Special Issue: Environmentalizing Urban Sociology

American Sociological Association

City & Community
00(0) 1–22

DOI: 10.1177/15356841231152616
journals.sagepub.com/home/cty
SAGE

Parks, People, and Pollution: A Relational Study of Socioenvironmental Succession

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Abstract

The urban environmental inequality literature holds that marginalized communities are generally concentrated in neighborhoods with greater levels of industrial pollution and lesser access to parks and playfields. Yet, "green" and "brown" land uses are also linked historically and through contemporary practices of green redevelopment. This article thus begins from the understanding that it is important to analyze both forms of urban land use at once, to avoid mistaking one historical process for another. Focusing on Providence, Rhode Island (1970–2010), we leverage original historical data on the location and operating years of public parks alongside comprehensive industrial site data to analyze the joint transformation of residential populations, parks, and industry over time. We find that park access generally increases for Latinx residents; however, after accounting for increases in park access associated with past industrial land use, we find that census tracts with growing proportions of African American residents are associated with relatively less access to parks than other census tracts. Results reveal additional dimensions to the role of industrial history in shaping the socioenvironmental trajectory of local neighborhoods and additionally emphasize the importance of a historical and relational view of urban land use in urban environmental research.

Keywords

environmental inequality, industrial land use, risk, environmental hazards, urban development, parks, green space

INTRODUCTION

Urban sociologists have long recognized the central role that parks play in the social and spatial life of urban neighborhoods, providing key spaces in the construction and maintenance of community identity (e.g., Anderson 1923) and as sites of racial and ethnic conflict over the right to urban space (Suttles 1968). More recently, Eric Klinenberg (2018) has pushed for increased scholarly attention to parks and playgrounds among other components of "social infrastructure"—features of the built environment that "[foster] contact, mutual support, and collaboration among friends and neighbors," and in so doing help to create the conditions for sustained

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face-to-face interaction, the "building blocks of all public life" (Klinenberg 2018:5). Complementary work by environmental social psychologists and health researchers documents the benefits of parks for public health (Bancroft et al. 2015; Cohen et al. 2007; Kaczynski and Henderson 2008; Veitch et al. 2021), while environmental justice scholars tend to view park access and distribution, respectively, as measures of environmental privilege (Murphy 2016) and urban inequality (Rigolon 2016). Urban political economists have also begun to study the role of green space in urban development (e.g., Clark et al. 2002; Cole et al. 2017; Loughran 2014) by attending to the historical and multi-scalar processes through which "greening interventions produce new urban geographies by reconfiguring the relationship between public and private and defining new sets of public behaviors" (Angelo 2021:81).

This article contributes to all three bodies of research. It does so by analyzing access to urban green space as a product of changing distributions of parks, residential populations, and industrial built environments in Providence, Rhode Island (1970–2010). By studying these changes as they unfold across an urban landscape over four decades, we hope to deepen sociological understanding of socioenvironmental succession as a series of long-term, multi-scalar processes in which greening and waste accumulation are mutually constitutive. Aligning with this special issue's thematic focus on environmentalizing urban sociology, our perspective insists that industrial and residential change are as "environmental" as the addition or subtraction of urban green space. By bringing the three processes into temporal and spatial focus, the study joins environmental sociology's concern with environmental risk and privilege to urban sociology's focus on longitudinal processes of urban development.

Our analysis centers on changes in park access and the factors that condition access over time. Social scientists have amassed considerable quantitative evidence showing that access to parks contributes to individual and community well-being. People who live near urban parks walk more (Kaczynski and Henderson 2008), get more exercise (Cohen et al. 2006, 2007), spend more time outside (Veitch et al. 2021), and engage in higher levels of moderate to vigorous physical activity (Bancroft et al. 2015). Urban landscapes with convenient access to managed green space also promote integration of "incidental physical activity" into residents' daily habits (Gies 2006). Compared with park-poor neighborhoods, park-rich neighborhoods are healthier (Fan and Jin 2014), wealthier (Crompton 2005), and experience less residential instability (Kim et al. 2015). Park-rich cities are similarly wealthier (Rigolon, Browning, and Jennings 2018) and benefit disproportionately from important ecosystem services that park-poor cities often lack (Mexia et al. 2018; Setälä et al. 2017). In these ways, parks can remake local neighborhoods by attracting wealthier nearby residents (Rigolon and Németh 2020)—a process that Cole et al. (2017:1121) argue serves as a "mediator between exposure to green space and health"—and may thus function as an important mechanism for gentrification and the reproduction of urban inequality.

Low-income and BIPOC (Black, Indigenous, and people of color) communities generally enjoy access to comparatively fewer nearby parks and recreation fields, though this varies by regional focus (Rigolon 2016; for a counterexample, see Hughey et al. 2016). Marginalized communities also face a variety of use barriers, ranging from formal segregation to discriminatory policing practices (Harris, Rigolon, and Fernandez 2020). Parks in BIPOC and low-income communities are comparatively smaller and more poorly appointed (Rigolon 2016; Suminski et al. 2012; Vaughan et al. 2013), more congested (Sister, Wolch, and Wilson 2010), and suffer disproportionate funding shortfalls (Wolch, Wilson, and Fehrenbach 2005) and safety concerns (Rigolon 2017). They also tend to receive less attention from city maintenance and beautification programs (Rigolon 2016) or volunteer groups (Holifield and Williams

2014). Parks are therefore integral to urban life, refracting various forms of urban inequality spatially and socially.

The following sections place the longitudinal transformation of urban park access within a wider framework describing processes of socioecological change in cities. First, we outline the various ways that urban sociologists have understood the links between city parks and urban development, making the case that urban parkland occupies a key nexus between the environmental, social, and built geographies of the city. Next, we extend this argument to draw out the important links between "green" land use and patterns of industrial development and post-industrial decline. Building from extant literatures, we extend the socioenvironmental succession model of urban change (cf. Frickel and Elliott 2018) to examine the joint transformation of residential, industrial, and "green" geographies over time. Our findings show that Providence's historical geography of industrial sites is an important factor shaping residents' access to neighborhood parks over the study period, placing park access within a broader context of the longitudinal, interlinked transformation of environmental risk and privilege.

Parks and Urban Development in U. S. History

According to Loughran (2020), green interventions in the United States have developed across four distinct historical periods, beginning in the mid-nineteenth century when city parks were considered useful tools for the areal expansion of growing cities and to tame nature. Aligning with then-current expansionist and racist ideologies, civic leaders and park developers often promoted parks "as safe spaces for middle-class white women and children to engage in familial recreation," and thus set them against "urban" spaces characterized by "racial others and the perception of danger lurking on city streets and sidewalks" (Loughran 2017:3). By the early twentieth century, as U.S. racial and ethnic structures gradually extended the benefits of whiteness to European immigrant communities (Loughran 2017), urban developers and reformers began reimagining parks as antidotes to the "crowded and purportedly degenerative conditions of urban public spaces, tenement housing, and industrial workplaces" (Gutman 2014; Loughran 2020:2331). Early twentieth century parks were generally smaller than nineteenth-century parks, facilitating their closer integration into the fabric of immigrant neighborhoods. Yet Black residents often found themselves excluded from green visions of social uplift, a result of spatial patterns of park construction, Jim Crow laws, and outright discrimination from white park users.

During the third period running through the middle of the twentieth century, investments in center-city parks languished. As deindustrialization and "white flight" shifted jobs, resources, and development and maintenance dollars to whiter and wealthier suburbs, urban parks were often recast as sites of criminal activity. At the same time, as suburban expansion began to absorb the nineteenth-century "natural" parks originally designed for white leisure at the urban periphery, planners redesigned the older parks with facilities to support structured activities, such as recreation centers, sports fields, and swimming pools. Thus, parks in this period reflected the racial order of a growing urban-suburban divide, such that "parks in white neighborhoods received funding for beautification and community programming [while] parks in black neighborhoods received the police" (Loughran 2017:10), or were demolished entirely as part of widespread "urban renewal" processes (More, Stevens, and Allen 1988).

Disinvestment in industrial and green spaces created conditions for a fourth period in which developers linked abandoned industrial lots and revitalized green spaces through a growing valorization of the "authentic urban experience" (Lloyd 2010). By the early 2000s, green redevelopment fueled by international capital was in full swing (Gould and Lewis 2016, 2018), though it would take years to filter from New York and other global cities to smaller municipalities like Providence. Reliant on public-private partnerships (Loughran 2014) and accompanied by the spatial exclusion of visible poverty (Stuart 2014), green redevelopment emerged as uneven and contested, often in tension with civil societal demands for "green equity" (Checker 2011; Rigolon 2019).

Across these broad historical changes in park policy, two important features remain relatively consistent. First, as Loughran and others have previously shown, the distribution and management of urban parkland emerges as a racial project, a means to control and manage the spatial and social lives of marginalized communities. These patterns are reflected in each of the periods outlined above, from the park policies that prioritized white, anti-urban recreation in the late nineteenth century to the uneven pursuit of exclusive green redevelopment today. Throughout, city parks have proven integral to the spatial reproduction of the color line, their siting, design, development, and maintenance invariably shaped by "white fears of interracial interactions and racialized concerns about crime and vice" (Loughran 2020:2333) and by the urban growth objectives of local, regional, and international capital (Clark et al. 2002; Loughran 2014). Second, the distribution and management of urban parkland is also an industrial project. Urban parks expanded as an offshoot of the growing concentration of industrial wealth in cities, with an eye to build spaces for white middle class recreation separated from the industrialized and racialized urban core. Later, parks were mobilized to provide factory workers, principally European immigrants, with respite from crowded and unhealthy industrial labor. A period of neglect followed as deindustrialization and suburbanization emptied city coffers, setting the stage for more recent efforts to attract global capital involving green redevelopment and the reclamation of industrial brownfields. Thus, analyzing change in urban park access requires a birds-eye view of urban development—one that contextualizes urban parkland within a wider historical perspective where interrelated social, environmental, and industrial processes of "socioenvironmental succession" come more clearly into focus.

PARK CHURNING AND PARK ACCESS AS MECHANISMS OF SOCIOENVIRONMENTAL SUCCESSION

The theory of socioenvironmental succession proposes that interlocking changes to places, people, and policies gradually alter urban spaces through cumulative processes of land use change (or "churning") (Frickel and Elliott 2018). Over time, as factories open, close and relocate, industrial churning accumulates and spreads contaminants unevenly across urban space. Residential areas also churn as people move in and out of different neighborhoods to generate new and shifting patterns of exposure risk to those same unevenly spreading contaminants. These relational processes are reinforced by government strategies of "risk containment," limiting the scope of regulatory oversight of hazardous land uses and remediation in ways that further growth machine interests in local redevelopment, including ongoing industrialization of urban lands and racial and ethnic segregation (Logan and Molotch 1987). While these underlying processes operate together to systemically degrade urban ecosystems, Frickel and Elliott (2018:112) acknowledge that "industrial waste accumulation is just one variant" and socioenvironmental succession "can also lead to outcomes that are more incrementally positive."

Cumulative increases in park construction that enhance residential access to neighborhood parks is one example (Elliott, Korver–Glenn, and Bolger 2019). Like industrial sites, parks transform urban nature; they also churn across urban space, built, redesigned, or bulldozed in different neighborhoods at different times to accommodate local redevelopment interests and political and social pressures (Elliott et al. 2019). There are also important differences between industrial churning and park churning. For example, at any given point in time, cities will contain far fewer parks than industrial sites—dozens of the former compared with many hundreds or thousands of the latter. It follows that parks will likely churn much more slowly than industrial facilities. Parks are created far less frequently, but also tend to remain open longer—often for decades rather than years (Elliott et al. 2019). Where industrial activities add pollution and increase environmental health risk to urban areas, parks add ecosystem services—sinks for carbon dioxide and other pollutants, filtration for storm wastewater, habitat for wildlife, and space for recreation and public health. Finally, unlike legacy contaminants that can remain on-site, unacknowledged and ignored long after the factories that produced them disappear, the socioecological benefits of parks are coextensive with the lifetimes of parks. As such, parks do not accumulate ecosystem benefits the same way that factories accumulate and spread ecosystem risks; when parks disappear, so do the green amenities parks offer. Thus, the spatial, temporal, and socioecological dynamics of brownfields and green spaces differ in potentially consequential but as-yet poorly understood ways, even as industrial churning, residential churning, and park churning are—we theorize—interrelated and, in some ways, mutually constitutive mechanisms of socioenvironmental succession.

Churning processes also hold distinct relationships to urban political economy and, more specifically, to the dynamics of local growth machines. At any given point in time, industrial and residential churning directly increase local tax receipts through rents on privately owned land, reinforcing the growth machine imperative to intensify local land use while minimizing the negative impacts of ongoing environmental degradation to capital returns. Parks, on the other hand, are integrated into the political economy of the city more indirectly, as public goods that ostensibly enhance use value and are organized primarily—though not exclusively—through the allocative politics of state and city administrations. Although Logan and Molotch (1987) were not concerned with parks in their classic study, more recent attention to "green growth machines" illuminates the role that growth coalitions can play in reshaping urban landscapes to "encourage economic growth under the guise of environmental protection" (Mullenbach et al. 2021:407) and attract wealthier "sustainability class" residents. The socioenvironmental succession framework draws attention to the interrelated dynamics of churning, emphasizing the ongoing *re*use of urban lands (Elliott and Frickel 2015), as city space is iteratively repurposed to support different, diverse, and uneven growth agendas.

Two examples from Providence illustrate some ways that parks become instruments of local land use change in response to the succession pressures of deindustrialization and subsequent redevelopment. Sited on the edge of the city's largest freshwater pond, Mashapaug Park sits on land formerly occupied and heavily polluted by the Gorham Manufacturing Company and exemplifies a tendency for municipal governments to convert vacant industrial lands into functional green space and the complicated remediation and environmental justice concerns that such land use changes can invoke. In this case, extensive remediation followed from years of environmental health and justice organizing from nearby residents and students attending an adjacent high school.[1] At the same time, such functional green space remains vulnerable to redevelopment, as when the relocation of a short stretch of I-195 created 26 acres of prime, downtown-adjacent real estate. While the City quickly repurposed much of the land into semi-managed green space, hosting art and music events, garden and landscape installations, and various forms of informal community activity, since 2011 many parcels have been sold to private developers for higher-end apartments, hotels, and mixed-use projects, further gentrifying the historically immigrant Fox Point neighborhood nearby

(Kent-Daggett 2018; Pickens 2022). Thus, while residential, industrial, and park churning are fundamental to the socioenvironmental succession of cities, they are by no means "natural" or inevitable processes. Rather, they are mutually constituted by the dynamic relations of capital, civil society, and policymakers, whose competing interests in land use materially, incrementally, and successively remake the empirical ground we aim to center in this study.

Expanding the framework of socioenvironmental succession to include green space raises a number of empirical questions about how, where, and under what conditions parks "churn" and whether such processes intensify or reduce spatial patterns of environmental inequality. As public amenities with clear socioecological benefits, parks and park access also offer discrete empirical measures of environmental privilege, a condition that exists when urban residents enjoy disproportionate access to environmental amenities (including green space) and relative freedom from environmental risks (Pellow and Nyseth Brehm 2013). Conceptualized in this way, environmental privilege is a dynamic process that operates in relation to counter-veiling distributions of environmental burdens or risks (Murphy 2016). These frameworks build on Laura Pulido's classic study, which argued that considering environmental inequality as a manifestation of white privilege allows us to understand environmental outcomes as a result of "urban development in a highly racialized society over the course of 150 years" (Pulido 2000:32).

The theory of socioenvironmental succession provides a useful set of tools to trace these processes on (or more literally, in) the ground. Current theorizations posit a negative spatial relationship between brownfields and green spaces, where the concentrated presence of one predicts the relative absence of the other. Socioenvironmental succession holds out the possibility of a positive relationship linking industrial sites and parks in the same or adjacent urban neighborhoods by allowing the relationship between the two types of land use to change over time and across space. To date, researchers have examined the processes and consequences of industrial churning (Elliott and Frickel 2015) and park creation (Elliott et al. 2019) separately. Pairing longitudinal analysis of industrial and green space land-use changes, as we do here, thus opens a new line of inquiry into the relational dynamics of environmental risk and privilege that promises to refine understanding of the foundational mechanisms driving socioenvironmental succession. Our study of Providence, Rhode Island, illustrates the confluence of these interlinked processes.

CASE STUDY AND RESEARCH QUESTION

The City of Providence is replete with legacy environmental pollution stemming from centuries of concentrated industrial production. For much of the nineteenth and twentieth centuries, the city's industrial economy was dominated by textile, machine tool, and costume jewelry manufacturing, which operated out of dozens of large factory mill complexes and hundreds of smaller facilities scattered across the city. Factories clustered along the floodplains of the Providence and Woonasquatucket Rivers, stretching south and west of the downtown core. Worker housing generally followed, concentrating much of the city's housing stock in its most polluted sectors.[2]

By 1936, when the Home Owners' Loan Corporation (HOLC) published mortgage risk maps for Providence (see Figure 1), now-familiar patterns of environmental inequality conditioned by residential segregation and proximity to industrial production had already emerged (Frickel and Tollefson 2022). Lenders used HOLC maps to deny federal mortgage benefits to residents of neighborhoods labeled as "declining" or "risky"—labels that primarily reflected the racial composition of an area at the time that it was assessed by HOLC cartographers (Rothstein 2017). As in other cities, the HOLC mapping process fixed extant patterns of residential segregation

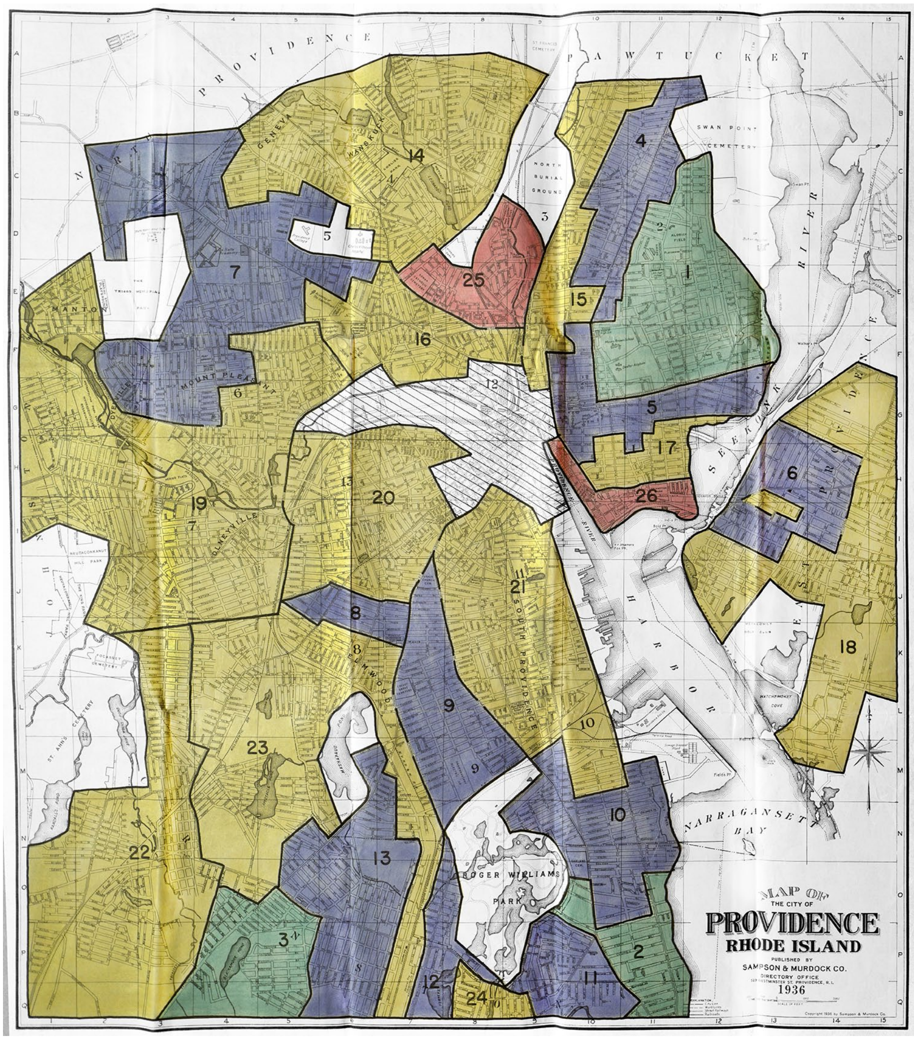

Figure 1. Home owners' loan corporation map for Providence, RI, 1936.
Source. Nelson et al. (2022).
Note. Shaded region in center of image includes the downtown business district and the industrialized areas and ports along the Woonasquatucket and Providence Rivers.

(Faber 2020) and environmental inequality in place.

In the mid-twentieth century, industrial decline prompted a broad shift in sociodemographic settlement patterns in Providence. As factories began in the 1970s to relocate from the city's urban core to nearby suburbs and white suburbanization soon followed, the city's Black and growing Latinx populations expanded their residential footprint within the city, mostly into contiguous neighborhoods located south and west of downtown. By the late 1990s, Providence had become a predominantly non-white city, with newer migrants and immigrants from Puerto Rico, the Dominican Republic, and Central and South America settling alongside existing African American, Cape

Table 1. Summary Statistics.

	1970		1980		1990		2000		2010	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Nearby parks	11.9	8.4	13	9.8	15.4	11.4	16.4	11.9	16.5	11.5
Population	4,589	1,593	4,012	1,613	4,102	1,663	4,451	1,640	4,565	1,672
% Black	9.9	14.9	13.3	17.1	13.6	13.7	15.5	9.2	15.7	8.2
% Latinx	1.2	1.4	6	6.1	15.8	12.4	29.5	18.3	36.3	21.3
% Youth	26.8	6.7	23.2	8.5	23.6	9.3	25.8	10.3	22.7	9.3
Median income	33,689	13,294	30,424	12,126	38,188	18,203	35,246	19,491	51,034	29,427
Housing units	1,746	592	1,727	641	1,704	651	1,741	602	1,834	622
% Rentals	59.8	14.6	57.2	14.8	57.5	13.3	60.9	14.8	57.4	14
% Vacant	7.4	4.6	11.3	6.7	12.4	4.5	8.4	3	12.5	3.9
Active manufacturing	89.9	64.6	80.9	50.9	65.5	39.6	37.4	22	34.1	17.3
Relic manufacturing	127.4	101	167.1	127.8	205.6	148.7	250.9	174	280	188.4
Census tracts	39		39		39		39		39	

Source. U.S. Census, Longitudinal Tract Database for 2010 (https://s4.ad.brown.edu/projects/diversity); Longitudinal Manufacturing Database for Rhode Island Establishments, 1953–2016 (https://repository.library.brown.edu/studio/item/bdr:841116/).

Verdean, West African, and various Caribbean communities (Itzigsohn 2009; Uriarte et al. 2002). In this way, shifting residential settlement patterns were layered spatially and temporally on top of economic changes in which urban deindustrialization created a growing tapestry of abandoned industrial lots. These linked processes of residential and industrial churning meant that Black and Latinx residents increasingly concentrated in formerly industrial areas (Marlow, Frickel, and Elliott 2020)—neighborhoods that, in many cases, were also home to parks and other green spaces in various stages of neglect.

One result is that Providence residents today experience conditions of environmental risk and privilege unevenly. They live in a highly racially and ethnically segregated urban landscape, characterized by the fifth highest level of income inequality of any large U.S. city, child poverty rates more than double the rest of the state (Rhode Island KIDS COUNT 2019), and where BIPOC communities are disproportionately poor and concentrate in older industrial neighborhoods (Marlow et al. 2020). At the same time, green redevelopment projects have flourished—driven in part by new public-private partnerships and joint efforts by state actors, universities, and private foundations that have rebranded Providence as Rhode Island's "Creative Capital" (Nicodemus 2012). Green redevelopment efforts such as those illustrated above, which now include new parks, greenways, playgrounds, and other forms of green infrastructure, are concentrated along the city's main watercourses, in the same neighborhoods where industrial activities once thrived.

This historical background sets the stage for our main research question: Does the iterative churning of people, industrial sites, and parks combine in ways that impact residents' access to neighborhood parks and thus alter the balance of environmental risk and privilege?

DATA AND METHODS

Our analysis incorporates three longitudinal spatial data sets to understand changing historical relationships between people, parks, and industrial places in Providence. We present variable descriptions and summary statistics in Table 1.

Sociodemographic Data

Historical census data standardized to 2010 census tract boundaries are drawn from the Longitudinal Tract Data Base (LTDB) (Logan et al. 2021; Logan, Xu, and Stults 2014), which uses full count data for race, ethnicity, and housing tenure variables. The LTDB also relies on the one-in-six decennial samples (1970–2000) and sample based American Community Survey data (2010) to track median income. Sample-based data are prone to high variability and spatial instability (Folch et al. 2016); however, the panel structure of our data significantly mitigates this concern. We focus on all 39 2010-equivalent Providence census tracts observed in five panel years (1970, 1980, 1990, 2000, and 2010), totaling 195 observations.

We use tract-level measures for median income (standardized to 2010 dollars) and population counts for African American and Latinx residents and children (under age 18). Because the U.S. Census did not collect data on Latinx ethnicity prior to 1980, we use the "Hispanic or Latino Origin" variable provided by the National Historic GIS (NHGIS) project to calculate the Latinx population in 1970 (Manson et al. 2021).[3] We also include variables for the number of vacant units, units rented, total number of household units, and total population to assess the impact of tract-level changes in population and housing characteristics and to interpret demographic variables proportionally. All variables are log-transformed to allow for direct comparison among covariates and between models.

Manufacturing Site Data

Address-level data on manufacturing sites are from the *Rhode Island Directory of Manufacturers*, a statewide reference source published semi-annually since 1953. A team of researchers drew on optical character recognition methods and other computational data extraction techniques to digitize all available information from every available directory from 1953 to 2012 (Berenbaum et al. 2019). For every listed facility, the data set contains information on company name, street name and number, city, zip code, the number of employees, and the two-digit standard industrial code. Following Elliott and Frickel (2013), locations were geocoded based on facility address, excluding all P.O. Box addresses to limit the inclusion of company headquarters where no manufacturing took place. The full data set contains information on nearly 12,000 unique industrial manufacturing sites operating in the state of Rhode Island and more than 34,000 site-years of data spanning 65 years (Marlow and Frickel 2018). While we lack specific information on the presence of on-site contaminants, we follow risk analysts (Noonan and Vidich 1992) and the Environmental Protection Agency's Toxic Release Inventory in assuming that previously industrialized lands are likely to contain contaminants that degrade ecosystems and may pose risks to human health.

For the present study, we restrict data to manufacturing sites located within Providence city boundaries and distinguish two types of manufacturing sites associated with different types of environmental risk (Frickel and Elliott 2018). "Active" sites correspond to addresses listed in the directories for a given year and represent point sources of current pollution; "relic" sites are formerly listed addresses that have dropped from the listings and represent presumptive sources of legacy pollution.[4] We aggregate active and relic sites at the census tract level for each of five sample waves (1970, 1980, 1990, 2000, and 2010). When log-transformed and operationalized as part of a longitudinal regression analysis, the two variables capture the rates of neighborhood-level change in the acute risks associated with active manufacturing (e.g., poor air quality) and the more chronic and often hidden risks associated with legacy contamination on previously industrialized lands (Frickel and Elliott 2018).

Green Space Data

We collected historical information on Providence parks and recreation fields by triangulating data from several archival sources.

Published annually from 1886 to 1998, the *Providence Journal-Bulletin Almanac: A Reference Book for the State of Rhode Island* (hereafter, *Almanac*) served as our primary source for these data. We cross-referenced *Almanac* data with data constructed by a comprehensive search of local newspaper archives. The search included the *Providence Journal* (est. 1829), the city's longstanding daily newspaper, along with 14 additional historical and contemporary regional and neighborhood newspapers, college newspapers, and local news publications.[5]

For each park or recreation field, we collected information on name, address or street intersection, opening year, closing year (where relevant), size (in acres, when available), and notes on any amenities, such as swimming pools or playgrounds. We coded opening year as the year in which a park first appears in the historical record. In most cases, this is the first instance that a park or recreation field is listed in the *Almanac*, but in several cases we were able to substantiate earlier opening dates using other archival records. For parks that are no longer in operation but that lack records of closure, we coded closure year as the last year that the site appears in the historical record.

Park locations were coded from *Alamanac* listings and newspaper archives and confirmed using a variety of data sources. Those that remain in operation today were easily confirmed using OpenStreetmap data, but closed parks represented a greater challenge. In these cases, we turned to a range of historic city maps, principally a series of highly detailed city atlases published in 1937 and fire insurance maps published by the Sanborn Map Company in 1889, 1905, 1921, and 1956. We took a conservative approach to guard against misidentifying location, including parks and recreation fields only when we were able to verify street location and approximate operating duration in at least two different data sources. We excluded 14 locations for these reasons or because archival research revealed that they represented duplicate entries. The 140 confirmed park and recreation field locations were subsequently geocoded.

Most studies of urban parks operationalize park accessibility as a distance threshold of quarter-mile, half-mile, or mile distances (Boone et al. 2009; Elliott et al. 2019; Talen 1997; Wolch et al. 2005), and the positive impacts of park proximity are generally consistent across this range (Bancroft et al. 2015). Following previous studies, we measure tract-level park access by counting the number of parks and recreation fields within a half-mile buffer around census tract boundaries. This half-mile buffer is also used to measure exposure to the active and relic manufacturing sites outlined above. We exclude Providence's oldest and largest park, Roger Williams Park, from our analysis because its prominence and relative accessibility make it a citywide resource and not solely a neighborhood amenity. At 435 acres, the park is substantially larger than other parks in the city; hosts a wide range of daily public programming, from concerts to films and fitness classes; and is home to a zoo, natural history museum, planetarium, and botanical center.[6]

Analytic Strategy

We analyze these data in two ways. First, we use descriptive statistics to examine residential, industrial, and park churning separately, in order to build an independent understanding of how each process has unfolded in Providence over the study period. We then employ a spatial panel regression model to investigate how the three types of churning have operated together across the landscape, tracking changes in tract-level park access from 1970 to 2010 using the "splm" package in R (Millo 2014; Millo and Piras 2012).

A spatial panel model approach allows us to compare static units—in this case, 2010-equivalent census tracts—across multiple observations over time, while also controlling for spatial autocorrelation in the dependent variable through the inclusion of its spatial lag and controlling for autocorrelation in model errors through the introduction of a

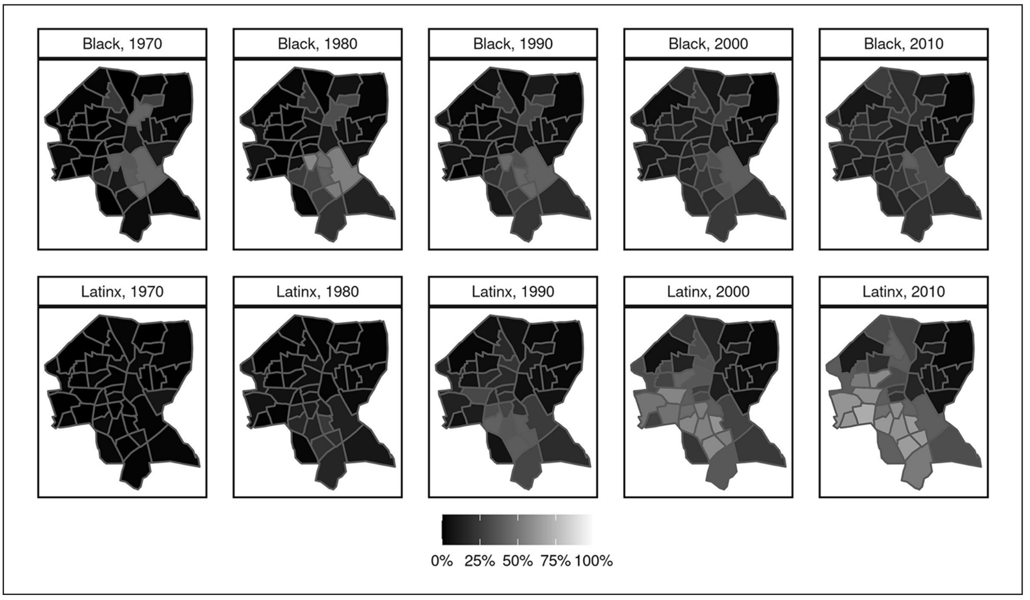

Figure 2. Black and Latinx population, Providence, RI, 1970–2010.

spatial error term. LM tests for error models alone reveal residual spatial lag dependence ($p < .001$ for Model 1; $p < .01$ for Model 2); conversely, LM tests for lag models alone reveal residual spatial error dependence for Model 1 ($p < .05$). We therefore present results using a mixed "sarar" model specification, which accounts for both forms of spatial dependence.[7] While models based on Poisson or negative binomial distributions are more commonly used for count variables, we track park access as a log-count outcome to accommodate limitations in statistical modeling software, following Jiang et al. (2021).

RESULTS

Residential Churning

The iterative churning of people across urban space is the most dynamic element in the long-term transformation of neighborhood park access and industrial exposure. In Providence, residential churning led to a sustained and significant demographic transition from a majority-white to a majority-BIPOC city—a process with different implications for Black and Latinx residents. The city's Black population experienced 170 percent proportionate growth over the study period, an impressive growth rate accompanied by steady spatial diffusion and decreasing levels of Black segregation. Black settlement concentrated in four contiguous south-side census tracts and two tracts north of downtown through the 1980s, at which point three of those tracts were more than 50 percent Black. But spatial diffusion began to reduce prior patterns of concentration. By 1990, no census tract was predominantly Black, and by 2010, Black residents comprised at least 10 percent of 30 of 39 census tracts. The top panel in Figure 2 shows how Black residential churning unfolded as a process of gradual spatial diffusion.

Latinx communities experienced churning as rapid growth and areal expansion. The Latinx population grew exponentially in real terms from less than 2,000 in 1970 to more than 67,000 by 2010, a four-decade growth rate of 3,350 percent. As described in an earlier section, exponential growth was largely the result of in-migration from outside the United States, often via the New York City area (Uriarte et al. 2002). Beginning in the 1980s, new Latinx arrivals tended to settle in Providence neighborhoods immediately west

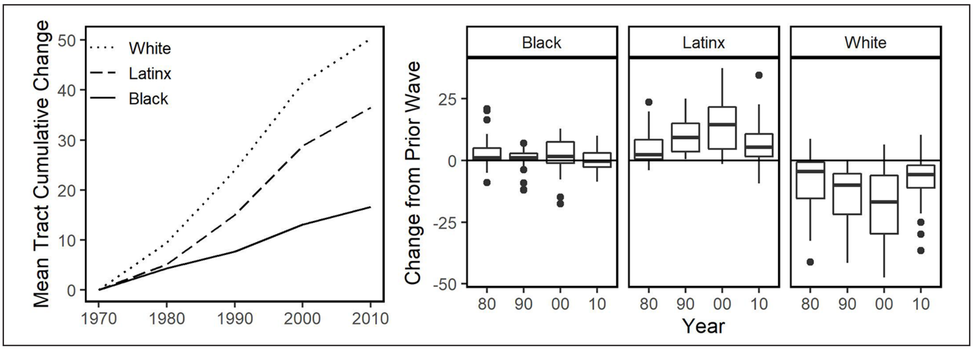

Figure 3. Residential churning, Providence, RI, 1970–2010.
Note. Left panel displays mean cumulative tract-level percent-point change in Black, Latinx, and white populations, 1970 to 2010. Percent-point change is calculated as the absolute difference between the percentage of each demographic subpopulation between census waves: an increase from 10 to 20 percent Black in one census tract would contribute 10 points to the cumulative change in Black population for that tract; likewise, a drop from 20 to 10 percent Black would contribute 10 points as well. Tract-wise changes are averaged across the 39-tract sample to produce an aggregate measure of residential change for each of the five waves. These changes are cumulative across census waves, so that the 2010 statistics represent the total tract-wise change in demographic subpopulations since the beginning of the study period. Right panel displays the distribution of wave-to-wave percent point changes in Black, Latinx, and white populations for the 1970–1980, 1980–1990, 1990–2000, and 2000–2010 periods. Note that nearly all of the tract-level change in Latinx population falls above the zero line, while most white churning occurred through a loss of white residents. Black churning is centered at the zero line across the sample period.

and south of the central business district, often in areas formerly occupied by higher densities of industrial manufacturing (Marlow et al. 2020). Yet, unlike the case with Black spatial diffusion, areal expansion of the city's Latinx population was accompanied by increasing levels of residential segregation, as new majority- or plurality-Latinx neighborhoods often emerged adjacent to existing Latinx enclaves. By 2010, while 32 of 39 census tracts were at least 10 percent Latinx, a third (n = 13) exceeded 50 percent (see Figure 2, lower panel). By 2010, Providence had not only become majority non-white, but predominantly Latinx.

The citywide reordering of racial and ethnic settlement patterns meant that individual neighborhoods experienced a sustained and cumulative transformation in local residential geographies. Following Frickel and Elliott (2018), the left panel of Figure 3 presents an aggregate measure of local residential churning measured as the cumulative percent-point change in tract-level Black, Latinx, and White populations, averaged across the 39 2010 -equivalent census tracts for each sample wave.[8] It shows that between 1970 and 2010, the average census tract sustained a 50-point change in the proportion of white residents, a nearly 30-point change in Latinx residents, and a 15-point change among Black residents. Tract-level demographic change was generally a unidirectional process, characterized by high rates of white out-migration and Latinx in-migration; this was joined by a process of Black population diffusion from majority-Black neighborhoods to adjacent areas vacated by whites. The right panel of Figure 3 presents the distribution of these tract-level wave-to-wave population changes and confirms that the high rates of Latinx and white churning were primarily driven by Latinx in-migration and white out-migration, respectively. The impact of high tract-level Latinx population influx and Black diffusion combined with significant and sustained loss in white residents over the study period substantially reorganized the racial and ethnic geography of Providence neighborhoods. This occurred even as relic industrial sites—and, on a smaller scale, parks and recreation fields—proliferated across the city, reshaping the social organization of park

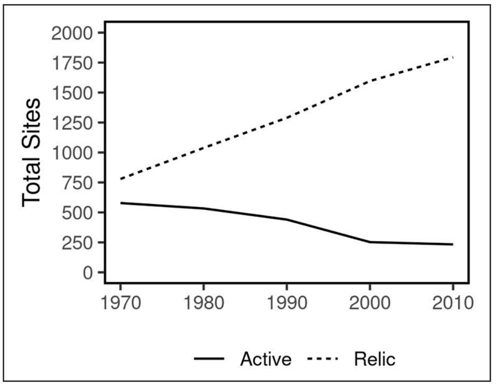

Figure 4. Total active and relic manufacturing sites, Providence, RI, 1970–2010.

access and industrial exposure in turn. We turn to these elements of socioenvironmental succession next.

Industrial Churning

Industrial churning is a prominent feature of socioenvironmental succession in U.S. cities, and Providence is no exception. Our data track 2,048 unique sites of manufacturing—1,269 of which were in operation at some point during the study period and 779 of which had already closed by 1970—and show that businesses occupying those sites remained in operation for just 12.25 years, on average. Figure 4 presents changes in the number of active and relic manufacturing sites over the study period and allows the dynamism of industrial churning to come into clearer view. Active sites decrease from 578 in 1970 to 233 in 2010. In contrast, relic sites accumulate steadily, increasing more than twofold from 779 in 1970 to 1,794 by 2010. This tells us that as active sites close and become relic sites, new businesses are continually opening, but usually on different parcels of land. Over time, this churning dynamic—at once temporal and spatial—steadily increases the number of urban lots subject to industrial uses. In this way, industrial churning continuously transforms urban nature through the accumulation of industrial contaminants used in the various manufacturing activities and often left behind across ever-expanding swaths of urban land.

As theorized above, local patterns of industrial churning form a key mechanism of socioenvironmental succession and risk accumulation while also setting the stage for subsequent processes of green redevelopment. Figure 5 displays neighborhood-level patterns of industrial churning over the 40-year sample. As active site density decreases with time, from a tract-level average of 36 nearby sites per square mile in 1970 to just 13 in 2010, their spatial variation decreases as well. In contrast, the tract-level density of relic sites increases steadily over time, with the mean relic site density more than doubling from 51 in 1970 to 111 sites per square mile by 2010. The standard deviation in tract-level site density increases as well, yet it does so at a slower rate than the mean. This is consistent with Elliott and Frickel's (2015:1767) finding for other U.S. cities that industrial churning continuously "fills in older areas of cities with land-based hazardous wastes" as industrial land use scales up and spills over from one parcel or block to the next. As developers and city officials look for new, publicly amenable ways to redevelop and reuse industrialized lands, the steady accumulation of relic sites creates economic and environmental conditions for park creation, our next topic.

Park Churning

Like manufacturing facilities, parks also come and go. Park churning is a far slower process than industrial churning, but even gradual changes in park access have the capacity to substantially reshape neighborhoods. In Providence, the total number of neighborhood parks and recreation fields rose 31 percent from 86 in 1970 to 118 in 2010. The expansion of green space involved the addition of 38 new parks and the closure and subsequent redevelopment of 7 others. In total, 45 parks churn in or out of the data over the study period, giving us an initial sense of green space dynamics.

Figure 6 illustrates park churning over each of the five census waves from 1970 to 2010, characterized by sustained growth

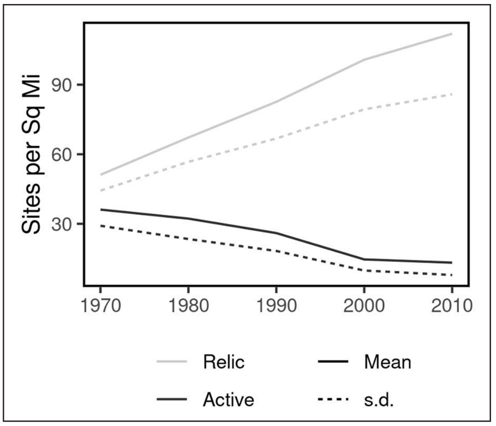

Figure 5. Active and relic site density, Providence, RI, 1970–2010.
Note. Mean tract-level density of active and relic manufacturing sites, 1970–2010. Manufacturing density is calculated for half-mile tract buffer regions to match park access calculations. This approach has the additional effect of smoothing differences between adjacent tracts and reducing standard deviation statistics.

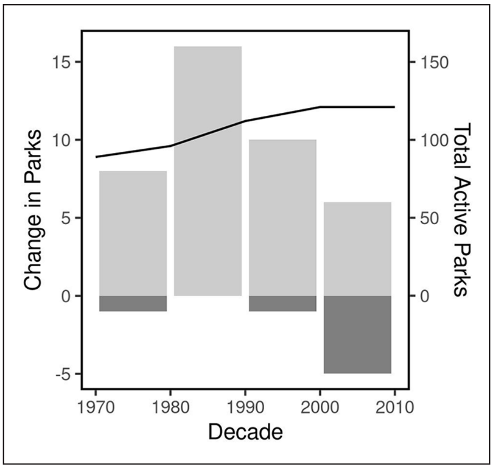

Figure 6. Decadal and cumulative park count, Providence, RI (1970–2010).
Note. Positive bars represent new parks opened during each decade. Negative bars represent the total number of parks lost over the same period. The "Total Active Parks" line represents the number of parks and recreation fields that were open at the start of each decade.

punctuated by episodic pulses of green space creation and destruction. The 1980s are one such outlier, when the city added 16 new parks and recreation fields, the largest single-decade total in the second half of the twentieth century. The 2000s are another, when the city lost at least one park every two years, more than any other decade in our data.

Parks and recreation fields also exhibit significant churning within neighborhoods. Figure 7 presents the mean and standard deviation of park density averaged across all census tracts and shows that tract-wise park density increased across the study period, from an average of about 4.5 to just over 6 parks per square mile. Between 1970 and 1980, the standard deviation in tract-wise park density increased in accordance with the mean, suggesting that tract-level park access became more varied over time. In the 1980s, however, the mean and standard deviation begin to diverge, and between 2000 and 2010 the spatial variation in tract-level park access began to decrease. Thus, similar to our findings for manufacturing sites, 40 years of park churning appears to have functioned to increase neighborhood-level access to parks and recreation fields. In the second part of our analysis, we link these divergent findings through a series of spatial panel regression models that sets residential, industrial, and park churning in motion together.

Spatial Panel Regression Analysis

Spatial panel model results appear in Table 2. As noted, 1970-2010 was a period of transformational racial, ethnic, and economic change as Providence experienced sustained industrial churning (even during a prolonged period of steep deindustrialization) and demographic transition on its way to becoming a majority-BIPOC city. To capture these changes, Model 1 predicts park access using a series of demographic, socioeconomic, and housing characteristics, while Model 2 introduces two additional variables that control for changes in industrial land use. Comparing both models allows us to measure the impact of industrial churning on the relationship between residential and "green" geographies over time, linking the three elements of socioenvironmental succession together.

Model 1 shows that tract population size had a small but significant effect on park

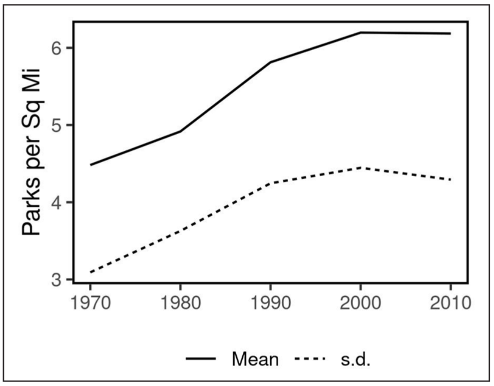

Figure 7. Park density, Providence, Rhode Island, 1970–2010.
Note. Mean and standard deviation of the density of city parks and recreation fields within a half-mile buffer of Providence's 39 2010-equivalent census tracts, 1970–2010. Standard deviation is low relative to the mean because tract-wise park density is calculated using a half-mile access buffer, smoothing differences between adjacent tracts.

access. Net of other covariates, a 1 percent increase in tract-level population is on average associated with 0.19 percent greater proximity to parks. Independent of tract-level population growth, a 1 percent increase in Latinx population is also associated with a 0.02 percent increase in park access relative to other census tracts, with the small coefficient of the Latinx variable offset by substantial growth in Latinx populations over the 1970 to 2010 period. In this way, 40 years of residential and green space churning has linked increasing park access with growing Latinx population at the tract level and thus has slowly rendered Latinx and non-Latinx access to green space less uneven.

A corresponding result is that neighborhoods with growing rates of rental housing have also seen increasing park access while, conversely, neighborhoods with increasing housing density (that is, growing population and decreasing numbers of housing units) and more children correlate with declining levels of green space access overall. In real terms, a 1 percent increase in rental housing units correlates with a 0.33 percent increase in resident park access; conversely, a 1 percent increase in housing density and youth population correlates with a 0.38 and 0.12 percent decrease in parks access, respectively. In this way, Model 1 generally tracks Elliott et al.'s (2019) findings in Houston, where park access increased alongside total population and Latinx population even as families with more children generally came to occupy neighborhoods with comparatively fewer parks over time.

Model 2 introduces tract-wise measures of longitudinal change in the number of active and relic manufacturing sites, which we use to measure industrial activity and industrial land use conversion, respectively. Here, we find that despite a negative but non-significant relationship between active manufacturing and park access, relic manufacturing exposure exhibits a strong positive association with park access over time. Indeed, relic site accumulation has one of the strongest effects on park access in Model 2—such that a 1 percent increase in relic manufacturing proximity corresponds with a 0.23 percent increase in the number of nearby parks and recreation fields. This finding provides strong evidence that urban brownfields and urban green space are positively correlated.

Controlling for industrial land use changes, the positive impact of rental housing and the negative impact of the number of children remain essentially unchanged from Model 1 results. The coefficients for total population and housing units are also consistent with Model 1, although they drop below the $p < .05$ significance level once the two manufacturing variables are introduced, suggesting that industrial history is a better predictor of park access than residential density. Yet we observe very different results for race and ethnicity: Latinx population is not a significant predictor of tract-level park access once we control for active and relic industry; instead, results indicate a significant negative association between African American population counts and park access, where a 1 percent increase in Black population is associated with a 0.02 percent decrease in park access at the tract level.

Table 2. Spatial Panel Model Predicting Park Access.

	Model 1		Model 2	
	Coefficient	SE	Coefficient	SE
Spatial lag of DV	0.73***	0.08	0.37	0.29
(Intercept)	0.32	0.44	0.22	0.58
Total population	0.19*	0. 09	0.14	0.09
Black	0.00	0.01	–0.02*	0.01
Latinx	0.02**	0.01	0.01	0.01
Children	–0.12**	0.04	–0.10*	0.04
Median income	–0.01	0.03	–0.01	0.04
Total housing units	–0.38*	0.18	–0.30	0.19
Vacant units	0.02	0.03	0.01	0.03
Rental units	0.33**	0.12	0.31*	0.12
Active manufacturing			–0.04	0.04
Relic manufacturing			0.23*	0.11
Spatial error parameter	–0.03	0.20	0.37	0.30
Tract-years	195		195	
Panels	5		5	

Note. SE = standard error; DV = dependent variable.
*$p < .05$. **$p < .01$. ***$p < .001$. Two-tailed tests.

This value is more meaningful than it may seem. In 1970, African Americans made up just 2 percent of the median population of Providence census tracts. By 2010, after 40 years of residential churning, the median tract-level Black population had grown to 13 percent, a nearly sevenfold increase. A hypothetical census tract that experienced this sevenfold median increase would host nearly 14 percent fewer nearby parks and recreation fields relative to other census tracts where the Black population remained unchanged. Thus, in real terms, even the relatively small coefficient associated with tract-level Black population points to substantial spatial inequality across the year-over-year racial, ethnic, and economic transformation of the city.

CONCLUDING DISCUSSION

Our analysis reveals complex interrelationships among residential, industrial, and green space geographies and their socioenvironmental outcomes over time. We find clear evidence of residential, industrial, and park churning, with each exhibiting distinct spatial and temporal patterns. These churning processes intersect to produce complex patterns of land use that reverberate, unevenly but successively, across urban landscapes. A key focus for this study is whether, as the three churning processes unfold in relation to one another, they reinforce or alleviate disproportionate environmental risk and privilege among city residents.

Our main finding is that industrial churning impacts urban residents' access to parks and recreation fields. Latinx population is not a strong predictor of changes to urban park access when we account for industrial land use change, despite the addition of nearly 40 neighborhood parks and this group's exponential growth during the study period. Black population growth has a negative impact on tract-level park access over the same period, net other variables and despite the diffusion of African Americans throughout many parts of the city. In both cases, patterns of segregation channel non-white residents into census tracts that are relatively park-poor and have higher densities of active or relic industrial sites. Controlling for those environmentally risky sites brings these relationships into sharper focus and highlights the importance of conceptualizing park access as a socioenvironmental process that unfolds through the relational interface of multiple forms of urban land use.

In developing a relational approach to environmental risk and privilege, this article goes beyond most park access studies by introducing geographical dynamism: over time, parks are created but also closed and transformed into new land uses in relation to shifting patterns of industrial development, deindustrialization, and "green" redevelopment. The 1970–2010 period spans these historical moments, allowing us to consider the shifting nature of urban parks in the context of a dynamic period of change in the local industrial political economy. Together, the shifting spatial relationship between parks, people, and pollution reveals an uneasy tension baked into the long history of urban development and urban parkland specifically. This has implications for urban policy and environmental justice as well as theoretical understandings of the processes that produce environmental risk, privilege, and inequality.

Regarding environmental justice, demographic turnover associated with deindustrialization may allow marginalized communities access to former zones of exclusion—including areas with a high concentration of accessible green space—but access comes at the price of institutional disinvestment and industrial contamination (e.g., Boone et al. 2009). Similarly, while new forms of green development may introduce parks and green space into formerly polluted areas, these strategies are often deployed as part of a broader urban transformation that maintains preexisting inequalities (Anguelovski, Connolly, and Brand 2018). Considered longitudinally and at the neighborhood level, the joint transformation of "green" and "brown" land uses may produce surprising outcomes, and linking industrial and green land uses, as we do here, helps to refine understanding of "who benefits" from greening interventions (Cole et al. 2017:1118) and "who has the right to the green city" (Anguelovski et al. 2018:418). Appreciating the conditional nature of environmental inequality thus contributes to the work of scholars, policymakers, and activists to promote environmental justice and "green equity" writ large—for instance, by integrating more comprehensive historical data and the interaction between industrial and "green" land use change into environmental justice screening tools (Holifield 2014; Kuruppuarachchi, Kumar, and Franchetti 2017).

These findings also complicate theoretical understandings of the processes that produce environmental inequality and privilege. Specifically, our results highlight the importance of accounting for the closely related processes that produce place-based environmental risk and privilege. Neglecting to account for the joint transformation of various features of the built environment in neighborhood-level research, especially when the built environment is treated as an outcome of interest, has the potential to hide important forms of social inequality from view. Extending the churning model to urban parks opens up one approach to parse this complex push and pull between residential change and environmental risk and privilege.

More broadly, this study underscores the need to integrate urban political economy more fully within the socioenvironmental succession framework that we seek to both expand and refine. As noted earlier, socioenvironmental succession attunes us to the local, particular, and empirical, while also allowing researchers to trace the dynamic meso-level geographies of urban environmental change as they emerge across specific landscapes over time. Our analysis of the joint transformation of residential, industrial, and green geographies extends from a theoretical and historical understanding that these local changes are a result of the interplay between politics and policy, local and regional economies, and local environmental conditions, among other forces. Linking the empirical, scalar, and longitudinal focus of the succession framework with urban political economy's concern with agency and power promises to extend urban environmental theory and methodology in important ways, as more thorough longitudinal land-use data give us insight into stratification processes unfolding across a continuum of neighborhood outcomes, ranging from elite green gentrification to concentrated environmental disadvantage. As longitudinal data collection strategies continue to develop, such projects are growing increasingly feasible.

Demonstrating the flexibility of the socioenvironmental succession framework thus opens several doors for future research. An *extensive* approach might take advantage of this flexibility to model increasingly complex forms of urban land use and residential change. For example, scholars might aim to link a variety of environmental land uses that are usually examined separately, from environment and health benefits like community gardens, grocery stores, walking paths, or public pools to risks in a variety of forms. Extending such an approach over a multidecade timescale requires highly detailed and comprehensive historical site data for a wide range of urban land uses. We are beginning to collect these data for the Providence area, following the lead of researchers' significant progress mapping historical land uses in London, ON, and Michigan's Upper Peninsula, respectively (see Hayek et al. 2010; Trepal and Lafreniere 2019; Trepal, Lafreniere, and Gilliland 2020). Alternatively, an *intensive* approach that complicates notions of proximity is another promising avenue for scholars to pursue, for example, by examining smaller-scale proximity measures (see Frickel and Tollefson 2022) or by looking to mobility and movement to measure risk and access beyond the home (Jones and Pebley 2014; Kwan 2018). Related analysis of place-based relationships that encompass cultural narratives, identity and identification, and creation and defense of social boundaries will require the triangulation of multiple forms of data, measurement, and ways of knowing.

Intensive approaches may also complicate how we conceptualize park access itself. This study has relied on an access-first approach, flattening differences between individual sites in order to measure "green" goods as a function of areal proximity. Yet park quality is an equally important mechanism of inequality (see Rigolon 2016). It is possible, therefore, that our results understate extant environmental inequalities embedded in the Providence park landscape. Further research might build out a historical census of park size and quality, and measure inequality as a function of both quality and access at once—or may open up the processes driving neighborhood-level succession, to weigh the role of park construction and closure compared with the more rapid processes of iterative population change in shaping access over time.

More generally, this study makes the case that urban environmental inequality is necessarily relational, produced through a multiscalar set of socioenvironmental processes involving shifting demographic patterns and iterative change in multiple forms of urban land use. Exploring the relational and conditional nature of urban environmental inequality, we believe, is a small but important step toward a deeper and broader environmental sociology of cities. Whether through extensive or intensive approaches, the relational socioenvironmental dynamics of cities deserve sustained empirical attention.

FUNDING

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Support from the Superfund Research Program of the NIEHS, grants P42ES013660 and 3P42ES013660-14S1. Thomas Marlow supported by the NYUAD Center for Interacting Urban Networks (CITIES), funded by Tamkeen under the NYUAD Research Institute Award CG00.

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NOTES

1. The park's opening in 2019 was the subject of a recent public radio story which notes that, despite intensive remediation, the underlying soils remain

contaminated. Monitoring for vapor intrusion inside the high school is ongoing (https://thepublicsradio.org/article/remediation-of-gorham-factory-site-finishes-off-with-opening-of-public-park).

2. Contaminants included heavy metals such as lead, mercury, and cadmium used in electroplating and machining; VOCs, such as trichloroethylene; long-chain PFAS, particularly those used in textile industries; and polychlorinated biphenols (PCBs) and polycyclic aromatic hydrocarbons (PAHs) common to all industrial production.
3. The data are computed from a question asked as part of the 5 percent sample questionnaire that allowed respondents to identify their "origin or descent" as Mexican, Puerto Rican, Cuban, Central or South American, or "Other Spanish" (Manson et al. 2021).
4. Thus, in our data set, the same sites can appear as active and relic across different years.
5. The expanded list of archival sources includes the Valley Breeze (1996–), the Providence American (1986–), Providence Business News (1986–), and Jewish Rhode Island (1929–); college newspapers associated with Brown University (1866–), the University of Rhode Island (1907–1971; 1971–), Rhode Island College (1928–), Roger Williams University, and the Community College of Rhode Island system; and several defunct news publications, including the *American Journal and General Advertiser, Providence Gazette, State Gazette, US Chronicle*, and *Providence Phoenix*. We do not rely on government reports; these provide overviews of parks and budgets in aggregate and are a poor source for building out a historically comprehensive list of parks and recreation fields.
6. While we have substantive reasons for excluding Roger Williams Park, running the same analytical models with the park included produces nearly identical results.
7. Models 1 and 2 are presented using Sarar specifications, though a lag-only specification returns comparable results for Model 2.
8. Churning indices measure cumulative change in residential demographics and are sign-agnostic, such that a 10-point increase in percent-Black in 1970 followed by a 10-point decrease in percent-Black in 1980 produces a 20-point change overall.

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