2018 BIODIVERSITY REPORT

City of Los Angeles

Measurement of the Singapore Index of Cities' Biodiversity and Recommendations for a Customized Los Angeles Index

Prepared by:

Isaac Brown Ecology Studio and
LA Sanitation & Environment

LA Sanitation environment
CITY OF LOS ANGELES

LA Sanitation and Environment

environment
LA SANITATION
CITY OF LOS ANGELES

1149 South Broadway, 9th Floor
Los Angeles CA 90015

Enrique C. Zaldivar, Director and General Manager
Traci J. Minamide, Chief Operating Officer
Lisa B. Mowery, Chief Financial Officer
Mas Dojiri, Assistant General Manager
Adel H. Hagekhalil, Assistant General Manager
Alexander E. Helou, Assistant General Manager

Board of Public Works Commission

200 North Spring Street, 3rd Floor
Los Angeles, CA 90012

Kevin James, President
Heather M. Repenning, Vice President
Michael R. Davis, President Pro Tempore
Aura Garcia, Commissioner
Joel Jacinto, Commissioner

Mayor

Eric Garcetti

City Council

Council District 1	Gilbert Cedillo
Council District 2	Paul Krekorian
Council District 3	Bob Blumenfield
Council District 4	David E. Ryu
Council District 5	Paul Koretz
Council District 6	Nury Martinez
Council District 7	Monica Rodriguez
Council District 8	Marqueece Harris-Dawson
Council District 9	Curren D. Price, Jr.
Council District 10	Herb J. Wesson, Jr.
Council District 11	Mike Bonin
Council District 12	Mitchell Englander
Council District 13	Mitch O’Farrell
Council District 14	Jose Huizar
Council District 15	Joe Buscaino

Preface

The City of Los Angeles lies within the California Floristic Province, which is globally recognized as a hotspot of native biodiversity across many groups of organisms. What this designation also means is that the biodiversity is threatened, and innovative strategies are needed to ensure its resilience. The survival and well-being of the City's residents also depend on ecosystem services provided by biodiversity, including air pollution reduction, strongly and rapidly mitigating and adapting to climate change, mental health and educational opportunities, water cleansing, and aesthetic benefits. These services are built directly from an integrated ecosystem of natural biodiversity and sustainable urban landscapes.

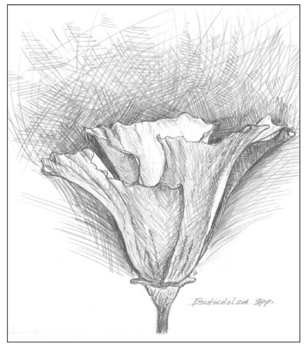
In line with the Mayor's goal of a "no net loss" biodiversity strategy identified in the City's 2015 Sustainability pLAn, Councilmember Paul Koretz of the 5th Council District introduced the Los Angeles Biodiversity Motion. On May 10, 2017, the Los Angeles City Council adopted the amended motion (Motion 25A, Council File No. 15-0499) unanimously, and directed the Bureau of Sanitation (LASAN) to oversee efforts to evaluate biodiversity in the City and develop an index to measure no net loss going forward. The original Motion was the culmination of more than a year of groundwork with a public Biodiversity Stakeholder group led by Andy Shrader of the 5th Council District and Dr. Travis Longcore (USC). On recommendation of Dr. Longcore, and with the support of the Stakeholder Group, LASAN chose to measure the Singapore Index on Cities' Biodiversity as the first step in implementing the Motion. Los Angeles is the first City in the U.S. to perform this measurement, joining Helsinki, Montreal, Lisbon, and other global cities. LASAN enthusiastically embarked on this journey and brought together interested individuals to form an Expert Council and an Interdepartmental Biodiversity Team. The collective knowledge and data resources from these esteemed individuals were tapped to measure the Singapore Index and provide the recommendations presented throughout this document.

The exceptional level of passion among stakeholders, the esteemed Expert Council, and Interdepartmental Biodiversity Team became apparent early in the outreach process. The breadth and complexity of the topic, and long struggle of many stakeholders to advance biodiversity in the City, was also clear. What those early meetings and work since continue to reveal is that biodiversity in Los Angeles is globally significant, is a source of great pride for Angelenos fortunate enough to have access to and awareness of it, and is central to the sustainability and resilience of the City. Virtually every City Department has a role in protecting, enhancing, and benefiting from biodiversity, and LASAN is thrilled to continue advancing this important topic for the benefit of the public and the nature we jointly steward.

LASAN Biodiversity Team
Mas Dojiri
Doug Walters
Melinda Bartlett
Isaac Brown
Peggy Nguyen
Deborah Deets
Michelle Barton
Hubertus Cox

Andy Shrader, 5th Council District

Mayor's Sustainability Office
Liz Crosson
Kathryn Mika



Acknowledgments

This report was prepared by Isaac Brown Ecology Studio and the Los Angeles Bureau of Sanitation (LASAN) Biodiversity Team. LASAN team members Peggy Nguyen and Michelle Barton led the documentation process under the direction of Dr. Mas Dojiri, Assistant General Manager of LASAN. LASAN team members Doug Walters (LASAN Chief Sustainability Officer), Melinda Bartlett, Deborah Deets, and Hubertus Cox were integral in shaping this document and process. Additional document contributors include: Oscar Figueroa (City of LA), Elizabeth Reid-Wainscoat (Mayor's Office), Dr. Ryan Harrigan (UCLA), Dr. Brad Schaffer (UCLA), Dr. Jing Liu, Natalie Farnham, and class (Santa Monica College), Wendy Katagi (Stillwater Sciences), Karin Wisenbaker (Aquatic Bioassay & Consulting Laboratories), Dan Cooper (UCLA/Cooper Ecological), and Dr. Travis Longcore (USC).

We would also like to thank iNaturalist, and its network of users, who generously made their data and imagery available for public use.

Expert Council Members

The following Expert Council members provided guidance on this effort: Arlene Hopkins (Arlene Hopkins & Associates), Bill Neill (California Native Plant Society), Brad Rumble (LAUSD), Dr. Brad Shaffer (UCLA), Dr. Bruce Orr (Stillwater Sciences), Dr. Casandra Rauser (UCLA), Daniel Cooper (UCLA/Cooper Ecological), Dr. Eric Strauss (LMU), Dr. Eric Wood (CSULA), Ileene Anderson (Center for Biological Diversity), Jessica Arriens (UCLA), Dr. John Fleming (Center for Biological Diversity), Johnathan Perisho (Watershed Conservation Authority), Kai Craig (California EcoDesign), Kat Superfisky (Mia Lehrer Associates/Grown in LA), Dr. Katherine Pease (Heal the Bay), Dr. Katy Delaney (National Park Service), Leon Boroditsky (City of LA), Lila Higgins (LA County Natural History Museum), Paolo Perrone (Trust for Public Lands), Dr. Ryan Harrigan (UCLA), Dr. Seth Riley (National Park Service), Dr. Sophie Parker (The Nature Conservancy), Dr. Travis Longcore (USC), Wendy Katagi (Stillwater Sciences), Dr. Yareli Sanchez (Council for Watershed Health), Dr. Karen Martin (Pepperdine University).

City of Los Angeles Interdepartmental Biodiversity Team

The following City staff also provided guidance on this effort: Liz Crosson (Mayor's Sustainability Office), Andy Shrader (CD5), Aaron Gross (LADWP), Oscar Figueroa (City of LA), Chris Pina (Planning), Claire Bowin (Planning), Diana Kitching (Planning), Michelle Levy (Planning), Beth Schaefer (LA Zoo and Botanical Gardens), Catherine Cox (LA Zoo and Botanical Gardens), Darryl Pon (LA Zoo and Botanical Gardens), Jane Adrian (BOE), Emily Moos (CD5), Julia Epstein (CD5), Lauren Faber (Mayor's Sustainability Office), Richard Fisher (BOE), Sabrina Bornstein (Mayor's Office), Scott Cher (Mayor's Office), Shana Bonstin (Planning), Tami McCrossen-Orr (LAWA), Carolyn Lin (LAWA), Charles Holloway (LADWP), Chris Cannon (POLA), Christopher Adams (BOE), Daniel Hackney (LASAN), Debbie House (LADWP), Greg Spotts (BOSS), Kathie Hirata (LADWP), Marissa Aho (Mayor's Office), Mahmood Karimzadeh (BOE), Matthew Rudnick (RAP), Nancy Sutley (LADWP), Paul Davis (RAP), Rachel McPherson (POLA), Rafael Prieto (CLA), Timothy Tyson (Bureau of Street Services Urban Forestry Division), Tom Gibson (RAP), William Jones (BOE).

Table of Contents

01 Executive Summary

photo: Isaac Brown

01 Executive Summary

Biodiversity in Los Angeles is truly unique. On one hand, LA includes the highest population density of all major U.S. cities according to the 2010 U.S. Census, and is known to be one of the most "park poor" cities in the country[1, 2]. On the other hand, LA falls within a "Global Biodiversity Hotspot" and the City includes an exemplary range of biodiversity and large natural areas. This study documents approximately 1,200 different native species recorded within the City, and perhaps more than double that are present, but unrecorded. This richness is driven by diverse ecosystems and microclimates spanning 5,000 feet in elevation from the coast to mountains, and over 61,000 acres of natural areas comprising more than 20% of the City footprint. The territory is home to mountain lions, the occasional steelhead trout, uniquely diverse herbaceous and shrub plant communities, picturesque oak savannas, and over 150 threatened and endangered species and ecosystems.

In urban areas, biodiversity can be thought of as the variety of flora, fauna, and ecosystems that help maintain the balance of nature and sustain cities. Urban natural areas provide habitat connectivity and support conservation of numerous sensitive species. Urban biodiversity includes both native and non-native species, including LA's urban forest, which provide many ecosystem services that enhance the City's resilience to climate change. Native and non-native urban landscapes contribute to improved mental and physical health, and can be the primary means by which urban dwellers connect with nature. Even in the densest areas of the City, this initial analysis reveals unusually high levels of native biodiversity and opportunities for enhancing the urban ecosystem.

This report provides a summary of LA's biodiversity based on a set of indicators that make up the "Singapore Index of Cities' Biodiversity" (Singapore Index or SI). The Singapore Index is being applied in at least 40 cities worldwide and this is the first measurement that we know of in the U.S.; Los Angeles received a preliminary score of 48 out of 72 possible points (see Table 1). This score is "preliminary" because five of the indicators (indicators 4-8) measure change in the number of recorded species over time. Therefore, the score for these indicators is determined during a second measurement of the SI using the preliminary measurement as the baseline. The indicator measurement process for LA has helped put our high biodiversity relative to other cities into context. LA receives the highest scores possible for a number of indicators including the percentage of natural areas, number of native bird species in the City, and protection of sensitive species and ecosystems. However, other indicators reveal opportunities for improvement, such as our relatively low urban tree canopy and limited formal education programs addressing local biodiversity. Current City biodiversity management practices mostly fall within the somewhat narrow focus of the California Environmental Quality Act-mandated (CEQA) conservation framework to protect sensitive species on a project-by-project basis, rather than a comprehensive approach aimed at enhancing overall biodiversity. Other indicators also do not do a good job at accounting for unique contextual factors, such as the City's large footprint, very large, but concentrated natural areas, and unique governance structures. For example, the City receives the highest score for "access to nature", yet a large segment of the population has relatively limited access to natural areas in proximity to their residence. Therefore, we see the Singapore Index as the first step in developing a customized index for LA to support a comprehensive management strategy for biodiversity per the requirements of the City's Biodiversity Motion.

This measurement of the Singapore Index is part of Los Angeles Bureau of Sanitation's (LASAN) response to the City's Biodiversity Motion, passed on May 10, 2017. The Motion includes three main objectives: 1) develop an index to measure protection, enhancement, and mitigation of impacts to biodiversity; 2) develop policies and projects to enhance biodiversity, including improving access for communities that lack access and contributing toward broader ecosystem functions and sustainability; and 3) develop options for community outreach and engagement. Under direction from City Council, and the guidance of the City of LA Biodiversity Interdepartmental Team, Biodiversity Stakeholder Group, and Expert Council, the measurement of the SI was performed as a first step in implementing the Motion. This report includes recommendations for a customized Los Angeles Index, and general recommendations for addressing the requirements of the Motion (see Section 6).

Table 1: Singapore Index of Cities' Biodiversity score summary for Los Angeles

Indicator	Numeric Result	Index Score 0	Index Score 1	Index Score 2	Index Score 3	Index Score 4	Total
1. Natural Areas	20.5% of City (~62,000 acres)					4	**4**
2. Connectivity Measures	738 ha. effective mesh			2			**2**
3. Native Birds in Built Areas	292 native species recorded					4	**4**
4. Native Vascular Plants Change	449 native species recorded	Baseline in year 1					
5. Native Birds Change	325 native species recorded	Baseline in year 1					
6. Native Butterflies/Moths Change	215 total species* recorded	Baseline in year 1					
7. Native Freshwater Fish / Benthic Macroinvertebrates Change	6 fish/291 BMI native spp. recorded	Baseline in year 1					
8. Native Reptiles/Amphibians Chg.	39 total species recorded	Baseline in year 1					
9. Protected Natural Areas	12.2% of City (~36,800 acres)				3		**3**
10. Invasive Species	~20% invasive plant species			2			**2**
11. Pervious Surfaces	~62% pervious surfaces			2			**2**
12. Urban Forest Canopy	~19% tree canopy		1				**1**
13. Access to Natural Areas	3.33 ha/1000 population					4	**4**
14. Natural Area Educational Visits	0.09 visits/student/year	0					**0**
15. Biodiversity Budget	1.2% of budget ($110M)		1				**1**
16. # Biodiversity Projects	117 projects/programs					4	**4**
17. Biodiversity Strategy/Action Plan	no Biodiversity Action Plan	0					**0**
18. # Biodiversity Related Institutions	>3 functions					4	**4**
19. Interagency Cooperation	5 agencies cooperate on bio.				3		**3**
20. Public Consultation Process	proposed as routine process			2			**2**
21. # City Biodiversity Partnerships	40+ partners					4	**4**
22. School Curricula	included					4	**4**
23. Public Outreach Events	660+ events per year					4	**4**
Total (72 potential points in year 1)		average = 2.67					**48**

* native vs. non-native species of butterflies/moths to be determined

02 Profile of the City

Los Angeles

photo: Phil Needy
https://www.ucdavis.edu/sites/default/files/news/general-news/2017/may/phil_reedy_spawning_rainbowcaltrout2015-4.jpg

02 Profile of the City

Introduction

On May 10, 2017, the Los Angeles City Council passed the Biodiversity Motion (Motion 25A), which directed the Bureau of Sanitation (LASAN) to oversee efforts to calculate the Singapore Index for the City of Los Angeles and develop a unique biodiversity index customized for the City of Los Angeles. More specifically, LASAN was tasked with developing an index that quantifies biodiversity and identifies strategies to enhance and protect biodiversity and associated ecosystem services, to develop policies and projects that enhance biodiversity, particularly in areas that lack access to open space, and to engage the larger Los Angeles community in its efforts.The following report contains information regarding the calculation of the Singapore Index, an existing framework developed by international experts in urban biodiversity to quantify existing biodiversity and the resources allocated to protect it within a city, for the City of Los Angeles (LA). The Singapore Index has been measured, or is in the process of being measured, for approximately 40 cities, counties, or metro regions worldwide. To our knowledge, this is the first complete measurement of the Singapore Index by a U.S. city.

It was determined that measuring the Singapore Index would be a useful first step in developing a customized Los Angeles Index by: 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 which can be used as a point of comparison between LA and other cities; and 3) determining appropriate indicators and identifying key management issues unique to LA that can be incorporated into a customized index for the City, biodiversity strategy, and action plan.

In order to measure the Singapore Index for the City of Los Angeles, and develop recommendations for a customized Los Angeles Index and biodiversity practices, LASAN's Internal Biodiversity Team received input from City staff and local experts via three main partnerships: 1) an Interdepartmental Team composed of representatives from various City Departments that perform work related to biodiversity, 2) a Stakeholder Group composed of individuals from City Departments, non-governmental non-profit organizations (NGOs), regulatory agencies, academics, and subject matter experts, and 3) an Expert Council composed of experts on various aspects of biodiversity who volunteered to lend their expertise and data to the endeavor. The Interdepartmental Team met on July 18, 2017 and October 12, 2017. We met with the Stakeholder Group to solicit input from them early in the process on July 20, 2017. An Expert Council workshop, to gather the data and input needed to calculate the Singapore Index for Los Angeles, was held on August 30 and 31, 2017.

The final section of this report, titled "Recommendations for the Customized Los Angeles Biodiversity Index and City Biodiversity Practices", contains valuable information on each of the 23 indicators of the Singapore Index, as well as general suggestions that the City can employ as it continues work on this Biodiversity Project. The information presented is a valuable resource from which an effective biodiversity strategy, action plan, and index, unique to the City, can be developed that appropriately values biodiversity and helps to create equitable access to natural places while protecting and conserving biodiversity, maximizing the ecosystem services associated with biodiversity, and making the City of Los Angeles a better place to live.

According to recommendations made by stakeholders and experts involved in this preliminary Singapore Index measurement, continuing biodiversity efforts will need to focus on improvement in the following areas: species conservation, public access to biodiversity, invasive species control, habitat quality, habitat connectivity, environmental stewardship, and climate change resilience (e.g., genetic diversity and habitat connectivity, including distribution and climate-driven migration of habitat and species across the City and protection of corridors).

Location and Climate

Los Angeles is located along the coast of the Pacific Ocean in the Northern hemisphere, with City Hall positioned at 34.0522 N Latitude, 118.2437 W Longitude[3]. According to the US Forest Service's ecological mapping hierarchy of the United States, Los Angeles (LA or City) falls in the Humid Temperate Domain, Mediterranean Division[4]. LA has exceptionally diverse microclimates and topography, with strong coastal influence in areas within a few

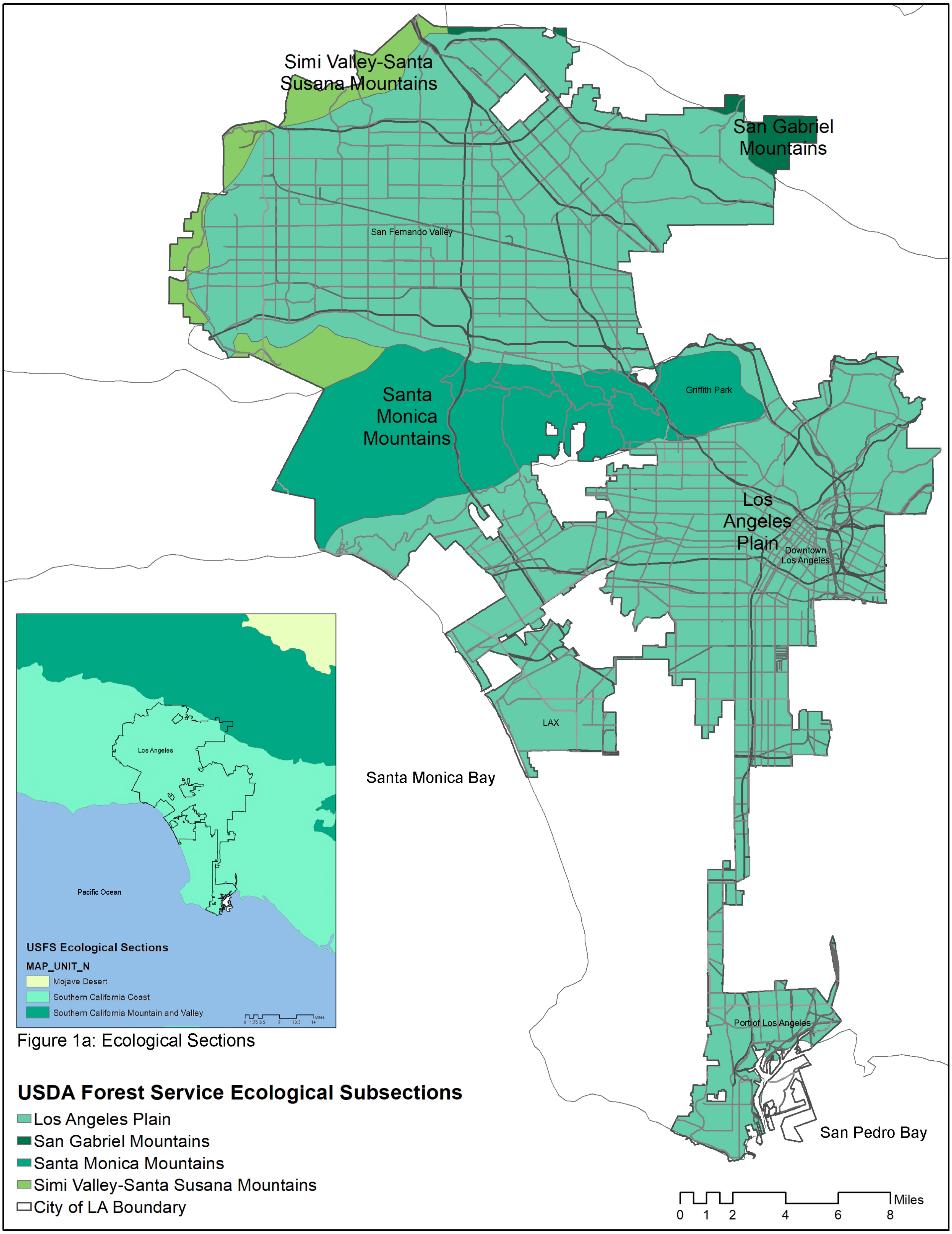


Figure 1: US Forest Service Ecological Sections and Subsections of Los Angeles[4]
These major ecological features are useful in large-scale ecological planning and management frameworks (see Appendix A1).

miles of the Pacific Ocean, to more climate variability and continental influence in the San Fernando Valley/San Gabriel Mountains[5]. It is not uncommon for temperature differences across the City to exceed 30 °F from coast to mountains. Rainfall occurs predominantly in winter, except for occasional summer monsoons that are more frequent in montane and adjacent valley areas. Annual rainfall ranges from about 15 inches downtown to over 30 inches at 7,000' elevation in the upper Los Angeles River watershed just outside of the City borders[3,6,7]. Elevations within the City range from sea level to over 5,000' at Mt. Lukens, which receives measurable snow in most winters. While droughts are common, intensive rainfall periodically occurs during so-called "atmospheric river" events, which can produce some of the heaviest and most concentrated rain in the country. Orographic enhancement of precipitation due to the dramatic elevation change is also an important feature shaping biodiversity and the character of local watersheds. This effect can result in more than double the rainfall rates between coast and mountains. Los Angeles also exhibits an urban heat island effect. In LA, this has been referred to as an urban heat "archipelago" since heat is produced throughout the City, especially within extensive areas of impermeable surfaces; but, the effect is most pronounced in inland areas where heat is generally transported, especially adjacent to the San Gabriel Mountains (see CalEPA's recent Urban Heat Island Index Report for more information[8]).

Physical Features of the City

LA covers approximately 469 square miles, or 301,000 acres (121,000 hectares). The City contains four ecological "subsections" according to the US Forest Service's (USFS) national ecological typology system (Figure 1). Subsections are defined by similar climate, landform, and vegetation characteristics. In LA, subsections range from the flat alluvial plains and coastal terraces of the Los Angeles Plain that are naturally dominated by scrub, savanna, and riparian woodland vegetation types, to chaparral and coniferous forests on very steep rocky slopes in montane areas of the Santa Monica Mountains and San Gabriel Mountains (see Appendix A1 for more information). Along with microclimates, the variety and extent of these major physical features, along with the predominantly north-south oriented aspect of the San Gabriel and Santa Monica Mountains, are the foundation for the high natural biodiversity in the City. It also is notable that the City and surrounding metropolitan region completely bisect the Southern California Coast Section, which may have implications for climate change adaptation and species migration (see Figure 1a). Many regionally endemic species ranges are exclusively contained within this narrow coastal Section, and therefore, any shifts in species range north or south due to climate change may be impacted by the ability of species to migrate through the City over time[9].

Most flat areas in the City have been built upon and development has spread to the foothills, including very steep slopes[10]. The periodically dry climate, combined with steep terrain and fire-adapted native vegetation, results in an extreme fire regime that frequently causes catastrophic damage to communities near the urban- wildland interface. Frequent landslides and mud and debris flows, which are often triggered by rain events in the seasons following wildfires, are also a major impact in interface areas. Extreme runoff rates caused by orographically enhanced rainfall, erosive soils, and the very steep slopes of some of the fastest-rising mountains in the world have driven radical engineering of lower watersheds to mitigate urban flooding, sediment transport, and landslide hazards. Consequently, most urban streams now flow in concrete-lined channels protected by massive debris catch-basins in the foothills that are increasingly challenging to maintain[11,12]. Riparian flooding may be isolated, as most of the City falls outside of the FEMA-designated 100-year flood zone. However, large areas of the City and surrounding metropolis occur within the designated 500-year flood zone, and climate change may alter future flood regimes potentially leading to more frequent strong storms impacting these areas. The City also includes estuaries and low-elevation coastal areas susceptible to sea-level rise. Intensive urbanization has led to low soil permeability across the plain and reduced water tables. Extensive areas of soil and groundwater contamination, including many brownfield sites, are also present within City limits (see Appendix A4 for EPA Superfund Database and brownfields)[13].

Demographics & Economic Parameters

In July 2016, the estimated population of the City of Los Angeles was 3,976,322, with a population density of 8092.3 people per square mile (13.2 per acre)[14]. The Los Angeles metropolitan region had a population of 17.8 million. The gross domestic product (GDP) for the Los Angeles-Long Beach-Anaheim, CA metropolitan area was just over one trillion dollars, the second highest GDP in the country. Per capita income in the City of Los Angeles was $28,761 per year[15,16]. Major economic drivers in the City include the Port of Los Angeles, which captures about 40% of containerized goods entering the U.S. and the entertainment industry. LA County also has the largest manufacturing center in the country (see Appendix A4 for additional demographic and economic information)[14,17].

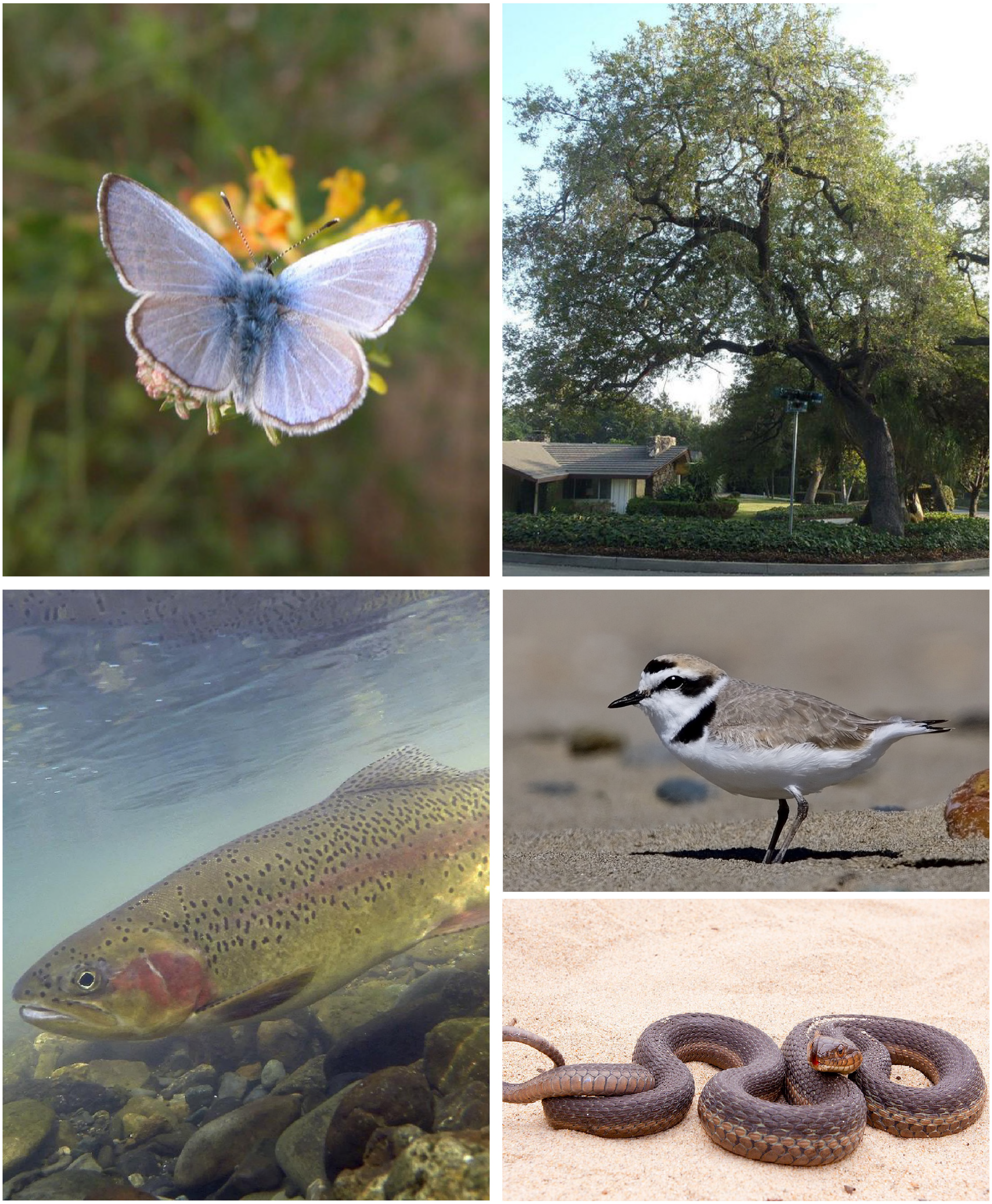


Figure 2: Sensitive Species of Los Angeles (See Appendix A1)

TL: Palos Verdes blue butterfly; © Travis Longcore; https://www.inaturalist.org/taxa/236268-Glaucopsyche-lygdamus-palosverdesensis

TR: Engelmann oak; Los Angeles photo by Rodger: http://www.laspilitas.com/images/grid24_24/12803/images/native-plants/quercus-engelmannii.jpg

BL: Southern California steelhead ***(photo of northern variety);*** Phil Needy; https://www.ucdavis.edu/sites/default/files/news/general-news/2017/may/phil_reedy_spawning_rainbowcaltrout2015-4.jpg

BRT: Western snowy plover; © Mike Baird; http://www.flickr.com/photos/mikebaird/324187595/

BRB: Two-striped garter snake; © Bill Bouton. https://www.inaturalist.org/taxa/28396-Thamnophis-hammondii

Drivers & Pressures on Biodiversity

Dense development, imperviousness, and high population growth are key pressures on biodiversity. Over the years, development along the Southern California Coast has been intense, reducing habitat and negatively impacting native species. Further, as many species in the region are endemic, and rely on unique habitats that are only located regionally, habitat loss has diminished many native populations, and in certain cases led to extirpation. Over 150 sensitive species and plant communities associated with the City have protections under various environmental laws including the California Environmental Quality Act (CEQA), the Migratory Bird Treaty Act, the California Endangered Species Act, and the federal Endangered Species Act (see Figure 2 and Appendix A1)[9]. Impacts from development can be caused by direct loss from land conversion, but also from "edge effects" from development, light and noise pollution, cats and dogs, and changes to natural processes such as wildfire intensity and frequency, hydrology, and habitat fragmentation. Invasive species introductions are often associated with ports, agriculture, and diverse population centers. High housing demand, land shortages, and a sales-tax-based municipal funding structure (California Proposition 13) have also lead to increased infill development. Ongoing conversion of urban landscape areas into high density development may further reduce urban biodiversity and habitat connectivity over time.

Climate change is also predicted to have profound negative effects on biodiversity in Los Angeles, and some effects will likely be complex and unpredictable. The State of California has released reports such as the Climate Change Vulnerability Assessment of California's Terrestrial Vegetation and Safeguarding California Plan: California's Climate Adaptation Strategy that discuss threats to local biodiversity[18,19,20]. Species' processes of migrating to future favorable climates will likely be impacted by habitat fragmentation, and new models of conservation design are needed (often considering the need for species to move either upwards in elevation, northward, toward the coast, or toward more northerly aspects of hillsides)[21]. Susceptibility of low-lying ecosystems to sea-level rise occurs along the coast near the Port of Los Angeles, Venice, Playa del Rey, and Ballona Creek, with limited land area available for inland/upland migration. Species currently at the southern edge of their ranges in Southern California, including the Southern

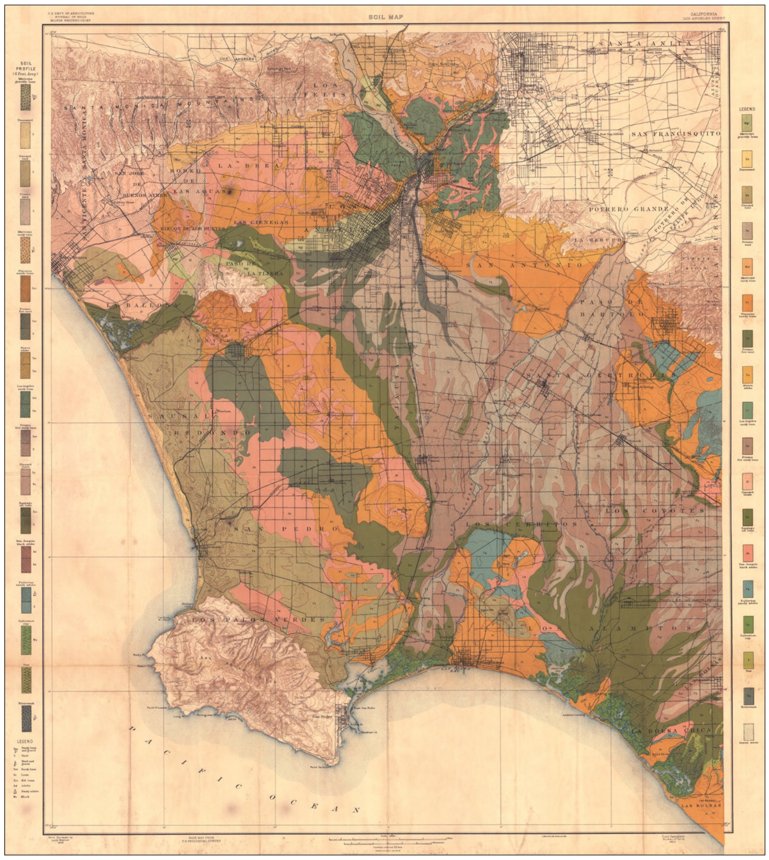


Figure 3a: 1903 Los Angeles Soils.
This soil and landform information is an indicator of the historic pattern of biodiversity and ecosystems[31].

Figure 3b: Sunset Climate Zones for Los Angeles.
This map produced by the gardening industry provides the most detailed map of microclimates in LA, a key driver of biodiversity[5].

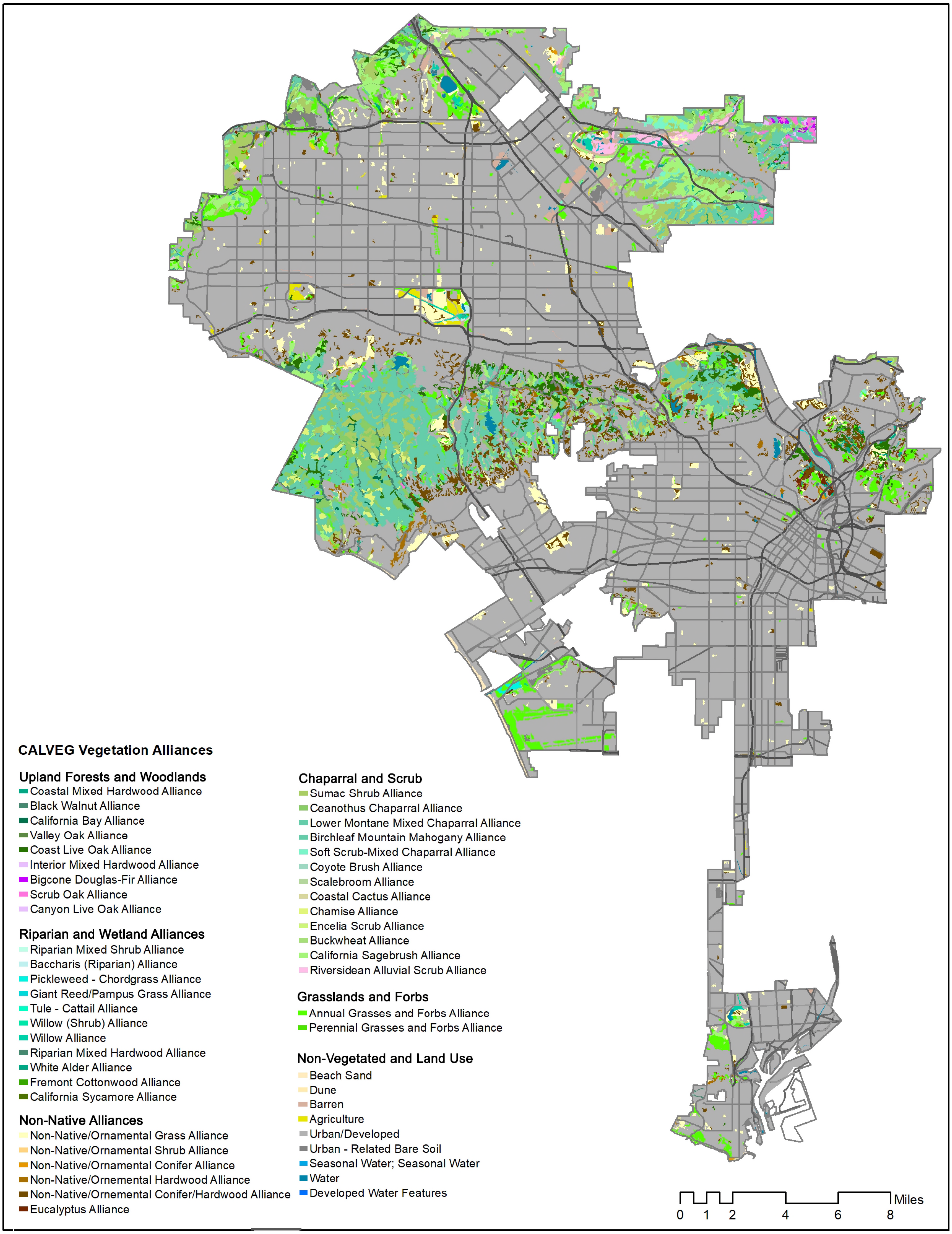


Figure 4: USFS CALVEG Vegetation Alliances 2000-2010[37]
Alliances are useful for understanding species distribution, habitat quality, and species conservation priorities (See Appendix A3).

California steelhead and the California red-legged frog, may be more vulnerable to climate change[22,23]. However, these southern genotypes are also thought to possess important genetics that may help more northerly populations adapt to warmer temperatures; therefore, their conservation is believed to be of high importance to overall conservation of the species[24]. In these cases, Southern California conservation activities may be important to broader species survival. Climate change may also push species from Baja California northward, or from the desert toward the coast, which will have implications for habitat restoration, conservation design, and species' native "status" within the City. Warmer temperatures may also impact public health and the value of urban ecosystem services, such as tree canopy shade[25].

Biodiversity Features

Los Angeles falls within the California Floristic Province, which has been designated as a global biodiversity hotspot[26]. Characterized by high species richness and endemism (species only occur in a specific area), biodiversity hotspots are globally significant conservation priorities. Due to rainfall patterns, the natural growing season in Los Angeles occurs in the winter and spring, when abundant wildflower blooms are important biological and cultural events, including the superbloom of 2017. The California poppy, the State Flower of California, and other wildflowers occur on many of the foothills in the City (a list of other officially designated State species in Los Angeles is included in Appendix A4)[27]. Many native plant species enter seasonal states of dormancy to survive high temperatures and low soil moisture.

Native biodiversity in LA is strongly driven by abiotic factors, including high variability in microclimates and physiography (soil, topography, hydrology, etc.). These factors and other natural processes support LA's 37 native vegetation "alliances", the USFS's most detailed level of its ecological classification hierarchy (see Figure 4 and Appendix A3)[28]. These alliances provide unique habitat conditions for many of our rarest native species. The City also contains many additional, more altered, vegetation alliances comprised of both native and non-native biota that also provide important habitat for native biodiversity, especially in urban areas.

Los Angeles boasts a variety of coastal and riparian habitats. Coastal habitats in the region include shorelines and estuaries around the mouth of Ballona Creek, which includes diverse intertidal and closed wetland ecosystems. The Los Angeles River estuary and adjacent wetlands are largely altered, but patches of restored habitat

Figure 5a: Los Angeles Green Infrastructure (provides beneficial habitat and connectivity for urban biodiversity)

TL/BL: Los Angeles Zoo: Green Parking Lot and Vegetated Bioswale
TR: Ed P. Reyes River Greenway
BM: Avalon Green Alley, South Los Angeles
BR: South Los Angeles Wetland Park

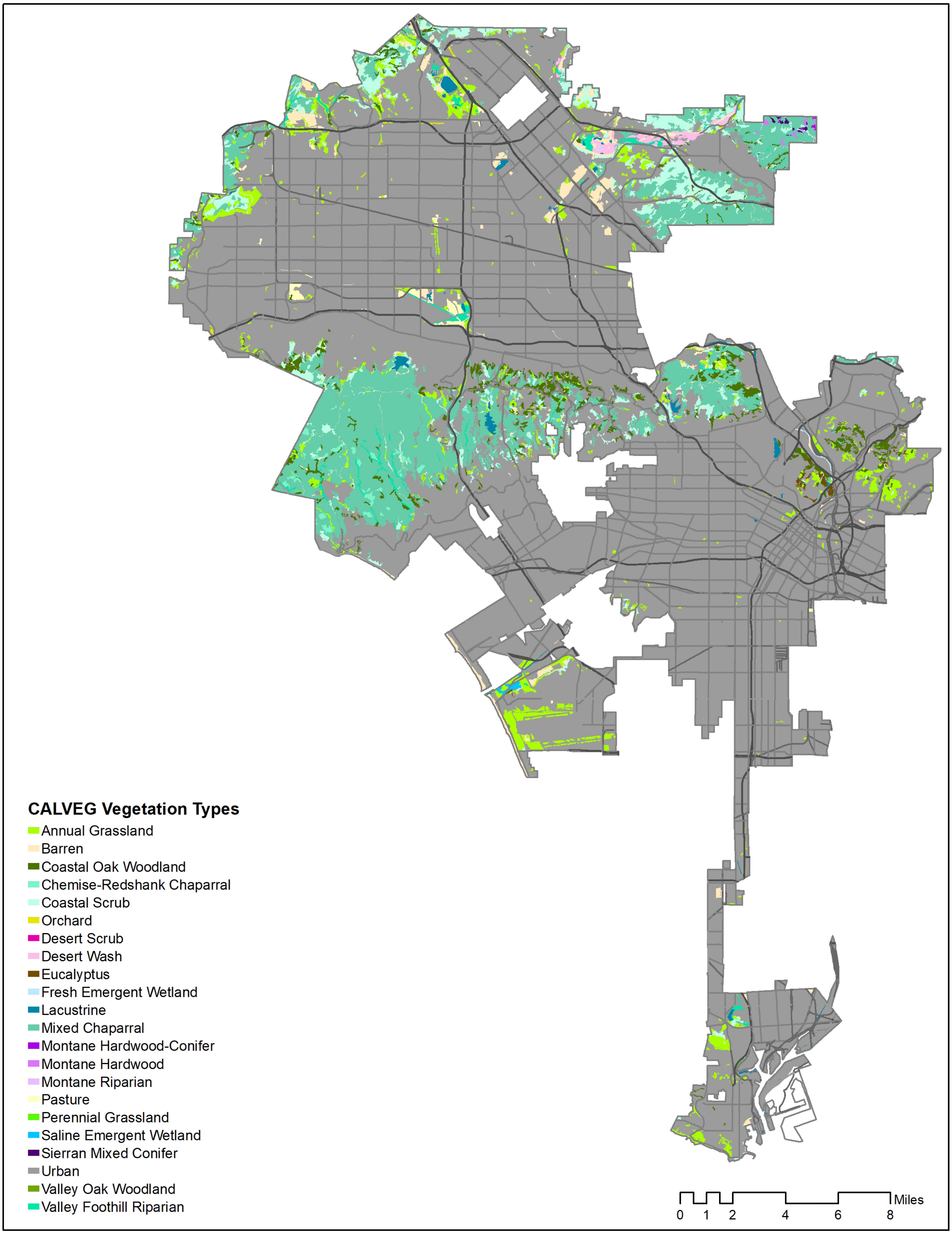


Figure 5: USFS CALVEG Vegetation Types[37]
Vegetation types are useful for understanding general habitat structure and ecosystems services relationships.

occur in adjacent Long Beach and at Machado Lake. Riparian habitat is found along the LA River, which supports high diversity of resident and migratory bird species across its length, despite being mostly concrete-lined[11]. Unlined sections through the Elysian Valley and Big Tujunga Wash include some of the highest riparian species diversity.

Remnant “old growth” coast live oaks, California sycamores (including one that still marks the boundary of LA and Compton), and endemic Engelmann oaks are still scattered across the Los Angeles Plain, however, most natural vegetation has been lost from the vast alluvial plains that comprise most developed areas of the City[29]. These areas once likely contained coastal sage scrub, oak savanna, and grassland complexes interspersed with floodplains, riparian woodlands, alluvial riversidean scrub, and extensive seasonal freshwater wetlands[30]. An historic 1903 soil map (see Figure 3a) provides a good approximation of past hydrology, vegetation, and location of historic wetlands; these soils and landforms also have important implications for future enhancement of biodiversity and ecosystem services[31]. Diverse microclimates are also key drivers of past and present biodiversity in LA, and Figure 3b presents a detailed classification scheme that combines considerations of growing season, timing and amount of rainfall, winter low and summer high temperatures, wind, humidity, and topography (see Appendix A5 for more information)[5].

The highest concentration of biodiversity in the City occurs within the foothills of the Santa Monica, San Gabriel, and Santa Susana Mountains. Large intact tracts of coastal sage scrub, chaparral, alluvial scrub, and evergreen oak woodland types persist here. Tracts are large enough to provide habitat for large mammals including mountain lions, mule deer, and black bears. The famous mountain lion, P-22, resides in Griffith Park (LA’s “central park”), and has captured the imagination of the City[32]. The highest terrain in the City occurs in the San Gabriel Mountains, reaching over 5000’, and is home to a few native conifer tree species including the bigcone Douglas-fir and gray pine[28,30,33].

With the exception of large patches of major vegetation alliances, distributions of populations of flora and fauna species across the entire City have not been well documented. Most detailed studies address smaller areas such as Griffith Park, Ballona Wetlands, El Segundo Dunes, and the Santa Monica Mountains. Species composition

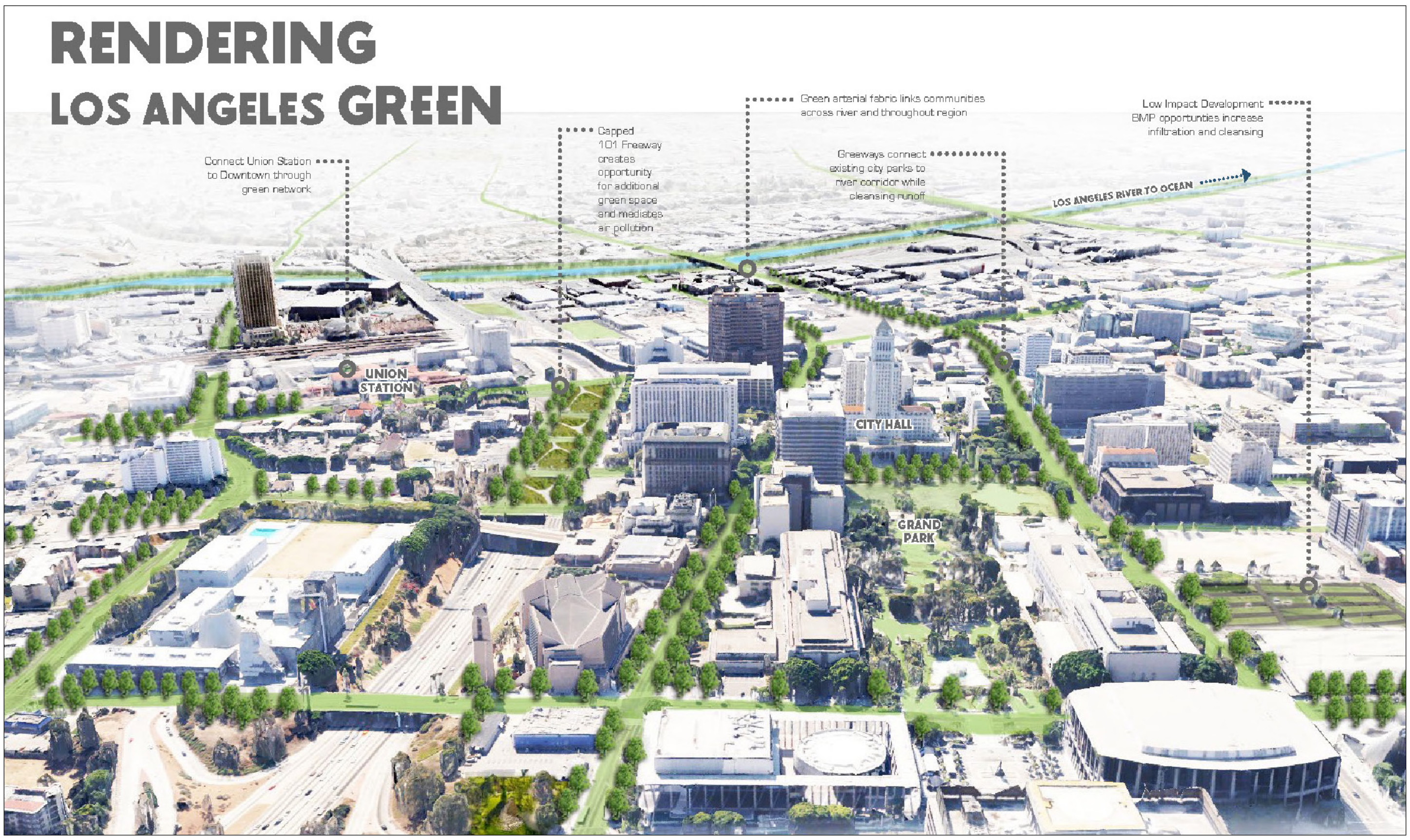


Figure 6: The Greenways to Rivers Arterial Stormwater System (GRASS)
GRASS is a nationally recognized (NACTO, 2017) and award winning (ASLA, 2017) tool developed by LASAN and California State Polytechnic University, Pomona for building increasingly self-regulating and sustainable projects that support greater biodiversity, public health, and equity within the existing street tributary system[38,39].

and distribution within more urban areas and landscapes are not well understood or mapped. However, citizen scientist apps, like iNaturalist, provide large amounts of data across the City and are just beginning to be evaluated. Further citizen data gathering and processing may eventually help determine distribution and abundance of species across the City, and should be aggressively promoted. Comprehensive mapping of key urban biodiversity hotspots and coolspots across the more developed areas of the City is needed.

The City of Los Angeles is also associated with two additional major biodiversity areas, (1) Santa Monica and San Pedro Bays and (2) the Owens Valley. The Hyperion Water Reclamation Plant releases recycled water and permitted discharges into the Santa Monica Bay, and the D.C. Tillman and Los Angeles-Glendale Water Reclamation Plants release to San Pedro Bay via the Los Angeles River. The Terminal Island Water Reclamation Plant discharges its tertiary-treated effluent into the Los Angeles Outer Harbor. Advances in wastewater treatment and increasing water reuse are reducing impacts of this infrastructure on biodiversity over time. Stormwater discharges, predominantly by way of the LA River and Ballona Creek, also impact marine and riparian biodiversity. Increased City initiative to achieve compliance with the federal Clean Water Act is helping to reduce negative impacts to biodiversity. Los Angeles also receives a portion of its water supply from City-owned infrastructure in the Owens Valley, on the eastern slope of the Sierra Nevada Mountains north of the City. This water diversion impacts biodiversity and ecosystems there, and will be addressed in future City biodiversity initiatives.

Administration of Biodiversity

The following City Departments have a role in administration of biodiversity in the City:

- Animal Services (wildlife, feral cats, etc.)
- City Planning (land use, open space, and conservation planning)
- Los Angeles Zoo (biodiversity education, conservation, research)
- Department of Water and Power
- Los Angeles World Airports (LAX El Segundo Dunes Nature Preserve)
- Port of Los Angeles (manages marine zone of Los Angeles Harbor)
- Recreation & Parks (parks, natural areas, Cabrillo Marine Aquarium)
- Public Works
    - Bureau of Sanitation (manages streets, stormwater, wastewater, solid waste, environmental monitoring)
    - Bureau of Street Services (streets, urban forestry)
    - Bureau of Engineering (urban design, landscape guidelines, major development projects, new parks, CEQA/NEPA, regulatory compliance)

Other government agencies responsible for biodiversity:

- Los Angeles County
    - Planning
    - Department of Parks and Recreation
    - Museum of Natural History (education, conservation, research)
- State of California
    - California Department of Fish and Wildlife (threatened and endangered species, habitat conservation, Fishing in the City program)
    - California Department of Parks and Recreation (LA has 10 State Parks)
    - California Coastal Commission (coastal wetlands, marine and terrestrial biological resources)
- Federal Agencies
    - U.S. Army Corps of Engineers (Los Angeles River, flood control, stream impacts)
    - United States Forest Service (urban initiatives, research stations, Angeles National Forest, San Gabriel Mountains National Monument)
    - National Park Service (Rim of the Valley Initiative, Santa Monica Mountains National Recreation Area)

See Appendix A4 for additional links, references, and City profile data.

03 Indicators 1-10

Native Biodiversity in the City

photo: Nurit Katz, UCLA

Indicator 1: Proportion of Natural Areas

Isaac Brown Ecology Studio provided data analysis for this indicator, and Dr. Travis Longcore, Faculty Member at USC, provided guidance.

Singapore Index Score

4/4

20.55% natural areas
(61,931 acres natural areas of 301,345 acres measured)

0 points: <1.0%
1 points: 1.0%-6.9%
2 points: 7.0% - 13.9%
3 points: 14.0%-20.0%
4 points: >20%

CALVEG 2000-2010 dataset (see Figure 4) was used to estimate natural areas in the City. The dataset relies on satellite remote sensing to estimate vegetation alliances and is the only complete, uniformly sampled dataset covering the entire city area. Alliances were classified as "natural" based on consensus of the Expert Council (see Appendix B1, Table 1.2). See Appendix B1 for additional detailed methods and data discussion.

Results Discussion

LA has a relatively high proportion of natural areas according to the Index. Most of these are in the large, high quality open spaces of the Santa Monica and San Gabriel Mountains. Of the 55 vegetation alliances mapped in CALVEG, 34 have been classified as "natural"; three alliances as "degraded natural areas" comprised of mostly non-native annual grasses and forbs; five as "non-native shrubs and trees"; five as agricultural; four as "water" that are mostly reservoirs and artificial lakes, however, may include some more natural water bodies that require further investigation; two as urban; and one as "non-native perennial grasses" (see Figure 7). This remotely sensed data is not able to capture smaller urban natural areas, and there is some level of error in the original classification. Fires, land development, and other disturbance events since around year 2000, when the data was collected, may have contributed to a reduction in vegetated lands and changes in land cover character that are not captured in this assessment. These impacts may have also resulted in further degradation of natural areas. While tracking the total amount of natural areas is an important indicator, measurement of the quality of natural areas and changes between alliance types is also important going forward.

Management Implications and Recommendations for the LA Index

1. Quality and extent of natural vegetation is a key indicator for any city biodiversity index and should be incorporated and modified in the LA Index.
2. Since the CALVEG dataset is over 15-years old, updated data is needed to provide a more accurate characterization of the current vegetation conditions across the City. Additionally, higher resolution imagery is currently available, which could greatly improve the quality of measurement.
3. An updated assessment should also attempt to map and classify smaller urban natural areas.
4. Numerous smaller-scale projects, such as vegetation mapping in Griffith Park and Ballona Wetlands, EIRs, and other project areas, have been completed and may be assembled and processed to provide additional clarity on existing conditions. Feasibility of such a compilation process should be evaluated.
5. Urban areas and non-natural areas should also be classified and evaluated for native biodiversity value. A preliminary list of "areas of obvious biodiversity" has been collected by stakeholders in Council Districts across the City and should be evaluated for biodiversity value.
6. A ranking system to better differentiate the gradient of natural to non-natural, and high to low biodiversity value areas should be developed. This system should be capable of assessing all landscapes, parks, and open spaces and could become the basis for indicators.
7. Vegetation classification and mapping protocols should be identified for future project-specific (suitable site to regional scale projects) to ensure that the quality of data continues to improve over time. The Survey of California Vegetation Classification and Mapping Standards (June 30, 2015), produced by the CDFW Veg CAMP should be referenced. Such mapping would help address the need to better differentiate the quality of natural areas based on association and alliance-level classification at finer resolutions (i.e., smaller minimum map units for natural and semi-natural vegetation types).

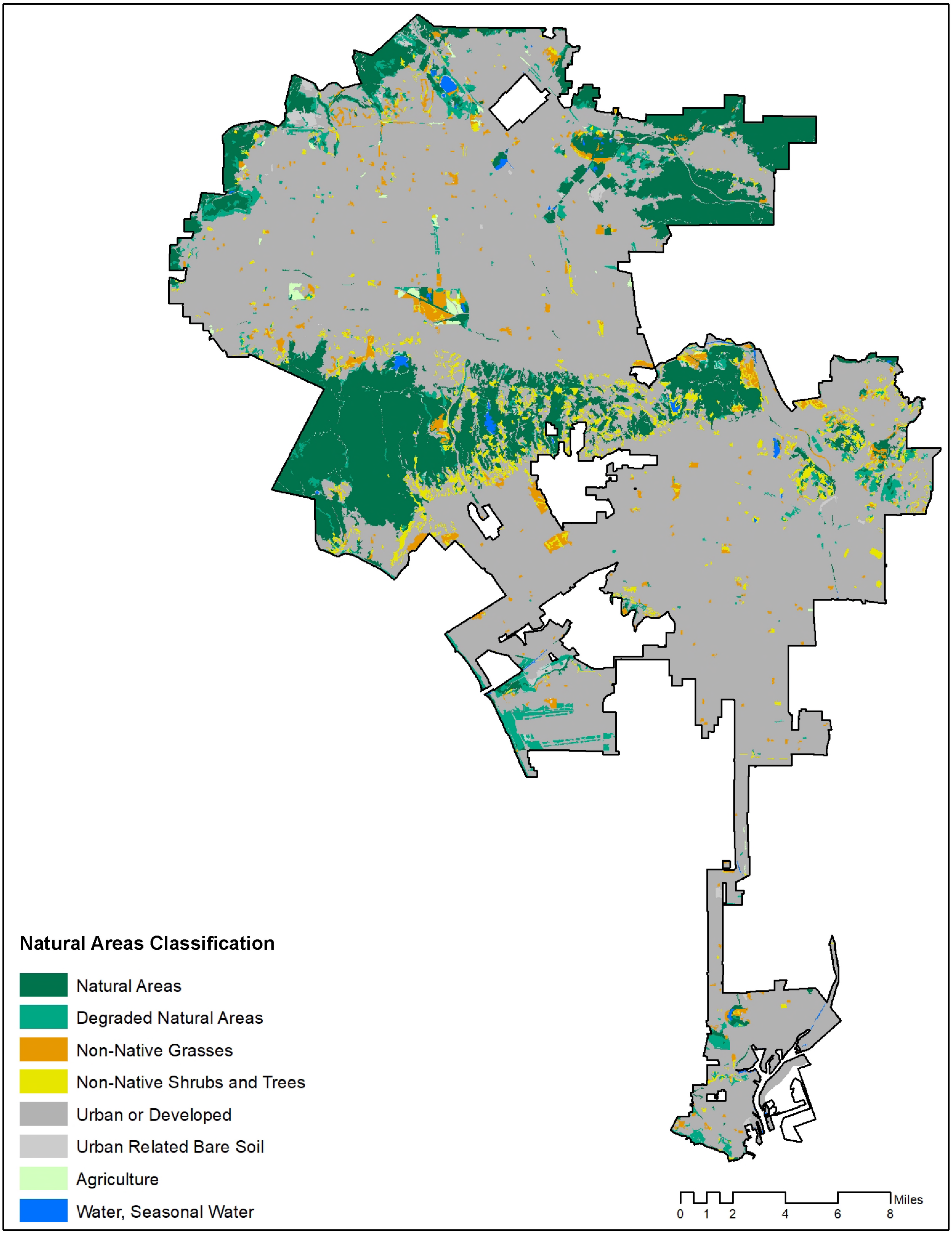


Figure 7: Natural Areas Classification (see Appendix B1 for source data discussion)

Indicator 2: Connectivity Measures

Isaac Brown Ecology Studio provided data analysis for this indicator.

Singapore Index Score

2/4

738.32 hectares
= effective mesh size

0 points: < 200 ha
1 points: 201-500 ha
2 points: 501-1000 ha
3 points: 1001-1500 ha
4 points: > 1500 ha

Measuring connectivity can be complex and approaches may address movement of individual species or more basic measurements of the pattern of natural areas and landscapes across a city. "Effective mesh size" is a measure of the probability that two random points in the city would fall into the same habitat "patch". In the Singapore Index, patches are comprised of natural areas with gaps of less than 100 meters and not bisected by major transportation corridors. Methods and factors considered in measuring effective mesh size are mapped in Figure 8 and described in more detail in Appendix B2.

Results Discussion

Effective mesh size is a useful measure of the overall pattern of natural areas in the City without consideration of specific species movement characteristics. It also emphasizes contiguous connections, such as corridors and relatively close habitat proximity (100-meter gap distance). Yet many species, including many birds and "adapter" species may be willing to travel greater distances between patches. Such species may benefit from "habitat stepping stones" that are not contiguous with other natural areas by this SI measure. Other indicators are needed to measure connectivity in this regard. Additionally, while LA has a relatively moderate effective mesh size, many of the large natural areas around the northern and eastern rim of the San Fernando Valley are in fact connected to much larger natural areas in the region, which if also measured, would increase this result dramatically. Regardless, increasing connectivity between patches within the City could provide additional habitat benefits that would be reflected by improvement of this indicator over time.

Management Implications and Recommendations for the LA Index

1. Effective mesh size does not address configuration of ecological networks, only total connectivity. Identifying priority areas for connectivity and areas where connectivity is being reduced by development are important considerations. There are several notable connections within the City, and across the City border, that should be evaluated further (see Section 6.4.b. for more information). Connections between smaller urban natural areas should also be identified.
2. The impact of climate change on connectivity within LA's narrow coastal Ecological Section should be assessed.
3. Existing "least cost paths" of connectivity between patches should be identified and evaluated for protection and enhancement. Least cost paths should consider the role of habitat stepping stones and urban landscapes in connectivity, in addition to contiguous corridors. The potential for an urban greenways initiative to enhance connectivity, such as the Greenways to Rivers Arterial Stormwater Systems (GRASS - see Figure 6), to enhance connectivity should be considered.
4. Use of indicator species to measure and plan for habitat connectivity should be assessed. "Adapter", "avoider", and "wobbler" species have been suggested as potential indicator species guilds. Species associated with different habitat types (e.g., wetlands/riparian, uplands, specific vegetation associations) should be considered as indicator species. Additionally, the basic pattern of connectivity within and between habitat types should be considered independent of indicator species. The dispersal of plant species by wind, animals, and water should also be considered in connectivity design.
5. An important principle of connectivity planning is that patches should have at least two primary routes of connectivity (i.e., least cost paths) to adjacent patches.
6. Urban habitat connectivity should be measured and modeled using the latest software (e.g., Circuitscape). Land use, landscape/vegetation, and patterns of night lighting are useful "landcover" data layers to consider as a basis for connectivity modeling. While some relationships between such landcover characteristics and the distribution and movement of wildlife are known, additional research to assess the distribution of wildlife should be conducted in the City to improve the effectiveness and local "calibration" of this modeling. New genetic sampling techniques are an especially promising method for understanding these relationships.

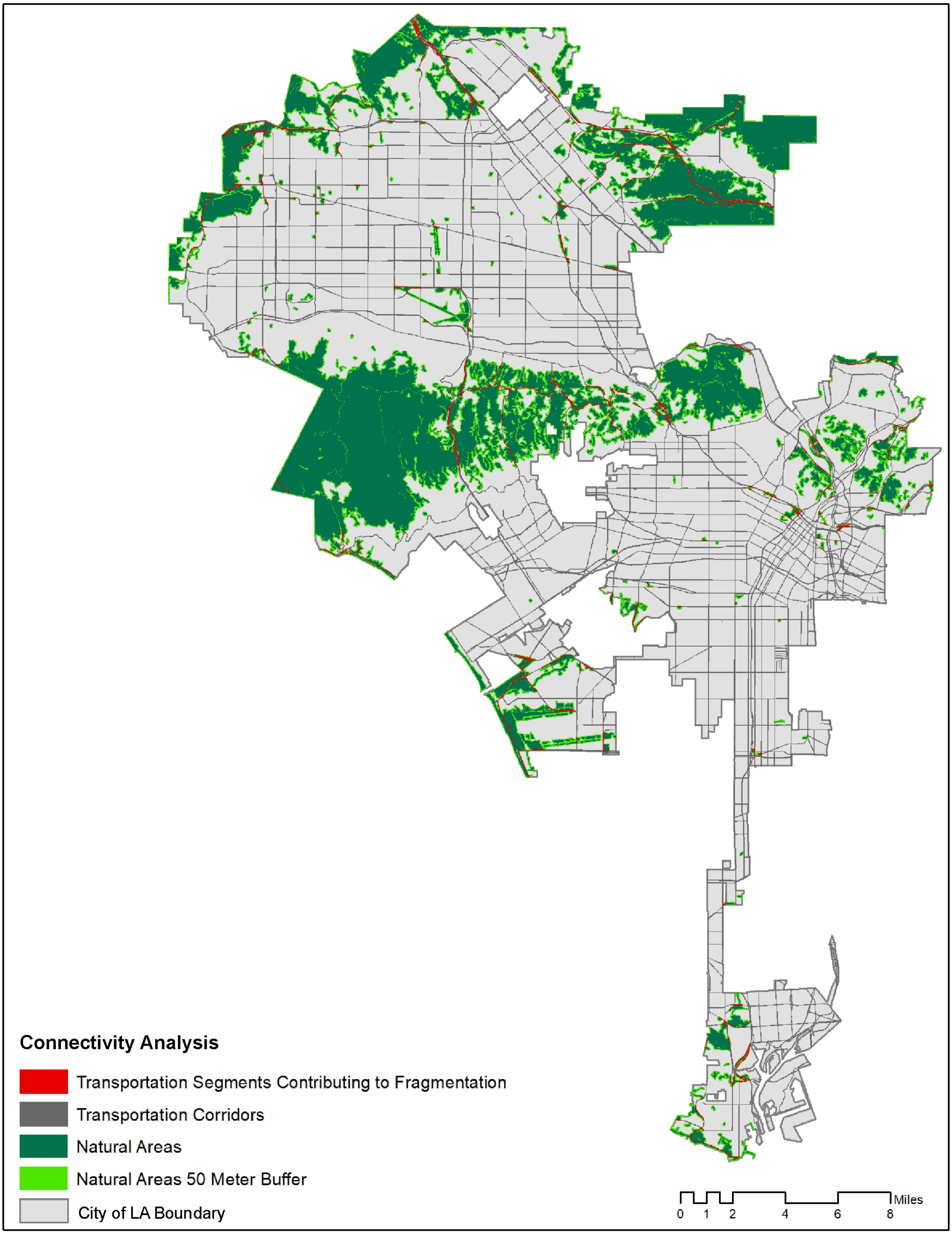


Figure 8: Effective Mesh Size Analysis (see Appendix B2 for source data discussion)

Indicator 3: Native Birds in Built Up Areas

Dr. Ryan Harrigan, Faculty Member at UCLA, provided data analysis for this indicator.

Data from the eBird citizen science data set was evaluated for 2011-2016 for built areas. Natural areas per Indicator 1, plus all water bodies were excluded and the remaining areas were classified as “built-up areas”. An additional 100’ buffer was added to natural areas and water to potentially reduce observations recorded from outside natural areas or water looking in (see Figure 9). Native species were classified using the County Bird List from the Los Angeles Audubon Society. See Appendix B3 for detailed methods and data discussion, including results in Table 3.2.

Singapore Index Score

4/4

292 native bird species documented (of ~500+ total species observed in LA)

0 points: < 19 native species
1 points: 19-27 native species
2 points: 28-48 native species
3 points: 48-69 native species
4 points: >68 native species

Results Discussion

The number of native species in built LA far surpasses the Singapore Index score categories, a testament to the bird diversity within the City. However, this is likely somewhat of an overestimate due to possible location error in citizen observations. For example, many marine species are recorded as observed in built areas. Smaller water bodies or natural areas may have also not been classified appropriately in the CALVEG dataset (used to map Indicator 1) and observations may be from these areas. Regardless, the variety of habitats present from coastal to montane areas, and the location along the Pacific Flyway for migratory birds are key drivers of such high bird richness in built areas. Citizen science data provides a convenient way to measure bird occurrences across the entire city and efforts should be made to better leverage this tool for expanding the characterization of bird species in built areas, including addressing potential location error. Formal scientific sampling for the entire City through all seasons should also be considered.

Management Implications and Recommendations for the LA Index

1. The presence of native bird species in built areas is key to understanding urban habitat connectivity, and further research of this relationship is needed.
2. Species distribution and abundance are better indicators than total number of species (i.e., species richness) because a few high-quality areas can result in high species richness. The Shannon Index and Simpson’s Diversity Index may be useful tools to account for richness, abundance, and distribution across the entire City. Citizen science programs can be leveraged to increase bird observations and improve understanding of these indicators.
3. Improving understanding of the distribution and urban habitat suitability characteristics of rare and more common native bird species may lead to the identification of urban bird “hotspots” and “coolspots”. The potential correlations between bird species and land use, landscape, and building density should be evaluated.
4. “Indicator species” to track the quality and location of urban bird habitat should be identified. Such indicator species should be sensitive to environmental changes that result from management of City land uses and landscapes. Concentrating efforts on a selection indicator species (i.e., 12 or less, ideally) may be a more effective and efficient way to measure change in the City than measuring total bird species richness. The Expert Council has proposed considering “umbrella species”, “keystone species”, breeding birds, overwintering birds, “adapters”, “avoiders”, “wobblers”, and/or species associated with particular habitat types as indicator species.
5. Tree canopy is a good indicator of urban bird diversity, especially for wintering forest birds, and this relationship should be evaluated further.
6. Migratory birds, both long distance migrants and species that move between the City and local mountains, are also potentially important indicator species, since many rely on the LA River, foothill woodland patches, and other sites proximate to the coast as migratory stopovers or wintering habitat.
7. Using birds as an indicator of equitable distribution of biodiversity across neighborhoods should be considered. Council Districts, census tracts, census blocks, census block groups, land uses, landcover types, and neighborhoods should be considered as units of measurement of distribution.

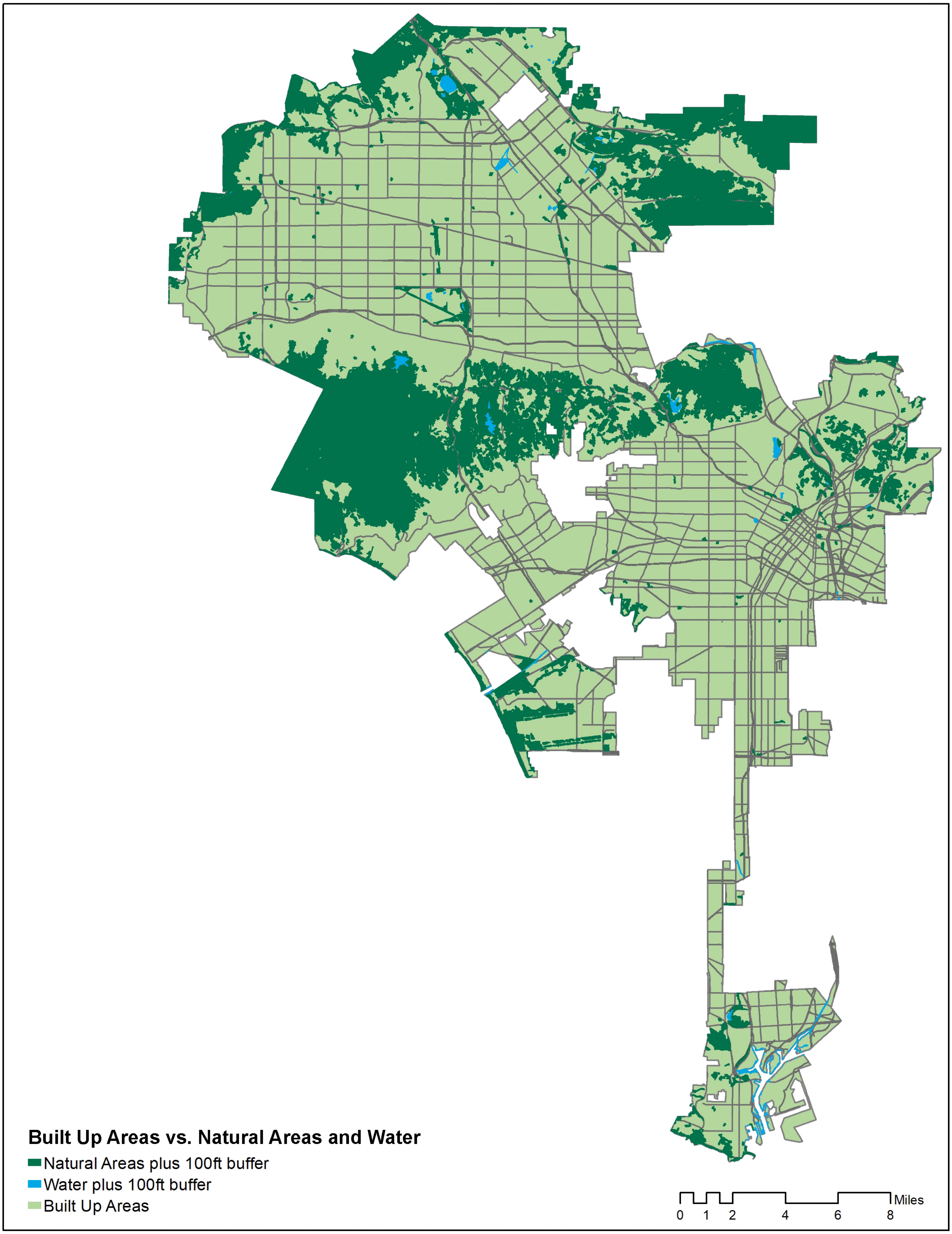


Figure 9: Built vs. Natural Areas and Water.
Light green areas are considered as “built up”, and only bird records from these areas were analyzed.

Indicator 4: Change in Vascular Plant Species

Natalie Farnham from Santa Monica College and Dan Cooper from UCLA/Cooper Ecological assisted in data analysis for this indicator.

Singapore Index Score

Baseline

449 native plant species recorded, 67 are rare with special protected status

0 points: maintaining or decreasing the number of native species
1 points: 1 native species increase
2 points: 2 native species increase
3 points: 3 native species increase
4 points: 4+ natv. species increase

The Calflora dataset was used to assess native vascular plants observed in the City. This dataset contains recorded observations from herbaria and iNaturalist, and was used to generate a list of recorded observations within a rectangular area based on the City boundary. Observation accuracy in this dataset is considered high, but location precision varies, and the number of observations within the City is limited. Therefore, this list is most likely an underestimate; however, some older observations may also include species no longer present in the City. Also, observations are concentrated in wilder areas of the City; therefore, this does not represent a complete inventory of urban areas or smaller natural areas.

CalScape is a database produced by the California Native Plant Society. It includes observations and estimates of species' native ranges by USGS Quads across California. This database was also used to generate a general list of potential native species in the City. However, the coarse resolution of USGS Quads and the fact that estimates are projections based on suitable environmental conditions mean that actual native status of species should be considered on a case-by-case basis. It is highly unlikely that all 1,127 species potentially present based on this dataset occur or are native to the City. Expert Council member, Dan Cooper, has also assessed plant species reports from iNaturalist and identified over 900 species that were not indicated as "introduced" within the City (i.e., potential native plant species). See Appendix B4 for detailed methods and data discussion.

Results Discussion

(Note: Change in vascular plant species is measured over time, therefore the initial Singapore Index measurement is considered the "baseline"). Observations of 449 different native plant species have been recorded in Calflora (Appendix B4, Table 4.2), including 67 special status species (Appendix B4, Table 4.4), and 1,127 native plant species are projected to have suitable range in the City in the Calscape database (Appendix B4, Table 4.3). While 1,127 is an overestimate, Calscape may be useful to help determine native plant species that may be present in the City of Los Angeles, but have not been recorded in Calflora or iNaturalist (Appendix B4, Table 4.4). Initiatives, possibly utilizing citizen science, to determine which species from this list are actually present within the City, including their distribution and abundance, should be considered.

Management Implications and Recommendations for the LA Index

1. Measuring the total number of species within the entire City is difficult and may not be an effective metric to support management decisions. Total species richness does not reflect changes in the City well since a few high quality natural areas may "dominate" the species count. As a result, only the addition of relatively rare species to these areas may result in positive change of the indicator. Enhancements to degraded natural areas with more common native species may not be reflected.

2. Considering the entire City-extent, species distribution and abundance are perhaps more useful indicators than total species richness. Species richness metrics may be more useful to measure quality of specific focus areas of interest, such as individual parks or habitat patches.

3. A citizen science program to locate native species not currently observed (Calflora list), but have the potential to occur here (Calscape List), should be considered. Updating mapping of CALVEG alliances, which are good indicators to track changes to natural areas, based on more recent vegetation data will improve the quality of this indicator.

4. Focusing effort on the recovery of a smaller number of species that have been extirpated from the City, rather than overall change in the number of vascular species present, may provide a more accurate measure of how vascular plants are changing in the City over time. Areas in which native vascular plants do not occur should be considered as a measure of poor access to native biodiversity.

Figure 10: Example Native Flora of Los Angeles

TL: Bigcone Douglas-fir *(Pseudotsuga macrocarpa)*, on of LA's few native conifer trees; © Stephanie Calloway; http://www.inaturalist.org/photos/5527134

TR: Fragrant pitcher sage *(Lepechinia fragrans)*, © scott.zona; https://www.inaturalist.org/photos/536457

BLT: Purple owl's clover *(Castilleja exserta)*, © sarahwenner; https://www.inaturalist.org/photos/6975308

BLB: Bright green dudleya *(Dudleya virens)*, © vireolanius; https://www.inaturalist.org/taxa/79821-Dudleya-virens-virens

TR: California poppy *(Eschscholzia californica)*, © Hartwig Adam; https://www.inaturalist.org/photos/9520929

5. Monitoring change by urban ecosystem type/ecotope, rather than the City as a whole, may lead to a better understanding of how plant species are distributed and how distribution changes over time. This in turn could enhance the protection and diversity of species and associated biotic and abiotic features through ecosystem-specific urban biodiversity management programs.
6. The variety and quantity of native and other biodiversity-beneficial plant species used in landscape design and sold in nurseries should be evaluated. Similarly, the presence of these species in existing built areas should be evaluated. The existence of landscape design specifications using native plant species and/or strategies for enhancing habitat value should also be assessed.
7. An indicator should address how landscape structure, pattern, and plant growth form serve as habitat for native fauna since pattern and structure can sometimes be as important for habitat value as the landscape's composition of native vs. non-native plant species.
8. Climate change impacts, and projected impacts, on native plant species should be considered. In particular, vulnerable populations and potential climate "refugia" (e.g., north-facing slopes, future vegetation/habitat range, potential for intertidal wetlands to reestablish upslope/inland from future sea level rise, changes to ground water depth, species/genotypes at southern edge of range, etc.) should be assessed.
9. As climate change will likely result in changes to native species range and presence in the City, and this indicator's intent is to assess changes driven by local decision making and land use, the role of climate change in future species composition should be considered when refining this indicator.
10. A formal field survey, or a more extensive verification of citizen science observations by trained specialists to expand "research grade" observations in the City, should be performed to improve this assessment.
11. A Habitat Conservation Planning process, already applied across many California landscapes, may be useful to manage biodiversity in the City.

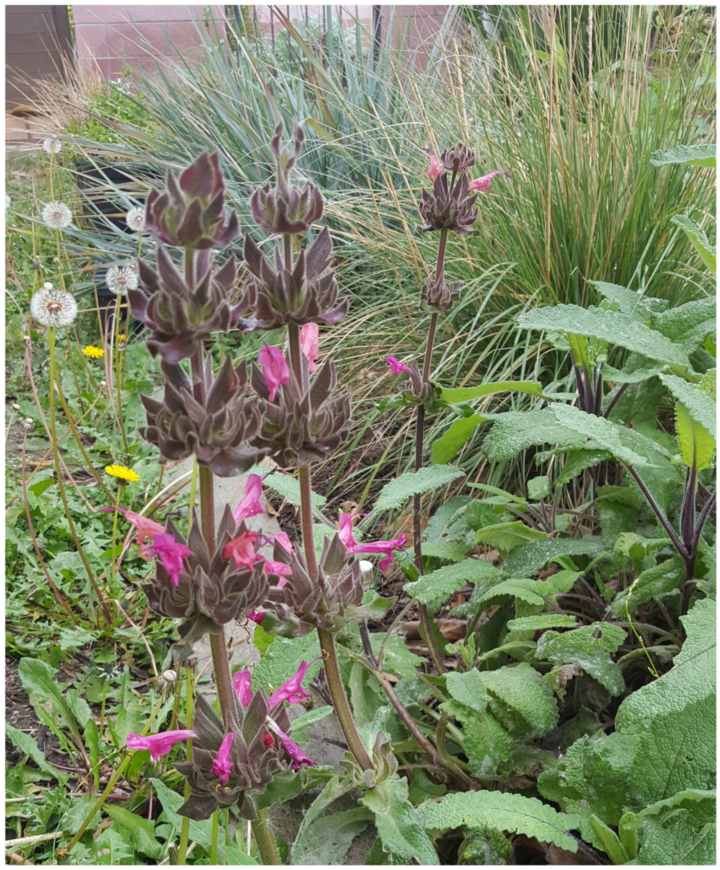


Figure 11: Example Native Flora of Los Angeles
TL: Purple needlegrass *(Nassella pulchra); State grass of California;* © James Bailey; http://www.inaturalist.org/photos/3447440
BL: Coulter's matilija poppy *(Romneya coulteri)*; © Dana; http://www.inaturalist.org/photos/1919371
R: Hummingbird sage *(Salvia spathacea);* photo: Isaac Brown

Figure 12: Example Native Flora of Los Angeles

***TLT: Dune buckwheat** (Eriogonum parvifolium);* host plant for the El Segundo blue butterfly; © James Bailey; http://www.inaturalist.org/photos/2871733

***TLB: Valley oak** (Quercus lobata);* © Carol Blaney; https://www.inaturalist.org/photos/11977089

TR: California buckwheat** (Eriogonum fasciculatum)**; © Naomi Fraga; https://www.inaturalist.org/photos/10810281

***BL: Coast sunflower** (Encelia californica);* © subiehiker; https://www.inaturalist.org/photos/7492762

***BR: Purple sage** (Salvia leucophylla);* © Timothy Gallagher; https://www.inaturalist.org/photos/7807776

Indicator 5: Change in Bird Species

Dr. Ryan Harrigan, Faculty Member at UCLA, provided data analysis for this indicator.

Sightings documented in the citizen scientist web-based tool eBird were collected for years 2011 to 2016. All observations occurring within the City boundary were included. Native status was classified based on the County Bird List from the Los Angeles Audubon Society. A five-year interval was selected as a suitable interval for measurement and comparison. See Appendix B5 for detailed methods and data discussion.

Singapore Index Score

Baseline

325 native bird species observed

0 points: maintaining or decreasing the number of native species
1 points: 1 native species increase
2 points: 2 native species increase
3 points: 3 native species increase
4 points: 4+ ntv. species increase

Results Discussion

(Note: change in bird species is measured over time; therefore, the initial Singapore Index measurement is considered the "baseline"). Of the more than 500 bird species reported in Los Angeles in eBird, 325 are local native species (see Appendix B5, Table 5.2). Of the native bird species observed, 19 additional species were present in natural areas compared to built areas measured in indicator #3 (326 vs 306 species). Such close results could imply that many bird species are tolerant of built conditions; however, location error in eBird reporting, or inaccuracy in natural areas mapping, are also likely contributors.

Management Implications and Recommendations for the LA Index

1. Distribution and abundance are also important indicators of bird biodiversity, and should be built into indicators. The focus of this indicator should be on a smaller number of extirpated species and their recovery efforts.
2. Bird species are likely a key indicator of habitat connectivity due to their movement characteristics, level of interest and monitoring by the public (bird watchers), and association with urban landscape character.
3. Areas where native bird species do not occur should be considered as a measure of equitability of access to native biodiversity.
4. Change should be monitored by ecosystem type/ecotope to better understand level of protection and diversity of species and associated biotic and abiotic features.
5. Relationships between urban landscape pattern and structure with native bird habitat should be evaluated. Associations between birds and land use types should also be evaluated to help identify important land use design-biodiversity relationships.
6. Climate change impacts, and projected impacts, on native bird species should be considered. Particularly, identifying vulnerable populations and potential climate "refugia" (e.g., north-facing slopes, future vegetation/habitat range, potential for intertidal wetlands to reestablish upslope/inland from future sea level rise, changes to ground water depth, species/genotypes at southern edge of range, etc.).
7. Since species range shifts driven by climate change (northward and coastal) may be impacted by the ability of species to migrate through the City, particular for non-migratory, local breeding birds associated with vegetation alliances of the South Coast Ecological Sections and Subsections, enhancing urban connectivity could be an important adaptive management strategy.
8. A scientific field survey, or more extensive verification of citizen science observations by experts to expand "research grade" observations in the City, would improve this assessment approach.

Figure 13: Example Native Birds of Los Angeles
TL: California quail; © NHM Citizen Science Program; http://www.inaturalist.org/photos/5127119
TRT: Townsend's warbler; © jmaley; https://www.inaturalist.org/photos/11576998
TRB: Western snowy plover (Federally Threatened); © Mike Baird; http://www.flickr.com/photos/mikebaird/324187595/
BL: Hooded oriole; © yburch; https://www.inaturalist.org/photos/7539398
BR: California least tern chick (Federally Endangered); © Jennifer Rycenga; http://www.inaturalist.org/photos/927321

Indicator 6: Change in Butterflies & Moths

Isaac Brown Ecology Studio provided data analysis for this indicator.

Singapore Index Score

Baseline

215 native and non-native butterfly and moth species observed

0 points: maintaining or decreasing the number of native species
1 points: 1 native species increase
2 points: 2 native species increase
3 points: 3 native species increase
4 points: 4+ native species increase

Observations of moths and butterflies documented in the citizen scientist web-based tool iNaturalist were collected for years 2011 to 10/31/2017. All observations occurring within a rectangle representing the City boundary extents were included (therefore, there is a chance that some species may occur outside of the City; however, the City is likely suitable range). Native status is not classified in iNaturalist, so all species were included. See Appendix B6 for detailed methods and data discussion, including Tables 6.2 and 6.3 for lists of butterfly and moth species recorded.

Results Discussion

(Note: change in butterfly species is measured over time; therefore, the initial Singapore Index measurement is considered the "baseline".) Many of our local native butterflies are closely associated with native plant species that provide habitat, especially coastal sage scrub and other herbaceous species. Enhancement of these plant species in city landscapes may help expand distribution of butterflies and moths in the City.

As of 2006, LA was home to two federally endangered butterfly species, the El Segundo blue butterfly and the Palos Verdes blue butterfly. These species inhabit a very limited range within the Los Angeles Plain and Palos Verdes, so management of habitat in the City is critical to their survival. These species have become endangered due to loss of coastal dune habitat (El Segundo blue) and coastal sage scrub habitat within favorable microclimates of Los Angeles and a few nearby areas. Protection of habitat is key; however, these butterflies associate closely with host plants (locoweed, *Astragalus trichopodus* var. *lonchus,* and deerweed, *Acmispon glaber,* for the Palos Verdes blue, and dune buckwheat, *Eriogonum parvifolium,* for the El Segundo blue) and expansion of these plant species in favorable areas of the City may also provide new suitable habitat, potentially even within yards, parks, or other green infrastructure. In this way, Los Angeles may contribute to the sustainability of broader ecosystem functions and biodiversity.

Management Implications and Recommendations for the LA Index

1. A scientific field survey, or more extensive verification of citizen science observations by experts to expand "research grade" observations in the City, would improve this assessment approach.
2. Smaller scale surveys exist for parts of the City, including the Griffith Park butterfly survey (Dan Cooper - includes extirpated species); UCLA/NHM re-survey of butterflies of the Santa Monica Mtns; and the NHM BioSCAN data review (Elizabeth Wong); and the NHM BioSCAN (Brian Brown). Aggregation of these surveys and others into a citywide assessment would improve accuracy.
3. Distribution and abundance are also important indicators of butterfly biodiversity and should be considered.
4. Extirpated, threatened, and endangered species and their recovery efforts should be addressed in an indicator. This will help to identify species that have the potential to be re-established or be lost, which would impact this indicator.
5. Butterfly species may be an indicator of habitat connectivity due to their movement characteristics.
6. Native plant species that provide habitat for butterflies and moths should be considered and promoted for planting in parks, yards, landscapes, and green infrastructure.
7. Associations between butterflies, land use types, and land use patterns could help identify important urban and landscape design-biodiversity relationships and should be researched.
8. Climate change impacts on butterfly species should be considered. Populations present in potential climate "refugia" (e.g., areas above projected sea level rise areas, north slopes, species/genotypes at southern edge of range, etc.) should be identified and considered for enhanced conservation.
9. Potential species range shifts with climate change (northward and coastal) may be impacted by the ability of species to migrate through the City, so means to enhance movement through the City should be examined.

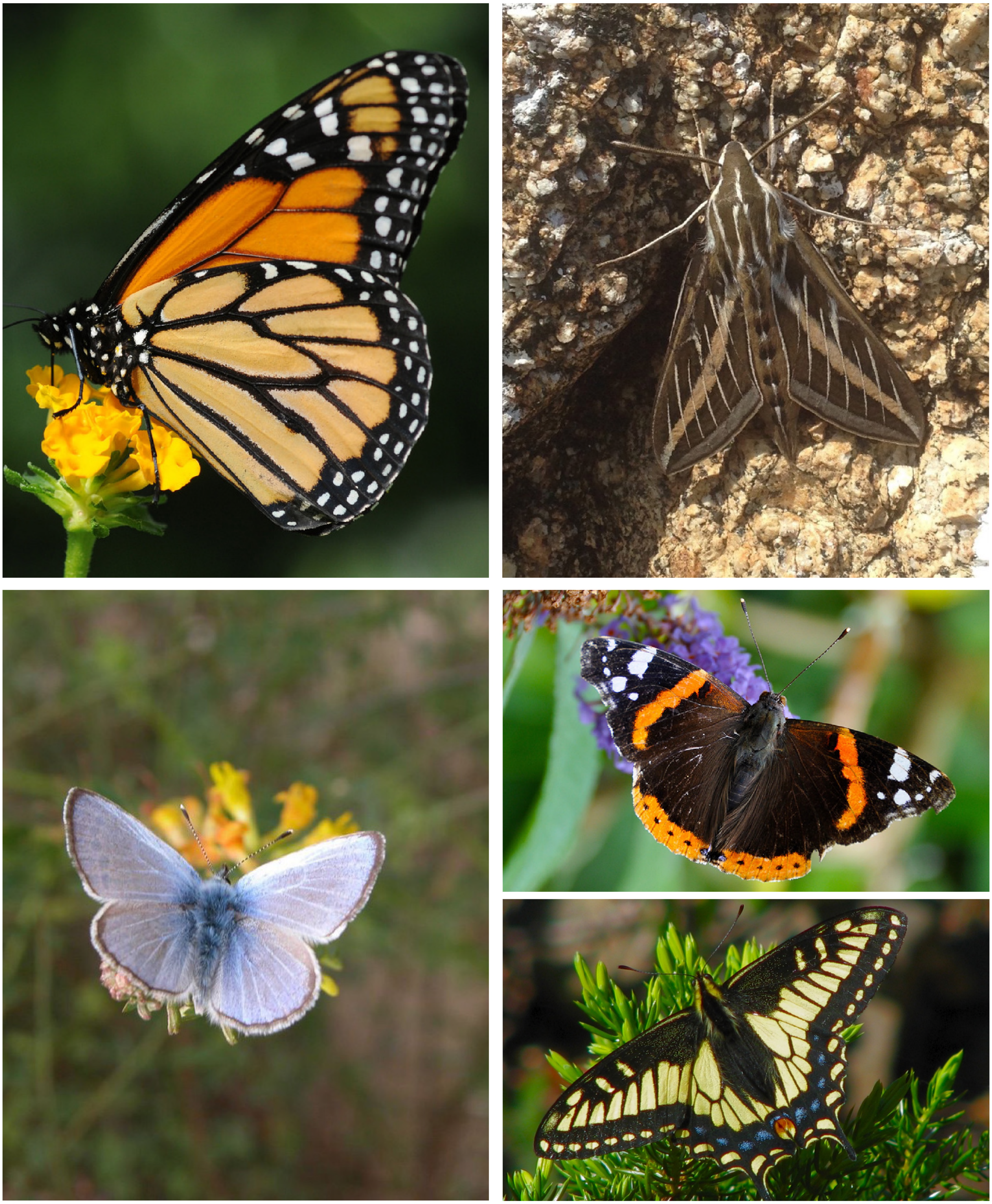


Figure 14: Example Native Butterflies and Moths of Los Angeles
TL: Monarch; © Thomas Bresson; https://www.flickr.com/photos/computerhotline/3877362343/
TR: White line sphinx; © Adam Searcy; https://www.inaturalist.org/photos/4822175
BL: Palos Verdes blue butterfly (Federally Endangered); © Travis Longcore; https://www.inaturalist.org/taxa/236268-Glaucopsyche-lygdamus-palosverdesensis
BRT: Red admiral; © Drriss & Marrionn; https://www.inaturalist.org/taxa/49133-Vanessa-atalanta
BRB: Anise swallowtail; © Peter Prehn; https://www.inaturalist.org/taxa/51097-Papilio-zelicaon

Indicator 7: Freshwater Fish & Benthic Macroinvertebrates

Karin Wisenbaker of Aquatic Bioassay & Consulting Laboratories, Inc. and Wendy Katagi of Stillwater Sciences, Inc., assisted in data analysis for this indicator.

Singapore Index Score

Baseline

6 native freshwater fish species / 291 native and non-native BMI species observed

0 points: maintaining or decreasing the number of native species
1 points: 1 native species increase
2 points: 2 native species increase
3 points: 3 native species increase
4 points: 4+ native species increase

Data on benthic macroinvertebrates (BMI) is collected annually at a number of sampling locations within the LA River watershed (all species from 2008-2016 were counted). This high-quality data is ideal for measuring changes in the taxa and associated water quality. Native status of BMI is not well documented, so all observations were included. Native freshwater fish are not sampled regularly and their presence in local watersheds is less well documented. The number of freshwater fish species present is based on the 2006 City of LA CEQA Thresholds Guide listed in Appendix B, Table 17.2.

Results Discussion

Benthic macroinvertebrates are valuable indicator species since they are regularly sampled as part of water quality compliance activities in compliance with the federal Clean Water Act. They are also good indicators of water quality. Results are provided for the LA River watershed and include native and non-native species (see Appendix B7, Table 17.3). Three of the species reported are notable invasive species; *Corbicula* (bivalve), *Procambarus clarkii* (crawfish), *Cambaridae* (crawfish family), *Potamopyrgus antipodarum* (New Zealand mud snail, not in the LARWMP dataset).

There are few native freshwater fish in Southern California and their range is very limited within the highly modified fresh waterbodies in LA. Their locations and ranges are not well mapped. The Santa Ana sucker was documented in the LA River from the mouth of Big Tujunga Canyon upstream in 1999, and is a locally endemic species native to only the Santa Ana, San Gabriel, and LA River watersheds[34]. Status of the unarmored threespine stickleback is unknown and the last documented sighting of a steelhead in the City was in Ballona Creek in 2008 (See Figure 15, Top). These fish species are useful indicators of biodiversity in the City, because they are somewhat easy to spot and also indicate water quality. The charismatic Southern California steelhead, perhaps like the mountain lion P-22, may also engage the attention of the public and be leveraged to support recovery efforts in City streams. The LA River, while largely concrete-lined, is somewhat unique in the region by being relatively barrier free. Enhancement of the river channel to support migration of the species to and from headwaters may be feasible. Restoration, or creation, of spawning and rearing habitat with suitable water quality, particularly in tributaries, may also support recovery of these relatively resilient fish species.

Management Implications and Recommendations for the LA Index

1. Abundance and distribution of freshwater fish and BMI are better indicators of water quality and biodiversity than total number of species, since a few high quality sites may produce a high number of total species. Therefore, abundance and distribution of species should be incorporated into a modified version of this indicator.
2. The successful re-establishment of steelhead in LA could demonstrate the City's contribution toward sustaining globally significant biodiversity. It would also support the National Marine Fisheries Service Southern California Steelhead Recovery Plan[24], which includes the LA River as potential restoration watershed. Southern California steelhead populations are seen as possessing key genetic adaptations to high water temperatures that may be important to species survival with climate change[24].
3. Anadromous fish, like the Southern California steelhead, may provide an indicator of habitat connectivity across a watershed.
4. Additional BMI species may be present in Ballona Creek, Dominguez Channel, and the watersheds flowing to the coast from Topanga Canyon State Park, so further research is needed. Isolated local springs should also be evaluated for BMI presence.
5. Indicators of aquatic habitat quality, connectivity, and instream flow conditions to help interpret changes over time should be considered. For example, performing wet/dry-season mapping to identify perennial reaches of natural-bottom channels would be useful. Identification of % channel length (or miles) with natural-bottom and native riparian vegetation, by flow category (perennial, intermittent, ephemeral) can be a useful measure of habitat quality change over time.
6. The CDFW Fishing in the City program and other City lake stocking activity should be considered as an indicator of public engagement with biodiversity.

Figure 15: Example Native Freshwater Fish and Benthic Macro Invertebrates of Los Angeles

T: Southern California steelhead (Federally Endangered), last recorded sighting in LA., Ballona Creek, 3/12/2008; Photo: Steve Williams, Resource Conservation District of the Santa Monica Mountains

ML: Stonefly exoskeleton, Santa Clara River watershed; © Daniel S. Cooper; https://www.inaturalist.org/photos/5609179

MR: Darner (Aeshnidae), Eaton Canyon; © yetikat; https://www.inaturalist.org/photos/7361082

B: Santa Ana sucker (Federally Threatened)***,*** San Gabriel River, June 27th, 2007; Photo: Manna Warburton. http://calfish.ucdavis.edu/species/?uid=87&ds=241

Indicator 8: Reptiles & Amphibians

Isaac Brown Ecology Studio and Dr. Brad Schaffer of UCLA provided data analysis for this indicator.

Sightings documented in the citizen scientist web-based tool iNaturalist for the LA County Natural History Museum Reptiles and Amphibians of Southern California (RASCals) program were downloaded. All observations occurring within a rectangle representing the City boundary extents were extracted (therefore, there is a chance that some species may occur outside of the City; however, the City is likely suitable range). Native status is not classified in iNaturalist, so all species were counted. A five-year interval was selected as a suitable interval for measurement and comparison over time. See Appendix B8 for detailed methods and data discussion, includingTable 8.2 for results.

Singapore Index Score

Baseline

39 native reptile and amphibian species and subspecies observed

0 points: maintaining or decreasing the number of native species
1 points: 1 native species increase
2 points: 2 native species increase
3 points: 3 native species increase
4 points: 4+ native species increase

Results Discussion

Note: change in amphibian and reptile species is measured over time; therefore, the initial Singapore Index measurement is considered the "baseline". The Natural History Museum of Los Angeles County leads an effort called RASCals that encourages citizen scientists to increase understanding of reptiles and amphibians in Southern California. This initiative has increased observations of the taxa and has improved documentation of abundance and distribution. iNaturalist allows users to download species lists based on latitude and longitude extents; therefore, the City boundary was not used, but data could be further evaluated to identify any species not actually present in the City.

As of 2006, LA was home to four sensitive amphibian species and seven sensitive reptile species (see Appendix A2). The federally threatened California red-legged frog has been largely extirpated from areas south of Malibu Creek, although, restoration activities are now underway in creeks of the Santa Monica Mountains. Recovery of the species in LA would represent re-expansion of the range and southern genotypes, which may have potential benefits for climate change adaptation of the species. However, competition with non-native frog species is a significant constraint to recovery.

Management Implications and Recommendations for the LA Index

1. Distribution and abundance are also important indicators of biodiversity, and should be considered in addition to species richness.
2. Amphibians are good indicators of water quality, but distribution and abundance are better indicators of water quality than total number of species because a few high quality sites may result in high total species richness results regardless of the spatial extent of high quality conditions.
3. Reptiles and amphibians are charismatic and generally easy to spot; therefore, citizen science may be an effective tool for assessing distribution and abundance of these taxa.
4. Reptiles are highly mobile species and, therefore, may be useful indicators of habitat connectivity.

Figure 16: Example Native Reptiles and Amphibians of Los Angeles
TL: Western fence lizard; © dickwood***;*** https://www.inaturalist.org/photos/11390228
TRT: Southwestern pond turtle; © Jorge H. Valdez; https://www.inaturalist.org/taxa/39769-Actinemys-marmorata-pallida
TRB: San Diego alligator lizard; © Greg Pauly; https://www.inaturalist.org/photos/6776371
BL: California red-legged frog (Federally Threatened)**,** status in LA is unknown; © oneillcraig; http://www.inaturalist.org/photos/5527134
BR: Arroyo southwestern toad (Federally Endangered); © Pacific Southwest Region U.S. Fish and Wildlife Service; https://www.inaturalist.org/taxa/64971-Anaxyrus-californicus

Indicator 9: Proportion of Protected Natural Areas

Isaac Brown Ecology Studio provided data analysis for this indicator.

Singapore Index Score

3/4

12.2% of the City is protected (59.3% natural areas are protected)

0 points: < 1.4%
1 point: 1.4% - 7.3%
2 points: 7.4% - 11.1%
3 points:11.2% - 19.4%
4 points: > 19.4%

The 2016 California Protected Areas Database (CPAD) and the 2016 California Conservation Easement Database (CCED) were used to assess protection status of natural areas. Some additional natural areas have County Sensitive Ecological Area (SEA) status; however, the level of protection afforded through the program was deemed not significant. Database records were overlaid with natural areas. Natural areas falling within protected areas were assumed to be protected and area was measured. Various levels of protection are included in the Databases and may be evaluated to further differentiate protection status. See Appendix B9 for detailed methods and data discussion.

Results Discussion

12.2% (36,885 acres of 301,345 acres total LA land area) of the City is protected, which includes about 59.3% of City natural areas (see Figure 17). Given the number of threatened and endangered species present in natural areas, their high biodiversity, development pressure, and close proximity to such a large population center, increased natural areas protection warrants strong consideration.

Management Implications and Recommendations for the LA Index

1. The proportion of protected natural areas is generally a good indicator and should be included in the LA Index. However, it could be expanded to consider the quality of habitat contained within protected areas and evaluate the distribution of protection based on species, habitats, or ecosystem types.

2. Further evaluation of unprotected natural areas and protection priority and feasibility should be evaluated and included in an indicator that addresses priority areas for enhanced protection.

3. Strengthening protections of SEAs may be low-hanging fruit for expanding protection.

4. Creating a City-wide Multi-Species Habitat Conservation Plan or Natural Communities Conservation Plan, a mechanism developed to streamline the CEQA process and enhance environmental benefits, or something similar to increase protection and coordination of site priorities, should be considered.

5. A mitigation program may be a useful tool to protect key habitat areas and should be considered. The City of LA Transportation Mitigation Program could be a useful precedent. Conservation easement incentive programs administered by the CDFW may also be applicable and should be examined.

6. Strategies for further protections through zoning, easements, and design guidelines should be evaluated.

7. Since natural areas are important features for achieving overall regional habitat connectivity, identifying, protecting, and enhancing corridors may be a convenient mechanism to prioritize and coordinate protection of natural areas.

8. Protection status of non-natural areas that provide biodiversity should be considered, particularly in neighborhoods under-served by natural areas.

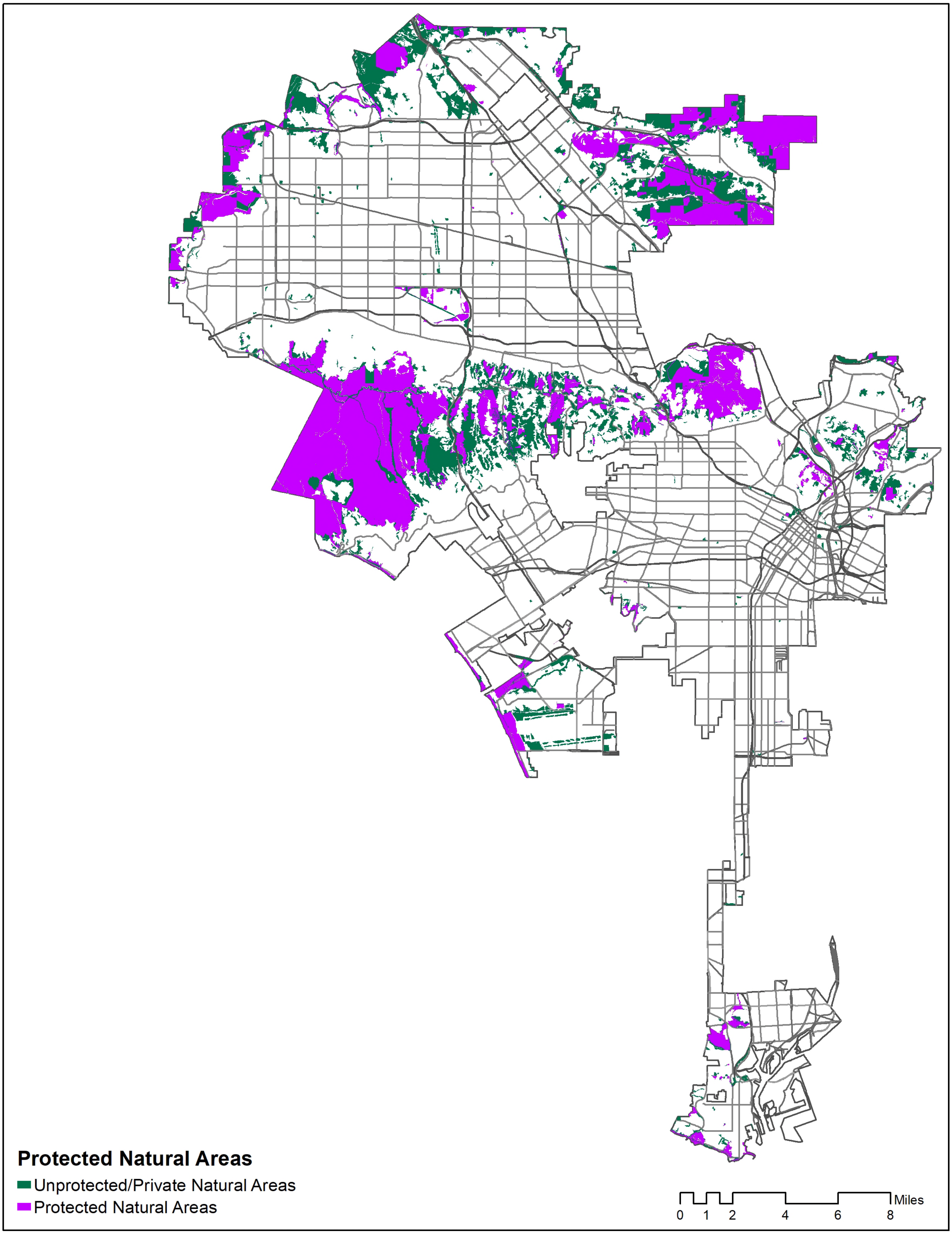


Figure 17: Protected Natural Areas (see Appendix B9 for source data discussion)

Indicator 10: Invasive Species

Isaac Brown Ecology Studio provided data analysis for this indicator.

California Invasive Plants Council (CAL-IPC) Weedmaps were used to estimate presence of invasive plants in the City. Only invasive plants were measured for LA, no spatial data on other taxa, including pests, was identified. A list of California invasive species present in LA is included in Appendix B10, Table 10.2. This dataset contains recorded observations of invasive plants, and their level of "abundance" and "spread" (by USGS Quad) of individual species. It is a subset of the broader CalFlora database. Specific locations within Quads are not provided. Species in all Quads touching the City of LA boundary were included. The % invasive relative to native was estimated by taking the average between the % relative to observed native species and % relative to potential native species (see Indicator 4). See Appendix B10 for detailed methods and data discussion.

Singapore Index Score

2/4

20.0% average of: invasive plant spp. relative to *recorded* native spp. (128/449 = 28.5%); and invasive plants relative to *potential* native spp. (128/1,127 =11.4%)

0 points: > 30.0%
1 point: 20.1% - 30.0%
2 points: 11.1% - 20.0%
3 points: 1.0% - 11.0%
4 points: < 1.0%

Results Discussion

CAL-IPC Weedmaps include 128 invasive plant species identified as present in quads that overlap with the City of Los Angeles. Since all USGS quads touching the City were evaluated, there is a chance some invasives might actually occur in portions of quads outside of the City boundary. More specific mapping of the extent of invasives in the City should be considered. Additionally, CAL-IPC Weedmaps do not address all invasive plant species in the City, and further evaluation of other potential species is needed.

This indicator relies on an accurate measurement of native plant species in the City, per Indicator 4, to estimate the % invasive. Since the list of recorded native species is likely incomplete, we also considered the list of potential species in the City from Calscape.

Lists of invasive species from other taxa are needed for Los Angeles, particularly for insect pests and other threats to native species. A list that includes aquatic BMI invasive species is available from the Los Angeles River Watershed Monitoring Program in their BMI Taxonomy 2008-2016 dataset.

Management Implications and Recommendations for the LA Index

1. The footprint of CALVEG non-native, annual grassland, and giant pampas grass alliances should be monitored as an indicator of the distribution and extent of invasive species.
2. This is an important indicator topic that merits additional attention, since invasive species often receive too little management attention relative to the level of impact.
3. The City should create its own invasive species list. The Department of Recreation and Parks "dirty dozen" should be used as a starting point.
4. Extent of invasive insects, mammals, birds, and pests should be incorporated into an indicator.
5. A system to rank the invasiveness of species in the City is needed. Ranking should include the level of environmental threat and cost of management. CAL-IPC Weedmaps include additional information on local status and threats posed by species and could be a good resource in generating such a system.
6. Invasive insects, fungi, and pests that attack urban trees cause significant financial, environmental, and social impacts. Quantifying the economic impacts of these species may be a useful indicator.
7. County Weed Management Area (WMA) manages high profile weed species, including giant arundo. This, and other similar programs operating in the City, should be monitored as an indicator, possibly including budget and area managed.
8. Sale of weed species and invasive potential of new plants introduced should be addressed.
9. Controlling invasives might be more feasible than eradicating them.
10. Culturally valued invasive species should be addressed and considered independently of other invasive species.
11. Further identification and tracking of aquatic invasive species is needed (in addition to *Corbicula, Procambarus clarkii, and Potamopyrgus antipodarum* discussed in Indicator 7).

Figure 18: Example Invasive Species of Los Angeles

TL: Black mustard;; © Shutterstock; https://la.curbed.com/2017/4/18/15351548/super-bloom-weeds-wildflowers-southern-california
TR: Barb goatgrass, common annual grassland species; http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=7868
BL: Giant arundo; photo by Joseph DiTomaso; http://www.cal-ipc.org/plants/profile/arundo_donax-profile/
BR: Iceplant *(Carpobrotus edulis);* http://www.panoramio.com/photo/4610760

04 Indicators 11-14

Ecosystem Services

"California Wash", Streetscape by Harrison Studio, Pico Street, Santa Monica
Photo by Isaac Brown

Indicator 11: Regulation of Water Quality - Pervious Surfaces

LASAN GIS Group provided data analysis for this indicator.

A GIS analysis of City land use was performed to measure perviousness. The City imperviousness map layer is constructed from two data sources: the 2005 SCAG (Southern California Association of Governments) land use classification layer, and the 2006 Los Angeles County Hydrology Manual, which assigns runoff values for each land use category (see Figure 19). Runoff values range from 0 and 1, indicating total retention and total runoff, respectively. The cutoff value between pervious and impervious has traditionally been set to 0.42, as this is the runoff value for High Density Single-Family Residential parcels, of which most city areas are composed. We also performed the analysis using the 2011 National Land Cover Dataset perviousness layer and found similar results. See Appendix B11 for detailed methods and data discussion.

Singapore Index Score

2/4

62.2% pervious
(187,066 acres of 300,664 acres measured)

0 points: < 33.1%
1 point: 33.1% - 39.7%
2 points: 39.8% - 64.2%
3 points: 64.2% - 75.0%
4 points: > 75.0%

Results Discussion

The primary goal of measuring perviousness is as an indicator of stormwater runoff. Creating runoff estimates for cities is challenging since many factors affect the process, including underlying soil characteristics, slope, and tree and vegetation canopy intercept. This dataset is also based on older land use data, so perviousness has likely decreased further. However, increasingly, green infrastructure (Low Impact Development - LID) in the form of bioswales, underground infiltration features, and rainwater capture are altering stormwater runoff rates and can not be captured in satellite-based perviousness estimates. New measurement methods are being implemented across City Departments to account for stormwater capture. These metrics will be increasingly necessary to integrate with perviousness in monitoring stormwater impacts to water quality, particularly as the City's LID policy is implemented for land conversion to new development over time.

Management Implications and Recommendations for the LA Index

1. LASAN tracks "green acres", which is an indicator that integrates drainage area, perviousness, and stormwater management infrastructure. Since LASAN measures this annually, it is a better measure of stormwater impacts than perviousness alone and could be a more useful metric to measure in the LA Index.

2. LADWP may also have stormwater capture data that could be used to determine impervious areas with reduced stormwater impact. The LADWP Stormwater Capture Master Plan should be reviewed to verify, in addition to contacting LADWP.

3. Schoolyard projects and residential initiatives not requiring permits (e.g., rain gardens) may also be promoted, but could be difficult to track in models.

4. Tree canopy provides stormwater intercept value that is not often included in stormwater management models (usually due to the perceived impermanence of trees). Other plants and vegetation also provide intercept and enhanced soil infiltration. The ways in which these benefits can be accounted for should be examined.

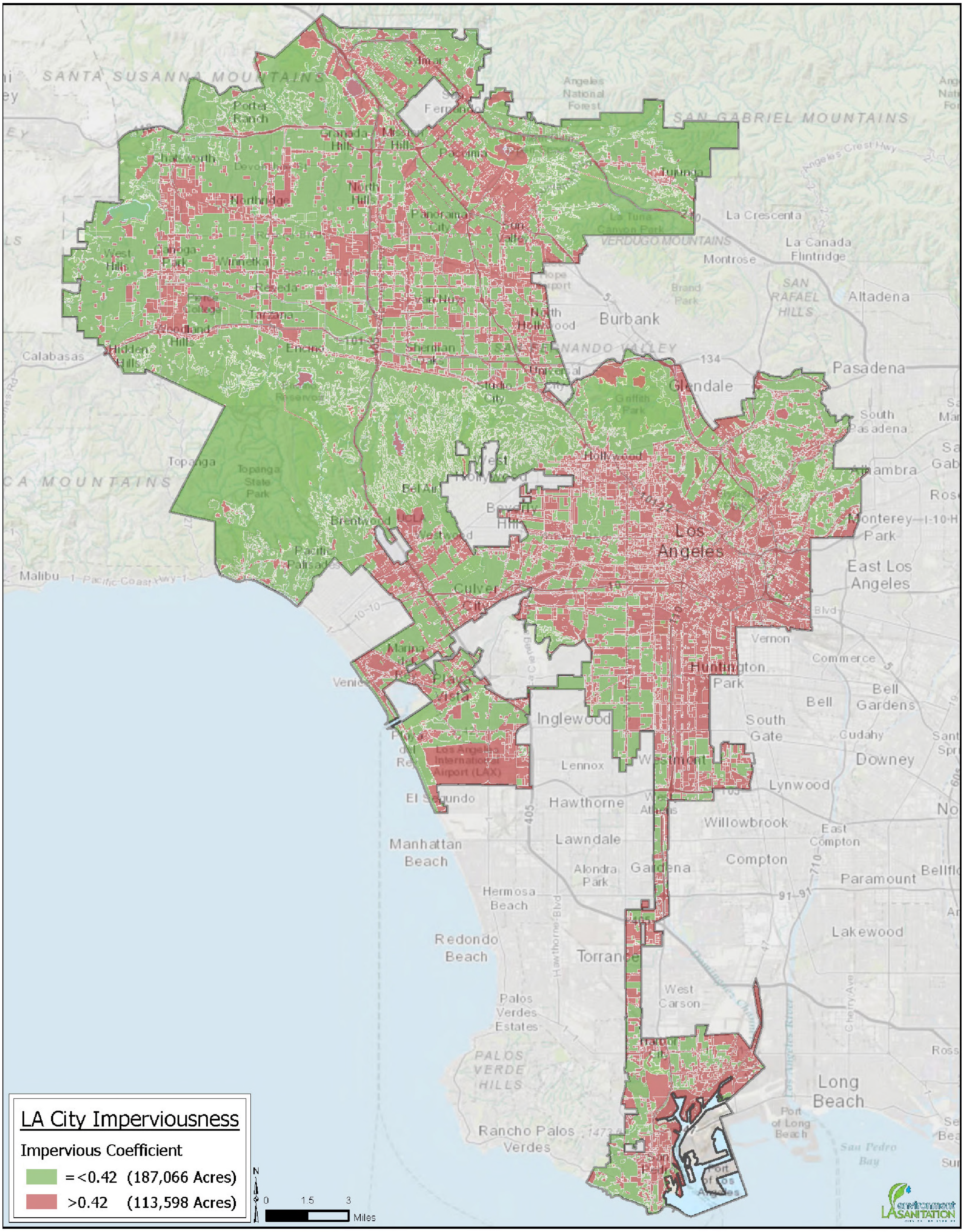


Figure 19: LA City Imperviousness 2005

Imperviousness indicates how much stormwater infiltrates into soil vs. runs off into stormdrains.

Indicator 12: Climate Regulation - Carbon Storage and Cooling Effects of Tree Canopy

LASAN GIS Group provided data analysis for this indicator.

Singapore Index Score

1/4

19.0% tree canopy
(~57,000 acres, or approximately 88 sq. miles)

0 points: < 10.5%
1 point: 10.5% -19.1%
2 points: 19.2% - 29.0%
3 points: 29.1%- 59.7%
4 points: > 75.0%

Tree canopy was measured based on interpretation of 2006 4-inch Color Infrared Orthophotography (LAR-IAC). The spectral band for tree vegetation was extracted and measured for the entire City. Measurements were corrected for error based on manual measurement of six sample plots (additional error correction may further improve this dataset). See Appendix B12 for detailed methods and data discussion.

Results Discussion

Trees provide many benefits to cities including carbon sequestration, criteria air pollutant reduction, local cooling and reduction of the urban heat island effect, habitat, stormwater intercept, traffic calming, and enhanced real estate value. However, some tree species also contribute to ozone formation, damage infrastructure, and are susceptible to pests and disease. Location of trees is also an important factor in the benefits they provide, such as building cooling, pedestrian comfort, and air pollutant removal, and further analysis of this dataset may examine whether the urban tree canopy is optimally configured.

Historically, before the arrival of agriculture and cattle ranching, Los Angeles was a mix of oak savannas, riparian woodlands, and vast areas of shrub-dominated plains and rolling hills. Dense, shaded forests were not common. Therefore, in many of today's natural areas, particularly shrub-dominated uplands, tree planting is not appropriate. Restoration of oak and riparian woodlands in some natural areas may be appropriate and can provide additional biodiversity and ecosystem services benefits.

Management Implications and Recommendations for the LA Index

1. The City's tree canopy should be examined to determine whether it is optimally configured to maximize benefits. Canopy near key pedestrian corridors can improve walkability by providing shade and traffic calming. Canopy can also help reduce temperature in areas of high urban heat island exposure or contribution, provide visual and noise buffers, and intercept air pollutants around freeways and transport centers. However, dense street tree canopies have also been shown to reduce air quality in the pedestrian zone by trapping air pollutants at street level.

2. Estimating carbon storage (carbon stock) contained in trees and vegetation as an indicator of climate change mitigation benefits should be considered. Strategies for measuring and monitoring this metric that do not involve time-consuming field measurements should be explored.

3. Since carbon sequestration may be maximized by planting tree species that are longest lived, largest growing, and/or lowest maintenance, prioritizing planting of such species in the City will maximize the environmental benefits associated with tree planting.

4. Native tree species that are most suitable for urban areas considering impacts from pests, maintenance, and benefits provided should be prioritized.

5. Due to the potentially long lifespan of trees, future climate conditions and species' climate suitability should be considered when selecting species.

6. Since trees can be an indicator of bird diversity, relationships between tree and bird species should be evaluated in Los Angeles, and tree species should be selected to maximize benefits as bird habitat.

7. Carbon sequestration and air pollution benefits of other woody vegetation, herbaceous plants, soils, and wetlands should be evaluated.

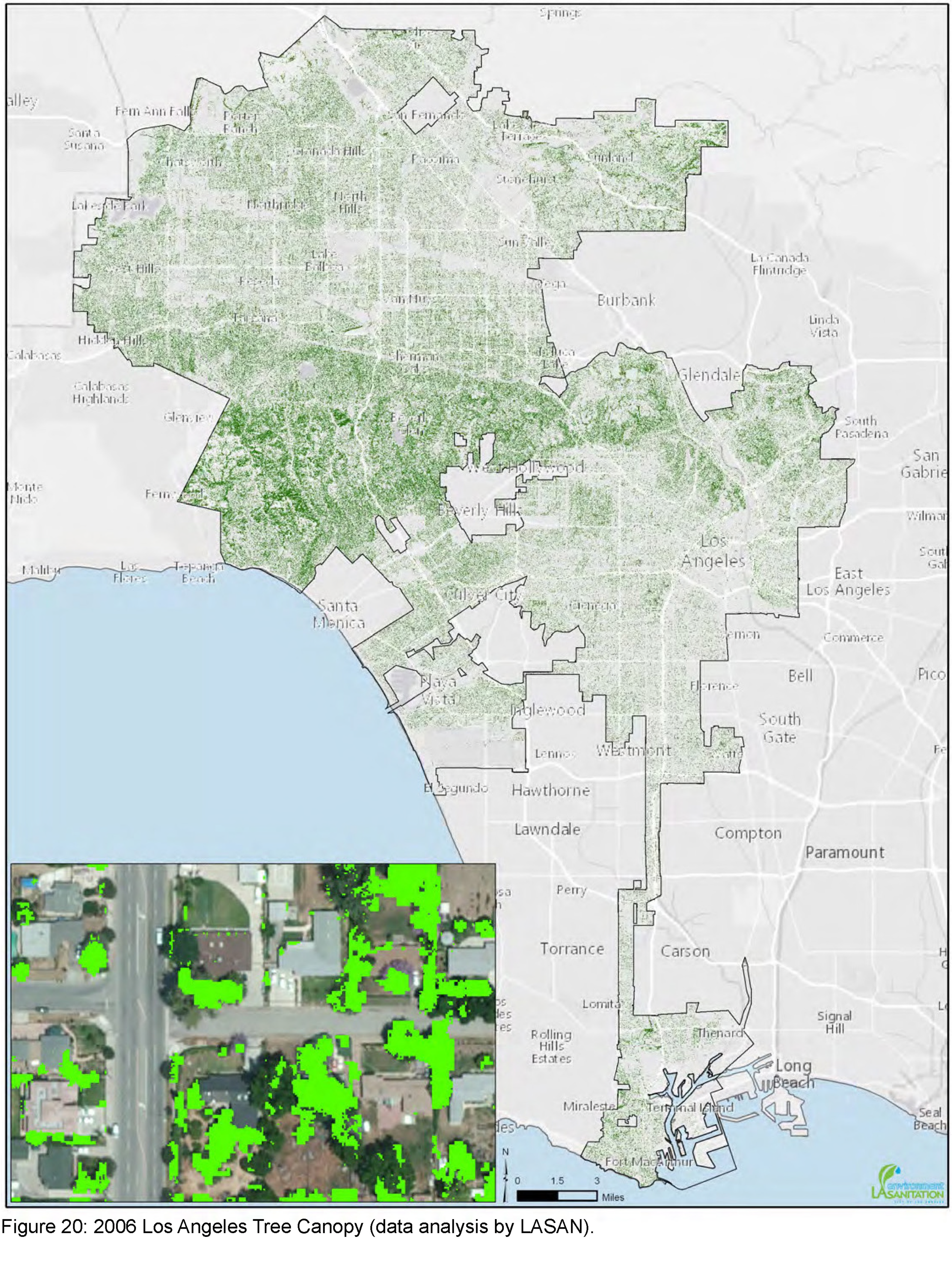


Figure 20: 2006 Los Angeles Tree Canopy (data analysis by LASAN).

Indicator 13: Recreational and Educational Services - Accessible Natural Areas

Isaac Brown Ecology Studio provided data analysis for this indicator.

Singapore Index Score

4/4

3.33 hectares/1000 residents in Los Angeles

0 points: < 0.1 ha/1000 persons
1 point: 0.1-0.3 ha/1000 persons
2 points: 0.4-0.6 ha/1000 persons
3 points: 0.7-0.9 ha/1000 persons
4 points: >0.9 ha/1000 persons

The California Protected Areas and Conservation Easement Databases include accessibility status for each area. Protected natural areas that include open or restricted access were mapped, and the total area of accessible natural areas was measured. Accessible hectares per 1000 residents was calculated based on a total City population of 3.98 million. See Appendix B13 for detailed methods and data discussion.

Results Discussion

The City contains 13,238 hectares (32,686 acres) of natural areas with open or controlled access (see Figure 21). Despite LA's reputation as having some of the lowest access to open space in the country based on proximity, LA excels according to this metric. Angelenos have access to very large, very wild natural areas in relatively close proximity compared to other cities. However, considering proximity to population centers, public transit access, and steep terrain, much of this natural area is difficult to access. Smaller natural areas embedded within the urban areas near population centers would improve access and provide important additional benefits.

Due to the sensitivity of habitats, access is often actively discouraged to protect highly sensitive species. Docent guided tours, and other more intimate access options, are sometimes available in these situations. Restricted access or closed access is often appropriate in many of these cases.

Management Implications and Recommendations for the LA Index

1. Measurement of total accessible area is not a strong indicator for Los Angeles due to the large size and remote location of many natural areas. Much of the terrain in these natural areas is also quite steep and densely vegetated, so much of the area is not actually that accessible. This is a very important topic, however, and additional indicators that better measure the availability of accessible open space are needed.

2. The park access score measurement processes conducted by The Trust for Public Lands for cities across the country should be evaluated as a precedent for measuring access to natural areas.

3. Accessibility may be measured more accurately by expanding the definition of "natural areas" and identifying smaller natural areas in urban areas. These areas should be identified through an improved natural areas and biodiversity inventory process and incorporated into measurements.

4. The City should seek new opportunities for open space such as paving reduction with reinforced soils or creation of new permeable filter layers over impervious areas.

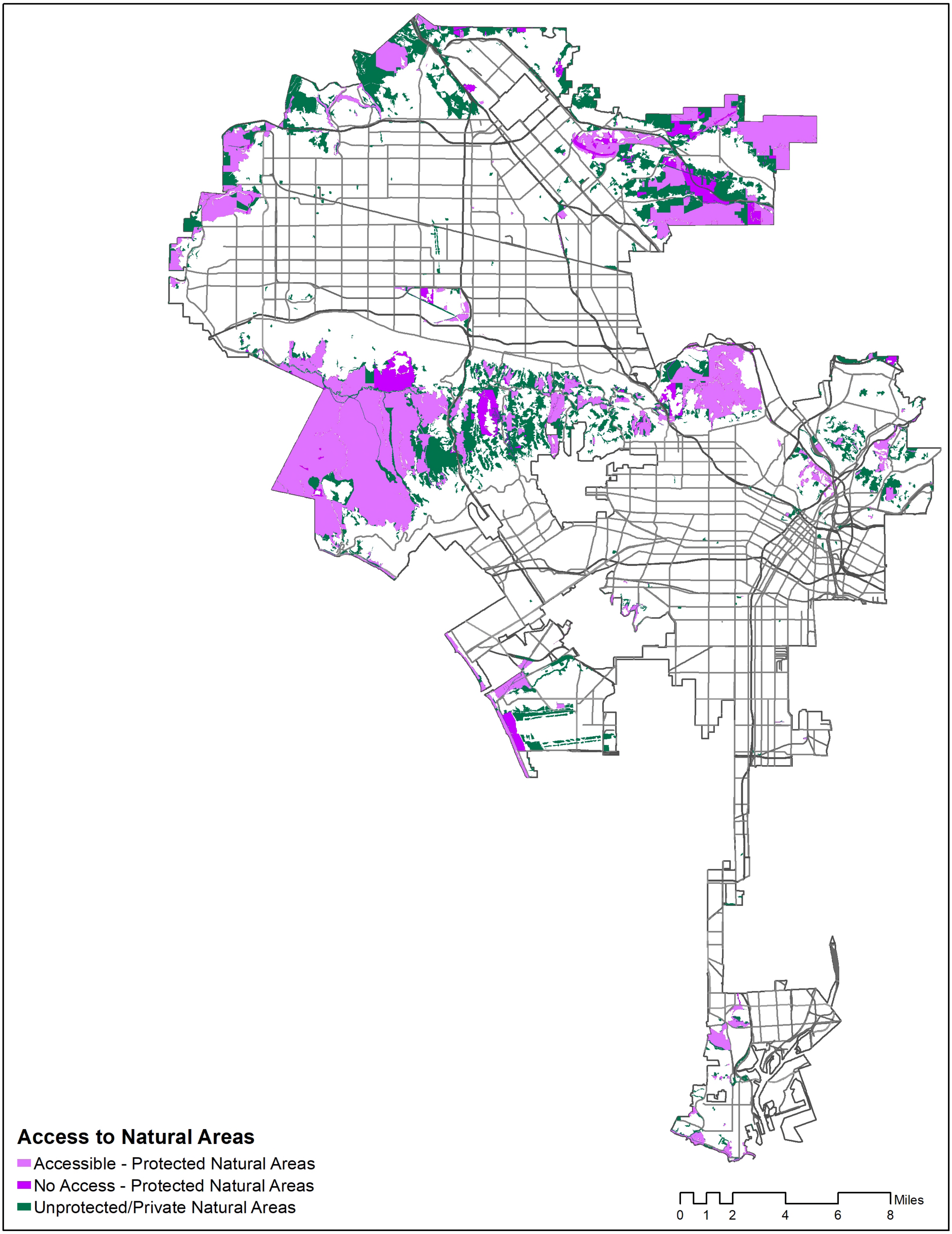


Figure 21: Accessible Natural Areas in the City of LA
This mapping is based on 2016 CPAD and 2000-2010 CALVEG datasets.

Indicator 14: Formal Educational Visits Per Child Below 16 Years to Natural Areas

LASAN provided data analysis for this indicator.

Evaluation of programs at LAUSD schools revealed that only 5th graders in LA participate in formal natural areas visits on an annual basis. Results include the estimate of 5th grade outdoor education visits/total number of students below 16 at LAUSD. See Appendix B14 for detailed methods and data discussion.

Singapore Index Score

0/4

0.09 formal educational visits/year

0 pts: 0 formal education visit/yr
1 pts: 1 formal education visit/yr
2 pts: 2 formal education visit/yr
3 pts: 3 formal education visit/yr
4 pts: >3 formal education visit/yr

Results Discussion

Los Angeles Unified School District (LAUSD), the second largest school district in the nation, is the Local Education Agency for the City of Los Angeles. LAUSD enrolls over 645,000 students from over 720 square miles in the greater Los Angeles area, including the City of Los Angeles, as well as all or parts of 31 smaller municipalities, plus several unincorporated sections of Southern California. In addition to the LAUSD schools, there are nearly 300 charter schools and 1,000 private schools. 5th grade students enrolled in LAUSD participate in the LAUSD Outdoor and Environmental Education camp experience in a natural area. In addition, LAUSD has 26 schoolyard habitats that students can access on their school campuses (See Indicator 22). However, such experiences do not occur annually for all children below 16 enrolled in LAUSD. Students enrolled in grades 9 and 10 and below are usually below 16 years old. There are on average 49,721 5th graders (2012-2017) enrolled per year out of an average below age 16 enrollment population (10th grade and younger) of 557,906 students (2012-2017) (https://www.ed-data.org/district/Los-Angeles/Los-Angeles-Unified); 5th graders make up approximately 8.9% of the below age 16 enrolled student population. Taking 49,721 formal education visits per year and dividing that by 557,906 children under the age of 16, gives us an estimated average of 0.09 formal education visits per year per child below the age of 16. This rounds to zero. For this reason, a zero was given as the score for this indicator.

Management Implications and Recommendations for the LA Index

1. Types of natural areas should be clarified and differentiated. Non-"natural" areas with biodiversity and biodiversity programming should be included with hierarchy/ranking/weighting.
2. An indicator for opportunity to experience schoolyard habitats/natural areas on campus, with distance being part of the indicator, should be included.
3. Educational programming should be considered. Further, quality and quantity of educational visits to natural areas should be addressed.
4. Visits to the zoo, botanical garden, etc. should be included in the count of visits.
5. Indicators should assess strength/quality of education about the local ecosystem and biodiversity (there is currently more emphasis on the natural world in general than the local ecosystem/biodiversity).

Figure 22: LA Zoo & Botanical Gardens Community Programs (http://www.lazoo.org/education/community/)

This page intentionally left blank

05 Indicators 14-23

Governance and Management of Biodiversity

Bigcone Douglas-fir
photo: © stephanomeria
http://www.inaturalist.org/photos/5527134

Indicator 15: Budget Allocated to Biodiversity

LASAN provided data analysis for this indicator.

LASAN prepared a functional budget based on the City of Los Angeles General Plan Conservation Element and identified conservation departments/functions, and contacted selected City Departments to collect data listed in the budget shown in Table 15-2 of Appendix B15. These reported annual expenditures were made by LA Sanitation, LA Rec and Parks, Bureau of Street Services Urban Forestry Division, Zoo Department, and the Department of Water and Power. Other Department expenditures were not provided, so were not included in the calculation; therefore, the amount is likely an underestimate. See Appendix B15 for detailed methods and data discussion.

Singapore Index Score

1/4

~$110M (~1.2%) average annual budget
(includes water quality management for aquatic habitats)

0 points: < 0.4%
1 point: 0.4% - 2.2%
2 points: 2.3% - 2.7%
3 points: 2.8% - 3.7%
4 points: > 3.7%

Results Discussion

The City was given a score of 1, because as Table 15-2 indicates, the total reported budget of ~$110M, or ~1.2% of the City's total budget, is spent annually on biodiversity and ecosystem services administration, including watershed protection, and water quality management in the City. Not all departments provided data for this indicator. As a result, $110M is likely an underestimate.

The City owns and operates the LA Zoo and Botanical Gardens (operated by LA Zoo Department) and the Cabrillo Marine Aquarium (operated by LA Department of Recreation and Parks), whose functions are to help to conserve biodiversity and educate the public about terrestrial and marine biodiversity and its conservation. In addition, the City owns and operates over 16,000 acres of park land. This includes Griffith Park, a biodiversity hotspot in the City of Los Angeles, and wetlands, lakes, and streams managed for recreation, fish, and wildlife. Department of Water and Power, Port of Los Angeles, and Los Angeles World Airports also own and manage lands with protected natural ecosystems, such as the El Segundo Dunes, a federal endangered species recovery unit. The City also maintains a system for stormwater conveyance, capture, and infiltration that increasingly supplies water for the region's landscapes. Wastewater is treated at four regional plants to high water quality levels before being released to spreading grounds, the LA River, the Santa Monica Bay, Los Angeles Harbor, and other water bodies that support local and migratory wildlife. The City has an extensive water quality monitoring program that includes aquatic invertebrate and fish monitoring. Maintaining local water quality helps ensure that biodiversity can thrive in the City of Los Angeles.

The City's General Plan Conservation Element outlines policy objectives for endangered species, habitats, fisheries, forests, and ocean habitats, and identifies responsible agencies (functions/institutions). Specific sites, habitats or species for which conservation activities are required per the Conservation Element are Ballona Lagoon Marine Preserve, Ballona Wetlands SEA (Belding's savannah sparrow and coastal wetlands) and Ballona Creek Channel, California condor, Los Angeles Harbor (California least tern), Venice Beach (California least tern and canal coastal wetlands), California native oaks, and the Los Angeles International Airport (El Segundo blue butterfly) within the City of Los Angeles. Habitats outside the City that are identified include the Grand Canyon-Colorado River Plateau, Owens Valley, Owens Lake, Mono Lake, and San Pedro and Santa Monica Bays. The City of Los Angeles Conservation Element identifies City Departments responsible for the implementation of the conservation policies and programs (functions are listed in Appendix B15, Table 15-2)[35].

Management Implications and Recommendations for the LA Index

1. The index should be more specific as to what expenses qualify.
2. The indicator should be rewritten specifically for LA regulatory, environmental, and planning processes.
3. Eliminating funding associated with compliance with environmental regulations should be considered. It would be more accurate to only include proactive projects that provide net biodiversity benefits and expenditures beyond mandated mitigation requirements.
4. Biodiversity components of capital improvement projects should be included.
5. Biodiversity line items in Capital Improvement Program budget worksheets, program planning budget worksheets, and in the City budget should be included (e.g., special status species, landscape ordinance, protected tree ordinance). This information should be made publicly available to improve data accessibility for measurement of this indicator.
6. All biodiversity and ecosystem services expenses, mandatory and voluntary, should be included. Traditional expenses that provide ecosystem services should be included. Clear cost breakdowns are needed for accurate measurement.

Indicator 16: Number of Biodiversity Projects Implemented by the City Annually

LASAN provided data analysis for this indicator.

The City of Los Angeles has many biodiversity and ecosystem service enhancing projects and programs currently in progress. These projects are in various stages including implementation, design, and planning. The City also has biodiversity- and ecosystem-mitigation, monitoring, and protection projects in progress. LASAN requested a list of projects from City Departments. Projects were designated as voluntary or legally-mandated. Not all departments reported, and therefore this information about the projects is incomplete. See Appendix B16 for detailed methods and data discussion.

Singapore Index Score

4/4

117 biodiversity and ecosystem service-related projects under City of LA leadership

0 pts: < 12 programs/projects
1 pts: 12-21 programs/projects
2 pts: 22-39 programs/projects
3 pts: 40-71 programs/projects
4 pts: > 71 programs/projects

Results Discussion

Appendix B16, Table 16-2 contains a list of current biodiversity and ecosystem services projects identified by City staff. These projects are in various stages of planning and implementation. There are 117 total programs on the list. This list is self-reported by the listed department and has not been verified for accuracy or relevance.

Management Implications and Recommendations for the LA Index

1. Criteria for biodiversity projects should be developed. For instance, “biodiversity” must be a stated objective. Installation of native plant landscapes or other species with known habitat value could also be assessed.
2. Mitigation and compliance projects should not be included.
3. A triple bottom line indicator (i.e., social, environmental, and economic value of projects) should be added.
4. The number of programs, not size or breadth, should be measured to indicate how many times people are talking about something being important for biodiversity.

Figure 23: LA Marine Water Quality Programs
(Left) Cabrillo Marine Aquarium Beach Survey, http://www.cabrillomarineaquarium.org/_photos/beach-survey.jpg.
(Right) Venice Beach, http://www.laparks.org/sites/default/files/styles/xlarge/public/venice/images/gallery/main/Venice-3.jpg?itok=HsS-V5iqH.

Indicator 17: Polices, Rules, and Regulations - Existence of Local Biodiversity Strategy and Action Plan

LASAN provided data analysis for this indicator.

Singapore Index Score

0/4

no local biodiversity strategy and action plan

0 pts: no LBSAP
1 pts: LBSAP, not aligned w/ national plan
2 points: LBSAP w/elements of national plan, no CBD initiatives
3 points: LBSAP has elements of national plan, includes 1-3 CBD initiatives
4 points: LBSAP has elements of national plan, includes 4+ CBD initiatives

LASAN examined status of local biodiversity strategy and action plan (LBSAP) and how it is aligned with the Convention on Biological Diversity (CBD) Aichi Targets. Appendix B17 includes more detailed discussion of methods and policies.

Results Discussion

While the City has high-level planning documents such as the General Plan Conservation Element, and more specific project and habitat management plans, such as the LA River Ecosystem Restoration Project and the LA International Airport El Segundo Dunes Long-Term Habitat Management Plan, the City does not have an overarching Local Biodiversity Strategy or Action Plan. Therefore, the City receives a score of 0 at this time. In addition, existing plans do not include recently published California and U.S. national biodiversity policies that take climate change impacts into account. As such, there are funding gaps for the implementation of biodiversity goals and objectives identified in the Conservation Element (see Appendix B15, Table 15-2) and poor coordination in management of the City's natural resources. The City's 2015 Sustainable City pLAn lists the development of a no-net loss biodiversity strategy as a priority initiative. This SI measurement, and the future customized LA Index are steps toward developing such a strategy. Additionally, the Conservation Element and other General Plan Elements, which address overarching physical planning and urban design in the City, are being updated to address biodiversity and ecosystem services. Additionally, there are numerous other small and large-scale biodiversity initiatives occurring across the City and region; however, the Expert Council reports that most are poorly funded and therefore poorly implemented.

A more detailed biodiversity and ecosystem services physical plan will be included in the General Plan Conservation Element and other Element updates currently in progress, the first updates since 2001. The new Conservation Element will guide projects to address these topics and has the potential to coordinate strategies across the City based on their unique site conditions and opportunities. Aside from these planning documents, there are a number of vision and implementation plans that have biodiversity/habitat restoration and enhancement action elements for different sites in the City. Many City Departments have biodiversity efforts taking place. Efforts by the LA Zoo and Botanical Gardens, Cabrillo Marine Aquarium, LASAN, and LARAP are often voluntary and collaboratively developed, implemented and funded together with stakeholder organizations and agencies. Many biodiversity efforts related to City capital improvement projects are not voluntary or proactive. Instead, they are driven by the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) requirements, water resource protection laws, and coastal development laws, and do not result in net biodiversity benefits because they are often mitigation for other damage. Environmental Impact Reports and Implementation Plans often contain measures related to biodiversity conservation under the umbrella of listed sensitive species, habitats, communities, or water quality. These mitigation measures and permit conditions align with state and national wildlife protection, management and enhancement policies under the jurisdiction of the US Fish and Wildlife Service, and with some of the Convention on Biological Diversity (CBD) Aichi Targets as shown in Appendix B17, Table 17-2. Yet, no unified biodiversity strategy or implementation action plan exists in the City that would support overall biodiversity protection and enhancement goals.

Since the City's 2001 Conservation Element Update, the State of California has released a number of plans that address overall biodiversity including a State Wildlife Action Plan (SWAP), Climate Change Vulnerability Assessment of California's Terrestrial Vegetation, and Safeguarding California Plan: California's Climate Adaptation Strategy. The U.S. Fish and Wildlife Service has also created a non-regulatory National Fish Habitat Action Plan and the Southern California Steelhead Recovery Plan, among other wildlife action plans. In keeping with the City's goal to achieve protection and support for biodiversity, forthcoming updates to the City's Conservation Element must ensure alignment with these federal, state, regional, and local biodiversity efforts. An up-to-date biodiversity strategy and action plan would also help improve the City's ability to obtain State and National (CDFW, FWS) and other funding for biodiversity projects.

Management Implications and Recommendations for the LA Index

1. Specific state and federal policies, guidance, goals, and objectives should be identified. An indicator should be assigned for each and integrated with the LBSAP.

2. Criteria should be developed for scoring project performance. For instance, include number and quality of projects, acreage protected or enhanced, and level of habitat quality achieved.

3. Project managers should evaluate their projects and track project biodiversity score as an indicator.

4. Creation of a biodiversity masterplan and design guidelines should be considered. These should address urban habitat suitability, connectivity, and ecosystem services, with special attention to their relationships to urban ecological hazards, climate change, pollution, and public health. Comprehensive urban ecosystem management frameworks and placetypes (i.e., ecotopes) should also be considered.

5. Processes should be created to ensure science-based, data-driven, and best practices-oriented planning and design approaches are incorporated into biodiversity management. Existing City design codes, engineering standards, planning documents, construction practices, and operations and maintenance practices for opportunities to incorporate such standards should be evaluated.

6. Creating an administrative prioritization indicator that assesses whether the Mayor's budget approval process prioritizes biodiversity and Sustainable City pLAn projects should be considered.

7. A gap analysis of CEQA/NEPA guidelines, environmental review documentation, and approval processes should be performed to ensure that biodiversity is explicitly included in the environmental review process. CEQA/NEPA processes within the City should be monitored to ensure that there is no-net-loss of biodiversity.

8. Indicators to address the relationship between biodiversity and sustainability and resilience should be considered.

9. Indicators for habitat conservation plans, wildlife corridors, biodiversity, etc., in local CEQA Appendix G checklist/ NEPA environmental studies checklists should be considered.

10. Indicators to address consideration of biodiversity in local regulations, codes, and City policies should be considered.

11. Indicators to evaluate effectiveness of the Protected Tree Ordinance should be considered, including expanding the ordinance to protect other habitat (trees, shrubs, vegetation, landscapes, etc.).

Indicator 18: Biodiversity-Related Functions

LASAN provided data analysis for this indicator.

Singapore Index Score

4/4

City uses more than 20 functions

0 points: No functions
1 point: 1 function
2 points: 2 functions
3 points: 3 functions
4 points: >3 functions

Biodiversity Expert Council members and City Departments were asked to identify biodiversity-related institutions necessary for the effective implementation of projects and programs used by the City. LASAN assessed whether the functions of these institutions exist rather than just the physical existence. Two functions may exist in the city under one institution. The number of institutions with biodiversity-related functions was quantified.

Results Discussion

The City of Los Angeles has access to, and uses, a number of different biodiversity-related functions and institutions (See Table 18.2 in Appendix B18). A score of 4 was given, because the City uses more than 3 functions (20 were tallied). The institutions listed in Table 18.2 were identified by Expert Council participants; their biodiversity functions are listed in the table. (The list of functions and institutions is not exhaustive.) Such institutions greatly enhance biodiversity conservation in the City of Los Angeles.

Management Implications and Recommendations for the LA Index

1. This indicator measurement reveals investment by the City, City residents, and stakeholders in biodiversity functions. However, most of the investment is with ex-situ conservation and recovery, research, monitoring, and stewardship development, not always resulting in in-situ conservation and recovery.

2. Consider developing criteria and indicators for level-of-use of functions, not just their existence.

Figure 24: Los Angeles School Habitat Concept
Biodiversity functions provided by NGOs and private-sector professionals are important drivers of biodiversity change in the City. (source: "Urban Wildlife Connectivity Analysis", National Wildlife Federation and Studio-MLA)

Indicator 19: Institutional Capacity - City or Local Government Agencies in Interagency Cooperation on Biodiversity Matters

LASAN provided data analysis for this indicator.

LASAN requested a list of interagency cooperative programs or projects benefiting biodiversity and ecosystem services from City Departments. The number of cooperating agencies on the list was tallied to determine a score for Indicator 19. See Appendix B19 for detailed methods and data discussion.

Singapore Index Score

3/4

5 agencies cooperate on biodiversity matters

0 points: <two agencies cooperate
1 point: three agencies cooperate
2 points: four agencies cooperate
3 points: five agencies cooperate
4 points: more than five agencies cooperate on biodiversity matters

Results Discussion

Interagency cooperation identified by the Expert Council included the following:

1) Santa Monica Bay Restoration/TMDLs: City/local government interagency collaboration for ocean water quality/bay health is spearheaded locally by a state organization, the Santa Monica Bay Restoration Commission (SMBRC). SMBRC has worked with local government agencies to coordinate improvement of water quality and bay health over the last decade, laying the foundation for successful marine ecosystem recovery efforts by SMBRC and partnering cities, agencies, and organizations.

2) Integrated (Water) Resource Plan: The City also has long-term internal interdepartmental cooperative relationships that have helped to lay the foundation for biodiversity health by increasingly moving toward better wastewater treatment and reclamation, stormwater recapture and reuse, and water quality monitoring to ensure the health of LA's water bodies. This partnership between the Departments of Water and Power, LASAN, and other City Departments has resulted in the OneWaterLA Plan.

3) LA River Ecosystem Restoration/Revitalization: An important interagency partnership is embodied in the LA River Office with the Mayor's Office and Bureau of Engineering, Department of Recreation and Parks, LASAN, coordinating with other non-City of LA municipal river restoration partners for the revitalization of the river and development of parklands alongside it. The Los Angeles River Watershed Monitoring Program is another long-standing partnership between the City and the Council for Watershed Health to promote ecological heath of the watershed and community well-being.

4) Prop O Program Multi-Benefit Projects: A partnership between LASAN, City Planning, Bureau of Engineering, Department of Water and Power, and Recreation and Parks also exists for the implementation of multi-benefit projects that improve water quality, increase reuse of treated recycled water, and increase stormwater recapture while restoring drainage systems, wetlands, and other native landscapes, and improving park access.

5) Biodiversity Interdepartmental Team: Recently, for this biodiversity indexing effort, a Biodiversity Interdepartmental Team was formed under the direction of the City Council and with the assistance of Council District 5 and the Mayor's Sustainability Office who have been convening a citizen biodiversity stakeholder group for the last two years. The Interdepartmental Team consists of ten City Departments, Offices, or Bureaus (Los Angeles World Airports, Street Services, Recreation and Parks, Port of LA, Department of Water and Power, LASAN, City Planning, Chief Legislative Office, Council District 5, and the Mayor's Office of Sustainability).

Management Implications and Recommendations for the LA Index

1. Criteria and indicators that demonstrate interagency cooperation pertaining to biodiversity and ecosystem services matters (i.e., ecosystem services, effectiveness, biodiversity, number of successful projects per year and level of quality, acreage restored per year, and level of quality, type of cooperation, co-funding/resource-sharing structure) should be developed.

2. An indicator for advocacy for resources and funding should be included.

3. Indicators should be developed that demonstrate City leadership, raise awareness, and provide educational value to the broader metropolitan area and region.

Indicator 20: Participation and Partnership - Formal or Informal Public Consultation Process on Biodiversity Matters

LASAN provided data analysis for this indicator.

Singapore Index Score

2/4

consultation is proposed as part of the routine process

0 pts: < no routine process
1 pts: being considered as part of the routine process
2 pts: being planned as part of the routine process
3 pts: being implemented as part of the routine process
4 pts: exists as part of the routine process

LASAN evaluated and requested input from other City Departments about existing formal or informal public consultation processes pertaining to biodiversity-related matters and described them here. See Appendix B20 for detailed methods and data discussion.

Results Discussion

Public engagement and consultation are cornerstones of City of Los Angeles governance. There are both formal and informal consultation processes pertaining to biodiversity-related matters that exist as part of the routine process; however, comprehensive biodiversity is not explicit within these processes. Instead, sensitive species and resources that are typically addressed within the CEQA process are emphasized; therefore, a score of 2 was given. Routine formal processes include City Planning and Environmental Planning, Review and Permitting Processes, and Stakeholder Engagement Processes, and the Building and Safety Plan Check and Permitting Process. However, staff have identified areas that need refinement in order for the City to better achieve biodiversity goals and objectives.

In addition to the formal public consultation processes described above, the following consultation activities are also being performed:

1. Council District 5 Biodiversity Working Group/Biodiversity Stakeholders Meetings - Stakeholder group that provides input to elected officials on City biodiversity needs and concerns.
2. Biodiversity Expert Council - Council of biodiversity experts who are assisting the City with the measurement of the City's biodiversity index.
3. LAWA LAX Dunes Advisory Committee - Committee of regulatory agency representatives and two citizens responsible for guiding biodiversity conservation and enhancement activities in LAWA's LAX Dunes nature preserve.
4. Neighborhood Council Stakeholder Meetings.

Management Implications and Recommendations for the LA Index

1. Information on public consultation processes on biodiversity by Neighborhood Councils should be compiled.
2. Information on public consultation processes on biodiversity by the Department of City Planning, Bureau of Engineering, Los Angeles Recreation and Parks, Port of LA, LA World Airports, LA Department of Water and Power, Housing, LASAN, and other department's Habitat Conservation Units should be gathered.
3. An indicator to address environmental justice and the ability of consultations to reach all stakeholder groups accurately and equitably should be added. This should address the equitable distribution of biodiversity enhancements including supporting hydrology.
4. Training programs/certifications for City staff, designers, engineers, and developers; and design and engineering standards for biodiversity should be incorporated into indicators.

Indicator 21: Participation and Partnership - Non-Municipal Partners in Biodiversity Activities, Projects and Programs

LASAN provided data analysis for this indicator.

Singapore Index Score
4/4
City in partnership with 40 or more organizations
0 points: No partnerships 1 point: 1-6 partnerships 2 points: 7-12 partnerships 3 points: 13-19 partnerships 4 points: 20 or more partnerships

LASAN requested a list of cooperative programs or projects with national or subnational agencies/private companies/NGOs/academic institutions/international organizations benefiting biodiversity and ecosystem services, along with the partners with whom the City is collaborating from City Departments. See Appendix B21 for detailed methods and data discussion.

Results Discussion

The City partners with many organizations for international and local biodiversity conservation through the Zoo. In addition, the City partners with local academic organizations, NGOs, and regulatory and natural resource conservation agencies in biodiversity activities, projects and programs, many of which are listed in Appendix B, Tables 21-2 and 23-2. The following list of partners was created by contributors to this report. It is not exhaustive.

1. Angeles National Forest
2. Biodiversity Expert Council
3. Biodiversity Stakeholder Group
4. Council for Watershed Health
5. LASAN Biodiversity Team
6. National Association of City Transportation Organizations (NACTO)
7. Santa Monica Mountains National Recreation Area
8. Santa Monica Bay Restoration Commission/Watershed Advisory Council
9. Zoo partners with NGOs and Countries for at least 25 conservation projects/year (see Table 21-2, Appendix B).

Management Implications and Recommendations for the LA Index

1. The indicator scoring approach should reflect both local and global biodiversity conservation.

2. The rating of partnerships for different aspects of interest such as dollars spent or City/partner ratio of spending on biodiversity and ecosystem services enhancement should be considered.

3. An indicator assessing outside funding received for implemented projects in the City should be considered. It should include names of grantors and show City match. Names of projects, activities, and programs and in-kind donations should be tracked.

4. Community involvement based on job creation and education should be prioritized.

Figure 25: Biodiversity Expert Council Meeting at the Los Angeles Zoo, August 30th, 2017.

Indicator 22: Biodiversity and Nature in the School Curriculum

LASAN provided data analysis for this indicator.

LASAN assessed California state educational content standards for biodiversity components. See Appendix B22 for additional details on methodology.

Singapore Index Score

4/4

biodiversity included in California state science standards

0 pts: not in the school curriculum
1 pts: considered for curriculum
2 pts: planned for curriculum
3 pts: in process of being implemented in curriculum
4 pts: biodiversity included in school curriculum

Results Discussion

Biodiversity is included in the California State Science Standards that govern what is taught in California public schools. Biodiversity is in the biology curriculum at the elementary, middle, and high school levels; therefore, a score of 4 was given.

California State educational content standards describe what students should know and be able to do in each subject at each grade. The Next Generation Science Standards for California Public Schools, Kindergarten Through Grade Twelve (CA NGSS) educational content standards were adopted in 2013, and the current Science Framework, which was based on the CA NGSS was adopted in 2016 (http://www.cde.ca.gov/ci/sc/cf/scifwprepubversion.asp) by the State Board of Education. Biodiversity awareness is included in the 2016 California Science Framework in Grades 3-8, and in high school biology as shown in Table 22-2 in Appendix B22. These standards may be taught in public schools in the classroom and/or in outdoor education and experiential education settings. Examples of LAUSD non-classroom curricular experiences that can increase biodiversity awareness, such as field trips and experiential education through schoolyard wildlife habitats are shown in Table 22-3 and Figure 22-2 in Appendix B22.

Management Implications and Recommendations for the LA Index

1. Indicators for deeper analysis of curricula (e.g., field trips to learn about/visit biodiversity, school yard habitats, and service learning/stewardship activities) should be considered.

2. Separate indicators for “existence” and actual “use” may be useful.

3. Indicators measuring partnership in biodiversity education and enhancement at schools could be worth tracking.

Figure 26: Machado Lake Ecosystem Rehabilitation Project
This multi-benefit project included extensive public outreach and awareness building with the primary goals of improving the water quality, enhancing natural habitat, and providing recreational features at one of LA’s few remaining historic wetlands.

Indicator 23: Education and Awareness - Outreach or Public Awareness Events

LASAN provided data analysis for this indicator.

Singapore Index Score

4/4

City agencies organize over 660 biodiversity events per year

0 pts: 0 outreach events/year
1 pts: 1-59 events/year
2 pts: 60-149 events/year
3 pts: 150-300 events/year
4 pts: >300 outreach events/year

The Expert Council identified City agencies involved in biodiversity outreach or public awareness events within the City of Los Angeles. An estimate was generated based on review and input by City staff from these agencies. Per the indicator requirements, the event should either be organized entirely by City authorities, or there should be a heavy involvement of the authorities before the event can be considered for inclusion in the indicator. This measurement does not include biodiversity-oriented public events that are not initiated by a City Department. See Appendix B23 for additional detailed information as to how the results for this indicator were calculated.

Results Discussion

The primary City agencies that were identified by the Expert Council as organizers of biodiversity outreach or public awareness events were the LA Zoo and Botanical Garden, the Cabrillo Marine Aquarium, and City of LA Park Rangers. The LA Zoo and Botanical Garden organizes 200-260 biodiversity-related outreach events per year in the City. In addition to the daily biodiversity conservation and education operations at their facility, Cabrillo Marine Aquarium organizes 200-260 biodiversity-related outreach events per year, some of which occur off-site. In addition, the City of LA Park Rangers host about 60 walks per year and give many nature awareness presentations. A score of 4 was given, because the City organizes over 660 such events per year, and has biodiversity educational exhibits available to the public year-round. Table 23-2 in Appendix B contains a list of City events identified for this indicator.

Numerous other non-City entities also provide biodiversity outreach and awareness events including the Los Angeles County Museum of Natural History, organizations associated with the LA River, and the Theodore Payne Foundation, among others. The number of events in the City annually far exceeds 660.

Management Implications and Recommendations for the LA Index

1. This indicator should differentiate between local vs. global biodiversity education, perhaps even having separate indicators for each. The indicator should also address depth of analysis/instructiveness.

2. Indicators could be created for awareness building for different local ecosystems/habitats including terrestrial, marine, and freshwater types.

3. Indicators that evaluate awareness/outreach regarding local native plants, landscaping-related activities, urban agriculture, and resilience, etc. should be considered.

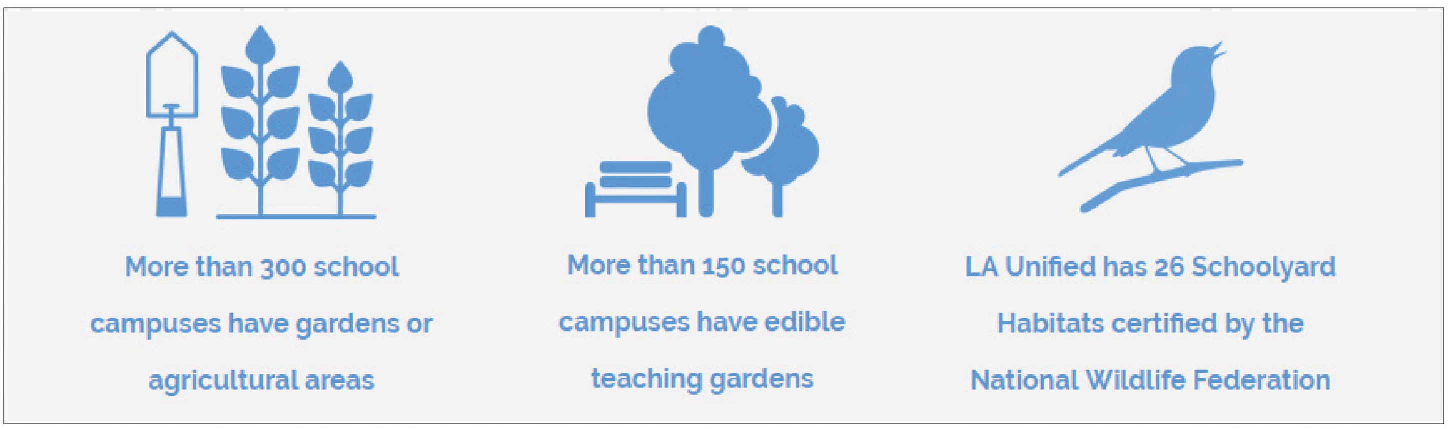


Figure 27: LAUSD Biodiversity-Related Programs
(http://learninggreen.laschools.org/campus-ecology.html)

06 Synthesis

Recommendations for the Customized Los Angeles Biodiversity Index and City Biodiversity Practices

California Quail, Santa Monica Mountains
photo by Nurit Katz

06 Recommendations for a Customized Los Angeles Index and City Biodiversity Practices

Measurement of the Singapore Index (SI) for the City of Los Angeles allowed participants to evaluate its suitability as the primary index for monitoring and managing LA's biodiversity. Based on the recommendations received from participants, the SI alone is not an adequate tool. Modifications of SI indicators, and new indicators are needed. Specific recommendations for modifications to SI indicators, and related management activities, were included with each SI indicator score in the previous sections. The following synthesis includes additional indicators and overall improvements to be addressed in the future LA Index, along with discussion of associated management activities and recommendations. Recommendations are grouped by major themes that may form the overall structure for the LA Index.

A. General Recommendations

1) Update and expand characterization of biodiversity in LA as a foundation for indicators, including characterization of equitable access to biodiversity

Indices like the Singapore Index rely on availability of data. Data availability for biodiversity in urban areas is limited and will require further gathering and processing to fully characterize biodiversity. Providing a full characterization of biodiversity in the City is a foundational step for creating a customized index. The Singapore Index process revealed that our understanding and formal characterization of biodiversity in Los Angeles is mostly limited to large natural areas (e.g., the LA River). Our understanding and characterization of biodiversity of landscapes in built areas is limited and should be expanded. Google street view, citizen science, and remote sensing methods such as NDVI and LIDAR may be used to assess biodiversity of these areas. Individual project areas subject to the CEQA process have also been characterized, and review of these documents may provide useful information. Processing and assembling these datasets, and others, to provide a uniform characterization for the entire City should be explored.

CALVEG and Citizen Scientist Data from iNaturalist are the only relatively complete and methodologically uniform characterizations of biodiversity in the entire City. CALVEG provides uniform sampling across the entire City, but is oriented toward vegetation only and is more than 15-years old. The level of precision also deteriorates at finer scales and newer high resolution processes will greatly improve the product. Updating this data set using satellite remote sensing processes should be evaluated. iNaturalist provides a less uniform sampling across the City, but has the potential to cover all species. Strategies to leverage the platform to provide a measurement of species presence, distribution, and abundance should be explored. Additionally, mapping according to other classification systems oriented toward species conservation, such as Sawyer, Keeler-Wolf, and Evans classification system, should also be considered.

2) Incorporate environmental justice/equity into indicators

Most indicators can be viewed through an environmental justice/equity lens, including access to nature and biodiversity, cultural sensitivities and values of biodiversity, and potential disproportionate impacts or benefits of urban ecosystem services (i.e., ecosystem services supply and demand). Aspects of this important topic can be embedded within multiple indicators throughout the future index. Environmental justice considerations should also address Native American (Gabrielino/Tongva and others) cultural sensitivity and values of local biodiversity and landscapes.

3) Provide more location-based indicators

The Singapore Index requires very little assessment of spatial context such as distribution, populations, or patterns of biodiversity. Conservation and enhancement activities may be more valuable in some areas than others, such as: improving access to biodiversity in under-served areas; enhancing broader ecosystem benefits by considering the City's role in providing regional habitat connectivity; or optimizing supply and demand of urban ecosystem services by locating tree canopy in high pollution or urban heat island areas. These kinds of spatial context-based indicators should be included in the index and will rely on an improved characterization and mapping of biodiversity across the City per Recommendation No. 1.

4) Have more urban emphasis

With the exception of the "birds in built-up areas" indicator, most SI native biodiversity indicators are oriented around large natural areas. Better characterization and indicators for native species and other beneficial biodiversity within urban areas are needed. New indicators that address equitable access to biodiversity in urban areas are also needed.

5) Address the Owens Valley and other nonproximal ecosystems associated with the City

The Singapore Index is oriented around biodiversity within the urban footprint. The City's activities in the Owens Valley and impacts in Santa Monica Bay and Los Angeles Harbor are direct impacts that should be considered. Additionally, impacts based on where we get additional water, power, and other resources could be evaluated.

6) Consider relationships to adjacent ecosystems, communities, and counties

The City plays a role in the biodiversity across its borders. This is particularly true for habitat connectivity and biodiversity in locations, such as Santa Monica and Baldwin Hills, which are surrounded by the City. There are many benefits that can be gained from addressing biodiversity at a regional extent, including improved habitat connectivity.

7) Place emphasis on "quality" in addition to "quantity"

Many SI indicators emphasize inventories of programs, species, etc. The future index should expand to address the quality of those programs, habitats, etc. Weighting systems, ordinal rankings, and other approaches to evaluating quality should be explored.

8) Leverage citizen science

Citizen science has great potential to improve data availability across the City. Initiatives to improve, expand, and focus this activity around key data needs should be emphasized.

9) Leverage research activities at local universities, NGOs, and agencies, etc.

Evaluate how research is improving our understanding of biodiversity and ecosystems in LA, including key research gaps, strengths, applicability in applied management, and levels of support for such research.

10) Normalize the indicator performance levels and score thresholds

Many of the Singapore Index indicators rely on total numbers of species, acreages, etc. Instead, consider measurements relative to existing or natural conditions by measuring percentages. For example, instead of total native bird species in built-up areas, set performance thresholds as percentages of the total number of native species throughout the entire City or in natural areas. Measuring percentage change from year to year is another more useful approach.

B. Native Biodiversity Indicators

1) Species indicators should measure distribution and population size, species richness, and genetics

The Singapore Index emphasizes total species richness of the City. However, distribution of species in the City and population sizes are important indicators to better address potential benefits of future management. Species richness in individual parks, neighborhoods, or ecosystems would help characterize the distribution and access to biodiversity across the City. Citizen science, such as eBird and iNaturalist, may be leveraged to accomplish this, but will likely require focused initiatives. Genetic diversity is an important component for understanding diversity and sustainability of species, and genetic diversity within species across the City should also be evaluated through scientific study.

2) Create a habitat quality index for existing/planned landscapes

The Singapore Index emphasizes "natural" landscapes as the top priority for biodiversity conservation. However, quality of natural landscapes and other non-native landscapes can also provide biodiversity value. Size, connectivity, and structure of landscapes are also important factors. Additionally, some areas of the City with limited access to natural areas may gain biodiversity value from non-native landscapes or built infrastructure that provides habitat value. A strategy for valuing landscapes for their biodiversity value in context that takes multiple factors into account is needed.

3) Consider additional taxa and indicator species

Indicator species are easier to measure and monitor than overall biodiversity. Identify a key set of indicator species for use in the index. See additional discussion of indicator species in SI Indicators 4-8 Recommendations.

Additional taxa should also be considered including fungi as an indicator of soil and habitat quality (perhaps better than vegetation). The presence of intact native soils is also easy to track and map and is more resilient than vegetation, which may be more susceptible to disturbance. Lichens may also track air quality. Marine species such as grunion and abalone may be useful for monitoring the Santa Monica Bay and Los Angeles Harbor.

4) Consider enhanced indicators of habitat connectivity

Identify key corridors, stepping stones, and least cost paths for biodiversity to move in and through the City and evaluate progress toward protecting and enhancing connectivity. Key areas for connectivity include:

- Debs Park to Griffith Park
- Debs Park and Griffith Park to Chino Hills
- Griffith Park to Verdugo Mountains
- Baldwin Hills, Santa Monica Mountains, Ballona Wetlands, LAX Dunes and Palos Verdes
- Santa Monica Mountains, Sepulveda Basin, Santa Ynez Hills and Verdugo Mountains
- LA River and coast to all major habitat patches.

Habitat core areas should include two priority routes for connectivity per best practices of conservation design. Assessment of habitat connectivity value provided by urban landscapes between numerous smaller urban biodiversity areas should also be considered.

5) Include indicators that address edge effects on open space and corridors

Consider the effects of night lighting, noise, pets, fuel modification/fire management, etc., from development on adjacent open space and wildlife corridors.

6) Establish landscape cover type priorities

Plant communities are foundational for biodiversity. Relatively self-sustaining natural ecosystems that are high-integrity are most important to protect, and some plant communities are rarer than others. For example, riparian areas that are still interconnected, soft-bottomed, and directly influenced by key natural processes including flooding that support self-germination and resist exotic invasive species are irreplaceable. The California Wildlife Action Plan emphasizes the significance of wetlands and riparian areas for the Los Angeles area: mesic habitat that supports more wildlife across landscape cover types than any other in our semi-arid climate. Today less than 5% of our historic wetland and riparian habitats remain. Wet meadow has been extirpated completely.

7) Improve understanding of historic ecology of LA as a benchmark for restoration, biodiversity enhancement potential, and ecosystem services opportunities.

Estimates and maps of the historic pre-European landscape of Los Angeles can serve as a benchmark for environmental performance, a framework for biodiversity enhancement, and an information source for ecological innovation. Similar work has been completed for New York in the Mannahatta project, which has been featured in National Geographic Magazine[36]. Evaluate the level of impact to native ecosystems and identify key priorities and opportunities for restoration, including unique ecosystems that may be largely lost, but have potential for restoration and contribution to broader ecosystem function and services. Build from historic ecosystem mapping work that has already been completed for the Elysian Valley and the San Gabriel River/Rio Hondo Watersheds. Also, consider historic Gabrielino/Tongva and other Native American land uses, processes, and cultural landscape features.

C. Access, Perception, and Behavior Indicators

1) Measure access to biodiversity and use to locate biodiversity enhancement in underserved areas

Human dimensions of biodiversity, including access, equity, and cultural values, should be incorporated. Expand on this, include specific methods for measuring population density, distance to natural areas, and identification of relatively high quality hot spots. Community areas used for accessing biodiversity, including natural areas and other more urban biodiversity areas, should be surveyed and incorporated into indicators.

2) Implement enhancements to biodiversity in areas identified as "undeserved"

Once underserved areas are identified, track progress toward addressing the gap. Identify key opportunities for biodiversity enhancement, particularly those that might provide multiple benefits, such as improved habitat connectivity and ecosystem services (e.g., air pollution reduction).

3) Improve perception and behavior toward biodiversity and measure changes

Evaluate community perceptions of biodiversity. Consider programs to raise awareness and appreciation of biodiversity. Encourage the public to be knowledgeable about wildlife habitat/corridors and how to care for them. Advocate for use of nontoxic personal care products and appropriate disposal of pharmaceutical waste with a freshwater fish advocacy campaign.

4) Increase access to native plants and improve integration in landscape management industry

Evaluate sales in nurseries and retail stores for native plants and/or those that improve ecosystem services/conservation (i.e., water-efficient, non-native plants). Train landscape designers and managers to design, install, and maintain native plant landscapes. Control the sale and propagation of invasive species.

5) Improve accessibility and awareness of existing natural areas

Have City Department of Transportation and City Department of Recreation and Parks Park Rangers collaborate with LAUSD Environmental and Outdoor Education Division to increase formal education visits to natural areas in the City and raise awareness of public transit access to natural areas.

D. Ecosystem Services Indicators

1) Expand indicators of local urban ecosystem services (pollution mitigation, climate adaptation, urban heat island reduction, walkability, urban agriculture, local water supply, etc.)

Evaluate the City for supply and demand of urban ecosystem services emphasizing tree canopy, vegetation, soils, other natural features, natural hazard protection, and pollution mitigation. Evaluate tree canopy and urban cooling features to mitigate extreme heat and the urban heat island. Evaluate shading around key areas for pedestrian movement (e.g., first/last mile, transit lines, etc.) to improve pedestrian comfort and traffic calming/buffers (i.e., walkability). Evaluate distribution of recycled water for use in landscape irrigation, which is the foundation for other urban ecosystem benefits like biodiversity, cooling, and shade trees, etc. Urban agriculture encourages contact with nature, mental health/well-being, healthy food, etc. Craft indicators to measure whether ecosystem services are being optimized over time.

2) Consider expanding climate regulation indicators to include enhancing landscape carbon storage in trees, vegetation, and soils and the cooling benefits of trees

Carbon stored in the urban forest can mitigate climate change and contribute to reduced City greenhouse gas emissions. The California Cap and Trade Program includes protocols for measuring urban forests to receive carbon credits. The longest-lived, largest-growing, and lowest-maintenance tree species appropriate for site contexts are most beneficial. Efficient ways of measuring and monitoring stored carbon are needed. Tools like iTree measure stored carbon and also estimate the cooling benefits of trees and associated reductions in building energy use, which may also be incorporated into indicators. Protocols also exist for measuring and receiving credit for carbon stored in soils and wetlands.

3) Consider ecosystems services indicators focused on climate change resiliency and sustainability

Consider ecological impacts of climate change on the built environment and the relationship with urban ecosystem characteristics including *resilience* (ability to recover from stress/impacts), *resistance* (ability to withstand stress/impacts), and *responsiveness* (ability to adapt and change in response to stress/impacts)

3) Consider cultural ecosystem services indicators

Ecosystems and landscapes provide a variety of cultural ecosystem services including recreation, civic opportunities, aesthetics, and educational value. For example, because of the relatively steep topographies in the City, we have opportunities to develop tremendous vistas providing visual connections with the natural landscape. Capturing this cultural opportunity, and others, in indicators as we redevelop the City could be beneficial.

E. Pollution and Ecological Hazard Indicators

1) Include indicators that address specific types of pollution

Address soil contamination, air quality, water quality, urban heat island (thermal pollution), light pollution, and noise pollution.

2) Consider indicators addressing relationships between the built environment and local ecological hazards.

Address sea-level rise/coastal flooding, riparian flooding, wildfire, landslides/erosion, tsunami, and liquefaction hazards.

3) Integrate ecosystem services management between urban and natural areas.

Develop systems for integrated management of ecosystem services between natural ecosystems and human infrastructure/ecosystem (e.g., One Water LA, wastewater/organic waste to energy and fertilizer, etc.)

F. Education, Awareness, and Advocacy Indicators

1) Expand indicators of educational programs, practices (life-long learning)

Increase visits by schools and other educational entities to natural areas, the LA Zoo, Natural History Museum, botanical garden, and other nature/biodiversity areas. Conduct additional biodiversity education and outreach awareness efforts through the public library and school systems, including use of natural areas and biodiversity stewardship efforts.

Continue to partner with California Department of Fish and Wildlife's Fishing in the City Program for stocking of fishing lakes in the City. Collaborate with CDFW to offer more frequent fishing and aquatic education clinics in City Parks, and include water quality education and program criteria in the training. Provide similar training/ presentations to municipal managers and decision-makers.

Plant demonstration food and ethnobotanical plants (e.g., herbs, shrubs, and trees) where citizen orchard and garden stewardship groups are established to harvest them. Engage the public in educational activities that include food gathering and use and citizen science: gathering, evaluating and using plant data to improve food and flower plants (horticultural science). Horticultural education programs can be administered by UC Cooperative Extension, possibly at demonstration areas to provide hands-on learning.

Include soil health and water quality programs. Provide similar training/presentations to municipal managers and decision-makers. Demonstrate key, cost-effective strategies that empower the public and agencies to meet regional goals. Partner with local organization such as the Theodore Payne Foundation, California Native Plant Society, and the River Project on water capture and conservation programs focused on native plants and soil as important foundations of resilient systems, habitat, and wildlife.

2) Measure native habitats and ecosystem services on school campuses

Measure campuses establishing native biodiversity gardens, habitat, and ecosystem services on site (e.g., rainwater capture, tree planting, food gardens, etc.) and encourage others to follow suit.

3) Measure local biodiversity education

Encourage school curricula to incorporate education related to local ecology. Evaluate biodiversity curricula to evaluate emphasis on local vs. global biodiversity. Expand education of local ecology, including emphasis on coursework in the field. Leverage location in Global Biodiversity Hotspot to create world class, place-based ecological education programs.

4) Measure quality of education

Include indicators that address quality of education programs, in addition to presence of programs.

5) Operations and Maintenance education and outreach

a. Implement a policy and process for sustainable funding and O&M of stormwater facilities and all green infrastructure because these features should be budgeted as capital investments.
b. Consider tree and plant improvement program that includes genetic testing; selection and breeding for resistance to diseases, insects, and adverse environments such as street tree wells; and data- and science-based vegetative propagation. If contracting out, pay for this service and trees grown in a scientific manner, instead of paying for just replacement trees; pay for applied horticultural science services, not just trees. Manage the urban forest adaptively.
c. A GIS database inventory of urban forest resources may facilitate more effective management and measurement of future indicators.
d. Consider developing a masterplan for urban reforestation and biodiversity protection, maintenance, and enhancement (including tree removal and replacement).
e. Consider more planting of California native trees, shrubs, and herbs, throughout the City. In deciding where and how to plant native plants, take into consideration ecosystem services value; some trees may be better suited to parklands than to City streets, etc. If contracting out, purchase applied horticultural science services, not just plants or landscaping.
f. Evaluate beneficial insect partnerships with UC Cooperative Extension.

6) Native American cultural awareness

Incorporate biodiversity that is culturally significant to indigenous tribes of Los Angeles, including the Gabrielino/Tongva. Consider ethnobotany, native species, and landscape features and engage local tribal experts/stakeholders in the process.

G. Governance and Management Indicators

1) Craft indicators around a vision and targets for biodiversity in Los Angeles

Indicators are most useful when tracking progress toward goals. Create a Local Biodiversity Action Plan while creating the Los Angeles Index. Ensure that plan targets are oriented around the indicators. Clearly define "success" in the context of such a plan to make sure achieving targets is meaningful. Take care to ensure that the plan, and associated targets, accurately measure progress and successes.

2) Craft indicators around management practices that shape biodiversity

Good indicators are sensitive to land management activities. Evaluate City activities that influence biodiversity and identify key points of management and enhancement opportunities.

3) Measure the existence of biodiversity protocols, processes, and policies within City Departments.
Track the number of policies and the reach.

4) Create a biodiversity measurement protocol for projects in the City that alter landscapes

Use a protocol to track the amount of biodiversity influenced by the City in terms of land area and quality of impacts or enhancements. Place emphasis on green infrastructure, LID, and open space projects.

5) Secure and quantify incentives for biodiversity enhancement

Consider a grant program or other strategies to encourage biodiversity projects across the City. Measure performance. Collaborate with other agencies; secure funding for bundled projects.

6) Planning/Code and Standard Development and Enforcement/Project Design and Implementation

a. Review the Los Angeles Greenways to Rivers Arterial Stormwater System (GRASS) document (https://www.asla.org/2017awards/327241.html) for opportunities for urban biodiversity and biodiversity-based ecosystem services protection, maintenance, and enhancement.
b. Considering GRASS, One Water LA, and the LA River initiatives, a new Urban Hydrology and Water Element (or possibly as part of the Open Space Element) may be an appropriate addition in the General Plan 2040 update. Water is a unifying feature connecting the City and key to optimizing these multiple parallel initiatives.
c. Review formal/informal consultations, codes and standards, departmental performance metrics, and project and annual budgeting processes for opportunities to encourage biodiversity and biodiversity-based ecosystem services protection, maintenance, and enhancement.
d. Align the General Plan Conservation and Open Space Elements with state, federal, and regional biodiversity and climate change adaptation policies.
e. Consider developing a comprehensive biodiversity vision, strategy, and action plan that includes spatially specific landscaping standards. Include historic, current, and desired urban ecosystem/ecotope/urban-wildland interface maps. Include information on biodiversity and potential biodiversity, protected and special status species and habitats at the site scale. Inventory and address threats to biodiversity. Include definitions for biodiversity, preservation, restoration, and enhancement. This document should be a physical masterplan for biodiversity enhancement, preservation, and mitigation across the City. The vision statement should be officially adopted by the City and be understandable to the public, conserve endemic species/plant communities and species quantity, promote ecosystem function and environmental quality, create a centralized biodiversity institution (with staff), serve as a valuable tool with which to advocate for biodiversity and obtain funds to implement projects, and contain a monitoring and reporting program that is adopted by the City. Include the strategy in City General Plan Elements (e.g., Open Space, Conservation, Health) and in project planning, design, funding, review and approval, and implementation checklists.
f. Perform gap analysis of City permits and approval processes and ensure that biodiversity protection, maintenance, and enhancement measures and training are included and prioritized. For instance are protected tree ordinance requirements at the top of the Building and Safety permit checklist? Are existing trees/habitat prioritized for protection, including deterring construction and parking beneath them? Is there a 2:1 replacement requirement or other mitigation requirement?
g. Consider ban on invasive species. Create criteria for complete and ongoing elimination of invasive species from a property as a condition for a City permit/approval/lease/contract.
h. Develop policy and regulatory instruments (codes and enforcement) in support of state and federal biodiversity and climate policy implementation in the City.
i. Improve soil quality throughout the City. Reclaim areas with contaminated soils for biodiversity enhancement and ecosystem function improvement.
j. Recognize critical significance of riparian and wetland resources, and imperative to conserve them as critical resources.
k. Add biodiversity and ecosystem services protection, maintenance, and enhancement to values and criteria considered when value engineering of projects takes place.
l. Revise construction site preparation protocols to incorporate best management practices for biodiversity and ecosystem services and function protection, maintenance, and enhancement.
m. Develop intersectoral best management practices for biodiversity, ecosystem function and services protection, maintenance, and enhancement, and disseminate and train developers/industry/others about them.

n. Update the City Landscape Ordinance with biodiversity, biodiversity-related ecosystem services, and ecosystem functions protection, maintenance, and enhancement best management practices.
o. Prohibit sale of exotic invasive species listed as top concerns for the City (e.g., by Parks and Recreation, Community Forestry Advisory Committee)
p. Review and revise City plant and tree lists to support biodiversity, including City parkway plant lists and tree lists, to emphasize native and climate-resilient material and practices.

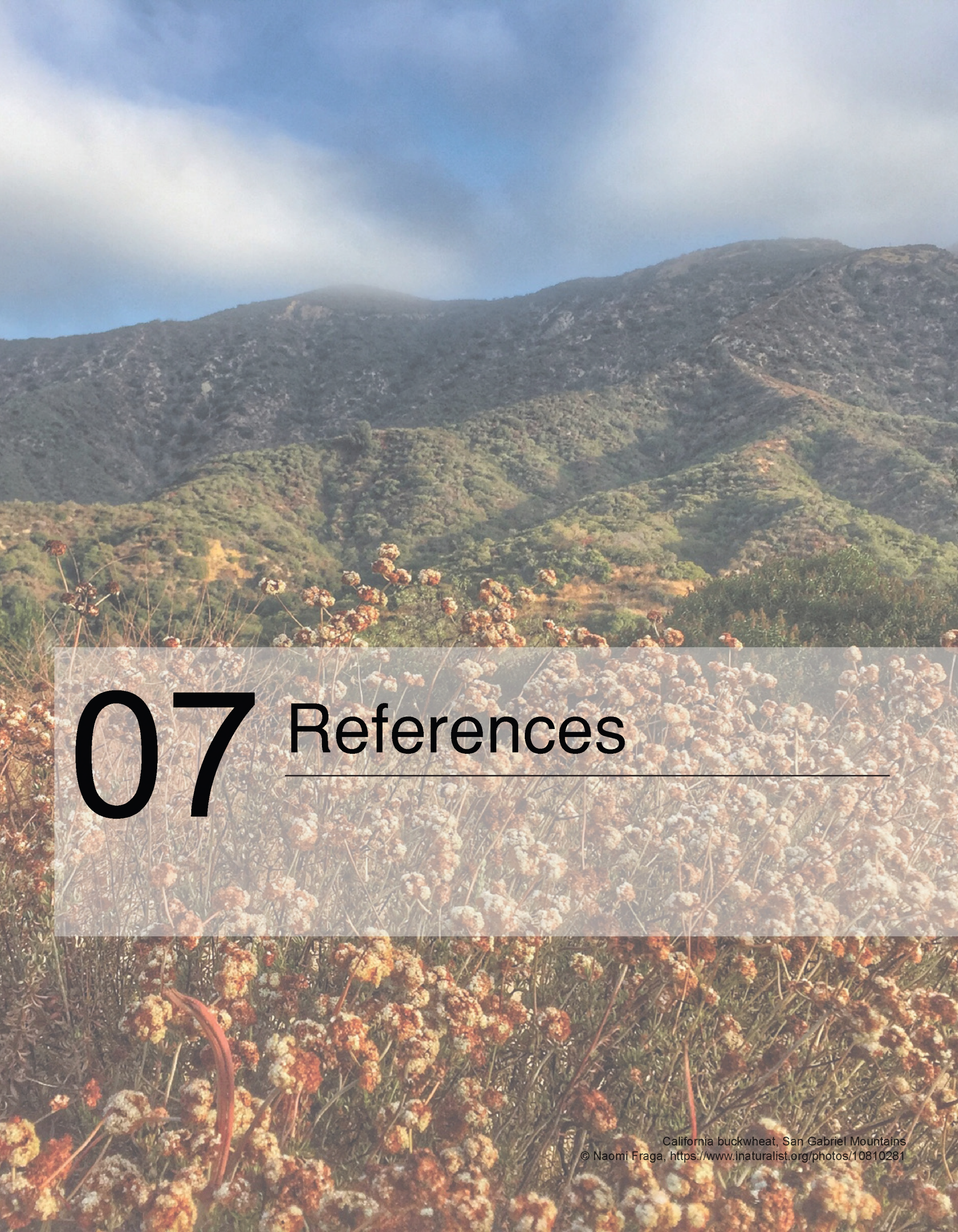
7) Administration/Resource Development and Assignment

a. Consider performance metrics for departmental management of City landscape and biological resources, such as plant, insect, fungal, and wildlife species, habitats, ecosystems, protected natural lands. Allocate funding for programs and resources that can help departments meet performance requirements.
b. Consider performance metrics for departmental prevention of air, soil, and water pollution, as well as resiliency and climate change adaptation.
c. Review gaps in Table 15-2 in Appendix B for opportunities for additional biodiversity investment. Assign adequate resources to biodiversity and biodiversity-based ecosystem services protection, maintenance, and enhancement.
d. Using identified biodiversity enhancement projects, consider a mitigation bank in the City, and a separate fund for O&M administered by the City's lead "environmental" entity, that requires developers (including City Departments) to purchase mitigation credits with proceeds used for biodiversity enhancement projects. Create an online tool for the public to track and contribute to biodiversity efforts.
e. Consider creating an entity dedicated to monitoring and managing invasive species from City landscapes, waterways, and natural areas.
f. Consider policy enforcement program resources for biodiversity and ecosystem services policies.
g. Consider allocating grant writing/administration resources, GIS/IT resources, and scientific/technical resources for biodiversity and ecosystem services management.
h. Consider allocating scientific/technical resources for CEQA/NEPA biological resource and ecosystem services mitigation/environmental commitment measures implementation, monitoring, and reporting. Limit approval of projects that require major mitigation to offset impacts.
i. Invest in training and certification programs to train operations and maintenance staff in best practices for landscape care and climate resilience. Gardener/caretaker, tree surgeon, conservation manager, and similar functional classifications should have horticultural science or similar education. Contract with UC Cooperative Extension to provide horticulture/urban forest management/urban ecosystem and biodiversity education to these City staff. Require classifications that manage these classifications to receive similar training, but on a management/program design/operation level. Provide similar training/presentations to municipal managers and decision-makers.
j. Consider contracting with designated state or regional conservation management agencies for the maintenance, and management of City natural resources such as species, habitat, ecosystems, wildlife corridors, and ecosystem function and services.
k. Include biodiversity and ecosystem function in legislative and regulatory advocacy agendas (e.g., advocating for a biodiversity and ecosystem function analysis category in CEQA and NEPA).

Next Steps

This collection of recommendations, ideas, and management considerations provides an overview of content that should be considered in the future LA index. The above sections may be thought of as categories of indicators for the index. The Singapore Index process provided our team with an understanding of current data and data gaps related to SI indicators in LA. It also helped us understand the value of these indicators as measures of our current biodiversity. A key next step would be to explore the topics and recommendations included in this synthesis that are not addressed in the Singapore Index, and evaluate data availability, gaps, and any existing management plans or objectives related to measurement or performance goals. This information, along with additional information needs associated with relevant SI indicators, should be incorporated into a full biodiversity characterization of the City. This characterization will form the scientific basis for biodiversity measurement and planning. A process should then be undertaken to determine the biodiversity priorities of decision makers and stakeholders; and to clarify the appropriate application contexts for the Index. One early-stage application context may be to aid in the crafting and performance measurement of a City Biodiversity Action Plan. Such an index, that is scientifically sound, measurable, and applicable in a variety of City management and analysis contexts, can provide an effective gauge of biodiversity management and change in the City going forward.

07 References



California buckwheat, San Gabriel Mountains
© Naomi Fraga, https://www.inaturalist.org/photos/10810281

References

1. Trust for Public Land ParkScore 2017: Los Angeles. http://parkscore.tpl.org/map.php?city=Los%20Angeles#sm.001xiiony16ledqovw91ib2n95oc3. Accessed 12/7/17.

2. 2010 Census Urban Area Facts. United States Census Bureau. https://www.census.gov/geo/reference/ua/uafacts.html. Accessed 12/6/17.

3. U.S. Climate Data (2017). Temperature - Precipitation - Sunshine – Snowfall. https://www.usclimatedata.com/climate/los-angeles/california/united-states/usca1339. Accessed 11/15/17.

4. Bailey, Robert G. United States Department of Agriculture Forest Service. Ecoregions of the United States. https://www.fs.fed.us/rm/ecoregions/products/map-ecoregions-united-states/#. Accessed 11/15/17.

5. Sunset Climate Zones of Los Angeles; http://www.sunset.com/garden/climate-zones/climate-zones-intro-us-map. Accessed 11/14/17.

6. National weather service (2017, October 11th). NWS Forecast Office Los Angeles, CA. http://www.weather.gov/lox/

7. Given Place Media, Los Angeles Almanac (2017). Monthly Climate Summaries Selected Los Angeles County Locations through 2015. http://www.laalmanac.com/weather/we02.php#rain. Accessed 11/15/17.

8. Creating and Mapping an Urban Heat Island Index (2015). California Environmental Protection Agency / AltoStratus Inc. https://calepa.ca.gov/climate/urban-heat-island-index-for-california/urban-heat-island-report/. Accessed 11/15/17.

9. City of Los Angeles (2006). L.A. CEQA Thresholds Guide. http://www.environmentla.org/programs/Thresholds/C-Biological%20Resources.pdf. Accessed 11/15/17.

10. Atlas for Urban Expansion (2016). Los Angeles. http://www.atlasofurbanexpansion.org/cities/view/Los_Angeles. Accessed 11/15/17.

11. City of Los Angeles (2017). Los Angeles River Revitalization. http://lariver.org/blog/about-la-river. Accessed 11/15/17.

12. Los Angeles Basin Stormwater Conservation Study, December 2013. https://www.usbr.gov/lc/socal/basinstudies/LA-Basin-Study-Task-3-2%20Report-FINAL.pdf. Accessed 11/30/17.

13. United States Environmental Protection Agency. (2017, July 17). Overview of the Brownfields Program. https://www.epa.gov/brownfields/overview-brownfields-program. Accessed 11/15/17.

14. U.S. Census Bureau (2016). American Community Survey 1-year estimates. Retrieved from Census Reporter Profile page for Los Angeles, CA. https://censusreporter.org/profiles/16000US0644000-los-angeles-ca/. Accessed 11/15/17.

15. Bureau of Economic Analysis. “Gross Domestic Product by Metropolitan Area.” U.S. Department of Commerce (2016) https://www.bea.gov/newsreleases/regional/gdp_metro/2017/pdf/gdp_metro0917.pdf. Accessed 11/15/17.

16. Mitra, S., Sedgwick S.M., De Anda R., and Perdomo A. “Los Angeles: People, Industry and Jobs, 2016-2021.” Institute for Applied Economics (2017, June) https://laedc.org/wp-content/uploads/2017/06/People-Industry-and-Jobs_FINAL_2016-2021.pdf. Accessed 11/15/17.

17. Cooper, C., Ritter-Martinez, K., and Sedgwick, S. “Economic Update for Los Angeles.” Institute for Applied Economics, Los Angeles County Economic Development Corporation (2016, De cember). file:///C:/Users/myriid483/Downloads/2016-LAC-Economic-Update_20161129.pdf. Accessed 11/15/17.

18. Vitousek, S., Barnard, P. L., Fletcher, C. H., Frazer, N., Erikson, L., & Storlazzi, C. D. (2017). Doubling of coastal flooding frequency within decades due to sea-level rise. Scientific Reports, 7(1), 1399.

19. California Department of Fish & Wildlife (2016). A Climate Change Vulnerability Assessment of California’s Terrestrial Vegetation. https://lccnetwork.org/resource/climate-change-vulnerabil ity-assessment-californias-terrestrial-vegetation. Accessed 11/15/17.

20. California Natural Resources Agency (2017). Safeguarding California Plan: California’s Climate Adaptation Strategy. http://resources.ca.gov/climate/safeguarding/. Accessed 11/15/17.

21. Graham, L. J., Haines-Young, R. H., & Field, R. (2017). Metapopulation modelling of long-term urban habitat-loss scenarios. Landscape Ecology, 32(5), 989-1003.

22. Center for Biological Diversity. Southern California Steelhead Trout. http://www.biologicaldiver sity.org/species/fish/southern_California_steelhead_trout/. Accessed 11/15/17.

23. Center for Biological Diversity. California Red-legged Frog. http://www.biologicaldiversity.org/species/amphibians/California_red-legged_frog/natural_history.html. Accessed 11/15/17.

24. Southern California Steelhead Recovery Plan (2012). National Marine Fisheries Service. Southwest Region, Protected Resources Division, Long Beach, California.

25. Salata, F., Golasi, I., Petitti, D., de Lieto Vollaro, E., Coppi, M., & de Lieto Vollaro, A. (2017). Relating microclimate, human thermal comfort and health during heat waves: An analysis of heat island mitigation strategies through a case study in an urban outdoor environment. Sustainable Cities and Society, 30, 79-96.

26. Conservation International, Critical Ecosystem Partnership Fund (2016). California Floristic Province. http://www.cepf.net/resources/hotspots/North-and-Central-America/Pages/California-Floristic-Province.aspx. Accessed 11/15/17.

27. California State Library (2017). State Symbols. http://www.library.ca.gov/history/symbols.html. Accessed 11/15/17.

28. United States Department of Agriculture Forest Service (2009). South Coast and Montane Ecological Province. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_045405.pdf. Accessed 11/15/17.

29. California Native Plant Society (2014). Engelmann Oak. http://calscape.org/Quercus-engel mannii-(Engelmann-Oak)?srchcr=sc59f8dc4f96bb5. Accessed 11/15/17.

30. California Native Plant Society (1999-2017). A Manual of California Vegetation. http://www.cnps.org/cnps/vegetation/manual.php. Accessed 11/15/17.

31. Bureau of Soils, Soil Survey of the Los Angeles Area, California (1903). NRCS Soil Survey Archive https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=CA Accessed 11/15/17.

32. Pratt, Beth (2014). National Wildlife Federation. https://www.nwf.org/~/media/PDFs/Wild life/V-Z/Beth-Booklet_WhenMountainLionsAreNeighbors_web.pdf. Accessed 11/15/17.

33. Given Place Media, Los Angeles Almanac (2017). Mountain Peaks & Other High Points Los Angeles County by Elevation (feet above sea level). http://www.laalmanac.com/geogra phy/ge05.php. Accessed 11/15/17.

34. Stephenson, John R.; Calcarone, Gena M. (1999). Southern California mountains and foothills assessment: habitat and species conservation issues. General Technical Report GTR-PSW-175. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 402 p

35. City of Los Angeles (2001). Conservation Element of the City of Los Angeles General Plan. (https://planning.lacity.org/cwd/gnlpln/consvelt.pdf). Accessed 10/18/17.

36. The Mannahatta and Welikia Projects. https://welikia.org/explore/mannahatta-map/. Accessed 11/30/17.

37. CALVEG, [ESRI personal geodatabase]. (2004). McClellan, CA: USDA-Forest Service, Pacific Region. EvegTile03B_99_04_v2.

38. National Association of City Transportation Organizations, Urban Street Stormwater Guide, Island Press 2017.

39. American Society of Landscape Architects, National Research Award (Professional Category). https://www.asla.org/2017awards/327241.html.

List of Abbreviations

BioSCAN	NHMLA Biodiversity Science: City and Nature
BMI	Benthic macroinvertebrates
BOE	Bureau of Engineering
BOSS	Bureau of Street Services
CA	California
CalEPA	California Environmental Protection Agency
CalFlora	California Flora Nursery
CAL-IPC	California Invasive Plants Council
CALVEG	Classification and Assessment with Landsat of Visible Ecological Groupings system
CBD	Convention on Biological Diversity
CCED	2016 California Conservation Easement Database
CD	Council District
CDFW	California Department of Fish & Wildlife
CEQA	California Environmental Quality Act
City	Los Angeles
CLA	Chief Legislative Analyst
CPAD	California Protected Areas Database
CSULA	California State University Los Angeles
EIR	Environmental Impact Report
EPA	Environmental Protection Agency
F	Fahrenheit
FEMA	Federal Emergency Management Agency
FWS/USFWS	US Fish & Wildlife Service
GDP	Gross Domestic Product
GIS	Geographic Information System
GRASS	Greenways to Rivers Arterial Stormwater Systems
IT	Information Technology
LA	Los Angeles
LADWP	LA Department of Water and Power
LAR-IAC	Los Angeles Region Imagery Acquisition Consortium
LASAN	Los Angeles Bureau of Sanitation
LAUSD	Los Angeles Unified School District
LAWA	Los Angeles World Airports

LAX	Los Angeles International Airport
LBSAP	Local Biodiversity Strategy and Action Plan
LID	Low Impact Development
LIDAR	Light Detection and Ranging
LMU	Loyola Marymount University
Mt.	Mount
N	North
NA	Not applicable
NACTO	National Association of City Transportation Organizations
NDVI	Normalized Difference Vegetation Index
NEPA	National Environmental Policy Act
NGO	Non-profit Organization
NGSS	Next Generation Science Standards
NHM/NHMLA	Natural History Museum of Los Angeles County
O&M	Operations & Management
POLA	Port of Los Angeles
RAP/LARAP	LA Department of Recreation and Parks
RASCals	LA County Natural History Museum Reptiles and Amphibians of Southern California
SCAG	Southern California Association of Governments
SEA	Sensitive Ecological Area
SI	Singapore Index
SMBRC	Santa Monica Bay Restoration Commission
SWAP	Wildlife Action
TMDL	Total Maximum Daily Loads
UC	University of California
UCLA	University of California Los Angeles
US	United States
USC	University of Southern California
USFS	US Forest Service
Veg CAMP	Vegetation Classification and Mapping Program
W	West
WMA	County Weed Management Area

www.lacitysan.org

LA Sanitation environment
CITY OF LOS ANGELES

Isaac Brown
Ecology Studio