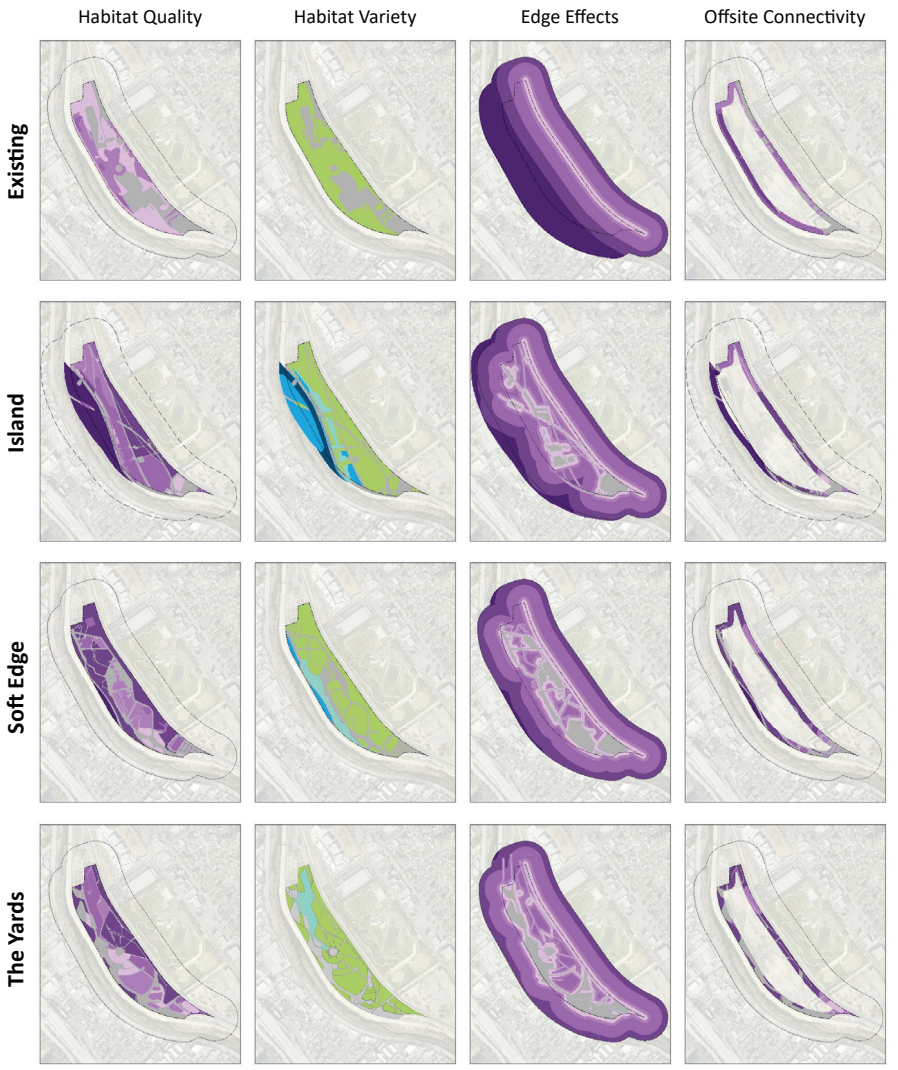


Figure 4-4: The Island alternative is estimated to provide the highest biodiversity benefits based on preliminary measurements (top left). Select target species for site habitats: blue grosbeak, source: San Fernando Valley Audubon Society (top right top); Pacific chorus frog, source: LA County Trails (top right middle); arroyo chub, source: NANFA Website (top right bottom). Site Biodiversity Index metrics and score maps for the three alternatives compared to the existing condition are also shown (bottom).

CASE STUDY 4: MACARTHUR PARK LAKE WATER QUALITY ENHANCEMENT BIODIVERSITY APPROACH

MacArthur Park is a 30-acre public recreation facility in Los Angeles that is owned by the Department of Recreation and Parks (RAP). MacArthur Park is in one of the most densely populated neighborhoods in Los Angeles. As a regional destination, the park provides valuable open space and its landscapes and recreational spaces are heavily used year-round.

As seen in the figure showing the aerial view of MacArthur Park, Wilshire Boulevard bisects the park, dividing it into a northern and southern portion. The southern portion includes MacArthur Park Lake, which covers an area of approximately 7.8 acres. Although the Lake is not currently listed as a 303(d) impaired waterbody, its water quality at times is degraded due to trash, bacteria, algae, and bird waste. Thermal pollution also impacts oxygen levels and, subsequently, aquatic life.

Despite the dense development in the vicinity of MacArthur Park, the central position in the watershed makes it important to local biodiversity. Given its size, vegetation, open water, and avian usage, MacArthur Park has the potential to serve an important biodiversity role. Enhancing the habitat and water quality in the park is expected to increase habitat connectivity and benefit local wildlife.

LASAN's MacArthur Park Charette invited professionals and academic teams from college and accredited landscape architecture programs to participate in a three-part Charette in late 2018/early 2019. Landscape architecture students, professors, and team advisors from the following academic institutions participated in this significant design and engineering milestone for the City:

- California State Polytechnic University, Pomona (Cal Poly Pomona),
- Los Angeles Trade-Tech College (LATTC),
- Univ. of California Extension Professional Landscape Architecture Certification Program, Los Angeles (UCLA/UNEX), and
- University of Southern California (USC).

Incorporating historic resources circumvented by development, along with park ecosystem enhancements to propose a feasible, yet broader foundation for community input was a key focus of the Charette.

The Charette served the following purposes:

1. To enhance viable and funded scope opportunities and so provide the community with a broader selection of input when commenting on the Measure W funding outreach, and the pending MacArthur Park Master Plan,
2. To bring diverse skills, insights, and abilities to enhance the process of restoring and re-imagining storm water within the MacArthur Park Master Plan,
3. To hone professional, private, and public technical skills in otherwise routine sustainability, and water capture/reuse programs, and
4. To provide professional mentorship and career networks for young professionals.

Over three days, attendees discussed opportunities and constraints related to drainage, topography, vegetation, water quality, habitat connectivity, and landscape features that could improve the existing conditions. Breakout sessions allowed subject matter experts to debate and develop refined concept proposals. On the final day, the four groups presented their work products, all of which focused on enhancing:

- habitat (using native plants and shrubs),
- connectivity, and
- water quality.

Other biodiversity elements, such as land bridges, bird poles, floating wetlands, and developing hydraulic connections to nearby Ballona Creek were proposed. Many of these solutions can be seen on the annotated map that includes key concepts from the Charette proposals. Each team demonstrated invaluable strengths-- the USC team's geospatial analyses and mapping of biodiversity and hydrology effectively displayed the relationships of MacArthur Park to supporting wildlife in one of the densest areas of Los Angeles.

Work products from the event will serve as important City resources as this process proceeds. Additional information about the event, including the final work products, is available online at: https://socal-asla.org/macarthur-park-a-3-day-charette/.

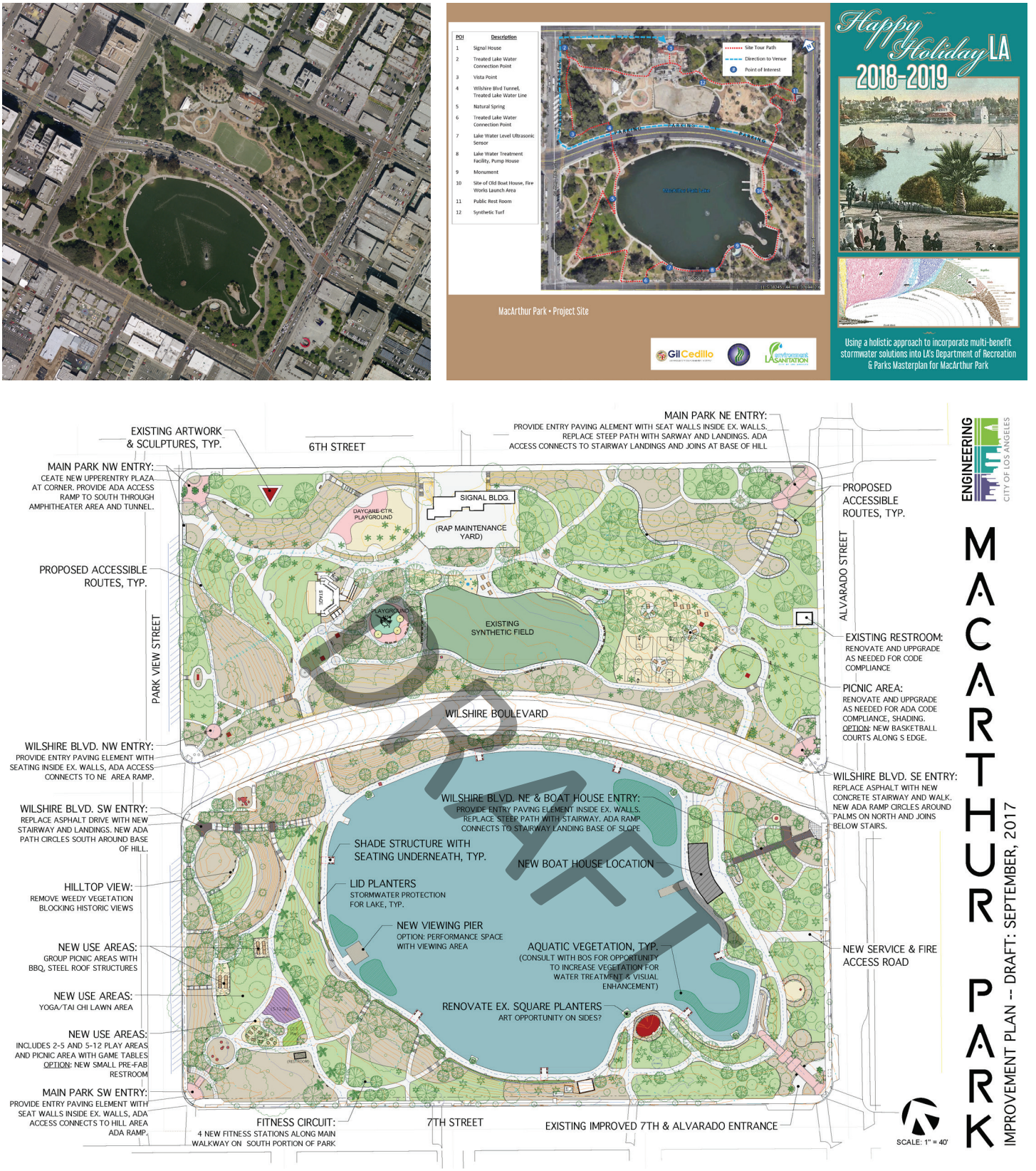


Figure 4-5: MacArthur Park improvement plan incorporating charrette ideas (bottom)

CREDIT/CONTRIBUTORS

- LA Sanitation and Environment
- LA Recreation and Parks
- Charette attendees

CASE STUDY 5: LOS ANGELES RIVER FISH PASSAGE AND HABITAT STRUCTURES DESIGN PROJECT

The Southern California Distinct Population Segment (DPS) of steelhead trout (*Oncorhynchus mykiss*) are federally endangered anadromous fish. The federal listing includes Los Angeles County and refers to the area bounded by the Santa Maria River to the north and the San Mateo Creek to the South. Southern California Steelhead face many threats including habitat impediments, such as dams, habitat degradation, habitat loss, and climate change.

The successful re-establishment of Southern California steelhead in Los Angeles would help demonstrate the City's contribution toward sustaining globally significant biodiversity. It would also support the National Marine Fisheries Service Southern California Steelhead Recovery Plan, which includes the Los Angeles River as potential restoration watershed. Southern California steelhead populations are seen as possessing genetic adaptations to high water temperatures that may be important to increase resilience of the species to the effects of a warming climate. Anadromous fish, like the Southern California steelhead, serve as indicators of aquatic habitat connectivity and quality at the watershed scale.

The National Marine Fisheries Services indicates in its Southern California Steelhead Recovery Plan that the overall goal is to prevent the extinction of Southern California steelhead in the wild and ensure the long-term persistence of viable, self-sustaining, wild populations of steelhead distributed across the Southern California DPS. It is also the goal of the Recovery Plan to re-establish a sustainable Southern California steelhead sport fishery.

"We are creating inspiring urban revitalization and biodiversity projects that set the stage for greater wildlife connectivity, scientific research, education, and stewardship in the recovery of our threatened and endangered species and their habitats, such as the first steelhead fish passage pilot project for the Los Angeles River."

(Wendy Katagi, CEP Stillwater Sciences)

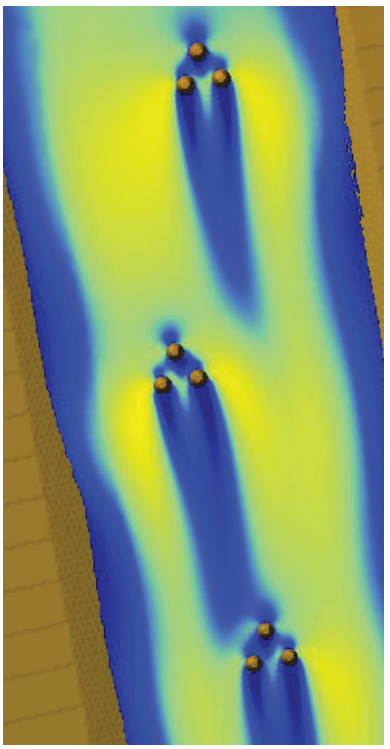
Recovery of the DPS will require the protection, restoration, and maintenance of habitats of sufficient quantity, quality, and natural complexity throughout the Southern California Steelhead Recovery Planning Area so that all life history forms of *O. mykiss* (e.g., switching between resident and anadromous forms, timing and frequency of anadromous runs, and dispersal rates between watersheds) are able to successfully use a wide variety of habitats in order to overcome the natural challenges of the highly variable physical and biological environment.

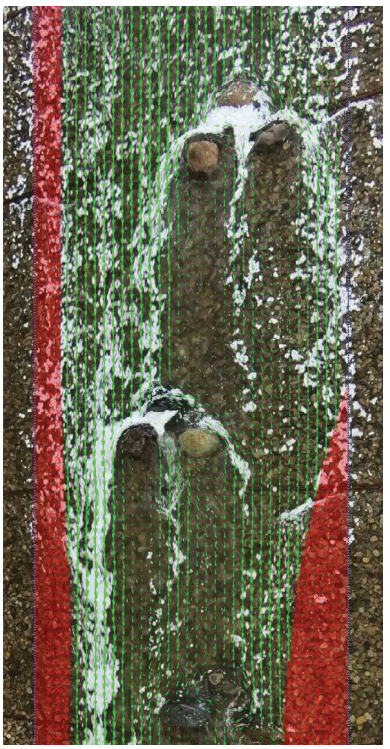
To support all of these efforts, NMFS, City of LA, and its partners will need to provide technical expertise and public outreach and education regarding the role and value of the species within the larger watershed environment and the compatibility of sustainable development with steelhead recovery.

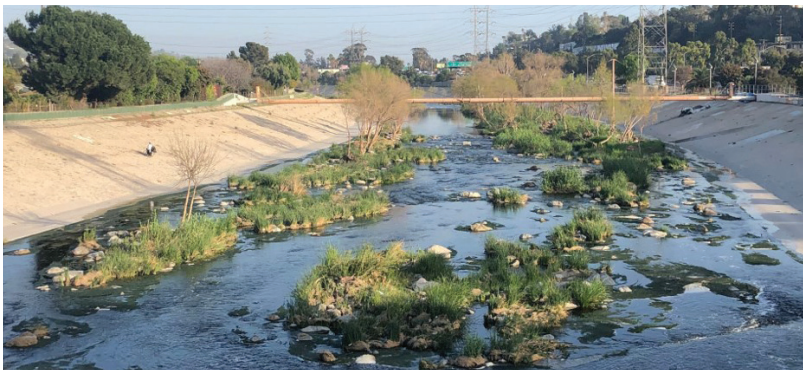
The Los Angeles River Fish Passage and Habitat Structures (LAR FPHS) Design project will involve preparation of designs to modify the existing LA River flood control concrete-lined channel to improve fish passage for steelhead migration to soft-bottom reaches of the LA River and upper tributaries, addressing native fish habitat needs at all life stages. The project also includes a steelhead conceptual model for the LA River watershed. The LAR FPHS Design project reach extends from the Glendale Narrows soft-bottom reach to Washington Boulevard, a total of 4.8 miles of the concrete-lined LA River through Downtown LA. The LA River in the project reach is a trapezoidal concrete channel approximately 30 feet deep with a bottom width of 160 feet and a top of bank width of about 280 feet. There is a low-flow notch along the channel center that is approximately 0.5- to 1-foot deep and has a top width of 20 feet. The channel was designed for a capacity of 80,000 to 100,000 cubic feet per second (cfs), yet the flow is less than 300 cfs about 90-percent of the year. Hydraulic modeling has demonstrated that current depth and velocity conditions are fish passage barriers at nearly all flows. Even at low flows, velocities are above the suitable range for native fish.

The proposed design process for the 4.8-mile project reach will evaluate the concrete-lined channel and focus on the low-flow notch and channel invert as well as connections to related restoration opportunities such as Piggyback Yard, the confluence of the Arroyo Seco and LA River, and the upstream soft-bottom LA River system. The proposed construction involves cutting and modifying the low-flow notch and channel invert to enhance habitat and migration corridors for native fish while maintaining flood control capacity.

The LAR FPHS Design project, a high-priority project for the City of Los Angeles Mayor's Office, is connected to the U.S. Army Corps of Engineers, Los Angeles District (USACE) 2016 adopted LA River Ecosystem Restoration ("Area with Restoration Benefits and Opportunities for Revitalization," or ARBOR reach) to restore LA River habitat in and along an 11-mile segment of the River from approximately Griffith Park to Downtown Los Angeles, while maintaining existing levels of flood risk management (C.F. 14-1158-S2). The LAR FPHS project also links to other biodiversity projects within the City of Los Angeles, the LA River watershed, and its upper tributaries (Arroyo Seco and Tujunga watersheds). The LAR FPHS project is consistent with the Los Angeles River Revitalization Master Plan (LARRMP) adopted by the City in May 2007. While focused







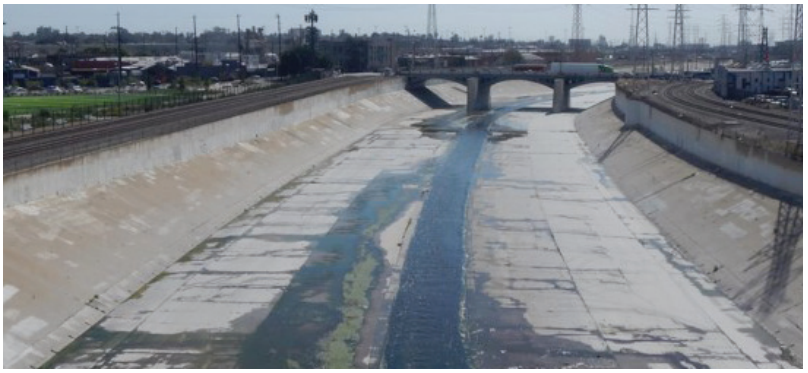


Figure 4-6: Potential future flows following modifications of the channel bed are being modeled to estimate suitability for fish passage (upper right). Soft bottom sections within the Elysian Valley are suitable for fish passage, but are separated from the ocean by concrete bottom sections with flows that are too strong over long distances to allow migration of steelhead (bottom right).

on providing fish passage and habitat structures to address limiting factors to steelhead trout and other native fish, the LAR FPHS project also addresses watershed-wide data gaps and opportunities to promote future projects and address other limiting factors to steelhead recovery from coast to crest.

CREDIT/CONTRIBUTORS

- City of Los Angeles
- Stillwater Sciences
- Bureau of Reclamation
- Wildlife Conservation Board
- Council for Watershed Health
- National Marine Fisheries Service
- California Department of Fish and Wildlife

CASE STUDY 6: HYPOTHESIZED POTENTIAL NATURAL VEGETATION OF THE LOS ANGELES RIVER WATERSHED

The concept of potential natural vegetation (PNV) was developed in the early twentieth century to envision what species a landscape would support in the absence of human disturbance. It is described as "the vegetation that would develop in a particular ecological zone or environment, assuming the conditions of flora and fauna to be natural, if the action of man on the vegetation mantle stopped and in the absence of substantial alteration in present climatic conditions" (Tüxen 1956, translated in Gallizia Vuerich et al. 2001). For landscapes such as the Los Angeles Basin, understanding potential natural vegetation provides a reference point to understand the distribution and effects of the long period of human occupation, and guideposts to understand the processes that shape the landscape and could be incorporated into future ecological restoration and management. As part of an investigation into the historical ecology of the Los Angeles Basin, the research team developed a 1-km resolution map of the potential natural vegetation to describe the broad patterns and processes shaping the landscape and its ecological function. Because the USC and UCLA research team expects this map to be refined, it is included as a "working draft," a hypothesis to be tested and amended as research in the region advanced.

The team used a 1-km grid that is one of the hierarchical levels of the Military Grid Reference System as the unit of analysis. The team compiled an extensive set of historical data in the form of maps, texts, and geolocated records of natural history observations. These data included, for example:

- Topographical Map of the Los Angeles River (1897);
- Detail Irrigation Map, Los Angeles Sheet (1888);
- Soil Map, California, Los Angeles Sheet (1903, 1916, and 1917);
- USGS topographic surveys (1897, and a composite of 1:24000 maps from the 1920s);
- Georeferenced localities of oak and walnut tree species recorded through 1930 from the Jepson Online Interchange for California Floristics;
- Sketch maps digitized and georeferenced from the late 1800s and early 1900s;
- Orthogonal aerial photographs from the 1920s compiled by the UC Santa Barbara library; and
- Georeferenced texts describing natural landscape features extracted from diaries written during Spanish expeditions in the 1700s.

In addition, the study team consulted high-resolution maps of contemporary annual precipitation, slope, elevation, and aspect, as available through ESRI's Living Atlas.

With all these layers available and easily toggled on and off in a geographic information system (ArcGIS Pro), each cell in the grid was assigned to a vegetation macrogroup. Macrogroups were used to remain compliant with national vegetation mapping standards and because finer-scale inferences about potential vegetation across the region would be difficult without extensive environmental niche modeling. Macrogroup classification considers regional topographic differences and provides an ideal starting point to understand landscape processes in shaping vegetation patterns.

VEGETATION MACROGROUPS OF THE LOS ANGELES RIVER WATERSHED AND ENVIRONS

- California Chaparral
- California Grasslands and Flowerfields
- Coastal Dune and Bluff Scrub
- Coastal Sage Scrub
- Desert Wash Woodland and Scrub
- Foothill and Valley Forests and Woodlands *(including Oak and Walnut woodlands)*
- Mixed Evergreen and Foothill Forest
- Montane Riparian Forest and Woodland
- Riparian Forest
- Riverwash
- Freshwater Marsh
- Lakes
- Salt Marsh
- Salt Marsh Meadows *(including Alkali Meadow not tidally influenced)*
- Vernal Pools
- Wet Meadow

A 50% rule was used to assign each 1 km grid cell to a macrogroup, except for isolated water features in an upland matrix, which was assigned the water feature at 40% to illustrate distribution of such features. For areas of the study area for which historical ecology studies had already been completed (Mattoni and Longcore 1997, Stein et al. 2007, Dark et al. 2011, Longcore 2016) or where current vegetation is relatively undisturbed, those studies were used and converted to macrogroups using the 50% rule.

The resulting map of potential natural vegetation illustrates the geomorphological features and landscape function of the region. South facing slopes of the Santa Monica Mountains and Verdugo Hills were chaparral, while the north facing slopes

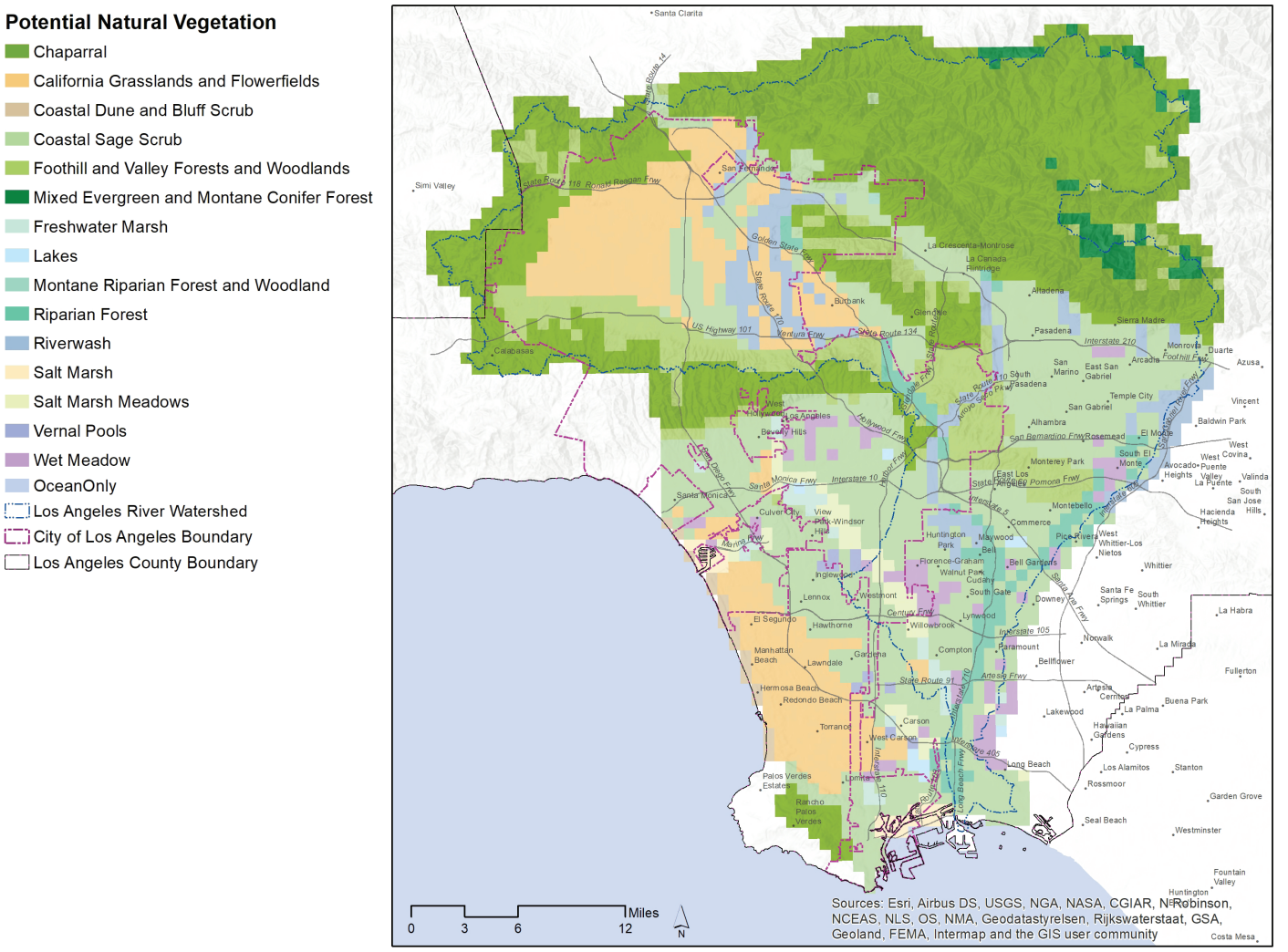


Figure 4-7: Potential natural vegetation of the Los Angeles River watershed

supported walnut and oak forests. The Los Angeles River and larger tributaries were defined by distinct segments that included riverwash across the San Fernando Plain, riparian forest through the Elysian Valley, riverwash through and southward from downtown, the riparian forest in the lower alluvial plain. The elevated hills of the Newport-Inglewood fault ponded water at their inland base, creating a series of wet meadows and alkali meadows extending southeast to northwest until terminating at the extensive marsh inland of the Baldwin Hills. California grassland and flowerfields likely dominated the San Fernando Plain, as they did the sandy soils of the Los Angeles Coastal Prairie covering the former dune system from the Westchester Bluffs southward to the Palos Verdes Peninsula. The hills of Boyle Heights, Mount Washington, and southeast toward the Puente Hills were likely a large oak and walnut woodland, mentioned in Spanish diaries and the basis of the indigenous economy for thousands of years. Finally, coastal scrub habitats were found throughout many of the lower slopes and plains. This map is a hypothesis, based on the information currently available and the study team's interpretation of it. The researchers propose that the map be amended as more detailed information becomes available and quantitative approaches, such as those used for the potential natural vegetation of Catalina Island (Longcore et al. 2018), be applied to a reconstructed historical topography of the region. Potential natural vegetation is itself a "provisionally useful fiction" (Jackson 2013), in that it represents conditions that will not be replicated. It is, however, useful in highlighting the types of habitats most lost to urban development and to help interpret the units (ecotopes) of the modern landscape.

CREDIT

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- Philip J. Ethington
- Beau MacDonald
- Gary Stein
- Travis Longcore
- UCLA Institute of the Environment
- USC Spatial Sciences Institute

Citation: Ethington, MacDonald, Stein, Deverell, and Longcore (2020). USC Spatial Sciences Institute/UCLA Institute of the Environment: Historical Ecology of the Los Angeles River Watershed Project

CASE STUDIES DISCUSSION

This chapter presented a number of case studies that demonstrate how the concept of biodiversity is changing the way we manage and steward nature in City projects. These case studies are meant to both showcase existing/ongoing biodiversity work in the City of Los Angeles as well as inspire new projects. These also projects provide early examples of projects that address the metrics in LA City Biodiversity Index. Table 4.1 identifies the LA City Biodiversity Index metrics that are being explored, addressed, or can by impacted by individual case studies. Generally, projects are shaping biodiversity in Los Angeles, and therefore performance of the LA City Biodiversity Index, in the following ways:

CASE STUDY 1: Successful Community Wildlife Habitat Certification of the Greater Wilshire Neighborhood Council area will strongly influence social benefits of biodiversity in this highly urbanized neighborhood, as well as improve habitat for common native biodiversity species in the City.

CASE STUDY 2: Implementation of the Wildlife Pilot Study will improve native biodiversity conservation in an area that connects Griffith Park and the Western Santa Monica Mountains. These two major ecologically sensitive areas, and numerous smaller habitat patches between them, are home to many species of conservation concern that rely on habitat connectivity for long-term resilience in a rapidly developing area of the City. Successful implementation of the policy will strongly influence performance of most native species habitat conservation and connectivity metrics across a large, high-value area.

CASE STUDY 3: The G2/Taylor Yard park design project along the LA River by the Bureau of Engineering will provide major habitat restoration benefits and public access to biodiversity in a highly programmed park setting, with many programs focused on biodiversity-oriented recreation, education, and research.

CASE STUDY 4: The LASAN water quality project at MacArthur Park would benefit common native biodiversity and access to nature in a highly urbanized neighborhood. Restoration of natural functions of this historic wetland may also enhance habitat for species of conservation concern and historically significant ecosystems and habitats.

CASE STUDY 5: The native fish passage project within the LA River has the potential to provide habitat for recovery of an endangered species, the Southern California Steelhead, within the Los Angeles River Watershed. Success will improve most native biodiversity conservation indicators across a large area. It will also improve access to nature in this highly urbanized area.

CASE STUDY 6: This USC and UCLA research is being highlighted because of its significance to the ecotope concept and has a role in guiding which biodiversity to conserve and enhance in Los Angeles. This work can also be used to inform a biodiversity action plan, policy, or local, site-specific landscaping, ultimately shaping performance of the Index's governance and management indicators, along with native biodiversity conservation.

Table 4-1: LA City Index expected influence on scores by Case Studies

Theme	Metric CODE	Metrics	Case Study 1: Greater Wilshire Neighborhood Biodiversity	Case Study 2: Wildlife Pilot Project	Case Study 3: Taylor Yard/G2 Biodiversity	Case Study 4: MacArthur Park Water Quality Enhancement	Case Study 5: LA River Fish Passage Project	Case Study 6: Historical Vegetation Mapping
1. Native Species Protection & Enhancement	1.1a	1.1a: % Natural Areas		X	X	X	X	
	1.1b	Habitat Quality of Urban Landscapes & Open Space	X	X	X	X	X	X
	1.1c	Habitat Quality of Streams		X	X		X	X
	1.1d	Connectivity of Natural Areas		X	X		X	X
	1.1e	Connectivity of Urban Landscapes & Open Space	X	X	X	X	X	X
	1.1f	Connectivity of Streams and Riparian Areas		X	X		X	X
	1.2a	% Open Space with Charismatic Umbrella Species		X	X		X	
	1.2b	Native Species Presence in Urban Areas	X	X	X	X	X	
	1.2c	Species of Conservation Conern Gained or Lost		X	X	X	X	X
	1.3a	Urban Edge Effects on Natural Areas		X	X		X	
	1.3b	Presence & Spread of Invasive Plants						
	1.3c	Wildfire Frequency Departure from Natural						X
2. Social Equity Considerations & Biodiversity	2.1a	Access to Natural Areas		X	X	X	X	
	2.1b	Neighborhood Landscape/Tree Canopy Footprint	X	X	X	X		
	2.2a	School (K-12) Biodiversity Topics						
	2.2b	Off-Campus Biodiversity Educational Visits			X		X	
	2.2c	Campus Nature Education Gardens/Areas	X		X	X	X	
	2.3a	Community Scientist Activities and App Utilization	X					
	2.3b	# Certified Biodiversity-Friendly Areas	X					X
3. Governance & Management of Biodiversity	3.1a	Biodiversity Vision/Action Plan						X
	3.1b	% Departments with Biodiversity Programs & Policies		X				
	3.2a	% Protected Natural Areas		X				
	3.2b	Protected Natural Areas Management and Monitoring		X				X
	3.2c	Management of Invasive Species & Pests						
	3.2d	Management of Threatened, Endangered, & Species of Concern		X				X

CONCLUSION

We hope that this report, and the information it contains on the LA City Biodiversity Index, ecotopes framework, and connectivity, inspires action to protect and enhance biodiversity across all sectors of the City. We hope that other City departments, neighborhood councils, environmental firms and scholars will continue to actively pursue projects that highlight and protect the incredible biodiversity of Los Angeles. Achieving the no-net loss goal will only be possible with the help and dedication of community scientists, educators, policy makers, researchers, and inspired residents.

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