Enhancing Biodiversity and Water Quality in Los Angeles:
Expanding Application of the Greenway Concept

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Client Westwood Neighborhood Greenway, Inc.

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Executive Summary

Purpose of Report

Hydrological systems such as rivers and streams have been significantly impacted as a result of urbanization and the wide scale use of gray infrastructure for water movement. Ecosystem services including water filtration and riparian habitat to support native species have become diminished as a result. Recent efforts to daylight streams, a technique of resurfacing underground water channels, have provided avenues to reestablish elements of historical hydrology in highly urban spaces. Infrastructure projects which daylight streams in combination with producing recreational outdoor spaces have gained momentum in the past two decades throughout Los Angeles County. On the westside of Los Angeles, the Westwood Greenway is one such example of a recreational-water treatment greenway that resurfaces and filtrates water in the Ballona Creek Watershed as it makes its way to the Santa Monica Bay. The Greenway provides stream-like habitat to help improve local water functions and expand native and riparian biodiversity, while also supporting access to nature and opportunities for outdoor education. This final report culminates the efforts of our UCLA Environmental Science Practicum Team to evaluate the Westwood Greenway's impacts on biodiversity and water quality to quantify the benefits of urban greenways and inspire replication.

The Westwood Greenway, completed in 2020, is a relatively new project for which environmental impacts are assessed throughout the report. The research questions that we explore are:

- What impacts do green infrastructure elements at the Westwood Greenway have on biodiversity and water quality, and how can modifications further improve outcomes at the site?
- How and where can lessons from the Westwood Greenway project be applied and improved upon at other potential sites in the City of Los Angeles? What best practices can be used to build and maintain other greenways?
- How can community engagement tools support expanded visibility of and access to the Westwood Greenway and the greenway model across the City of Los Angeles?

Methods Used

To identify and record the biodiversity hosted at the Westwood Greenway, we relied primarily on the app iNaturalist. A site-specific project was created to keep track of all visual fauna observations at the Greenway. To encourage the input of observations from the community, the project was kept open for two months. Within that time period, three designated bioblitz events were hosted: one in the early morning, one mid-day, and one in the evening. Because the Greenway is divided into two parcels of land by the Westwood/Rancho Park light rail train station, we placed malaise traps on either side to quantify insect species abundance. Following methods used by the City of Los Angeles in its biodiversity index, data from iNaturalist and malaise trapping were compiled into a biodiversity index that included metrics on the Greenway's habitat quality, habitat variety, edge effects, and offsite connectivity. Habitat quality was determined using iNaturalist to assess species consistency and the number of native fauna observations since the Greenway's completion in October 2020 through May 2022. Habitat variety was quantified by counting the number of native flora species compared to the number of native flora species counted in the 2018 Los Angeles Biodiversity Index. Edge effects were calculated based on the number of human interferences within the site present in relation to other urban environments. Offsite connectivity was assessed using a GIS study evaluating greenspace in the City of Los Angeles.

To assess water quality, the team collected data along the project's stormwater treatment train, influent (north pump) to effluent (south drain). Four rounds of sampling were conducted: two during dry weather and two during wet weather. Each round consisted of sampling water at the drain and pump of each side of the Greenway. Data describing the integrity of the water were gathered using the LaMotte Urban Water Quality Test Kit, a meter that measured both electrical conductivity and total dissolved solids, and the SenSafe Water Metals Check test strips.

To promote replication of the Westwood Greenway concept alongside ongoing green infrastructure projects in Los Angeles County, we explored data from the Safe Clean Water Program (SCWP) to locate project proposals in flood-prone areas. Project data were paired with a Geographic Information Systems (GIS) suitability analysis using the Trust for Public Land's Climate-Smart Cities, a GIS tool that compiles many relevant data layers into general themes to help cities build green infrastructure projects with the goal to increase climate resilience ("Decision Support," n.d.). In our suitability analysis, we identified high priority areas for greenways by combining relevant data layers related to absorbing water and reducing flooding as well as addressing climate equity. In addition, social media content on the Westwood Greenway's Instagram page was periodically updated with educational posts highlighting the benefits of biodiversity found at the Greenway. The team also updated the Westwood Greenway, Inc.'s website to share the findings of our research questions and deliverables with the general public.

Findings & Implications

Eighty research-grade observations, and 58 unique species of fauna, were identified using iNaturalist. We identified the densest collection of insects near native flowering plants closest to the stream. The insects collected between the north and south side of the Greenway showed consistency between the two sides of the Greenway, indicating the significance of connectivity. By comparing the temperatures in different days of malaise trapping, we found a correlation between warmer weather and a greater amount of insect collection. In the biodiversity index, the metric rating for each respective category received a score out of 5. Habitat quality received a 4, habitat variety received a 4.5, edge effects received a 3.75, and offsite connectivity received a 4, indicating that the site currently serves important functions in support of biodiversity, but also that there is room to further improve conditions. Visual observations included a bumblebee, an indicator species for Los Angeles, and five of the state's native butterflies. In just two acres of land, the Westwood Greenway hosts an outsized number and variety of species, indicating that spaces like the Greenway provide critical habitat in a heavily urbanized metropolitan area.

Water sampling showed notable reduction in the hardness, total dissolved solids, electrical conductivity, and heavy metal concentrations in water movement from influent to effluent. Wet-weather data demonstrated reduction in nitrate and iron pollution. Water quality findings and discussion provide the first evidence of improvements made by the project and demonstrate the site's role in assisting the City in complying with total maximum daily load (TMDL) water quality regulations in Ballona Creek Watershed.

We also found that funding is a major limitation that can discourage groups and communities from building and maintaining green infrastructure projects. We highlight County funding opportunities through Measure W and the resultant Safe Clean Water Program (SCWP), as well as through Measure A. We present additional information on grants available from federal, state, and regional sources. Our GIS analysis confirmed a high need for green spaces in the East Los Angeles and Willowbrook regions and found that of the 18 SCWP projects in Los Angeles County that are still in the design phase, eight were suitable to include a greenway while five were located in disadvantaged communities (DAC). To advance environmental equity, it will be critical for green infrastructure funding to be allocated to high-priority communities.

Recommendations

To increase species richness at the site, we recommend planting flora that attracts specific indicator species which will then invite other taxonomic groups to inhabit the Greenway. For instance, to attract the cedar waxwing (*Bombycilla cedrorum*), planting native plants like the western chokecherry (*Prunus virginiana*), Nevin's barberry (*Mahonia nevinii*), and toyon (*Heteromeles arbutifolia*) would be favorable. In addition, maintaining running water in the Greenway stream is a vital factor for supporting habitat variety and quality for biodiversity. During the iNaturalist project we observed more bird species and collected more diverse species of insects in malaise trapping near the stream. The stream that runs through the Greenway can also help sustain indicator amphibians or reptiles through a species introduction initiated by anthropogenic efforts, should one be undertaken.

To further improve water quality we suggest continued use of native trees and other plants that reduce the concentration of pollutants identified in the Ballona Creek TMDLs and the water quality assessment we conducted for this project. We also suggest investigating hydraulic residence time inside the bioswale by implementing a remote flow monitoring device.

It is common for aspiring green infrastructure projects to find inspiration and guidance in existing models and to duplicate and improve upon their design and processes. However, we identified that a number of infrastructure projects typically do not define or track their operational metrics. We thus recommend a more institutional avenue that allows realized projects to report their successes, challenges, and failures, where they occur. By reporting project lessons at all phases of a project, new proposals can leverage best practices, maximize efficiencies, and provide functional green spaces that provide multiple social and ecological benefits.

1 Introduction

In 2010, the Census Bureau estimated that 80.7% of the U.S. population was living in cities, a number that has since increased to 86% in 2020 and is projected to reach 89% by 2050 (University of Michigan, 2021). Los Angeles (LA) ranks as the second largest city in the country and has one of the highest population densities, with approximately 7,755 people per square mile (US Census, 2020). Tendencies towards city dwelling have led to the wide scale transformation of land to impervious surfaces, causing both increased surface runoff and decreased groundwater recharge (Chithra et al., 2015). Extensive urbanization and development have also impacted natural freshwater resources such as streams and rivers and threatened biodiversity through fragmentation and habitat loss (Brown et al., 2005; United Nations, 2019). As a result, ecosystem services such as water filtration, flood mitigation, nutrient recycling, and riparian habitat to support biodiversity become impaired or are lacking (Yeakley et al., 2016). In 2010, 57% of streams and rivers in LA County were unable to maximize use for recreation, habitat, or water supply because they contained high concentrations of at least one pollutant (Federico et al., 2019). And while Los Angeles sits within the California Floristic Province — one of the world's 36 biodiversity hotspots — it is also home to over 50 species listed as endangered or threatened (Brown, 2019). Reintroducing elements of historical hydrology can provide avenues to bring back stream habitats lost to development, while providing local water supply and quality benefits and expanding biodiversity (Pinkham, 2000).

Located adjacent to the Westwood/Rancho Park station of LA Metro's light rail E Line, the Westwood Neighborhood Greenway is a working example of an urban waterway. The site design centers around an engineered stream approximately 800 hundred feet long that pumps mostly dry-weather flow up from a storm drain, through the stream, and then back out into the storm drain system to eventually be released into Santa Monica Bay and the Pacific Ocean. The Westwood Greenway was constructed on the basis of an increasingly popular green infrastructure tactic known as daylighting, wherein the flow of a natural stream, creek, or stormwater drain is exposed to the surface in order to revitalize natural hydrological functions (Pinkham, 2000). In a narrow stretch of land off Exposition Blvd, the Greenway is designed to restore natural ecosystem services of water filtration and serve as habitat for native flora and fauna. Daylighted streams can also support recreational activities, access to nature, and opportunities for outdoor teaching.

The Greenway was developed on two parcels with a combined area of approximately two acres that were slated to become parking near the newly-developed Metro light rail line. However, strong grassroots efforts spearheaded by a group of concerned neighborhood advocates brought about a much different fate for the site. Long-term support of the project by the community via the incorporation of the nonprofit entity Westwood Greenway, Inc., our project client, enabled a multi-year effort to culminate in the daylighting of a stream and creation of a green space that saw a soft opening in October 2020 ("History," n.d.). Partnering with LA Sanitation and Environment (LASAN) and the City of Los Angeles Bureau of Engineering (BOE) enabled the community's grassroots effort to be realized. In a city with extensive gray storm drain infrastructure and growing concerns over sustainable water supply, the proliferation of the Greenway concept in Los Angeles has the potential to address a number of environmental concerns while also providing valuable sites for community pride, health, and education.

Between January and June 2022, our practicum team conducted research and analysis to both measure the impacts of the Greenway and examine the potential for realizing similar Greenway sites in the future. We conducted multiple bioblitizes to collect data on present fauna at the Greenway using iNaturalist. We used this information to create a site-specific biodiversity index, a species appendix, and provide recommendations to enhance biodiversity at the Greenway. We conducted water quality sampling at the site for both dry- and wet-weather flows. We analyzed these data and concluded that the Greenway provides water quality improvement for a number of constituents. Our team also conducted a GIS analysis, comparing projects from the Safe, Clean Water Program to areas we determined were high priority for instituting a greenway. We identified a number of hotspots across LA County, notably in East Los Angeles and in the Willowbrook region of South Central Los Angeles. Finally, we increased digital engagement with the Greenway by updating the Westwood Greenway's social media and creating future content to facilitate future posts by the client, focusing on building digital partnerships and sharing our group's work in order to promote greater visibility of the Greenway and its value to the community.

2 Background

2.1 Biodiversity

Biodiversity refers to the variety of plants, animals, bacteria, and fungi or all living things on earth in a specific region or ecosystem (National Geographic Society, 2019). Both native and nonnative species contribute to the biodiversity in a specific region. In urban ecosystems, biodiversity may look and function differently than in a wild, natural area; consequently, the definition of biodiversity in urban regions is evolving. Urban biodiversity includes foundational ecosystems amongst urban development generating ecological conditions that are supportive of various species (Pierce et al., 2022). From an ecological engineering perspective, a healthy, sustainable ecosystem, "may be novel assemblages of species that perform desired functions and produce a range of valuable ecosystem services," (Costanza, 2012). This could look like native plants in building landscapes or where possibly, greenways and walkways for pedestrian passage through busy intersections. Some alien species can be accounted for in urban biodiversity assessments as long as they are not over-consuming resources. Plant ecologist Robert Harding Whittaker further defined diversity over spatial scales as either alpha, beta, or gamma (Duke University, 2021). Alpha diversity looks at the richness and evenness of species within a given habitat unit, beta compares how many species are found in only one habitat unit across the ecosystem and gamma measures the total diversity throughout the entire ecosystem. When biodiversity is protected and functioning at its maximum, ecosystems can

2.1.1 How is Biodiversity Measured?

When measuring biodiversity in a given landscape, ecosystem, or habitat, gathering information on the species richness in the region of focus is the first step to gain a better understanding of the organisms that inhabit the area. Several methods exist to measure and evaluate the complexities of biodiversity, including remote sensing, ecosystem analysis, and biodiversity indices. To traditionally calculate biodiversity in an index, one divides the number of species in an area by the total number of individuals in the area (American Museum of Natural History, 2001). Once there is a substantial understanding of the kind of organisms that live in the land of study, the biodiversity analysis can become directed towards topics like genetic diversity, endemic species, or ecosystem diversity. This estimation of biodiversity fails to acknowledge how an ecosystem is functioning, its resilience, or its "naturalness." Considering indicator species and abiotic conditions such as microclimate, soils, stream morphology, and landform leads to a more comprehensive approach and addresses all of the underlying factors that drive biodiversity (Pierce et al., 2022).

Specifically, some tools scientists use to collect data that encompasses the species count in varying habitats include fogging, quadrat sampling, transect sampling, malaise traps, and netting (Blake, 2009). The most suitable method for measurement varies by species and habitat. Canopy fogging utilizes low-dose insecticides sprayed into the tops of trees and a funnel-shaped screen to collect the species as they fall, which is ideal for insects (Blake, 2009). Quadrat sampling includes counting different species and their abundance within a quadrant that can range from 1 to 20 square meters and is repeated throughout the habitat to obtain an accurate representation of biodiversity (Blake, 2009). Transect sampling uses a transect line such as a rope or a measuring tape marked at set intervals (i.e. every meter) and the type and number of species are recorded at every interval along the line (Blake, 2009). Netting, a common method for birds, bats, and fish, uses fine mesh nets to capture organisms and identify them. Malaise trapping relies on insects' tendency to move upwards or towards light and ensure they end up in the collecting jar (Karlsson et al., 2020).

2.1.2 Biodiversity in Los Angeles

There is extensive opportunity to measure and study biodiversity in Los Angeles. The City of Los Angeles is recognized as a biodiversity hotspot and is considered among the most biodiverse cities in the continental United States (Preziotti, 2021). The city contains over 450 certified wildlife habitat sites in its borders alone. Historically, LA's location and climate aided in its rise to becoming a "biodiversity jewel" (LA Sanitation and Environment, 2020). In addition, LA's waterways, including the LA River, are valuable resources supporting biodiversity. The river's constant change in flow and direction, plus the occasional flooding, helped create several habitats like lakes, wetlands, and mudflats (Gumprecht, 1997; Pilon-Briggs, 2019). Although conditions have changed, waterways continue to be a critical resource for biodiversity. These diverse habitats attracted a variety of plants and animals, from deer and antelope that lived near the river in what is now Griffith Park, to muskrats that fed on the cattails in river marshes (Gumprecht, 1997). Although the Mediterranean climate allows Los Angeles to host more than 3,500 different species of plants and animals, further urban development will continue to force a decline in biodiversity, creating several anthropogenic threats such as habitat fragmentation and pollution (Keeley & Swift, 1995). Several studies conclude that urbanization reduces species richness, especially at high levels (McKinney, 2008).

Today, nonnative plant species that are imported into residential areas contribute to a majority of LA's vibrant vegetation but outcompete L.A.'s native flora, which can lead to overall decrease in species richness (McKinney, 2008). Loss of native plant species can also negatively affect the animal populations that rely on them for food and habitat. The state of biodiversity in Los Angeles is greatly dependent on whether species diversity and ecosystem services are valued over urban growth.

2.1.2 Biodiversity Conservation in Los Angeles

In May 2017, the City of Los Angeles moved to increase efforts to restore and prioritize the conservation of biodiversity. City Councilmember Koretz, representing the 5th Council District, introduced a biodiversity motion that was unanimously adopted by Los Angeles City Council. The motion had three 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 contribute toward broader ecosystem functions and sustainability 3) develop options for community outreach and engagement (LA Sanitation and Environment, 2020). Since the motion's adoption, Los Angeles published the 2018 Biodiversity Report: Los Angeles, followed by a customized biodiversity index in 2020 that includes over 20 indicators.

The Los Angeles Biodiversity Index is designed to monitor progress towards the City's no-net loss of biodiversity target and includes the three major objectives from the biodiversity motion (LA Sanitation and Environment, n.d.). The index consists of a "Profile of the City" that provides background information and a set of 23 indicators that measure native biodiversity, ecosystem services, and governance and management of biodiversity. The indicators are based on guidelines from the User's Manual on the Singapore Index on Cities' Biodiversity (Chan et al., 2014). Background information includes location, physical features, demographics, economic parameters, biodiversity features, administration of biodiversity, and links to relative websites. Each indicator has a unique way of calculating its score and can receive a score between zero and four, four representing ideal conservation efforts. Los Angeles plans to release recommendations based on index measurements every three years as well as major milestone measurements every ten years with hopes to inform decision makers, governance, and management.
The LA Biodiversity Index provided several other examples of revitalization projects and sites aiming to maintain native biodiversity and restore ecosystems.

To increase awareness of biodiversity, UCLA published a Biodiversity Atlas of Los Angeles online. The website offers information on the environment, such as climate and land cover type, and categorizes plant and animal species as endangered, threatened, or invasive if applicable (UCLA, 2020). In recent years, online applications such as iNaturalist and PlantNet have also been utilized by community members to map and share species occurrence data, also known as citizen science or community science (Li et al., 2019). These apps are especially useful in urban areas where professional data collection is far less common than community-generated data. Information on species occurrence from community science programs has advanced researchers' understanding of animal behavior and species distribution and has influenced biodiversity planning and conservation practices.

2.2 Hydrology

2.2.1 Historic Hydrology in Los Angeles

Hydrology is the study of the distribution and movement of water and the impacts humans have on its quality and availability (National Geographic Society, 2019). The story of Los Angeles hydrology begins along the LA river, where the Indigenous Tongva people and more than 200 Native American tribes once lived (Pilon-Briggs, 2019). In 1781, Spanish settlers established Pueblo de Los Angeles along the LA River and developed a system of aqueducts, or "Zanjas," that amplified their civilization and farming ability. Rapid growth in the city led to a charge being placed on water in the 1850s for a system that consisted of 9 aqueducts, a water wheel, a reservoir, and some wooden pipes (Pilon-Briggs, 2019). In 1913, Chief Engineer William Mulholland completed the Los Angeles Aqueduct marking the start of a "modern hydraulic society" allowing the city to support greater numbers of people with imported water from Owens Valley (Pilon-Briggs, 2019). Present-day LA water sources include the Eastern Sierra Nevada Mountains, the Sacramento-San Joaquin River Delta, the Colorado River Basin, local groundwater and recycled wastewater; the LA River is no longer used as a water source (Pilon-Briggs, 2019).

Historically, Los Angeles was a flood-prone coastal plain due to its climate and topography. A drainage network with resistance to flooding was never developed due to sporadic rain falling over short periods and in high volumes, and runoff being sped up by the surrounding Santa Monica Mountains (Gumprecht, 1997). The LA River had an erratic flow, lacking a defined channel and changing course frequently. In 1825, the river — which previously flowed west along Ballona Creek into the Santa Monica Bay — began emptying into the San Pedro Bay at Long Beach (Gumprecht, 1997).

The Ballona Creek Watershed has three distinct hydrology zones: headwaters, transfer, and depositional (Braa et al., 2001). In the headwaters zone flows travel down mountain slopes and disappear into the thin alluvium of the plain to restore nutrients and groundwater stores downstream. The transfer zone consists of an underground aquifer that sustains base flow with a shallow water table and streams merging at lower elevations. In the depositional zone water flows primarily above ground (Braa et al., 2001). Geomorphic faults under West Hollywood allowed groundwater to pool, forming marshes, swamps, and springs. Native plant communities developed in response to terrain and soil types, climate, and availability of water, and these natural resources supported high amounts of biodiversity (Braa et al., 2001).

Urban development alongside natural hydrology led to many floods in the early 1900s. As a result, parts of Ballona Creek were channelized between 1935 and 1939 with its first tributary channelized in the Sawtelle-Westwood system between 1950 and 1960 (BCWTF, 2004). Most of the channels are still maintained by the U.S. Army Corps of Engineers (USACE) or the Los Angeles County Department of Public Works (LACDPW) (BCWTF, 2004). Today, most of the drainage network in the Ballona Creek Watershed has been moved underground as gray infrastructure (Hamilton, 2021). Similar trends are

2.2.2 Impacts of Modern Hydrology

Approximately 40% of the Ballona Creek Watershed is covered with impervious surfaces, which leads to unmitigated hydrologic impacts, such as increased peak flow, increased durations of high flows, and seasonal flow volume shifts (Stolzenbach, et al., 2001, Batts et al., 2021). Rapidly flowing runoff strains pipe networks, erodes streambeds, and contaminates groundwater (Strohbach et al., 2019; Braa et al., 2001). Runoff collects sediment along impervious surfaces, resulting in sediment depositions that destroy fish spawning areas, reduce channel capacity, and decrease overall waterway quality (USDA, 2008). Impermeable surfaces reduce infiltration and refill of groundwater, which is key to the formation of streams, wetlands, and springs and a vital water source for the City of LA (BCWTF, 2004; Braa et al., 2001; Pincetl et al., 2019). Reduced water quality and impaired stream health can result, with stream channels losing stability and eroding, stream temperatures increasing, and habitat quality consistently poor when impervious area exceeds 10-15% of land area (Schueler, 1994). Predevelopment channel stability and biodiversity cannot be maintained for areas with more than 25% impervious area even with best management practices (Schueler, 1994). Another study found that having an average percent of anywhere between 3.6% to 50% of impervious surfaces before water quality begins to degrade to range between 3.6 to 50%. threshold for water quality degradation to be a range between 3.6%-50% average percent of impervious surfaces (Brabec, et al., 2002).

Key functions of a healthy watershed are transport and storage of water, cycling and transformation of nutrients and energy, and revitalization of ecology (Braa et al., 2001). Hydrology and its associated geomorphology including sediment transport, flood regimes, runoff seasonality, water temperature, and infiltration and groundwater interactions are key pieces in supporting biodiversity. Riparian vegetation, aquatic habitat, and stream function are virtually nonexistent on the coastal plain today as concrete-lined channels and storm drains provide little opportunity for trees, plants, and bacteria to support fauna living

2.2.3 Hydrology Analysis

Analysis of hydrology can be used to better understand and manage water resources and the impacts greenways have on stream health, however restoration projects should be thoughtfully designed in order to improve hydrological outcomes. A case study review of 19 completed stream daylighting projects in the United States found only five (26%) completed some type of pre-design hydrology analysis and most were designed by "trial and error" (Buchholz et al., 2016). However, all documented channel intervention (re-grading banks, installing rock weirs, recreating floodplains etc.) required frequent monitoring to discover harm if not fully researched prior to implementation (Buchholz et al., 2016). Measurement of upstream meander and width and modeling of hydraulic events for bankfull discharge were analyzed and aerial photos or reference reaches were used as guides for stream channel placement in "trial and error" methods (Buchholz et al., 2016).

Preparatory measures used in stream restoration can be used for daylighting projects including consideration of current and future storm discharges, floodplain elevations, infrastructure, encroachment, and erosion potential (Buchholz et al., 2016). Other hydrologic factors include land use, vegetation cover, soil properties, drainage features, flow, and precipitation statistics (Thomason, 2019). Previous hydrologic analysis found daylighting streams to be cost- effective because it removes the need for pipe replacement and the risk of flood damage. Streams convey water levels better than traditional pipes and any miscalculations of surface stream size can be recognized and fixed more readily (Buchholz et al.,

2.2.4 Water Quality Analysis

Water quality analysis is important to public and environmental health as well as industrial and agricultural use. In the past, many daylighting projects have not included a monitoring plan for stream health, typically relying on observations. However, this poses the problem of mistaking successful vegetation growth for water quality restoration regardless of actual water sampling results (Buchholz et al., 2016). Water quality can be assessed by measuring indicators including: concentration of dissolved oxygen (DO), amount of salt (salinity), total suspended solids (TSS), how basic/acidic the water is (pH), temperature, turbidity, and levels of bacteria (Hayder et al., 2020; Florida Keys National Marine Sanctuary, n.d.). Other parameters include concentration of microscopic algae, quantities of pesticides, herbicides, heavy metals, and other contaminants, electrical conductivity, and biological and chemical oxygen demand (Florida Keys National Marine Sanctuary, n.d.; Ji et al., 2016; Hayder et al., 2020). When sampling water, parameters such as pH, residual chlorine, turbidity, and temperature should be measured immediately after sampling as these parameters can change during transportation and storage (WHO, 1997).

2.3 Urban Runoff Management

Urban runoff or nonpoint source pollution, is pollution caused when water diffuses across large areas of ground and picks up contaminants causing detrimental effects on water quality (US EPA, 2015). In LA, while stormwater runoff occurs in spurts because of inconsistent precipitation, dry-weather flow through storm drains occurs year-round. Dry-weather flows include day to day excess irrigation or outdoor water use and permitted discharges from industrial sources (California State Water Boards, 2006). In highly urbanized areas such as Los Angeles, greater combinations of impervious surfaces, pollution sources, and runoff volumes cause a greater potential for accumulated contaminants, streambed erosion, sedimentation, and flooding risk (Gallo et al., 2020; Field et al., 2006).

2.3.1 BMPs

In response to these impacts, best management practices (BMPs) are a suite of tools and strategies to reduce nonpoint source pollution and meet water quality criteria in receiving waters (Susilo et al., 2006; Chau, 2009). BMPs are defined in the Code of Federal Regulations as "methods, measures, or practices selected by an agency to meet its nonpoint source control needs…[including] but not limited to structural and nonstructural controls and operation and maintenance procedures" (40 C.F.R. § 130.2(m)). With such an inclusive definition, BMPs cover a broad range of management tactics from permeable pavement to government ordinances. Green infrastructure (GI) can also be included under the BMP umbrella, which has emerged more recently as a design strategy to integrate natural elements into development projects and reduce stormwater runoff volumes and contaminants. Legally referenced in the amendments to the 1972 Federal Water Pollution Control Act — also known as the Clean Water Act (CWA) — BMPs were designated as a key instrument to reduce the discharge of point source pollutants under the National Pollutant Discharge Elimination System (NPDES) permitting program (US EPA, 2005). In 1990, further regulation included requirements for NPDES permits for small and large municipal separate storm systems to address nonpoint source pollution (Field et al., 2006). See section 2.4.2 for further discussion.

2.3.2 Types of BMPs

Structural BMPs are systems, facilities, or other technology that aim to treat, and in certain cases store, stormwater to prevent the accumulation of pollutants in runoff (Susilo et al., 2006; Clar et al., 2003). These can include any number of engineered or nature-based constructions for regional or local management. Implementation of either structural or nonstructural BMPs depends largely on the watershed, existing water quality, management context, the extent of urbanization, available resources and funding, and stakeholder support (Field et al., 2006). Distinctions between the two are not always clear, in part because nonstructural BMPs are not consistently named, but also because there tends to be overlap in some cases. For example, nonstructural BMPs can involve plans to implement structural ones, and structural BMPs might also rely on non-structural ones for public support to implement them. Despite the more nuanced differences, combining non-structural and structural practices is often the most common, cost-effective, and successful approach (US EPA, 2005).

A further category acknowledged within structural management determines whether the structure relies on "gray" or "green" infrastructure. Gray infrastructure refers to traditional methods for dry- and wet-weather water management using gutters, pipes, sewers, and ponds built with concrete, steel, and plastic materials to store and transport runoff away from urban centers (Bell et al., 2019). Gray infrastructure is often employed at large scales and has a reputation of being technologically and economically efficient (Ozment et al., 2019). Green infrastructure, in contrast, is designed to use natural systems to capture water on-site, providing filtration and evaporation opportunities, and reducing runoff volumes and pollutant levels (Bell et al., 2019). BMPs using green infrastructure aim to restore natural hydrological processes, often requiring less maintenance, offering greater resilience, and providing co-benefits such as aesthetic improvements, water conservation, and increased biodiversity (Frey et al., 2015). In areas with large-scale gray infrastructure, further implementation of green infrastructure BMPs can alleviate stress on these systems. Proponents of green infrastructure believe that, at the very least, continuing to develop a balance between gray and green is critical to ensuring future resilience of stormwater management systems under increasing stress from climate change and extreme weather (Ozment et al., 2019).

Common non-structural BMPs consist of planning and design of developments that minimize water quality impacts, maintenance of ground surfaces that minimize pollutant loads, and education and training that promotes awareness of impacts from stormwater runoff and of the potential for BMPs to address these impacts (Field et al., 2006). On the ground, more specific examples of these BMPs include instituting vegetation controls, reducing or disconnecting impervious areas, choosing materials with reduced concentrations of pollutants, cleaning streets, cleaning catch basins, maintaining roads and bridges, cleaning spills, instituting controls on illegal dumping, and increasing attention on stormwater reuse practices for residential and commercial properties (Field et al., 2006; Clar et al., 2003). Public education and campaigns related to any of these topics would also fall under nonstructural BMP types.

Major categories of structural BMPs include ponds, stormwater wetlands, vegetative biofilters, sand and organic filters, and other technological measures (Clar et al., 2003). More specifically, practices include dry and wet retention ponds, detention basins, grass swales, filter strips, perimeter filters, chemical treatments, rainwater gardens, permeable pavement, depression storage and soil amendments to help reduce runoff volume (City of Santa Barbara, 2020). Inclusion of plants, microorganisms, and amendments is critical in GI systems because they phytoremediate, bioremediate, and remediate contaminates and enhance infiltration (Brumley et al., 2018).

This report focuses on the application of BMPs in an urban greenway setting. Specifically, it focuses on a newer type of BMP using green infrastructure on the rise in the United States: urban stream daylighting. Stream daylighting refers to the process of "deliberately [exposing] some or all of the flow of a previously covered river, creek, or stormwater drainage" (Buchholz et al., 2016). Benefits include restoration of hydrological habitat, natural filtering ability, and storage capacity. Daylighting also serves to provide open space in urban environments and provide lower maintenance costs compared to gray stormwater infrastructure. The size and popularity of these types of projects have grown over time, though costs and technical complexity remain a barrier to more extensive implementation of this type of BMP, in addition to limited information on long-term costs and benefits (Kenney et al., 2012).

2.4 Water Quality Regulations

2.4.1 Federal Regulations

In 1972, the United States enacted the Clean Water Act (CWA), creating water quality management and assessment standards to oversee pollution control in the nation's waterways (Bureau of Ocean Energy Management, 2017). The objective of the CWA is to conserve and restore the chemical, physical, and biological components of the country's surface waters. To regulate the chemicals in water discharge, the CWA created a permit program that requires facilities that discharge from a point source to have a National Pollutant Discharge Elimination System (NPDES) permit (US EPA, 2018). Under the CWA, point sources are transportation mechanisms like pipes, ditches, or channels that carry water. The permit includes the limits on what can be discharged and requires monitoring and reporting of pollutants to sustain water quality standards (US EPA, 2019). The CWA gave the Environmental Protection Agency (EPA) the authority to implement wastewater standards for industry and recommend national water quality criteria for toxins in surface waters (Bureau of Ocean Management, 2017). Impaired and threatened waterways are added to a state's 303(d) list as well as the pollutant causing impairment, if known (US EPA, n.d.). States are required to develop total maximum daily loads (TMDLs) or the maximum amount of pollutant allowed to enter a waterbody for 303(d)-listed waterways and the associated pollutant to maintain NPDES permits which must first be approved by the EPA (US EPA, n.d.). Regardless, each state has unique water infrastructure and pollutant concerns, leading water policy to become more stringent at the state level, especially in California.

2.4.2 State Regulations

In California, the State Water Resources Control Board, a branch of the California Environmental Protection Agency, implements the Clean Water Act and provides statewide standards in water quality (US EPA, 2014). The State Water Board is responsible for protecting the quality of groundwater and surface water, allocating water resources, providing permits regarding pollution discharges, and directing the cleanup of contaminated groundwater. To ensure water quality policy is being carried out, nine Regional Water Quality Control Boards within the State Water Board focus on the distribution of water supply and water quality. The Regional Water Boards are also responsible for developing new approaches that improve water quality, educate the public on water quality issues, and monitor the compliance of waste discharge requirements and NPDES permits (US EPA, 2014). As a result, the State Water Board reviews efforts made by the Regional Water Boards to improve water quality while also ensuring their actions meet statewide water quality policy (US EPA, 2014). Because every region has different environmental characteristics, sector-specific water quality regulations are contained in Water Quality Control Plans (Basin Plans) that recognize beneficial regional uses and issues

2.4.2 Local Regulations

Regulations narrow even further at the local level. The Los Angeles Regional Board is one of the nine Regional Water Quality Control Boards in California and its jurisdiction covers a large area from Rincon Point (on the coast of western Ventura County) to the eastern Los Angeles County line. The Los Angeles Regional Board's Basin Plan has legal grounds to designate advantageous uses for surface and ground waters, regulating the standards of pollutants in water quality that must be achieved or maintained to protect the primary beneficial uses and conform to the State's anti-degradation policy, and outlining implementation programs essential to achieving the water quality goals established in the Basin Plan (US EPA, 2014). The Los Angeles Regional Board oversees over 1,000 discharges of wastewater from different metropolitan and industrial sources throughout the region including storm drain systems that serve two counties and 99 cities (US EPA, 2014).

The City of Los Angeles relies on LASAN to manage stormwater in five watersheds: Ballona Creek, Dominguez Channel, Marina Del Rey, Santa Monica Bay, and Upper Los Angeles River (LA Sanitation and Environment, n.d.). LASAN is devoted to protecting the integrity of the city's watersheds by working on projects that implement overarching objectives, including those of Proposition O and the Enhanced Watershed Management Program (EWMP) (LA Sanitation and Environment, n.d.). In 2004, residents of Los Angeles passed Proposition O, a $500-million bond which aimed to remove and stop pollutants from entering its regional waterways and oceans. The projects it funded focus on recycling stormwater, water conservation, flood water reduction, and protection of surface waters (LA Sanitation and Environment, n.d.). More recently, efforts made by the EWMP provide guidelines to assist municipalities throughout Los Angeles to "comply with federal water quality mandates, improve the quality of rivers, creeks and beaches, and address current and future regional water supply challenges" (LA Sanitation and Environment, n.d.). The EWMP is a written document meant to identify present and future multi-benefit projects that will capture, treat, and use rainwater (LA Sanitation and Environment, n.d.). Through funds and niche goals for specific watersheds, Los Angeles is exploring beneficial methods to capitalize the attainment and function of rainwater and stormwater.

2.5 Urban Green Spaces

Green spaces are a type of undeveloped space that is covered by some form of vegetation such as trees, shrubs, or grass (US EPA, 2017). Within an urban setting, where land area is often developed, green space can include vegetated spaces that may be a combination of natural and semi-natural elements (Iraegui et al., 2020). On the ground, urban green spaces range from areas like parks and street trees to community gardens, local stream habitats, botanical gardens, or other landscaped spaces (Wolch et al., 2014). This would also include urban stream daylighted areas as described in section 2.3.2.

2.5.1 What is the Value of Urban Green Spaces?

While green spaces can take on a variety of forms, at their core, they can provide a number of benefits, making them a valuable resource in urban settings. They can improve mental and physical health encouraging increased physical activity and time spent outdoors (Lee et al., 2019). Access to nature or green space has also been demonstrated to promote lower rates of heart disease, stroke, obesity, stress, and depression and lower rates of mortality and illness (American Public Health Association, 2013). Urban green spaces are able to provide an appealing and functional area for people to remove themselves from stressors, be active and exercise, and socialize with others (Lee et al., 2019). They also create a sense of place within a dense and developed environment and provide opportunity to increase community cohesion (County of Los Angeles, 2016). Urban green spaces have also become highly valued throughout the COVID-19 pandemic, providing safe social opportunities and refuge in nature (Slater et al., 2020).

Urban green spaces can also provide ecosystem services that can be used for the protection and convenience of the city and neighborhood. These services vary depending on the setting and type of space, but can include flood prevention, water treatment, air quality regulation, erosion prevention, and much more (Semeraro et al., 2021). The increase in vegetation from these spaces can also help to increase albedo and thus combat urban heat island effect (Wolch et al., 2014). These same spaces also benefit the natural environment by providing habitats for plants and animals to live and grow, helping increase local biodiversity (Semeraro et al., 2021). When multiple green spaces are available, corridors can be created that allow animals and plants to travel from one area to another by utilizing the smaller green spaces as stepping stones, improving biodiversity by increasing gene flow. This combination of natural and urban environments helps incorporate natural systems and services as solutions to problems caused both directly and indirectly by urbanization.

2.5.2 Access to Green Spaces in Los Angeles

Despite the benefits of urban green spaces, not everyone has equal access to them. In Los Angeles, where urban space dominates, the County averages only 3.3 acres of local and regional recreational park per 1,000 people compared to the national average of 6.8 acres per 1,000 people (see Figure 1) (County of Los Angeles, 2016). Across the County, however, values range from 0 acres per 1,000 residents to 1,295 acres per 1,000 residents. LA County's 2016 Park Needs Assessment found that only 49% of residents live within a half mile of a park and the California Department of Parks and Recreation identified that 79% of LA County residents live in areas with less than 3 acres of parks or open space per 1,000 residents (County of Los Angeles, 2016; California Department of Parks and Recreation, 2020). Low-income and minority communities often experience limited access to parks, reduced quality of park space, and disparities in access to parks and recreation funding (Gibson et al., 2019; Joassart-Marcelli, 2010). Limited access to recreational spaces combined with existing equity concerns over park access create public health and social justice imperatives. LA County Department of Parks and Recreation aims to prioritize these imperatives through its Needs Assessment, which is presently in the process of receiving an update specific to regional and rural study areas. Their goals include: ensuring park access to everyone, distributing park resources more equitably, and developing inclusive community engagement procedures (County of Los Angeles, 2016).

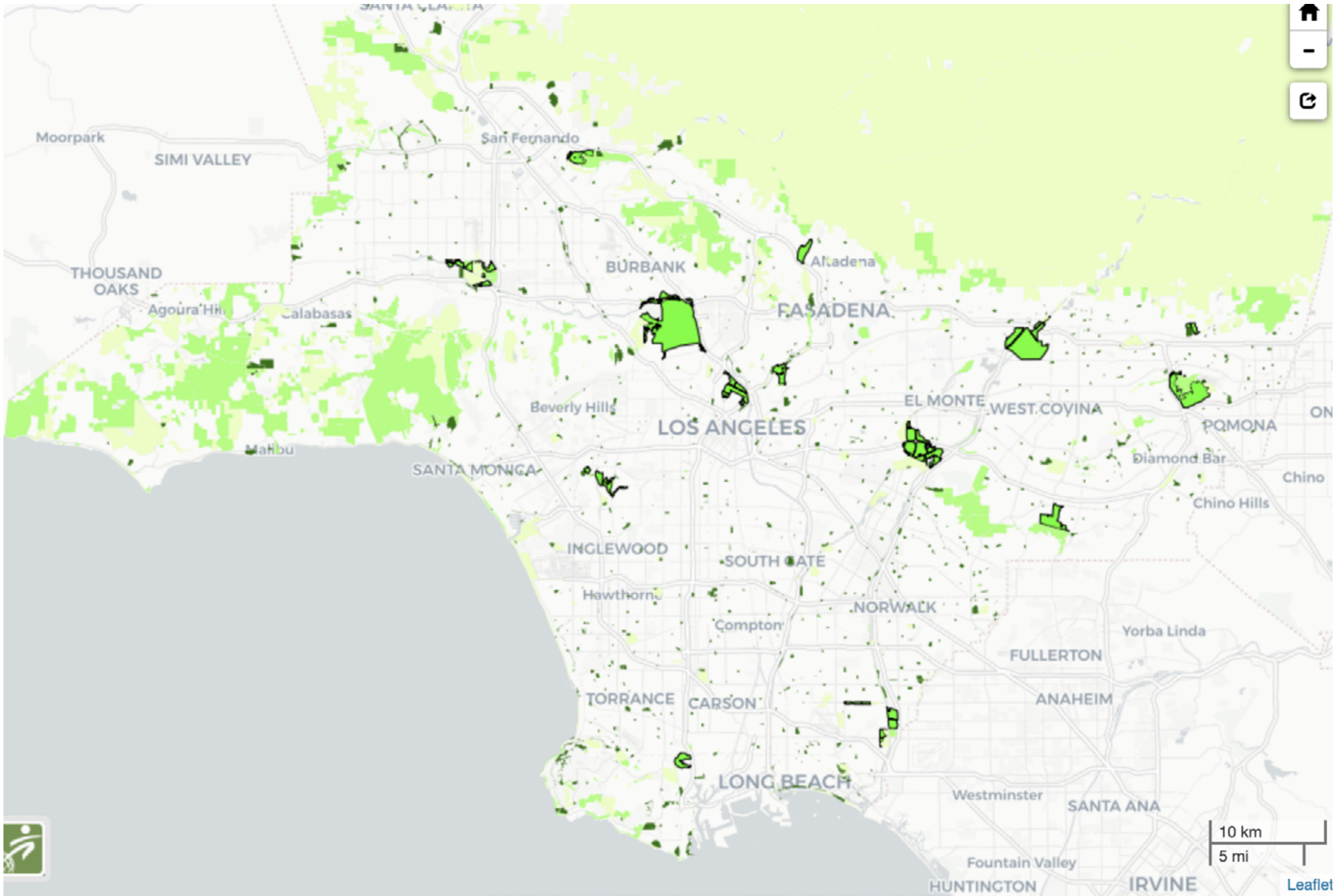

Figure 1: Parks and Open Space in LA County (County of Los Angeles, 2016)
The map shows the sparse distribution of parks across LA County. Local parks are shown in dark green and natural areas in the palest green. Regional parks and open space are shown in bright green, with regional parks differentiated by the dark outline.

3 Research Questions

This practicum project aims to answer three primary research questions:

1. What impacts do green infrastructure elements at the Westwood Greenway have on biodiversity and water quality, and how can modifications further improve outcomes at the site?
2. How and where can lessons from the Westwood Greenway project be applied and improved upon at other potential sites in the City of Los Angeles? What best practices can be used to build and maintain other greenways?
3. How can community engagement tools support expanded visibility of and access to the Westwood Greenway and the greenway model across the City of Los Angeles?

4 BIODIVERSITY

4.1 Methods

4.1.1 iNaturalist

To conduct a biodiversity assessment, we collected and recorded species data at the Westwood Greenway through an application known as iNaturalist. iNaturalist is a "crowdsourced species identification system and an organism occurrence recording tool," that can be utilized to evaluate the different types of plants and animals present at the Greenway (Seltzer, 2021). iNaturalist provides a platform for experts and members of the community to assist with identification as well as access the observational data. We used the app to record project-period observations and track past species identifications at the site. A unique feature of iNaturalist is the ability to host a project to internally track species diversity in a particular geographic area, such as the Westwood Greenway. We created a project on iNaturalist to track species during a two-month time frame. We also created a shapefile of the Greenway that was used to demarcate the site as a specific project space recognized by iNaturalist. Any observations geotagged within the shapefile's location by users would automatically populate into the project.

We hosted a bioblitz at the site to encourage community participation in collection of iNaturalist identification. A bioblitz is a "communal citizen-science" effort within a specific time period to collect as many species observations as possible within a given area (iNaturalist, 2022). Our team conducted three organized bioblitz site visits to observe biodiversity at the Greenway on February 26, March 23, and April 24, 2022. Each bioblitz event was held at a different time of day — in the morning, afternoon, and evening — in order to optimize species exposure and detect differences in species presence at different times of day. For example, due to various factors including less traffic, there are typically more species of birds occupying the Greenway in the morning. We also utilized a motion-sensored camera to capture images of nocturnal animals. The iNaturalist project remained open from February 25 through April 30, 2022 for users to submit observational data.

4.1.2 Malaise Trapping

To identify smaller insects that are difficult to observe and photograph, we employed Malaise traps. Invented by the Swedish entomologist René Malaise, the Malaise trap is a "simple tent-like structure designed to trap insects and other small organisms by passively obstructing their flight or drift patterns and then relying on their natural tendency to move upwards or towards light to ensure that they end up in the collection bottle" (Karlsson et al., 2020). We used bottles filled with an ethanol solution to preserve and trap the insects in the bottles. These traps were distributed across the Greenway near shrubs and plant species for three separate periods of three days each. Weather, wind, and humidity were recorded hourly during the tests. Some insects are carried into the trap passively by winds, however, in many cases, the insects tend to move up and down vegetation during the day (Karlsson et al., 2020). Although this trap is effective for smaller insects, large, active insect flyers with better vision such as dragonflies and butterflies are able to avoid being trapped. Malaise traps were an ideal option for the project because they can be left without emptying for a week or longer while most other insect traps must be emptied more frequently. The samples are also well preserved in ethanol and can be stored for a period before going to a lab. Based on where the species density/diversity is the greatest, the plants and natural spaces surrounding them were analyzed by correlation.

4.1.3 Biodiversity Index Metrics

The species data collected from iNaturalist are presented in a site-specific biodiversity index we created for this project. Using the methods described in Brown, 2019, the index also presents ratings for metrics we used to assess the biodiversity at the greenway:

- Habitat quality: Rating for habitat quality were determined based on the species present at the greenway when it was first created. The species consistency and overall number of natives were used to rate this metric.
- Habitat variety: The number of native plant species per square acre were calculated as well as the number of native species found in this short period of time in relation to the number of native species that were counted in the 2018 LA biodiversity index.
- Edge effects: Rating for edge effects was given observationally, based on the number of human interferences with the site present in relation to other urban environments. Although the greenway is in an urban area, the greenway's partitions and large area allow for some species to feel protected and thrive.

- Offsite connectivity: Offsite connectivity was given a rating based on a gis database evaluating greenspace in the city of Los Angeles.

The biodiversity index is available as a static PDF file (Appendix C) and is also available at westwoodgreenway.org. An updated subdomain on the website features information about the project as well as tools to navigate through biodiversity at the site including the index in an aesthetic, easily digestible way. In addition to the index outlining biodiversity at the site, there is an appendix with all of the species that were found during this 2 month study and all observations on iNaturalist that were recorded at the site prior to this project. There is also an appendix listing all of all the plant species which were planted at the greenway.

4.2 Findings

4.2.1 Biodiversity Metrics

Habitat quality received a 3.2 out of 4 based on the numerous native plants and non-native plant species planted and growing voluntarily at the Greenway, which draw native species to the site. Habitat quality has improved since water flow began at the site, as the density of species increased and more insects were collected. There are a number of native "volunteer" plants (plants that were not planted at the site), which indicates that the Greenway is a viable landscape for native plants to thrive on their own. Volunteer plants were distinguished by a comparison to a list of known planted species.

Habitat variety received a 3.6 out of 4. This value was derived by calculating the number of native fauna per acre. For the relatively small physical footprint of the Greenway there is a very high number of species. Habitat variety was assessed by looking at the overall number of different plant species — both planted and volunteer. For example, during spring of 2022, California poppy (*Eschscholzia californica*) plants were found all across the site There is also a variety of sage, common milkweed (*Asclepias syriaca L.*), and white alder or California alder (*Alnus rhombifolia*). There is also a great variety of native volunteer plants at the Greenway. The site was designated an Ocean Friendly Garden by Surfrider's program, which identifies sites that have a selection of plants that require less watering and block pollutants from free-flowing into the ocean (Dias, 2022). With runoff being the main source of urban pollution in the ocean (Dias, 2022), spaces like the Westwood Greenway act as a filter preventing urban waters from polluting coastal waters (Dias, 2022). In relation to the City of LA biodiversity index, there were 215 native butterflies and moths recorded, at our project there were 5 native species of butterflies and moths. This is 2.33% of the species found in the entire city, which is 2330 times more than the expected 0.001% (the portion of Greenway area relative to the City of Los Angeles).

Based on information from previous GIS studies, **off-site connectivity at the Greenway was observationally rated 3.6 out of 4.** For urban biodiversity to succeed at the site, it is important for there to be connectivity to other waterways and habitats. Protected 'islands' themselves cannot restore ecosystems without some connection to other urban systems. An island, or protected greenspace on all sides, if isolated without connectivity is at risk of species extinction and loss of critical ecosystem functions (Tabor, 2018). Some examples of existing and potential connectivity pathways at the Westwood Greenway include: twin culverts connecting the north and south sides; stream connectivity to other waterways; fence holes for small animals to pass; and native plants that are adapted to local environments providing consistency for native species to survive. Connectivity is critical for biodiversity to thrive. We found evidence that the addition of this natural habitat in a densely urbanized area will add another passage for wildlife and native plants to spread in the City of Los Angeles. We also looked at the types of insects collected in Malaise traps on the north versus the south side of the site. There were very similar insect species across both sides of the site. Consistent native plantings and volunteer plant species may play a large role in connectivity across the site. In a GIS study of greenspace in Los Angeles conducted by the City of Los Angeles Environment and Sanitation, it is evident the Greenway falls within a large swatch of gray area that implies lacking presence of habitat (see Appendix C, Biodiversity Index page 6).

The edge effects rating for the Greenway was 3 out of 4. For edge effects, the influence of humans at the Greenway is largely due to adjacency to Metro traffic. At the site, we identified the following: neighborhood pets such as feral cats sighted on the motion sensor camera preventing amphibians and reptiles (important indicator species); the Metro line; Overland Elementary School with pick-up and drop-off traffic; general rush hour traffic; and overnight camping by unhoused individuals. The surrounding neighborhood is also developed and adjacent to a major walkway and bike path, which makes it difficult for many larger indicator species to establish at the site. Although these effects may play a larger role in the continual growth of biodiversity found at the site, it appears the Greenway has nevertheless maintained species that have been present since the site was completed. These include the Gulf Fritillary (*Dione vanillae*), Monarch (*Danaus Plexippus*), and Lesser Goldfinch (*Spinus psaltria*). Attributes that likely support the survival of species at the site include the protected south side and chain link fences around the north side which keep pedestrians out of the site for the majority of time. Observations made at the site have increased since the Greenway was created. iNaturalist observations in the surrounding area have also increased since the site's completion in October, 2020. Even though the types of species that can be sustained at the site may be altered by the amount of human activity, overall observations in the surrounding neighborhood have also increased since the adoption of the Greenway. For example, observations on iNaturalist from the neighborhoods surrounding the Greenway went from less than 5 per year to over 30 in 2019.

4.2.2 Data

Malaise trap data suggests there is a healthy variety of insect species and connectivity between the north and south side of the Greenway through the presence of similar plant species that promote biodiversity and provide space for fauna to flourish. This finding was supported by a particularly dense species collection closer to the stream and native flowering plants. When the malaise trapping was conducted during warmer weather, the insect collection also increased. We did not catch any butterflies, dragonflies, or moths during the three different testing periods, all observations of larger flyers were made through iNaturalist. All of our collected species have been sent to the Natural History Museum of LA County's archive to be cataloged. Once cataloged with location and duration of collection, the species data will be available for scientists at the museum to draw from. Bioblitz events contributed 139 fauna observations to iNaturalist. Over 80 expert and volunteer identifiers helped contribute to 80 research-grade observations. Eight native species were identified at the Greenway in a period of two months. For this project, we did not have access to a laboratory for a more detailed taxonomy of the species caught. Due to time and resource constraints, our species were classified by sight, iNaturalist, and density of species rather than in a laboratory.

4.3 Discussion

4.3.1 Implications

For the future expansion of greenways in Los Angeles there are key elements at the Greenway to replicate that enrich species variety and habitat quality. First, planting native plant species such as narrow leaf milkweed (*Asclepias fascicularis*) and white alder (*Alnus rhombifolia*) attracted monarchs and a variety of insects. Native plant species are suitable to Southern California's climate therefore, drought tolerant. This benefits conservation efforts and connects future greenways to other native habitats. A daylighted stream or water source flow is also important for future greenways. This water source not only sustains the plants at the greenway but also insects, invertebrates, and birds who live at or visit the site. Without native plants or a daylighted stream, urban biodiversity cannot be as highly supported.

4.3.2 Recommendations

The index can serve as a tool to evaluate the evolution of biodiversity at the site. As the site ages, the index can be referred to as a comparison tool and glossary of species that were observed during the Winter/Spring of 2022. To continue to support vibrant biodiversity at the Greenway, we offer several recommendations that are further described in the index.

1. In order to attract more indicator species and native bird species, we recommend planting a few specific native plants. For example, planting California buckeye (*Aesculus californica*) could help to attract the Lorquin's admiral butterfly (*Limenitis lorquini*), which relies on the flower's nectar for food (Butterflies, 2020). The red winged blackbird (*Agelaius phoeniceus*), could also be drawn to the site. They live in or near wetlands full of cattails,and also near water in shrubby thickets of willow or blackberry (Kaufman, 2022). Another example, to attract the cedar waxwing (*Bombycilla cedrorum*) it would be beneficial to plant juniper (*Juniperus*) species or western chokecherry (*Prunus virginiana*) (Kaufman, 2022).
2. To attract the indicator species, western bluebird (*Sialia mexicana*) bluebird boxes could be placed at the site. Bluebirds seek tree cavities for nesting and a bluebird box mimics this natural nesting space to help boost bluebird populations (Society, 2022).
3. Reintroduction of an indicator amphibian or reptile could be possible for the site, particularly if the threat neighborhood pets pose is mitigated. Neither amphibians or reptiles have been spotted at the site despite these creature's attraction to running water.
4. We also recommend keeping an ongoing iNaturalist project active. This would allow for monitoring of continual changes to biodiversity, as well improve long-term record keeping and encourage sustained community investment in the site.

5 WATER QUALITY

5.1 Methods

To assess how stormwater and urban runoff is affected by sand filters and bioswales at the Greenway water quality was assessed using the LaMotte Urban Water Test Kit, Extenuating Threads TDS/EC portable meter, and SenSafe Water Metals Check test strips. Water quality samples were collected during two dry-weather events and two wet-weather events of water both entering and leaving the Greenway between March and April 2022. Time of day was a factor in collection time to account for pollutant fluctuations that may occur throughout the day.

Event Type	Date	Sampling time
Wet	March 28, 2022	3:45 PM
Dry	April 3, 2022	11:26 AM
Wet	April 22, 2022	12:59 AM
Dry	April 28, 2022	6:30AM

Table 1: Water Quality Sample Collection Details

Four locations at the site were sampled; one for the influent (north pump), two at midpoints (north drain and south pump), and one for the effluent (south drain). A fifth distilled water sample served as a control throughout the assessment. Our team collected water samples using clean glass jars rinsed with distilled water prior to collection time. At each sampling site, jars were rinsed with flowing water three times before being filled to the top. Some tests, such as temperature, dissolved oxygen (DO), total dissolved solids (TDS), and electrical conductivity (EC) were performed on site. Remaining samples were taken off-site to be tested for additional parameters which include; coliform bacteria, chlorine, copper, hardness, iron, nitrate, pH, phosphate, and general heavy metals. SenSafe metals test strips tested for cadmium, cobalt, copper, iron (ferrous), lead, mercury, nickel, zinc and other +2 valence metals concentrations in combination not individually. Collection from all four locations on site was generally completed in 20 to 30 minutes (from north pump to south drain) per sampling event, and samples were kept on ice while being transported to the off-site testing location. All tests were conducted using kit protocols (LaMotte Urban Water Test Kit, n.d.).

5.2 Findings

Refer to Appendix A for further data

The data in Table 2 shows evidence that the Greenway's sand filter and bioswale is reducing pollutant levels in stormwater and urban runoff in both dry- and wet-weather events. Appendix A presents more detailed analyses. Improvement can most readily be seen in hardness, TDS, EC, and heavy metals. Reductions in iron concentrations can be seen in the wet-weather samples collected April 22. A significant reduction in nitrate was found on March 28 during a wet-weather sample, and phosphorus showed minimal reduction throughout the sampling. Healthy DO (7-8 ppm) and pH (7-8) levels were recorded in the water at the Greenway for all samples (See Appendix A). All sampling sites tested positive for bacteria. Chlorine and copper were not detected or detected in minimal quantities (<1 ppm and <1.5 ppm, respectively). Hardness is a measure of dissolved minerals — mainly calcium and magnesium — and when water has concentrations below 50 ppm it is called soft (LaMotte Urban Water Test Kit, n.d.). Our samples of water at the Greenway indicate hard water, with concentrations of 80 ppm and above. Through the course of the water quality assessment we saw an improvement in water quality in the following parameters in one or more tests: TDS, EC, DO, hardness, nitrate, iron, and heavy metals.

5.3 Discussion

We saw low concentrations of nitrogen and phosphate in the influent. A study of bioswales with various media and structures in China found nitrogen removal rates decreased and phosphorus removal rates increased with increase of inflow concentration at Xi'an University of technology (Li et al, 2016). In our study, we saw higher reductions in nitrogen in one sampling but otherwise concentrations remained low and consistent. Phosphate levels were also low and consistent in our assessment. These findings provide foundational information for water quality at the greenway, but signal the need for more assessment to be done. DO is a sign of healthy water and low or anoxic conditions are a sign of pollution, 5 ppm is usually required for aquatic metabolisms (LaMotte Urban Water Test Kit, n.d.). Chlorine drinking water has concentrations typically of 0.5 ppm and swimming pools typically have concentrations of 1 ppm (LaMotte Urban Water Test Kit, n.d.). Although the treatment train had no significant effect on pH the discovered range of 7-8 is within the range of 6.5 to 8.2 considered optimum for aquatic flora and fauna (LaMotte Urban Water Test Kit, n.d.). Metal adsorption profiles are found to be related to pH and "at pH 7, adsorption was greater than 90% for lead, greater than 80% for copper, and approximately 50 to 70% for zinc" (Davis, 2001).

Parameter	Results
Coliform Bacteria	Positive presence at all four locations
Chlorine	Not detected or in minimal quantities (<1 ppm)
Copper	Not detected or in minimal quantities (<1.5 ppm)
Dissolved Oxygen	• Ranges between 4-8 ppm for wet weather with some signs of improved quality on 3/28 sample • Consistently 8 ppm for dry weather
Hardness	• Ranges between 80-300 ppm for wet weather with some signs of improved quality on 3/28 sample • Ranges between 360-410 ppm for dry weather with some signs of improved quality on 4/28 sample • These ranges show water at the Greenway is hard water
Iron	• Ranges between <1-5 ppm for wet weather with some signs of improved quality on 4/22 sample • Ranges between 0-1 ppm for dry weather
Nitrate	• Ranges between >20-<5 ppm for wet weather with some signs of improved quality on 3/28 sample • Consistently 5 ppm for dry weather
pH	• Ranges between 7-8 for both wet and dry weather • The water at the Greenway has neutral to basic pH
Phosphate	• Consistently 4 ppm for wet weather with slight signs of improved quality on 4/22 sample • Consistently 2 ppm for dry weather with slight signs of improved quality on 4/28 sample
Temperature	• Ranges between 61.8-66.2 °F for wet weather • Ranges between 65.6-72.5 °F for dry weather
Total Dissolved Solids	• Ranges between 163-554 ppm for wet weather with some signs of improved quality on 3/28 sample • Ranges between 486-599 ppm for dry weather
Electrical Conductivity	• Ranges between 326-1047 µS/cm for wet weather with some signs of improved quality on 3/28 sample • Ranges between 972-1198 µS/cm for dry weather
Heavy Metals	• Ranges between <100-20 ppb for wet weather with some signs of improved quality on 3/28 sample • Ranges between <100-10 ppb for dry weather

Table 2: Water Quality Assessment Results at the Westwood Greenway by Parameter
*Ranges in Dry and Wet Weather of Parameters (green indicates improved treatment or viable living conditions, orange indicates minimal treatment, and white indicates inapplicable).

TMDLs for the Ballona Creek Watershed originally intended to compare to the Westwood Greenway's water quality assessment data to include copper, lead, zinc, total coliform bacteria, E. Coli, and Enterococci. Coliform bacteria, copper, lead, and zinc data from our water assessment was incomparable to TMDLs reported in MPN or ppb. Copper is typically found in natural water in small quantities and drinking water concentrations range from 0.03-0.6 ppm (LaMotte Urban Water Test Kit, n.d.). Our LaMotte kit could only read concentrations as low as 0 ppm, making our collected data for copper too general to compare to the TMDLs standards for Ballona Creek Watershed. Heavy metals can exist in two forms; particulate, usually removed utilizing a filter media and dissolved, typically removed via adsorption (Li et al, 2016). We were not able to directly test for lead or zinc, but tested general heavy metal presence in both forms (which included lead and zinc) using the SenSafe test strips and reported >10 ppb. The LaMotte kit tested for total coliform bacteria using an indicator organism, coliform, that produces gas as it grows in lactose (Stenstrom, 2022). The kit tested for presence of bacteria and classified samples as "positive" or "negative" for coliform and "many gas bubbles present" indicated a positive sample. Commonly coliform is measured in MPN or most probable number since it is easy to miss them in a sample and likelihood of discovery goes down the smaller the sample (Stenstrom, 2022). Although we saw no reduction in bacteria at the Greenway, the TMDLs for bacteria in Ballona Creek are 10,000 MPN/100 mL. Coliform is present even in drinking water, so the absence or presence of coliform at the Greenway is not meaningful.

5.3.1 Recommendations

Pollutant removal in bioswales is related to channel dimensions, slope, and type of vegetation (Caltrans, 2012). A study done by a team at the Department of Environmental Toxicology at the University of California found bioswales reduced suspended solids by 81%, metals by 81%, hydrocarbons by 82%, and pyrethroid pesticides by 74% through the metabolism of plants (Wilmoth et al, 2019), so it is likely the Greenway is already improving these conditions. Planting vegetation that has high surface area for adequate contact with stormwater. Thicker, heavier grasses can better filter out contaminants, and deep-rooted native plants are good for infiltration and may require less maintenance (NRCS, 2005).

Hydraulic residence time (HRT) is the minimum amount of time polluted water should spend within the bioswale for optimal pollutant removal and is calculated by dividing the flow velocity by the length of the bioswale and it is recommended to be a minimum of five minutes (Caltrans, 2012). Planting native trees and larger shrubs in and around the bioswale could help ensure efficient hydraulic residence time (HRT). A student-conducted study at University of Pittsburgh found trees and larger shrubs improve the efficiency of the bioswale and the environment at the site by cycling a larger amount of water than smaller plants via transpiration and their long root systems increase infiltration (Wilmoth et al., 2019). Adding a remote device at the Westwood Greenway to monitor flow rate at the north pump of the influent would enable monitoring to ensure HRT is efficient. Suggestions for improvement of HRT under 5 minutes include lengthening the bioswale or decreasing velocity by increasing width or decreasing slope inside the bioswale (Caltrans, 2012). For already completed bioswales, these options are not available however manning roughness (n) can be altered by adding or removing items that cause friction against the bioswales flow such as additional plants or rocks.

A field experiment conducted eight years after the completion of two bioswales at the University of California, Davis found a 99.1% reduction in nitrogen and 99.5% reduction in phosphate in a bioswale with engineered soil mix (75% native lava rock and 25% loam soil) planted with Red Tip Photinia (Photinia x fraseri Dress) trees and Blueberry Muffin Hawthorn (Rhaphiolepis umbellata (Thunb.) Makino) when compared to a control that was unplanted (Xiao, 2017). It is important to maintain the bioswale through regular monitoring and maintenance of vegetation and infiltration capacity. Soil infiltration capacity should be assessed on occasion to determine if soils become clogged.

5.3.2 Limitations

The water quality parameters listed as treatable in the the Greenway's grant application to the Santa Monica Bay Restoration Commission are based on TMDLs for local waterways and include: 303(d)-listed impairments (mercury, nickel, silver, dichlorodiphenyldichloroethylene (DDE), and several polycyclic aromatic hydrocarbons (PAHs)) and non-303(d) listed impairments (cadmium, several pesticides, insecticides, and organic pollutants and more PAHs. Nitrate, copper, lead, zinc, and fecal coliform bacteria were also listed as treatable at the Greenway by project partner and city entity LA Sanitation and Environment in Fall 2011. The original scope of our project relied on data collected by LASAN to more fully assess water quality at the Westwood Greenway. This would have allowed us to look at accurate concentrations of various constituents that relate to the local waterway's TMDLs, and make specific recommendations from that comparison. However, as of the writing of this report, LASAN has yet to collect any data. Another limitation we encountered was that COVID-19 restrictions limited student access to the UCLA laboratories that relate to water quality, such as the Environmental Engineering Laboratories or the Hydrology Laboratory, where a more thorough analysis could have been executed. Therefore, while we pivoted to conduct our own water quality data, the assessment was executed based on available DIY kits that we could order on the internet without state restrictions. The DIY kit we used allowed us to gather data on some constituents found at the Greenway, however it lacked accuracy as it used a color scale to indicate concentration levels. However, we hope our assessment will inspire official testing to be conducted to ensure funding.

We did not have the chance to test for DDE, pesticides, and other organic pollutants also known as persistent organic pollutants (POPs) or PAHs. These constituents can be difficult to analyze, for example the health risk limit for DDE is 0.2 μg/L but the minimum reporting level (MRL) used for monitoring is 0.8 μg/L (EPA, 2008). DDE presence is rare with only 1 in 3,874 EPA surveyed public water systems triggering detection of DDE, making it an important factor to address if present (EPA, 2008). PAHs can harm the health of wildlife, pregnant women and children.

6 GREENWAY DIFFUSION

6.1 Methods

6.1.1 Greenway Replication

To provide information in support of replicating and improving upon the Westwood Greenway model at other sites in Los Angeles, we identified suitable sites based on a selection of vital factors. Our main goal was to identify potential sites for daylighting streams in Los Angeles, as treating urban runoff is one of the key purposes of the Westwood Greenway. The stream supports the biodiversity present at the site and was essential for funding the project.

We considered the following factors most relevant to identifying other potential sites for a greenway-like stream daylighting project: proximity to flood-prone areas, surrounding area park need, and considerations of social vulnerability.

With this understanding, we used the GIS Climate-Smart Cities tool developed by the Trust for Public Land (TPL) as the primary mode of site suitability analysis. Created via a stakeholder process with LA-area experts, the tool compiles a number of relevant spatial data layers into themes relevant to increasing climate resilience, including layers called "Cool," "Connect," "Absorb," "Protect," and "Climate Equity." Absorb and Climate Equity themes were most relevant to identifying potential greenway sites. The Absorb theme aims to identify areas most suitable to absorb groundwater and decrease flooding. Absorb compiles data layers on soil permeability, flood risk, spreading grounds, and riparian areas, focused on how areas that could be prioritized to "absorb rainfall, reduce flooding, and recharge drinking water supplies while saving energy for water management" (Trust for Public Land, 2022). The Climate Equity theme aims to identify high-priority areas of social vulnerability under climate change, including data on demographics such as linguistic isolation, youth, and elderly populations, and unemployment values. The tool allows users to weight each category out of a maximum value of 10 and then develops a heat map based on high, medium, and low scenario values. As shown in figure 4, darker values on the heat map demonstrate higher priority areas. In our assessment, absorb was weighted a 10, presenting the highest priority for relevant traits to developing an urban greenway. Climate equity was weighted a 9, critical to advocating for these types of projects elsewhere where need is high but community resources may be less limited. Weighting both factors equally led to wide swaths of high priority areas that were too broad across Los Angeles to be useful for the purposes of this analysis. Therefore, we weighed climate equity only one degree lower in order to further narrow high priority areas without diminishing its importance to the analysis.

The Los Angeles region has been attempting to allocate park and recreation resources more equitably (Joassart-Marcelli, 2010). To maximize funds set aside for green infrastructure projects, priority should be focused towards areas with high green space need and disadvantaged communities. We were interested in comparing projects relying on current funding mechanisms for green infrastructure projects, primarily by considering the Safe Clean Water Program (further described in section 5.2.1). We downloaded TPL data as PDF files, converted them to TIFF files, and georeferenced the images in ArcMap. We then used SCWP data to map sites with infrastructure funding, sites under consideration for funding, and sites that were not yet funded. We also included a data layer demarcating the watershed boundaries.

The Safe Clean Water Program website was used to identify these projects and provided a direct link to a PDF of feasibility reports for each project. Due to the high volume of green infrastructure projects seeking funding through the Program, we chose to investigate these projects and apply the Greenway model where applicable. The focus of our analysis was on project location and how it compares to our GIS findings and providing recommendations that emphasize nature-based solutions and community engagement.

6.1.2 Community Outreach and Social Media

To realize the vision of the Westwood Greenway, community involvement was needed from the start, and engagement must be sustained to keep the greenway sustainable. Engagement with the community is also critical to spreading the greenway concept and the lessons it offers about local water management and biodiversity. Social media provided a viable and important avenue to expand the visibility and accessibility of the Westwood Greenway and the greenway concept. We created a Social Media Engagement Plan (Appendix B) that focuses on communication efforts to effectively convey the Westwood Greenway's messages and themes to its audience. We also applied this plan for 8 weeks of our project, as we created and shared content for the Westwood Greenway's social media,

6.2 Findings

6.2.1 Funding

Securing adequate funding for design, implementation, and maintenance is the primary barrier to introducing more green infrastructure projects to Los Angeles. Even where the expertise and support from communities exist, the process of realizing green infrastructure projects must rely on government funding for implementation. A variety of funding sources are available at the federal, state, and local levels, though securing these types of grants can in itself impose financial limitations by tying projects to bureaucratic timelines and processes. Simulated models and feasibility reports are the current planning practice, which is more abstract than other methodologies that involve on-site surveying. The multiple stakeholders involved in managing green infrastructure projects are often not aware how to optimize project funds (Jayasooriya, 2020). To support future projects, we reviewed various funding sources relevant to Los Angeles.

6.2.1.1 Measure W

In November 2018, Measure W was approved by LA County voters with goals of addressing local water supply and water quality issues. Measure W is funded by a parcel tax, which is levied at 2.5 cents per square foot of impermeable surfaces throughout the County ("Los Angeles County Flood Control District," 2018). These funds provide for projects that capture, clean, and recycle stormwater. Project selection criteria favor projects that incorporate nature-based solutions and provide community investment benefits. This tax raises approximately $300 million annually and the measure has no sunset date. In 2020, 41 infrastructure projects were approved for funding by Measure W, totaling $352.2 million in promised funds. In 2021, 35 infrastructure projects were approved for funding totaling $264.4 million (City News Service, 2021).

The Safe Clean Water Program (SCWP) was formed to carry out the vision set by Measure W. The SCWP is overseen by the Regional Oversight Committee, a group of 9 members with professional backgrounds in water management. They are responsible for meeting the goals set by the program and identifying concerns or limitations. The program divides the county into nine watersheds and allocates funds to green infrastructure projects and scientific studies ("Safe Clean Water Program," 2021). The projects submitted for funding vary in size, scope, and amount of funds requested; however, all incorporate some degree of nature-based or nature-mimicking solutions, as well as elements designed to benefit the community. Projects are scored by the SCWP scoring committee in coordination with the LA County Flood Control District. A score of at least 60 out of 100 is required to be considered for funding ("Safe Clean Water Program," 2021). The SCWP is currently working to redefine its scoring metrics to better prioritize projects that use primarily nature-based solutions and engage meaningfully with disadvantaged communities.

6.2.1.2 Measure A

In 2016, voters approved Measure A, which is also funded by a parcel tax. This measure allocates funds towards park improvement projects under the management of the Community-based Park Investment Program and Neighborhood Parks, Healthy Communities, and Urban Greening Program. Since 2019, the City of LA Department of Recreation and Parks has been able to manage projects that have received Measure A funds through their Park Improvement Plan ("Measure A Projects," 2021). Each year, 35% of Measure A funds are spent on the Community-Based Park Investment Program. Among the list of projects that qualify for this grant are greenspaces and greenway development. Additionally, 13% of funds are allocated towards the Neighborhood Parks, Healthy Communities, and Urban Greening Program (RPOSD, 2022). Recipients of the funding are typically in areas of high or very high park need as identified by the Park Needs Assessment (County of Los Angeles, 2016). Community engagement plans and feasibility studies can also be financially supported by Measure A. Maintenance and service funding is available if requested and approved.

6.2.1.3 Other Grants

wEven with County support, the implementation, operation, and maintenance of green infrastructure projects still faces funding and oversight challenges (US EPA, 2022). In many instances, projects may require additional funding for operation and maintenance and have to seek support elsewhere. Listed below are additional funding sources with their general requirements.

Program	Eligibility	Funding Availability
Clean Water State Revolving Fund	Eleven different types of projects qualify for assistance including stormwater, water conservation, and reuse, and watershed pilot projects.	Project funding: <$1 million to >$100 million Typically $200 million to $300 million available annually
Rose Foundation- California Watershed Protection Fund	Projects must be designed to benefit the surface water quality of a California watershed. It is encouraged that projects are community-oriented and focus on principles of environmental justice.	Project funding: $7,500 to $25,000
California State Water Bond	Funds are available for multi-benefit projects such as green infrastructure and stormwater capture and treatment.	$7.5 billion available
California Natural Resources Agency- Environmental Enhancement and Mitigation	Projects must mitigate, directly or indirectly, the impact of a new or existing transportation facility. This can be done through the protection of open spaces or watersheds.	Project funding: Up to $500,000 $8.3 million available
San Gabriel and Lower LA Rivers and Mountain Conservancy	Proposed projects must protect open space or habitat to provide watershed improvements, biodiversity protection, and/or recreation.	N/A

Table 3: Grant Programs in California Applicable to Building Greenway Projects

6.2.2 SCWP Projects

The SCWP website includes a portal that lists all projects seeking funding. Each project includes a description, application, feasibility report, and final score. In order to demonstrate how elements at the Westwood Greenway can be replicated, we analyzed infrastructure project reports to determine if they were suitable to include a greenway. These projects are seeking funding for the 2022-2023 year and are in the design phase.

6.2.2.1 Region Identification

Based on our focus on flood-prone areas, we were advised by experts in watershed management to consider the San Fernando/Sun Valley region, an area that has historically been flood-prone and provides good opportunities for groundwater replenishment. To address areas with a high need for green spaces, we were advised by biodiversity experts to consider the East LA and Willowbrook regions. These recommendations aligned with regions of high need we identified through our GIS consultation. The Sun Fernando/Sun Valley region is a part of the Upper LA Watershed, the East LA region is a part of the Rio Hondo and Upper San Gabriel Watersheds, and the Willowbrook region is a part of the Lower LA River Watershed. The Westwood Greenway is a part of the Central Santa Monica Bay Watershed and was not identified as a region of high need.

6.2.2.2 Suitable Projects

Project proposals from the Upper LA, Rio Hondo, Upper San Gabriel, and Lower LA River Watersheds were reviewed. Of the 18 projects analyzed from the Safe Clean Water Program Portal, eight are suitable to include a greenway, five of which are located in disadvantaged communities (DAC). The chart below includes the name of the project, characteristics from the report that support greenway replication, and recommendations to include more nature-based solutions. As shown in Figures 2 and 3, all eight of the sights identified fall in moderate and moderate to high priority zones for siting a greenway. This confirms a level of comparability between our analysis and siting for green infrastructure projects by SCWP. We identify that there is potential, however, for a greater proportion of investment in what our team determined as high priority zones for siting a greenway in both areas of this watershed.

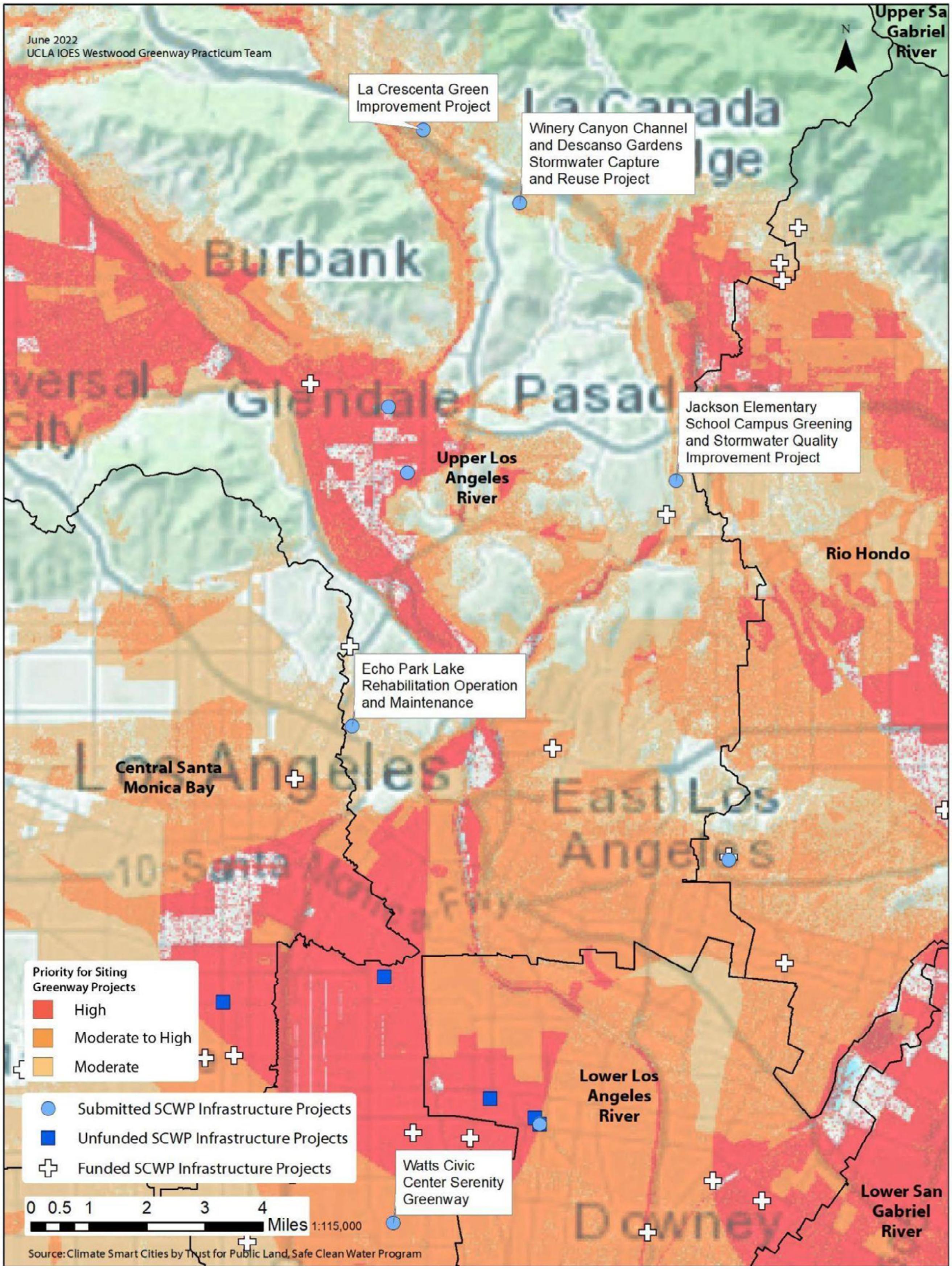

Figure 2: SCWP Projects in the Upper Los Angeles River Watershed Suitable for a Greenway
(Submitted projects refer to SCWP projects under review)

Project Name (Watershed)	Replication Characteristics and Further Recommendations
Winery Canyon Channel Stormwater Capture (Upper LA)	Plans to divert, treat, and store stormwater to supply irrigation and water features at a local garden. Water treatment, diversion channel, and cistern are all gray infrastructure based. A greenway at the initial diversion point can achieve the project's goal of removing trash and pollutants before reuse. Reducing impervious surfaces where feasible would boost the design's nature-based elements.
La Crescenta Green Improvement Project (Upper LA)	Project will infiltrate stormwater runoff through a dry well and uses bioswales to capture additional runoff. A greenway could potentially replace the pre-treatment device to incorporate a nature-based solution. Proposed tree plantings should consider native species, such as oaks, to reduce water use and support native biodiversity.
Echo Park Lake Rehabilitation* (Upper LA)	Plans to improve water quality and include water features for the local community. A greenway or other similar elements could potentially aid in treating water before it enters the lake. Native plants and incorporating teaching elements can better serve the local community, who lack access to recreational opportunities. Currently the space is visitor focused and neglects the needs of biodiversity and the local community.
Watts Civic Center Serenity Greenway* (Upper LA)	Project will replace a concrete alley with vegetated porous pavers. Recommendations could include using more nature-based elements such as bioswales and incorporating native plants.
Jackson Elementary Greening and Stormwater Improvement* (Upper LA)	The project will replace 60% of asphalt with permeable surfaces to improve drainage. A greenway at the front of the school may help address flooding that affects the school and surrounding neighborhood. The greenway and proposed native plantings could serve as an outdoor laboratory for the students.
Marchant Park* (Upper San Gabriel)	The project will incorporate an infiltration gallery to city park. Recommendations could include diverting stormwater above ground to create a greenway, which could serve as a teaching center alongside the proposed sensory garden for the underserved local community.
Glendora Avenue Green Streets (Upper San Gabriel)	Plans to capture, divert, and clean stormwater as a green street project. Current proposed nature-based solutions align with greenway elements. A recent expansion of public transportation in Downtown Glendora could justify the transformation of a parking lot into a greenway.
Pelota Park* (Upper San Gabriel)	Plans to incorporate an infiltration gallery into a city park. Recommendations could include diverting stormwater above ground to create a greenway, which could serve as a teaching center in an underserved community. Including native plants and trees would support biodiversity.

Table 4: SCWP Projects Reccomeded for Greenway Replication
*Located in a disadvantaged community as defined by LA County

Figure 4 shows that SCWP infrastructure projects are distributed across many parts of LA County. Infrastructure projects demonstrate no clear trend of being located in high-priority areas – those that could help to absorb water and reduce flooding as well as address social vulnerability under climate change. Notably, a number of funded infrastructure projects are found in dispersed high-priority areas in the Upper LA River Watershed as described above. However, a greater number of projects could be focused in the central high-priority area on the map around South Central LA and Huntington Park, where there are currently two unfunded and two funded projects. The Willowbrook region of South Central also falls within high priority areas, though does not show overlap with any SCWP project. In addition,

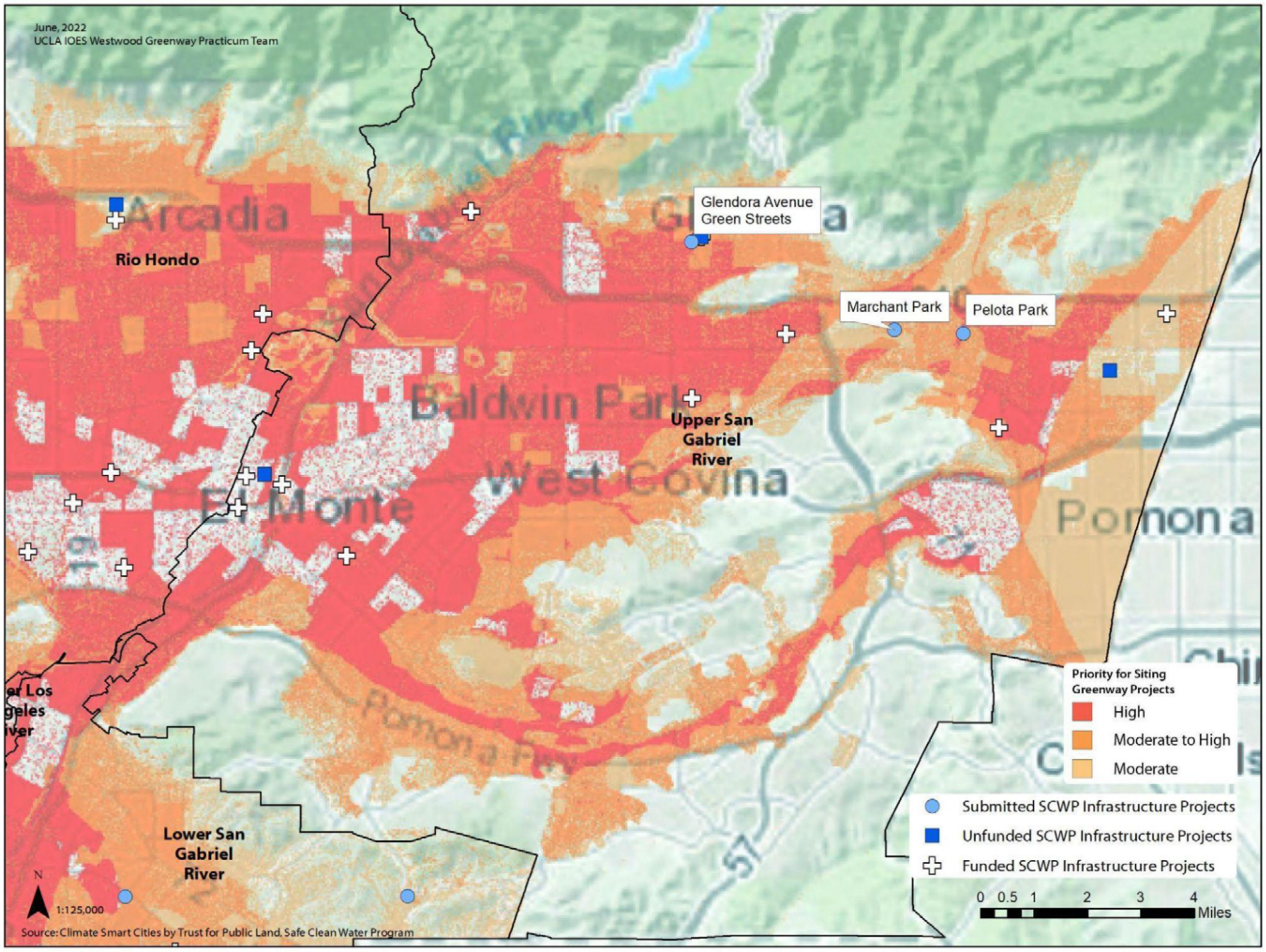

Figure 3: SCWP Projects in the Upper San Gabriel River Watershed Suitable for a Greenway
(Submitted projects refer to SCWP projects under review)

within the scope of this analysis, East LA falls under high to moderate priority and only shows three projects in the region. The Upper San Gabriel Watershed shows a greater density of SCWP projects, though has less apparent overlap with high priority areas. Greater attention to greenway project development in areas denoted as high priority by SCWP and other funding mechanisms could help to further LA County's goals to improve water quality and protect public health as well as meet high priority areas as defined by TPL.

6.2.2.3 Expanded Visibility

To realize the vision of the Westwood Greenway, community involvement was needed from the start, and engagement must be sustained to keep the greenway sustainable. Engagement with the community is also critical to spreading the greenway concept and the lessons it offers about local water management and biodiversity. Social media provided a viable and important avenue to expand the visibility and accessibility of the Westwood Greenway and the greenway concept. We created a Social Media Engagement Plan (Appendix B) that focuses on communication efforts to effectively convey the Westwood Greenway's messages and themes to its audience. We also applied this plan for 8 weeks of our project, as we created and shared content for the Westwood Greenway's social media, @westwoodgreenway on Instagram. During these 8 weeks, we made 8 posts and noted a 25% increase in followers since our first post on April 15, 2022.

6.3 Discussion

While financing green infrastructure projects is a vital step, a lack of effective oversight can inhibit the maximization of provided funds. This results in inefficiencies, duplication of efforts, and a disconnect between the degree of site maintenance that is needed and the entities that perform the maintenance. As emphasized by the literature, experimental governance between private, public, and academia, geared towards solving problems to benefit the public, often loses sight of meaningful democratic

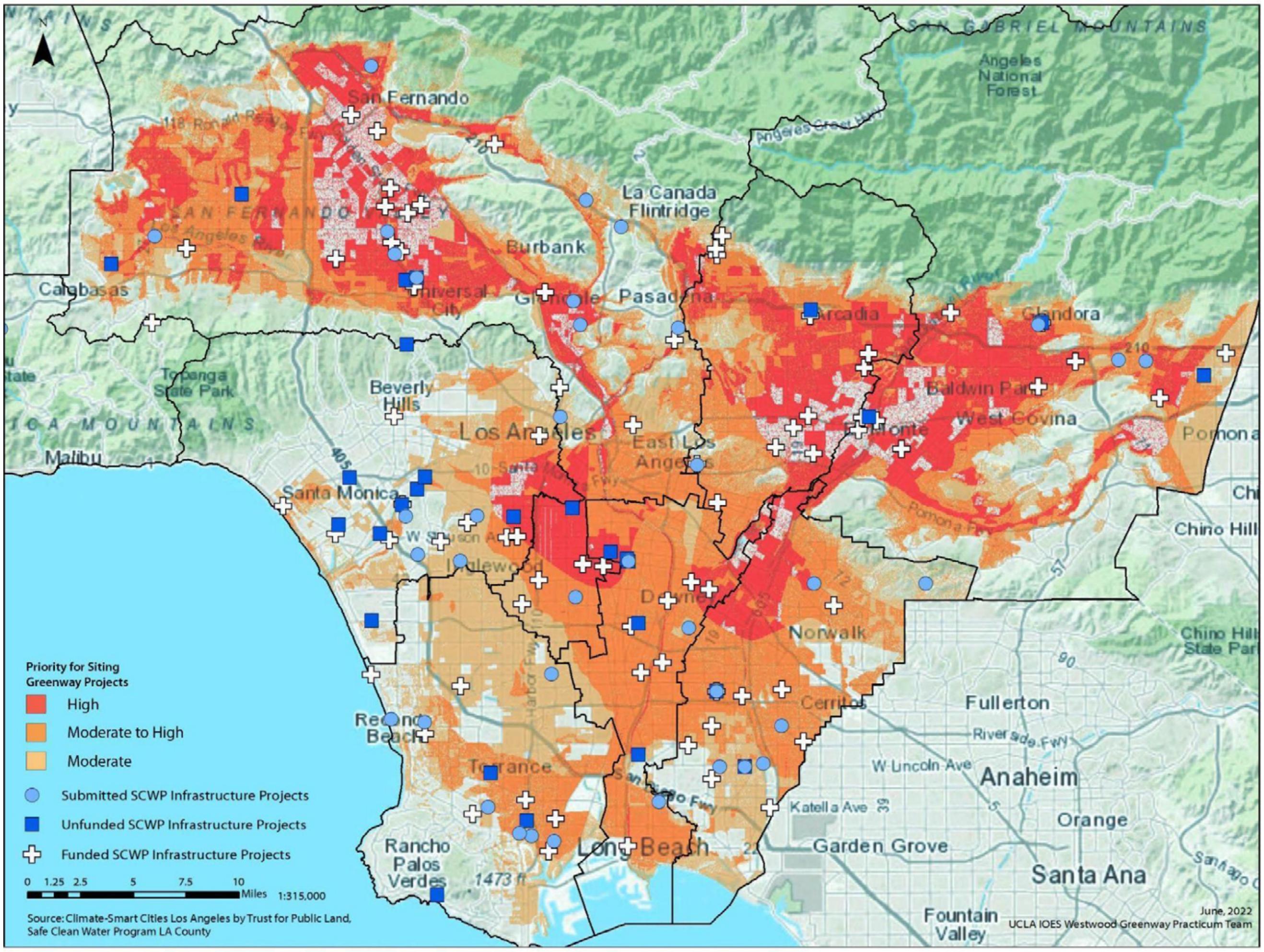

Figure 4: Scenario Analysis for Areas of High Priority for Siting Greenway Projects and SCWP Infrastructure Projects in Los Angeles

involvement from the public (Eneqvist et al., 2021). Programs are often outcome-driven, rather than public-good driven. These challenges are reflected in local infrastructure funding mechanisms. Oftentimes, design applications for projects seeking funding model their reports based on existing infrastructure projects without considering the successes, challenges, and lessons learned. Currently, there is no widely adopted framework for established projects to be assessed and for issues and challenges to be reported and addressed. Implementing an avenue for reporting successes and limitations of constructed SCWP projects can serve as a great resource for future projects. Those involved in the Westwood Greenway and future green infrastructure projects are strongly encouraged to periodically report to the entities responsible for supporting and implementing the project. Reporting on successes, challenges, changes to project design, maintenance needs, design flaws, and other issues post-implementation can alleviate some of the inefficiencies mentioned. Additionally, these projects are built with the purpose of supporting local communities, so it is important to report on the impact of the project on the community. Community engagement goals are defined within SCWP project proposals, however, how and if these goals are carried out remains unclear. Interviewing and surveying the local community before, during, and after project implementation is valuable, especially for DACs (National Recreation and Parks Association, 2020).

Many stakeholders are involved in the project process, so it is important that communication is established between all parties or that a liaison is appointed. A one size fits all approach will not serve as effective project management. Each project requires various levels of expertise ranging from designing the BMP, to properly caring for native plants, to engaging the local communities at all stages. Understanding these dynamics can help us better envision solutions to providing sustained maintenance throughout the life of a project and identify who will provide that maintenance — a component that would be best addressed prior to applying for and receiving funding. Finally, it is necessary for community engagement to be established prior to project design. Each community has a different need and use for green space and it is crucial to establish a relationship with the surrounding community. Not only will community input improve the final product, but it will also build trust and a sense of ownership, which increases participation in and care for the space.

7 Conclusion

While the greenway concept is relatively new, issues of habitat loss and water quality across Los Angeles are not. The Westwood Greenway demonstrates a functioning urban waterway promoting local biodiversity and improved water quality in a riparian habitat setting. We found that the Greenway hosts an outsized number and variety of species, and that the Greenway scores high across a variety of biodiversity metrics. We also found that water quality improved for several constituents under both dry- and wet-weather conditions. However, we found that funding is a major limitation that can discourage groups and communities from building and maintaining green infrastructure projects — a limitation that is even more pronounced in neighborhoods that are less well-resourced than Westwood.

Current environmental conservation successes at the Greenway can be leveraged by inspiring and informing diffusion of greenway-like spaces across Los Angeles. Doing so will support increasing connectivity between green spaces, improving water quality, and expanding outdoor recreational opportunities. Development of greenways in addition to complementary outdoor spaces is relevant to consider, particularly in flood-prone areas and neighborhoods with communities that have higher vulnerability to impacts from climate change. We hope that further exploration and improvement of the Westwood Greenway model can expand opportunities for creating desirable community space and restored ecosystems in Los Angeles and beyond.

8 Future Research

This practicum project was dynamic in nature, and over the course of the project our team had to adaptively manage our scope by keeping in mind our capacity and recognize limitations — including time. We considered a multitude of potential project components and deliverables, ultimately prioritizing those that are reflected in this report and electing to document additional components that may warrant future research. Below we have listed potential future research topics divided into the three main themes of our project. These were identified based on resources and opportunities we were unable to pursue, and we present them here with the intent to help guide future projects.

Biodiversity

Topic	Description
Increasing the Connectivity of Green Spaces	Utilizing the greenway as a way to increase the connectivity of green spaces around the site could help optimize the Greenway's provision of biodiversity and other ecosystem benefits. This could be accomplished within the Greenway itself — for example, by modifying existing culverts to support passage of fauna without compromising the culverts' water management functions. This could also be accomplished by linking the Greenway to other green spaces of varying sizes in the vicinity, which would serve as corridors or islands to support ecosystem services. Further research on the subject can help the creation of more greenways and other green spaces by providing data in support of ecological and social benefits.
Aerial Images for Monitoring	This would entail using drones to take aerial pictures of the greenway at timed intervals in order to keep track of vegetation coverage, growth rates, seasonal patterns, and other areas of interest. Such imagery could be used to supplement other points of future research with visual data, encourage engagement, and potentially inspire other green infrastructure projects.
Species Reintroduction	The project will replace 60% of asphalt with permeable surfaces to improve drainage. A greenway at the front of the school may help address flooding that affects the school and surrounding neighborhood. The greenway and proposed native plantings could serve as an outdoor laboratory for the students.
Classification of Insects at the Greenway	Reintroducing fauna to the Greenway and monitoring their success could boost biodiversity and ecological functions of the site. A potential partner to guide species reintroduction is Dr. Brad Shaffer, ecology and biology professor who lives near the Greenway. Dr. Shaffer suggests focusing a reintroduction on amphibians and reptiles due to the likelihood of them staying in the area (as opposed to birds or insects). This could further help increase biodiversity by allowing a future team to study how to further modify the greenway to support a habitat for species that either used to live there but no longer do, or new species who could find suitable habitat at the site.
Inclusion of Flora Observations	While our project closely focused on fauna at the Greenway on iNaturalist, an inclusive project consisting of both flora and fauna would be an effective way to monitor the volunteer plant species at the site in the future. Future research would benefit from tracking flora species along with fauna throughout the seasonal changes and years to observe the relationship that they have with each other in the Greenway environment.

Water Quality

Topic	Description
Water Quality Testing	Future directions could include using the UCLA water testing lab and working with LA Sanitation and Environment (LASAN) to obtain more precise data on a wider variety of water quality constituents at the site. Our team was able to provide water quality data, but our water sampling was limited to a few constituents and had somewhat limited precision due to the methods we had access to. Additional water quality sampling would also enable long-term analysis of how BMPs perform under varying conditions and as vegetation continues to mature.

Greenway Replication and Community Engagement

Topic	Description
School Involvement	Future directions could include using the UCLA water testing lab and working with LA Sanitation and Environment (LASAN) to obtain more precise data on a wider variety of water quality constituents at the site. Our team was able to provide water quality data, but our water sampling was limited to a few constituents and had somewhat limited precision due to the methods we had access to. Additional water quality sampling would also enable long-term analysis of how BMPs perform under varying conditions and as vegetation continues to mature.
Resources and Maintenance	Further research on funding the greenway and its maintenance will help make sure that the project thrives into the future. Continued maintenance is one of the barriers we identified that stand in the way of future greenways and other green infrastructure projects, especially in predominantly marginalized communities. Demonstrating a sustainable path to long-term maintenance at the Greenway would serve as a model for how to find the resources to help maintain such projects.

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Appendix A

Water Quality Data

Water Quality Data Wet Weather Event 3/28/22

		Concentration			
		Direction of Treatment Train ➡			
Contaminant	**Unit**	**N. Pump**	**N. Drain**	**S. Pump**	**S. Drain**
Results from LaMotte™ Urban Water Quality Test Kit *all data is approximate					
Coliform (Bacteria)					
Chlorine	ppm	0	0	0	0
Copper	ppm	0	0	0	0
DO	ppm	4	4	4	8
Hardness	ppm	160	120	120	80
Iron	ppm	<1	<1	<1	<1
Nitrate	ppm	>>20	5	5	<5
pH	pH	>8	7	7	7
Phosphate	ppm	<4	<4	<4	<4
Results from TDS Meter *Accuracy +/- 2%					
Temperature Taken at collection	°F	66.2	62.9	64.7	65.8
TDS	ppm	261	215	215	163
EC	µS/cm	522	430	430	326
Results from SenSafe® Metals Check					
Heavy Metals Cadmium, Cobalt, Copper, Iron (ferrous), Lead, Mercury, Nickel, Zinc and other +2 valence metals	ppb	<100	50	50	<50

Water Quality Data Dry Weather Event 4/28/22

		Concentration			
		Direction of Treatment Train ➡			
Contaminant	**Unit**	**N. Pump**	**N. Drain**	**S. Pump**	**S. Drain**
Results from LaMotte™ Urban Water Quality Test Kit *all data is approximate					
Coliform (Bacteria)	pos/neg	pos	pos	pos	pos
Chlorine	ppm	0	0	0	0
Copper	ppm	0	0	0	0
DO	ppm	<8	<8	<8	<8
Hardness	ppm	410	380	380	360
Iron	ppm	0	1	0	>1
Nitrate	ppm	5	5	5	5
pH	pH	8	7	8	7
Phosphate	ppm	2	<2	<2	<2
Results from TDS Meter *Accuracy +/- 2%					
Temperature Taken upon collection arrival	°F	65.6	66.2	66.3	67.1
TDS	ppm	599	578	599	556
EC	µS/cm	1198	1188	1198	1113
Results from SenSafe® Metals Check					
Heavy Metals Cadmium, Cobalt, Copper, Iron (ferrous), Lead, Mercury, Nickel, Zinc and other +2 valence metals	ppb	20	<100	<20	<20

Water Quality Data Dry Weather Event 4/3/22

		Concentration			
		Direction of Treatment Train ➡			
Contaminant	**Unit**	**N. Pump**	**N. Drain**	**S. Pump**	**S. Drain**
Results from LaMotte™ Urban Water Quality Test Kit *all data is approximate					
Coliform (Bacteria)					
Chlorine	ppm				1
Copper	ppm	0	0	0	0
DO	ppm	<8		8	8
Hardness	ppm		200		
Iron	ppm	0	0	0	0
Nitrate	ppm	5	5	5	5
pH	pH	8	8	7	8
Phosphate	ppm				
Results from TDS Meter *Accuracy +/- 2%					
Temperature Taken at collection	°F	68.7	71	69.9	72.5
TDS	ppm	486	523	523	523
EC	µS/cm	972	1047	1047	1047
Results from SenSafe® Metals Check					
Heavy Metals Cadmium, Cobalt, Copper, Iron (ferrous), Lead, Mercury, Nickel, Zinc and other +2 valence metals	ppb	20	10	10	20

Water Quality Data Wet Weather Event 4/22/22

		Concentration			
		Direction of Treatment Train ➡			
Contaminant	**Unit**	**N. Pump**	**N. Drain**	**S. Pump**	**S. Drain**
Results from LaMotte™ Urban Water Quality Test Kit *all data is approximate					
Coliform (Bacteria)					
Chlorine	ppm	0-1	0	0	0
Copper	ppm	0-1.5	0	0	0
DO	ppm	4-8	4	4-8	4
Hardness	ppm	240	280-300	280	260
Iron	ppm	1-5	1	1	<1
Nitrate	ppm	5	5	5	5
pH	pH	7-8	7-8	7-8	7-8
Phosphate	ppm	4	4	4	<4
Results from TDS Meter *Accuracy +/- 2%					
Temperature Taken at collection	°F	61.8	62.2	62	62.6
TDS	ppm	401	554	447	424
EC	µS/cm	803	1047	895	849
Results from SenSafe® Metals Check					
Heavy Metals Cadmium, Cobalt, Copper, Iron (ferrous), Lead, Mercury, Nickel, Zinc and other +2 valence metals	ppb	20	20	20	20

Appendix B

Social Media Engagement Plan for the Westwood Greenway Inc.

By UCLA IoES 2022 Westwood Greenway Practicum team

Introduction

Social media provides the option to connect with your audience, engage with similar organizations, and share information. Different platforms have different audiences, and having and using accounts on various platforms can help garner more interest in the Westwood Greenway. Educating the community on local Greenway benefits and earning support can aid in the goal to expand the Greenway concept across Los Angeles. This social media plan is meant to provide ideas, resources, and examples to expand the Greenway's social media reach.

Goals

- Educate audiences with Greenway related knowledge and resources
- Increase awareness and interaction with the Westwood Neighborhood Greenway
- Follow and inspire similar groups and organizations

Create and Share Valuable Content

This section contains example content for Westwood Greenway's social media that conveys information about the site and other related matters to the community in an engaging way. This section also contains guidance on practices to follow and to avoid, as well as potential resources.

Content ideas
- Photos
- Ask audience questions or test audience's knowledge
- Run polls
- Encourage audience to ask questions
- Infographics
- Resources, rebates, etc.

Recommended Ideas for Recurring Posts
- Native Species Highlight: how to identify (using iNaturalist); how to plant your own native garden; benefits
- Weeding Party Invitation: goals/areas of focus; pictures of previous event and finds
- Seasonal Blooming Period at the Greenway
- What can be found at the greenway and surrounding area; how long for (rough estimate); main reason for change (higher temperatures, more rainfall, less sun)

Recommended Ideas for Infrequent or One-Off Posts
- Educational posts: digestible info on how the greenway works, what is daylighting; water filtration at the Westwood Greenway; native species defined; biodiversity defined; LA as a biodiversity hotspot; highlight commonly found species (using statistics from bioblitz)
- Informational Posts: updating the community on important and relevant events/activities and actions they can take; UCLA IoES 2022 Practicum bioblitz at the greenway; April 24 Theodore Payne Walking Tour; Student groups at the greenway
- Asking questions or running polls: event planning; community engagement; community feedback (direction or thoughts for greenway); trivia

Suggestions to keep in mind when posting
- Consider cross-posting to keep relevant information on all platforms
- Elaborate in caption when needed
- Use multiple slides when needed
- Incorporate the greenway logo

- Assure pictures/infographics are easily digestible
- Fill out alternative text for accessibility
- Avoid text-heavy graphics

Resources to create content
- Canva
- How to make a poll on Instagram
- How to ask a question to your followers on Instagram

Interact with Similar Groups

Interacting with similar groups can bring more engagement to your pages. It also enables discovery of events and resources.

Groups we chose to follow on Instagram:

Native plant accounts	Green space / park focused accounts	Partnerships
@artemisia.nursery @californianativeplantsociety @cityplantsla @uclabotanical @lanativeplantsource @seedlibraryofla	@angelenosforgreenschools @altadenasafestreets @inaturalistorg @airport2park @grassrootsecology	@lacitysan @uclaioes @urbanconservancy @uclaroots

Expanding User Accessibility

At the time of our project, the Westwood Greenway was found on Google Maps readily, but not on Apple Maps. The Westwood Greenway Practicum team requested to have the site added onto Apple Maps for user accessibility, which was approved on April 30, 2022. We further suggest reviewing this listing, adding photos, and updating when necessary.

2022

The Westwood Neighborhood Greenway Biodiversity Index

Advisor: Edith de Guzman

UCLA IoES Westwood Greenway Practicum Team:
Cassandra Kays, Claire Villegas, Cortney Kleczka, Daniela Lopez, Danielle Hoekstra, Alé Pulido, and Lynsea May Southwick

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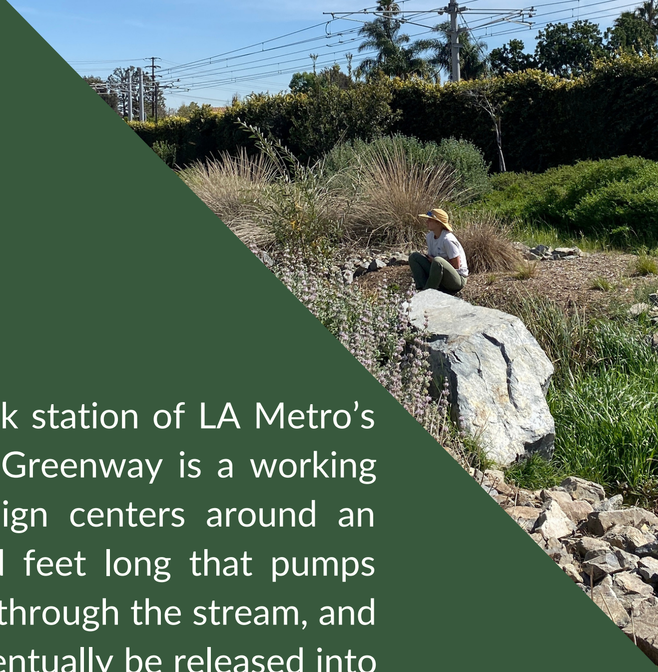
Western Lady Beetle *(Cycloneda polita)*

Westwood Neighborhood Greenway



Introduction

Located adjacent to the Westwood/Rancho Park station of LA Metro's light rail E Line, the Westwood Neighborhood Greenway is a working example of an urban waterway. The site design centers around an engineered stream approximately 800 hundred feet long that pumps mostly dry-weather flow up from a storm drain, through the stream, and then back out into the storm drain system to eventually be released into Santa Monica Bay and the Pacific Ocean. The Westwood Greenway was constructed on the basis of an increasingly popular green infrastructure tactic known as daylighting, wherein the flow of a natural stream, creek, or stormwater drain is exposed to the surface in order to revitalize natural hydrological functions (Pinkham, 2000). In a narrow stretch of land off Exposition Blvd, the Greenway is designed to restore natural ecosystem services of water filtration and serve as habitat for native flora and fauna. Daylighted streams can also support recreational activities, access to nature, and opportunities for outdoor teaching.

The Greenway was developed on two parcels with a combined area of approximately two acres that were slated to become parking near the newly-developed Metro light rail line. However, strong grassroots efforts spearheaded by a group of concerned neighborhood advocates brought about a much different fate for the site. Long-term support of the project by the community via the incorporation of the nonprofit entity Westwood Greenway, Inc., our project client, enabled a multi-year effort to culminate in the daylighting of a stream and creation of a green space that saw a soft opening in October 2020 ("History," n.d.). Partnering with LA Sanitation and Environment (LASAN) and the City of Los Angeles Bureau of Engineering (BOE) enabled the community's grassroots effort to be realized. In a city with extensive gray storm drain infrastructure and growing concerns over sustainable water supply, the proliferation of the Greenway concept in Los Angeles has the potential to address a number of environmental concerns while also providing valuable sites for community pride, health, and education.

What is Urban Biodiversity?

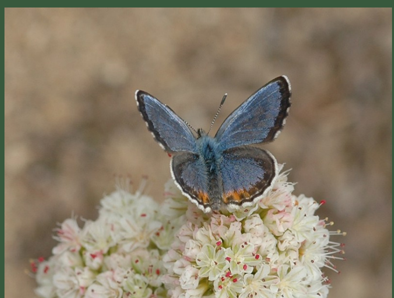
In Los Angeles, there is extensive opportunity to measure and study biodiversity. The City of Los Angeles is recognized as a biodiversity hotspot and is considered among the most biodiverse cities in the continental United States (Preziotti, 2021). The city contains over 450 certified wildlife habitat sites in its borders alone. Historically, LA's location and climate aided in its rise to becoming a "biodiversity jewel" (LA Sanitation and Environment, 2020). LA's waterways, including the LA River, are valuable resources supporting biodiversity. The river's constant change in flow and direction, plus the occasional flooding, helped create several habitats like lakes, wetlands, and mudflats (Gumprecht, 1997; Pilon-Briggs, 2019). Although conditions have changed, waterways continue to be a critical resource for biodiversity. These diverse habitats attracted a variety of plants and animals, from deer and antelope that lived near the river in what is now Griffith Park, to muskrats that fed on the cattails in river marshes (Gumprecht, 1997). Although the Mediterranean climate allows Los Angeles to host more than 3,500 different species of plants and animals, further urban development and population growth will continue to force a decline in biodiversity, creating several anthropogenic threats such as habitat fragmentation and pollution (Keeley & Swift, 1995). Several studies conclude that urbanization reduces species richness, especially at high levels (McKinney, 2008).

Today, nonnative plant species that are imported into residential areas contribute to a majority of LA's vibrant vegetation but outcompete LA's native flora, which can lead to overall decrease in species richness (McKinney, 2008). Loss of native plant species can also negatively affect the animal populations that relied on them for food and habitat. The state of biodiversity in Los Angeles is greatly dependent on whether species diversity and ecosystem services are valued over urban growth, which, unfortunately, is not often the case.

Indicator Species

The City of Los Angeles designated 37 species as indicators to assess biodiversity and habitat quality. Although in our project we did not observe any indicator species at the site, we have used this as a list of species to draw from when making recommendations for habitat quality and variety at the site in the future. Some examples of indicator species are pictured below.

Western Side-blotched Lizard (*Uta stansburiana*) by the Natural History Museum of Orange County, California



El Segundo Blue Butterfly *(Euphilotes battoides ssp. allyni)* by Butterfly Identification

Western bluebird *(Scalia mexicana) by Shawn McCready*

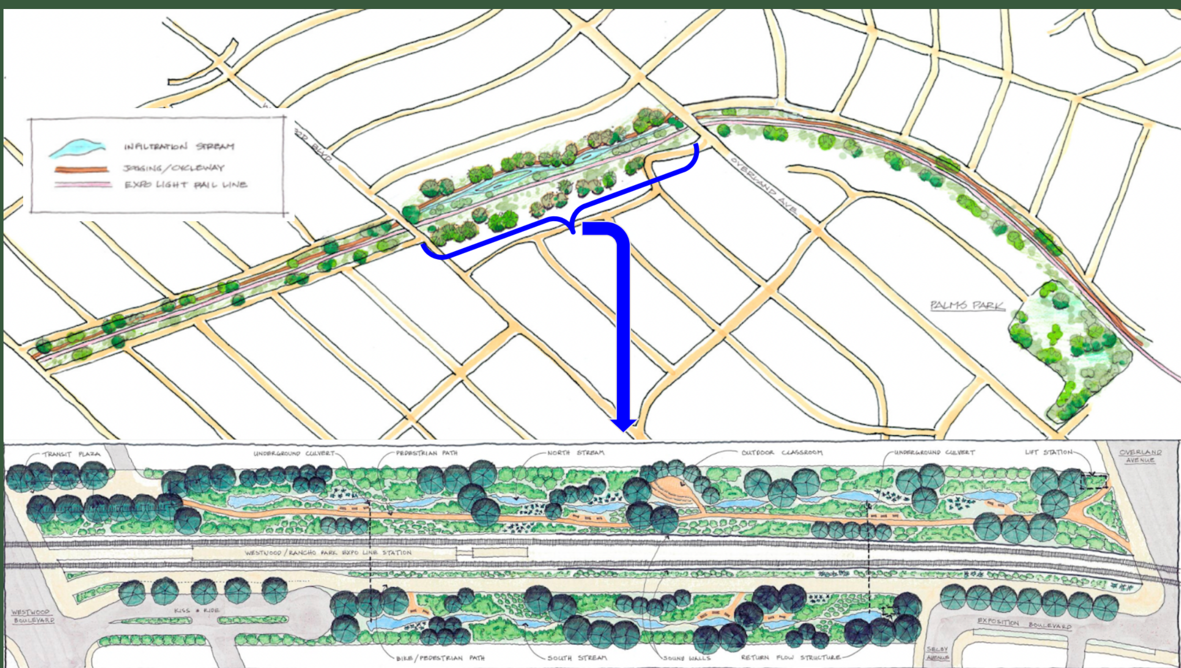
Benefits of the Westwood Greenway

Generally, urban greenways promote ecological benefits by enhancing biodiversity through habitat connectivity. By providing a variety of native plants, there is a network for insects, birds, and other animals to reproduce and thrive.

The Greenway also serves as a local green space for the community. The site is also a space for education about native plants and animals for local elementary schools, and a research opportunity for this UCLA practicum team.

The daylighted historic stream pumps urban water flows above ground into a vegetated bioswale for filtration. This effectively cleans dry- and wet-weather urban runoff.

The site was recently distinguished as an Ocean Friendly Garden by the Surfrider Foundation. Since runoff is the main source of urban pollution in the ocean, it is important for spaces like the Westwood Greenway to act as a filter.



Original layout planning for the Westwood Greenway courtesy of Westwood Greenway Inc

Habitat Quality

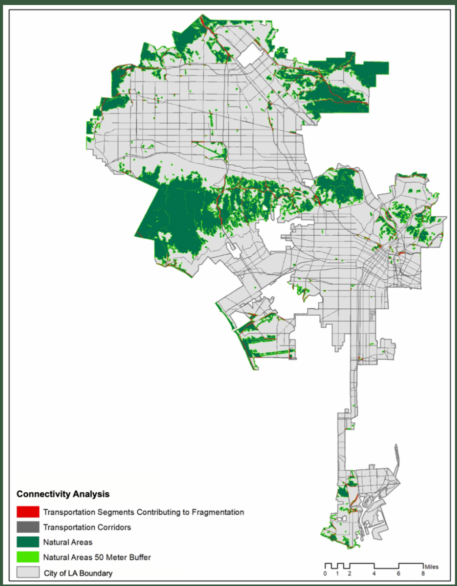
Habitat Quality describes the suitability of habitat to host native species. This metric was used to gauge the likelihood of fauna residing at the greenway and volunteer plants which have made the Greenway their home. Ratings for habitat quality were determined based on the species present at the Greenway when it was first created versus now. The species consistency and overall number of natives were used to rate this metric.

Habitat Variety

Habitat variety can be defined by the overall number of different plant species -- both planted and volunteer -- at the Greenway. For example, California poppies have self-established very successfully at the Greenway without being planted. There is also a variety of sage, milkweed, white Alden, and many more plants at the Greenway. The rating for habitat variety was calculated based on the number of native plant species per square acre as well as the number of native species found in this short period of time. This value was compared to the number of native species that were counted in the 2018 LA biodiversity index.

Offsite Connectivity

For urban biodiversity to succeed at the Greenway, it is important for there to be connectivity to other waterways and habitats. Protected islands themselves cannot restore ecosystems without some connection to other urban systems. Some examples of connectivity at the Westwood Greenway include twin culverts connecting the north and south side, stream connectivity to other waterways, fence holes that permit animals to pass back and forth, and native plants enhancing species richness (native plants are adapted to local environments and provide consistency for native species to survive). While connectivity to other urban habitats should be evaluated using mapping tools, the addition of this natural space in dense urban areas such as Westwood is contributing to the overall green space in Los Angeles, as seen in the 2018 biodiversity index map of natural spaces in Los Angeles, which shows a large gray area devoid of green space where the Greenway is located.



Los Angeles Biodiversity Index 2018

Edge Effects

Edge effects refers to the changes or interruptions present around habitat boundaries. In the Greenway's case, the north and south sides of the site are partitioned by a barbed wire fence and divided by the Metro rail. Although the Greenway is in an urban area, the partitions and open spaces allow for some species to feel protected and thrive. The south side is also a permanent sanctuary without a path for pedestrian traffic. Rating for edge effects was given observationally, based on the number of human interferences with the site present in relation to other urban environments.

A space for education at the Greenway

iNaturalist Data Collection


White-lined Sphinx *(Hyles lineata)*


Monarch butterfly *(Danaus plexippus)*


Oleander Aphid *(Aphis nerii)*


Gulf fritillary *(Dione vanillae)*


Three-lined potato beetle *(Lema daturaphila)*


Guinea paper wasp *(Polistes exclamans)*

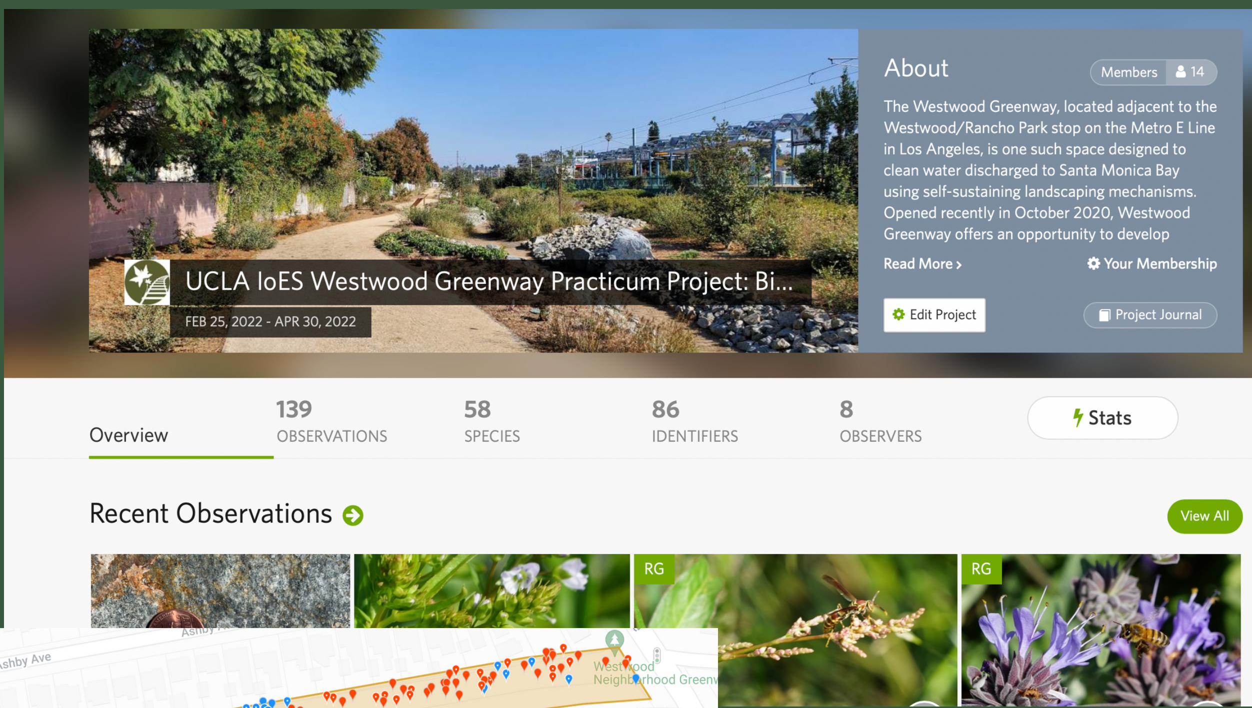

Lesser Goldfinch *(Spinus psaltria)*

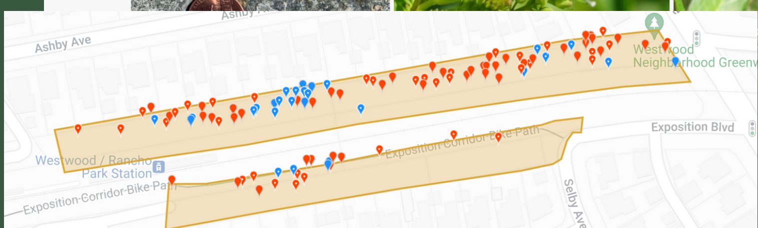

Red shouldered bug *(Jadera haematoloma)*


Argentine ant *(Linepithema humile)*


House Sparrow *(Passer domesticus)*

The project conducted during this practicum on iNaturalist recorded 139 fauna observations at the Greenway. At least six native species were identified at the greenway in a period of two months. Three group outings focused on collecting observations for iNaturalist took place at different times of day and during different months to capitalize on variable weather conditions that may effect different species appearances at the Greenway. Visiting the Greenway in the morning means seeing a find a variety of birds, whereas towards the end of the day there is less activity from birds and invertebrates. Over 80 identifiers helped contribute to more than 75 research grade observations at the Westwood Greenway!





(Top) Image of the project on iNaturalist. (Right) This shape file of the Greenway was created to designate the area where obervations in the project would be recorded.

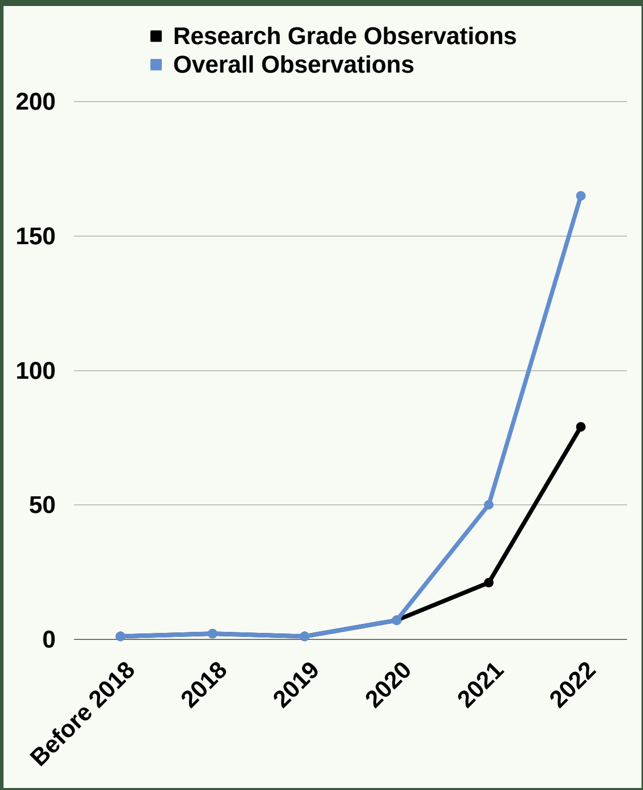


Figure 1: Number of observations made in the area surrounding and of the immediate site before and after its completion in the Fall of 2020.

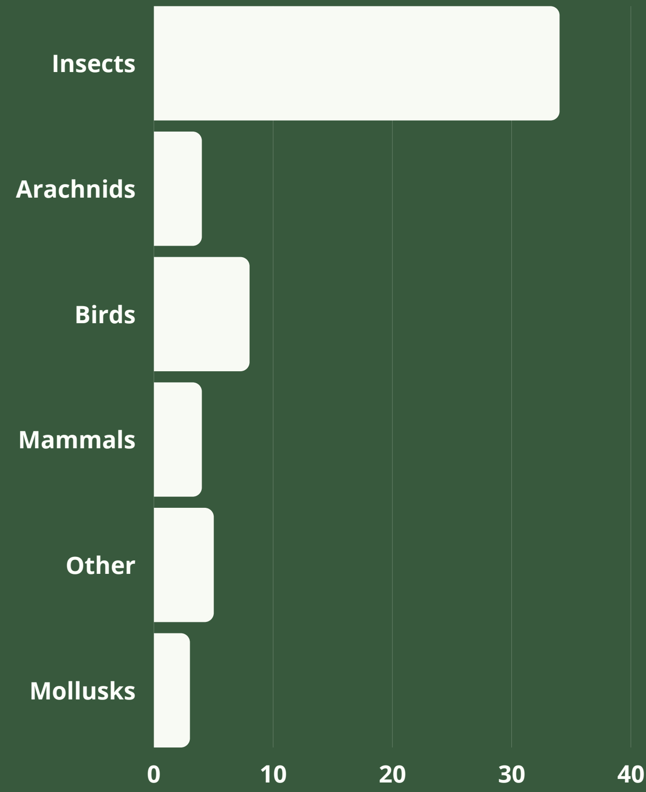
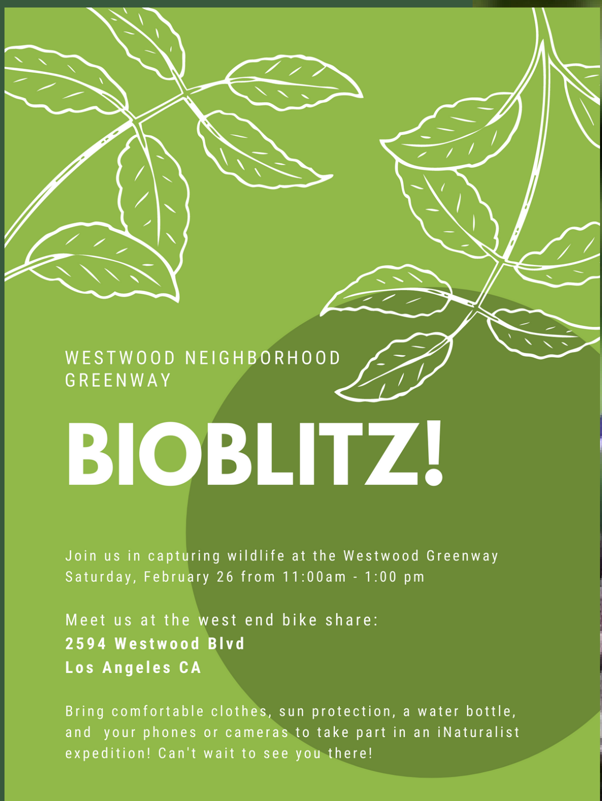


Figure 2: Classifications of Species Identified to research grade at the Westwood Greenway



3 Bioblitzes were held to encourage community engagement with the project!

Western Honeybee *(Apis mellifera)* captured by Annete Mercer

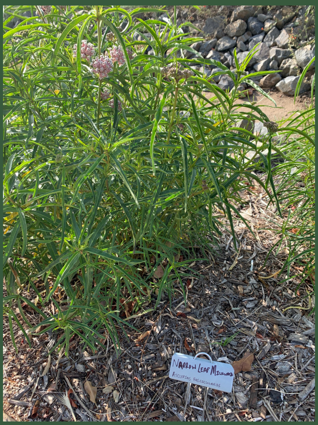
Malaise Traps

To identify smaller insects that are difficult to observe and photograph, we employed Malaise traps. Invented by the Swedish entomologist René Malaise, the Malaise trap is a “simple tent-like structure designed to trap insects and other small organisms by passively obstructing their flight or drift patterns and then relying on their natural tendency to move upwards or towards light to ensure that they end up in the collection bottle” (Karlsson et al., 2020). We used bottles filled with an ethanol solution to preserve and trap the insects in the bottles. These traps were distributed across the Greenway near shrubs and plant species for three separate periods of three days each. Weather, wind, and humidity were recorded hourly during the tests. Some insects are carried into the trap passively by winds, however, in many cases, the insects tend to move up and down vegetation during the day (Karlsson et al., 2020). Although this trap is effective for smaller insects, large, active insect flyers with better vision such as dragonflies and butterflies are able to avoid being trapped. Malaise traps were an ideal option for the project because they can be left without emptying for a week or longer while most other insect traps must be emptied more frequently. The samples are also well preserved in ethanol and can be stored for a period before going to a lab. Based on where the species density/diversity is the greatest, the plants and natural spaces surrounding them were analyzed by correlation.

We performed three different Malaise trappings, each over a period of 48 to 72 hours, on both the north and south end of the Greenway.

Malaise trap data suggests there is a healthy variety of insect species and connectivity between the north and south side of the Greenway through the presence of similar plant species that promote biodiversity and provide space for fauna to flourish. This finding was supported by a particularly dense species collection closer to the stream and native flowering plants. When the malaise trapping was conducted during warmer weather, the insect collection also increased. We did not catch any butterflies, dragonflies, or moths during the three different testing periods, all observations of larger flyers were made through iNaturalist. All of our collected species have been sent to the Natural History Museum of LA County’s archive to be cataloged. Once cataloged with location and duration of collection, the species data will be available for scientists at the museum to draw from. For this project, we did not have access to a laboratory for a more detailed taxonomy of the species caught. Due to time and resource constraints, our species were classified by sight, iNaturalist, and density of species rather than in a laboratory.

Flora at the site:


Narrowleaf milkweed
(Asclepias fascicularis)


California Sage Brush
(Artemisia californica)


White Alder
(Alnus rhombifolia)


Creeping Barberry
(Mahonia repens)


Douglas Iris
(Iris douglasiana)


California poppy
(Eschscholzia californica)


Brandegees Sage
(Salvia brandegei)


Tropical Milkweed
(Asclepias curassavica)

This project did not add images of flora at the Greenway to iNaturalist. Instead, we relied on a list of plants that were planted at the Greenway as well as some observational data of volunteer species or iNaturalist observations in the past.

From the images above:

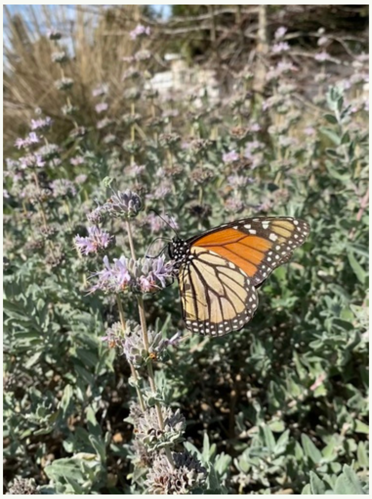
- Planted vegetation: Asclepias fascicularis (Narrowleaf milkweed), Artemisia californica (California Sage Brush), Alnus rhombifolia (White Alder), Mahonia repens (Creeping Barberry), Iris douglasiana (Douglas Iris), and Salvia brandegei (Brandegees Sage)

- Volunteer vegetation: Eschscholzia californica (California poppy) and Asclepias curassavica (Tropical Milkweed)

A complete inventory of planted species at the Greenway are listed in Appendix III.

Habitat Quality 3.2/4

Habitat quality received a 3.2 out of 4 based on the numerous native plants and non-native plant species planted and growing voluntarily at the Greenway, which draw native species to the site. Habitat quality has improved since water flow began at the site, as the density of species increased and more insects were collected. There are a number of native volunteer plants (volunteer plants are plants that were not planted at the site), which indicates that the Greenway is a viable landscape for native plants to thrive on their own. Volunteer plants were distinguished by a comparison to a list of known planted species.



Asclepias fascicularis (Narrowleaf milkweed)

Habitat Variety 3.6/4

Asclepias fascicularis (Narrowleaf milkweed)

Habitat variety received a 3.6 out of 4. This value was derived by calculating the variety of native fauna and flora per acre. For the relatively small physical footprint of the Greenway there is a very high number of species. Habitat variety was assessed by looking at the overall number of different plant species — both planted and volunteer. For example, during spring of 2022, California poppy *(Eschscholzia californica*) plants were found all across the site There is also a variety of sage, common milkweed *(Asclepias syriaca L.)*, and white alder or California alder *(Alnus rhombifolia)*.There is also a great variety of native volunteer plants at the Greenway. The site was designated an Ocean Friendly Garden by Surfrider's program, which identifies sites that have a selection of plants that require less watering and block pollutants from free-flowing into the ocean (Dias, 2022). With runoff being the main source of urban pollution in the ocean (Dias, 2022), spaces like the Westwood Greenway act as a filter preventing urban waters from polluting coastal waters (Dias, 2022). In relation to the City of LA biodiversity index, there were 215 native butterflies and moths recorded, at our project there were 5 native species of butterflies and moths. This is 2.33% of the species found in the entire city, which is 2330 times more than the expected 0.001% (the portion of Greenway area relative to the City of Los Angeles).

Asclepias fascicularis (Narrowleaf milkweed)

Edge Effects 3/4

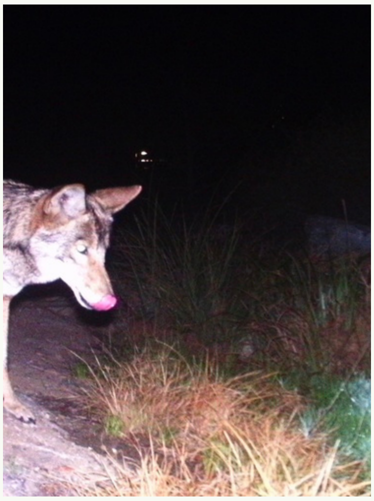

Armadillidium vulgare (Common Pill Woodlouse)

The edge effects rating for the Greenway was 3 out of 4. For edge effects, the influence of humans at the Greenway is largely due to adjacency to Metro traffic. At the site, we identified the following: neighborhood pets such as feral cats sighted on the motion sensor camera preventing amphibians and reptiles (important indicator species); the Metro line; Overland Elementary School with pick-up and drop-off traffic; general rush hour traffic; and overnight camping by unhoused individuals. The surrounding neighborhood is also developed and adjacent to a major walkway and bike path, which makes it difficult for many larger indicator species to establish at the site. Although these effects may play a larger role in the continual growth of biodiversity found at the site, it appears the Greenway has nevertheless maintained species that have been present since the site was completed. These include the Gulf Fritillary *(Dione vanillae)*, Monarch *(Danaus Plexippus)*, and Lesser Goldfinch *(Spinus psaltria)*. Attributes that likely support the survival of species at the site include the protected south side and chain link fences around the north side which keep pedestrians out of the site for the majority of time. Observations made at the site have increased since the Greenway was created. iNaturalist observations in the surrounding area have also increased since the site's completion in October, 2020. Even though the types of species that can be sustained at the site may be altered by the amount of human activity, overall observations in the surrounding neighborhood have also increased since the adoption of the Greenway. For example, observations on iNaturalist from the neighborhoods surrounding the Greenway went from less than 5 per year to over 30 in 2019.


Armadillidium vulgare (Common Pill Woodlouse)

Offsite Connectivity 3.6/4

Based on information from previous GIS studies, off-site connectivity at the Greenway was observationally rated 3.6 out of 4. For urban biodiversity to succeed at the site, it is important for there to be connectivity to other waterways and habitats. Protected 'islands' themselves cannot restore ecosystems without some connection to other urban systems. An island, or protected greenspace on all sides, if isolated without connectivity is at risk of species extinction and loss of critical ecosystem functions (Tabor, 2018). Some examples of existing and potential connectivity pathways at the Westwood Greenway include: twin culverts connecting the north and south sides; stream connectivity to other waterways; fence holes for small animals to pass; and native plants that are adapted to local environments providing consistency for native species to survive. Connectivity is critical for biodiversity to thrive. We found evidence that the addition of this natural habitat in a densely urbanized area will add another passage for wildlife and native plants to spread in the City of Los Angeles. We also looked at the types of insects collected in Malaise traps on the north versus the south side of the site. There were very similar insect species across both sides of the site. Consistent native plantings and volunteer plant species may play a large role in connectivity across the site.


Canis latrans (Coyote)

Recommendations

Attract more indicator species:

In order to attract more indicator species, we recommend planting several specific native plant species.

Lorquin's admiral butterfly *(Limenitis lorquini)*

- Planting California buckeye *(Aesculus californica)* could help to attract the Lorquin's admiral butterfly *(Limenitis lorquini)*, which relies on the flower's nectar for food (Butterflies, 2020).

Western Bluebird (*Sialia mexicana*) and Cedar Waxwing (*Bombycilla cedrorum*)

- To attract the California native cedar waxwing *(Bombycilla cedrorum)*, it would be beneficial to plant juniper *(Juniperus)* species or western chokecherry *(Prunus virginiana)* (Kaufman, 2022).
- Bluebird boxes could also be built at the site to draw the Western Bluebird *(Sialia mexicana)*.

The red winged blackbird (Agelaius phoeniceus), could also be drawn to the site. They live in or near wetlands full of cattails,and also near water in shrubby thickets of willow or blackberry (Kaufman, 2022).

Native lizard reintroduction:

Eventually, reintroducing native lizards and amphibians back to the greenway can support the health of the ecosystem. Possible candidates include the Western fence lizard *(Sceloporus occidentalis)*, alligator lizard *(Elgaria multicarinata)*, and/or Pacific tree frog *(Pseudacris regilla)*.

Blue Elderberry *(Sambucus nigra ssp. caerulea)*

Cedar Waxwing *(Bombycilla cedrorum)* photographed by James Brown/Audubon Photography Awards

Western fence lizard *(Sceloporus occidentalis)* by Jack Wolf, iNaturalist

Monitoring Biodiversity in the Future at the Greenway

Recommendations for evaluating biodiversity in the future:

- Continue a lifelong project on iNaturalist at the Greenway to continue making observations of volunteer flora and fauna.
- Organize longterm maintenance of noxious weeds to prevent suffocation of natives.
- Annual bioblitzes at the site to monitor the variety of species at the site and encourage community engagement with the site.
- Track sightings of indicator species at the Greenway.

Species: Eschscholzia californica (California poppy) and Sage

Species: Apis mellifera (Western honey bee) asleep in Eschscholzia californica (California poppy)

Thank you for making this index possible!

Joscha Beninde
Dr. Isaac Brown
Michelle Barton
Edith de Guzman
Annette Mercer
Dr. H. Bradley Shaffer
Alex Shepherd
Kat Superfisky
Jonathan Weiss
Alexis Wieland

Thank you to the iNaturalist community for research grade identifications and observations made during the project!

Mourning Cloak (*Nymphalis antiopa*) captured by Annette Mercer

iNaturalist Observations February 25, 2022 - April 30, 2022

Total # of Observations: 139	Total # of Research Grade observations: 80 (57.55%)	Total # of Species: 58
Group	**Common Name**	**Scientifc Name**
Invertebrates	Acute Bladder Snail	*Physa acuta*
Invertebrates	Argentine Ant	*Linepithema humile*
Invertebrates	Asian Lady Bettle	*Harmonia axyridis*
Invertebrates	Cabbage Aphid	*Brevicoryne brassicae*
Invertebrates	Cabbage White	*Physa rapae*
Invertebrates	Common Daddy Long-legs Spiders	*Genus Smeringopus*
Invertebrates	Common Earthworm	*Lubricus terrestris*
Invertebrates	Common Pill Woodlouse	*Armadillidium vulgare*
Invertebrates	Early Tachinid Fly	*Epalpus signifer*
Invertebrates	Earwig	*Genus Euborellia*
Invertebrates	False Black Widow	*Steatoda grossa*
Invertebrates	False Chinch Bugs	*Genus Nysius*
Invertebrates	Fiery Skipper	*Hyphila phyleus*
Invertebrates	Flat-backed Millipedes	*Order Polydesmida*
Invertebrates	Flowery Blue Isopod	*Porcellionides floria*
Mammals	Fox Squirrel	*Sciurus niger*
Invertebrates	Girdler Moth	*Dargida procinctus*
Invertebrates	Gray Bird Grasshopper	*Schistocerca nitens*
Invertebrates	Lesser Goldfinch	*Spinus psaltria*
Birds	Mallard	*Anas platyrhynchos*
Invertebrates	Marsh Crane Fly	*Tipula oleracea*
Invertebrates	Milky Slug	*Deroceras reticulatum*
Invertebrates	Millipede	*Ophyiulus pilosus*
Invertebrates	Monarch	*Danaus Plexippus*
Invertebrates	Mourning Cloak	*Nymphalis antiopa*
Invertebrates	Paradise Jumping Spider	*Genus Habronattus*
Invertebrates	Red Bugs	*Family Pyrrhocoridae*
Invertebrates	Red-shouldered Bug	*Jadera haematoloma*
Invertebrates	Scale Insects	*Superfamily Coccoidea*
Invertebrates	Seven spotted lady beetle	*Coccinella septempunctata*
Birds	Song Sparrow	*Melospiza melodia*
Invertebrates	Spottless Lady Beetle	*Cycloneda sanguinea*
Mammals	Striped Skunk	*Mephitis mephitis*
Invertebrates	Thin-legged Wolf Spiders	*Genus Pardosa*
Invertebrates	Three-lined Potato Beetle	*Lema daturaphila*
Invertebrates	Threeband Slugs	*Genus Ambigolimax*
Invertebrates	Tiger Crane Flies	*Genus Nephrotoma*
Invertebrates	Umber Skipper	*Lon melane*
Invertebrates	Western Aphideater	*Eupeodes fumipennis*
Invertebrates	Western Honey Bee	*Apis mellifera*
Invertebrates	White-lined Sphinx	*Hyles lineata*
Mammals	Virginia Oppossum	*Didelphis virginiana*
Birds	House Sparrow	*Passer domesticus*
Invertebrates	Gulf Fritillary	*Dione vanillae*
Invertebrates	Oleander Aphid	*Aphis nerii*
Mammals	Coyote	*Canis latrans*
Birds	American Crow	*Corvus brachyrhynchos*
Birds	Allen's hummingbird	*Selasphorus sasin*
Birds	Cooper's Hawk	*Accipiter cooperii*
Invertebrates	Nomad Bees	*Genus Nomada*
Invertebrates	Globetails	*Genus Sphaerophoria*
Invertebrates	Meadow Spittlebug	*Philaenus spumarius*
Invertebrates	Sweat Bees	*Genus lasioglossum*
Invertebrates	Calligrapher Flies	*Genus Toxomerus*
Invertebrates	Oblique Streaktail	*Allograpta obliqua*
Invertebrates	Guinea Paper Wasp	*Polistes exclamans*
Invertebrates	Volupial Mint moth	*Pyrausta volupialis*

*All listed historical and project observations were research grade identifications

Historical iNaturalist Observations

Group	Common Name	Scientifc Name	Date
Mammal	Virginia Opossum	*Didelphis virginiana*	04/02/2022
Birds	Red Tailed Hawk	*Buteo jamaicensis*	02/27/2022
Birds	American Crow	*Corvus brachyrhynchos*	02/27/2022
Birds	Black Phoebe	*Sayornis nigricans*	02/27/2022
Reptiles	San Diego Aligator Lizard	*Elgaria multicarinata webbii*	11/20/2021
Invertebrates	Johnson's Jumping Spider	*Phidippus johnsoni*	11/19/2021
Birds	Anna's Hummmingbird	*Calypte anna*	11/11/2021
Invertebrates	Gulf Fritillary	*Dione vanilllae*	11/11/2021
Birds	Coopers Hawk	*Accipiter cooperii*	11/07/2021
Invertebrates	Argentine ant	*Linepithema humile*	10/30/2021
Invertebrates	Yellow-legged Mud-dauber Wasp	*Sceliphron caementarium*	09/18/2021
Invertebrates	Flame Skimmer	*Libellula saturata*	09/05/2021
Plants	Sacred Datura	*Datura wrightii*	07/11/2021
Invertebrates	Spot-winged glider	*Pantala hymenaea*	05/28/2021
Invertebrates	Monarch Butterfly	*Danaus plexippus*	05/06/2021
Invertebrates	Red Shouldered Bug	*Jadera haematoloma*	05/01/2021
Invertebrates	Spottless Lady Beetle	*Cycloneda sanguinea*	05/01/2021
Birds	House Finch	*Haemorhous mexicanus*	05/01/2021
Birds	Lesser Goldfinch	*Spinus psaltria*	05/01/2021
Invertebrates	Western Honey bee	*Apis mellifera*	05/01/2021
Birds	Northern Mockingbird	*Mimus polyglottos*	05/01/2021
Invertebrates	Cabbage White	*Pieris rapae*	05/01/2021
Invertebrates	Convergent Lady Beetle	*Hippodamia convergens*	04/10/2021
Plants	Desert Globemallow	*Sphaeralcea ambigua*	03/26/2021
Invertebrates	Marine Blue	*Leptotes marina*	01/06/2021
Invertebrates	Grey Hairstreak	*Strymon melinus*	11/15/2020
Birds	Wilson's Snipe	*Gallinago delicata*	11/12/2020
Birds	Great Blue Heron	*Ardea herodias*	11/08/2020
Invertebrates	Anise Swallowtail	*Papillo zelicaon*	09/19/2020
Birds	Bushtit	*Psaltriparus minimus*	04/24/2020
Birds	Rufous, Allen's and Allied Hummingbirds	*Genus Selasphorus*	04/24/2020
Birds	California Towhee	*Melozone crissalis*	04/24/2020
Plants	Field Bindweed	*Convolvulus arvensis*	07/19/2019
Invertebrates	Southern Green Stink Bug	*Nezara viridula*	09/27/2018
Birds	Mourning Dove	*Zenaida macroura*	04/30/2018

*All listed historical and project observations were research grade identifications

Planted at the Westwood Greenway

Scientific Name	Common Name	Category
Alnus rhombifolia	White Alder	Trees
Juglans californica	So. California Black Walnut	Trees
Lyonothamnus floribundus ssp. aspleniifolius	Catalina Ironwood	Trees
Platanus racemosa	Western Sycamore	Trees
Prunus illicifolia lyonii	Catalina Cherry	Trees
Quercus agrifolia	Coast Live Oak	Trees
Quercus tomentella	Island Live Oak	Trees
Abutilon palmerii	Indian Mallow	Shrub
Arctostaphylos glandulosa "John Dourley" Artemisia californica	Manzanita	Shrub
Asclepias fascicularis	California Sagebrush Narrow leaf milkweed	Shrub
Baccharis piluaris 'Pigeon Pt,'	Coyote Bush	Shrub
Berberis x 'Golden Abundance'	Golden abundance Barberry	Shrub
Berberis repens	Creeping barberry California Lilac	Shrub
Ceanothus griseus horizontalis "yankee Point"	California fuchsia	Shrub
Epilobium canum Chapparal Silver	Santa Cruz Island Buckwheat	Shrub
Eriogonum arborescens	California buckwheat	Shrub
Eriogonum fasciculatum fasciculatum Gambelia speciosa	Island Snapdragon	Shrub
Salvia spathacea	Hummingbird sage	Shrub
Salvia leucophylla	Purple sage	Shrub
Sphaeralcea ambigua	Desert Globemallow	Shrub
Verbena lilacina	Lilac Verbena	Shrub
Achillea millefolium	Common Yarrow	Herb
Aster chilensis	Pacific aster	Herb
Carex barbarae	Santa Barbara sedge	Herb
Carex pansa	Sand dune sedge	Herb
Elymus triticoides	Alkali Rye grass or Creeping Wild Rye	Herb
Iris douglasiana	Douglas Iris	Herb
Juncus patens	California grey rush	Herb
Leymus condensatus	Native Blue Rye grass	Herb
Melica imperfecta	Imperfect melic grass	Herb
Muhlenbergia rigens	Deer grass	Herb
Grindelia stricta	Gumweed	Herb

Indicator Species

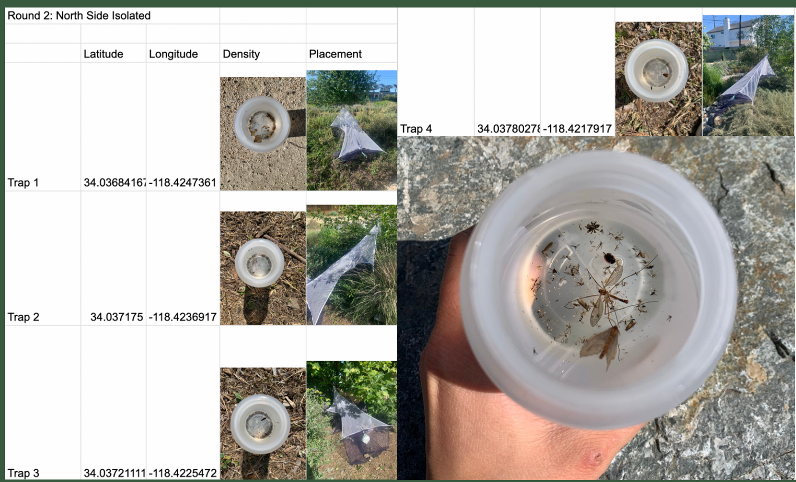
Group	Common Name	Scientific Name
Amphibians	Western Toad	Anaxyrus boreas
Amphibians	Black-bellied Slender Salamander	Batrachoseps nigriventris
Amphibians	Baja California tree frog	Pseudacris hypochondriaca
Birds	Red-winged blackbird	Agelaius phoeniceus
Birds	Great blue heron	Ardea herodias
Birds	Great horned owl	Bubo virginianus
Birds	Red-tailed hawk	Buteo jamaicensis
Birds	California quail	Callipepla californica
Birds	Canyon wren	Catherpes mexicanus
Birds	Northern harrier	Circus hudsonius
Birds	Greater roadrunner	Geococcyx californianus
Birds	Hooded merganser	Lophodytes cucullatus
Birds	Acorn woodpecker	Melanerpes formicivorus
Birds	Spotted towhee	Pipilo maculatus
Birds	Western bluebird	Sialia mexicana
Birds	Cinnamon teal	Spatula cyanoptera
Birds	Western meadowlark	Sturnella neglecta
Invertebrates	North American Jerusalem crickets	Ammopelmatus sp.
Invertebrates	Sara orangetip	Anthocharis sara
Invertebrates	Behr's metalmark	Apodemia virgulti
Invertebrates	Bumblebees	Bombus sp.
Invertebrates	Bramble green hairstreak	Callophrys dumetorum
Invertebrates	El Segundo blue butterfly	Euphilotes battoides ssp. allyni
Invertebrates	Lorquin's admiral	Limenitis lorquini
Invertebrates	Velvet ants	Mutillidae (Family)
Invertebrates	Harvester ants	Pogonomyrmex (Genus)
Mammals	Bobcat	Lynx rufus
Mammals	Dusky footed woodrat	Neotoma macrotis
Mammals	Mule deer	Odocoileus hemionus
Mammals	Mountain lion	Puma concolor
Mammals	Gray fox	Urocyon cinereoargenteus
Reptiles	Western pond turtle	Actinemys marmorata
Reptiles	Coachwhip snake	Masticophis flagellum
Reptiles	Western rattlesnake	Crotalus oreganus
Reptiles	California kingsnake	Lampropeltis californiae
Reptiles	Gopher snake	Pituophis catenifer
Reptiles	Sideblotched lizard	Uta stansburiana

Malaise Traps

Round 1									
	Latitude	Longitude	Density	Image of location					
Trap 1	34.0370477	-118.4247058			Trap 5	34.0373773	-118.4220899		
Trap 2	34.0370555	-118.4238972			Trap 6	34.0366137	-118.4241043		
Trap 3	34.03711147	-118.4238304			Trap 7	34.0367981	-118.4232781		
Trap 4	34.0371928	-118.4229858			Trap 8	34.0368737	-118.4228195		

Round 1	Weather
Data collection period:	3/08/2022 2:11 PM - 3/10/2022 12:00 PM
Average Temp (°F):	58
Average Wind (mph):	7
Average Humidity (%):	64

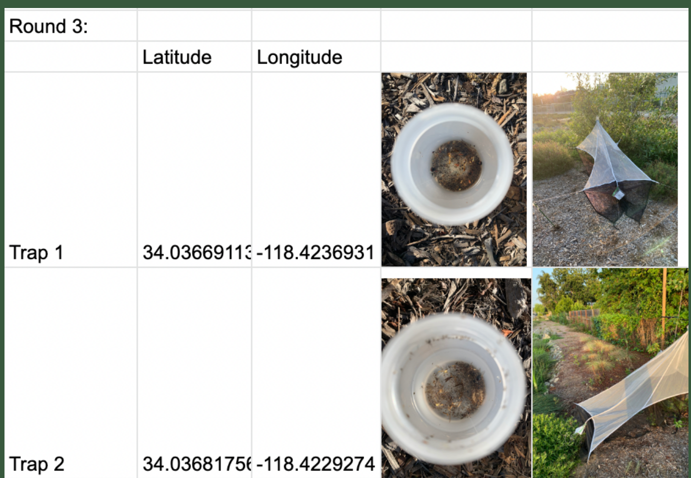
Figure 1: First round of Malaise trapping at the site. Eight traps located on both south and north sides of the Greenway.



Round 2: North Side Isolated							
	Latitude	Longitude	Density	Placement			
Trap 1	34.0368416	-118.4247361			Trap 4	34.0378027	-118.4217917
Trap 2	34.037175	-118.4236917					
Trap 3	34.03721111	-118.4225472					

Round 2	
Data collection period:	4/13/2022 9:00am - 4/15/2022 9:00am
Average Temp (°F):	59
Average Wind (mph):	11
Average Humidity (%):	49

Figure 2: Second round of Malaise trapping at the site. Four traps placed on the north side of the greenway in locations similar to those of round one where there was a larger species density collected.



Round 3:				
	Latitude	Longitude		
Trap 1	34.0366911	-118.4236931		
Trap 2	34.0368175	-118.4229274		

Round 3	Weather
Data collection period:	5/3/2022 6:00pm - 5/6/2022 6:00pm
Average Temp (°F):	62
Average Wind (mph):	7
Average Humidity (%):	76

Figure 3: Third and final round of trapping conducted on the south side only. Densest amount of species collected.

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