Front Yards as Green Infrastructure

Fragmented Yard Ecosystems Across Single-family Neighborhoods in Los Angeles

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ABSTRACT OF THE THESIS

Front yards as green infrastructure:

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by

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Efforts to incentivize green infrastructure on residential lands confront a range of challenges entangled in existing private property regimes. Land tenure fragments residential landscape management structures and limits who is able to make land cover changes on a property, exacerbating environmental problems and distributional inequity. This thesis explores how land tenure impacts front yard management practices and contributes to patterns of fragmentation and connectivity across residential landscapes in the city of Los Angeles. It assesses the relationships between land tenure and patterns of green infrastructure across neighborhood landscapes through the geospatial analysis of 120 yard surveys and a series of semi-structured resident interviews. Ultimately, it finds that owner occupancy is positively correlated with front yards that are rich in green infrastructure, and identifies patterns of structural fragmentation and spatial mimicry

across neighboring properties. It also provides further insights into the way socio-ecological influences shape landscaping decisions and build connectivity between residential yards.

The thesis of Annabelle Teresa Rosser is approved.

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1. Introduction

Widespread impermeable surfaces and a lack of diverse vegetation throughout urban landscapes prevent stormwater infiltration, exacerbate the urban heat island effect, and reduce regional biodiversity. As climate change fuels these challenges, how we manage urban land cover, and specifically the extent to which we develop green infrastructure, has the potential to compound or ameliorate harmful environmental conditions. However, fragmented land ownership inhibits collective action and expansion of green infrastructure networks required to achieve climate-adapted land cover changes. This problem is particularly acute on residential land, where individuals make independent yard management decisions on discrete, small-parcel lots, which often contribute to landscape patterns that disrupt the ecosystem services that more sustainable and cohesive urban land management could provide.

As the City of Los Angeles prepares for the impacts of climate change and pivots watershed management strategies to prioritize stormwater capture and local water resources, expanding green infrastructure has become a key policy goal. While many land typologies contribute to urban green infrastructure—from urban forests and parks to nature-based stormwater management projects—most of these spaces primarily exist on public land. As cities like Los Angeles work to increase the development of green infrastructure throughout their jurisdictions, the significant portions of land managed by private property owners have presented a challenging hurdle. Consequently, in many cities, private property has become a focal point of green infrastructure incentives, including grants, tax credits, and rebates (Gmoser-Daskalakis 2019). In Los Angeles, the city's Green New Deal calls for $80 million in Measure W revenues to fund the development of green infrastructure and the LA County Department of Public Works has established pilot projects, such as Elmer Ave, to demonstrate how small-scale vegetation changes like rain gardens on residential property have the potential to contribute to neighborhood-scale green infrastructure.

However, it is unclear whether new green infrastructure incentive programs targeting private property owners will effectively address existing neighborhood- and regional-scale landscape patterns that contribute to many of these environmental concerns. First, renters are typically unable to utilize resident incentive programs because they are not property owners, and it is unclear whether landlords will be motivated to make improvements that they do not directly experience. Considering that residents who own the property they live on have been shown to be more likely to maintain green infrastructure on that property (Troy et al 2007), it is plausible that green infrastructure will be primarily concentrated on resident-owned properties if the potential implementation gap between owners and renters is not explicitly addressed by policymakers. Additionally, green infrastructure is more effective as a network of vegetation (Walsh et al 2005). However, the household-scale governance structure inherent in residential land tenure means the impacts of individual interventions may be hamstrung by existing patterns of fragmented land management. Patchy land tenure arrangements may serve to further compromise connectivity. In order to effectively expand green infrastructure—especially in cities like Los Angeles, where residential private property owners manage a significant portion of urban space—policymakers and urban planners need to address the challenges to collective action embedded in single-family homeownership. Subsequently, efforts to incentivize residential landowners to add green infrastructure to their properties will need to understand and address how the ecological characteristics of individual yards in combination with land tenure form patterns of land cover across property lines at the neighborhood scale.

With respect to residential lands, both goals—sustainable land patterns and distributional equity—require a better understanding of the relationship between household decision-making processes and biophysical outcomes at the yard, neighborhood, and regional scale. Understanding the social processes that contribute to land cover fragmentation or connectivity will be critical to designing effective green infrastructure programs that achieve environmental sustainability and equity goals. Two intellectual traditions, land system science and urban political ecology, have revealed that land tenure—the bundle of formal and informal rights and obligations that people have to the land—is consequential to land management decisions. Land systems science has focused on the consequences of those land management decisions on land cover change. Political ecology has focused on the uneven spatial politics that contribute to inequitable outcomes of land change. Neither intellectual tradition has focused on urban systems until recently, but both hold promise in understanding dynamics related to residential yard ecology and the development of green infrastructure in these spaces. Within a joint context of land system science and political ecology, studying the problems and potential solutions associated with urban land cover change at the residential yard scale will develop new explanatory theory regarding the relationship between private property regimes and climate adaptation planning.

This thesis explores how housing and land tenure impact front yard management practices and patterns of fragmentation and connectivity across residential landscapes in the city of Los Angeles. It examines how the existing distribution of green infrastructure elements across residential front yards—permeable surface cover and the quantity and quality of vegetation—map across property lines and differences in land tenure. The primary research questions are (1) Do owner-occupied properties have more or less green infrastructure than renter-occupied properties? (2) How do individual residential yards contribute to the fragmentation or connectivity of urban ecological landscapes, particularly across property lines? (3) Does land tenure help explain patterns of fragmentation and connectivity? And (4) to what extent do socio-ecological factors influence residential yard management decisions in ways that disrupt neighborhood-scale patterns, like ecological homogenization and landscape fragmentation? To investigate these relationships between land tenure and landscape patterns, I conducted spatial analysis of 120 front yards within two Los Angeles neighborhoods, along with seven semi-structured resident interviews.

2. Background

2.1 Defining green infrastructure

Although green infrastructure, a component of the built environment, can take a variety of forms and is defined a number of ways, it is generally identified as a form of living infrastructure that "uses vegetation, soils, and other elements and practices to restore some of the natural processes required to manage water and create healthier urban environments" (EPA). Green infrastructure exists at various scales, from the building level to the broader landscape level. At the individual property scale, green infrastructure typically manages acute stormwater runoff, while at the neighborhood or city scale, a network of green infrastructure provides habitat, flood protection, cleaner air and cleaner water. Examples of green infrastructure broadly include everything from native vegetation and the urban tree canopy to rain gardens, bioswales and green streets:

- Native vegetation: restoring native vegetation, whether in the form of a wetland, preserve or native plants in a residential yard.

- Urban tree canopy: planting and maintaining a network of trees throughout an urban area and/or preserving urban forests.
- Rain garden: an ecologically designed depressed area with vegetation that can store runoff from impervious areas.
- Bioswale: a vegetated channel designed to convey urban stormwater runoff while removing debris and pollution.
- Green street: incorporating vegetation in order to slow and filter stormwater runoff from streets and sidewalks.

Since this thesis focuses on the scale of residential yards, the term “green infrastructure” primarily refers to native vegetation and the urban tree canopy.

2.2 Benefits of green infrastructure

The presence of green infrastructure—from vegetated surfaces and green open space to the tree canopy and green roofs (Koc et al 2016)—provides critical ecological and social benefits to urban communities, ranging from stormwater management and extreme heat mitigation to habitat expansion and increased biodiversity (Demuzere et al 2014, Meerow and Newell, 2017).

By increasing permeable surface area, green infrastructure projects manage and filter stormwater runoff, reducing flood damage and increasing local water quality. Especially in urban environments, the dispersal of green infrastructure serves as a core component of urban ecological networks that support biodiversity and critical ecosystem services (Ignatieva et al 2011, Tzoulas et al 2007). The presence of green infrastructure, especially the urban tree canopy, is also widely associated with improvements to local air quality as it contributes to the reduction of pollution (Nowak et al 2006). Likewise, green infrastructure has the ability to ameliorate the urban heat island effect and mitigate extreme heat (Norton et al 2015).

By improving air and water quality, mitigating climatic hazards such as flooding and extreme heat, and providing recreational green space to communities, green infrastructure also greatly improves public health (Branas et al 2011, Coutts et al 2009, Tzoulas et al 2007, Jennings et al 2016). Implementing green infrastructure projects can also build a community's social infrastructure and foster social benefits that further bolster local public health by reducing pollution, generating psychological benefits, and providing space for social engagement and recreation (Coley et al 1997, Kuo 1998).

Lastly, green infrastructure can serve an important role in climate mitigation strategies: tree canopies contribute to carbon sequestration, and cooling effects reduce the amount of energy needed for air-conditioning (Demuzere et al 2014). Furthermore, as climate change exacerbates urban ecological problems, green infrastructure can help communities build ecological and social resilience to climatic extremes like heat waves and flooding (Demuzere et al 2014, Meerow and Newell, 2017, Schiappacasse and Müller 2015).

2.3 Challenges invoked by green infrastructure development: private property, environmental inequity and green gentrification

However, a number of challenges complicate the expansion of green infrastructure in urban settings. Private property rights pose a significant barrier to developing these projects, as a considerable portion of urban land in most cities is private, rather than public (Dhakal and Chevalier 2017). Given private property protections and regulatory restrictions, there is significant uncertainty about how to maintain or improve green space quality on private property (Haaland and Konijnendijk van den Bosch 2015). Typically, initiatives to expand green infrastructure have been led by the public sector, while the private sector's contribution thus far has been minimal (Young and McPherson 2013). However, legal restrictions preventing the use of public funds on private property, along with private property protections and a lack of public funding, restrict the land where public agencies can develop green infrastructure. As a result, implementation on private land is often left to property owners (Keeley et al 2013).

Relying on property owners to implement green infrastructure inherently privileges homeowners and residents of higher socio-economic status (Heckert and Rosan 2016). Inequitable distributions in wealth and property ownership limit the development of ecological interventions, including green infrastructure, to already privileged communities (Heynen et al 2005). Consequently, efforts to develop green infrastructure on residential property will need to address these existing inequities. Integrating an emphasis on equity and environmental justice into these policy efforts is even more crucial considering the types of environmental hazards that the adoption of green infrastructure intends to address. For example, flooding, the urban heat island effect and air pollution are often disproportionately experienced by low-income communities of color across the country. In addition to these justice and equity concerns, the inequitable distribution of green infrastructure tends to reinforce environmental problems at a regional scale.

This is especially evident in California and the city of Los Angeles. For example, as Los Angeles prepares for the possibility of a 500- or 1,000-year flood—which would overwhelm the city's flood-control infrastructure and is becoming increasingly likely due to climate change—officials expect low-income people and people of color to be most vulnerable (Cooley et al 2012). Similarly, communities of color, persons living with disabilities, children and the elderly, and low-income communities in Los Angeles are the most vulnerable during heat waves (Mitchell and Chakraborty 2015) and the least likely to have access to the benefits of urban vegetation (Sampson 2017). Moreover, racial disparities in air pollution exposure—African American, Latinx and Asian Californians are 43, 39 and 21 percent more exposed to traffic pollution than white Californians—mean that the acute benefits of green infrastructure on air quality are the most needed in communities of color (Union of Concerned Scientists 2019). Yet members of those communities are also the most likely to live in neighborhoods with limited access to green space and fewer street trees (LA County Department of Parks and Recreation 2016).

Compounding these concerns around equity are growing instances of green gentrification. If green infrastructure is built on private land in disadvantaged communities, existing property tenure status can exacerbate socioecological inequalities by prompting displacement and green gentrification. In recent years, there have been a number of studies that illustrate the relationship between urban greening and adjacent property value increases (Heckert 2015, Heckert and Mennis 2012). If the residents living in a community where green infrastructure is introduced do not own property in that community, the associated property value increases of green infrastructure projects are especially likely to lead to green gentrification, which can be defined as "the urban gentrification processes that are facilitated in large part by the creation of an environmental amenity" (Gould and Lewis 2017). Vulnerable populations such as the elderly, renters and residents receiving government assistance—in many cases the populations most impacted by a lack of green infrastructure and those who would benefit the most from such projects—are at the highest risk of displacement due to green gentrification (Pearsall 2010).

3. Literature Review

Residential land cover patterns made up by individual properties contribute to local ecosystem services and ecological processes (Turner and Gardner 2015). Consequently, land management practices at the individual household scale contribute to the broader landscape ecology of urban areas like the city of Los Angeles. When property owners alter the composition or structure of their yards, they are also impacting the ecological function their property plays for the rest of their neighborhood and the greater region where they live. In these ways, residential properties have the potential to contribute to broader green infrastructure networks. The existing literature illuminates the many ways that residential yard management practices agglomerate into broader land cover patterns, including ecological homogenization and heterogeneity and landscape fragmentation, as well as many of the factors driving household-level decision making. However, a more thorough investigation of how land tenure and private property boundaries reinforce these patterns is lacking. Additionally, understanding the factors behind yard management practices that overcome fragmented land tenure—specifically through processes of spatial contagion—can help inform policy makers as we attempt to surmount some of the limitations inherent in existing land tenure regimes.

3.1 Homogenization and heterogeneity

Individual yard management practices collectively contribute to greater changes in the urban landscape and subsequent environmental functions in a few key ways. First, yards can form patterns of ecological homogenization—a similarity in yard structure, soil composition, hydrology and plant type in place of diversity across urban landscapes—or heterogeneity—where landscapes reflect a diversity of habitat and species. Across the United States, land-use changes on residential landscapes have been found to follow patterns of homogenization (Groffman et al 2014, Polsky et al 2014). As a result, two yards in distinct climatic regions are often more biophysically similar to each other than to their climatic region. Lawns are one of the most ubiquitous drivers of homogenization, as social norms and aesthetic preferences make them one of the most common residential yard cover types in the country (Ignatieva and Hedblom 2018). Residential lawns are not without some environmental and social benefits: they provide recreational space and increase the amount of permeable surface in a neighborhood. However, when they begin to dominate the landscape, replace diverse vegetation and drive ecological homogenization at a greater scale, they impede ecosystem services that would have otherwise helped manage local water resources[1], local climate and local habitat.

Alternatively, residential yards sometimes break patterns of homogeneity and contribute to increased heterogeneity, restoring ecological diversity to urban communities, and with it, various critical ecosystem services. In these cases, replacing lawn cover with more varied and dense vegetation can disrupt patterns of homogenization and help reintroduce ecosystem services to the surrounding area. Depending on their size, composition and configuration, they can provide multi-functional services, including biodiversity management (Goddard, Dougill, and Benton 2012), stormwater infiltration (Goonetilleke et al 2005) and microclimate regulation (Hall et al 2016). Ultimately, by reintroducing elements of the pre-development landscape that was replaced with concrete driveways and lawns, residential yards can address the environmental issues that have been exacerbated by urbanization.

[1] This impact is especially pronounced in arid and semi-arid regions, where the amount of water needed to maintain lawns typically cancels out the infiltration benefits provided by the permeable cover.

3.2 Fragmentation and connectivity

In addition to the role that aggregated front yard cover plays in greater patterns of ecological homogenization, residential properties also contribute to greater patterns of landscape fragmentation: "the breaking up of larger areas of natural land cover into smaller, more isolated patches, independent of a change in the total area of natural land cover" (Mitchell et al 2015). Fragmentation is widely associated with urban expansion (York et al 2011, Dadashpoor et al 2019), as roads, buildings and other urban design features often dissect and disconnect the biophysical components of urban land, such as vegetation and soil. In fragmenting green infrastructure across urban landscapes, ecosystem services like water infiltration and biodiversity management are often significantly disrupted (Mitchell et al 2015, Zambrano et al 2019). How the development of green infrastructure on residential private property can increase landscape connectivity remains an outstanding question.

The physical fragmentation of urban land associated with development is compounded by fragmented management practices, especially across public and private space. As a result, efforts to increase the connectivity of green infrastructure in the private residential realm tend to rely on the actions of individual property owners. Residential yards have been found to be incredibly important when it comes to sustaining the connectivity of urban forests (Ossola et al 2019). In addition to the urban tree canopy, the extent to which a yard has vegetative and permeable land cover can also further fragment or increase the connectivity of green infrastructure networks in urban communities (Cook, Hall and Larson 2012). However, there is more to understand about how land tenure and socio-ecological factors drive landscaping decisions that combat or reinforce fragmentation.

3.3 Factors influencing residential landscaping decision-making

Considering the impact that the individual landscaping decisions of residential property owners can have on greater landscape patterns and their associative environmental impacts, these property owners and their motivations are important to understand. First, property ownership and housing tenure are critical factors predicating who has the power to add green infrastructure to a front yard. Renters do not have the authority to make landscaping decisions on the property where they reside without permission from the owner, and are often excluded from green infrastructure incentive programs. Moreover, it is unclear how motivated Los Angeles landlords are to maintain green infrastructure on their properties, although it has been found that resident-owners are more likely to invest in landscaping activities (Perkins et al. 2004, Troy et al 2007). This relationship between front yard green infrastructure and housing tenure has been underexplored in the literature—especially in the context of Los Angeles—and has important implications for the equitable distribution of green infrastructure, as well as broader ramifications for the land cover patterns and associated environmental impacts outlined above.

In addition to housing tenure, a variety of socio-ecological factors impact residential landscaping decisions at various scales. Local ordinances and policies shape management decisions at the regional level, while social norms and formal codes regulate landscaping at the neighborhood level (Cook et al 2012). For the individual household, a variety of factors like cost, ecological contribution, maintenance, and recreation have been found to influence landscaping choices (Hayden et al 2015). At the neighborhood or regional scale, social norms can be incredibly influential, especially over decisions made about public-facing front yards (Locke et al 2018). Likewise, the landscaping of adjacent and neighboring properties can significantly influence one another; residential yard management features like easement gardens and vegetation composition have been shown to follow patterns of spatial contagion and neighbor mimicry, where yards in close proximity form clusters of similarity (Zmyslony and Gagnon 1998, Hunter and Brown 2012). Further understanding how social relationships between neighbors influence the spatial distribution of residential landscaping features will provide important insights into how socio-ecological factors might be utilized to produce neighborhood-scale networks of green infrastructure.

3.4 Intellectual motivation

This thesis is framed by two intellectual traditions, land systems science and urban political ecology. The land system science literature recognizes the power of urban residential landscapes in contributing to regional land cover patterns that drive environmental degradation or become a means of adaptation. Framing residential-scale green infrastructure in this way elevates the significance of seemingly small projects as important contributors to broader sustainable land use systems. However, the scale of analysis can miss critical relationships and patterns between individual properties and yards. In addition, while land systems scientists recognize the way land ownership regimes cause land cover patterns, they do not focus on how political processes structure those regimes, influence individual land owner decisions, and by extension underpin urban land cover change and perpetuate the land cover fragmentation that thwarts the expansion of green infrastructure urban networks. Conversely, urban political ecologists center questions about how power and processes of resource distribution and decision-making produce urban landscapes, urban greening and green infrastructure. They view the unequal patterns of land cover and urban ecology across residential private property as a product of land privatization and commodification. However, they often underemphasize the ways that institutions of private property ownership contribute to processes of biophysical environmental degradation. Bridging both literatures provides an opportunity to delve deeper into the connection between inequitable and fragmented residential yard cover and private property ownership, as well as the implications of both on the adoption of green infrastructure at this scale.

4. Methods

To assess the relationships between land tenure and patterns of green infrastructure across neighborhood landscapes, the front yard characteristics of 120 single-family residential properties in two neighborhoods in the city of Los Angeles were geospatially analyzed through yard surveys. Specifically, the analysis explores patterns of yard cover typologies between different occupancy statuses (owner-occupied and renter-occupied), as well as patterns of fragmentation, connectivity and spatial contagion across residential property lines. Additionally, a comparison of the 2020 yard-survey data and 2012 front yard imagery from Google Earth was employed to evaluate the distribution and impact of yard-scale green infrastructure changes in the last eight years (and notably during the period enveloping California's latest drought).

Finally, seven semi-structured interviews with residents living in the study neighborhoods were conducted to provide additional insights into the factors influencing individual yard management decisions and landscape changes. The qualitative data and thematic patterns from these interviews shed light on the socio-ecological factors that influence the yard characteristics observed in the yard surveys. Specifically, these interviews begin to illuminate how residents make sense of their yards as individual pieces of property and as part of the greater neighborhood landscape, and how these perceptions might shape landscaping decisions. Results from the interviews also help begin to explain how renters negotiate their relationships with their front yards, and whether they influence the landscaping despite the potential temporariness of their tenure and the fact that they do not own the property.

4.2 Case Selection - the city of Los Angeles and study neighborhoods

Due to climate change, the city of Los Angeles is currently facing the combined threats of increasingly scarce precipitation leading to more frequent drought, and more persistent and severe storms causing an uptick in flooding. Subsequently, smarter stormwater management strategies are being developed as a region with the intention of improving stormwater filtration and capture technologies in order to reduce runoff and mitigate some of the impacts of severe flooding while restoring local water resources to curb the effects of drought. By integrating nature-based solutions with its stormwater management practices, the City can also achieve a variety of co-benefits, like urban heat island mitigation, habitat and biodiversity restoration, increases in green space equity and improvements in community health.

At the same time, due to its exceptional lack of publicly managed green space and high proportion of private land ownership, the City of Los Angeles is uniquely limited as to where these types of practices can be implemented. Only 6.7% of all land within the city of Los Angeles is public parkland, and consequently the city has some of the least public green space compared to other major global cities, like New York City (27%), San Francisco (13.7%), London (33%) and Singapore (47%) (Hickman 2018). Furthermore, much of the private land in the city is managed by single-family homeowners; nearly half of all developable land in the city is zoned for single-family housing (Chiland 2020) and 38.2% of Angelenos—compared to 25% of Chicagoans and 9% of New Yorkers—live in detached single family housing (American Community Survey 2014-2018). Since such so much land is privately held by single-family homeowners, efforts to manage stormwater through widespread land cover changes must make particular progress in incentivizing improvements to residential yards. In these ways, the city of Los Angeles represents an extreme case that holds lesson for other cities struggling with similar issues.

Within the city, two case study neighborhoods were selected using a number of control characteristics. First, census blocks that represented a mix of owner-occupied and renter-occupied properties and had similar “middle-class” median incomes—between $61,424 and $187,872—were selected in order to account for confounding variables associated with place and income (Pew Research Center). Most census block groups in the city of Los Angeles that have a majority of single-family homes are dominated by owner-occupied structures. To find a mix of housing tenure, census block groups with fewer than 40% renter-occupied households were eliminated. Median income and housing tenure data was sourced from the latest 5-Year American Community Survey (2013-2017). After identifying two representative census block groups, Los Angeles County public assessor data was referenced to isolate parcel blocks with mostly single-family buildings.

Both selected neighborhoods are also located within the same watershed—Ballona Creek—which ensures that the yards in the study all have similar baseline biophysical characteristics, like soil type and hydrology. This also helps control for differing regional influences over residential yards, allowing the study to focus on neighborhood- and household-scale influences.

Additionally, neighborhoods where the structures were primarily built during the same period were identified to make sure the properties have been historically adherent to the same local planning and building ordinances, and therefore have similar building surface coverage (e.g. parcels with generally similar building footprints and setbacks). Most of the structures in each of the case study neighborhoods were built between 1945 and 1955. Finally, the two selected study neighborhoods have similarly flat topography.

Neighborhood A is located in the Del Rey neighborhood, and includes parcels along Greene Avenue between Mascagni Street and Beethoven Street. Neighborhood B is located in the Westchester neighborhood, and includes parcels along Gonzaga Avenue between 80th Street and 85th Street. In addition to being within the Ballona Creek watershed, each study site sits near Ballona Creek itself; neighborhood A to the north and neighborhood B to the south. Both communities have quieter residential streets with minimal street traffic. Homes are moderately set back, giving each parcel space for a front yard. Sidewalks line both ends of the street. In total, this thesis analyzes 120 residential yards between both neighborhoods.

Table 1. Study neighborhood characteristics

	Neighborhood A (060372753112)	**Neighborhood B** (060372765001)
Median Income	$90,536	$92,500
Median Build Year	1948	1953
Number of yards analyzed	53	67

Finally, by focusing on single-family structures, this study accounts for differences between the existing building footprints of single-family and multifamily structures, which limit the potential space available to maintain a “yard.” Due to data collection limitations, the thesis also only includes an analysis of front yards, as opposed to the entire property—an important limitation considering the evidence suggesting that maintenance practices often differ between the front and back yards of an individual property.

4.3 Methods of data collection

In order to analyze land cover patterns across the individual properties in each study neighborhood, various characteristics of the front yards were surveyed by parcel. This included field notes from in-person observations, spatial video transects taken on February 22 2020 (Curtis and Mills 2011), and digital imagery sourced from Google Earth (taken between July and August 2012). Geographic location tags on the 2020 spatial video along with parcel maps from the public assessor were used to corroborate the field imagery to individual properties, as well as to estimate the location of property lines and visually assess the boundaries between yards. Often, property lines were reinforced by design elements. Once collected, the yard images were coded according to the type of surface cover, the types of vegetation, and the landscaping style present on each parcel.

Based on the coded characteristics, the following six yard typologies were developed using a preliminary analysis of the study's yard survey results and the Central Arizona–Phoenix Long-Term Ecological Research (CAP LTER) Phoenix Area Social Survey (PASS):

1. A yard that is mostly or all grass with no trees.
2. A yard that is mostly or all grass with some plants and trees.
3. A yard that is more than half grass, with about a quarter plants and trees.
4. A yard that is about half grass and half plants and trees.
5. A yard with no grass and predominately mesic vegetation.
6. A yard with crushed stone, mulch or dirt and predominately xeric vegetation.

Additionally, three different yard styles were identified in each neighborhood according to habitat type: mesic, oasis and xeric.[2] For the purposes of this thesis, yards with no grass that had

[2] Mesic, oasis and xeric represent three habitat styles that a front yard could embody. Mesic refers to a habitat with high water use, oasis refers to habitat with a mix of high and low water use, and xeric refers to a habitat with low water use.

water efficient ground cover, like dirt, gravel or mulch, paired with native and drought tolerant plants were coded as xeric. Yards with full lawns and/or vegetation that require a moderate amount of water were coded as mesic, and yards with a mix of drought tolerant plants and some lawn were coded as oasis (Central Arizona-Phoenix Long-Term Ecological Research).

To corroborate informal property lines during the yard survey coding process, baseline parcel boundary maps from the Los Angeles County Office of the Assessor were used. Additionally, to distinguish between owner- and renter-occupied properties, property owner data from Strategic Actions for a Just Economy's (SAJE) Own It mapping tool was used.[3] While there is not parcel level housing occupancy data available in the city of Los Angeles, likely rental properties were identified by evaluating the listed address of each property owner and the number of properties listed under each owner. The following occupancy designations for each study property were made according to the records in SAJE's database:

- Designated owner occupied:
    - The property owner's address matches that property's address.
- Designated renter occupied:
    - The property owner's address does not match the property's address and SAJE's database includes another property that does match that address.
    - The property owner's address is a property management company.

Lastly, to better understand how residents perceive their front yard landscaping and what factors influence their yard management decisions, seven semi-structured interviews were conducted. Originally, 20 semi-structured interviews with 10 residents from each of the two study neighborhoods were planned, but due to unforeseen constraints caused by the COVID-19

[3] Strategic Actions for a Just Economy's Own-IT (Organizers warning notification and information for tenants) database takes publicly available but not digitized/online property owner data in order to identify predatory landlords and residents at risk of displacement throughout Los Angeles County. The tool kit was built through a partnership between SAJE and theworks.la with support from SPARCC-LA and Liberty Hill, and uses February 2019 LA County Assessor Parcels Data. (https://www.ownit.la/)

pandemic, specifically social distancing and shelter in place orders, conducting the rest of the interviews was no longer feasible nor safe. Despite this, the data demonstrates the importance of including subjective residential perceptions in green infrastructure research and policies, revealing critical themes for further study.

Participants were recruited from within the two study neighborhoods and selected at random based on who responded to in-person canvassing. Each interview focused on the subject's perception of their front yard, their perception of their neighborhood, the decision-making factors behind their land management practices, and potential changes they would like to make to their yard. Portions of the project's semi-structured interview instrument were developed based on two related and tested surveys: the "West Creek Ecosystem Restoration Project: Neighborhood Stormwater Stewardship Initiative," produced by Kent State University and Cleveland Metroparks, and the "Phoenix Area Social Survey 2016–2017," produced by Arizona State University and Central Arizona Phoenix Long-Term Ecological Research.

4.4 Methods of data analysis

A geospatial analysis of current and past front yard landscaping was conducted to investigate the relationship between land tenure, green infrastructure and neighborhood-scale land cover patterns. First, the Elmer Avenue Retrofit Project's landscaping guidelines were used to evaluate the extent to which each residential yard exhibited green infrastructure design elements.[4] Since subsurface infiltration galleries are unobservable in the spatial video, the

[4] The Elmer Avenue Retrofit Project is a demonstration project that developed out of the Council for Watershed Health's Los Angeles Basin Water Augmentation Study. Its purpose is to show how a neighborhood can capture rainwater and add it to the aquifer. The program worked with local residents to transform Elmer Avenue—a stretch of about 24 homes between Stagg Street and Keswick Street in Sun Valley—into a model "green street" through a range of stormwater management best practices. In addition to implementing vegetated bioswales and a subsurface infiltration gallery along the parkway

analysis focuses on identifying the presence of street trees and yards where native landscaping and permeable pavers are used in place of traditional lawns. Based on this, the six observed yard typologies were arranged on a one to six scale according to how many green infrastructure design elements they had. Then, to identify differences in yard cover across housing tenure, the distribution of the six different yard typologies and three different yard styles was compared across renter-occupied and owner-occupied households. To further analyze this relationship between housing tenure and yard type, the project also employed a simple linear regression model.

To identify changes in yard cover between 2012 and 2020, the yard typology and style of each parcel from each year were compared. Additionally, the original front yard spatial video was reviewed to verify identified landscaping changes. Then, the yard typology scale was referenced to evaluate whether green infrastructure elements were added to the front yard, improving its contributions to neighborhood-wide stormwater management, or removed. Once the yards that underwent significant landscaping changes were identified, the results were disaggregated according to housing tenure to assess the proportion of green infrastructure added and detracted across renter-occupied and owner-occupied properties.

The extent to which the structural design on individual front yards contributed to landscape fragmentation was also evaluated. Yards that were physically separated from the immediately adjacent properties by impermeable structures—specifically segments of concrete cover, often in the form of a driveway or narrow divider—were coded as disconnected from one

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between the sidewalk and the street for the length of Elmer Avenue, about half of the residents (13) opted into re-landscaping their front yards. Through this process, residents replaced more traditional lawn-covered front yards with permeable pavers, native landscaping, drip irrigation, rock swales and rain barrels. Now completed, the project captures approximately 5.4 million gallons of stormwater annually, improves water quality by reducing the concentration of pollutants, and increases soil sequestration potential by six times.

or both of their neighbors. Yards without impermeable barriers at the property line were identified as connected. The proportions of disconnected and connected properties within each study neighborhood were then used to summarize patterns of connectivity and fragmentation.

The yard types and housing tenure of each parcel were mapped in order to identify spatial clusters of similar yard characteristics within each neighborhood. Spatial patterns from 2012 were compared to 2020 to ascertain whether landscaping changes were isolated or occurred in groups. Housing tenure was also added as a layer to illuminate whether renter-occupied or owner-occupied properties were more likely to have yard types similar to or distinct from their neighbors. Finally, the project reviewed qualitative data from the semi-structured resident interviews for common themes and evocative insights. Responses were paired with the characteristics from the yard survey to explore potential explanatory narratives behind individual landscaping decisions.

5. Findings

The geospatial analysis of the yard surveys and the results of the resident interviews unveil a number of insights into the relationship between land tenure, land cover patterns, residential yard management decisions and green infrastructure. Throughout the study neighborhoods, the general distribution across yard typologies reveals a relative diversity in front yard characteristics within certain dominating compositional and structural patterns. First, while elements of ecological homogenization are recognizable in each neighborhood, the emergence of yards that diverge from a standard lawn and have more green infrastructure elements illustrates how residential properties are disrupting traditional landscaping trends. There is also a clear relationship between owner occupancy and yards rich in green infrastructure, suggesting that land tenure has limited the development of green infrastructure on renter-occupied properties. This correlation appears to be more pronounced historically than in the last eight years, as more recent landscaping changes were observed about equally across tenure. Additionally, the observed yard characteristics collectively form patterns at the neighborhood scale. Nearly all yards remain physically disconnected from one another, limiting some of the benefits associated with green infrastructure. However, while many properties are fragmented at the property line, similarities in yard characteristics were common between neighbors, forming clusters of spatial contagion in each neighborhood. Themes from the resident interviews—particularly the influence of social norms and social relationships over yard management decisions—provide further insight into the socio-ecological factors driving these patterns.

5.1 Geospatial analysis: yard typology distribution and patterns of spatial contagion and fragmentation

In both of the study neighborhoods, yard cover types and styles vary across individual properties. To an extent, many yards have a distinct visual character and incorporate unique features and yard structures. However, despite this landscape diversity, lawns are still incredibly common. In both neighborhoods, 67 properties—57% of the residences in the study—have yards that are entirely or almost entirely turf grass cover, resembling the “typical American lawn." Notably, the overwhelming majority of properties with full turf grass lawns also have at least one tree in the yard; only 27% are treeless.

Generally, the most common yard types are at the ends of the typology scale. The most prominent yard type between both neighborhoods—making up about 41% of all study properties—is Type 2, a yard with a lawn and at least one tree. By contrast, the second most prominent yard is Type 6, which is at the other end of the landscape design scale. Type 6 yards, which feature xeric landscaping with no grass, are found in about 18% of the properties in the study area.

Across all parcels in the study area, Type 3 and Type 4 yards—where one quarter to one half of the yard is covered by plants rather than lawn —are about as frequent collectively as Type 5 and Type 6 yards—where the entire yard surface is covered with either mesic or xeric planting and no grass is present. Only four households had a Type 5 yard, making it the least common yard type and suggesting that if a resident decides to eliminate grass entirely from their yard, they are more likely to incorporate xeric vegetation than mesic vegetation.

Additionally, both neighborhoods include yards that exhibit three different landscaping styles, mesic, oasis and xeric. Mesic yards dominate stylistically across the study area, occurring on 68% and 66% of properties in Neighborhoods A and B respectively. Xeric landscaping is the next most common style across all parcels, representing 18% of the study properties, while oasis landscaping represents 15% overall. Notably, oasis landscaping is slightly more popular in neighborhood B than neighborhood A.

Figure 1. Yard typologies 1 through 6

Figure 1a. Type 1

Figure 1b. Type 2

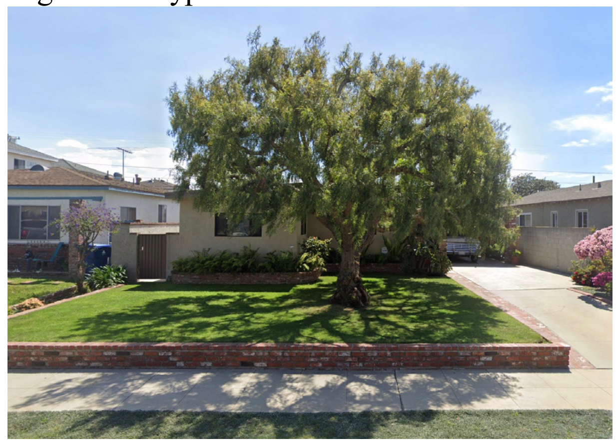


Figure 1c. Type 3

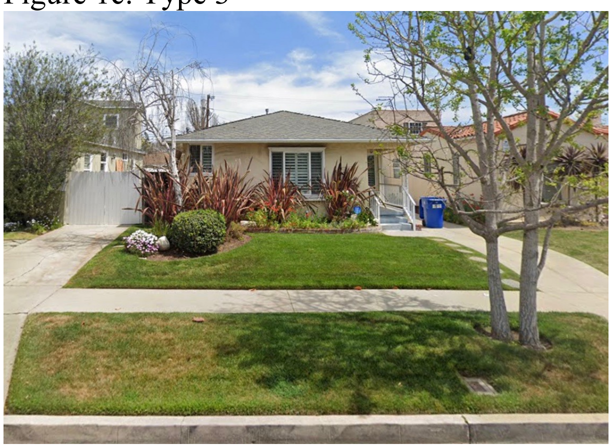


Figure 1d. Type 4

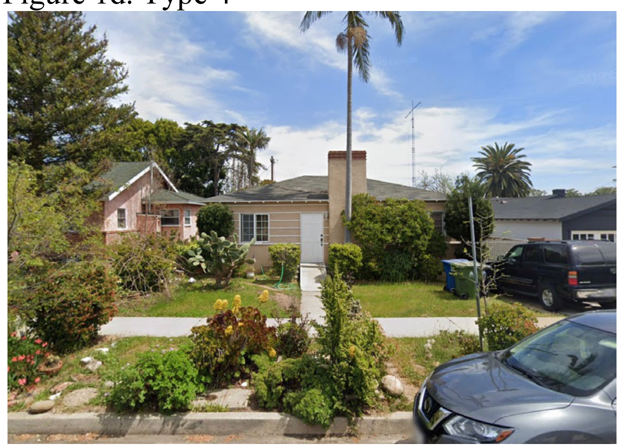


Figure 1e. Type 5

Figure 1f. Type 6

Front yards that are lacking green infrastructure were found to be disproportionately concentrated on renter-occupied properties. First, compared to the average distribution of yard typologies across the study area, renter-occupied properties have a much higher percentage of yards with traditional lawns and limited vegetation otherwise. For example, renter-occupied households in both neighborhoods have 20% more Type 1 yards than their owner-occupied counterparts. In Neighborhood A, only 9.5% of owner-occupied properties have Type 1 yards, while 45% have Type 2 yards. Comparatively, 36% of renter-occupied properties have Type 1 yards and 36% have Type 2 yards. A similar distribution is observed in Neighborhood B, where 10.6% of owner-occupied properties have Type 1 yards and 38% have Type 2 yards. In comparison, 26% of renter-occupied properties have Type 1 yards and 47% have Type 2 yards. This signifies that even within yards that are primarily lawn, owner-occupied properties are more likely to have additional trees and plants compared to renter-occupied properties.

Type 3, 4, 5 and 6 yards all occur less frequently on renter-occupied properties than on owner-occupied properties. For example, in Neighborhood A, grassless xeric yards (Type 6) occur about 7% less often across renter-occupied parcels than owner-occupied parcels. However, despite these differences between front yard types across housing tenure, Type 6 is the third most frequently observed yard type for renter-occupied homes.

Table 2. Yard typologies across housing tenure

Total Study Area

Typology	**Total**		**Owner-occupied**		**Renter-occupied**	
1	18	15.0%	9	10.1%	9	30.0%
2	49	40.8%	37	41.6%	13	43.3%
3	16	13.3%	12	13.5%	3	10.0%
4	10	8.3%	8	9.0%	1	3.3%
5	4	3.3%	4	4.5%	0	0.0%
6	22	18.3%	18	20.2%	4	13.3%
obstructed	1	1.5%	1	2.1%	0	0.0%
Total	120		89	74.2%	30	25.0%

Table 3. Yard typologies across housing tenure, by neighborhood

Neighborhood A

Typology	All		Owner-occupied		Renter-occupied	
1	8	15.1%	4	9.5%	4	36.4%
2	23	43.4%	19	45.2%	4	36.4%
3	4	7.5%	4	9.5%	0	0.0%
4	5	9.4%	4	9.5%	1	9.1%
5	1	1.9%	1	2.4%	0	0.0%
6	12	22.6%	10	23.8%	2	18.2%
obstructed	0	0%	0	0%	0	0.0%
Total	53		42		11	20.8%

Neighborhood B

Typology	All		Owner-occupied		Renter-occupied	
1	10	14.9%	5	10.6%	5	26.3%
2	26	38.8%	18	38.3%	9	47.4%
3	12	17.9%	8	17.0%	3	15.8%
4	5	7.5%	4	8.5%	0	0.0%
5	3	4.5%	3	6.4%	0	0.0%
6	10	14.9%	8	17.0%	2	10.5%
obstructed	1	1.5%	1	2.1%	0	0.0%
Total	67		47		19	28.4%

Furthermore, there is a statistically significant relationship between housing tenure and yard type. On average, owner-occupied parcels are more likely to have a yard types with more green infrastructure elements. A more focused analysis of the relationship between tenure and the extreme ends of the yard type spectrum shows that while Type 1 has a statistically significant relationship with tenure, Type 6 does not. In other words, renter-occupied properties are more likely to have Type 1 yards with few green infrastructure elements, but it is unclear based on these results whether tenure leads to the maintenance of yards like Type 6, which includes the greatest number of best practices for residential yard-scale green infrastructure.

Table 4. Regression results, housing tenure and yard type

	Dependent variable:		
	Yard Type 2020		
	(All)	(Type 1)	(Type 6)
Housing Tenure (Owner Occupied)	0.791**	-0.199***	0.413
	(0.355)	(0.074)	(0.494)
Constant	2.400***	0.300***	0.800*
	(0.307)	(0.064)	(0.428)
Observations	119	119	119
R2	0.041	0.058	0.006
Adjusted R2	0.032	0.050	-0.003
Residual Std. Error (df = 117)	1.682	0.351	2.342
F Statistic (df = 1; 117)	4.963**	7.215***	0.699
Note:	*p**p***p<0.01		

Similarly, when examining landscape style, the yards of renter-occupied homes were observed to incorporate mesic elements in their designs more often than owner-occupied homes, and featured oasis and xeric landscaping less often.

Table 5. Yard landscape style across housing tenure

Total Study Area						
Landscape Style	**Total**		**Owner-occupied**		**Renter-occupied**	
Mesic	80	67%	57	63%	23	77%
Oasis	18	15%	15	17%	3	10%
Xeric	21	18%	17	19%	4	13%
obstructed	*1*	*1.5%*	*1*	*2.1%*	*0*	*0.0%*

Table 6. Yard landscape style across housing tenure, by neighborhood

Neighborhood A

Landscape Style	All		Owner-occupied		Renter-occupied	
Mesic	36	68%	28	66.7%	8	72.7%
Oasis	6	11%	5	11.9%	1	9.1%
Xeric	11	21%	9	21.4%	2	18.2%
obstructed	*0*	*0%*	*0*	*0%*	*0*	*0.0%*

Neighborhood B

Landscape Style	All		Owner-occupied		Renter-occupied	
Mesic	44	66%	29	61.7%	15	79%
Oasis	12	18%	10	21.3%	2	10.5%
Xeric	10	15%	8	17.0%	2	10.5%
obstructed	*1*	*1.5%*	*1*	*2.1%*	*0*	*0.0%*

However, when it comes to landscape changes made in the last eight years, the relationship between resident-ownership and yards with green infrastructure is more complex. Despite policy efforts to encourage shifts away from water-intensive lawns, such as the Los Angeles County Waterworks Districts' Cash for Grass Rebate Program, most yards have not changed significantly in the last eight years or following the 2011–2019 drought, which peaked in July 2014 (The U.S. Drought Monitor [USDM]). In total, 23 of the 120 properties made recognizable changes to the front yard landscaping between 2012 and 2020. The overwhelming majority of these changes increased the amount of green infrastructure, typically by making alterations like replacing grass cover with permeable drought-tolerant land cover or adding vegetation. Often, changes made to the front yard involved entirely re-designing the space rather than adding a patch of new plants or planting a tree, but a few properties made more minor changes. Some of these changes appear to correspond to changes in ownership within the last eight years.

Table 7. Changes in front yard landscapes between 2012 and 2020 across housing tenure

Neighborhood A	**All**		**Owner**		**Renter**	
Landscape Change	12	23%	7	17%	5	45%
Increased GI	10	19%	7	17%	3	27%
Decreased GI	2	4%	0	0%	2	18%

Neighborhood B	**All**		**Owner**		**Renter**	
Landscape Change	11	16%	8	17%	3	16%
Increased GI	11	16%	8	17%	3	16%
Decreased GI	0	0%	0	0%	0	0%

Total Study Area	**All**		**Owner**		**Renter**	
Landscape Change	23	19%	15	17%	8	27%
Increased GI	21	18%	15	17%	6	20%
Decreased GI	2	2%	0	0%	2	7%

For example, in Figure 2b, the lawn-covered yard has been replaced by a mix of dirt and vegetation, while more drought-resistant species have taken over for water-intensive plants and the number of plants and plant varieties has increased. Additionally, while a tree appears to have been removed during the transition, a new one was planted in the parkway as a replacement. Likewise, as shown in Figures 3a and 3b, the 2012 lawn was predominately turf grass with a few small plants. By 2020, it has been replaced with dirt and a denser arrangement of diverse drought-resistant plants [Figure 3b]. The parkway[5] has also been changed along with the rest of the property.

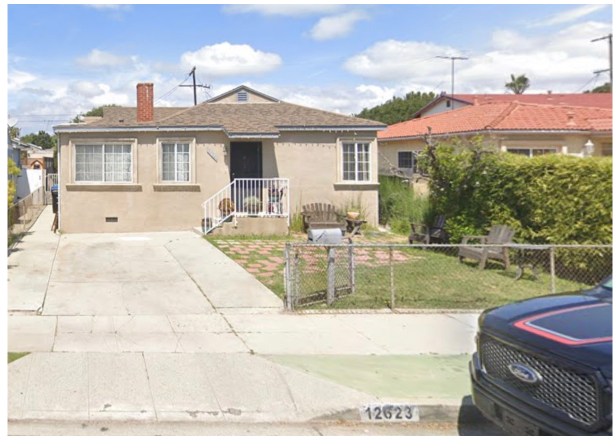
[5] The strip of land between the street and the sidewalk in front of a yard is commonly referred to as parkway.

Figure 2a and 2b. Landscape change between 2012 and 2020, adding GI (Neighborhood B)

Figure 3a and 3b. Landscape change between 2012 and 2020, adding GI (Neighborhood A)

Conversely, yard management changes on two properties reduced the amount of green infrastructure design elements on the site by removing plants and replacing drought-tolerant cover with grass. For example, Figure 4a shows the yard cover from 2012, which includes a bark chip cover, some permeable pavement and a mix of xeric plants. In contrast, Figure 4b illustrates the changes made between 2012 and 2020, including removing most of the plants and installing turf grass with a patch of permeable pavement.

Figure 4a and 4b. Landscaping change between 2012 and 2020, losing GI



When changes in front yard cover are disaggregated by housing tenure, some interesting patterns emerge. In Neighborhood A, a much higher proportion of renter-occupied than owner-occupied properties changed the front yard landscaping between 2012 and 2020—45% compared to 17%. However, two of the five renter-occupied parcels where there were significant changes in land cover during this period made alterations that decreased the extent to which the parcel contributed to green infrastructure. When comparing the number of properties that have increased the amount of green infrastructure elements since 2012, the proportion of renter- and owner-occupied parcels is much closer—20% and 17% respectively.

In addition to differences in yard management practices across tenure, the yard survey illustrates distinct trends in fragmentation and linkages across property lines. Of the 120 front yards in the study, 68% were not physically connected to any of the adjacent yards. In both neighborhoods, more than half of the parcels were completely disconnected from their neighbors' yards, with Neighborhood B exhibiting considerably more fragmentation than Neighborhood A. As is illustrated in Figures 5a and 5b, many residential yards follow a similar pattern of being enclosed by concrete paths, which are often front driveways or occasionally concrete paths or dividers. On average, across both study neighborhoods, about a quarter of the residences are linked to one of their neighbors. As is shown in Figures 6a and 6b, some residential yards spill across the property line, connecting the two landscapes. Often, even where yards are linked on an edge, natural or artificial barriers such as large hedges, plants and fences are used to reinforce property and distinguish two yards. In these cases, the front driveways are often located on alternating sides, so that the pavement links on one side of the property and green space connects on the other. Even fewer yards are connected to a neighboring yard on both sides of the parcel. In Neighborhood B, no yards were bilaterally linked, whereas in Neighborhood A, four of 53 yards were connected on either side. Notably, these front yards typically did not have fronts driveways.

Table 8. Fragmentation and connectivity between individual yards

	Connected to zero neighbors		**Connected with one neighbor**		**Connected with both neighbors**	
Neighborhood A	29	55%	20	38%	4	8%
Neighborhood B	52	78%	14	21%	0	0%
All	81	68%	34	28%	4	3%

Figure 5a and 5b. Fragmented landscapes

Figure 6a and 6b. Linked landscapes

While there is some diversity across the yard types and styles in each neighborhood, there are also clusters of similarity throughout the streetscapes. In Neighborhood A, there is an entire block with exclusively mesic landscapes, and elsewhere there are five additional sections with clusters of four or more mesic yards. While patches of mesic yards dominate across both neighborhoods, xeric and oasis yards can be seen interrupting these patterns, and in a handful of places, form clusters of their own.

When it comes to similar typologies, the spatial distribution of yard types illustrates more heterogeneity: about half of all yards in the study area share a similar yard type with at least one of their neighbors, while the other half have yard structures that are unique compared to adjacent properties. However, there are a handful of distinct clusters of certain yard types, which often correlate with parts of the street that saw recent and significant landscape changes. In Figure 3a, there is a group of four properties with xeric vegetation-covered yards (Type 6), all but one of which resulted from replacing the lawns that were there in 2012. Likewise, there is a similar patch in Neighborhood B where three households adjacent to a yard that was xeriscape in 2012 subsequently changed their yards from Type 2 to Type 6, forming a new cluster around the original Type 6 yard.

Table 9. Similarity in typology across adjacent yards

	Both neighbors are similar		**One neighbor is similar**		**Zero neighbors are similar**	
Neighborhood A	3	6%	20	38%	30	57%
Neighborhood B	6	9%	32	48%	28	42%
All	9	8%	52	43%	58	48%

Figure 7. Neighborhood map of housing tenure distribution

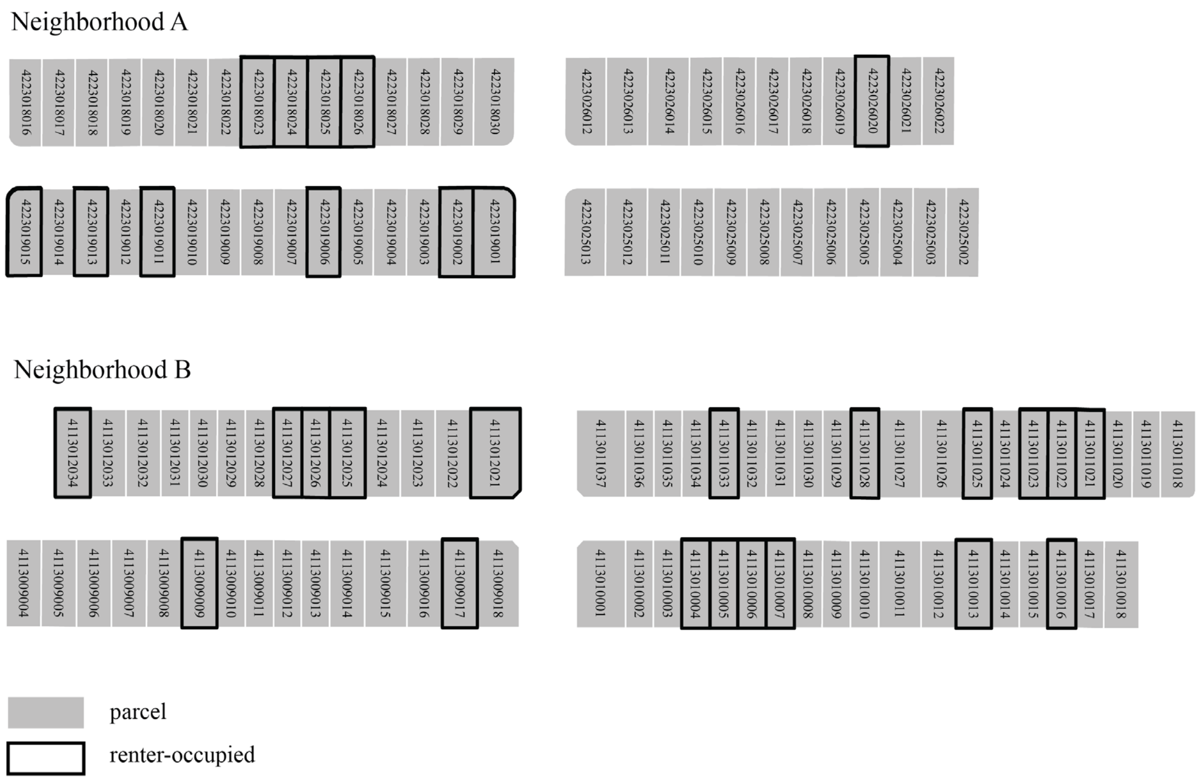


Figure 8. The spatial distribution of yard landscaping styles

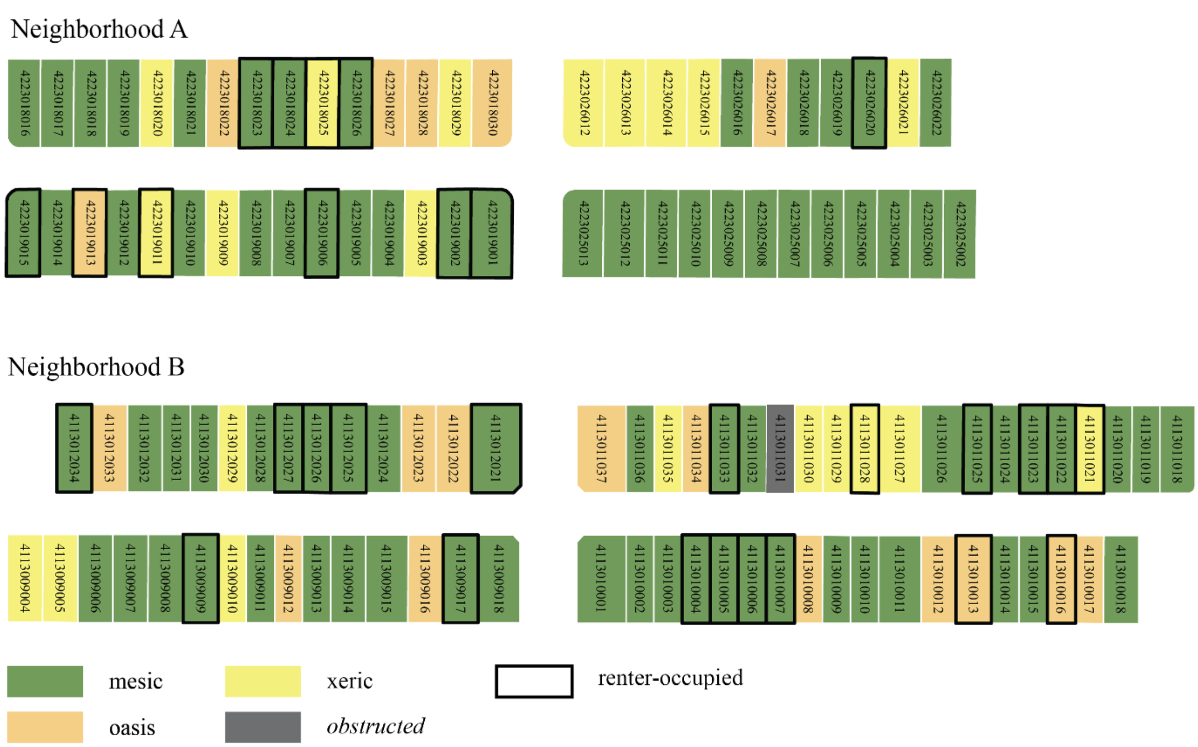
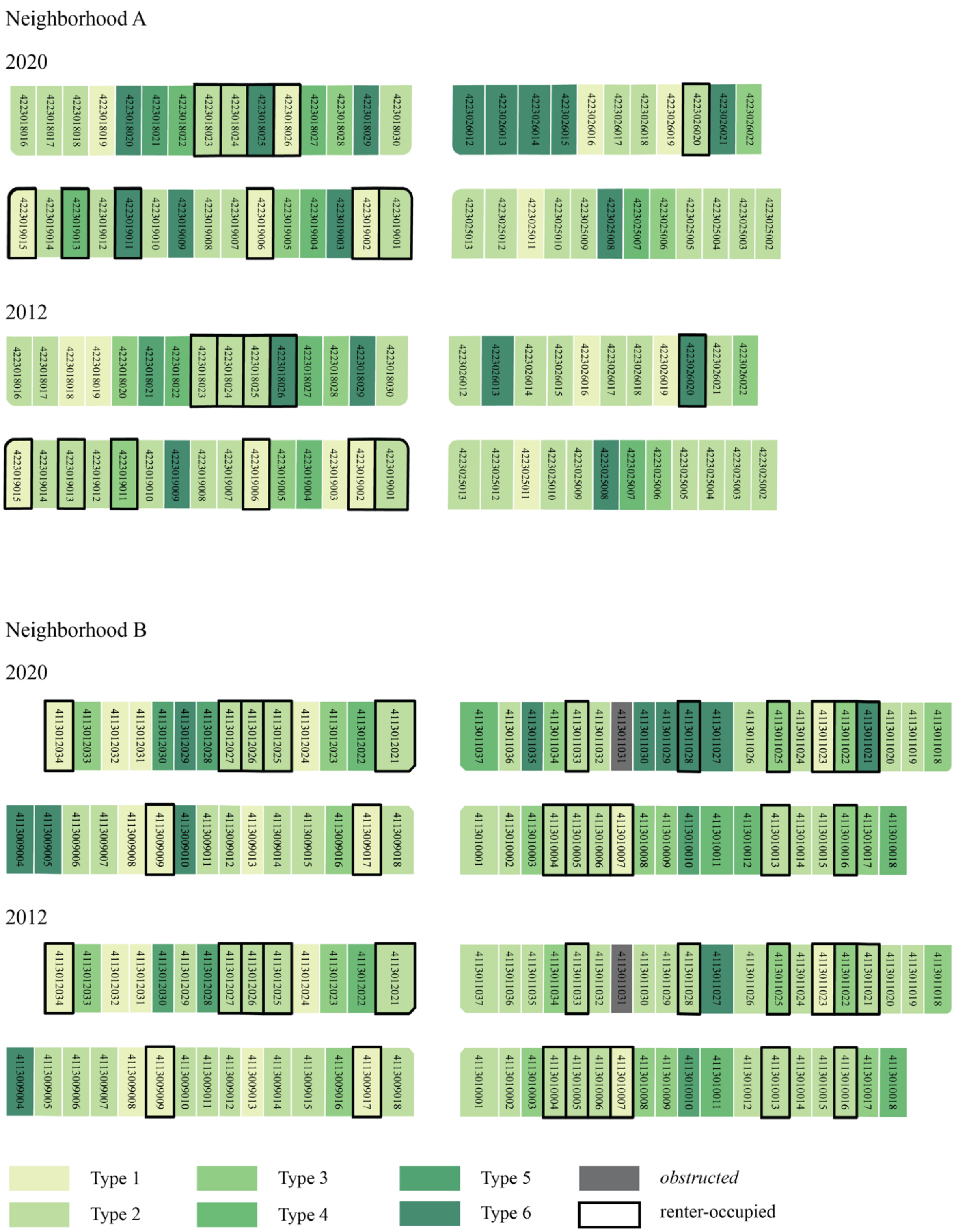


Figure 9. The spatial distribution of yard typologies



5.2 Socio-ecological drivers of green infrastructure and land cover connectivity

The residential interviews unveil a number of influences driving household landscaping decision-making. More critically, they highlight the way social norms and relationships within a community inform collective action and help shape patterns across the neighborhood landscape to improve environmental outcomes. They also provide insight into additional factors that influence the development of green infrastructure on individual properties and across communities.

Major Themes	**Minor Themes**
• Water consciousness • Social influence over landscaping decisions • Yard maintenance	• Privacy and recreational use • Ownership change

Water consciousness was a common theme across every interview. Respondents expressed concern about the amount of water their yards required, regardless of how "drought tolerant" their front yard's landscaping was. For some, water scarcity led to tangible changes in their front yards. When Respondent 1 replaced a large portion of the grass on their property with native drought-tolerant species, one of the main motivations was to reduce the amount of water needed.

> *"I used to do all the landscaping myself and that was all lawn out there…now it's got planted landscaping I put in there, some succulents and tall grasses and things like that, which helps with maintenance, but I was also hoping it would use less water than grass would" (Respondent 1, Type 4 yard, owner).*

Another interviewee participated in the Los Angeles County Waterworks Districts' Cash for Grass Rebate Program, a water conservation program that offers customers a rebate for replacing grass with drought-tolerant landscaping. Upon purchasing their home in 2014, Respondent 2's household removed the preexisting lawn and used the money they got from the City in return as "a front yard budget," enabling a xeriscaping style yard that is still present today. In addition to promoting water efficient planting, this program enabled Respondent 2 to achieve their "ideal" front yard.

Others demonstrated awareness around the water impacts of their yards but had yet to make changes that would lessen those impacts. Respondent 5, an owner with a Type 3 yard, discussed considering getting rid of a small patch of lawn in their front yard due to its watering requirements, but opted not to since it's about a quarter of the area. Alternatively, they use recycled shower water to irrigate the section as a temporary way to reduce overall water usage. Similarly, Respondent 4 shared that if they owned the property where they live and had the resources to do so, their ideal front yard landscaping would involve making a grass to drought-tolerant shift:

> *"If I could, I'd probably want it re-landscaped so it requires less water usage on it….but I would need ownership of the house and would need the money to do it" (Respondent 4, Type 2 yard, renter).*

While many interview participants were demonstrably aware of the impact drought has had on their front yards, few respondents explicitly connected aspects of their yards to stormwater management characteristics. No respondents discussed the ability of their yards to contribute to stormwater infiltration and groundwater recharge or runoff reduction. Few had direct experience with stormwater flooding, explaining that any runoff collected at the intersections away from their properties. However, one resident expressed a chronic frustration with runoff collecting at the edge of his driveway, primarily due to lawn watering:

> *"So one opinion that I hold particularly vehemently is that puddle there and there, there's an engineering problem in the street….these local low points, so any time there's local water in the street, which includes runoff from people sprinkling their lawns, it ends up in front of our house, their house, or there's one house down that gets a little bit….and*

it just stays there year round, and that's annoying and kind of disgusting, so if I were to pick something that bothers me, why do we have lawns that get watered.....it's primarily from lawn watering and secondarily from car washing, and some of it's definitely from recent rains as well" (Respondent 2, Type 6 yard, owner).

In these cases, consciousness about the greater environmental impact of their landscaping decisions can be seen as a driver behind yard changes that added green infrastructure, as well as preferences for green infrastructure additions yet to be made.

Social influence over landscaping decisions was another major theme. All respondents discussed their yard landscaping decisions or yet-to-be realized ideal front yards being influenced by their neighbors or social ties. For example, when Respondent 2 decided to re-landscape their yard from scratch, they explored the surrounding neighborhood for ideas and inspiration, determined what types of features they liked, took photos and incorporated elements into their own yard. In Respondent 2's case, neighboring landscaping directly influenced the development of a Type 6 yard. Additionally, Respondent 6's inspiration to add more native plants to their yard came from conversations with friends and visiting the garden beds at LACMA. Similarly, Respondent 5 referenced neighboring yards that they admire as a source of future inspiration for their own property. Beyond contributing to decisions about how to landscape their front yards, these social relationships were also commonly mentioned as a source of advice about maintaining certain plants and features once they had been planted.

Yard maintenance was another major landscaping consideration for respondents. While all of the homeowners mentioned paying a gardener or landscaping company to help with yard work, many still partake in watering, weeding and trimming activities. High-maintenance yards were generally associated with requiring a lot of watering or irrigation, and some respondents connected planting native, more drought-tolerant species with reducing required yard maintenance. Maintenance and aesthetics were at odds for Respondent 1, the owner of a Type 4 yard with a fair amount of vegetation, who discussed finding a middle ground between the two.

> *"I want it to look good, that's probably secondary, it's like a balance between what looks good and what's easy to maintain, I would say it's usually a little more difficult to maintain if it looks nicer, easy maintenance is kind of important" (Respondent 1, Type 4 yard, owner).*

Resident privacy and recreational uses, and perceptions about ownership change were minor themes. The level of exposure experienced in the front yard was another important factor guiding many of the landscaping decisions of some of the residents interviewed. When asked about changes they have made or would like to make to their front yards, respondents often included planting trees or plants in order to increase the privacy of their homes or to create a more enclosed front yard space. In the absence of these types of protective features, many residents reported spending little time in their front yards. Respondent 7 included this as a reason for replacing their front yard with more dense planting. Although a front yard covered in plants leaves little room for the residents to use recreationally, losing that recreational space had little impact since they preferred the more private backyard space anyway.

> *"….to some extent in the modern lifestyle front yards are wasted, I grew up playing in the front yard and not a lot of kids around here play in the front yard especially if you have a nice backyard that's enclosed, so ….if anything I wouldn't mind a tree for more shade and privacy" (Respondent 7, Type 6 owner).*

Respondents 1 and 6 also mentioned making major landscaping changes shortly after moving onto the property, and then making more minor changes as they maintained their yards over time, suggesting that some major landscape alterations might be triggered by changes in property ownership. When discussing the yard styles of the entire neighborhood, Respondent 3 mentioned the impact that rising housing prices and market sales have had on front yards. Specifically, they explained that the "Silicon Beach" effect caused by Playa Vista, a neighborhood near the study area, was driving up local housing costs and encouraging developers to buy homes as investment properties while razing post World War II houses and building larger modern homes, often with front yard xeriscaping.

6. Discussion

The patterns in the existing residential landscapes of these two neighborhoods, along with the observed changes in the last eight years, show the capacity of individual yards to contribute to greater patchworks of green infrastructure. They also expose some of the challenges entangled in land tenure and individual action.

First, the differences in yard typologies and styles across housing tenure reveal one way that private property ownership can restrict who is actually able to make these iterative land cover changes. Disparities in yards with green infrastructure elements—specifically the positive correlations between owner-occupied properties and yard types with more green infrastructure—reflect similar findings to studies that have found tenure-based disparities in tree canopy and green space proximity (Heynen and Perkins 2005). This also suggests that the benefits associated with these landscape characteristics might be lacking in neighborhoods with high percentages of renter-occupied homes, likely contributing to existing environmental inequities. Furthermore, given the socio-economic and racial inequities embedded in existing private property ownership, a failure by urban policy makers to address this tenure-based disparity as they incentivize green infrastructure development will likely perpetuate these injustices.

The extent to which this pattern is mirrored in the distribution of properties that have made significant green infrastructure-contributing changes to their front yards is more nuanced. Based on the results, it is unclear whether renter-occupied properties are less likely to have landscaping changes that contribute to neighborhood green infrastructure than owner-occupied properties. While in one of the study neighborhoods a greater proportion of owner-occupied households had made observable improvements to their front yards between 2012 and 2020, in the second study neighborhood, the percentages of each were comparable. Further research on the relationship between rental properties, social contagion in neighborhoods with a mix of owner-occupied and renter-occupied households, property value and income is required to better understand this difference.

The yard survey findings also illustrate how private property lines—often reinforced by impermeable barriers—can disrupt linkages between two yards with green infrastructure. This fragmentation in turn disrupts stormwater management services and co-benefits produced by individual yard cover developments (Mitchell et al 2015, Zambrano et al 2019). While the trends in yard cover practices caused by changing preferences and social influence have already begun to transform urban residential landscapes like the case neighborhoods in this study, these changes are still notably constrained by impermeable barriers like front driveways, concrete pathways and dividers. Disparities in green infrastructure across tenure further fragment landscapes insofar as the yards of renter-occupied households with minimal vegetation disrupt clusters of connectivity.

Additionally, the spatial distribution of yard types within each neighborhood illustrates how spatial contagion can encourage green infrastructure. In order for individual yard landscaping decisions to function and transform widespread urban land cover, making the associated climate adaptive changes, they have to be made collectively and compose a broader network. Social relationships within a neighborhood can influence these decisions, creating a more cohesive landscaping as a result. This appears to be present in both existing yard cover patterns—i.e., the prevalence of lawn cover throughout both neighborhoods, especially back in

2012—as well as emerging clusters of xeric front yards. These results are consistent with existing research on the spatial autocorrelation of residential landscaping, often referred to as "spatial contagion" or "neighbor mimicry," which finds that front yards in the immediate vicinity of a household can strongly influence the landscaping decisions of that household (Zmyslony and Gagnon 1998, Hunter and Brown 2012). For example, in a few places within each study neighborhood, social relationships between neighbors within a community seemed to facilitate clusters of similar yard types and styles, suggesting that social influence between neighbors—either passively or directly—encourages yard management changes and practices that add green infrastructure elements to individual properties in groups. In this way, social relationships are playing a role in breaking the traditional lawn landscapes and establishing a new normative aesthetic that is—with respect to stormwater management—more ecologically advantageous and climate adaptive.

Moreover, the type of front yard changes made in both neighborhoods, alongside responses from interviews with residents, suggest a shift in normative landscaping trends that is encouraging the addition and maintenance of green infrastructure. Although the majority of front yards between each study neighborhood have traditional grass lawns, nearly all of the properties that made observable changes between 2012 and 2020 have transitioned towards more xeric landscaping. This suggests a pronounced shift in aesthetic preferences, at least within middle-class single-family properties in West Los Angeles, from traditional mesic style front lawns to more drought conscious low-maintenance landscaping. In contrast to existing literature about traditional American front yard preferences (Robbins 2012, Ignatieva and Hedblom 2018), the proportion of yard changes that replaced grass with xeric landscaping and preferences expressed by the residents in the study area suggest that attitudes towards native plants and drought-tolerant yard design are becoming more favorable to some Angelenos.

One driver of this shift in preferences and the subsequent front yard changes is environmental impact. However, other motivating factors for households that prefer this type of landscaping are somewhat ambiguous. Based on the residential interviews, aesthetic preferences tend to take precedent when yard maintenance decisions are made. Others were demonstrably inclined towards low-maintenance and water conserving design features, or otherwise influenced by cost and recreational needs. These findings echo similar research that factors like cost, water use, ecological contribution, maintenance, and recreation significantly influenced the landscaping choices of residents (Hayden et al 2015), but also invite further study. Finally, the findings hint at a relationship between new ownership, rising property values and landscaping change. However, a deeper investigation is needed to unveil connections between property turnover and yard cover, particularly with respect to green gentrification.

The scope of this thesis generates some important limitations. By focusing on middle-income single-family homeowners, this study does not delve into the role of socio-economic status in yard management decisions or consider how housing tenure impacts the landscaping of multi-family residential properties. Consequently, further research into how the intersection of socioeconomic status and housing tenure shapes front yards is needed. Additionally, by focusing on front yard decisions, this thesis excludes the more private land cover patterns made up by back yards. This thesis also exclusively engages with residents, and so further study is necessary to understand the role and motivations of landlords in the development of green infrastructure.

7. Conclusion

This thesis uncovers some of the opportunities and challenges entangled in spatial distributions of green infrastructure across residential private property. First, disparities in green infrastructure between owner- and renter-occupied properties foreshadow potential environmental inequities in private property-based climate adaptation interventions. Moreover, this variation across tenure along with existing yard structures reinforces disconnections in front yard cover, limiting the environmental outcomes of green infrastructure. However, spatial clusters of neighbor mimicry along with insights from residential interviews suggest that social norms and neighboring yard cover can foster collective landscaping change in a way that builds greater connectivity across urban landscapes. Consequently, to build more connected landscapes, green infrastructure policy must be designed to address existing patterns of fragmentation across property lines and land tenure. They should also encourage the socio-ecological drivers behind collective yard cover changes that add green infrastructure. Projects like the Elmer Avenue Retrofit or Street Edge Alternatives in Seattle—where streetscapes have been collectively redesigned with public incentives and community agreements to improve stormwater management—also provide useful examples for how neighborhood-scale programming and collective parkway management practices might be introduced to achieve these goals.

Individual action is insufficient to tackle the scale of ecological crises like climate change. Environmental issues like water security, stormwater runoff and flood protection require changes at the scale of city-wide landscapes, and while residential yards are a critical site for these broader transformations, their contributions fundamentally function in connection with other yards. However, relationship-building within neighborhoods and community-scale interventions present opportunities for collective action that can transform urban landscapes and achieve some environmental outcomes within existing private property regimes. As Los Angeles and other cities continue to invest in the development of green infrastructure on residential lands, environmental and justice challenges embedded in private property will likely persist. Thoughtful community-based planning paired with incremental collective land management practices can enact landscape changes at a structural level, confronting many of these challenges.

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