Greening the Jade: An Economic Analysis of the Costs and Benefits of Urban Greening in SE Portland

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1 Introduction and Background

1.1 *Urban Greening*

With increasing concern for our environment, many U.S. cities have begun to explore opportunities to make urban centers more environmentally sustainable, leading to a rise in urban greening initiatives. Urban greening efforts often lead to the creation and maintenance of green infrastructure, which refers to an interconnected network of green space that conserves natural ecosystem values and functions, while providing associated benefits to human populations (Benedict and McMahon 2001). Street trees, which can help absorb stormwater runoff and thus prevent floods, and urban parks, which provide green spaces for community members, are both examples of green infrastructure.

There are seven main types of green infrastructure located in the public right of way: bioswales, street trees, rain gardens, restored open spaces, parkland, restored native plant habitat, and green streets (Enelow et al. 2017). Ecoroofs are another major type of green infrastructure, but they are primarily located on privately owned buildings. The different types of green infrastructure can work independently or together to provide environmental, social, and economic benefits. Urban greening efforts do more than improve environmental conditions through better air quality, stormwater management, reduced urban heat islands, and other ecosystem service benefits. The installation of green infrastructure also provides community livability benefits such as improved public health and community cohesion (Entrix 2010). Furthermore, green infrastructure can serve as a powerful catalyst for economic development and job creation (Enelow et al. 2017).

This paper makes a distinction between **revitalization** and **gentrification**. Investing in neighborhood improvements, such as urban greening projects, is often desirable for current residents – revitalization makes neighborhoods more attractive, more livable, and encourages more investment. However, when economic investment leads to residents involuntarily being pushed out of their homes, revitalization becomes gentrification. Professor Lisa Bates identifies this involuntary residential displacement as the important distinction between revitalization and gentrification, and outlines three common characteristics of gentrification: housing market changes, economic status changes, and demographic changes in a neighborhood that alter its character (Bates 2013).

As with all development initiatives, developers and policy makers must be proactive and intentional in their planning efforts to ensure development is equitable. Cities across the U.S. have faced many challenges with involuntary displacement stemming from rapid gentrification. While investment in an area can spur growth, the increased market demand for housing in the neighborhood may lead to higher-income households outbidding low-income residents for limited numbers of units. As new economic development begins to cater to higher-income tastes, low-income households and communities of color may be forced out of the neighborhood, resulting in an economic status and demographic change (Bates 2013, Wolch et al. 2014).

Urban greening efforts are especially important in underinvested urban areas because of their impact on environmental justice outcomes such as air and water quality, recreational

opportunities, and aesthetics. Urban areas suffering from underinvestment often have poor infrastructure and environmental degradation due to a history of public and private disinvestment in the area. These areas also tend to be home to low-income populations and communities of color because of exclusionary zoning histories as well as residential and commercial displacement. This often leaves low-income populations and communities of color disproportionately at risk to environmental threats (Wolch et al. 2014). Urban greening initiatives in these areas can serve as an important catalyst for revitalization while working to address these environmental injustices. A visible and permanent commitment to public investment in a neighborhood often spurs private investment, thereby revitalizing an area and providing opportunity for economic growth (Bates 2013). Furthermore, by applying a sustainability lens on such developments, both the community and the environment can reap the benefits.

1.2 *Jade District*

The Jade District is a commercial district centered around the intersection between SE 82nd Avenue and SE Division Street in outer southeast Portland. The district was formally designated as a Neighborhood Prosperity Initiative (NPI) area by the Portland Development Commission (now known as Prosper Portland) in 2011. As a part of their Neighborhood Economic Development strategy, the NPI works to encourage economic growth in underserved communities without displacing the communities living there (APANO 2017). The NPI area boundaries (Figure 1) highlight the major commercial thoroughfare in the area, with 432 businesses within the 0.91 square miles (Multi-cultural Collaborative 2014).
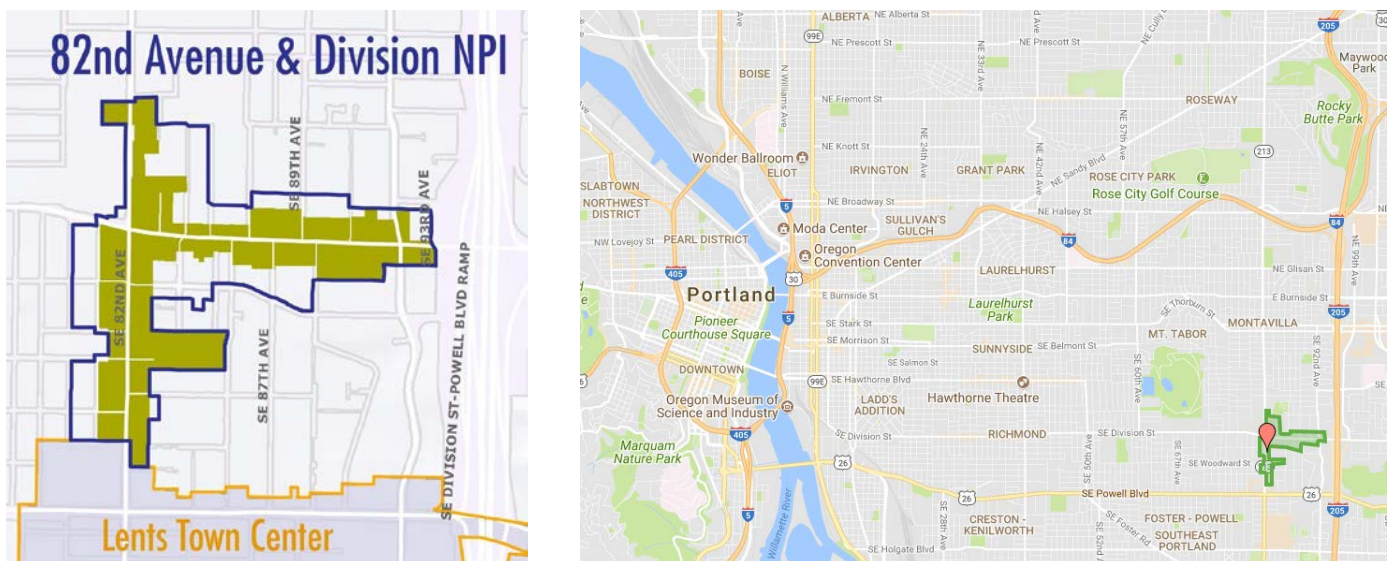
Figure 1. Maps of the Jade District. The Neighborhood Prosperity Initiative (NPI) area boundaries (left). The Jade District NPI area shown in relation to the greater Portland area (right).

According to the Portland Bureau of Planning and Sustainability, approximately 6,681 residents lived in the Jade NPI area in 2010, nearly 45 percent of whom identify as people of color and 23 percent as Asian. Compared to other areas in and around Portland, the

concentration of Asians and Pacific Islanders (APIs) in the Jade NPI area is nearly three times the citywide percentage, and the region witnesses population growth rate nearly three times as fast as the citywide rate. Additionally, despite an increase in the working age population from 55 percent in 2000 to nearly 70 percent in 2010, the Jade NPI area experienced a 2.3% per year decrease in total employment between 2006 and 2012, the second-fastest decrease in employment for all Portland city centers (Bureau of Planning and Sustainability 2014). This steep decline in total employment, combined with a rapidly growing population, is a potentially dangerous sign of the Jade District's vulnerability to gentrification pressures, especially considering the NPI captures most of the commercial activity in the area but does not capture the entire residential population.

Considering its diverse population, especially a large percentage of APIs, the statewide Asian and Pacific Islander grassroots advocacy organization APANO (the Asian Pacific American Network of Oregon) was contracted in early 2013 to help with community outreach in NPI efforts. APANO organized residents, local business owners, school volunteers, and neighborhood association representatives to form the Jade District Steering Committee (JDSC), which leads the visioning and planning of the NPI project in the area to ensure developments are in the best interests of community members. In the spring of 2014, APANO and the JDSC worked with the Multicultural Collaborative (MCC) to understand community-desired improvements through six workshops and an ethnic/racial specific outreach lens. The resulting Jade District Visioning Plan identifies current conditions, outlines key concerns and focus areas for development, and presents an integrated community vision from the community designs created by the various ethnic-based communities in the Jade (white [non-Russian speaking], Latino, Vietnamese, Chinese, and white [Russian-speaking]). This community-led visioning plan serves as a basis for NPI development in the Jade to ensure that development adequately addresses residents' top priorities and needs (Multi-cultural Collaborative 2014).

It is important, however, to clarify that the definition of the "Jade District" extends beyond the formal Jade NPI area. While there are a few landmarks commonly used to anchor the Jade District area – the SE 82nd Avenue and Division Street intersection and the Fubonn Shopping Center are two main markers – the Jade District is organized more around a concept and identity than a geographical area. Therefore, its definition as a district is more ambiguous – rather than a strict definition, it may depend on the definer's intentions and relationship with the area and should be used heuristically as a rule of thumb.

For example, according to APANO associate director Duncan Hwang, APANO's definition of the larger Jade District area focuses on Census Tracts 83.01 and 6.01 because of the programmatic fit to APANO's mission of broader community development and organizing work. These two tracts have a high proportion of Asian Pacific Islanders, and includes several different environmental and community health initiatives that impact APANO's communities, such as a future Asian health and service center in Lents in tract 6.01. On the other hand, a

different definition of the Jade District could include the six Census Block groups[1] that lie within or overlap the NPI area boundaries.

However, for the purposes of our study, we choose to focus on Census Tract 83.01. In this tract, there are 4,317 residents in 1,609 households, with nearly 62 percent of the population identifying as non-white. The area also is home to the largest concentration of Asian Americans in Portland (Sherrill 2015), with more than 33 percent of the population identifying as Asian (over 4 times the citywide percentage). The median household income is $28,656, barely 47 percent of the citywide median household income, and 36.1 percent of residents live below the poverty line. A larger percentage of housing is renter occupied compared to the rest of Portland, and a majority of residents speak languages other than English at home (U.S. Census Bureau 2015). Tract 83.01 is relatively representative of various other definitions of the Jade District, and all of the urban greening initiatives this paper analyzes fall within this census tract, but most strikingly, the disparities with the rest of Portland are largest in this tract. This reinforces the necessity for urban greening initiatives and revitalization in this area in particular, but also highlights the high risk of gentrification in the area.

Table 1. Census Tract 83.01 vs. City of Portland numbers and demographics[2]

	Census Tract 83.01	**City of Portland**
Total population	4,317	632,187
% non-white	61.9%	28.9%
% Asian	21.4%	7.9%
Median household income	$28,656	$60,892
Below poverty line	36.1%	15.8%
Renter occupied	69.4%	46.0%
Median value of owner-occupied housing units	$196,600	$348,300
High school graduate or higher	70.2%	91.3%
Bachelor's degree or higher	17.4%	48.6%
People with language other than English spoken at home	51.4%	19.5%
Foreign-born population	41.7%	13.6%

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[1] The six Census Block groups that lie within or overlap with the NPI area boundaries are 10510083012, 10510007012, 10510007011, 10510016023, 10510016022, and 10510016013.

[2] All data is from the 2015 American Communities Survey by the U.S. Census Bureau – 5-year for Census Tract 83.01 and 1-year for the City of Portland.

Jade District residents are disproportionately at risk of the effects of environmental degradation. The district is boxed in by major transportation corridors on all sides, which are some of the most traffic-congested corridors in the area (OPAL Environmental Justice Oregon 2017). The auto-oriented design of the area and inadequate tree canopy (about half of what the US Forest Service recommends) means that residents face increased risk of exposure to toxic air emissions, with 15 of the 17 hazardous air pollutants (HAPs) outlined in the Clean Air Act above the health benchmark in the area (Fleek 2016).

Public health indicators reflect the district's poor environmental conditions; for example, the percentage of residents who experience asthma in the Jade is nearly twice the national average. Furthermore, studies have also shown a connection between hazardous air toxins and low birth weight babies, potentially explaining the high percentage of Asian Pacific Islander babies in the region with lower birth weights – a percentage nearly 20 times the rate of low birth weight babies in white populations (Fleek 2016).

Current residents also express great concern for the area's lack of safety and walkability. Sidewalks along SE 82nd Avenue are patchy and narrow, at times too narrow for a wheelchair to pass, while SE 82nd Avenue's wide car lanes encourage speeding. Additionally, the lack of clear pedestrian crossings has resulted in a number of severe and at times fatal pedestrian accidents – in 2016, five deaths occurred along that stretch of road (APANO C 2017, APANO 2016). The area can be characterized as park-deficient with a lack of accessible green spaces, and the district ranks in the top 25 percent of urban heat island effect vulnerability (Fleek 2016).

All of this data points to significant environmental injustice in the area. Here, low-income communities and communities of color disproportionately bear the environmental and health costs, reflecting environmental justice trends across the country. It is important to recognize that the Jade District faces many challenges today because of a historical disinvestment in the area (APANO B 2017). In this context, urban greening efforts are all the more important in the Jade District, not only for economic revitalization, but also to combat environmental health disparities.

1.3 *Urban Greening Initiatives in the Jade*
The two main urban greening efforts currently underway in the Jade District are led by the Environmental Protection Agency (EPA) and a coalition of various stakeholders organized under Oregon Solutions, a statewide organization that facilitates community problem-solving. This paper chooses to focus on the EPA's Greening America's Communities process; however, it is important to acknowledge the other processes occurring in parallel (and at times collaboratively with the EPA process) to better understand the context of the projects.

The Jade District was selected as a partner community for the 2017 Greening America's Communities program, an EPA program designed to help cities and towns develop implementable urban greening visions. Initially focused on capital cities as the Greening America's Capitals program, the program has broadened to provide funding and support for the design of green infrastructure projects in partner communities. Though the program only

spans one year, these projects are intended to help catalyze or complement a larger planning process for the neighborhood beyond EPA's design process (Hall 2017, Smart Growth 2017). In the Jade District specifically, the EPA process concentrates on three demonstration projects or focus areas that can serve as a model for future implementation in the area: a potential park site, the Fubonn supermarket, and a small section of SE Division Street.

The first focus area, Community Park and Safe Routes, identifies a lot for potential park development in the future along SE 89th Avenue near an existing City of Portland Bureau of Environmental Services (BES) stormwater management site. SE 89th Avenue is currently riddled with potholes, very steep, and extremely pedestrian-unfriendly. Initial designs include road improvements to make it greener and safer for both cars and pedestrians, such as adding vegetated infiltration and traffic-calming basins to slow down traffic and help manage stormwater. Ideas for the park include a fitness trail, a community art fence, and a terraced community garden, with future housing development opportunities on the lot across from the park (Environmental Protection Agency 2017).
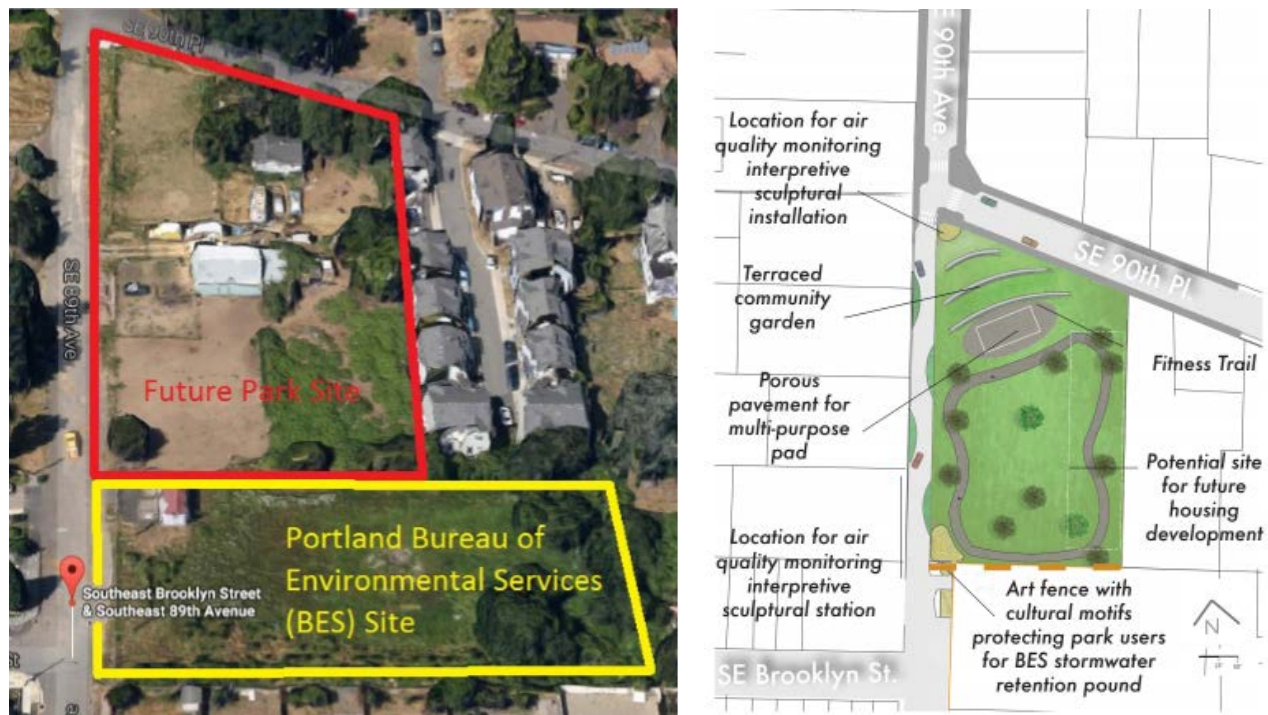
Figure 2. Focus Area 1: Community Parks and Safe Routes.
The current conditions (left). The initial proposed designs for a future park development (right).

The Fubonn supermarket is the target of Focus Area 2, Commercial Retail Property and Streets. With only one entrance and exit on SE 82nd Avenue west of Fubonn, the parking lot currently experiences significant congestion and accessing the supermarket is difficult for residents living east of the market. Initial designs propose to open this entrance on SE 82nd Avenue up into a larger plaza and gateway entrance, and create a connective exit onto SE 85th Avenue east of the supermarket to allow for easier movement of traffic. The designs also open up more pedestrian

and bicycle entrances to the neighborhoods north of the market, increasing accessibility. The parking lot has potential for tree planting to create a "parking forest," as well as room for stormwater gardens, and new housing developments are even proposed east of Fubonn along SE 85th Avenue (Environmental Protection Agency 2017).

Figure 3. Focus Area 2: Commercial Retail Property and Streets. An aerial shot of the current conditions at Fubonn supermarket (top). The initial proposed designs (bottom).

Finally, Focus Area 3 is centered on a portion of SE Division Street near an underutilized pedestrian overpass as the gateway to the Jade District. The auto-oriented nature of SE Division Street and narrow, unmaintained sidewalks currently leaves the road unfriendly to pedestrians and bikers as vehicles speed by. Suggestions for improvement transform the street into a green and complete street with a median, traffic-slowing trees and bioswales, raised table

crosswalks, and protected bike lanes. Air quality monitors as well as community art could be installed on the pedestrian overpass to transform it into an elevated greenscape or iconic gateway into the Jade District (Environmental Protection Agency 2017).

Figure 4. Focus Area 3: Gateway to the Jade. A shot looking west down Division Street in its current conditions (top). The initial proposed designs (bottom).

The EPA hired the MCC for the visioning and design process, in close partnership with APANO to aid with community outreach and engagement. In June 2017, the EPA and MCC hosted a

three-day design charrette for stakeholders to come together and contribute to the design process. The team presented preliminary designs of the three focus areas for community feedback from local residents as well as community organizations. In-language translation and childcare were provided as needed to participants. Once released, the final plans will provide community members and organizations with concrete, feasible designs to build a more compelling case for urban greening advocacy (Yap 2017).

While the EPA process is more short-term in nature, a simultaneous, longer-term Oregon Solutions process is also underway in the Jade District. Driven by a coalition of local residents and businesses, nonprofits, community-based organizations, and government agencies, group members work collaboratively to address street safety and traffic issues as well as advance environmental and greening projects. The initiative is supported by Oregon Governor Kate Brown, who wrote a letter officially designating the Jade Greening Project as an Oregon Solutions Project on September 21, 2016 ("Jade Greening" 2017).

A few of the key actors involved in the Oregon Solutions process could also be key partners in the potential implementation of the EPA's designs. For example, the City of Portland's Bureau of Environmental Services has committed to working with partner contractors and Friends of Trees to plant more street trees in the Jade District as a part of their Environmental Services Tree Project (ESTP). The Portland and Oregon Bureau of Transportation are both working on extensive transportation infrastructure developments that run through the Jade District, thereby presenting themselves as potential partners in a redesign of SE 82nd Avenue. Columbia Land Trust, which runs a Backyard Habitat Certification program in the Jade, as well as Depave, which promotes the transformation of over-paved places, are also both active in the Jade District and have committed to helping with Jade greening efforts ("Jade Greening" 2017).

2 Methods

We analyzed the three focus areas using a community benefits approach based in **cost-benefit analysis.** Cost-benefit analyses (CBA) are commonly used in public agency decision-making to determine the best option from several alternatives, by estimating and comparing the dollar values of the costs and benefits associated with each alternative. Typically, the costs and benefits of the alternatives are weighed against each other, and the option with the highest net benefit (total benefit minus total cost) is adopted. Because there are limited resources available for both private and public spending, cost-benefit analyses help illuminate the tradeoffs between different investments.

Cost-benefit analysis of prospective public investments allows a public agency to allocate funds in a way that maximizes social benefit by determining the net impact of different options and choosing the one(s) with the highest net benefits. Additionally, such analyses can assist project developers and planners in navigating the inevitable tradeoffs associated with budgeting decisions. It is especially important to engage with the cost-benefit analysis model within the context of potential greening projects because of the indirect, positive externalities that greening projects have.

Human health depends on a healthy environment and sufficient natural resources, yet modern urban life has obscured the interactions between human communities and ecosystems. The benefits that ecosystems provide to human communities are called *ecosystem services.* Noted ecologist Gretchen Daily defines ecosystem services as "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (Daily 1997). Ecosystem services are often provided indirectly to urban consumers by making possible everyday production processes. For example, if asked to list all the components of making a particular dish, a chef may list the ingredients, appliances, labor, and skills used in cooking. It is unlikely, however, that they would mention the bees pollinating the crops, the climate that allows ingredients to grow, and the bacteria that aid soil fertility. Urban living creates distance between communities and ecosystems, leading people to undervalue the essential services that ecosystems provide.

Ecosystem services can be categorized into four types: provisioning, supporting, regulating, and cultural. Provisioning services include material products that stem from ecosystem processes, such as timber and fiber. Supporting services include those that make ecosystem processes possible, such as soil formation; regulating services are those that ensure ecosystems remain stable, such as climate regulation. Cultural ecosystem services are those that benefit human communities through tradition, aesthetics, spirituality, the arts, recreation, or any other cultural practice. Although many provisioning services have observable market prices, such as timber, the other three types of services generally do not. For the most part, the benefits provided by healthy ecosystems are not traded in markets, making it difficult for people to adequately perceive their value. This undervaluation of ecosystem services causes an inefficiency in the market – the maximum social benefit that could be achieved by investing in healthy ecosystems have not been met by market processes. This shortfall is especially severe in urban locations, where the benefits provided by ecosystems are often harder to perceive than in rural areas.

The lack of markets for ecosystem services presents a problem for urban forestry: the gap between public perception of the value of urban forests and the actual benefits they provide is substantial. It is critical to apply value to both the market and non-market-realized services provided, in order to properly allocate funds and maximize social well-being. The market-realized benefits are determined by actual transactions, whereas other benefits are much harder to quantify. For example, the average street tree reduces particulate matter PM_{10} by 0.002 lbs annually, improving local air quality and thus respiratory health. However, this benefit may not be apparent to someone simply observing the tree. We will be using other studies on green infrastructure benefits and ecosystem services to determine the net benefit of the EPA visioning project in the Jade District by applying them to the design plans.

Traditional cost-benefit models analyze all quantifiable positive and negative impacts that can be measured in market prices. Our model differs from the traditional models in three ways: we include both quantifiable and non-quantifiable benefits, we include benefits from ecosystem services for which there are no markets, and we focus on unintended consequences in lieu of a discussion of costs. Because we do not have access to data on the capital and operational costs of implementation, we cannot speak to the net dollar value of the greening process.

We analyze benefits and costs using a triple-bottom-line approach, a standard that has become increasingly common in both for-profit and nonprofit organizations. The triple-bottom-line approach has three categories: "environmental stewardship, social equity and the economic bottom line (Strom 2005)." Using a triple-bottom-line approach ensures that the benefits are counted with three groups of recipients in mind. The first group of recipients are naturally occurring ecosystems and their component parts including plants, animals, fungi, and microorganisms, which are covered by the environmental stewardship pillar and can be summarized as "the planet." This group of recipients is relatively easily taken into account when identifying and classifying ecosystem services, as most people will understand the direct relationship between improving urban forests and environmental restoration.

The second category within the triple-bottom-line method, social equity, measures the impact of greening projects on the equitable distribution of environmental resources among people and communities. This issue is especially relevant in Portland, as neighborhood greening projects in low- to moderate-income neighborhoods have often contributed to market-driven gentrification pressures. As the city, county, and region have undertaken greening projects, rising land and home prices spurred by urban renewal policies have pushed less affluent people and racial minorities away from inner neighborhoods into remote spaces adjacent to industrial or postindustrial areas that lack robust urban forests, parks, or open spaces, and suffer from low environmental quality due to high concentrations of toxic emissions from industrial production or truck and rail transportation (Abbott and Enelow, 2017). The greening of the Jade District will improve the urban forest in an area that has a high concentration of racial minorities, immigrants, and people living far below Portland's median income levels.

The third category is the economic bottom line, which examines the effect of greening on the local economy. In a traditional financial analysis, the "bottom line" refers to the firm or financial institution's profit. Here, we define the economic bottom line as the impact of 'Greening the Jade' on the economic *development* of the Jade District, measured by the dollar value of total additional economic activity or output generated within the district, the number of additional annual full-time equivalent jobs created, and the dollar value of additional household income earned by residents. The Jade District is not a typical residential neighborhood; it functions as a commercial hub for a variety of racial and ethnic minority groups in Portland. Because the Jade District attracts consumers from a larger area than simply the boundaries of the district, an analysis of economic development impacts is especially relevant. Using the triple bottom line framework as the basis for a cost-benefit analysis allows us to understand the effects of greening on planet, people, and profit.

In addition to applying this model to the Jade District greening project, it is possible to apply a similar model to other EPA visioning projects. Many of the designs created by Greening America's Communities projects around the country have not reached the implementation phase. The program would potentially benefit from robust analyses that identify and quantify the net benefits of implementation, in order to raise funding and spur additional public and community support. Additionally, the net benefit of this analysis could stretch beyond the

scope of EPA projects, as many of the EPA-led designs were pilot projects for much larger renovations in other neighborhoods around the nation.

Although there are many benefits that come with using this model, it is important to acknowledge its limitations. Traditional cost-benefit analyses only encompass monetized costs and benefits, but we will attempt to surpass this limitation by exploring ecosystem services and related unobservable, non-market realized costs and benefits. Additionally, cost-benefit analyses count individuals equally. Neighborhood greening efforts concentrated in areas of high pollution and low levels of natural assets promise greater net benefits than the same efforts located in areas where environmental quality is already high. Further, environmental improvements may affect individuals differently based on their preferences; people who place a higher value on the health and wellbeing of children and future generations will benefit to a greater extent from environmental improvements than those whose preferences are more purely self-regarding. Finally, we believe that ecosystem services are largely undervalued by the average community member in the Jade due to the incomplete observability of the benefits. By using a CBA and diving into the benefits of ecosystem services, we are exposing the disconnect between the public's preferences and the benefits they would receive. Although this can be very helpful, it is crucial to still note the preferences of the public and keep the priorities mentioned by Jade community members in mind when implementing this greening project and allocating funds.

3 Problem Statement

This paper aims to serve as a case study analysis of the potential costs and benefits of urban greening in the Jade District, focusing specifically on the EPA's Greening America's Communities' design plans. By clearly and explicitly identifying and classifying the key benefits of urban greening efforts, this study can be used for future advocacy for the funding and implementation of urban greening initiatives. Our study will also explore the implications of urban greening projects on gentrification in the region and make recommendations for anti-displacement strategies.

The track record of past EPA Greening America's Communities' projects suggest a gap between design and implementation – while the EPA's technical design assistance has a strong track record across the country of producing polished, implementable designs, it has been difficult to find evidence of on-the-ground follow-up and implementation of these designs. In identifying this gap, we believe that an explicit cost-benefit analysis can help build the case for funding and implementation of urban greening designs. By explicitly outlining the benefits of investing in green infrastructure and urban greening and in presenting potential gentrification mitigation strategies, this paper works to bridge the gap between design and implementation as well as serve as a foundation for additional greening efforts in the area.

4 Results

We primarily looked at three main benefit categories along the triple bottom line approach: ecosystem services, community livability (social equity), and economic development. Under these three benefit categories, we can better understand how green infrastructure benefits the environment, community members, and the local economy. In general, it is important to note

that because this analysis is based on draft designs from the EPA technical assistance process, the following scenarios are not intended to be projected with certainty. Rather, they depict potential, plausible developments and their estimated benefits.

4.1 Data Sources and Methodology
Our analysis focuses on both quantitative impact as well as important qualitative benefits that cannot be quantified due to limitations of valuation techniques. Building upon existing work on the value of green infrastructure, quantifiable benefits were calculated through benefit transfer based on previously found data and statistics. Additionally, important qualitative benefits in community livability and economic development – improved respiratory health or decreased crime, for example – were drawn from a survey of similar case studies. Table 2 summarizes both the quantifiable and qualitative benefits to paint the full picture of the potential positive impacts of urban greening.

Table 2. Summary of Benefits of Green Features

Feature	Benefit Category	Benefits
Street trees	Ecosystem services	Air quality improvements (PM_{10} removal) and reductions in respiratory illnesses; stormwater runoff reduction; carbon sequestration.
	Community livability (social equity)	Increases social capital; decreases crime; slows down vehicle speeds and increases walkability; reduces noise pollution; educational opportunity; increases tree canopy; provides shade.
	Economic development	Leads to property value increases; increases revenues for businesses.
Green stormwater infrastructure	Ecosystem services	Stormwater runoff reduction (and associated avoided grey infrastructure costs); increased property values.
	Community livability (social equity)	Reduces noise pollution; educational opportunity; slows down vehicle speeds; increases walkability and pedestrian safety.
	Economic development	Catalyzes green stormwater infrastructure industry growth and innovation.
Parkland	Ecosystem services	Air quality improvements (PM_{10} removal) and reductions in respiratory illnesses; stormwater runoff reduction; increases average albedo.

	Community livability (social equity)	Provides urban agricultural opportunities (community gardens); increases social capital; decreases crime; leads to improvements in physical and mental health; improves environmental equity.
	Economic development	Leads to property value increases.
Permeable pavement	Ecosystem services	Stormwater runoff reduction; reduces heat island effect.
	Community livability (social equity)	Educational opportunity.
	Economic development	Not applicable.
Eco roofs	Ecosystem services	Air quality improvements (PM_{10} removal) and reductions in respiratory illnesses; stormwater runoff reduction; carbon sequestration.
	Community livability (social equity)	Provides valuable habitat; reduces noise pollution; educational opportunity.
	Economic development	Leads to property value increases; increased building insulation reduces energy costs.

We were able to quantify the value of three main ecosystem services: air quality improvements[3], stormwater runoff reduction, and carbon sequestration. Using the draft design plans from the EPA to scale, we approximated the extent of each green feature proposed in the designs (Table 3). We then applied data and valuation techniques from previous studies on the benefits of green infrastructure to each focus area in the Jade District. Using these benefit and valuation coefficients, we were able to estimate the value of the major ecosystem service benefits. We were able to quantify a few community livability and economic development benefits through a similar benefit transfer; however, these benefits tend to be more difficult to

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[3] To assess the impact of urban greening on air quality, concentration of particulate matter less than 10 micrometers in diameter (PM_{10}) was selected as a representative indicator. Because PM_{10} is small enough to enter human lungs, there are well-established correlations between PM_{10} and its impact on respiratory illnesses. Furthermore, extensive research on PM_{10} has been conducted in Portland, both in the ability for vegetation to remove PM_{10} from the air as well as levels of health benefits in terms of incidents of respiratory illness associated with these PM_{10} reductions (Entrix 2010). While the total effect on air quality from these urban greening initiatives will likely have a minor effect on overall respiratory illness and therefore was not estimated, the air quality benefits for each green feature were still calculated.

place a monetary value on and therefore ought to hold intrinsic value with the numbers as supporting evidence.

Table 3. Summary of EPA Draft Design's Green Features

Focus Area	Facility	Dimensions
1	Parkland	1.46 acres
	Park trees	12
	Street trees	10
	Green stormwater infrastructure	1162 sq ft
	Permeable pavement	6136 sq ft
2	Street trees	108
	Green stormwater infrastructure	6250 sq ft
	Eco roof	4500 sq ft
3	Street trees	18
	Green stormwater management	3305 sq ft
	Permeable pavement	7570 sq ft

The table above presents the green features proposed in each focus area as well as the quantity (or dimensions) of each feature. These numbers were drawn from the initial draft designs provided by the EPA's Greening America's Communities design team; all numbers are approximations either given by the design team or found using measurements to scale.

Some of the benefit factors we used in our calculations required a few assumptions, such as the average annual precipitation or the percentage of precipitation the feature is capable of retaining. For example, in calculating the total stormwater runoff reduction from permeable pavement, one needs information on the average annual precipitation data for the site (in inches), the square footage of the permeable pavement surface area, and the percentage of precipitation that the feature is capable of retaining (CNT 2010). Throughout our study (both in this calculation and beyond), 37 inches was used as the area's average annual precipitation

(Entrix 2010). Furthermore, studies have shown that permeable pavement can retain 80 to 100 percent of the rain that falls on a site, depending on the intensity of the precipitation (Booth et al. 1996; Bean et al. 2005; MMSD 2007; U.S. EPA and LID Center 2000). For the purposes of our study, we used the conservative estimate of 80 percent – therefore, actual benefits could be greater. After inserting all of this information into the CNT equation, we then came up with the benefit factor of 18.4562 gallons of stormwater retained per square foot of permeable pavement per year, which we then applied to our estimated area of permeable pavement to reach the projected benefit. This approach was replicated for other, similar calculations[4].

Total runoff reduction (gal)

1. = [annual precipitation (inches) * GI area (SF) * % retained] * 144 sq inches/SF * 0.00433 gal/cubic inch

2. = [37 in * (permeable pavement surface area (SF)) * (0.8)] * 144 sq in/SF * 0.00433 gal/cubic inch

3. = (18.4562 gal/SF) * (permeable pavement surface area (SF))

4.2 Focus Area Overview
The quantifiable benefits are organized by focus area, with the intention of providing a net benefit for the implementation of each project. This format allows for a situation in which there is not enough funding for all three focus areas, where the cost-benefit analysis could still be used to advocate for implementation for one or two of the focus areas.

The proposed park and surrounding safety and connectivity improvements in Focus Area 1 provide important environmental and social benefits. Besides the value of the park itself for direct use in a park-deficient area, the proposed park and green features' environmental benefits are valued at nearly $200,000 a year (see Table 4 below) due to their carbon sequestration, air quality improvement, and stormwater management abilities. Stormwater runoff reduction benefits are especially large because the park area would manage stormwater from a large area of the surrounding region, alleviating pressure on the existing stormwater facility just south of the park. Property values near the park are expected to rise, and the park's presence in the community could lead to important public physical and mental health and community cohesion benefits by providing outdoor, recreational opportunities and a place for increased social interactions (Harnik and Welle 2009).

The improvements to Focus Area 2, the Fubonn shopping market, focus largely on increasing accessibility to the shopping market and greening the parking lot through street trees and stormwater facilities, with proposed housing in the back of the lot in the long-term. The value of the environmental benefits of greening the parking lot total to around $25,000 a year, assuming the new housing developments are built with ecoroofs, but the most important

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[4] A more extensive presentation of our methodology can be found in Workbook A.

impact of Focus Area 2's improvements will likely be the economic impacts on Fubonn's business. Studies have found street trees encourages consumer spending, as increased shade causes shoppers to stay longer and spend up to 13 percent more (Ramsey, 2017). Additionally, opening up the parking lot and increasing pedestrian and cyclist access to the market will likely improve shopping experiences at Fubonn. Tree planting and the installation of ecoroofs also present important public education opportunities to raise awareness about the importance of green infrastructure (CNT 2010).

Finally, Focus Area 3 transforms a short section of SE Division Street into a green and complete street, providing important pedestrian safety improvements. The greening of the street would provide a return of more than $25,000 per year from ecosystem service benefits, but the most important benefit for this focus area would be the safety improvements considering the current, dangerous conditions. The street trees and traffic-calming vegetated basins will slow down vehicle speeds, reducing the risk of fatal accidents, and the addition of a median would make crossing the street more manageable (Friends of the Urban Forest 2017). Additionally, wider sidewalks protected by a buffered bike lane would make the commercial thoroughfare more friendly to pedestrians and cyclists and thus could encourage a transit mode shift, which could have positive impacts on the businesses along Division (Liu 2016). Designs also propose important placemaking improvements, such as a Jade District gateway sign that could help bolster community pride.

For our study, we chose to identify, classify, and estimate the numerous benefits of the proposed park in Focus Area 1. Due to time and capacity constraints, we felt it would be most effective to carefully examine all of the potential benefits of one focus area, rather than attempt to conquer all three focus areas shallowly. Because our study aims to aid implementation advocacy efforts, we felt that Focus Area 1 would be the best fit for our analysis. Focus Area 2 is located on private property and therefore follows a different implementation process outside of public jurisdiction, while current efforts focused on improving the Division transit corridor are already considering many of the improvements outlined in Focus Area 3. Therefore, the creation of a public park in Focus Area 1 falls most within the public purview and could benefit the most from an explicit benefits analysis. Furthermore, it could be argued that of all of the designed improvements, the creation of a 1.46-acre park in this park-deficient area has the biggest impact in terms of community benefits.

4.3 Focus Area 1
Focus Area 1 consists of two major interventions: first, the construction of a community park, and second, the installation of traffic calming devices on SE 89th Ave. Initial designs envision a 1.46-acre park with around 6,135 square feet of a mixed-use, porous pavement pad, and 12 park trees. Street improvements along SE 89th Avenue also include 450 square feet of green stormwater infrastructure through vegetated infiltration and traffic-calming basins and 10 street trees. These various green features work together to provide significant stormwater management, air quality, and carbon sequestration benefits. The addition of a green space can also lead to improvements in public health and community cohesion.

Table 4 (below) provides a brief summary[5] of the total annual quantifiable benefits of Focus Area 1 by type of green feature, with the key quantifiable benefit highlighted. Upper and lower bounds, if given, reflect differences in valuation for carbon sequestration benefits, determined by the lower and upper bounds on the price of carbon.

Table 4. Summary of Focus Area 1's Quantifiable Features and Benefits

Facility	Total Annual Quantifiable Benefits		Key Quantifiable Benefit
	Lower bound	*Upper bound*	
Parkland	$172,452.51		Stormwater runoff reduction
Green stormwater infrastructure	$3,282.06	$4,150.91	Stormwater runoff reduction
Permeable pavement	$13,302.85		Stormwater runoff reduction
Intrinsic value of park[6]	$63,921.24		Direct use value
TOTAL	$252,958.66	$253,827.51	

The park and its surrounding green features provide large stormwater runoff reduction benefits. This impact is relatively large because Focus Area 1's features would manage stormwater from an area larger than just the park – considering the surrounding topography and natural drainage, water from the surrounding area may flow toward the park and therefore be managed by the green features in the park. Therefore, because each feature manages stormwater for an area much larger than simply its surface area, the magnitude of their stormwater management benefit is larger than one might expect. This large benefit is important for this specific location because it can help alleviate pressures on the City of Portland Bureau of Environmental Service's existing stormwater management facility just south of the proposed park.

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[5] More detailed data about the quantifiable benefits as well as methodology can be found in Workbook A.

[6] This value stems from the mental and physical health and recreation benefits that result from regular use of the park.

The park is expected to have a positive impact on nearby property values, though the exact extent of this impact is unknown. Numerous studies on the impact of parks on property values have been conducted, largely focused on hedonic pricing models[7]. A study by the Trust for Public Land examined more than 30 different studies on the relationship and found that the magnitude and direction of the impact depends largely on the property's distance from the park and the quality of the park. Properties within a radius of 500 feet witnessed the largest value impact, and high-quality parks tend to add up to 15 percent to nearby property values, while low-quality parks can actually subtract 5 percent (Harnik and Welle 2009). Because there is not yet a reliable methodology to evaluate the quality of a park, like the Trust for Public Land, we will conservatively assume that parks have a positive impact of 5 percent on property values within 500 feet of the park. With a median value of $196,600 for owner-occupied housing units, this means that an average of $9,830 will be added to each house close to the park.

For the direct use benefits, we turned to a case study on Boston city parks from a study conducted by the Trust for Public Land in 2009 (Harnik and Welle 2009). They determined the "willingness to pay" of surrounding community members by conducting 600 phone surveys. The net direct use benefit is achieved by ascertaining the number of visits and activities they participated in and multiplying that value by the cost of those activities in the private market. In Boston, they determined the average value for a single, general use, park visit – trails, dog walking, picnicking, and so on – to be $1.91 (Harnik and Welle 2009). After determining the average use value, they were able to determine an average acreage value of $29,013.94 by multiplying the number of general use visits by $1.91. We used a similar methodology to estimate the direct use benefit for the proposed park in the Jade, with data specific to the area.

Using the direct use value of $1.91 per park visit, we attempted to estimate the annual direct use value of the proposed park. Because we were unable to survey local residents about how much they would use the park, we relied on park usage data from a survey on two nearby neighborhood parks in outer Southeast Portland to project park usage (Smith et al. 2012). We focused on user statistics for Ed Benedict Park in particular, due to its proximity to the proposed park location and similar demographics in the surrounding area (U.S. Census Bureau 2015). By assuming similar park usage patterns for the Jade, we estimated a little under 25,000 park visits per year. Using the value of $1.91 for per visit for general park use, this totals to an annual direct use value of $47,067.50.

However, it is important to recognize the limitations of this benefit transfer. Ed Benedict Park is much larger than the proposed park, with nearly 13 acres of park area. Additionally, it provides many unique services that might draw in more park users – most notably, the skate park and soccer fields. Therefore, the park usage of Ed Benedict Park may be much larger than the proposed park. However, Ed Benedict Park is also just south of the Kelly Butte Natural Area and west of nearby park (and school) Earl Boyles, meaning residents in the area have many

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[7] A hedonic pricing model is a statistical, econometric analysis that aims to measure the satisfaction or "utility" that residents on average obtain from the attributes of a good or service. In this case, the good/service in question is a home, and the attribute in question is proximity to a local park.

more choices in accessing green, natural areas for recreational purposes. In comparison, because the Jade District is flagged as a park deficient area in Southeast Portland, the proposed park might draw in more users due to limited choices. Therefore, it is difficult to tell if the usage statistics for Ed Benedict would be an overestimate or underestimate of the potential usage statistics for Focus Area 1's park.

From these quantifiable ecosystem service benefits alone, the proposed park would provide value of nearly $200,000 annually. However, the proposed park and nearby street improvements provide additional services beyond these quantifiable numbers – though more difficult to quantify, parks have direct use value as well as indirect, qualitative benefits. For example, building a park in this proposed location could increase community cohesion, improve environmental equity, and improve physical and mental health (Harnik and Welle 2009).

In addition to providing willingness to pay benefits from direct usage, there are health benefits involved as well. Studies have estimated a $250 benefit of avoided health care costs for every park user who engages in at least 30 minutes of moderate to vigorous activity within the park three or more times a week (Harnik and Welle 2009). Moreover, the benefit from physical activity for seniors is twice as high as the average park user, valued at $500 (Harnik and Welle 2009). Unfortunately, we do not have any previous studies on the physical activity of park users in the area, nor can we predict such activity for the future; however, even such factors imply greater indirect benefits that cannot be quantified. (Quantification in the future to find the net physical health benefit for the park would require numbers on park users who indulge in sufficient physical activity as well as the number of those park users who are seniors.) Furthermore, there is intrinsic value in increased physical activity of residents in the area, which an added green space would encourage.

Not only do parks create physical health benefits, they provide mental health benefits as well. Because the connections between green spaces and improved mental health are mostly qualitative, and because it is difficult to value mental health in dollar values, the mental health benefits found are to be taken upon intrinsic value. It was found that time spent in green spaces contributed to positive moods – especially for people suffering from major depressive disorder – when compared to time spent in urban, grey spaces. Additionally, green infrastructure reduces cognitive fatigue and mitigates stressors – benefits that could also potentially support workforce productivity and economic vitalization (Econsult Solutions 2016).

Furthermore, implementation of parks has positive safety and social cohesion externalities. Parks provide a safe, family friendly space for community members to interact with one another and engage with nature. In contrast, undeveloped areas provide refuge for criminal activity, and actually give off an appearance of neglect, which encourages additional criminal activity (Econsult Solutions 2016). This is known as the "broken windows" theory, which is supported by the research of Dr. Charles C. Branas, a Professor of Epidemiology at the University of Pennsylvania. He found a statistically significant relationship between the implementation of greening projects in urban areas and reduction of criminal activity (Econsult Solutions 2016). As safety was mentioned by Jade community members as a top priority (see

Section 1.2 above), there is an added importance to the community cohesion and crime reduction benefits that would arise from the creation of a park on SE 89th and Brooklyn. The increased community cohesion with the addition of a park could spur implementation of a neighborhood watch program. When people feel a connection to the neighborhood they live in, they are much more likely to assist those in need around them (Wolf and Rozance 2013).

5 Discussion

Although urban greening projects provide numerous benefits, it is important to recognize the potential unintended negative consequences they have as well. As mentioned earlier, investing in neighborhood improvements is classified as revitalization until it causes involuntary displacement of the current residents of the area. Professor Lisa Bates distinguishes between revitalization and gentrification by providing three indicators of gentrification: housing market changes, economic status changes, and demographic changes in a neighborhood that impacts its personality and culture (Bates 2013). Because this project has not been implemented, it is difficult to quantify the level of involuntary displacement that could occur.

Gentrification is a cluster of symptoms; occurring when enough of these symptoms exist in a space simultaneously. We cannot quantify the exact likelihood of future gentrification, nor the exact rate of present gentrification, due to a limited time frame and lack of data. It is possible, however, to look at current situations within the Jade District that may make the space susceptible to future gentrification. The median household income is less than 65 percent of the median household income of Portland. Additionally, more than 30 percent of the population lives below the poverty line (Table 1; U.S. Census 2015). The low income levels in the Jade create room for economic status changes with the implementation of green infrastructure. Because the Jade District functions as a commercial hub for a significant portion of the Asian American population in Portland, it has nearly three times the concentration of Asian Americans and double the concentration of non-white people than the rest of Portland. If involuntary displacement were to occur, the Jade would suffer significant demographic changes due to the high level of diversity that currently exists. Moreover, these diverse people are renting at a much higher rate (69.4%) than the rest of the City of Portland (46%). With the addition of infrastructure that makes a space desirable to live in, rent rates may rise and create large amounts of involuntary displacement. More information— language, education, and income statistics— can be found in Table 1.

Although it is clear the Jade District is at risk of gentrification, this does not mean that the urban greening projects should be abandoned. Instead, we ought to focus on ways to ensure the current residents of the area receive the benefits, rather than improving the space for wealthier residents to move in and enjoy. Providing homeownership assistance to renters currently residing in the area is one way to improve neighborhood stability as well as increase residents' economic security. Down payment assistance, increased construction and maintenance of affordable housing units, and increased parking for affordable housing units would allow Jade District residents to access jobs across a larger area (APANO C 2017).

Although there is no single cure for gentrification, best practices exist for minimizing the negative effects. Marjorie Kelly and Sarah McKinley from The Democracy Collaborative explain

how "traditional economic development is too often captured by the demands of major corporations and site development consultants (Kelly and McKinley 2015)." Instead of hiring large national or international firms for the implementation process, it is important to hire local businesses. When funds are spent at locally owned firms, the money recirculates in the local economy nearly three times more than if money is spent at larger, non-local firms (Kelly and McKinley 2015). However, this may create a situation in which a few local families control the majority of the wealth. It is crucial to support culturally specific, minority-owned businesses whenever possible in order to support the local residents in an equitable way. By creating revenue for local minority residents, the very greening projects that could have forced people out of the neighborhood are helping to give them the financial stability to stay.

6 Conclusion

This paper intends to support advocacy efforts for the implementation of the EPA's Greening America's Communities' design plans for the Jade District. This is achieved by presenting a forward-looking case study analysis of the costs and benefits of the project. We found that creating a park in the Jade District would produce annual benefits of nearly $200,000 due to its carbon sequestration, air quality improvement, and stormwater management abilities. However, because we do not have the data to determine implementation costs, we cannot provide a comprehensive net benefit value for the park. Additionally, there are potential negative externalities that can occur with urban investment, such as gentrification. We determined that the Jade District is susceptible to gentrifying pressures due to the high rates of renters, low median household incomes, and high levels of diversity. In order to mitigate gentrification, we recommended common best practices[8].

Although this cost-benefit analysis was created specifically for the Jade District, the model can be applied to other greening projects as well[9]. We believe that the quantification of ecosystem services is a valuable tool for advocating for implementation. Moreover, we recommend conducting a longitudinal study on the impact of gentrification indicators throughout the implementation process, in order to gather quantifiable data on the effect of urban greening projects on involuntary displacement.

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[8] See discussion section
[9] See workbook A

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