2022 Westwood Neighborhood Greenway Cost-Benefit Summary

Photo: Courtesy of Westwood Greenway, Inc. website ("Project Overview" page).

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Ecology and Evolutionary Biology 183

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14 March 2022

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1. Executive Summary

A brief overview of this report can be found in the 2022 Westwood Neighborhood Greenway Cost-Benefit Executive Summary. This summary includes the major components and findings of the full report condensed into an easily digestible and shareable format.

2. Introduction

This report uses the Westwood Neighborhood Greenway (hereafter, the "Westwood Greenway") as a model for outlining the costs and benefits of executing similar greenway projects in Los Angeles County. We consulted peer-reviewed literature, City of Los Angeles environmental reports, and governmental policy documents to synthesize a comprehensive analysis of greenway impacts on native plants and biodiversity, hydrology, and community wellness and education. By conveying the importance of various greenway components through these analyses, we aim to (1) convince governmental agencies, such as the Los Angeles County Metropolitan Transportation Authority (Metro), to execute more greenway projects throughout Los Angeles County, and (2) provide a detailed implementation guide for environmentally beneficial and cost-effective greenways.

3. What are Greenways and Why are they Important?

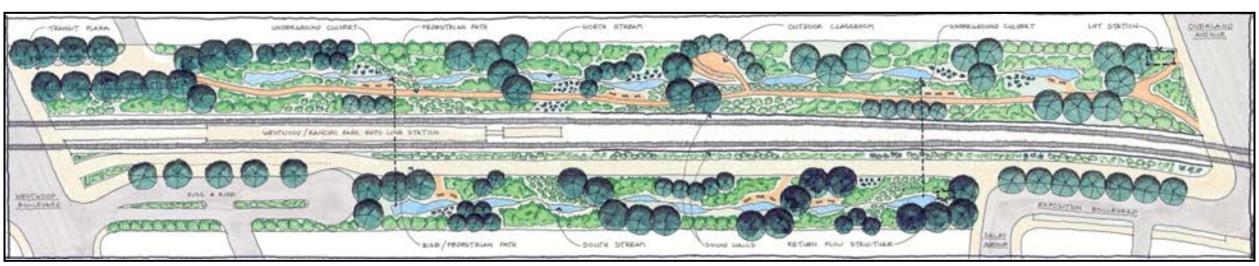

Figure 1. Westwood Greenway concept drawing by Sarah Hays. Photo courtesy of the Westwood Greenway, Inc. website ("History" page).

Greenways are linear green spaces (**Figure 1**) that run alongside natural or human-made infrastructure to create recreational areas, reserves, ecological corridors, or buffer zones (Theeba Paneerchelvam et al. 2020). Greenways offer both environmental and public health benefits, which can improve the quality of life for local residents and greenway visitors (Swanwick et al.

2003). For instance, greenways provide habitat for native species, combat the heat island effect currently being exacerbated by global warming, sequester carbon, enhance biodiversity, reduce water pollution, and improve the physical and mental health of nearby residents and frequenters (Theeba Paneerchelvam et al. 2020; Wang et al. 2021; Wang et al. 2020a).

The wide-ranging benefits of these green spaces warrant increased governmental funding for future greenway projects. Building greenways landscaped with endemic and locally-sourced Southern California native plants would support city and state-wide biodiversity initiatives, increase carbon sequestration (Pezner et al. 2019; Koutika et al. 2021), and combat urban air pollution (Chang et al. 2020), all of which are important for developing a comprehensive regional climate mitigation and adaptation strategy. Additionally, the inclusion of stormwater pollution mitigation measures in greenway design reduces the harmful effects of urban runoff and fosters compliance with water quality regulations at the local, state, and federal levels (EPA 2021c). These measures, called Best Management Practices (BMPs) and Low-Impact Development (LID) practices, are important components of "green infrastructure," a stormwater management concept that has evolved over the last century to prioritize ecological solutions that also benefit humanity (Buchholz & Younos 2007; Liu et al. 2016). How BMPs and LID practices manage pollution from urban runoff will be discussed in further detail in the Hydrological Services section of the report (Section 6.2). Greenways also provide unique benefits from a social and human health standpoint, as they have been shown to build community, provide outdoor education opportunities, and improve people's physical and mental well-being (Heller & Bhatia 2007; Rigolon 2013).

4. The Westwood Neighborhood Greenway

Situated within the Ballona Creek watershed (**Figure 2**, right) alongside the Metro E Line, the Westwood Greenway (**Figure 2**, left) was constructed during 2019 and 2020 in collaboration with Westwood Greenway, Inc., Los Angeles City Councilmember Paul Koretz, Los Angeles Sanitation and Environment (LASAN), the Bureau of Engineering, and Metro (J. Weiss, personal communication, January 31, 2022). Funded by Proposition O and Proposition 84, the primary goal of the project was to capture urban runoff in the Overland storm drain and improve water quality in the Ballona Creek Watershed (Westwood Greenway a). In addition to providing these essential hydrological services, the Westwood Greenway was landscaped exclusively with Southern California native plants that serve critical ecological functions. The space also acts as a field-trip destination, outdoor classroom, and peaceful place for visitors to exercise and socialize. These versatile components position the Westwood Greenway as an archetypal model for future greenways construction across Los Angeles County.

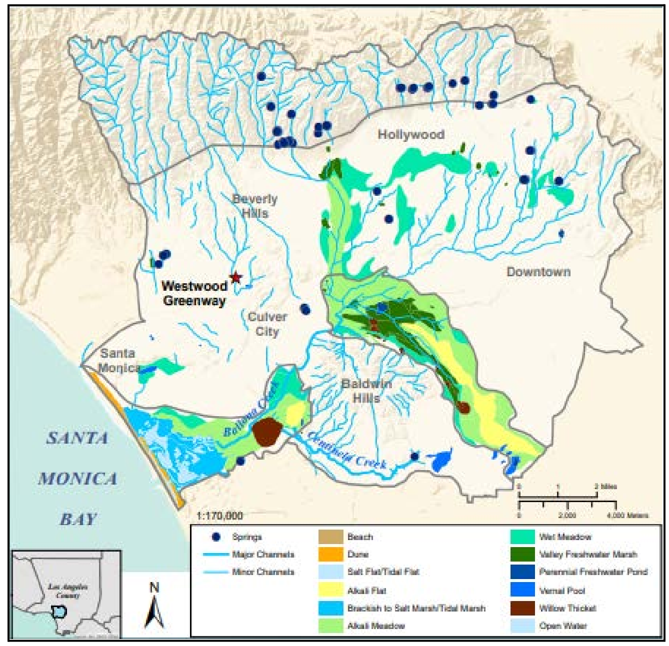

Figure 2. Left: Photo of the Westwood Greenway and adjacent Metro E Line Station. Photo courtesy of the Westwood Greenway, Inc. website ("Project Overview" page). Right: Map of the Ballona Creek Watershed, created by the Southern California Coastal Water Research Project (CCWRP). Image courtesy of the Westwood Greenway Inc. website ("Watershed" page).

5. Methodology

We performed numerous keyword searches of the relevant peer-reviewed literature using a variety of search engines, summarized in **Table 1**. It is worth noting that we searched all listed keywords in all listed search engines, however, each engine gave different results for the same terms. **Table 1** only displays the keyword searches for each search engine that provided us with the literature cited in this report. To avoid overlooking critical literature, we did not set any limitations on our search results. The literature regarding native plants focused on the ecological and economic benefits of native plant landscaping projects. For research on hydrological services, we prioritized sources on urban runoff and the costs and benefits associated with BMPs.

In regards to the health and social impacts of greenways, we concentrated on literature concerning physical health, community welfare, and educational value.

Table 1. Table detailing databases and keyword searches used, separated by section.

Research Topic	Search Engine	Keyword Searches
Native Plants and Biodiversity	GreenFILE	“greenway” AND “review,” “biodiversity” AND “stability,” “native plant” AND “fertilizer,” “native plant” AND “drought,” “native plant” AND “pollinat*,” “plant diversity” AND “carbon,” “California” AND “native” AND “fertilizer,” “soil health” AND “sequest*,” “leaf litter” AND “nutrient”
	Web of Science	“greenway” OR “green space” OR “greenspace” AND “heat island,” “heat island” AND “diversity” AND “plant,” “biodiversity” AND “stability,” “mycorrhiza*” AND “health, “soil health” AND “native plant,” “ecotype” AND “California”
	Google Scholar	“biodiversity” AND “stability,” “native plant” AND “fertilizer,” “native plant” AND “drought,” “native plant” AND “pollinat*,” “plant diversity” AND “carbon,” “biodiversity” AND “stability,” “mycorrhiza*” AND “health,” “native landscap*” AND “biodiversity,” “cultivar” AND “restoration,” “climate change” AND “native plant,” “heat island” AND “native plant”
Hydrological Services and Urban Runoff	GreenFILE	“stream daylighting,” “de-culverting” OR “daylighting” AND “restoration,” “urban runoff” AND “Los Angeles,” “best management practice*” AND “bioswale” AND “water quality” AND “greenway” OR “rain garden,” “best management practice*” AND “bioswale” OR “swale” AND “California”

	PubMed	“BMPs,” “water quality”
	Google Scholar	“stream daylighting,” “urban runoff,” “urban runoff Southern California”
Health and Social Impacts	PubMed	“driving” AND “health,” “healthy habits,” “movement and improved health,” “air pollution and health”
	Web of Science	“greenway” AND “social benefits,” “green spaces” AND “social benefits,” “social benefits of greenways,” “socioeconomic gaps”
	Google Scholar	“pollution and health,” “physical activity in cities,” “health effects of greenways,” “mental benefits in nature” “greenways outdoor education,” “youth inactivity”

In addition to the peer-reviewed literature, we referred to government websites and reports such as the Los Angeles County 2021 Climate Vulnerability Assessment and the LASAN 2020 “LA City Index” Biodiversity Report. Additional contacts and resources were also recommended by Annette Mercer and Jonathan Weiss of Westwood Greenway, Inc., Andy Shrader from the office of Los Angeles City District 5 Councilmember Paul Koretz, and Alison Lipman from the Department of Ecology and Evolutionary Biology at the University of California, Los Angeles. By their recommendations we consulted Kat Superfisky, Urban Ecologist for the City of Los Angeles Department of City Planning, and Michael Campbell from El Nativo Growers for resources and advice on large-scale native plant landscaping projects. We received a plant price catalog from Michael Campbell, which we imported into Microsoft Excel to determine the mean price for different plant types. We also obtained information regarding potential greenway funding sources from Susie Santilena, a Senior Water Infrastructure Specialist at LASAN. Furthermore, we contacted Ryan Thiha, an LASAN Senior Environmental Engineer, for the cost breakdown of the Westwood Greenway (**Appendix A**) as well as details regarding Clean Water Act (CWA) regulations and penalties.

To assess community impacts, we interviewed several people who have visited the Westwood Greenway. Using a list of previous visitors, provided by Westwood Greenway, Inc., we emailed multiple individuals to request interviews about their experiences. These interviews were conducted through email or brief phone call. Interviewees were asked a series of questions regarding their visit to the Westwood Greenway and any perceived benefits and/or notable experiences (**Appendix B**).

6. An Analysis of Greenway Benefits

The following sections (6.1-6.3) outline the Westwood Greenway's benefits, as well as emphasize their growing importance in the face of rapid biodiversity loss, climate change, watershed pollution, and increasing threats to public health.

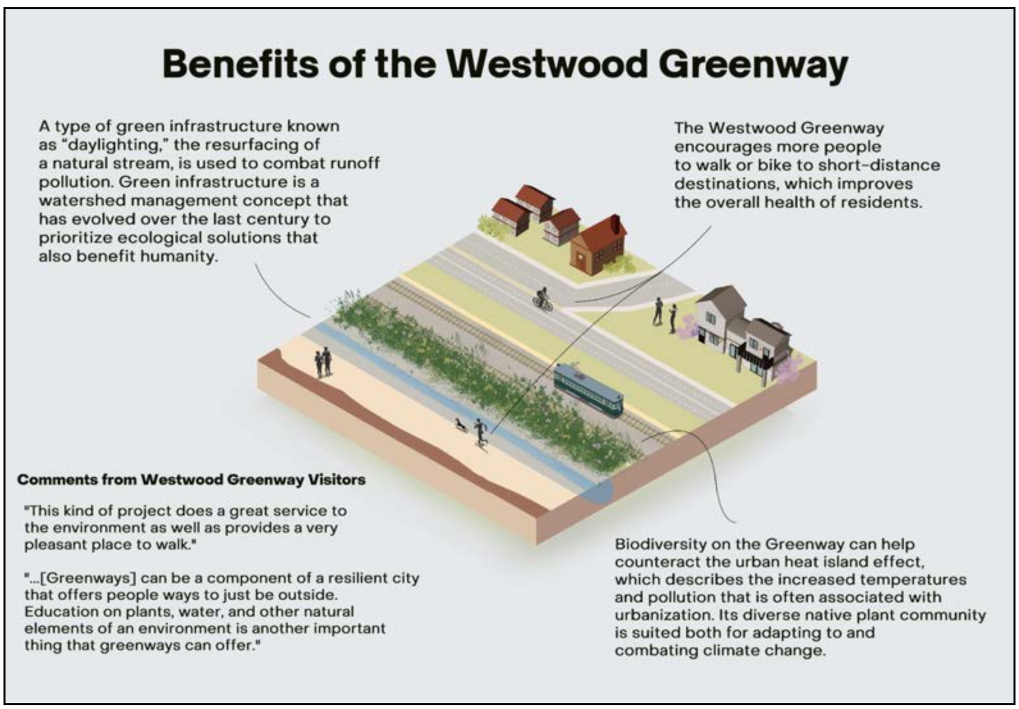

Figure 3. Infographic designed by Mercy Eme that provides a visualization of some of the Westwood Greenway's diverse benefits.

6.1. Native Plants and Biodiversity

Biodiversity hotspots refer to areas that have lost at least 30% of original plant cover and have at least 1500 endemic plants, or species exclusive to that region (Conservation International

2022). Los Angeles lies in the California Floristic Province (**Figure 4**), one of 36 global biodiversity hotspots, designating it as an area with an alarming number of species under threat of extinction. In Southern California specifically, industrial and agricultural developments have reduced wetlands, riparian forests, and coastal sage scrub habitats to 10% of their initial size, and grasslands have been reduced to 1% of their initial size (CEPF 2022). Across the entire California Floristic Province, only about 25% of the vegetation cover remains undisturbed today (CEPF 2022). Many of our native species are threatened, and these percentages will continue to decline unless actions are taken to protect the species that remain.

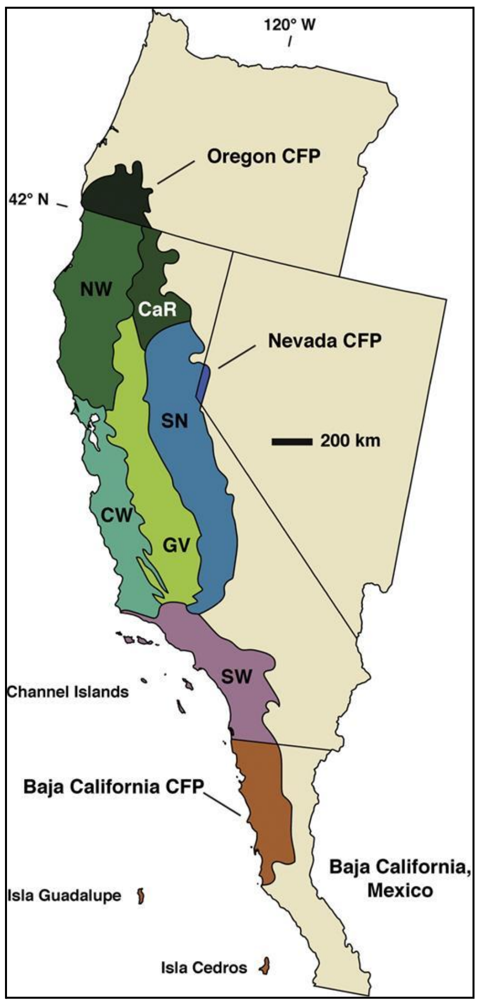

Figure 4. Map courtesy of Burge et al. (2016), detailing the regions of the California Floristic Province hotspot. These include the Northwestern California Region (NW), Cascade Ranges Region (CaR), Sierra Nevada Region (SN), Great Valley Region (GV), Central Western California Region (CW), and Southwestern California Region (SW).

One way to address the threats to our Southern California ecosystems is to support native plant populations. It is worth clarifying that “native plants” refer to wild-type plants with genotypes adapted to Los Angeles specifically, not California as a whole. This differs from nursery-raised hybrids and cultivars, which are genetically identical plants that have been bred for specific traits and have unknown or non-local seed sources (Gustafon et al. 2004). Cultivars also have lower genetic diversity than locally-sourced seeds, especially among species that can self-pollinate (Gustafon et al. 2004). This makes cultivars and non-local plants poor candidates for improving biodiversity, as their adaptations to non-local environments and low genetic diversity makes them maladapted for long-term survival (Seed LA 2022; Gustafon et al. 2004). Therefore, using locally-sourced Southern Californian seeds is the most effective way to protect threatened ecosystems and enhance biodiversity.

The decision to build more greenways landscaped with these beneficial plant populations lies in the hands of various local and regional governmental agencies. Metro should spear-head these efforts, as the linear landscape elements of Metro railway lines often provide ideal spaces for greenway construction (Yu et al. 2006). Additionally, Metro is a county-wide agency that should support the biodiversity goals and initiatives of the areas in which it operates, regardless of legal obligations. This includes working toward those outlined in the “Our County" LA Countywide Sustainability Plan, which aim to enhance native biodiversity and habitat quality throughout Los Angeles (Los Angeles County 2022a), as well as furthering Los Angeles Councilmember Paul Koretz’s 2017 Biodiversity Motion to develop projects and policies to enhance biodiversity in Los Angeles (Biodiversity Motion 2017). The 2017 motion resulted in the 2020 Biodiversity Index – a tool created to measure how effectively the City of Los Angeles is protecting native plant communities and the animals that depend on them (LASAN 2020). These action items ultimately strive to support the Los Angeles 2015 Green New Deal’s goal of “no net loss” of biodiversity by 2035 (LASAN 2020; Green New Deal 2015). This target aligns with both President Biden and Governor Newsom’s 30x30 Initiatives, which seek to designate 30% of natural areas to conservation and habitat protection by 2030 (30x30 Motion 2020).

Metro can support all of these efforts by constructing more greenways landscaped with native plants along its railway lines. The integration of these plant populations at the Westwood Greenway exemplifies their versatile ecosystem and landscaping benefits. In addition to enhancing biodiversity, native plants can also help combat anthropogenic climate change and improve ecosystem stability (Scott et al. 2021) in a cost-efficient manner. The remainder of this section provides a detailed analysis of these benefits to convey their importance for protecting and regenerating degraded landscapes.

6.1.1. Climate Suitability

High plant biodiversity, especially within native plant populations, is crucial to the creation of climate-resilient ecosystems (Fischer et al. 2006). In a recent literature review, De Boek et al. (2017) analyzed past studies of the relationship between plant diversity and ecosystem stability. Most of the studies reviewed concluded that diverse plant communities are highly resilient to disturbances because they effectively partition their resources, which makes them well-suited to survive in conditions with limited resources (DeClerck et al. 2006). Biodiversity, however, is not the only factor that impacts ecosystem stability. The ability for plant communities to recover from a disturbance also depends on the disturbance length and extremity, as well as the types of plants being studied (De Boek et al. 2017). Regardless of the diversity present, all plant communities are generally less able to recover from droughts that are longer in duration or higher in temperature than average (De Boek et al. 2017). Southern California native plants, however, are already adapted to withstand extreme heat and dry periods, making them better suited to survive in their local environments (Pezner et al. 2019). While future research is needed to explore the effects of climate change, designing greenways that incorporate climate-appropriate native vegetation is advantageous for long-term climate resilience.

The Westwood Greenway demonstrates how native plants can successfully establish themselves as a result of their climate-adaptive capabilities. Southern California vegetation that is well-adapted to survive extreme heat and drought conditions include many coastal sage scrub and chaparral plant species (Pezner et al. 2019). Because the Westwood Greenway incorporates multiple coastal sage scrub (**Figure 5**) and chaparral species within its design (**Appendix C**), its plants are more climate-appropriate and have a better survival chance than many non-native plants (Pezner et al. 2019). This, in turn, makes native plants a smarter financial investment for governmental agencies like Metro to consider when designing green infrastructure.

Figure 5. Photo of buckwheat (*Eriogonum* spp.) at the Westwood Greenway. Photo courtesy of the Westwood Greenway Inc. website ("Gallery" page).

Constructing biodiverse greenways can also help counteract the urban heat island effect, which describes the phenomenon of increasing temperatures and air pollution as a result of urbanization (Wang et al. 2021). Although this is more applicable to greenways with higher tree cover than the Westwood Greenway, diverse plant communities have greater cooling effects than monocultures (Wang et al. 2021). There is limited research comparing urban cooling effects between native and non-native plants (Block et al. 2012), but recent studies suggest that tree cover and plant diversity have a high impact on urban cooling (Block et al. 2012; Robbiati et al. 2022). Therefore, landscaping future greenways with a diverse plant palette can mitigate increasing temperatures brought on by climate change and the urban heat island effect.

6.1.2. Soil Health and Carbon Sequestration

Biodiversity and native plants also support soil health, which is a critical component of ecosystem stability. A healthy soil ecosystem depends on both soil invertebrates and soil microbial function. Both invertebrates and microbes enhance nutrient cycling and plant growth, the latter through rhizobacterial and mycorrhizal interactions (Kumar & Verma 2019;

Cifuentes-Croquevielle et al. 2020). These interactions are species-specific, meaning native and non-native plants attract different types of mycorrhizae and invertebrates (Siguenza et al. 2006; Cifuentes-Croquevielle et al. 2020). Plants native to the soil also have higher soil invertebrate diversity (Cifuentes-Croquevielle et al. 2020) and higher soil mycorrhizae biomass (Scott et al. 2021), both of which help maintain a stable and healthy soil microbe composition that can support long-term plant survival. Moreover, mycorrhizal activity promotes carbon sequestration (Koutika et al. 2021). Areas with high plant diversity have increased aboveground and belowground plant biomass, as well as soil carbon (Wang et al. 2020a), meaning there are greater deposits of sequestered carbon in diverse plant communities. Furthermore, native plants have increased soil carbon deposits (Scott et al. 2021), which means that prioritizing both native plants and biodiversity in green space design is the most effective way to promote carbon sequestration. This would also further Governor Newsom's state-wide initiative for carbon neutrality by 2035, supported by the California Public Utilities Commision and the California Air Resources Board's "2022 Climate Change Scoping Plan" (CPUC 2021; CARB 2021). This is beneficial from a holistic environmental perspective, as biodiverse greenways like the Westwood Greenway can help offset carbon emissions.

6.1.3. Wildlife Habitat Enhancement

Animals depend on plants for food and habitat, which means plant species diversity and abundance impact the species of animals that an ecosystem can support (Tallamy 2009). Many plant-animal interactions are species-specific, meaning that the survival of native fauna relies on the presence of specific native plant species (Tallamy 2009). The specificity of these interactions makes native plants better suited for supporting animal biodiversity than non-native plants. For instance, native pollinators form unique interactions with native plants that differ between their interactions with non-native plants (Seitz et al. 2020) This occurs because pollinators are not equally attracted to all plants, and they alter their behaviors to visit the plants they prefer the most (Seitz et al. 2020). By landscaping greenways with native plants that native pollinators and other animals are attracted to, future greenway projects can help support native fauna. Therefore, increasing California native plant populations through urban green spaces like greenways is the most effective way to further biodiversity initiatives.

Figure 6. Photos of a flame skimmer (*Libellula saturata*, top left), Anna's hummingbird (*Calypte anna*, bottom left), and monarch butterfly caterpillar (*Danaus plexippus*, right) at the Westwood Greenway. Photos courtesy of the Westwood Greenway Inc. website ("Gallery" page).

The Westwood Greenway incorporates a variety of Southern California native plants within its design (**Appendix C**), making it an excellent model for assessing the ecological benefits of native plant diversity. The native plants on the Westwood Greenway have attracted many native insect and bird species, such as those shown in **Figure 6**, providing them with habitat that would not have been available otherwise. As a result, the Westwood Greenway illustrates how future greenways, if intentionally designed with native plant landscaping, can promote interactions that enhance native fauna and biodiversity as a whole.

6.1.4. Economic and Environmental Landscaping Benefits

Greenways offer many economic and environmental benefits when landscaped with native plants. To maximize cost-efficiency, landscapers need to avoid excess costs associated with replacing plants that do not survive past their introduction. Therefore, a plant community's ability to recover from disturbances such as disease, climatic events, resource scarcity, and human interference must be considered (Hodgson et al. 2015). California native plants are already well-adapted to the environment, which means they require little intensive care for survival (California Native Plant Society 2022a). Although maintenance will still be necessary for a landscaped appearance, native plant communities have naturally-evolved mechanisms for pest control, nutrient acquisition, and water retention that are specific to their local environments (California Native Plant Society 2022a).

When native landscapes are appropriately watered and maintained, they eliminate the need for pesticides, fertilizers, and minimize the need for additional watering after establishment (California Native Plant Society 2022a). Not applying fertilizers or pesticides also minimizes continuous material expenses and reduces pollution from chemical runoff. This directly supports the aim of Measure W – a 2018 measure that generates $300 million in annual funding – to decrease the amount of contaminated stormwater flowing into Los Angeles County watersheds (Los Angeles County 2022b). Therefore, native plants should be used to landscape all Measure W projects, including greenways. Furthermore, native plants generally require little to no mowing or leaf-blowing, which lowers the costs of gas-powered equipment (Diekelmann & Schuster 2002). Limiting mowing and leaf-blowing during maintenance also results in increased leaf litter, which promotes soil nutrient cycling and improves plant health (Bai et al. 2022). Finally, these maintenance practices help limit smog-forming and greenhouse gas emissions, which is especially important in areas with unhealthy air quality such as Los Angeles (Los Angeles Almanac 2019).

6.2. Hydrological Services

A large impact of urbanization is the pollution of waterways, water bodies, and marine systems. In Los Angeles, most natural waterways have been rechanneled into underground storm drains (**Figure 7**) and aboveground concrete channels, causing polluted urban runoff to enter drainage systems and eventually empty into coastal waters (Westwood Greenway d). The diversion of streams into storm drains, or "culverts," was originally thought to be an effective method for flood prevention, removal of human waste (when streams were incorporated into sewage channels), and preservation of drinking-water sources (Buchholz & Younos 2007).

Figure 7. Photo of the Ballona Creek underground storm drains. Photo courtesy of Undercity.

However, this management practice is becoming increasingly regarded as both environmentally and economically counterproductive. Culverts, which can be expensive to repair or replace, have been shown to exacerbate flooding issues because they are unable to support present-day levels of water use (Buchholz & Younos 2007). As urban populations grow, water usage increases, and culverts are forced to carry water levels that exceed their capacities, which can choke the pipes and lead to backflow (Pinkham 2000; Buchholz & Younos 2007).

Additionally, rainfall patterns and flooding-events are expected to intensify in the coming years as a consequence of climate change (EPA 2021b). Such events will increase runoff water volumes and further overwhelm storm drains if BMPs are not incorporated into stormwater management systems (EPA 2021b).

Additionally, waterway channelization and urban development have destroyed large proportions of California wetland habitat and wetland-dependent populations (CEPF 2022). Riparian habitats, which also host a multitude of species and provide essential ecosystem services (e.g., flood control and water quality management), have seen nearly equal levels of degradation in the Los Angeles River watershed (Anderson & Masters 2017; Los Angeles River Revitalization). Ecologically, channelized waterways exhibit declines in water quality, species richness, and self-purification capability, which is referred to as "urban stream syndrome" (Walsh et al. 2005; Delibas & Tezer 2017). Poor water quality pollutes riparian, wetland and aquatic areas, which can lead generally to reductions in habitat functionality and species health (EPA 2012; Los Angeles River Revitalization). By reducing their functionality, these ecosystems lose the ability to effectively provide services that benefit both wildlife and society.

6.2.1. The Costs of Urban Runoff

Urban runoff, which includes both dry weather flow and stormwater runoff, is the most significant source of coastal pollution in Los Angeles (LASAN 2022). Dry weather flow consists of nuisance flows, such as residential irrigation and car-washing outputs, along with industrial, commercial, or other discharges permitted under the National Pollution Discharge Elimination System (NPDES) (Ballona Creek Bacteria TMDL 2006). Dry weather flow is especially important to consider in Los Angeles, where rainfall is notoriously sparse and impervious surface cover (e.g., surfaces such as concrete, asphalt, buildings, etc.) is exceptionally high (Baker et al. 2002). Nonetheless, stormwater runoff should also be regarded as a threat to coastal pollution. Initial runoff following small or large storm events, commonly referred to as the "first flush," contains extremely high pollutant concentrations when compared to later runoff from the same event (Lee et al. 2002). In Los Angeles, pollutant levels are especially high during the first flush as a result of pollutant build-up that occurs during long periods of dry weather (Lee et al. 2004).

Urban runoff has various environmental, economic, and social ramifications. One crucial impact to consider is that of decreased water quality caused by increased concentrations of nutrients and contaminants (Delibas & Tezer 2017). A short 15 mile stretch of coast connecting Long Beach and North Orange County is the drainage point for three of California's largest rivers (Baker et al. 2002). One of these rivers is the Los Angeles River, which drains into San Pedro Bay and contains a large proportion of the city's urban runoff (Baker et al. 2002). In a 2002 study on coastal water quality just south of Long Beach, researchers found a positive relationship between increased river discharge and total coliform bacteria presence, which increased during wet seasons (Baker et al. 2002). Total coliform bacteria is considered an indicator of pathogen presence by the U.S. Environmental Protection Agency (EPA) and is used to assess water quality (EPA 2021a). Other local studies have discovered relationships between urban runoff and the presence of urban pollutants in Southern California waters. These pollutants include viral matter (Jiang et al. 2020) and engineered titanium dioxide nanoparticles, which have unknown long-term effects on aquatic environments (Wang et al. 2020b). Exposure to metal, bacterial, and/or viral contaminants from urban environments can be harmful to surfers, beachgoers, and species that occupy coastal ecosystems (Baker et al. 2002; Jiang et al. 2020). Poor water quality can also lead to beach closures, which can decrease coastal tourism profits (Baker et al., 2002).

6.2.2. Policies and Regulations

There are various policies and regulations in place to manage water pollution caused by urban runoff, predominantly established by the 1972 Clean Water Act (CWA). Created by Congress and administered by EPA, the CWA outlines protocols and regulations for the releasing of contaminants into United States waters and sets quality standards for surface waters (EPA 2002). More specifically, each state must develop Total Maximum Daily Loads (TMDLs) for all at-risk waters, which are defined as the amounts of individual pollutants that can enter a body of water without inhibiting that water's designated uses (LASAN). To determine TMDLs for Los Angeles County, LASAN and neighboring municipalities are required to conduct and submit annual environmental testing results of Los Angeles County's six major watersheds (LASAN; County of Los Angeles Department of Public Works 2018). This includes the Ballona Creek Watershed, which is the destination of the Westwood Greenway's resurfaced stream following filtration.

Different agencies within Los Angeles County are subject to different CWA limits based on their estimated pollution contributions (EPA 2002). If pollution exceedances are found through the CWA's compliance monitoring programs, individual, industrial, and municipal entities can face substantial administrative civil penalties (EPA 2002). Specific fine amounts are dictated on a case-by-case basis, depending on how severely the violation impacts public health and the environment (R. Thiha, personal communication, February 23, 2022). In practice, however, it is challenging to measure even approximate quantities of pollution discharged by an individual source, which makes assigning violations extremely difficult (S. Santilena, personal communication, February 14, 2022). As a result, the majority of legal responsibility falls on the City of Los Angeles (S. Santilena, personal communication, February 14, 2022). Furthermore, the City of Los Angeles is responsible for the capital costs of developing projects to meet CWA standards (R. Thiha, personal communication, February 23, 2022). According to the most recent computational analyses, projection models, and judgments of environmental engineers, the expenses of these projects are estimated to cost the City of Los Angeles $2 billion to $8 billion over the next twenty years (R. Thiha, personal communication, February 23, 2022).

Although Metro's specific pollution contributions are unknown due to limitations of current monitoring technology, its transportation infrastructure contributes to the contamination of Los Angeles Country's watersheds by increasing impervious surface cover in the region (S. Sentilena, personal communication, February 14, 2022; Baker et al. 2002). Furthermore, while the construction of Metro railway lines is regulated by permits that mandate pollution mitigation strategies for a given project (S. Sentilena, personal communication, February 14, 2022), there are no such measures accounting for pollution produced by other components of Metro's infrastructure (J. Weiss, personal communication, March 3, 2022) The rubber tires of Metro buses are a notable example, as this rubber is a harmful contaminant that eventually enters waterways via storm runoff (Tian 2020). In a 2020 study conducted in the Pacific Northwest, researchers found tire rubber residues present in stormwater runoff to be highly toxic to coho salmon, resulting in acute mortality in these populations during their migration to urban creeks (Tian 2020). Even though Metro is not directly liable for CWA exceedances, it should still maintain a moral responsibility to develop sustainable practices and offset environmental harm it is causing. One way the agency can carry out this responsibility is by allocating more funding to pollution reduction and mitigation projects. The water filtration services provided by greenways make them especially good candidates for this funding.

6.2.3. Green Infrastructure and Daylighting

The inadequacies of our current storm and wastewater management systems illustrate the need for infrastructural solutions. BMPs can be incorporated into communities at different spatial levels (from residential to watershed) to strengthen stormwater management capabilities and offer additional environmental, economic, and social benefits (EPA 2022). Urban BMPs in particular are designed to address runoff quantity and quality, as well as the effects of land use and climate change (Liu et al. 2017). The Westwood Greenway and similar projects use "daylighting," or the resurfacing of once natural streams, to combat runoff pollution and restore historic stream ecosystems (**Figure 8**). Other BMPs, such as bioswales, rain gardens, and permeable pavements, can be implemented to achieve similar ecological goals.

Figure 8. Photo of the daylit stream at the Westwood Greenway taken on the south end, facing east. Photo courtesy of the Westwood Greenway, Inc. website ("Project Overview" page).

Due to lack of sunlight, absence of terrestrial and riparian inputs (e.g., soil, algae, plants), and alteration of natural geological features, culverts damage ecological integrity (Wild et al.

2010). Stream daylighting alleviates these issues and those caused by urban runoff through reintroduction of natural inputs. Incorporation of native plants, bioswales, and berms into daylit streams filters urban runoff by reducing the water's flow velocity, which allows plants and other structures to capture and subsequently decrease pollutant loads (Pinkham 2000; Buccholz & Younos 2007). Furthermore, properly daylit streams can act as restored aquatic and riparian habitats (Pinkham 2000). These restored environments can strengthen biodiversity by providing native plants and animals with viable habitats, as exhibited in **Figure 9**. Large-scale projects even have the potential to facilitate the return of aquatic species, as larger areas offer opportunities to recreate natural floodplains, stream morphology, and riparian buffer space (Buccholz & Younos 2007).

Figure 9. Photos of hummingbird sage (*Salvia spathacea*, left), rushes (*Juncus patens*, top right), and a great egret (*Ardea alba*, bottom right) at the Westwood Greenway. Photos courtesy of the Westwood Greenway Inc. website ("Gallery" page).

Further evidence of environmental benefits comes from a case study of a Minnesota daylighting project. At Phalen Creek, located in St. Paul, MN, health improvements to the macroinvertebrate community were observed within only five years (Pinkham 2000). Macroinvertebrates are often used as indicators of ecosystem health because of their high sensitivity to physical and chemical environmental changes (National Park Service 2015). They are specifically useful for assessing the effects of pollutants and management efforts on freshwater system health and water quality (National Park Service 2015). Exposure to natural stream elements and biodiversity improvements indirectly suggest that daylighting improves water quality, although long-term and multi-parameter investigations have yet to be conducted (Pinkham 2000; Buccholz & Younos 2007). However, a 2015 study based on field measurements recorded over the course of a year observed increases in nitrate (NO_3^-) uptake in daylit streams, leading to reduced NO_3^- transport downstream (Beaulieu et al. 2015). High NO_3^- levels in stream systems can lead to downstream eutrophication (Beaulieu et al. 2015), which can cause decreased oxygen levels and major loss of life in aquatic systems. While more studies need to be conducted to fully understand the relationship between daylighting and nitrogen cycle management, these results provide support for water quality improvements as a result of daylighting.

In addition to environmental advantages, daylighting has infrastructural utility that culverts do not. For example, daylighting generally provides more accessible means of management and repair when compared to culverts, as complications are easier to visualize and reach than those in underground systems (Pinkham 2000). The Westwood Greenway, however, does include multiple underground pump and diversion systems in its design (Westwood Greenway b). Additionally, threats of flooding and erosion can be significantly reduced by daylighting. Daylit streams slow and reduce runoff volumes by providing more space and promoting infiltration, which can further relieve pipes that may have otherwise been caused to choke and overflow (Pinkham 2000; Buccholz & Younos 2007). A case study by Pinkham (2000) of the Arcadia Creek daylighting project in Michigan revealed that flood insurance became inessential after implementation reduced flood risks, saving local businesses a significant amount of money annually. It is important to reiterate that climate change is expected to increase the likelihood of flood events in Los Angeles (Los Angeles County 2021), making flood risk mitigation a high priority for environmental and economic perspectives.

Daylighting is not the only form of green infrastructure used at the Westwood Greenway. At the Westwood Greenway, daylit water from the Overland storm drain moves through sand-filters and undergoes vegetated bioswale treatment, illustrated in **Figure 10** (Westwood Greenway e). Bioswales are one of many LID practices that have shown efficiency in slowing runoff, reducing water volumes by facilitating groundwater infiltration, and sequestering metals/other pollutants associated with urban systems (e.g., zinc, lead, suspended solids, hydrocarbons) (Anderson et al. 2016; Evans et al. 2019). Bioswales can also be incorporated into parking lots or roadsides to manage runoff produced by transportation infrastructure during storm events (Davis et al. 2012).

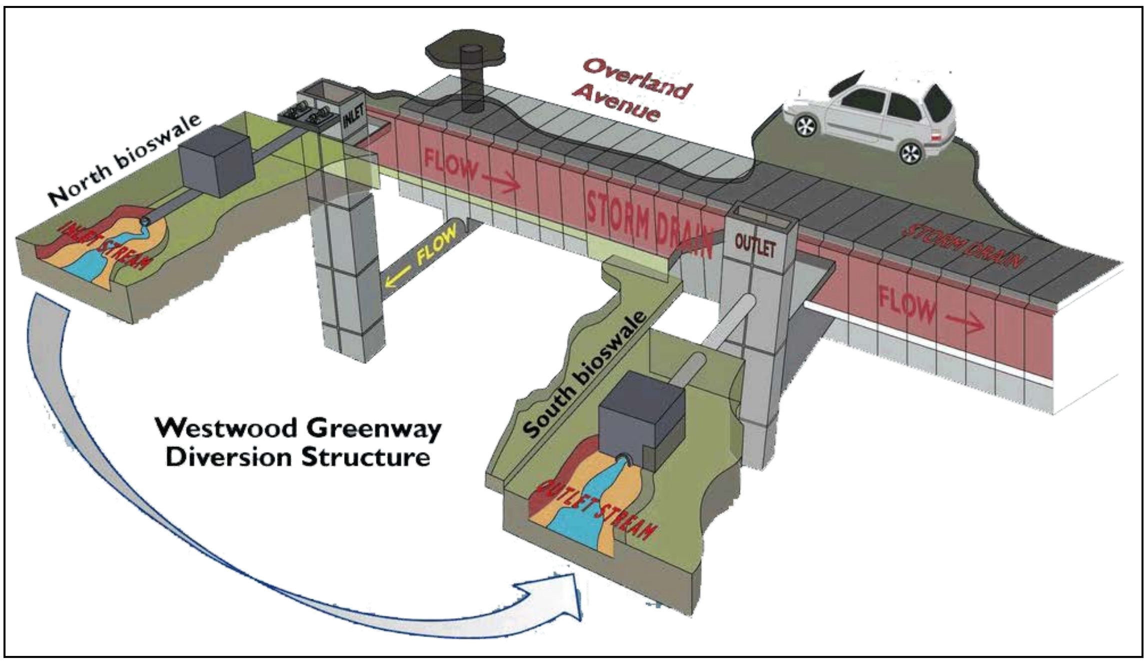

Figure 10. Schematic of the diversion infrastructure used at the Westwood Greenway. Image courtesy of the Westwood Greenway, Inc. website (“Project Overview” page).

Other LID practices that convey similar benefits to bioswales are rain gardens and permeable pavement. Rain gardens are gardens situated within a slightly sloped depression in the ground, which allows runoff water to permeate more effectively than in a conventional lawn (Groundwater Foundation). Ideally, rain gardens are landscaped with native plants to provide added biodiversity benefits. Rain gardens are ideal for areas with limited open space, such as residential yards, and are cost-efficient in terms of their nutrient removal capabilities (EPA

2021c; Heidari et al. 2022). However, they must be situated so that they collect water directly from impervious surfaces, such as rooftops or driveways, making them less versatile than other BMPs. Separately, permeable pavement is a pervious pavement, concrete, or asphalt that facilitates runoff infiltration (EPA 2021d). Permeable pavement is practical for municipal and commercial areas, as it can act as functional sidewalk or road space, and its benefits and long-term performance have been well studied (Heidari et al. 2022; EPA 2021d). Each of these BMPs, along with many others, possess respective benefits that promote essential hydrological and ecological services.

6.3. Health and Social Impacts

The growth of cities has not only destroyed the natural environment, but has also decreased urban green spaces (Colding et al. 2020). Consequently, the decrease in outdoor green spaces has led to social, psychological, and health-related ramifications as people spend less time outside (O'Loughlin & Tarasuk 2003). In addition, transportation infrastructure has increased the presence of environmental stressors and pollutants that threaten public health. Dependence on driving in Los Angeles also has adverse effects on people's physical health, as the transportation infrastructure in Los Angeles forces people to drive to most destinations rather than walk (Ding et al. 2014). Greenways can offset these issues and improve visitors' quality of life by promoting exercise, reducing exposure to urban pollution, connecting residents to nature, strengthening community values, and providing educational opportunities for all ages (He et al. 2021). Therefore, the city should focus on constructing more greenways in urban areas, as these spaces are crucial to the overall well-being of a city's inhabitants.

6.3.1. Physical Activity and Physiological Benefits

Los Angeles is an automobile-oriented city dominated by thousands of miles of roadways (Wachs 1993). People who drive frequently are more likely to suffer from insufficient physical activity and sleep, as well as weakened physical health, compared to people who don't drive as often (Ding et al. 2014). The spatial structure of Los Angeles makes it difficult for people to travel by foot, as most destinations are separated by highly-trafficked streets and highways (Ding et al. 2014). Because Los Angeles infrastructure supports driving more than walking, people are less likely to choose walking as a mode of transportation. These factors have contributed to a decline in physical activity, with approximately one third of the US population failing to reach recommended levels in 2020 (WHO 2020). Greater participation in physical activity can delay a variety of diseases and illnesses, as exercise has been linked to improved health outcomes (Ruegsegger & Booth 2018). Greenways can facilitate the physical movement essential to reducing obesity, diabetes, cardiovascular diseases, osteoporosis, improve mental health, increase lifespan, and more (Heller & Bhatia 2007).

Greenways help combat inactivity by providing a safe place for city dwellers to partake in recreational movement, as shown in **Figure 11** below. One study found that increasing access to greenways resulted in improved walking behaviors, which entails increased walking speed and more time spent walking (He et al. 2021). As a result of seeing the physical and mental benefits of implementing healthy habits, people are more motivated to implement other healthy lifestyle choices (Gardner et al. 2012). In conversational interviews with Westwood Greenway visitors, interviewees commented on their gratitude for the opportunities that the Westwood Greenway provides to be active outdoors (Anonymous, personal communication, February 23, 2022). Visiting the Westwood Greenway has motivated guests to take walks with family and friends and support each other in their efforts to get more exercise (Anonymous, personal communication, February 23, 2022).

Figure 11. Photo of the pedestrian path at the Westwood Greenway. Photo courtesy of the Westwood Greenway, Inc. website ("Project Overview" page).

Despite their similarities to outdoor parks, greenways have a linear structure that encourages visitors to continue moving along the trailway (Keith 2016). This design provides fewer opportunities for sedentary activities like sitting and picnicking that occur in other urban parks. When comparing a group of greenway visitors to a group of urban park visitors, a Chicago study found that the greenway group was generally more active during their visit and engaged in physical activities for longer periods of time (Keith 2016). This highlights the unique benefits of greenways compared to other types of green spaces, which should be reflected in funding allocation for future projects.

6.3.2. Urban Pollution Exposure Reduction

Urbanization has increased contaminants in the environment (e.g. chemical emissions and particle pollutants) and consequently degraded air quality (Zhang 2021). Globally, air pollution is responsible for 29% of all lung cancer cases/deaths, 24% of all stroke deaths, and 25% of all heart disease (Fidaev et al. 2021). Air pollution is an established cause for an extensive array of health issues, because inhaling smoke and pollutants leads to carbon deposits in the lungs (Kelly et al. 2015). Green spaces filter out many environmental stressors (e.g. air pollution and noise) present in urban settings. Therefore, due to their abundance of plants that act as a natural filtration system, greenways have higher quality air (Chang et al. 2020). This reduces exposure to toxic pollutants, which improves overall health (Kelly et al. 2015). These benefits are exemplified by the Westwood Greenway, as visitors have emphasized the joy and clarity they felt after breathing the Westwood Greenway's fresh air (Anonymous, personal communication, February 23, 2022). One visitor in particular expressed how peaceful it was to escape from urban noise during their visit (Anonymous, personal communication, February 23, 2022). Additionally, people visiting greenways reported reduced fatigue, tension, anger, confusion, and stress (Wolf et al. 2020). Greenways allow people to disconnect from fast-paced city life, which positively impacts overall mental health. A study on the East Lake Greenway in Wuhan, China, concluded that homeowners who lived closer to the greenway self-reported better mental health compared to residents who lived farther away (Xie et al. 2021).

6.3.3. Building Community

Greenways also improve mental health by promoting social interactions. Within greenways, neighborhood residents are able to socialize with other community members, increasing social cohesion (Heller & Bhatia 2007). Maintaining social networks is vital to ensuring one's well-being, and greenways encourage people to build these support systems (Heller & Bhatia 2007). For instance, volunteers from various backgrounds are brought together at the Westwood Greenway's weekly Saturday morning garden weedings (Westwood Greenway c). Beyond the residents living immediately around the greenways, people from farther communities are also able to connect with the greenway locals. This is due to greenways being built near public transportation infrastructure, just as the Westwood Greenway is alongside the Metro E Line (**Figure 12**). Therefore, greenways allow for society as a whole to reap the physical and mental health benefits of these spaces, as people from different parts of the city can easily visit a greenway situated near a transit hub (Lee 2018).

Figure 12. Photo of the Metro E Line Station taken from the Westwood Greenway. Photo courtesy of the Westwood Greenway, Inc. Facebook page.

6.3.4. Education

Greenways also provide an educational space for visitors of all ages to interact with the natural environment, promoting ecological literacy (Rigolon 2013). Additionally, the patches of rest areas along greenway trails allow visitors to stop and observe their surroundings. This gives people a chance to immerse themselves in their environment in many ways, such as identifying native plants pictured on signage. The use of signage can also educate visitors about the importance of protecting native species and biodiversity, increasing public motivation to partake in community volunteer efforts (Rigolon 2013). Examples of informative signage included along the Westwood Greenway are shown in **Figure 13**.

Figure 13. Photo of a Westwood Greenway Signage. Photo courtesy of the Westwood Greenway, Inc. website ("Project Overview" page).

Additionally, greenways can act as outdoor classrooms and field-trip destinations for students (**Figure 14**). The Westwood Greenway, for example, has hosted educational excursions for fourth-grade students at Overland Elementary School for Advanced Studies, as well as multiple dens of Cub Scouts (A. Mercer, personal communication, March 1, 2022). Educating the youth about anthropogenic environmental impact through hands-on engagement with the natural world inspires them to care more about protecting nature (Pinkham 2000). Fostering this inspiration at a young age drastically increases the likelihood that people will put more effort into conservation later in life (Holfelder 2019). Westwood Greenway visitors were also delighted by the educational opportunities that the Westwood Greenway provides to teach people about native plants, water filtration, and other ecosystem services (Anonymous, personal communication, February 23, 2022). Some visitors of the Westwood Greenway stated that learning about the water filtration infrastructure and biodiversity found in the space was the most memorable part of their visit (Anonymous, personal communication, February 23, 2022).

Figure 14. Photo of a Westwood Greenway Educational Excursion. Photo courtesy of the Westwood Greenway, Inc. Facebook page.

Developing outdoor education programs is especially important considering the isolating impacts of the COVID-19 pandemic on school systems (LA Unified Board of Public Education, 2021). On April 14, 2021, the LA Unified Board of Education unanimously approved Board Member Nick Melvoin's initiative to make outdoor learning opportunities more accessible for LA Unified School District students (LA Unified Board of Education 2021). The initiative calls for more resources and funding for existing programs as well as developing new methods of educational engagement with nature (LA Unified Board of Education 2021). Allocating funding to greenway construction would be an impactful way for LA Metro to support this initiative, along with a multitude of others with similar goals.

7. Cost-Benefit Summary

Table 2 summarizes the costs and benefits of various greenway components that have been outlined thus far. It is worth noting that, although the Westwood Greenway was constructed on public land, future greenway projects might warrant additional costs for land acquisition. From this table, it is clear that costs are mostly monetary and largely associated with initial greenway construction (excluding maintenance costs). However, landscaping with climate-appropriate native plants and incorporating BMPs can reduce long-term costs associated with biodiversity loss, habitat destruction, runoff pollution, and climate change. Because greenways' benefits span economic, ecological, and sociological domains, their value to the community is worth the financial investment.

Table 2. Table detailing a cost-benefit summary of the Westwood Greenway

Greenway Component	Costs	Benefits
Native Plants/ Landscaping	● Plant materials/seeds ● Installation equipment (e.g. shovels, rakes, gloves, etc.) ● Landscaping design and installation	● Support and enhance native plant biodiversity ● Provide habitat to animals and promotes animal biodiversity ● Counteract heat island effect

	• Native plant management training (not a financial cost but a time cost; see section 8.2.1.) • Maintenance for landscaped appearance (e.g. weeding, pruning, sweeping, watering during establishment, sporadic watering after establishment, irrigation)	• Carbon sequestration • Major reduction in long-term watering • No pesticides/herbicides • No need for smog-producing mowing • Locally-sourced seeds are climate-appropriate • More likely than exotics to survive past introduction • Increased climate resilience • Support numerous goals of the “Our County” Sustainable LA County Plan • Further City of Los Angeles Biodiversity Motion and Green New Deal • Support Governor Newsom’s carbon neutrality initiative • Support President Biden and Governor Newsom’s 30x30 initiatives
Daylighting/ BMPs	• Technical/professional consultation • Land acquisition • Demolition, excavation and rough grading • Construction • Stream bed infrastructure • Channel structures	• Flood prevention and control • Urban runoff filtration • Slowing runoff • Groundwater recharge • Water pollution abatement • Avoidance of fines through compliance with CWA regulations

	• Pumping equipment purchase and installation • Maintenance	• Aquatic and riparian habitat restoration/provision • Strengthens ecological integrity and ecosystem services • Management/maintenance is easier to view and access compared to underground systems, aside from underground pump and diversion infrastructure
Physical Health/ Educational/ Community Value	• Volunteer outreach materials • Signage • Promotion for continued community interest • Educational materials and tools	• Increases accessibility of greenspaces to disadvantaged communities • Improves overall mental health • Encourages physical activity, which decreases health issues • Fosters connections between greenway visitors • Promotes community through volunteering • Provides opportunities for outdoor education • Informs the public about their natural environment • Increases ecological literacy to encourage regenerative practices

8. A Construction Guide for Future Greenways

This section is meant to be a guide for navigating greenway implementation for the convenience of any agency considering future greenway projects. The guide includes cost estimates for native plants and daylighting, native plant resources including wholesale nursery recommendations, strategies for cost-savings and long-term project success, and potential funding sources for future greenways. We have also included a cost breakdown of the Westwood Greenway for reference (**Appendix C**).

8.1. Itemized Cost Estimates

8.1.1. Native Plants

The following cost estimates (**Table 3**) are based on the wholesale nursery El Nativo Growers' unit plant prices as of February 7, 2022. The price catalog was obtained from Michael Campbell upon request, and it clearly indicates which plants are California natives as well as their availability. It is worth noting that these estimates are based off of list prices, and El Nativo Growers offers tiered pricing to returning, high-spending customers. The average prices for both California native and non-native plants were within two dollars of each other, and generally, native and non-native plants did not differ in price range. Although the data is only representative of one nursery, it indicates that choosing native plants over non-native plants for greenway landscaping does not need to require a higher budget.

Table 3. Table detailing El Nativo Growers unit price ranges with the average price displayed in parenthesis. *El Nativo Growers only carries 2 native succulent species, both of which are $6.50 for 1 g.

Plant Growth Type	Size (gallons)	Native Plants Unit Price	Non-Native Plants Unit Price
Shrub	1g	$3.50–$5.85 ($4.71)	$3.00–$5.85 ($3.79)
	5 g	$10.50–$16.50 ($13.17)	$7.50–$18.50 ($11.21)
Perennial	1 g	$3.00–$5.50 ($4.53)	$3.00–$6.50 ($4.20)
Grass	1 g	$3.50–$5.85 ($4.11)	$3.00–$5.50 ($4.13)
Sedge	1 g	$3.50–$4.50 ($3.94)	$3.00–$4.25 ($3.55)

Succulent	1 g	$6.50*	$3.00–$7.50 ($4.50)
Tree	1 g	$4.25–$5.85 ($4.86)	$3.50–$4.25 ($4.10)

8.1.2. Daylighting vs. Storm Drains

Pinkham (2000) cites Gary Mason – a daylighting project designer and coordinator – when stating that $1,000 per linear foot is a sufficient approximation for daylighting project costs. Buchholz and Younos (2007) provide a more detailed breakdown of average daylighting project costs in their report. By their calculations, small and medium scale projects (< 250 linear feet, 250-1,000 linear feet, respectively) cost no more than $100 per linear foot, while large scale projects (> 1,000 linear feet) cost about $800 per linear foot. The individual projects analyzed for these calculations were all across the United States, with costs likely varying by city. It is clear from this breakdown, however, that longer daylighting strips are more expensive, as are projects in more urban areas due to demolition and land-purchase fees (Buchholz and Younos 2007). Nonetheless, additional costs may be worthwhile given the expectation that larger daylighting projects often result in increased ecological benefits (Buchholz and Younos 2007). It should be noted that these estimates are for daylighting projects – not necessarily entire greenways – and thus should *not* be considered estimates for greenway costs. With that said, the information is useful given that the daylighting component is likely the most costly and labor-intensive part of a greenway project.

There is a significant knowledge gap regarding the long-term costs of culverts versus daylighting projects. Despite this gap, it is clear that culverts will inevitably require complete or partial replacement, while daylit streams will not (Buccholz & Younos 2007). From a long-term perspective, avoiding these repeat installation costs suggests that daylighting is the more cost-efficient option (Pinkham 2000; Buccholz & Younos 2007). However, the Westwood Greenway is an exception, as its pump wells and diversion infrastructure require distinct installation, maintenance and potential replacement costs (see **Appendix A** for pump and diversion infrastructure unit and extension costs). Since this infrastructure allows for removal of trash, debris and heavier sediments that may not be filtered out otherwise (Westwood Greenway b), these additional costs should be considered worthwhile from an environmental perspective.

8.2. Recommendations and Resources for Implementation

8.2.1. Landscaping

As a part of the "City Biodiversity Index," the City of Los Angeles 2020 Biodiversity Report incorporates the ecotope map shown in **Figure 15**. The map divides Los Angeles into 27 ecotopes, or areas with distinct topography, species populations, microclimates, and environmental features (LASAN 2020). The "City Biodiversity Index" includes an ecotope-specific biodiversity assessment that can be useful for identifying which ecotopes have experienced the most biodiversity loss. To prevent further biodiversity loss in these ecotopes, it is important for city planners to prioritize these ecotopes when deciding where to implement future greenway projects. Landscapers can consult "Appendix B" of the 2020 Biodiversity Report for information regarding the best-suited native vegetation for the appropriate ecotope (LASAN 2020). Landscapers can use this information to identify the most beneficial plants to include in their designs.

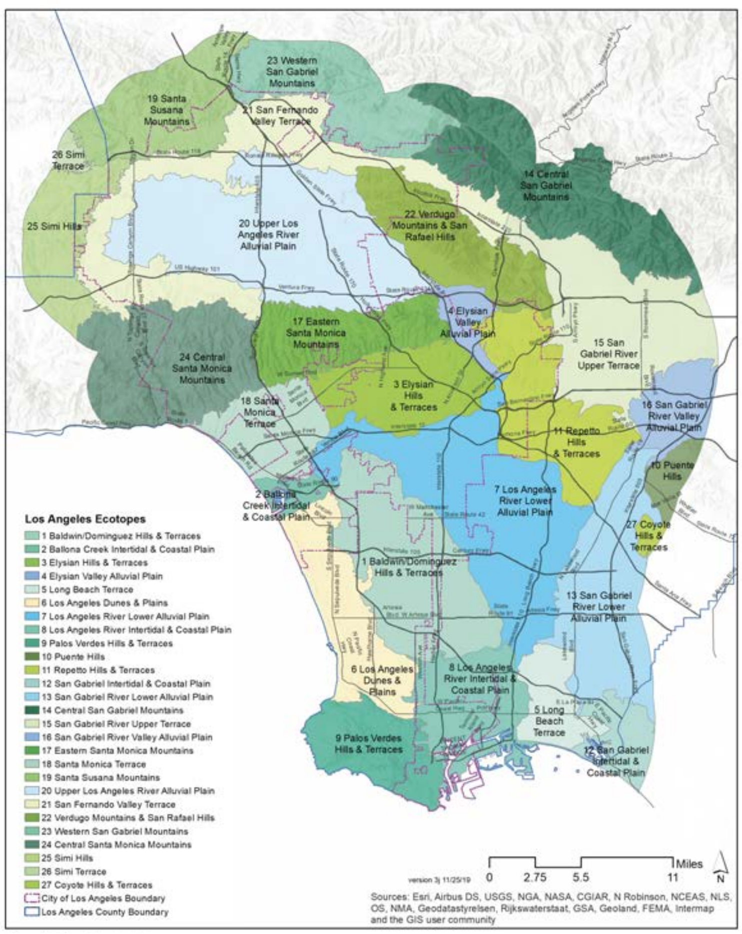

Figure 15. City of Los Angeles Ecotope Map.

To ensure the plants in a greenway design are well-adapted to their respective locations, it is preferable to source seeds and plants from the same or similar ecotopes because subpopulations of plants within the same species may differ in morphology or growing behavior based in their geographic region (Daehler et al. 1999). For example, plants belonging to the same species could have very different needs and adaptations depending on whether they are sourced from Northern or Southern California (Daehler et al. 1999). Seed LA, Los Angeles' Regional Native Seed Network, is a useful resource for acquiring locally-sourced seeds. The organization focuses on collecting, distributing, and banking locally-sourced seeds to promote climate-resilient landscaping (Seed LA 2022). The California Botanic Garden Seed Conservation Program and Theodore Payne Foundation Long Live LA Conservation Seed Bank also collaborate with Seed LA as a part of a regional seed bank network (CBG 2022; TPF 2022a).

Another available resource is the Calscape Garden Planner search engine (California Native Plant Society 2022b), which is a valuable tool for locating the nearest plant nursery carrying a desired species. The Calsacape Garden Planner can also help landscapers determine which plants are native to a specific zip code, and it can provide plant species recommendations for attracting pollinators and birds, conserving water, and resisting deer (California Native Plant Society 2022b). Although these nurseries cannot always guarantee that their seeds are sourced from Southern California, they are useful alternatives in the event that locally-sourced seeds are unavailable. Using this search engine, we have compiled a list of wholesale nurseries (**Table 4**) and retail nurseries (**Table 5**) in LA County that sell California native plants.

Table 4. Table detailing the names and contact information for wholesale nurseries within LA County that sell California native plants.

Nursery Name	Address	Contact Information
El Nativo Growers	200 S Peckham Rd, Azusa, CA 91702	(626) 969-8449
Devil Mountain Wholesale Nursery	2501 Manhattan Beach Blvd, Redondo Beach, CA 90278	(310) 909-7620 Redondo@devilmountainnursery.com

	8625 Grand Ave, Rosemead, CA 91770	(626) 365-0339 Rosemead@devilmountainnursery.com
Stover Seed Company	9180 San Fernando Rd, Sun Valley, CA 91352	(213) 626-9668 (818) 351-4090 customer_service@stoverseed.com
Tarweed Native Plants	1307 Graynold Ave, Glendale, CA 91202	(626) 705-8993
Tree of Life Nursery	33201 Ortega Highway, San Juan Capistrano, CA 92675	(949) 728-0685 inquiries@treeoflifenursery.com

Table 5. Table detailing the names and contact information for retail nurseries within LA County that sell California native plants.

Nursery Name	Address	Contact Information
Artemesia Nursery	5068 Valley Blvd, Los Angeles, CA 90032	(323) 795-5515 artemisianursery@gmail.com
Hahamongna Native Plant Nursery	4550 Oak Grove Dr, Pasadena, CA 91103	(626) 657-0392 nursery@arroyoseco.com
Tree of Life Nursery *offers wholesale and retail services	33201 Ortega Highway, San Juan Capistrano, CA 92675	(949) 728-0685 inquiries@treeoflifenursery.com
Theodore Payne Foundation for Wild Flower & Native Plants	10459 Tuxford St, Sun Valley, CA 91352	(818) 768-1802 info@theodorepayne.org sales@theodorepayne.org
Grow Native Nursery at	1500 N College Ave,	(909) 625-8767

California Botanic Garden	Claremont, CA 91711	info@calbg.org gnnclaremont@calbg.org
Plant Material	3081 Lincoln Ave, Altadena, CA 9100	(626) 345-5750 info@plant-material.com
	3024 La Paz Dr, Los Angeles, CA 90039	(323) 486-7072 silverlake@plant-material.com
	3350 Eagle Rock Blvd, Los Angeles, CA 90065	(323) 474-6842 glassell@plant-material.com

When landscaping with native plants, it is essential to have a maintenance plan to ensure plant survival. Tree of Life Nursery offers free resources on their website regarding native plant establishment and care, available as a "Creating and Caring for your Native Garden" blog post and a 90 minute video, "Natural Garden "How-To" Guide," by Mike Evans (Tree of Life 2021). In addition, the Theodore Payne Foundation offers the California Native Plant Landscaper Certificate Program, a free native landscape maintenance training program available for landscapers and gardeners (TPF 2022b). This program includes valuable information regarding pest management, irrigation, and native plant identification (TBF 2022b). While maintenance training does require an investment of time, it is extremely important for developing an educated maintenance plan for long-term greenway success.

8.2.2. Green Infrastructure

Consideration of BMPs and their individual benefits is essential for optimizing the ecological benefits of a greenway. Daylighting a stream is not recommended for every greenway, as not all locations are satisfactory candidates. Soil contamination, amount of impervious cover, and the layout of existing storm drains can eliminate areas as viable project sites due to low restorative potential and physical restrictions (Buchholz and Younos 2007; Pinkham 2000). Determining whether or not a location is suitable for a particular BMP before construction will help avoid expenditure on projects that will not be effective long-term. A green infrastructure design tool called GiDesigner is available as a free online web application that can be used to spatially visualize and estimate costs of potential projects (Leonard et al. 2019). GiDesigner does, however, require Jupyter Notebook experience to use effectively. Nevertheless, using these types of tools can help ensure effective and cost-efficient implementation of BMPs.

It has also been shown that combining green infrastructure with conventional stormwater management leads to better flood control and more significant water quality improvements than when either is used individually (Heidari et al. 2022). The project at Westwood Greenway achieves this by filtering water that it diverts from the Overland storm drain before sending it back into the drain (Westwood Greenway e). In this way, BMPs work alongside existing infrastructure. Finally, given limited funding, BMPs should be considered in the context of whether there are (or will be) superseding projects upstream or downstream to avoid wasteful redundancy.

8.2.3. The Importance of a Multifaceted Approach

Initiating greenway projects through a restorative, community-driven approach can greatly influence project success. In a research paper, Delibas and Tezer (2017) offer a useful model for implementing ecologically and socially valuable daylighting projects called the "Conceptual Model of Integrated Stream Daylighting" (Co-MISDAL). This model provides a framework for stream re-naturalization that is centered around an ecohydrological, "nature-oriented" perspective. Notably, Co-MISDAL accounts for environmental, socio-cultural, legal, economic and technical aspects. Each of these aspects is associated with project success indicators that may be considered during the planning, implementation and/or monitoring phases of a project. These themes highlight the importance of considering projects, their potential for success, and their widespread implications within multiple ecological and social contexts.

Furthermore, Pinkham (2000) highlights the importance of involving both technical consultants and the community in daylighting project development, which may reduce costs by way of well-informed planning and volunteering/donations. Inspiring community members to donate or volunteer, however, requires extensive community outreach. Involving nearby landowners, local schools and politicians early-on in the planning and design processes can ensure a collective enthusiasm that will serve as the backbone of a project's success (Pinkham 2000). While these tools and suggestions were made for daylighting projects, the tenets of restoration, interdisciplinary perspective, and community involvement are equally applicable to greenways as a whole.

8.2.4. Monitoring

Buchholz and Younos (2007) note that the majority of daylighting project monitoring has consisted of visual rather than quantitative measurements, making it difficult to quantify the long-term effects on habitat and water quality. There is therefore a need for quantitative monitoring in future projects. This will ensure that projects can be properly assessed to determine which strategies are the most successful. Delibas and Tezer (2017) recommend the use of the International Union of Geological Sciences' (IUGS) geoindicator list for daylighting project monitoring. This list provides various physical indicators of a healthy stream system. The California Rapid Assessment Method (CRAM) should also be used to monitor riparian environmental conditions prior to and following restoration projects, as it is the standard method for assessing riparian system health in California (San Francisco Estuary Institute 2022). Monitoring a greenway's hydrological, geological and riparian health at multiple stages of implementation can help ensure that the project is providing expected ecosystem services.

8.2.5. Potential Funding Sources

This section provides potential funding sources for governmental agencies looking to implement future greenway projects. The versatility of greenway benefits makes their construction relevant to a wide range of grants and programs, however, this list prioritizes sources focused on water quality management. Our research found that these funding opportunities are not only more numerous, but they also tend to have more available funding than those pertaining to biodiversity, greenspaces, and/or outdoor education.

Table 6. A list of potential funding sources for future greenway projects, including a description summary, the managing agency, total funding amount available, and website link for each source.

Funding Source	Managing Agency	Description Summary	Total Amount Available	Website
CWA Section	EPA	Funds for this program are	$185 Million	https://tinyur

319 Nonpoint Source Pollution Management Program		provided by the EPA. They aim to assist designated tribal and state agencies with implementing their approved nonpoint source pollution management programs. These programs include financial, education and technical training. assistance, regulatory programs, and demonstration projects.	(annual disbursement)	l.com/ktadhrt8
Integrated Regional Water Management (IRWM) Grant Program	California Natural Resources Agency	These grants will be awarded to projects that further the goals of Proposition 1, Chapter 7 to improve the self-reliance of regional water and help water infrastructure systems adapt to climate change.	$192 Million (second round of two round disbursement that will be awarded in April 2022)	https://tinyurl.com/2p83ytu5
Safe Clean Water Program	County of Los Angeles	Created by Measure W in 2018, this program aims to increase the local water supply and improve water quality by providing local funding for stormwater and urban runoff projects.	$285 million (annual disbursement)	https://tinyurl.com/2exdjemf
Urban Streams	California Department	The USRP provides grants to local communities for	Not stated, however	https://tinyurl.com/27avn

Restoration Program (USRP)	of Water Resources	projects that (1) protect, restore, and/or enhance the natural ecological values of streams, (2) reduce erosion, flooding, and associated property damage, and (3) promote education and community involvement.	$8,840,335 was disbursed in the 2014 cycle (this is the most recent cycle with available disbursement data)	m7u

9. Knowledge Gaps

9.1. Future Impacts of Climate Change on California Vegetation

California vegetation communities are dynamic. In the past, species ranges have shifted along longitudinal and elevational gradients in response to climatic changes (Hannah et al. 2012). These changes open the definition of "native plant" up for debate, as plants that may be historically native to an area might not be well-adapted to survive current climatic conditions. Although models can be used to predict changes in species range, it is still largely unknown how climate change will continue to impact vegetation communities (Hannah et al. 2012). According to the 2021 Los Angeles County Climate Vulnerability Assessment, climate change is likely to cause increases in extreme heat, wildfire, and megadrought frequency in the coming decades (Los Angeles County 2021). These changes will likely cause future shifts in plant species range, making it more important to landscape with climate-appropriate native species, not just historically native species.

9.2. Quantifying Health and Social Impacts of Greenways

Currently, there lacks an effective way to quantify the social and health-related benefits of greenways. Developing a standard metric or system of measurement for these greenway aspects would increase public awareness and appreciation for greenways, as well as provide a better argument for funding future projects. The Institute for Ecological Civilization is in the process of measuring and mapping wellbeing in California (Institute for Ecological Civilization

2020). This kind of index could supplement the existing qualitative analyses and case studies that highlight the social and health benefits of greenways. Future research to address this knowledge gap should focus on similar efforts.

9.3. Inequitable Access to Greenways

The ability for greenways to address issues relating to green space accessibility remains unknown. Greenway spatial distribution is a knowledge gap, and empirical data suggests that minorities and underserved communities are less likely to access recreational trails and parks (Lindsey 2001). While there are concerns about the population demographics that have access to green spaces, research has shown that greenways' proximity to transportation systems makes them more accessible to all socio-demographic groups (Lee 2018). Due to the placement of greenways, they can be most beneficial in future implementations of public greenspaces to address equity of access. Therefore, more research can be done to analyze the implementation of greenways as tools to overcome public space injustices.

9.4. Monitoring of Greenway Services

There are also knowledge gaps concerning the long-term benefits of daylighting, specifically those related to water quality (Buchholz and Younos 2007). According to a Los Angeles Regional Water Quality Control Board guide, acidity/alkalinity, temperature, dissolved oxygen, turbidity, and total suspended solids are sufficient parameters for monitoring the water quality of diversion projects (County of Los Angeles Department of Public Works 2016). Monitoring of all the physical and ecological aspects of a greenway should be highly prioritized. Currently, an Institute of the Environment and Sustainability (IoES) senior practicum group at the University of California, Los Angeles is evaluating both water quality and biodiversity at the Westwood Greenway. The results of their study could provide a baseline for future monitoring. Knowledge concerning the short and long-term health of these systems, as well as how to monitor them, is not only important for individual projects, but also for project replicability.

9.5. Increased Pollution Accountability

Lastly, there is a significant knowledge gap regarding the amounts that specific parties are contributing to watershed pollution. This makes CWA regulation enforcement extremely difficult and results in the City bearing the majority of financial consequences (S. Santilena personal communication, February 14, 2022). Future research should focus on developing technology to better quantify the pollution contributions of various parties. This would increase the accountability of individuals, corporations, and governmental agencies alike, allowing for more accurate and equitable distribution of CWA violation penalties. The power of accountability would also result in an overall decrease in watershed pollution, as parties would be incentivized to avoid the fines and poor reputations that would ensue upon excessive pollution exceedances.

10. Conclusion

The Westwood Greenway provides many ecological, hydrological, community, and health benefits that warrant investing in similar greenway projects in the future. Although more research is necessary to understand the impact of climate change on native plant populations, climate-appropriate and locally-sourced native plants are essential for reducing long-term maintenance costs (Diekelmann & Schuster 2002), promoting biodiversity (Tallamy 2009), offsetting pollution (Wang et al. 2021), and working towards a carbon neutral future (Koutika et al. 2021). Inclusion of BMPs, such as stream daylighting, should also be considered in future greenway construction. While long-term effects on water quality are still uncertain, daylighting's ability to filter urban runoff, prevent flooding, and strengthen the ecological integrity of riparian and stream systems has been well documented (Pinkham 2000; Buccholz & Younos 2007). Regardless of the type of BMP that is chosen for a greenway location, water quality monitoring should be prioritized to ensure project success. Furthermore, despite the lack of a standard metric to quantify social and health impacts, numerous studies exemplify greenways' role in increasing physical activity (He et al. 2021), decreasing exposure to air pollution (Chang et al. 2020), fostering social connections (Heller & Bhatia 2007), and providing outdoor education opportunities (Rigolon 2013).

The versatile benefits of greenway spaces further various governmental goals and initiatives relating to biodiversity enhancement, urban pollution reduction, and outdoor education (LASAN 2020; CARB 2021; LA Unified Board of Public Education, 2021) They also promote compliance with water quality regulations, which has enormous cost-saving potential (EPA 2002; R. Thiha, personal communication, February 14, 2022). Aside from maintenance expenses, our report indicates that the majority of greenway costs are incurred during initial construction. These costs are almost entirely monetary. The economic, environmental, and social benefits greenways offer drastically outweigh these costs, making greenway projects valuable investments for improving the future of Los Angeles County.

11. Appendix A

Westwood Greenway Cost Breakdown Estimates

Item	Quantity	Units	Unit Cost	Extension
Mobilization	1	Lump Sum	$100,000.00	$100,000.00
Diversion Structure	1	Lump Sum	$150,000.00	$150,000.00
Shoring	1	Lump Sum	$275,000.00	$275,000.00
Vortex Separator	2	Each	$75,000.00	$150,000.00
Wetwell	2	Each	$300,000.00	$600,000.00
Pumps	5	Each	$45,000.00	$225,000.00
Electrical	1	Lump Sum	$250,000.00	$250,000.00
Drainage Swales	1700	Linear Foot	$135.00	$229,500.00
Drainage Swale Connection to Expo Utility Crossing	2	Lump Sum	$25,000.00	$50,000.00
Connection to Return Storm Drain	1	Lump Sum	$10,000.00	$10,000.00
Pedestrian Path	622	Square Yard	$45.00	$28,000.00
Site Grading	741	Cubic Yard	$75.00	$55,555.56
Landscaping	42000	Square Foot	$3.50	$147,000.00
Irrigation	1	Lump Sum	$100,000.00	$100,000.00
Traffic Control	1	Lump Sum	$100,000.00	$100,000.00
Clearing and Grubbing	1	Lump Sum	$50,000.00	$50,000.00
Kiosk Signage	10	Each	$2,500.00	$25,000.00
Boulders/Architectural Features	1	Lump Sum	$200,000.00	$200,000.00
			Subtotal:	**$2,745,055.56**
			Escalation (1.5 year at 3% per year)	$123,527.50
			Subtotal:	$2,868,583.06

Estimation Contingency (25%)	$717,145.76
Subtotal:	$3,585,728.82
Construction Contingency (20%)	$717,145.76
Project Construction Costs (Class C):	**$4,302,874.58**

12. Appendix B

Interview Questions

1. Had you heard anything about the Westwood Greenway before visiting? If so, do you mind elaborating?
2. What were your reasons for touring the greenway?
3. How did you feel while visiting the site?
    a. Emotionally, psychologically, physically, ….
    b. Do you think there were mental or physical health benefits you gained from the experience?
    c. Did your group enjoy touring the space? Did they say anything about their experience after the visit?
4. Do you think society could benefit from the implementation of more greenways? If so, in what ways do you think people could benefit from increased access to greenways?
5. Was there anything surprising or unexpected about the greenway?
6. What could be done to improve the greenway?
7. Was there anything missing from the greenway that you expected?
8. Would you keep using/visiting the greenway after what you saw?
9. What's one thing that stuck out from your visit to the greenway?
10. Is there anything else you would like to share?

13. Appendix C

Westwood Greenway Plant List

Trees	
Alnus rhombifolia *Juglans californica* *Lyonothamnus floribundus* subsp. *aspleniifolius* *Platanus racemosa* *Prunus ilicifolia* subsp. *lyonii* *Quercus agrifolia* *Quercus tomentella*	White Alder Southern California Black Walnut Catalina Ironwood Western Sycamore Catalina Cherry Coast Live Oak Island Live Oak
Shrubs	
Abutilon palmerii *Arctostaphylos glandulosa* *Artemisia californica* *Asclepias fascicularis* *Baccharis piluaris* *Berberis* spp. x “Golden Abundance” *Berberis repens* *Ceanothus griseus* var. *horizontalis** *Epilobium canum* *Eriogonum arborescens* *Eriogonum fasciculatum* var. *fasciculatum* *Gambelia speciosa* *Salvia spathacea* *Salvia leucophylla* *Sphaeralcea ambigua* *Verbena lilacina*	Indian Mallow “John Dourley” Manzanita California Sagebrush Narrow Leaf Milkweed “Pigeon Point” Coyote Brush Golden Abundance Barberry Creeping Barberry “Yankee Point” California Lilac “Chapparal Silver” California Fuchsia Santa Cruz Island Buckwheat California Buckwheat Island Snapdragon Hummingbird Sage Purple Sage Desert Globemallow Lilac Verbena
Herbs	
Achillea millefolium *Aster chilensis* *Carex barbarae* *Carex pansa* *Elymus triticoides* *Iris douglasiana* *Juncus patens* *Leymus condensatus* *Melica imperfecta* *Muhlenbergia rigens* *Grindelia stricta*	Common Yarrow Pacific Aster Santa Barbara Sedge Sand Dune Sedge Alkali Rye Grass or Creeping Wild Rye Douglas Iris California Grey Rush Native Blue Rye Grass Imperfect Melic Grass Deer Grass Gumweed

*This name has since changed to *Ceanothus thyrsiflorus var. griseus* (Burge & Wilken 2020).

The Westwood Greenway Plant List displays the proposed plant palette for the Westwood Greenway. Although there may be some discrepancies between this list and what was actually planted at the Westwood Greenway (A. Mercer, personal communication, February 18, 2022), this list provides an example plant palette for future greenway design.

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