sustainability

MDPI

Article

Neighborhood Decline and Green Coverage Change in Los Angeles Suburbs: A Social-Ecological Perspective

Farnaz Kamyab [1,*] and Luis Enrique Ramos-Santiago [2]

[1] School of Architecture, Clemson University, Fernow Street, Lee Hall, Clemson, SC 29634, USA
[2] Department of Urban Planning and Community Development, School for the Environment, University of Massachusetts (Boston), 100 Morrissey Blvd., Boston, MA 02125, USA; enrique.ramos@umb.edu
* Correspondence: farnaz_kamyab@yahoo.com; Tel.: +1-(803)-569-5826

Abstract

Suburban green areas provide significant health, economic, social, and ecological benefits. They are a key element in advancing sustainability at local and regional scales. However, they become threatened in the presence of other competing land uses, neighborhood-change processes, and/or weak built-environment governance. Consequently, suburban green area loss and/or degradation is problematic. In this study, we tested whether socioeconomic decline is significantly correlated with loss or degradation of suburban green areas at a neighborhood scale. This phenomenon has been previously studied with a limited sample and methodology and needs further empirical documentation and more nuanced modeling and testing. We employed Social-Ecological System theory in scoping and framing this multidisciplinary study and informing multilevel panel-data regressions. This approach allowed us to identify key factors and lagged effects behind green area degradation in outer-ring suburbs of Los Angeles. In addition to internal socioeconomic factors, random components associated with ecological zonal distribution and county-level clustering registered significant variability in their influence on greater likelihood of green coverage loss and degradation in declining outer-ring suburbs. Findings from this study can inform intelligent spatial planning, management, and monitoring of suburban areas, and showcase the value of a social-ecological system lens in suburban green infrastructure research, as well as contribute to SES theoretical development and research methodology at the neighborhood scale.

Keywords: social ecological system; suburbs; green coverage; neighborhood decline; green infrastructure management

check for updates

Academic Editors: Qingsong He, Jiayu Wu, Chen Zeng and Linzi Zheng

Received: 18 August 2025
Revised: 13 September 2025
Accepted: 24 September 2025
Published: 4 November 2025

Citation: Kamyab, F.; Ramos-Santiago, L.E. Neighborhood Decline and Green Coverage Change in Los Angeles Suburbs: A Social-Ecological Perspective. *Sustainability* **2025**, *17*, 9850. https://doi.org/10.3390/su17219850

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Ongoing rapid climate change warrants a better understanding of how human settlements influence and are influenced by the biosphere at multiple geographic and temporal scales. Diminishment and/or degradation of green coverage in suburban areas is an understudied phenomenon with potentially significant implications for metropolitan and neighborhood vitality and ecosystem services. This study explores how neighborhood socioeconomic change might be correlated with green area loss and/or degradation in suburban areas, and potential relationships with broader regional zonal ecologies and local county effects. Previous studies link changes in green space to neighborhood change, but their findings are often constrained by small samples [1], narrow focus on single

factors [2–5], or analyses at broad regional scales that overlook neighborhood-level dynamics [6–9]. Many also lack a unifying theoretical framework and fail to consider the interconnected effects of socioeconomic, demographic, and ecological variables. Our study addresses these gaps by developing an indicator of neighborhood change that integrates multiple socioeconomic factors drawn from theories of urban economics and planning. Using data from 331 outer-ring suburban neighborhoods in Los Angeles and applying multilevel longitudinal models, we test hypotheses and provide new insights into this complex phenomenon and explore how it may unfold on a less-frequently studied geographical scale and context for SES studies: suburban neighborhoods.

The leading research questions are:

(1) Is there an association between neighborhood decline and the loss of green coverage and/or degradation in outer-ring suburbs of the Los Angeles Metropolitan Area?
(2) Which factors associated with neighborhood change are statistically correlated with changes in green coverage, and what are the potential policy implications?

Our main hypothesis posits that the phenomenon of neighborhood changes in suburbs—particularly neighborhood decline—is significantly correlated with green coverage loss and/or degradation. This relationship has been previously suggested but with a much smaller sample and less robust methods [1]. In contraposition, we expect no significant or less green coverage loss when suburban neighborhoods have been improving or experienced relative stability across the study period.

This study draws on various concepts from Social-Ecological Systems (SES) theory, including the interconnectedness of human and natural systems, social-ecological keystones, lagged effects, and adaptive management [10]. We also leverage SES central concepts of Adaptive Cycle and Panarchy in framing this investigation [11]. These inform this study's overarching theoretical framework, research design, and model specifications, and help in exploring and interpreting system dynamics and potential interactions across spatial and temporal scales. Given the multidisciplinary nature of the phenomenon of interest, we draw from urban planning, urban economics, and landscape ecology disciplines.

2. Literature Review

2.1. Suburbs and Green Area Loss and/or Degradation

Uncontrolled suburban expansion often leads to negative sprawl effects, disrupting natural ecosystems through the fragmentation of green area networks among other environmental, economic, and social externalities [12,13]. Nevertheless, the private and public semi-natural green areas that remain in suburbs provide vital ecosystem services, which are essential for local and broader populations. These services include supporting vulnerable wildlife species, facilitating ecological dispersal, and offering recreational opportunities [14], as well as providing resources and regulating essential environmental elements such as climate, water, soil, and air [15,16]. Hence, understanding the processes leading to green coverage loss and/or degradation in suburbs and its long-term implications is crucial for effective metropolitan and suburban resilient planning, management, and sustainability efforts [17].

Demographic and socioeconomic shifts can also lead to the fragmentation, degradation, and encroachment of suburban green spaces, compromising local ecological integrity and diminishing the myriad benefits these spaces provide to communities [18]. Recent scholarly interest has focused on the loss and recovery of suburban green spaces, with an emphasis on intelligent planning and preservation/recuperation strategies [1,17,19,20]. However, these approaches are constrained by limitations related to the spatial and temporal scale of analysis, as well as by the restricted range of factors considered in their investigation.

Despite the growing concern regarding suburban green area loss and the assessment and dimensioning of associated socioeconomic and environmental impacts, scholarly research on the causes and processes associated with this phenomenon remains limited (see Appendix A.1). This research addresses the existing empirical gap by analyzing outer-ring suburbs of Los Angeles through a social-ecological systems lens using longitudinal data. By modeling relationships across multiple scales and timeframes—linking neighborhood-level socioeconomic trends, county-level governance, and variations in regional ecological zones—the study helps identify and better understand which factors are more likely to impact suburban green coverage and quality. We also consider the broader policy implications of these findings for planning (see Appendix A.1).

2.2. Social-Ecological System Theory

Social-Ecological System (SES) theory has its roots in General System Theory (GST). GST emerged as a framework instrumental to elucidating the intricacies of interconnected dynamic entities [21]. Transformations within the urban milieu are complex and multi-faceted, arising from a confluence of interconnected factors originating both within and beyond the geographical boundary of the system under study [22]. Hence, they would also be amenable to GST analysis.

The Social-Ecological Systems (SES) theory concept of Adaptive Cycle provides a framework for understanding ecosystem dynamics over time. It illustrates how a subsystem emerges, stabilizes, undergoes rapid shifts, and eventually reorganizes to initiate a new phase in the cycle [23]. This concept focuses its attention on destruction and reorganization processes, and we find it compatible with life-cycle neighborhood change models derived from urban economics' neighborhood change literature [24–27].

In urban planning contexts this implies that multiple outcomes for a neighborhood are possible, including urban blight, stability, or resurgence (e.g., re-development). The experience of urban renewal in various cities in the USA during mid-twentieth century [28] is an example of neighborhoods entering a new phase after years of decline, with planned public and private interventions and reinvestments. On the other hand, the stability and protection achieved in some older neighborhoods and suburbs in New York City during the mid-twentieth century [29], thanks to community action and advocacy reacting to the threat of urban renewal, is another potential outcome for neighborhoods experiencing duress. This exemplifies how advocacy and activism by residents and owners can also influence the trajectory of declining neighborhoods. As such, experiencing neighborhood decline will not necessarily result in total urban blight and is contingent on a myriad of internal and external factors related to public policy, economics, and/or local social capital, among others.

The focus of SES theory differs from that of ecological studies, which emphasize growth and conservation processes. In SES, "creative destruction" and "reorganization" interact across an evolving Adaptive Cycle [11] and extend the ecological linear perspective. This is sequentially represented in four phases (Figure 1).

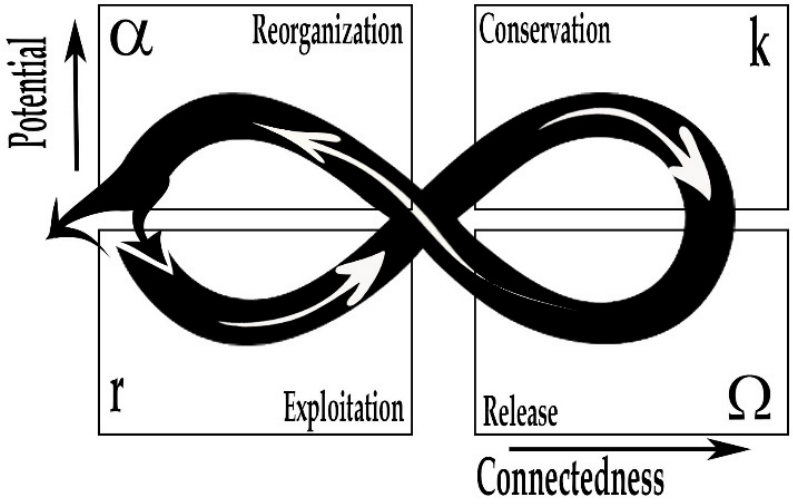


Figure 1. Adaptive Cycle (based on [11]). Growth or exploitation (r) = a slow-changing phase; conservation (k) = a fast-changing phase; collapse or release (Ω) = a fast-changing phase; reorganization (α) = a slow-changing phase [11].

Another central concept in SES is Panarchy, which extends the idea of the Adaptive Cycle to a cross-scale and temporal framework. It characterizes systems as interconnected sets of Adaptive Cycles that operate across hierarchical levels and at different rates of change, emphasizing their dynamic and interdependent nature [11] (Figure 2).

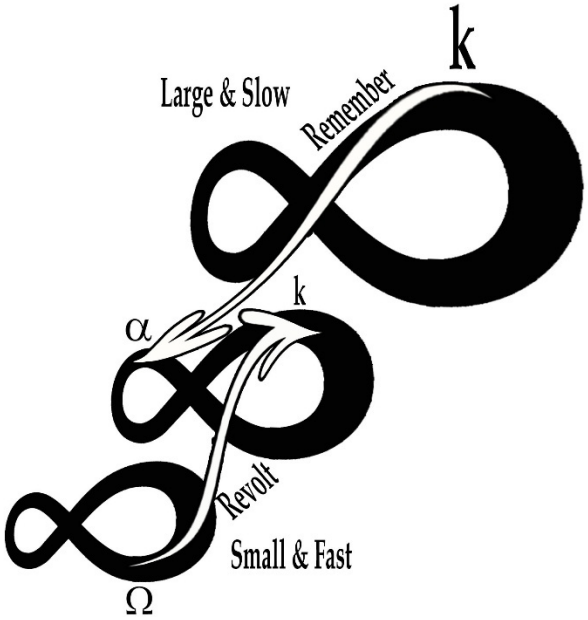


Figure 2. Panarchy (This image is based on [11]).

Both Adaptive Cycles and Panarchy can be applied to a variety of SES studies [11], where researchers define the boundaries and scope of interacting subsystems and cycles depending on the phenomenon of interest, theories, and/or data and methodological resources.

2.3. Neighborhood Change Models

The suburban neighborhood is our primary unit of analysis. It can be understood as a dynamic system comprising people, built environments, institutions, and semi-natural areas. Like social-ecological systems (SES), neighborhoods exhibit cyclical change patterns [30]. Changes can manifest as improvements or declines, with the latter often linked

to socioeconomic deterioration and physical neglect [26] (see Table A2 in Appendix A.2 for the literature review on neighborhood change theories).

Hoover and Vernon (1959) [24] propose that neighborhoods evolve through a sequence of five stages (see Table A3 in Appendix A.3 to place life-cycle theory in the literature of neighborhood change): 1—initial residential development; 2—subsequent growth; 3—followed by downgrading; 4—eventual decline; and 5—in some cases, renewal or urban blight [24,26,31]. We posit that the process of neighborhood change can be interpreted as an Adaptive Cycle. In the case of suburban neighborhoods in decline, the loss and/or degradation of green spaces can be analyzed as one component of the suburban social-ecological system transitioning through phases of release (α) and reorganization (Ω; Figure 1).

This study proposes a Social-Ecological Systems (SES) framework for analyzing suburban neighborhood change by extending the neighborhood life-cycle model from urban economics theory [24] with the SES Adaptive Cycle framework [11] (see Figure 3), explicitly considering its proposed effect on suburban green coverage and quality.

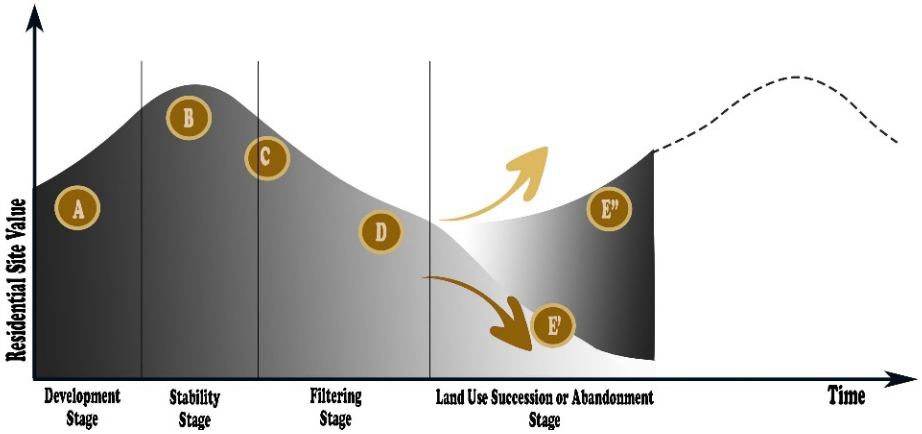


Figure 3. Proposed neighborhood life-cycle model (inspired by Hoover and Vernon's neighborhood life-cycle's theory [24])—Phase A: New residential developments featuring uniform housing types are constructed, primarily catering to moderate- and higher-income residents who have access to traditional financing and insurance options. Phase B: Higher density, signal of decrease in income, and apprehension of ethnic change. Phase C: Aging structural deterioration, overcrowding, density, decline in white in-movers, immigrants rise in rental accommodations. Phase D: Decline in price and investments, lack of upkeep, mainly low-income residents and elderly, ethnic rising, vacancies, and high unemployment. Phase E′: Slum settlements, extreme decadence, high crime rate, and blight. Phase E″: Land use succession—redevelopment.

The life-cycle phases in neighborhood transformation correspond to the four stages of change in the Adaptive Cycle, with Phase A relating to the (r) phase and Phase B to the (k) phase, while Phases C, D, and E (E′ or E″) align with the release (Ω) phase or reorganization phase (α).

We employed the Adaptive Cycle framework to analyze suburban neighborhood change and its relationship to green coverage, which aligns with social-ecological system (SES) principles and emphasizes dynamic and cyclic patterns of transformation (Figures 1–3). This framework acknowledges the interconnectedness of societal and natural systems (semi-natural in the case of suburbs) and considers green coverage and/or quality as a key component of the system. Accordingly, we posit that a neighborhood's Adaptive Cycle stage—whether reorganization (E″) or decline (E′)—is likely linked to shifts in green coverage and/or quality.

We identified six key factors in the neighborhood change literature, in alignment with Vernon and Hoover's life-cycle theory, that include demographic, social, housing, and economic aspects. These factors are operationalized into the study's neighborhood change variables, which will be described in detail in the section on independent variables (Table 1). The factors are:

- Population Composition
- Intensity of Land and Dwelling Use
- Quality of Housing
- Rate of Growth in Housing/Population
- Economy and Accessibility to Employment
- Social Resilience to Change

Table 1. Regression explanatory variables.

	Factors of Neighborhood Life Cycle	Variables	Scale	Type of Analysis
1	Outcome Variable	Green Space Coverage	Census tract	Quantitative
2	Population Composition	Median Income	Census Tract	Quantitative
		% Married households	Census Tract	Quantitative
		% Housing Units: Renter Occupied	Census Tract	Quantitative
		Racial/Ethnic Diversity using the Shannon–Wiener Index	Census Tract	Quantitative
3	Intensity of Land and Dwelling Use	% Housing Units: Vacant	Census Tract	Quantitative
		Housing Density (Gross Density)	Census Tract	Quantitative
		Population Density (per sq. mile)	Census Tract	Quantitative
4	Quality of Housing	% Multifamily housing	Census Tract	Quantitative
		% Room occupancy of one and less than one person	Census Tract	Quantitative
		Median House Value	County	Quantitative
5	Rate of Growth in Housing/Population	Housing Units	Census Tract	Quantitative
		Population	Census Tract	Quantitative
6	Accessibility to Employment Opportunities	% Labor Force: Male Unemployed	Census Tract	Quantitative
		% Female employed in the Civilian Sector	Census Tract	Quantitative
7	Social Resilience to Change	% Residency length of more than five years	Census Tract	Quantitative
		% Population over 65 years old	Census Tract	Quantitative
8	Public Agencies	General Plans Index—Evaluation for Green Preservation	County	Qualitative—Quantified
		Ordinances Index—Evaluation for Sustainability Principles	County	Qualitative—Quantified

2.4. The Potential Role of Governance and County-Level Policies

Public agencies strive to frame and control land-use redevelopment and the built environment through various regulations and policies, aiming for ordered growth and societal well-being [32]. The relationship between suburban neighborhood decline and the loss or degradation of green coverage may also be influenced by these institutional and governance factors [32–34]. However, these aspects have received limited attention in previous studies that focused on neighborhood change and green area loss, and warrant further investigation [35–37].

While there has been a recent emergence of Social-Ecological Systems (SES) studies examining the influence of socioeconomic drivers on spatial changes and green area/cover change [38–40], studies focused on how governance and/or presence of environmental-friendly policies at county level remain limited [41,42].

3. Materials and Methods

3.1. Research Design

This case study utilizes a quasi-experimental design with Convergent Parallel Mixed Method approach, integrating both quantitative and qualitative data over several decades (Figure 4). This data is fitted and evaluated in two sequential models: a multilevel mixed-effects ordered probit regression and a multilevel mixed-effects multivariate regression. The primary focus is on outer-ring suburban neighborhoods in Los Angeles, defined by census-tract boundaries and parameters derived from urban planning, urban economics, ecology, and design literature. Quantitative decadal data spans from 1970 to 2020 and includes U.S. Census socioeconomic and demographic variables, standardized to 2010 census tracts. Ecological factors, such as EPA-defined ecoregions, precipitation, and drought data, are included as independent variables. We operationalized 'green coverage and/or degradation' as our outcome of interest variable by incorporating longitudinal green coverage data using the Normalized Difference Vegetation Index (NDVI), derived from USGS Landsat satellite imagery to measure vegetation health (Figure 4).

NDVI data, calculated using the (NIR − R)/(NIR + R) formula, helps assess vegetation greenness, quantity, and health. The longitudinal green coverage data is collected from Earth Explorer's Landsat archive, spanning multiple satellite missions. The study also employs several indexes, including a racial diversity index, Neighborhood Change Index, and general plan evaluation, as independent variables in quantitative models.

Qualitative methods support the development of indexes derived from county-level general plans and ordinances over the study period. Content analysis, conducted through NVivo, examined the proportional frequency of green space-related keywords. The analysis focuses on green space-friendly policies and criteria, including Hostetler's Green Space Preservation Criterion [43]. These policies were evaluated in historical general plans and zoning ordinances, with two indexes created, one for general plans, and the other for ordinances, scored within a summative framework.

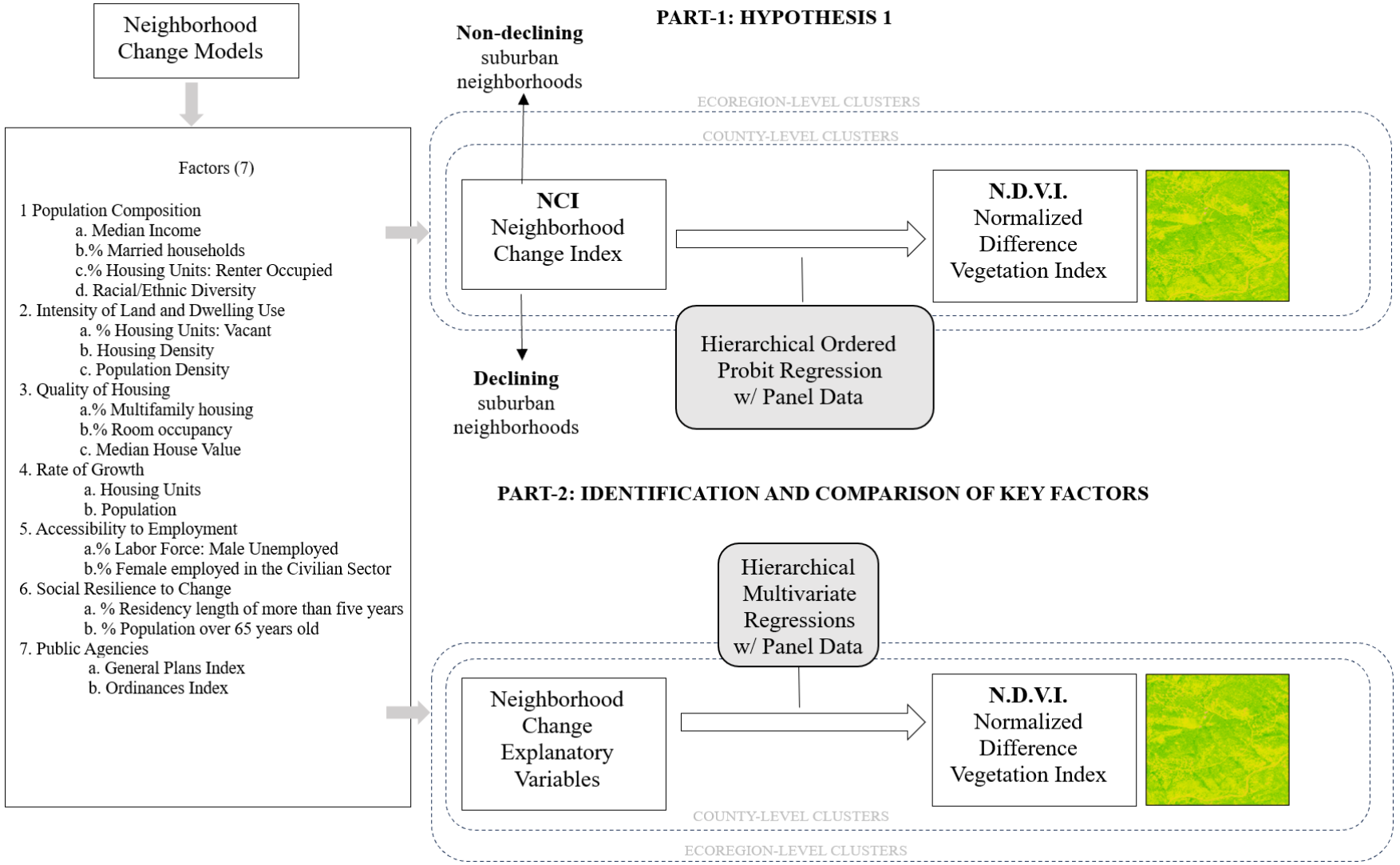


Figure 4. Research design and procedure.

3.2. Case-Sampling and Study Delimitation

Los Angeles (LA) is a polycentric city with a vast metropolitan area, often portrayed as an expansive suburban sprawl connected by automobile freeways [44]. This study defines LA's metropolitan boundaries based on 60-min drive buffers from multiple subcenters, as identified by Giuliano and Small (1991) [45], using ArcGIS network analysis (Figures 5 and 6). To capture outer-ring suburban areas, the study considers the 85th percentile of commute times in LA [46], accounting for variations over the 50-year study period (a table on change in the average commuting time in 2010–2020 and 2021 is provided in Table A4 in Appendix A.4—The 60 min interval is selected as a margin representing the average).

The cases were selected based on key characteristics of outer-ring suburbs, including their development post-1970, predominant residential land use, and a population density threshold (1500 people per square mile), aligning with city planning and urban design literature [47–49].

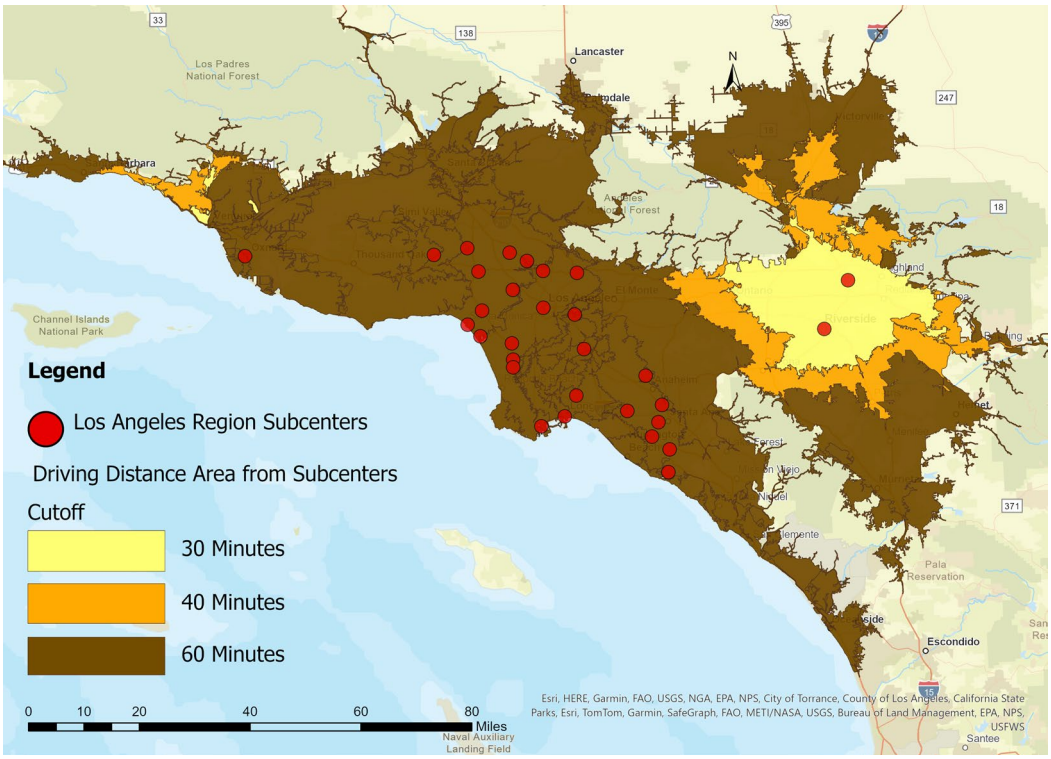


Figure 5. ArcGIS Pro network analysis on driving distances of 30, 40, and 60 min toward defined subcenters. The metropolitan area is defined by average driving distance. Both commute statistics (See Table A4 in Appendix A.4) and threshold analyses (30–40–60 min) confirm 60 min as the appropriate criterion.

After excluding neighborhoods with high density, military bases, national and regional parks, and large preserved areas, the final sample includes 331 census tracts (Figure 6). These cover 908.18 square miles and house a population of 1,758,458, with 512,972 housing units [50].

The study area exhibits considerable ecological diversity across multiple ecoregions. Acknowledging the potential influence of ecoregions within the Panarchy framework is a key feature in our study (Figure 7).

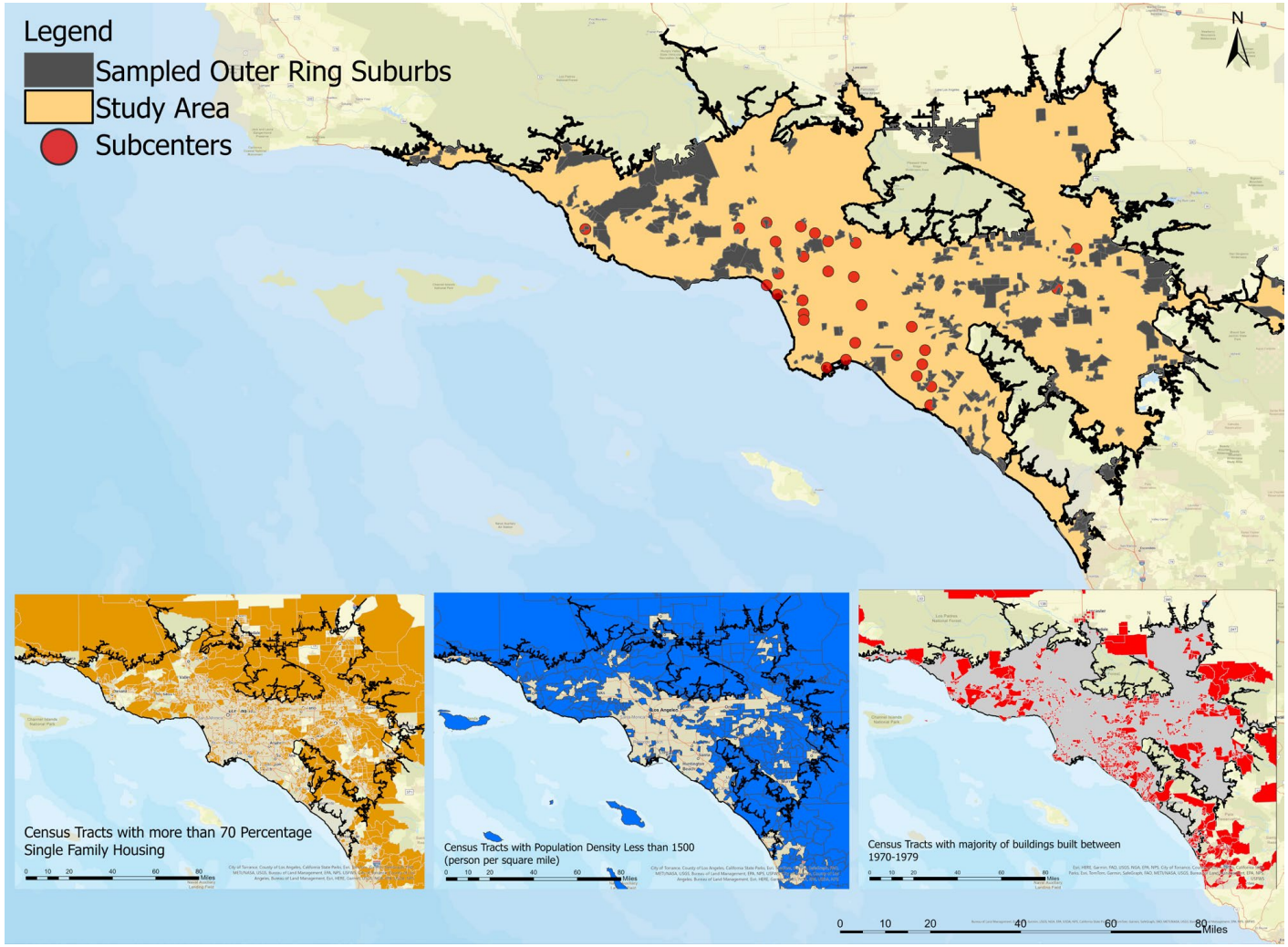


Figure 6. Sample of 331 Census tract cases were selected with criterion defining Outer-Ring Suburbs. These were identified using four criteria: location within sub-centers average commute service area; low population density, predominant residential land use, and majority of buildings constructed between 1970–1980. The overlap of these criteria defines the tracts shown.—According to ESRI data [50] median household disposable income is USD 79,372. Employment patterns reveal that 70% of jobs are in white-collar occupations, 19% in blue-collar roles, and 14% in service sector.

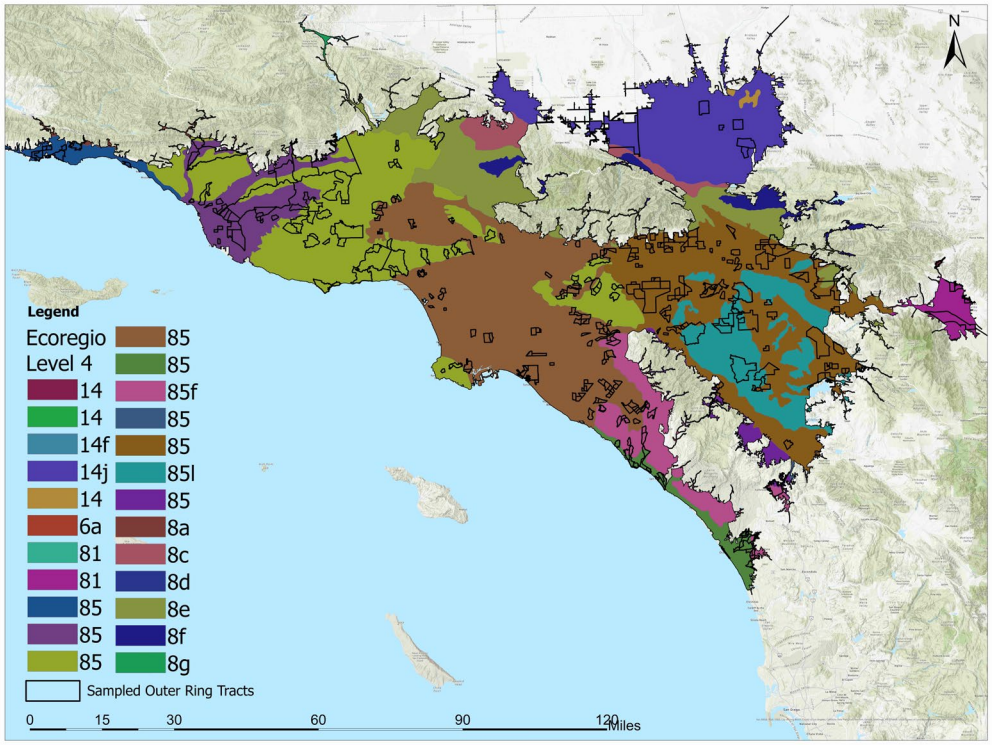


Figure 7. EPA ecoregions in study area—Level IV. 8a = Western Transverse Range Lower Montane Shrub and Woodland; 6ap = Solomon-Purisima-Santa Ynez Hills; 85a = Santa Barbara Coastal Plain and Terraces; 8e = Southern California Lower Montane Shrub and Woodland; 8c = Arid Montane Slopes; 8f = Southern California Montane Conifer Forest; 85d = Los Angeles Plain; 85c = Venturan-Angeleno Coastal Hills; 85l = Inland Hills; 85k = Inland Valleys; 8d = Southern California Subalpine/Alpine; 14f = Mojave Playas; 14k = Western Mojave Low Ranges and Arid Foot slopes; 81e = Upper Coachella Valley and Hills; 14b = Eastern Mojave Low Ranges and Arid Foot slopes; 85b = Oxnard Plain and Valleys; 85g = Diegan Western Granitic Foothills; 85f = Diegan Coastal Hills and Valleys; 85e = Diegan Coastal Terraces; 81a = Western Sonoran Mountains; 85m = Santa Ana Mountains; 14a = Eastern Mojave Basins; 8g = Northern Transverse Range; 14j = Western Mojave Basins.

3.3. Model Variables

3.3.1. Response Variable

Green coverage data was calculated in ArcGIS Pro 3.0 platform using satellite imagery from six decadal intervals (1970–2020) collected during the summer months (June–August). The earliest available imagery dates to 1972. The Normalized Difference Vegetation Index (NDVI), which measures vegetation health and density, was used to capture and operationalize the response variable, green coverage and health. Areas with an NDVI score above 0.1, ranging from sparse grassland to dense vegetation, were considered green coverage, following the USGS definition [51].

3.3.2. Explanatory Variables

The neighborhood life-cycle model informed the selection of key explanatory variables (Table 2). These were also used to develop a multidimensional Neighborhood Change Index (NCI) that is specified as a key explanatory variable for hierarchical ordered probit Models 1 and 2. These first two models test the hypothesis that outer-ring suburban neighborhoods that experienced decline during the study period also experience more loss and degradation of green coverage. The hierarchical multivariate Models 3, 4, and 5, which aim to identify and compare key factors associated with green coverage decline, reference multiple elements of life cycle theory of neighborhood change (Table 2). These

were developed in sequence in pursuit of minimizing bias and parsimony, as well as identification of potential legged effects.

Table 2. Regression explanatory variables. The factors are key elements of life cycle theory [24] derived from [25].

Factors of Neighborhood Life Cycle		Variables	Scale	Type of Analysis
1	Outcome Variable	Green Space Coverage	Census tract	Quantitative
2	Population Composition	Median Income	Census Tract	Quantitative
		% Married households	Census Tract	Quantitative
		% Housing Units: Renter Occupied	Census Tract	Quantitative
		Racial/Ethnic Diversity using the Shannon–Wiener Index	Census Tract	Quantitative
3	Intensity of Land and Dwelling Use	% Housing Units: Vacant	Census Tract	Quantitative
		Housing Density (Gross Density)	Census Tract	Quantitative
		Population Density (per sq. mile)	Census Tract	Quantitative
4	Quality of Housing	% Multifamily housing	Census Tract	Quantitative
		% Room occupancy of one and less than one person	Census Tract	Quantitative
		Median House Value	County	Quantitative
5	Rate of Growth in Housing/Population	Housing Units	Census Tract	Quantitative
		Population	Census Tract	Quantitative
6	Accessibility to Employment Opportunities	% Labor Force: Male Unemployed	Census Tract	Quantitative
		% Female employed in the Civilian Sector	Census Tract	Quantitative
7	Social Resilience to Change	% Residency length of more than five years	Census Tract	Quantitative
		% Population over 65 years old	Census Tract	Quantitative
8	Public Agencies	General Plans Index—Evaluation for Green Preservation	County	Qualitative—Quantified
		Ordinances Index—Evaluation for Sustainability Principles	County	Qualitative—Quantified

To capture the broader potential ecological influences on green coverage in outer-ring suburbs, precipitation and wildfire—recognized as key local ecological factors [52]—were introduced as exploratory variables in Models 3–5. These variables encompass the most influential ecological features of southern California's Mediterranean climate, defined by pronounced dry summers, high annual variability in precipitation, and an inherent susceptibility to wildfire [52].

3.3.3. The Neighborhood Change Index: NCI

In this study, we developed a Neighborhood Change Index (NCI) to register multi-decadal neighborhood change. NCI mirrors the Gentrification Index created in 2014 by

the Voorhees Center for Neighborhood and Community Development for Chicago [53], here modified for use on outer-ring suburbs. This standard composite index evaluates a neighborhood's state relative to others based on socioeconomic and physical trends, incorporating key factors from neighborhood life-cycle theory (Table 3). The indexation process involves the following steps:

Table 3. NCI variables evaluation.

Variables	Type of Association
Median Income	If above average in the study area, +1; otherwise, −1
% Married households	If above average in the study area, +1; otherwise, −1
% Housing Units: Renter Occupied	If above average in the study area, −1; otherwise, +1
Racial/Ethnic Diversity using the Shannon–Wiener Index	If above average in the study area, −1; otherwise, +1
% Housing Units: Vacant	If above average in the study area, −1; otherwise, +1
Housing Density (Gross Density)	If above average in the study area, −1; otherwise, +1
Population Density (per sq. mile)	If above average in the study area, −1; otherwise, +1
% Multifamily housing	If above average in the study area, −1; otherwise, +1
% Room occupancy of one and less than one person	If above average in the study area, +1; otherwise, −1
Median House Value	If above average in the study area, +1; otherwise, −1
Growth Rate of Housing Units	If above average in the study area, −1; otherwise, +1
Growth Rate of the Population	If above average in the study area, +1; otherwise, −1
% Labor Force: Male Unemployed	If above average in the study area, −1; otherwise, +1
% Female employed in the Civilian Sector	If above average in the study area, +1; otherwise, −1
% Residency length of more than five years	If above average in the study area, +1; otherwise, −1
% Population over 65 years old	If above average in the study area, −1; otherwise, +1
Qualitative (Quantified)	
General County Plans Index—Evaluation for Green Preservation	If above average in the study area, +1; otherwise, −1
Ordinances County Index—Evaluation for Sustainability Principles	If above average in the study area, +1; otherwise, −1

Step 1. Value Comparison to the Sample Average: Each neighborhood is scored relative to the average measurement of outer-ring suburban neighborhoods in the study area. For each decade, variables of neighborhood change are evaluated, as shown in Table 3. Directionality of each factor is based on life-cycle literature and considers the effect of the variable on neighborhood decline. We assigned a negative or positive (−/+1) score depending on whether its value is above/below the sample average.

Step 2. Calculation of the Distance from Average: Each neighborhood variable is weighted by its distance from the sample's average. The numeric subtraction to the center was incorporated as the weighting coefficient.

Step 3. Calculation of NCI Values: The NCI value for each neighborhood is the weighted sum of all relevant variables for each decade. This index reflects the neighborhood's status among outer-ring suburbs in LA concerning socioeconomic and physical factors from life-cycle models. Values were standardized and rescaled across the six decades to yield analogous rates of change among outer-ring suburbs in the sample (see Step 4, below).

Step 4. Calculation of Overall "Neighborhood Change" Based on Multi-Decadal NCI Values: This phase calculates the neighborhoods' overall rate of change from 1970 to 2020 using a Compound Decadal Growth Rate (CDGR) approach. The CDGR metric [54] computes the average annual growth rate over a specified period, accounting for compounding effects. This method is particularly suitable for measuring overall growth trends, even when individual growth rates fluctuate decade to decade (Equation (1)).

$$\text{CDGR} = \left(\frac{\text{Beginning Value}}{\text{Ending Value}}\right)^{\frac{1}{\text{Number of Decades}}} - 1, \quad (1)$$

where

Beginning Value: The value of NCI in 1970.

Ending Value: The value of NCI in 2020.

Number of Decades: The period (in decades) over which growth is measured (in this study we measured for 6 decades).

The CDGR rates are then standardized and cases with CDGR below the mean are identified as declining suburbs (Figure 8). The declining neighborhoods are tagged in the hierarchical ordered probit Model 2 with a dummy variable to facilitate hypothesis testing.

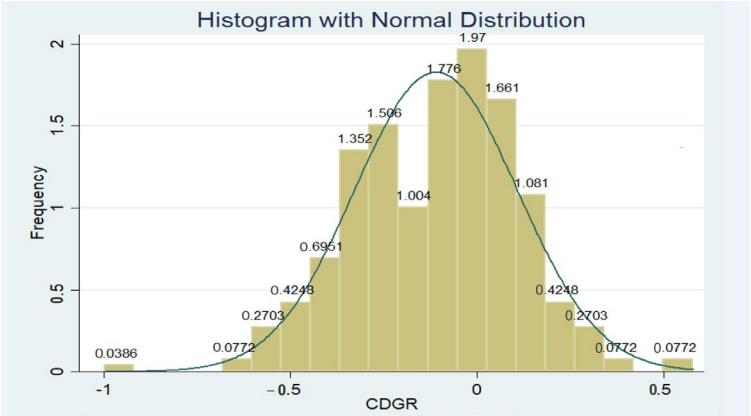


Figure 8. CDGR histogram, mean = −0.11001; standard deviation = 0.2181.

3.4. Models Description

We explored neighborhood change and its potential impact on suburban green spaces with probit and multivariate longitudinal mixed-effects hierarchical models. The aim was to register processes of change in suburban neighborhoods' social, built environment, and semi-natural green coverage systems (SES), whilst considering an overarching Panarchy of County and Ecoregion clusters (Figure 9). These models extend traditional linear models by combining fixed and random components, allowing for a more nuanced analysis of neighborhood change over time that considers both time and spatial data clusters [55] in tune with temporal and spatial hierarchies of Panarchy.

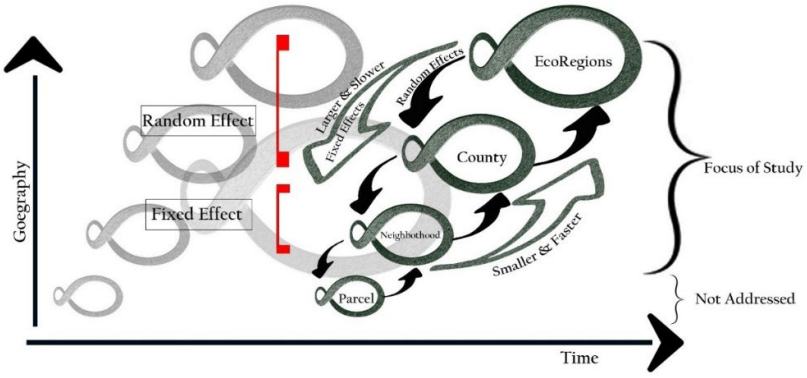


Figure 9. Composition of random and fixed effects in developed mixed-effects models.

Fixed effects in the models estimate the impact of observed neighborhood life-cycle factors on green coverage and/or degradation. Meanwhile, random effects control the hierarchical structure of the data, which nests neighborhoods within political boundaries (Counties) and ecological boundaries (Ecoregions). These random effects account for the potential non-independence of observations by including time, county-level clustering and policies, and broader ecoregion attributes as we also posit these may distinctly affect the outcome of interest [56].

By using the mixed-effects approach the study was able to account for temporal and geographical Panarchy effects and provide a more theoretically robust and unbiased framework for understanding how neighborhood socioeconomic factors might relate to changes in green coverage and/or degradation over five 10-year intervals in outer-ring suburbs of Los Angeles. The final Model 5 also incorporates lagged variables to detect potential delayed effects in some fixed components, as is often found in SES systems.

3.4.1. Model 1 and 2: Hypothesis Testing

These two models test the main hypotheses. Whether outer ring declining suburbs exhibit larger declines in green area coverage and/or quality compared to non-declining suburbs. Model 1 and Model 2 implement a longitudinal ordinal mixed-effects probability model (See Equation (A1) in Appendix A.5). Model 1 is the restricted model and Model 2 is the full (unrestricted) model where a declining neighborhood dummy is specified. The explanatory variable in this model is the ordered decadal NCI score. Random components associated with county-level and ecoregion-level clustering were also specified. Both the NCI index and the outcome variable, green coverage-quality (NDVI), were ordered in quartiles.

3.4.2. Models 3, 4, and 5: Identifying Factors of Neighborhood Change Associated with Green Coverage Loss and/or Degradation

In the second step of this investigation, we implemented longitudinal mixed-effects regressions that aim to identify and compare which neighborhood change factors are associated with green coverage and/or quality loss in LA's outer-ring suburbs, and their relative impact. This is explored in subsequent Models 3, 4, and 5 (see Equation (A2) in Appendix A.6). Model 3 served as a baseline model from which we assessed expected multicollinearity among explanatory variables. In Model 4, we corrected for high multicollinearity between some covariate pairs by removing problematic covariates using a backward stepwise approach, whilst maintaining at least one explanatory variable for each of the six key factors of neighborhood change, identified in the life-cycle literature. In Model 5, the final, more parsimonious, and best fit model, we explored and introduced lagged variables in pursuit of better model fit and understanding of this complex and dynamic phenomenon. The explanatory variables in Models 3, 4, and 5 were sourced from the set of neighborhoods change factors identified in the neighborhood life-cycle model literature (Table 1).

4. Results

Model 1 and Model 2. The association between green space coverage and quality (NDVI) and the Neighborhood Change Index (NCI) was examined using mixed effects ordered probit regression with panel data. This approach incorporates random effects to account for unobserved contextual factors at broader scales, including temporal effects, neighborhood location within distinct ecological zones, and county-level geographies that potentially harbor distinct green area policies. The model estimated both fixed and random effects probabilistically, with variables categorized into quartiles (n = 4, from lowest to highest values). In the unrestricted Model 2, a dummy variable representing declining suburbs was included to evaluate its impact and test the first hypothesis: that outer-ring neighborhoods experiencing socioeconomic decline exhibit greater likelihood of green space loss or degradation. Low *p*-values from Chi-squared tests in both models reject the null hypothesis of zero coefficients, while likelihood-ratio tests indicate highly significant results, and a reduction in information criteria AIC and BIC statistical scores suggest better fit of full model. These statistics support an overall robustness and fit of the models (Table 4).

Table 4. Longitudinal mixed-effects ordered probit regression—fit statistics and results.

	Model 1			**Model 2**		
	Green Coverage ← NCI			Green Coverage ← NCI + Dummy		
Model-fit Statistics:						
N	1976			1976		
Likelihood-ratio	−2519.1884			−2514.703		
AIC	5052.377			5045.406		
BIC	5091.456			5090.068		
Integration method:	mvaghermite			mvaghermite		
Wald chi2(1)	61.21			65.72		
Prob > chi2	0.0000			0.0000		
Integration points	7			7		
Random Effect Attributes:						
Group Variable	No. of Groups			No. of Groups		
Time	6			6		
County	42			42		
Eco-Region	138			138		
Fixed Effects:						
GRN Coverage and Quality-Categorical (NDVI)	Coef.	Sig.	$p > \|z\|$	Coef.	Sig.	$p > \|z\|$
NCI_Categorical	0.445075	***	0.000	0.400922	***	0.000
Declining Suburbs (dummy)	(not used)	-	-	−0.201354	**	0.032
cut1	0.376409	*	0.075	0.180237	-	0.278
cut2	1.192608	***	0.000	0.999673	***	0.000
cut3	1.989563	***	0.000	1.798216	***	0.000
Random Effects:						
Time var (_cons)	0.1049516	.	.	1.64×10^{-14}	.	.
Time > County var (_cons)	0.2001868	.	.	0.2584589	.	.
Time > County > Ecoregion var(_cons)	0.5815022	.	.	0.6040833	.	.
Notes	LR test vs. oprobit regression: chi2(2) = 364.97 Prob > chi2 = 0.0000			LR test vs. oprobit regression: chi2(2) = 337.01 Prob > chi2 = 0.0000		

* $p < 0.05$. ** $p < 0.01$, *** $p < 0.0001$. Dot signs represent standard error for that variance component cannot be calculated.

Model 1 demonstrates a significant positive relationship between higher Neighborhood Change Index (NCI) scores and elevated Normalized Difference Vegetation Index (NDVI) values, lending support to the study's first proposition. This pattern is consistent across three separate cut-points based on latent continuous variables used to determine observed ordinal outcomes, with particularly strong significance observed in cut-points 2 and 3.

Model 2 indicates that outer-ring suburbs in Los Angeles experiencing socioeconomic decline are approximately 0.2 times less likely per decade to exhibit higher green space coverage and quality (NDVI), with results significant at the 95% confidence level. These outcomes confirm the hypothesis that socioeconomic decline in LA's outer-ring suburbs is strongly associated with greater reductions in the extent and/or quality of green coverage, relative to neighborhoods with stable or improving NCI trends (see Figure 10).

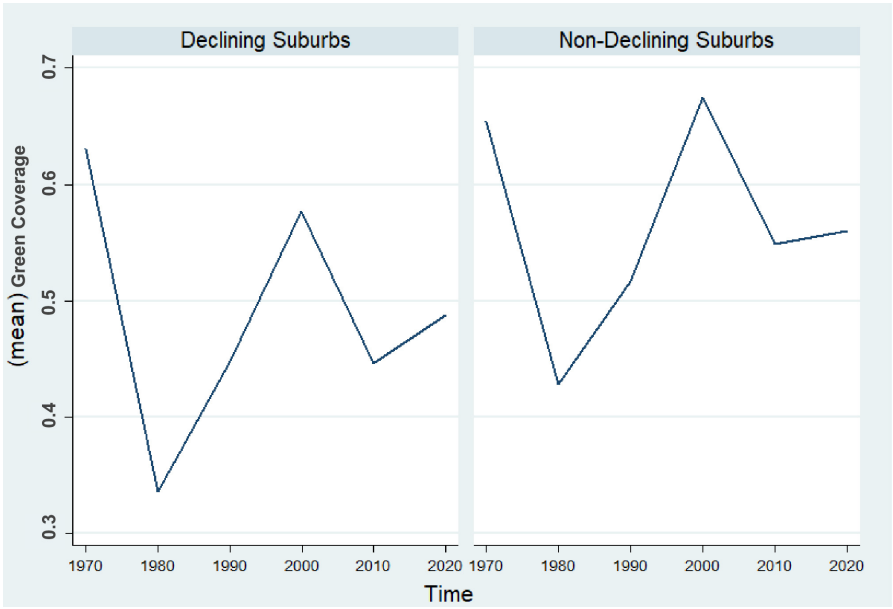


Figure 10. Change in means of green coverage between declining and non-declining suburbs in decades.

Acknowledging that the Neighborhood Change Index (NCI) is a multidimensional indicator that approximates a neighborhood's stability relative to others, we extended the analysis to examine multiple potential links between factors associated with decline in outer-ring suburbs and reductions or degradation of green spaces. This was done using a more comprehensive set of neighborhood life-cycle predictors within longitudinal mixed-effects multivariate Models 3, 4, and 5.

Model 3, our baseline model, initially included all 16 neighborhood change variables. However, the presence of multicollinearity among some explanatory variables led to redundancies and biases in variable estimates. To optimize Model 3, a correlation analysis of explanatory variables was conducted, retaining variables with a variance inflation factor (VIF) of less than 3. A backward stepwise variable selection method was employed to identify significantly associated variables with low or no multicollinearity while ensuring at least one explanatory variable was included for all six key factors identified in the neighborhood life-cycle theory (Table 1).

The explanatory variables in the more parsimonious Models 4 include housing units, the proportion of the population aged over 65, diversity index, median home value, multi-family housing proportion, vacancy rates, unemployment rates, and residency duration (over five years), along with key contextual ecological factors precipitation and wildfire incidents, whilst maintaining the random effects specified in Model 1 and Model 2.

Following SES theory and to further enhance the explanatory power of the model, in Model 5 we explored and introduced lagged effects to capture expected delayed impacts of some predictors in neighborhood status. As dynamic socio-ecological systems, outer-ring suburbs may experience these mechanisms as well as potential feedback effects that may contribute to further decline, blight, and loss of green area and/or degradation.

After testing each explanatory variable and evaluating model fitness indicators (pseudo-R^2, AIC, BIC), variables with significant lag effects were retained in Model 5 (Tables 5 and 6).

Table 5. Lagged variables, estimated parameters, significance levels, and AIC statistics. Note: Red: no lag effect. Orange: Possible lag effects. Green: Significant lag effects.

Variable	Coefficient and Significanc of Model 4	Coefficient and Significance of Lag Effects		
		AIC w/Concurrent	Lag Coefficients	AIC w/Lag Effect
Housing Density	−0.044774 ***	−319.8051	−0.0411465 ***	−307.6707
Population Over 65	0.019255 ***	−265.5189	0.0093374	−242.9864
Diversity Index	−0.020064 ***	−263.2322	−0.0088939	−250.1652
Median Home Value	0.081188 ***	−435.1778	0.080445 ***	−438.3483
Multi-Family%	−0.074161 ***	−455.8101	−0.0616515 ***	−394.9729
Vacancy%	−0.031374 ***	−281.1201	−0.3353455 ***	−272.9887
Unemployment Male%	−0.030400 ***	−277.7273	−0.0319059 ***	−279.5974
Residence over five years	0.073930 ***	−297.2209	0.0791249 ***	−307.1305
Precipitation	0.125966 ***	−271.4826	0.1378985 ***	−273.9

*** $p < 0.0001$.

Unemployment, median home value, precipitation, and residence history were identified as variables with a significant lagged effect on neighborhood green coverage and/or quality. Conversely, housing density, multifamily housing, vacancy rates, population aged over 65, and diversity are posited to have a more direct or short-term influence and remain untransformed in Model 5.

Table 5 presents a comparison of regression fit and results across Models 3, 4, and 5. The evaluation of the model's fitness is primarily based on the analysis of the Akaike Information Criterion (AIC) scores and other fit statistics. The analysis of estimated parameter focuses on significance level, magnitude, and directionality.

Model 4, aimed for parsimony and to address issues with multicollinearity found in Model 3, shows improved AIC, Bayesian Information Criterion (BIC), and Chi-squared fit statistics. The Intraclass Correlation Coefficient (ICC) value also increases for the Time and County random components. Model 4 integrates the most influential variables capturing all major dimensions of neighborhood change, while also addressing multicollinearity effectively.

Fit statistics in Model 5, which include lagged effects, demonstrate further enhancements, best fit, and register increases in variance of random effects related to Time, County, and Ecoregion levels. It also reports the largest ICC statistics. The inclusion of lagged effects provides a more nuanced understanding of the temporal impacts of some neighborhood life cycle factors and yields an increase in size effects and a higher pseudo-R^2 that evaluates predictive power for fixed effects.

The results of Model 5 suggest that 'Multifamily housing', 'Vacancy rates', number of 'Housing units', the delayed effect of 'Unemployment rate', 'Diversity index', and 'Multifamily' have long-term negative impacts on LA's outer-ring suburbs green coverage. In contrast, the lagged effect of 'Precipitation', 'Median home value' and 'Residency length', and the rate of 'Population over 65' have a positive influence.

Despite non-significant results for governance/institutional indices, it is important to acknowledge the significance of the institutional/organizational components within Social-Ecological System (SES) theory and literature. Potential explanations for the non-significant findings in this study include measurement errors in the qualitative indicators (weak instrument validity) requiring refinement, or the possibility that county-level random effects (unobserved estimated variables in the hierarchical model) may already capture variance attributable to distinct regulations, policies and/or governance at county-level.

Table 6. Longitudinal mixed-effects models 3, 4, and 5—fit statistics and results.

	Model 3			**Model 4**			**Model 5**		
Model-fit statistics:									
N	1942			1949			1946		
Likelihood-ratio	373.2			376.9			403.7		
AIC	−690.5			−723.9			−777.4		
BIC	−534.5			−640.3			−693.8		
Integration method:	ML regression			ML regression			ML regression		
Wald chi2(1)	556.95			575.68			651.03		
Prob > chi2	0.0000			0.0000			0.0000		
Chi-Squared	494.28			582.94			534.35		
R^2m	0.289305125			0.258691469			0.2916		
R^2c	0.50455			0.50758			0.50701		
ICC	Time	0.078		Time	0.164		Time	0.172	
	County	0.080		County	0.164		County	0.172	
	Ecoregion	0.462		Ecoregion	0.498		Ecoregion	0.497	
Random Effects Attributes									
Group Variable	No. of Groups			No. of Groups			No. of Groups		
Time	6			6			6		
County	42			42			42		
Eco-Region	138			138			138		
Fixed Effects									
GRN Coverage	Coef.	Sig.	$p > \|z\|$	Coef.	Sig.	$p > \|z\|$	Coef.	Sig.	$p > \|z\|$
Population	0.0020	.	0.8460	-	-	-	-	-	-
Housing Units	−0.0048	.	0.6600	−0.022	***	0.000	−0.0213	***	0.000
Pop Density	0.0089	.	0.2760	-	-	-	-	-	-
Housing density	−0.025	***	0.0010	-	-	-	-	-	-
Population Over65	0.024	***	0.0000	0.020	***	0.000	0.0195	***	0.000
Married Households	−0.001	.	0.8880	-	-	-	-	-	-
Diversity Index	−0.013	**	0.0120	−0.014	**	0.0020	−0.014	***	0.001
Median Income	0.030	***	0.0000	-	-	-	-	-	-
Lagged HomeValue	-	-	-	-	-	-	0.068	***	0.0000
Median HomeValue	0.046	***	0.0000	0.063	***	0.000	-	-	-
Renters%	0.015	**	0.0640	-	-	-	-	-	-
Room Occupancy ≤ 1	0.006	.	0.2060	-	-	-	-	-	-
MultiFamily%	−0.046	***	0.0000	−0.046	***	0.000	−0.049	***	0.000
Vacancy%	−0.028	***	0.0000	−0.031	***	0.000	−0.039	***	0.000
Lagged Unemployment	-	-	-	-	-	-	−0.015	***	0.001
UnemploymentMale%	−0.0093	**	0.0690	−0.011	*	0.019	-	-	-
FemaleEmployement	−0.001	.	0.7850	-	-	-	-	-	-
Lagged ResidenceDu	-	-	-	-	-	-	0.033	***	0.001
Residence ≤ 5 Years	0.034	***	0.0010	0.0272	**	0.009	-	-	-
Lagged Precipitation	-	-	-	-	-	-	0.090	***	0.000
Precipitation	-	-	-	0.0069	***	0.0000	-	-	-
Golf_Park	-	-	-	0.011	**	0.00	0.010	*	0.0120
Multi Ecoregions	0.022	**	0.0420	-	-	-	-	-	-
WildfireIncidents	0.089	***	0.0000	0.092	***	0.000	0.103	***	0.000
Random Effects	Estimate	Std.Error		Estimate	Std.Error		Estimate	Std.Error	
Time var (_cons)	6.73×10^{-3}	5.23×10^{-3}		1.14×10^{-2}	0.0076844		1.16×10^{-2}	0.0079067	
County var (_cons)	2.06×10^{-9}	1.21×10^{-8}		1.11×10^{-10}	7.56×10^{-10}		1.83×10^{-10}	1.19×10^{-9}	
Var (Residual)	0.0346366	0.0011685		0.034802	0.0011682		0.0338761	0.0011364	
Notes	LR test vs. linear model: chi2(8) = 494.28 Prob > chi2 = 0.0000			LR test vs. linear model: chi2(3) = 582.94 Prob > chi2 = 0.0000			LR test vs. linear model: chi2(3) = 534.35 Prob > chi2 = 0.0000		

* $p < 0.05$. ** $p < 0.01$, *** $p < 0.0001$. Dot signs represent standard error for that variance component cannot be calculated.

5. Discussion

This study argues that outer-ring suburbs can be conceptualized and analyzed as social-ecological systems. The Neighborhood Change Index (NCI), a multidimensional indicator that integrates key socioeconomic indicators of neighborhood change, is found to be significantly correlated to the extent and quality of green space in Los Angeles outer-ring suburbs. Hierarchical ordered probit mixed-effects regressions (Models 1 and 2) reveal

a significant relationship between trends in the Neighborhood Change Index (NCI) and changes in green coverage. Specifically, neighborhoods undergoing decline are more likely to experience green space loss or degradation, whereas non-declining neighborhoods are associated with stabilized or improved green coverage.

Model 5 registers the independent effects of significant factors of neighborhood decline: housing units, population over 65, diversity index, multifamily housing, and vacancy; and the lagged effects of home value, unemployment, and length of residency.

These quantitative results and trend analyses suggest that the decline in quantity and condition of suburban green spaces in Los Angeles outer-ring suburbs is associated with neighborhoods' Adaptive Cycle phase of 'Release' (Omega) and possibly 'Reorganization' (alpha) phases.

These results are consistent with and extend prior work by Ramos-Santiago et al. (2014) [1], which examined a limited sample of inner-ring suburbs in San Juan, Puerto Rico where a correlation between neighborhood decline and loss of green areas was also found. The inclusion of lagged median home value effects in Model 5 enhances the models' explanatory power, highlighting the delayed impact of housing market changes on local green infrastructure.

Increase in multifamily housing in LAs outer-ring suburbs logically pose challenges to green space as they tend to feature larger footprints, unless proper planning and design ensures its integration. This housing typology is often associated with lower-income populations in the USA [57]. Despite an apparent conflict between green space conservation and affordable housing, which often manifest in multifamily and denser developments, a balance between housing affordability and green space provision can be achieved as seen in the 'gentle density' approach [58].

The length of residency significantly and positively impacts green space preservation, likely due to the sense of community and stewardship [59]. On the other hand, vacant lots contribute to neighborhood instability, reducing green spaces and property values [2,3], both considered factors in neighborhood decline. Vacant lots can restrict access to valued amenities such as parks, green spaces, and community gardens [2], while also contributing to unsafe conditions [60], which may accelerate overall neighborhood decline. Conversely, these vacant parcels also offer potential opportunities to introduce new green spaces and community-oriented activities, supporting neighborhood revitalization.

Unemployment also poses a threat to suburban green spaces by indirectly inducing higher crime rates [61] and under-maintenance of housing inventory as result of redirecting resources away from conservation [62–64]. Unemployment leads to economic and social instability and an increase in mortgage payment defaults, fostering hopelessness and increasing crime rates [65]. Increase in crime rate has also been identified as a key factor in overall neighborhood decline [66–68]. The negative effects of unemployment on green spaces may take time to appear, as resources are often redirected to address crime and unemployment issues, leaving less funding for green space conservation [69].

Racial diversity has also been associated with neighborhood decline in the U.S. and with reduced green space coverage [9,70]. Factors such as income inequality, discrimination, and limited access to public and private resources—including healthcare and green spaces—can make racially diverse neighborhoods particularly susceptible to decline [71,72]. The interplay of racial diversity, low income, and inequality has been linked to reductions in both the extent and quality of green spaces, as constrained economic resources restrict public and private investment in property upkeep. Additionally, the pursuit of higher income may lead some households or property owners to engage in rental market speculation, altering or expanding housing stock in ways that further diminish green area coverage in suburbs [73,74].

On the other hand, Model 5 also reveals a significant positive link between a higher population of residents over 65 years old and greater green space preservation. This challenges the common belief that seniors contribute to neighborhood decline due to gentrification and displacement risks [75]. The positive effect may stem from factors like extended occupancy, aging in place, and a stronger sense of belonging [76]. Or perhaps this outer-ring group enjoys higher income levels and stability as compared to other groups and suburbs in LA.

At a broader ecoregional level, this study identified a notable positive effect on green space preservation and quality in neighborhoods with the occurrence of wildfires in the same year data was collected. Although further research is needed to understand this counterintuitive finding, potential explanations include the regenerative capacity of local vegetation following wildfires [77]; ecological succession [78]; and/or human interventions [79]. Additionally, the local chaparral biome's plant adopted species to drought and wildfires, promoting rapid regrowth [80]. Furthermore, the significant influence of precipitation as a key variable in Model 5 further reveals the significance of ecoregional and biome factors.

Two essential features of Social-Ecological Systems (SES), Adaptive Cycles and Panarchy, also manifest in this case study. These concepts highlight neighborhoods' cyclical patterns and capacity to recover, reorganize, and adapt to various internal and external stressors, as evinced by distinct trends in Neighborhood Change Index (NCI) scores and green coverage trends for declining and non-declining suburbs in Los Angeles; and in the variability captured in random effects for time, county grouping, and ecoregion groupings.

A key insight drawn from this research is the identification of statistically significant neighborhood change factors, which can be interpreted as disturbances. In SES theory these are events or conditions that disturb the equilibrium of a system [81]. The significant variables in Model 5 can be interpreted as disturbances affecting trajectories of outer-ring suburbs in LA, revealing both short- and long-term impacts for neighborhood stability and green coverage. Planners can leverage this knowledge in monitoring, planning, designing, and managing suburban green-prints.

Additionally, the use of multilevel hierarchical mixed-effects models in analyzing Los Angeles outer-ring suburbs' panel data reveal Panarchy interactions. Random effects associated with Time, County, and Ecoregions constitute close to 50 percent of the total variance explained by the model (see Table 6). Ecoregion appears as the most influential component in enhancing the model's fit and illustrating variability in the interaction between local communities' socioeconomic trends, local green coverage, and the larger ecological systems in which the suburbs are nested. Finally, the importance of *Time* emerged as the second most influential random component, as expected from the neighborhood life cycle and SES Adaptive Cycle theories.

6. Spatial Planning Insights and Conclusions

Addressing rapid climate change requires better understanding and integration of suburban green areas, public and private semi-natural asset management into adaptation strategies at multiple spatial levels. A social-ecological systems (SES) approach can offer insights for enhancing suburban neighborhood and citywide resilience, emphasizing the need to co-manage socioeconomic decline and green coverage loss. This approach could help stabilize at-risk outer-ring suburbs in Los Angeles and beyond while mitigating negative spillover effects on broader natural and semi-natural environments. It can also help in monitoring trends in suburban areas and inform spatial planning strategies aimed at buttressing sustainability and resilience into the future.

From theoretical and methodological perspectives, results from this exploratory study demonstrate how Social-Ecological Systems theory can assist modeling, interpretation, and our understanding of complex land use dynamics in suburban areas. The application of hierarchical mixed-effects models illustrates key determinants in neighborhoods Adaptive Cycles that register at multiple spatial and temporal levels in LAs outer-ring suburban Panarchy.

Outer-ring suburban neighborhoods in Los Angeles with decreasing socioeconomic status as reflected in NCI multi-decadal rates experienced significant green area loss and/or degradation from 1970 to 2010. Recognizing how neighborhood change factors impact green coverage and/or degradation can help urban planners craft policies to manage suburban green coverage and ideally preserve ecosystem services for local and metropolitan communities.

Some spatial strategies and policies at neighborhood and city levels could focus on stronger governance for the management and protection of suburban green areas, both in public and private domains. A protected and publicly owned network of interconnected green corridors and preserves should be identified and protected as part of spatial planning processes at neighborhood/citywide/regional scales in existing and in future areas designated for suburban and/or urban expansion. This would help buffer critical ecological areas in suburbs from private real-estate market speculation and/or potentially harmful household-level practices on privately owned suburban yards. As consequence, ecological functions and services could be sustained for the benefit of present and future generations.

If suburban neighborhoods are to evolve into higher intensity urban landscapes, then this would ideally be matched by the simultaneous protection of greenfield territories elsewhere to mitigate the losses of ecosystem services that result from a suburban landscape transmuting into an urban landscape. Transfer of development rights [82] is an example of a land-use planning mechanism that could assist this agenda.

Best practices related to green architecture and green ecological urbanism should also be required and accompany larger neighborhood and regional scale initiatives, aimed to preserve and mitigate losses in ecological services with local architectural and ecological urban design interventions [20,39,83].

Examples of spatial planning methods and precedents related to these proactive public and/or private initiatives in suburban and urban territories can be found in the 'McHargian' approach to land-use planning and design [84] or the 'Green Print' and 'Green Preserve' approach to regional land-use planning espoused by the New Urbanist in the USA [85]. Precedents like Boston's 19th-century 'Green Emerald Necklace' system of green corridors and parks at metropolitan scale; Savannah's matrix of urban parks, integral to its colonial core; China's 'Sponge City' green infrastructure program; or New York City's Central Park, established in year 1857, serve as examples for interventions in future suburban and urban landscapes in the USA, and beyond, that aim for sustainability and resilience.

Part of this agenda can also be locally enforced by private and/or public organizations, such as Homeowners' Association (HOA). These refer to land-use controls and agreements that guide development to comply with environmental regulations and protect natural resources within specific areas. These restrictions are typically established through legal covenants and incorporated into project approvals or community agreements to ensure environmental objectives are met.

Practical application of SES in suburban areas planning could facilitate the monitoring and identification of neighborhood "disturbances" within the SES framework and inform intelligent planning and management approaches to foster sustainable and resilient outer-ring suburbs and regions. The ecosystem services offered by suburban green spaces, along with the resilience they support, can enable communities to better absorb future local and

regional changes, fostering a renewed dynamic equilibrium in response to environmental and social shifts [23].

By taking a proactive approach, urban planners working with local communities can develop adaptive or transformative spatial strategies to restore lost environmental attributes of healthy suburban green areas through both socioeconomic and/or spatial interventions in declining suburbs. At the same time, implementing land-use preservation regulations in stable and growing suburbs can help safeguard existing green coverage and enhance the ecosystem services it provides. Such measures not only aim to restore green areas but also promote additional socioeconomic benefits and stability for local communities.

Research extension and limitations: As a case study this investigation has limited generalization. However, it is plausible that the SES framework and methods applied in this study could yield significant insights in other suburban territories. This type of study would also benefit from higher temporal and geographic resolution in pursuit of more robust statistical models. Availability of yearly socioeconomic and green coverage data in recent years could make this possible. Documenting more spatially disaggregated panel and household-level data would facilitate a more complete Panarchy ensemble that includes parcel-level data and household socioeconomic, cultural, and attitudinal/perceptual factors related to suburban green areas. Likewise, this study did not identify the specific mechanisms and processes that take place in the field behind green coverage loss and/or degradation. Future studies with more resources could address these gaps with field surveys and observations, interviews, and other qualitative methods.

Author Contributions: This article was developed as part of the corresponding author's Ph.D. dissertation under the supervision of L.E.R.-S. The conceptualization, methodology, software development, validation, formal analysis, investigation, resources, data curation, original draft writing, review and editing, visualization, supervision, project administration, and funding acquisition were conducted by F.K., with review and editorial input from L.E.R.-S. All authors have read and agreed to the published version of the manuscript.

Funding: This research is based on my dissertation. I received Clemson University's Graduate School (5713 Graduate School) Doctoral Dissertation Completion Grant 2022–2023 which funded me to complete this research (https://www.clemson.edu/research/division-of-research/resources/r-init-sub-pages/doctoral-dissertation-grant.html, accessed on 17 August 2025). The author was a Ph.D. candidate in the Planning, Design, and Built Environment (PDBE) program, and the co-author served as the supervisor.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are openly available in [Kamyab, Farnaz (2025), "SES Analysis Data", Mendeley Data, V2, doi: 10.17632/2wghjchjnv.2], https://data.mendeley.com/preview/2wghjchjnv?a=1e50dc38-99d8-4c2d-8ae4-bcf0fcd8359c, accessed on 17 August 2025 [Mendeley] [https://data.mendeley.com] [10.17632/2wghjchjnv.2].

Acknowledgments: The authors confirm that they used ChatGPT and Perplexity, AI language models developed by OpenAI and Perplexity AI, Inc. (respectively), for assistance in summarizing and improving readability, grammar, and flow of the manuscript in American English. All content generated by the AI tools was carefully reviewed and edited by the authors to ensure accuracy and compliance with academic standards. All intellectual content and ideas presented are solely those of the authors, and the AI tool was not involved in the generation of ideas or interpretation of results. The final responsibility for the content of this manuscript lies with the authors.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Abbreviations

The following abbreviations are used in this manuscript:

NCI	Neighborhood Change Index
GRN	Green Coverage
SES	Social-Ecological System

Appendix A

Appendix A.1. Suburbs and Green Area Loss and/or Degradation

Table A1. Identified literature gaps in green infrastructure studies-table guide: A = Addressed.

Addressed Gaps Authors	Unit of Analysis	Long-Term Analysis	Drivers/Dynamics	Ecosystem Service/Sustainability	Ownership	Preservation	Policy/Design	Green Economics	Equity/Distribution	Public Perception/Preference	Health andWell-Being
Costanza and Limburg (1997) [86]	Global			A				A			
Ewing (1997) [87]	City		A	A		A	A	A			
Brueckner (2000) [88]	City	A	A	A			A	A			
New Urbanism (2000) [89]	City/Neighborhood			A		A	A	A	A		A
Dunnett et al. (2002) [90]	City			A			A	A	A	A	A
Jim (2000, 2004, 2005) [91–93]	City	A	A	A		A					
Pauleit et al. (2005) [94]	City	A	A	A		A		A			
Kong and Nakagoshi (2006) [95]	City	A						A			
Hope et al. (2006) [96]	City	A	A	A							
Ahern (2007) [97]	Multi-Scale			A					A		
Gill et al. (2007) [98]	City			A		A					
Loram et al. (2007) [99]	Parcel		A	A							
Mell (2008) [100]	Global	A		A		A		A			
McPhearson (2009) [101]	Global	A		A				A			
Smith et al. (2009) [102]	Neighborhood/Parcel		A	A				A	A		
Dale and Newman (2009) [103]	City		A	A				A	A		
Jorgensen and Gobster (2010) [104]	City			A							A
Hanlon, (2010) [105]	Neighborhood	A	A						A		
Hall (2010) [106]	Neighborhood/Parcel	A		A	A			A			
Byrne and Sipe (2010) [107]	City		A	A		A		A			
Chowdhury et al. (2011) [41]	Multi-Scale	A	A					A			
Zhou and Wang (2011) [108]	Global	A		A				A			
Xu et al. (2011, 2018) [7,109]	Regional		A	A		A		A	A		
Wilson and Hughes (2011) [110]	City/Regional	A		A				A			A
Benedict and McMahon (2012, 2002) [8,12]	Global			A		A		A			
Sivam et al. (2012) [111]	Neighborhood	A			A						A
Gupta et al. (2012) [112]	Neighborhood								A		
Coolen and Meesters (2012) [113]	Parcel			A	A					A	
van Heezik et al. (2012) [114]	Parcel			A	A					A	A
Brunner and Cozens (2013) [115]	City	A	A	A		A					
Kabisch and Haase (2013) [116]	City	A	A	A							
Tan et al. (2013) [6]	City	A	A							A	

Table A1. *Cont.*

Addressed Gaps Authors		Unit of Analysis	Long-Term Analysis	Drivers/Dynamics	Ecosystem Service/Sustainability	Ownership	Preservation	Policy/Design	Green Economics	Equity/Distribution	Public Perception/Preference	Health andWell-Being
Müller et al. (2013) [117]	City/Regional		A	A	A							
Colding and Barthel (2013) [118]	City				A	A					A	
Ramos-Santiago et al. (2014) [1]	Neighborhood		A	A	A							
Wolch et al. (2014) [119]	City				A	A						A
Young et al. (2014) [120]	City/Regional									A		
Lin et al. (2015) [121]	Global		A	A	A	A	A					A
Haaland and van Den Bosch (2015) [122]	City		A	A	A	A				A		
Locke and Grove (2016) [123]	City/Global		A	A			A		A		A	
Kanniah (2017) [124]	City		A	A		A						
Chen et al. (2017) [125]	Global		A	A	A							
Nor et al. (2017) [126]	City/Regional		A	A								
Chuang et al. (2017) [127]	Neighborhood				A					A		
Giezen et al. (2018) [128]	City											A
Brooks (2018) [129]	Neighborhood										A	
De Carvalho and Szlafsztein (2019) [130]	City/Global		A	A	A							
Cronin-de-Chavez et al. (2019) [131]	Multi-Scale									A		
Mears and Brindley (2019) [132]	City									A	A	
Sarzynski and Vicino (2019) [133]	Neighborhood		A	A	A							
Lotfata (2021) [134]	City/Regional											
Dinda et al. (2021) [135]	Regional		A	A	A					A		

Appendix A.2. Neighborhood Change Factors

Table A2. Synthesis of academically discussed neighborhood change underlying causes and factors.

Indicator	References	Theoretical Justification
Structure's Aging	Hoover and Vernon [24]; (Schwab [25]; Sternlieb et al. [136]; Choldin et al. [137];	Coming from Life-Cycle Model, neighborhoods have a natural life-cycle. The factor of time and aging—neglected in Burgess model—was reconsidered by Hoover and Vernon in "Anatomy of a metropolis."
Structure's Obsolescence	Grigsby [27]; Sternlieb et al. [136]; Wiechmann and Pallagst [138]; Crump et al. [139]; Raleigh and Galster [140]	Empirically, many depopulated neighborhoods are characterized by high unemployment rates, poverty, and crime rate, and the number increases as the vacancies and abandonment increase. Neighborhoods with a growing number of vacancies are described with visible symptoms of urban decline.
Mobility Rate	Downs [47]; Speare et al. [141]; Choldin et al. [137]; Varardy [142]; [1] Newman and Duncan [143]	Housing and neighborhood quality are highly correlated. An inadequate residential environment decreases neighborhood satisfaction. The inadequacy of dwellings and the surrounding neighborhoods has been shown to have a significant role in encouraging residents to move to a better place, which exacerbates the deterioration of the environment. The arbitrage model describes neighborhood change with mobility.

Table A2. *Cont.*

Indicator	References	Theoretical Justification
Home Foreclosure Rate	Williams et al. [144]; Baxter and Lauria [145]	Home foreclosure can be the result of an unexpected tension in the household's income level (due to layoffs) or the out-migration of the residents due to the deterioration of the ratio between the value of the mortgage and the market value of the home. The consequences of an increase in home foreclosure (racial/economic transition) will bring lots of changes to the neighborhoods.
Crime Rate	Golash-Boza and Oh [67]; Raleigh and Galster [140]; Skogan, [146]; Taylor [147]	The increase in crime rate is either caused by a change in racial composition or depopulation, and disinvestment decreases the neighborhood's desirability. It can also result in a drop in property stocks. Depopulated and abandoned spaces within the neighborhood provide cover for criminal and illegal activities.
Home Ownership Rate	Solomon and Vandell [148]; Smith [74]; Sternlieb et al. [136]; Delmelle and Thill [149]	Home ownership status is linked to neighborhood change through behavioral logic. High desirability of ownership means more families consider the property a capital asset. With the hope of economic returns, landlords tend to improve their environment, look for compatible neighbors, and their tenure tends to be longer. In return, renters are less committed to the property and reluctant to the social/racial composition of the neighborhood.
Individual Satisfaction/Participation	Miller et al. [150]; Temkin and Rohe [151]; Varardy [142]; Schwab [25]; Berger and Neuhaus [152]; Speare et al. [141]; Newman and Duncan [143]	Individuals' preference is a critical factor of neighborhood change. Residents' satisfaction determines the stability of the neighborhood against the external/internal stimulus of change.
Neighborhood Social Capital	Kruger et al. [153]; Oakerson and Clifton [154]	The neighborhood is in the common interest of its residents. The stronger the community bonding gets, the better the resiliency of the neighborhood is ensured. Residents can be an internally driven, self-reinforcing dynamic of change who can determine the process of neighborhood change through their collective actions.
Urban Service Status	Sternlieb et al. [136]; Varady [142]; Hanlon [105]	Urban facilities' excellence is the factor of comfort for the residents and is also an element of economic revenue for the industries. The spatial proximity of employment centers has significant effects on neighborhoods' change cycle.
Racial Composition/Segregation	Sternlieb et al. [136]; Varady [142]; Lucy and Phillips [155]; Hill [156]; Bailey [157]; Baxter and Lauria [145]; Grigsby [27]	Considering the vivid tendency of the white population to maintain separatist behavior against other races in the US, the concept of racial composition plays a critical role in the analysis of neighborhoods in this country. There is evidence both for and against racial diversity and its effects on the decline/improvement of neighborhoods.
Reginal Market	Solomon and Vandell [148]; Schwab [25]; Cooke and Marchant [158]; Baxter and Lauria [145]	The property value of a neighborhood depends highly on the regional land market. The geographical distribution of wealth and investment determines the neighborhoods' future changes in the region. Filtering models describe neighborhood shifts as a result of owner decisions, which essentially influence the attractiveness of the rental market of a city compared to the newly constructed housing stock.
Land-Use/Price Change	Aitken [159]	Besides taking land-use changes as the consequence of decline/improvement in urban areas, the desirability of a neighborhood is shown to be associated with the impact of land-use changes on the residents' satisfaction and preferences. The property value is a game-changing factor in directing the neighborhood change. The home value is an indicator of the socioeconomic characteristics of the residents.

Table A2. *Cont.*

Indicator	References	Theoretical Justification
Place Attachment	Saegert [160]	Residents' bonding with the social and physical settings of their neighborhoods is critical in maintaining resiliency. Place attachment focuses on the percentual aspect of social capital.
Neighborhood Economic Conditions	Delmelle and Thill [149]; Varady [142]; Hanlon, [105]; Farley [161]; Goodall [30]; Fishman [162]; Grigsby [27]	The neighborhood's median income level, home value, and gross rent determine all types of present and future investments/disinvestments in the neighborhoods. Neighborhood change cycles have been studied with a political economic approach in the literature of neighborhood change. This approach regards towns as growth machines, where regional policies on the market tend to profit from unregulated economic growth, and the benefits of development do not evenly distribute within social classes.
Maintenance Level	Smith [74]; Goodall [30]	Neighborhood change is a gradual spatial transformation of the environment. Constant maintenance is a crucial component of stable and resilient neighborhoods, presenting collective efforts to protect the neighborhood against aging.
Housing Problems	Speare et al. [141]; Newman and Duncan [143]; Varady [163]	The level of upkeep is determined by a logistic evaluation of landlords expecting to get an economic return. In the lack of those financial benefits of preservations, some housing problems caused by aging will remain unsettled and reduce the dwellings' quality.
Residents' Health Status	Varady [163]; Barrett et al. [164]; Narita et al. [165]; Kruger et al. [153]	Change is inherently a stressor. A declining neighborhood affects residents psychologically. Local health records can be interpreted as an indication of neighborhood decline in certain circumstances.
Educational Attainment Rate	Quercia and Galster [166]; Nilsson and Delmelle [167]	Attaining education requires specific financial/conceptual capital. Educated residents demand higher-income jobs; they present higher expectations for living quality. High-tech employment centers' locations are correlated with the neighborhoods that highly educated employees choose to reside in.
Urban Development Policies	Varardy [142]; Temkin and Rohe [151]	Urban growth in the dynamic of funds and resources distribution. Policies and plans direct urban expansion. Conventionally, urban policy is considered a top-down measurement. However, development can be bottom-up conducted. Local growth control initiatives are one tool used by citizens to slow down growth
Household Characteristics	Temkin and Rohe [151]; Sternlieb et al. [136]	Households' choices and preferences determine a neighborhood's transformations. Within the traditional economic theory, individuals are regarded as logistic system components. Confident choices/preferences are shown to be associated with particular characteristics, which results in neighborhood transitions.
Employment and Job	Quercia and Galster [166]; Baum-Snow and Hartley [168]	The spatial location of employment activities is the driving force shaping and urban conditioning growth
Demographic Characteristics	Hanlon [105]; Sternlieb et al. [136]; Baum-Snow and Hartley [169]	Population age and gender composition, ethnicity, length of the resident ship, career, and bindings are the demographic aspects that determine the residents' influence on their surrounding environment.

Appendix A.3. Neighborhood Change Models

Neighborhood change models are essential in city planning, real estate, and urban economics literature. Three primary models have dominated the discourse: the invasion-succession model [170], the filtering model [171], and the life-cycle model [24]. These models incorporate perspectives from human ecology, sociology, economics, and political economy to explain neighborhood dynamics and transitions, and have been adapted to re-

flect recent trends in multi-ethnic communities [172,173]. Urban blight, a common outcome of neighborhood decline, often leads to abandonment and the accumulation of negative externalities at both local and regional levels, contributing to broader urban degradation [30,74,172]. Key socioeconomic and physical factors identified from the Neighborhood Change literature were extracted for this study and are listed in Table 3.

Table A3. Potential neighborhood change factors.

Neighborhood Change Schools	Developed Models	Assumptions	Influential Socioeconomic Factors
Ecological School	Filtering Model; Life-Cycle Model; Arbitrage Model; and Composition Model	Decision made by landlord	Institutional policies; residents' satisfaction [151] Maintenance failure; land-use changes; transition to lower-income occupancy in adjacent or nearby neighborhoods; obsolete structures; Segregation; Housing abandonment [26,47,174] Cycle of change [24] Cycle of ownership and maintenance [74] Background characteristic of neighborhood; Existing housing problems; Mobility rate [141] Demographic characteristics; Housing and community problems [142,143] Family income. Education; Age; Race; Female headed household; Single male household; Duration of residence at location; Housing costs to income ratio; Ownership. Public housing; Rental subsidy; Housing problems; Public service deficiencies; Community crisis; Development typology; Persons per room; Age of dwelling unit; SMSA (Standard Metropolitan Statistical Area) size; Geography of context (Northeast vs. South vs. West); Resident dissatisfaction. [142] Building age; Household preference; Surrounding neighborhoods [25] Residents' participation [152] Space quality; Privacy; Accessibility; Prestige values (attractors of suburbs) [30] Income level; Population growth; Fiscal distress; Provision of standardized public schools; Governmental aid [105] Housing aging [137] Adjacent neighborhoods with raising poverty [158] Age; Class; Gender balance; Education; Cultural norms; Membership to certain social taxonomy [175]
Subcultural School	Bid Rent and Border Model	Consumer Decisions	Confidence in the future of the area; Residential mobility; House repair activity; Neighborhood cohesiveness; Local social interaction; Resident perceptions [142] Initial status of the first residents [161] Residents' perceptions Neighborhood maturation [151] Residents satisfaction [141] Residents satisfaction; Moving intentions; Mobility behavior [143] Residents satisfaction; Moving plans [163] Individual preferences [39] Desirability of residents for maintenance [30] Intentions for segregation among affluent families [156] Increase in African American population [155] Social order; Ownership and its organizational structure; Access to and control of the land; Financial resources and social dynamics; Knowledge [176]
Political Economy	Neo Marxist	Exchange value of land	Metropolitan area characteristics (social, political, economic) [151] Withdrawal of a key local institution; Large increase in property taxes; Declining public service [174] Value of a property; Income level [30] House as an investment [162]

Appendix A.4. Case-Sampling and Study Delimitation

Table A4. Commuter travel time to work—workers age 16+ who did not work at home. Source: U.S. Census Bureau.

Travel Time to Work	2021		2020		2010	
	Percent	Cumulative Precent	Percent	Cumulative Precent	Percent	Cumulative Precent
Less than 5 min	1.23%	1.23%	1.20%	1.20%	1.60%	1.60%
5 to 9 min	5.42%	6.65%	5.40%	6.60%	7.10%	8.70%
10 to 14 min	10.20%	16.85%	10.10%	16.70%	11.60%	20.30%
15 to 19 min	13.58%	30.43%	13.40%	30.10%	14.00%	34.30%
20 to 24 min	13.55%	43.98%	13.40%	43.50%	14.20%	48.50%
25 to 29 min	5.68%	49.66%	5.50%	49.00%	5.50%	54.00%
30 to 34 min	17.71%	67.37%	17.60%	66.60%	17.30%	71.30%
35 to 39 min	2.97%	70.34%	2.90%	69.50%	2.70%	74.00%
40 to 44 min	5.16%	75.50%	5.20%	74.70%	4.80%	78.80%
45 to 59 min	10.45%	85.95%	10.80%	85.50%	9.30%	88.10%
60 to 89 min	10.25%	96.20%	10.60%	96.10%	8.70%	96.80%
90 or more min	3.80%	100.00%	4.00%	100.10%	3.00%	99.80%

Appendix A.5. Models 1 and 2: Hypothesis Testing

Model 1 and Model 2 implement longitudinal ordinal mixed-effects probability model (Equation (A1)).

For set of fixed effects x_{ij}, a set of cut points κ, and a set of random effects u_j, the cumulative probability of the response being in a category higher than *k* is:

$$\Pr\left(y_{ij} > k \mid x_{ij}, \kappa, uj\right) = \Phi(x_{ij}\beta + z_{ij}u_j - \kappa_k)], \quad \text{(A1)}$$

where

φ (.) represents the cumulative standard normal density function.

β is regression coefficients for fixed effect.

The $1 \times q$ vector z_{ij} are the covariates corresponding to the random effects and can be used to represent both random intercepts and random coefficients [177].

Appendix A.6. Models 3, 4, and 5: Identifying Key Factors of Neighborhood Change on Suburban Green Health

Models 3 and 4 regressed key explanatory variables from the set of neighborhoods change factors identified in the life-cycle model literature (Equation (A2)).

$$y = X\beta + Zu + \xi, \quad \text{(A2)}$$

where y is the $n \times 1$ vector of responses, X is an $n \times p$ design/covariate matrix for the fixed effects β, and Z is the $n \times q$ design/covariate matrix for the random effects u. The $n \times 1$ vector of errors ξ is assumed to be multivariate normal with mean 0.

This methodological approach allows for a comprehensive analysis at the intersection between neighborhood dynamics and green coverage and/or degradation, while considering county-level policies, ecological factors, and time as random factors.

References

1. Ramos-Santiago, L.E.; Villanueva-Cubero, L.; Santiago-Acevedo, L.E.; Rodriguez-Melendez, Y.N. Green area loss in San Juan's inner-ring suburban neighborhoods: A multidisciplinary approach to analyzing green/gray area dynamics. *Ecol. Soc.* **2014**, *19*, art4.
2. Newman, G.; Lee, R.J.; Gu, D.; Park, Y.; Saginor, J.; Van Zandt, S.; Li, W. Evaluating drivers of housing vacancy: A longitudinal analysis of large US cities from 1960 to 2010. *J. Hous. Built Environ.* **2019**, *34*, 807–827. [CrossRef] [PubMed]
3. Noh, Y.; Newman, G.; Lee, R.J. Urban decline and residential preference: The effect of vacant lots on housing premiums. *Environ. Plan B Urban Anal. City Sci.* **2021**, *48*, 1667–1683.
4. Bolitzer, B.; Netusil, N.R. The impact of open spaces on property values in Portland, Oregon. *J. Environ. Manag.* **2000**, *59*, 185–193. [CrossRef]
5. Kimpton, A.; Corcoran, J.; Wickes, R. Greenspace and crime: An analysis of greenspace types, neighboring composition, and the temporal dimensions of crime. *J. Res. Crime Delinq.* **2017**, *54*, 303–337. [CrossRef]
6. Tan, P.Y.; Wang, J.; Sia, A. Perspectives on five decades of the urban greening of Singapore. *Cities* **2013**, *32*, 24–32. [CrossRef]
7. Xu, X.; Duan, X.; Sun, H.; Sun, Q. Green space changes and planning in the capital region of China. *Environ. Manag.* **2011**, *47*, 456–467. [CrossRef]
8. Benedict, M.A.; McMahon, E.T. Green infrastructure: Smart conservation for the 21st century. *Renew. Resour. J.* **2002**, *20*, 12–17.
9. Locke, D.H.; Hall, B.; Grove, J.M.; Pickett, S.T.; Ogden, L.A.; Aoki, C.; Boone, C.G.; O'Neil-Dunne, J.P.M. Residential housing segregation and urban tree canopy in 37 US Cities. *npj Urban Sustain.* **2021**, *1*, 15.
10. Berkes, F.; Folke, C. Linking social and ecological systems for resilience and sustainability. In *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*; Cambridge University Press: Cambridge, UK, 1998; Volume 1, p. 4.
11. Gunderson, L.H.; Holling, C.S. *Panarchy: Understanding Transformations in Human and Natural Systems*; Island Press: Washington, DC, USA, 2002.
12. Benedict, M.A.; McMahon, E.T. *Green Infrastructure: Linking Landscapes and Communities*; Island Press: Washington, DC, USA, 2012.
13. McGranahan, G.; Schensul, D.; Singh, G. Inclusive urbanization: Can the 2030 Agenda be delivered without it? *Environ. Urban.* **2016**, *28*, 13–34. [CrossRef]
14. Fahrig, L. Ecological responses to habitat fragmentation per se. *Annu. Rev. Ecol. Evol. Syst.* **2017**, *48*, 1–23. [CrossRef]
15. Gómez-Baggethun, E.; Barton, D.N. Classifying and valuing ecosystem services for urban planning. *Ecol. Econ.* **2013**, *86*, 235–245. [CrossRef]
16. Wu, S.; Li, S. Ecosystem service relationships: Formation and recommended approaches from a systematic review. *Ecol. Indic.* **2019**, *99*, 1–11. [CrossRef]
17. Hagan, S. *Ecological Urbanism: The Nature of the City*; Routledge: Milton Park, UK, 2014.
18. Wilson, B.; Chakraborty, A. The environmental impacts of sprawl: Emergent themes from the past decade of planning research. *Sustainability* **2013**, *5*, 3302–3327. [CrossRef]
19. James, P.; Tzoulas, K.; Adams, M.; Barber, A.; Box, J.; Breuste, J.; Elmqvist, T.; Frith, M.; Gordon, C.; Greening, K.; et al. Towards an integrated understanding of green space in the European built environment. *Urban For. Urban Green.* **2009**, *8*, 65–75. [CrossRef]
20. Meléndez-Ackerman, E.; Nytch, C.; Santiago-Acevedo, L.; Verdejo-Ortiz, J.; Santiago-Bartolomei, R.; Ramos-Santiago, L.; Muñoz-Erickson, T.A. Synthesis of Household Yard Area Dynamics in the City of San Juan Using Multi-Scalar Social-Ecological Perspectives. *Sustainability* **2016**, *8*, 481. [CrossRef]
21. Boulding, K.E. General Systems Theory-The Skeleton of Science. *Manag. Sci.* **1956**, *2*, 197–208. [CrossRef]
22. Homer-Dixon, T.F. On the threshold: Environmental changes as causes of acute conflict. *Int. Secur.* **1991**, *16*, 76–116. [CrossRef]
23. Gunderson, L.; Kinzig, A.; Quinlan, A.R. *Assessing Resilience in Social-Ecological Systems: Workbook for Practitioners*; Resilience Alliance: Wolfville, NS, Canada, 2010.
24. Hoover, E.M.; Vernon, R. *Anatomy of a Metropolis: The Changing Distribution of People and Jobs Within the New York Metropolitan Region*; Harvard University Press: Cambridge, MA, USA, 1959.
25. Schwab, W.A. The predictive value of three ecological models: A test of the life-cycle, arbitrage, and composition models of neighborhood change. *Urban Aff. Q.* **1987**, *23*, 295–308. [CrossRef]
26. Downs, A. *Neighborhoods and Urban Development*; Brookings Institution Press: Washington, DC, USA, 2010.
27. Grigsby, W. *The Dynamics of Neighborhood Change and Decline*; University of Pennsylvania: Philadelphia, PA, USA, 1986.
28. Wilson-Doenges, G. *Confronting Suburban Decline: Strategic Planning for Metropolitan Renewal*; Island Press: Washington, DC, USA, 2002.
29. Campanella, T.J. Jane Jacobs and the death and life of American planning. In *Reconsidering Jane Jacobs*; Routledge: Milton Park, UK, 2017; pp. 141–179.
30. Goodall, B. *The Economics of Urban Areas*, 1st ed.; Pergamon Press: Oxford, NY, USA, 1972; p. 379.

31. Birch, D.L. Toward a stage theory of urban growth. *J. Am. Inst. Plann.* **1971**, *37*, 78–87. [CrossRef]
32. Frantzeskaki, N.; Kabisch, N.; McPhearson, T. Advancing urban environmental governance: Understanding theories, practices and processes shaping urban sustainability and resilience. *Environ. Sci. Policy* **2016**, *62*, 1–6. [CrossRef]
33. Daniel, C.; Morrison, T.H.; Phinn, S. The governance of private residential land in cities and spatial effects on tree cover. *Environ. Sci. Policy* **2016**, *62*, 79–89. [CrossRef]
34. McGinnis, M.D.; Ostrom, E. Social-ecological system framework: Initial changes and continuing challenges. *Ecol. Soc.* **2014**, *19*, 30. [CrossRef]
35. Ali, L.; Haase, A.; Heiland, S. Gentrification through Green Regeneration? Analyzing the Interaction between Inner-City Green Space Development and Neighborhood Change in the Context of Regrowth: The Case of Lene-Voigt-Park in Leipzig, Eastern Germany. *Land* **2020**, *9*, 24. [CrossRef]
36. Shandas, V. Neighborhood change and the role of environmental stewardship: A case study of green infrastructure for stormwater in the City of Portland, Oregon, USA. *Ecol. Soc.* **2015**, *20*, 16. [CrossRef]
37. Sugiyama, T.; Giles-Corti, B.; Summers, J.; Toit, L.; Leslie, E.; Owen, N. Initiating and maintaining recreational walking: A longitudinal study on the influence of neighborhood green space. *Prev. Med.* **2013**, *57*, 178–182. [CrossRef]
38. Jennings, V.; Larson, L.; Yun, J. Advancing sustainability through urban green space: Cultural ecosystem services, equity, and social determinants of health. *Int. J. Environ. Res. Public Health* **2016**, *13*, 196. [CrossRef]
39. Larson, K.L.; Casagrande, D.; Harlan, S.L.; Yabiku, S.T. Residents' yard choices and rationales in a desert city: Social priorities, ecological impacts, and decision tradeoffs. *Environ. Manag.* **2009**, *44*, 921. [CrossRef]
40. Roy Chowdhury, R.; Larson, K.; Grove, M.; Polsky, C.; Cook, E.; Onsted, J.; Ogden, L. A multi-scalar approach to theorizing socio-ecological dynamics of urban residential landscapes. *Cities Environ. CATE* **2011**, *4*, 6.
41. Cilliers, S. Social aspects of urban biodiversity—An overview. In *Urban Biodiversity and Design*; John Wiley & Sons: Hoboken, NJ, USA, 2010; pp. 81–100.
42. Knox, P.L. The restless urban landscape: Economic and sociocultural change and the transformation of metropolitan Washington, DC. *Ann. Assoc. Am. Geogr.* **1991**, *81*, 181–209. [CrossRef]
43. Hostetler, M. *The Green Leap: A Primer for Conserving Biodiversity in Subdivision Development*; University of California Press: Oakland, CA, USA, 2012.
44. Krim, A. Los Angeles and the anti-tradition of the suburban city. *J. Hist. Geogr.* **1992**, *18*, 121–138. [CrossRef]
45. Giuliano, G.; Small, K.A. Subcenters in the Los Angeles region. *Reg. Sci. Urban Econ.* **1991**, *21*, 163–182. [CrossRef]
46. Hu, L. Changing effects of job accessibility on employment and commute: A case study of Los Angeles. *Prof. Geogr.* **2015**, *67*, 154–165. [CrossRef]
47. Downs, A. Some realities about sprawl and urban decline. *Hous. Policy Debate* **1999**, *10*, 955–974. [CrossRef]
48. Green Leigh, N.; Lee, S. Philadelphia's space in between: Inner-ring suburb evolution. *Opolis* **2005**, *1*, 13–32.
49. Hanlon, B. A Typology of Inner–Ring Suburbs: Class, Race, and Ethnicity in US Suburbia. *City Community* **2009**, *8*, 221–246. [CrossRef]
50. ESRI. ESRI Data. Redlands (CA): Environmental Systems Research Institute; 2023. Vintage 2022, 2027. Available online: https://doc.arcgis.com/en/community-analyst/help/create-infographics-and-reports.htm (accessed on 20 September 2025).
51. Brown, J.; NDVI, The Foundation for Remote Sensing Phenology | US. Geological Survey. 2018. Available online: https://www.usgs.gov/special-topics/remote-sensing-phenology/science/ndvi-foundation-remote-sensing-phenology (accessed on 2 January 2023).
52. Morris, T.R. *The Climate of Los Angeles, California*; National Weather Service, Los Angeles/Oxnard: Los Angeles, CA, USA, 2006.
53. Garcia, I. The Socioeconomic Change of Chicago's Community Areas (1970–2010). 2014. Available online: https://voorheescenter.red.uic.edu/wp-content/uploads/sites/122/2017/10/Voorhees-Center-Gentrification-Index-Oct-14.pdf- (accessed on 11 January 2022).
54. Seymour, D.B.; Calculating Decadal Growth Rate. OC Research. 2004. Available online: https://www.ocresearch.info/sites/default/files/DGR%20Equations.pdf (accessed on 2 January 2023).
55. Brown, V.A. An introduction to linear mixed-effects modeling in R. *Adv. Methods Pract. Psychol. Sci.* **2021**, *4*, 2515245920960351. [CrossRef]
56. Harrison, X.A.; Donaldson, L.; Correa-Cano, M.E.; Evans, J.; Fisher, D.N.; Goodwin, C.E.; Robinson, B.S.; Hodgson, D.J.; Inger, R. A brief introduction to mixed effects modelling and multi-model inference in ecology. *PeerJ* **2018**, *6*, e4794. [CrossRef]
57. Levy, D.K.; McDade, Z.; Dumlao, K. *Effects from Living in Mixed-Income Communities for Low-Income Families*; Urban Institute: Washington, DC, USA, 2010.
58. Baca, A.; McAnaney, P.; Schuetz, J. Gentle Density Can Save Our Neighborhoods. 2019. Available online: https://policycommons.net/artifacts/4141232/gentle-density-can-save-our-neighborhoods/4950454/ (accessed on 17 October 2024).

59. Kitchen, P.; Williams, A.M.; Gallina, M. Sense of belonging to local community in small-to-medium sized Canadian urban areas: A comparison of immigrant and Canadian-born residents. *BMC Psychol.* **2015**, *3*, 28. [CrossRef]
60. Ceccato, V.; Canabarro, A.; Vazquez, L. Do green areas affect crime and safety? In *Crime and Fear in Public Places*; Routledge: Milton Park, UK, 2020; pp. 75–107.
61. Raphael, S.; Winter-Ebmer, R. Identifying the effect of unemployment on crime. *J. Law Econ.* **2001**, *44*, 259–283. [CrossRef]
62. Aaltonen, M.; Macdonald, J.M.; Martikainen, P.; Kivivuori, J. Examining the generality of the unemployment–crime association. *Criminology* **2013**, *51*, 561–594. [CrossRef]
63. Cantor, D.; Land, K.C. Unemployment and crime rates in the post-World War II United States: A theoretical and empirical analysis. *Am. Sociol. Rev.* **1985**, *50*, 317–332. [CrossRef]
64. Schleimer, J.P.; Pear, V.A.; McCort, C.D.; Shev, A.B.; De Biasi, A.; Tomsich, E.; Buggs, S.; Laqueur, H.S.; Wintemute, G.J. Unemployment and crime in US cities during the coronavirus pandemic. *J. Urban Health* **2022**, *99*, 82–91. [CrossRef] [PubMed]
65. Britto, D.G.; Pinotti, P.; Sampaio, B. The effect of job loss and unemployment insurance on crime in Brazil. *Econometrica* **2022**, *90*, 1393–1423. [CrossRef]
66. Boessen, A.; Chamberlain, A.W. Neighborhood crime, the housing crisis, and geographic space: Disentangling the consequences of foreclosure and vacancy. *J. Urban Aff.* **2017**, *39*, 1122–1137. [CrossRef]
67. Golash-Boza, T.; Oh, H. Crime and Neighborhood Change in the Nation's Capital: From Disinvestment to Gentrification. *Crime Delinq.* **2021**, *67*, 00111287211005394. [CrossRef]
68. Harrell, A.V. *Predicting Neighborhood Risk of Crime*; US Department of Justice: Washington, DC, USA, 1994.
69. Chapman, R.; Foderaro, L.; Hwang, L.; Lee, B.; Muqueeth, S.; Sargent, J.; Shane, B. *Parks and an Equitable Recovery*; Trust for Public Land: San Francisco, CA, USA, 2021.
70. Farrell, C.R.; Lee, B.A. Racial diversity and change in metropolitan neighborhoods. *Soc. Sci. Res.* **2011**, *40*, 1108–1123. [CrossRef]
71. Olzak, S.; Shanahan, S.; McEneaney, E.H. Poverty, segregation, and race riots: 1960 to 1993. *Am. Sociol. Rev.* **1996**, *61*, 590–613. [CrossRef]
72. Orfield, M.; Luce, T.F. America's racially diverse suburbs: Opportunities and challenges. *Hous. Policy Debate* **2013**, *23*, 395–430. [CrossRef]
73. Lowry, I.S. Filtering and Housing Standards: A Conceptual Analysis. *Land Econ.* **1960**, *36*, 362. [CrossRef]
74. Smith, N. Toward a Theory of Gentrification A Back to the City Movement by Capital, not People. *J. Am. Plann. Assoc.* **1979**, *45*, 538–548. [CrossRef]
75. Crewe, S.E. Aging and gentrification: The urban experience. *Urban Soc. Work.* **2017**, *1*, 53–64. [CrossRef]
76. Langendoerfer, K. I Never Thought About Leaving: Why Residents Aged in Place Within Neighborhoods Experiencing Urban Decline. *Innov. Aging* **2020**, *4*, 483. [CrossRef]
77. Ramirez Lopez, L.J.; Grijalba Castro, A.I. Sustainability and resilience in smart city planning: A review. *Sustainability* **2020**, *13*, 181. [CrossRef]
78. Baasch, A.; Kirmer, A.; Tischew, S. Nine years of vegetation development in a postmining site: Effects of spontaneous and assisted site recovery. *J. Appl. Ecol.* **2012**, *49*, 251–260. [CrossRef]
79. Cleary, B.D. *Vegetation Management and Its Importance in Reforestation*; Oregon State University: Corvallis, OR, USA, 1978.
80. Dempsey, C. Chaparral in California. 2024. Available online: https://www.geographyrealm.com/chaparral-california/ (accessed on 5 January 2025).
81. Scholes, R.J.; Reyers, B.; Biggs, R.; Spierenburg, M.; Duriappah, A. Multi-scale and cross-scale assessments of social–ecological systems and their ecosystem services. *Curr. Opin. Environ. Sustain.* **2013**, *5*, 16–25. [CrossRef]
82. New York State Department of State. Transfer of Development Rights. Available online: https://dos.ny.gov/transfer-development-rights-0 (accessed on 5 January 2025).
83. Girling, C.L.; Helphand, K.I. *Yard, Street, Park: The Design of Suburban Open Space*; John Wiley & Sons: Hoboken, NJ, USA, 1996.
84. Mc Harg, I. The ecology of the city. *J. Archit. Educ.* **1962**, *17*, 101–103. [CrossRef]
85. Delafons, P. *The New Urbanism: Toward an Architecture of Community*; Peter Katz McGraw-Hill: New York, NY, USA, 1994.
86. Costanza, R.; Limburg, K. *The Value of the World's Ecosystem*; Elsevier: Amsterdam, The Netherlands, 1998.
87. Ewing, R. Is Los Angeles-style sprawl desirable? *J. Am. Plann. Assoc.* **1997**, *63*, 107–126. [CrossRef]
88. Brueckner, J.K. Urban Sprawl: Diagnosis and Remedies. *Int. Reg. Sci. Rev.* **2000**, *23*, 160–171. [CrossRef]
89. Congress for the New Urbanism. Charter of the new urbanism. *Bull. Sci. Technol. Soc.* **2000**, *20*, 339–341. [CrossRef]
90. Dunnett, N.; Swanwick, C.; Woolley, H. *Improving Urban Parks, Play Areas and Green Spaces*; Department for Transport, Local Government and the Regions London: London, UK, 2002.
91. Jim, C.Y. Monitoring the performance and decline of heritage trees in urban Hong Kong. *J. Environ. Manag.* **2005**, *74*, 161–172. [CrossRef]
92. Jim, C.Y. Green-space preservation and allocation for sustainable greening of compact cities. *Cities* **2004**, *21*, 311–320. [CrossRef]

93. Jim, C.Y. The urban forestry programme in the heavily built-up milieu of Hong Kong. *Cities* **2000**, *17*, 271–283. [CrossRef]
94. Pauleit, S.; Ennos, R.; Golding, Y. Modeling the environmental impacts of urban land use and land cover change—A study in Merseyside, UK. *Landsc. Urban Plan.* **2005**, *71*, 295–310. [CrossRef]
95. Kong, F.; Nakagoshi, N. Spatial-temporal gradient analysis of urban green spaces in Jinan, China. *Landsc. Urban Plan.* **2006**, *78*, 147–164. [CrossRef]
96. Hope, D.; Gries, C.; Casagrande, D.; Redman, C.L.; Grimm, N.B.; Martin, C. Drivers of spatial variation in plant diversity across the Central Arizona-Phoenix ecosystem. *Soc. Nat. Resour.* **2006**, *19*, 101–116. [CrossRef]
97. Ahern, J. Green infrastructure for cities: The spatial dimension. In *Cities of the Future: Towards Integrated Sustainable Water and Landscape Management*; IWA Publishing: London, UK, 2007; pp. 267–283.
98. Gill, S.E.; Handley, J.F.; Ennos, A.R.; Pauleit, S. Adapting cities for climate change: The role of the green infrastructure. *Built. Environ.* **2007**, *33*, 115–133. [CrossRef]
99. Loram, A.; Tratalos, J.; Warren, P.H.; Gaston, K.J. Urban domestic gardens (X): The extent & structure of the resource in five major cities. *Landsc. Ecol.* **2007**, *22*, 601–615. [CrossRef]
100. Mell, I.C. Green infrastructure: Concepts and planning. *FORUM Ejournal* **2008**, *8*, 69–80.
101. McPhearson, P.T. Solving the Environmental Crisis with a Tree? *E SAY* **2009**, *6*. Available online: https://d1wqtxts1xzle7.cloudfront.net/52089483/Solving_the_Environmental_Crisis_with_a_20170309-15569-u1ihyd-libre.pdf?1489076249=&response-content-disposition=inline%3B+filename%3DSolving_the_Environmental_Crisis_with_a.pdf&Expires=1761579036&Signature=BM82FzeJ~mFQfymKhr9LCsxOOKIhaWYyU865ed9pCjrS~QFVaa-hr8ThwA9QPQqdE6vFgPQZP4LKp5YAuuDO8JrwJccWXArNjqKS8MTacCaBfaoqeJktNCFUYfjeMNBuyHa5ovlUKbS7OFK3Swl1dayPoYHBtbjxS~hJdeQluYQ6pTXBAbK~NkjzvOB8J6q~dpoCaijZgrrpulkT07tuBftA-f1GVcwgw~O9m4B5I7K6jlHag6BZWq-xKL1AZq2fGs6Oz4grCrpCC4hPRbrz-o-tSdetm-o3GUbZbYuYpn9PMD5-qFcIBj22ERNz8dHAEn3i4aBGhzDaynRGUaqSaw__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA (accessed on 17 August 2025).
102. Smith, C.; Clayden, A.; Dunnett, N. An exploration of the effect of housing unit density on aspects of residential landscape sustainability in England. *J. Urban Des.* **2009**, *14*, 163–187. [CrossRef]
103. Dale, A.; Newman, L.L. Sustainable development for some: Green urban development and affordability. *Local Environ.* **2009**, *14*, 669–681. [CrossRef]
104. Jorgensen, A.; Gobster, P.H. Shades of Green: Measuring the Ecology of Urban Green Space in the Context of Human Health and Well-Being. *Nat. Cult.* **2010**, *5*, 338–363. [CrossRef]
105. Hanlon, B. *Once the American Dream: Inner-Ring Suburbs of the Metropolitan United States*; Temple University Press: Philadelphia, PA, USA, 2010; p. 203.
106. Hall, T. Goodbye to the backyard?—The minimisation of private open space in the Australian outer-suburban estate. *Urban Policy Res.* **2010**, *28*, 411–433. [CrossRef]
107. Byrne, J.; Sipe, N. Green and Open Space Planning for Urban Consolidation—A Review of the Literature and Best Practice. 2010. Available online: https://research-repository.griffith.edu.au/server/api/core/bitstreams/60289e60-4b96-5c4b-99de-d39d2c8db305/content (accessed on 17 August 2025).
108. Zhou, X.; Wang, Y.C. Spatial–temporal dynamics of urban green space in response to rapid urbanization and greening policies. *Landsc. Urban Plan.* **2011**, *100*, 268–277. [CrossRef]
109. Xu, C.; Haase, D.; Pauleit, S. The impact of different urban dynamics on green space availability: A multiple scenario modeling approach for the region of Munich, Germany. *Ecol. Indic.* **2018**, *93*, 1–12. [CrossRef]
110. Wilson, O.; Hughes, O. Urban green space policy and discourse in England under New Labour from 1997 to 2010. *Plan Pract. Res.* **2011**, *26*, 207–228. [CrossRef]
111. Sivam, A.; Karuppannan, S.; Mobbs, M. How "open" are open spaces: Evaluating transformation of open space at residential level in Adelaide—A case study. *Local Environ.* **2012**, *17*, 815–836. [CrossRef]
112. Gupta, K.; Kumar, P.; Pathan, S.K.; Sharma, K.P. Urban Neighborhood Green Index—A measure of green spaces in urban areas. *Landsc. Urban Plan.* **2012**, *105*, 325–335. [CrossRef]
113. Coolen, H.; Meesters, J. Private and public green spaces: Meaningful but different settings. *J. Hous. Built. Environ.* **2012**, *27*, 49–67. [CrossRef]
114. van Heezik, Y.M.; Dickinson, K.J.; Freeman, C. Closing the gap: Communicating to change gardening practices in support of native biodiversity in urban private gardens. *Ecol. Soc.* **2012**, *17*, 34. [CrossRef]
115. Brunner, J.; Cozens, P. 'Where have all the trees gone?'Urban consolidation and the demise of urban vegetation: A case study from Western Australia. *Plan Pract. Res.* **2013**, *28*, 231–255. [CrossRef]
116. Kabisch, N.; Haase, D. Green spaces of European cities revisited for 1990–2006. *Landsc. Urban Plan.* **2013**, *110*, 113–122. [CrossRef]

117. Müller, N.; Ignatieva, M.; Nilon, C.H.; Werner, P.; Zipperer, W.C. Patterns and trends in urban biodiversity and landscape design. In *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities*; Springer: Dordrecht, The Netherlands, 2013; pp. 123–174.
118. Colding, J.; Barthel, S. The potential of 'Urban Green Commons' in the resilience building of cities. *Ecol. Econ.* **2013**, *86*, 156–166. [CrossRef]
119. Wolch, J.R.; Byrne, J.; Newell, J.P. Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough. *Landsc. Urban Plan.* **2014**, *125*, 234–244. [CrossRef]
120. Young, R.; Zanders, J.; Lieberknecht, K.; Fassman-Beck, E. A comprehensive typology for mainstreaming urban green infrastructure. *J. Hydrol.* **2014**, *519*, 2571–2583. [CrossRef]
121. Lin, B.; Meyers, J.; Barnett, G. Understanding the potential loss and inequities of green space distribution with urban densification. *Urban For. Urban Green.* **2015**, *14*, 952–958. [CrossRef]
122. Haaland, C.; van Den Bosch, C.K. Challenges and strategies for urban green-space planning in cities undergoing densification: A review. *Urban For. Urban Green.* **2015**, *14*, 760–771. [CrossRef]
123. Locke, D.H.; Grove, J.M. Doing the hard work where it's easiest? Examining the relationships between urban greening programs and social and ecological characteristics. *Appl. Spat. Anal. Policy* **2016**, *9*, 77–96. [CrossRef]
124. Kanniah, K.D. Quantifying green cover change for sustainable urban planning: A case of Kuala Lumpur, Malaysia. *Urban For. Urban Green.* **2017**, *27*, 287–304. [CrossRef]
125. Chen, B.; Nie, Z.; Chen, Z.; Xu, B. Quantitative estimation of 21st-century urban greenspace changes in Chinese populous cities. *Sci. Total Environ.* **2017**, *609*, 956–965. [CrossRef] [PubMed]
126. Nor, A.N.M.; Corstanje, R.; Harris, J.A.; Brewer, T. Impact of rapid urban expansion on green space structure. *Ecol. Indic.* **2017**, *81*, 274–284. [CrossRef]
127. Chuang, W.C.; Boone, C.G.; Locke, D.H.; Grove, J.M.; Whitmer, A.; Buckley, G.; Zhang, S. Tree canopy change and neighborhood stability: A comparative analysis of Washington, D.C. and Baltimore, MD. *Urban For. Urban Green.* **2017**, *27*, 363–372. [CrossRef]
128. Giezen, M.; Balikci, S.; Arundel, R. Using Remote Sensing to Analyse Net Land-Use Change from Conflicting Sustainability Policies: The Case of Amsterdam. *ISPRS Int. J. Geo. Inf.* **2018**, *7*, 381. [CrossRef]
129. Brooks, E. *Public Perception of Potential Neighborhood Scale Green Infrastructure: A Case Study Analysis of a Neighborhood in Richland County, South Carolina*; Clemson University: Clemson, SC, USA, 2018.
130. De Carvalho, R.M.; Szlafsztein, C.F. Urban vegetation loss and ecosystem services: The influence on climate regulation and noise and air pollution. *Environ. Pollut.* **2019**, *245*, 844–852. [CrossRef]
131. Cronin-de-Chavez, A.; Islam, S.; McEachan, R.R. Not a level playing field: A qualitative study exploring structural, community and individual determinants of greenspace use amongst low-income multi-ethnic families. *Health Place* **2019**, *56*, 118–126. [CrossRef]
132. Mears, M.; Brindley, P. Measuring urban greenspace distribution equity: The importance of appropriate methodological approaches. *ISPRS Int. J. Geo. Inf.* **2019**, *8*, 286. [CrossRef]
133. Sarzynski, A.; Vicino, T.J. Shrinking Suburbs: Analyzing the Decline of American Suburban Spaces. *Sustainability* **2019**, *11*, 5230. [CrossRef]
134. Lotfata, A. Using Remote Sensing in Monitoring the Urban Green Spaces: A Case Study in Qorveh, Iran. *Eur. J. Environ. Earth Sci.* **2021**, *2*, 11–15. [CrossRef]
135. Dinda, S.; Chatterjee, N.D.; Ghosh, S. An integrated simulation approach to the assessment of urban growth pattern and loss in urban green space in Kolkata, India: A GIS-based analysis. *Ecol. Indic.* **2021**, *121*, 107178. [CrossRef]
136. Sternlieb, G.; Hughes, J.W.; Hussey, P. *Analysis of Neighborhood Decline in Urban Areas*; Rutgers University, Center for Urban Policy Research: New Brunswick, NJ, USA, 1973; Volume 230, pp. 1–150.
137. Choldin, H.M.; Hanson, C.; Bohrer, R. Suburban status instability. *Am. Sociol. Rev.* **1980**, *45*, 972–983. [CrossRef]
138. Wiechmann, T.; Pallagst, K.M. Urban shrinkage in Germany and the USA: A comparison of transformation patterns and local strategies. *Int. J. Urban Reg. Res.* **2012**, *36*, 261–280. [CrossRef]
139. Crump, J.; Newman, K.; Belsky, E.S.; Ashton, P.; Kaplan, D.H.; Hammel, D.J.; Wyly, E. Cities destroyed (again) for cash: Forum on the US foreclosure crisis. *Urban Geogr.* **2008**, *29*, 745–784. [CrossRef]
140. Raleigh, E.; Galster, G. Neighborhood disinvestment, abandonment, and crime dynamics. *J. Urban Aff.* **2015**, *37*, 367–396. [CrossRef]
141. Speare, A.; Goldstein, S.; Frey, W. *Residential Mobility, Migration, and Metropolitan Change*; Cambridge University Press: Cambridge, UK, 1974; pp. 1–250.
142. Varady, D.P. Determinants of Residential Mobility Decisions: The Role of Government Services in Relation to Other Factors. *J. Am. Plann. Assoc.* **1983**, *49*, 184–199. [CrossRef]
143. Newman, S.J.; Duncan, G.J. Residential problems, dissatisfaction, and mobility. *J. Am. Plann. Assoc.* **1979**, *45*, 154–166. [CrossRef]

144. Williams, S.; Galster, G.; Verma, N. Home foreclosures as early warning indicator of neighborhood decline. *J. Am. Plann. Assoc.* **2013**, *79*, 201–210. [CrossRef]
145. Baxter, V.; Lauria, M. Residential mortgage foreclosure and neighborhood change. *Hous. Policy Debate* **2000**, *11*, 675–699. [CrossRef]
146. Skogan, W.G. *Disorder and Decline: Crime and the Spiral of Decay in American Neighborhoods*; University of California Press: Berkeley, CA, USA, 1992; pp. 1–300.
147. Taylor, R.B. *Crime, Grime, Fear, and Decline: A Longitudinal Look*; U.S. Department of Justice, Office of Justice Programs, National Institute of Justice: Washington, DC, USA, 1999; pp. 1–200.
148. Solomon, A.P.; Vandell, K.D. Alternative perspectives on neighborhood decline. *J. Am. Plann. Assoc.* **1982**, *48*, 81–98. [CrossRef]
149. Delmelle, E.C.; Thill, J.C. Mutual relationships in neighborhood socioeconomic change. *Urban Geogr.* **2014**, *35*, 1215–1237. [CrossRef]
150. Miller, F.D.; Tsemberis, S.; Malia, G.P.; Grega, D. Neighborhood satisfaction among urban dwellers. *J. Soc. Issues* **1980**, *36*, 101–117. [CrossRef]
151. Temkin, K.; Rohe, W. Neighborhood Change and Urban Policy. *J. Plan. Educ. Res.* **1996**, *15*, 159–170. [CrossRef]
152. Berger, P.L.; Neuhaus, R.J. *To Empower People: The Role of Mediating Structures in Public Policy*; American Enterprise Institute for Public Policy Research: Washington, DC, USA, 1977; pp. 1–120.
153. Kruger, D.J.; Reischl, T.M.; Gee, G.C. Neighborhood social conditions mediate the association between physical deterioration and mental health. *Am. J. Community Psychol.* **2007**, *40*, 261–271. [CrossRef] [PubMed]
154. Oakerson, R.J.; Clifton, J.D. The neighborhood as commons: Reframing neighborhood decline. *Fordham Urban Law J.* **2017**, *44*, 411–440.
155. Lucy, W.H.; Phillips, D.L. Suburban decline: The next urban crisis. *Issues Sci. Technol.* **2000**, *17*, 55–62.
156. Hill, R.C. Unionization and racial income inequality in the metropolis. *Am. Sociol. Rev.* **1974**, *39*, 507–522. [CrossRef]
157. Bailey, M.J. Note on the economics of residential zoning and urban renewal. *Land Econ.* **1959**, *35*, 288–292. [CrossRef]
158. Cooke, T.; Marchant, S. The changing intrametropolitan location of high-poverty neighbourhoods in the US, 1990–2000. *Urban Stud.* **2006**, *43*, 1971–1989. [CrossRef]
159. Aitken, S.C. Local evaluations of neighborhood change. *Ann. Assoc. Am. Geogr.* **1990**, *80*, 247–267. [CrossRef]
160. Saegert, S. Unlikely leaders, extreme circumstances: Older black women building community households. *Am. J. Community Psychol.* **1989**, *17*, 295–316. [CrossRef]
161. Farley, R. Suburban persistence. *Am. Sociol. Rev.* **1964**, *29*, 38–47. [CrossRef]
162. Fishman, R. Beyond Suburbia: The Rise of the Technoburb. In *The City Reader*; Routledge: London, UK, 1987; pp. 99–116.
163. Varady, D.P. Housing problems and mobility plans among the elderly. *J. Am. Plann. Assoc.* **1980**, *46*, 301–314. [CrossRef]
164. Barrett, R.E.; Cho, Y.I.; Weaver, K.E.; Ryu, K.; Campbell, R.T.; Dolecek, T.A.; Warnecke, R.B. Neighborhood change and distant metastasis at diagnosis of breast cancer. *Ann. Epidemiol.* **2008**, *18*, 43–47. [CrossRef] [PubMed]
165. Narita, Z.; Knowles, K.; Fedina, L.; Oh, H.; Stickley, A.; Kelleher, I.; DeVylder, J. Neighborhood change and psychotic experiences in a general population sample. *Schizophr. Res.* **2020**, *216*, 316–321. [CrossRef] [PubMed]
166. Quercia, R.G.; Galster, G.C. Threshold effects and neighborhood change. *J. Plan. Educ. Res.* **2000**, *20*, 146–162. [CrossRef]
167. Nilsson, I.; Delmelle, E. Transit investments and neighborhood change: On the likelihood of change. *J. Transp. Geogr.* **2018**, *66*, 167–179. [CrossRef]
168. Baum-Snow, N.; Hartley, D. Causes and Consequences of Central Neighborhood Change, 1970–2010. 2016. Available online: https://www.philadelphiafed.org/-/media/frbp/assets/events/2016/community-development/research-symposium-on-gentrification-and-neighborhood-change/research-symposium-on-gentrification-and-neighborhood-change-p1_baum-snow-paper.pdf (accessed on 17 August 2025).
169. Baum-Snow, N.; Hartley, D. Accounting for central neighborhood change, 1980–2010. *J. Urban Econ.* **2020**, *117*, 103228. [CrossRef]
170. Park, R.E.; Burgess, E.W.; McKenzie, R.D.; Wirth, L. *The City*; The University of Chicago Press: Chicago, IL, USA, 1925.
171. Hoyt, H. *The Structure and Growth of Residential Neighborhoods in American Cities*; US Government Printing Office: Washington, DC, USA, 1939. Available online: https://books.google.com/books?hl=en&lr=&id=GXxAq1bof4kC&oi=fnd&pg=PA7&dq=Hoyt,+H.+(1939).+The+Structure+and+Growth+of+Residential+Neighborhoods+in+American+Cities.+Federal+Housing+Administration&ots=iMySquZytx&sig=ewa3QgVoKvszjJcMgOLxQMG_QbE (accessed on 13 August 2024).
172. Metzger, J.T. *Planned Abandonment: The Neighborhood Life-Cycle Theory and National Urban Policy*; Taylor & Francis: Milton Park, UK, 2000.
173. Logan, J.R.; Zhang, C. Global Neighborhoods: New Pathways to diversity and Separation. *Am. J. Sociol.* **2010**, *115*, 1069–1109. [CrossRef]
174. Downs, A. *Opening Up the Suburbs: An Urban Strategy for America*; Yale University Press: New Haven, CT, USA, 1973.
175. Burch, W.R., Jr.; DeLuca, D.R. *Measuring the Social Impact of Natural Resource Policies*; University of New Mexico Press: Albuquerque, NM, USA, 1984.

176. Bruch, E.E.; Mare, R.D. Neighborhood choice and neighborhood change. *Am. J. Sociol.* **2006**, *112*, 667–709. [CrossRef]
177. StataCorp. *Multilevel Mixed-Effects Ordered Probit Regression Manual*; Stata Press: College Station, TX, USA, 2023. Available online: https://www.stata.com/manuals/memeoprobit.pdf (accessed on 5 January 2022).

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.