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Forewarned: The Use of Neighborhood Early Warning Systems for Gentrification and Displacement

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Abstract

The 1980s saw the emergence of neighborhood early warning systems that use indicators to assess patterns of neighborhood change. In more recent years, new systems and analyses are measuring the risk of gentrification and displacement. Using information from a dozen interviews with developers and users and from a survey conducted in one region, we show that policymakers, community residents, and other stakeholders are actively using these early warning systems strategically, tactically, and for empowerment. Although the extent to which the analyses have actually caused policy shifts is unknown, the early warning systems clearly have influenced the urban debate about housing and neighborhood change. The durability of these efforts, however, remains an outstanding question. Cities have not yet sought to develop these tools and strategies for more equitable, inclusive neighborhood change, yet city government is a logical home for early warning systems, especially given new technological capabilities.

Introduction

Neighborhoods change continually because of the movement of people and capital, both private and public. Change is often visible, as newcomers walk the streets or buildings and infrastructure are built and demolished. At the same time, change may be hard to discern, as property transfers and even the arrival of new tenants are not publicized. The process may take decades to unfold and may be nonlinear; change can stall or reverse, and the neighborhood may never fully transform.

As local residents and policymakers struggle to discern the nature and extent of changes, researchers have devised “neighborhood early warning systems” to describe change processes and even

predict future transformation. These toolkits, which take the form of either reports or online guides, tend to focus on economic and racial/ethnic change at the neighborhood scale via demographic and property data. The idea of early warning is that, by tracking investment, disinvestment, and population flows at the local level, policymakers can design cost-effective interventions before the pace of change accelerates and patterns become entrenched (Snow, Pettit, and Turner, 2003). In the case of neighborhood decline, early warning might mean identifying crime hotspots or abandoned properties. For neighborhoods that are revitalizing, toolkits tend to focus on areas of housing sales, racial transition, and new amenities, among other factors.

The first generation of toolkits from the 1980s and 1990s has now disappeared,¹ but both the overheating of the housing market and the planning of new transit systems have led to new interest in understanding neighborhood change, specifically in the form of gentrification and displacement. New early warning systems with an online presence have emerged in Portland, Oregon; the San Francisco Bay Area in California; Chicago, Illinois; and Minneapolis-St. Paul, Minnesota. Many other regions also have conducted analyses. This new generation of toolkits has the potential to transform policies to stabilize and/or revitalize neighborhoods, especially if, this time around, they find more permanent homes. One pathway might be to expand the “smart cities” movement beyond its current focus on efficiency to proactive policymaking around inclusion (Pettit and Greene, 2016).

Little is understood, however, about precisely how stakeholders are using the systems and what impact those systems have on policy. Early warning systems have complex and multiple goals in contrast with smart cities systems, which primarily attempt to make city systems more responsive to constituents. To make the case for integrating early warning systems into city operations, it is important to understand their value. This article describes the intent and use of these toolkits, assessing their ability to make policy more effective, their potential sustainability, and, for a few, their predictive capability.

The following section discusses the evolution of urban data capabilities and then describes the first generation of early warning toolkits. The next section presents a survey of the landscape of current toolkits, including the Urban Displacement Project tool in the San Francisco Bay Area, which the authors developed. The next section, using information from a dozen interviews with developers and users and also from a survey conducted in one region, explores the different ways that toolkits have been used. The final section lays out next steps for system development, suggesting ways to increase the relevance of toolkits to the planning and development decisions that elected officials and communities face.

¹ Snow, Pettit, and Turner (2003) profiled four early warning systems: the Chicago Neighborhood Early Warning System, by the Center for Neighborhood Technology; Neighborhood Knowledge Los Angeles, at the University of California, Los Angeles Center for Neighborhood Knowledge; the Philadelphia Neighborhood Information System, at the University of Pennsylvania; and the Minneapolis Neighborhood Information System, at the University of Minnesota. Each has either disappeared or not been updated in many years.

Perspectives on Smart Cities, Neighborhood Change, and Early Warning Toolkits

The current generation of neighborhood early warning systems dates from the emergence of Geographic Information Systems (GISs). A movement to democratize data resulted in broad experimentation with data portals that characterize neighborhood change. Most recently, the movement has shifted focus to making cities smarter.

The Use of Data and Maps in Cities and Neighborhoods

Shortly after GISs became widely available on personal computers in the early 1990s, a set of intermediaries emerged to create more democratic access to data; many of these intermediaries were part of the Urban Institute's National Neighborhood Indicators Partnership (NNIP; Treuhaft, 2006).² These intermediaries, often community-based organizations working in partnership with universities, gather neighborhood-level data, organize them into a database, and help community actors map and analyze the data by themselves. The focus thus was on *empowerment*, building trust and capacity in communities that historically had been on the wrong side of the map (for example, through practices such as redlining) (Treuhaft, 2006).

The movement to democratize data has recently morphed into interest in smart cities, which optimize urban systems and service delivery through real-time monitoring and control. The promise of smart cities is that new digital tools that aid in the collection, analysis, and dissemination of data will help cities shift from a compliance mode to a problem-solving mode (Goldsmith and Crawford, 2014). At the same time, it is believed, technology will strengthen civil society as constituents coproduce solutions with government (Goldsmith and Crawford, 2014). Absent, however, from smart cities experiments is the application of technology to more equitable outcomes, particularly in neighborhoods, and also the input from community organizations (Baud et al., 2014; Pettit and Greene, 2016).

Despite the enthusiasm about moving toward smarter cities and more democratic data, questions remain about how the data and maps produced are actually used. Data analysis and maps either remain for internal use in decisionmaking, whether by government agency or community organization, or they are made available to external audiences to garner attention or generate new ideas. Users, particularly community groups, may use maps in a *strategic* way (for example, to identify needs or target resources), as a *tactic* to raise awareness or implement solutions, for *administration* (for example, for service delivery), for *organizing* or building the capacity of a constituency, or simply for *exploration* to see if spatial knowledge legitimizes local experience or raises questions about city policy (Craig and Elwood, 1998; Ghose, 2011). Over the long term, GIS analysis and maps are thought to have the potential to transform planning, policy, and programs (Ramasubramanian, 2011)—yet, little systematic evidence supports this thinking.

² NNIP, founded in 1996, consists of a loose network of data intermediaries in 30 cities.

The Rise of Neighborhood Early Warning Systems

Scientists and social scientists alike have long coveted the ability to predict the future. As the availability of new data has made it possible to identify the factors predicting or simply has correlated with different phenomena, researchers have tried to use these indicators to predict future change. Thus, early warning systems are now available for crime hotspots and gang homicides (Gorr and Lee, 2015; Sampson, 2011), housing abandonment and foreclosure (Hillier et al., 2003; Williams, Galster, and Verma, 2013), housing price appreciation (Galster and Tatian, 2009), land use change (Waddell, 2002), and even tornados (Oleske, 2009).

The first neighborhood-level early warning system was pioneered beginning in 1984 by the Center for Neighborhood Technology in Chicago. The idea was to create a portal of property data, such as information on tax delinquencies, code violations, and utility shutoffs, which could then be used to monitor neighborhood housing conditions (and thus spur intervention). Because many forms of financial disinvestment are invisible, identifying patterns in a timely manner can be preventative. An early Urban Institute report describing four such systems (in Los Angeles, California; Minneapolis; and Philadelphia, Pennsylvania—in addition to Chicago) found that they all provided indicators of financial disinvestment based on parcel-based data—aggregated in different ways, depending on the issue—obtained from the local government (Snow, Pettit, and Turner, 2003). With an audience of government agencies and community-based organizations, the systems were disseminated on the web and housed at academic or research institutions.

Cities and other stakeholders are interested in monitoring neighborhood decline for immediate reasons—the potential that families will lose their shelter—and for long-term issues—particularly the spiral of decline that can result in a variety of costly impacts for families and cities alike (Wilson, 1987). By contrast, the rationale for monitoring neighborhood revitalization or gentrification is murkier.

Gentrification is a simultaneously spatial and social practice that results in “the transformation of a working-class or vacant area of the central city into middle-class residential or commercial use” (Lees, Slater, and Wyly, 2008: xv)—meaning the influx of both capital (real estate investment) and higher-income or higher-educated residents. Displacement—when households are forced to move out of their neighborhood—can be a negative outcome of gentrification but may also precede it (Marcuse, 1986). Real estate investors, including prospective homebuyers, certainly take an interest in gentrification. For cities, it is important to understand neighborhood upgrading not only to stabilize communities but also to intervene proactively before intervention (for example, mitigating displacement) becomes costly and difficult (Pettit and Greene, 2016).

In one earlier iteration of work predicting gentrification—a presentation by researchers from the Urban Institute (Turner and Snow, 2001)—the researchers characterized the process of gentrification by (1) shift in tenure, (2) increase in downpayment and decrease in FHA financing, (3) influx of households interested in urban living, and (4) increase in high-income-serving amenities such as coffee shops or galleries. Analyzing data for the DC area, they identified the following five predictors of future gentrification (defined as sales prices that are above the DC average) in low-priced areas: (1) adjacency to higher-priced areas, (2) good access to the Metro subway system,

(3) historic architecture, (4) large housing units, and (5) more than 50 percent appreciation in sales prices between 1994 and 2000. Census tracts were scored for each indicator and then ranked according to the sum of indicators, with a maximum value of 5.

In 2009, the Association of Bay Area Governments sponsored an analysis of neighborhood change in the San Francisco Bay Area from 1990 to 2000, which predicted neighborhood susceptibility to gentrification, with a disclaimer that it was not possible to measure resident displacement via this method (Chapple, 2009). Chapple adopted Freeman’s (2005) definition of gentrifying neighborhoods as low-income census tracts in central city locations in 1990 that, by 2000, had experienced housing appreciation and increased educational attainment that were higher than the nine-county regional average and then constructed a multivariate statistical model that had gentrification as the dependent variable and a set of 19 socioeconomic, locational, and built environment factors for 1990 as independent variables. When census tracts scored above the regional average for each variable, they received a value of 1; the susceptibility index summed the scores across the variables.

In 2011, Atkinson et al. characterized household vulnerability to displacement from neighborhoods that gentrified between 2001 and 2006 in the Melbourne and Sydney, Australia, greater metropolitan areas. A vulnerability score (from 1 to 13) was measured based on tenure, number of employed people per household, and occupation. Displacement rates were calculated by dividing the number of out-migrants with vulnerability characteristics by the number of households with these characteristics exposed to the likelihood of moving in 2001. Neighborhoods that had higher-than-projected numbers of high-income, owner-occupant, and professional populations were designated gentrified.

Researchers have used myriad indicators and sources of data for characterizing residential gentrification displacement, each with its own set of advantages and disadvantages (exhibit 1). The table in exhibit 1 summarizes quantitative data sources only; however, data on many of the drivers and impacts of gentrification and displacement are not regularly gathered or are difficult to quantify.

Exhibit 1

Indicators and Data Sources for Analyzing Gentrification and Displacement (1 of 2)

Indicator Type	Indicators	Data Sources
Change in property values and rents	Sales value, property value	County tax assessors’ offices, finance departments, data aggregators
	Rent	Data aggregators, apartment operating licenses, craigslist
	Changes in availability of restricted affordable housing	HUD, housing departments

Exhibit 1

Indicators and Data Sources for Analyzing Gentrification and Displacement (2 of 2)

Indicator Type	Indicators	Data Sources
Investment in the neighborhood	Building permits, housing starts, renovation permits, absentee ownership	Jurisdictions' building or planning departments
	Mortgage lending and characteristics	HMDA and assessors' data
	Sales (volume and price)	County assessors' offices, data aggregators
	Condominium conversions	Assessors' offices, housing departments, public works departments
	Change in community and business organizations (for example, number, membership, nature of activities)	Chambers of Commerce, Dun & Bradstreet, neighborhood or local business associations, and so on
	Public investments (for example, transit, streets, parks)	Public works departments, transit agencies, parks and recreation departments, and so on.
Disinvestment	Building conditions, tenant complaints, vacancies, fires, building condemnation	Surveys, censuses, maps, building departments, utility shut-off data, fire departments
	School quality, crime, employment rates, neighborhood opportunity	Departments of education, police departments/crime maps, censuses, Bureau of Labor Statistics
	Neighborhood quality	Local surveys
Change in tenure and demographic changes	Tenure type, change in tenancy	Building departments, assessors' offices, censuses
	Evictions	Rent boards, superior courts
	Foreclosure	HUD, proprietary data sources
	Demographics data on in- vs. out-movers (for example, race, ethnicity, age, income, employment, educational achievement, marital status)	Censuses, voter registration data, real estate directories, surveys, American Housing Survey, departments of motor vehicles
Investment potential	Neighborhood and building characteristics (for example, age and square footage, improvement-to-land ratio)	Tax assessors, censuses, deeds, and so on
	Neighborhood perceptions	Surveys of residents, realtors, lenders, neighborhood businesses, newspapers, television, blogs, and so on
Reasons that people move in or out of neighborhood	Reason for move	Surveys of in-movers and out-movers, state housing discrimination complaints database
Coping strategies and displacement impacts	Crowding or doubling up	Censuses, utility bills, building footprints
	Increased travel distance and time	Censuses

HMDA = Home Mortgage Disclosure Act. HUD = U.S. Department of Housing and Urban Development.

The Future of Neighborhood Early Warning Systems

More than 30 years after the first neighborhood early warning system emerged, those systems arguably have failed to meet their potential. In fact, the first early warning systems for neighborhood decline have not survived the test of time. Although more research would be necessary to determine why, three explanations seem likely: (1) all the systems were housed at nonprofit organizations or universities, where changes in personnel and leadership can change institutional focus (as opposed, for example, to a city, which has a more constant mission); (2) all the systems relied primarily on funding from philanthropy, which changes its focus frequently, and/or the U.S. Department of Housing and Urban Development (HUD), which has experienced repeated budget cuts in the past few decades; and (3) none of the systems developed a broad base of users (beyond community-based organizations).

The first generation of early warning systems innovated new uses of local data and offered considerable promise to shape policymaking (Snow, Pettit, and Turner, 2003). The lack of sustainability in these systems, however, suggests that they failed to convince potential users about the importance of early warning and preventive approaches to neighborhood change. Moreover, three decades after the first research on gentrification and displacement, we continue to struggle to predict which neighborhoods will gentrify and who will benefit (and suffer). Most of the debate about gentrification and displacement has remained in academic spheres, outside of the policy realm—until the recent arrival of warning systems for gentrification and displacement.

The emergence of the smart cities movement suggests the potential of these tools. Research suggests that data on gentrification and displacement underrepresents the most disadvantaged populations and presents a mismatch between data and lived experience (Zuk et al., 2015). This underrepresentation might be overcome by user-generated geographic content, volunteered by residents and posted via interfaces like Flickr (Goodchild, 2007). With better data, prediction might improve, and, with more accessible portals, different stakeholders may coproduce more effective policies. Pettit and Greene (2016) envision the following—

But what if city leaders and community groups could get ahead of these changes and act early to direct neighborhood changes toward more inclusive outcomes? Using big data and predictive analytics, they could develop early warning systems that track key indicators of neighborhood change and predict future trajectories (Pettit and Greene, 2016: 2).

The next section presents an overview of how the next generation of early warning systems is faring.

Neighborhood Early Warning Systems: Surveying the Landscape

To examine further the use of early warning systems for neighborhood change—and gentrification and displacement in particular—we next establish the universe of systems via a web scan. Two starting points were the Urban Institute’s NNIP and the Obama administration’s open data portal, The Opportunity Project. We also searched the web on terms such as “neighborhood,” “gentrification,” and “displacement” and asked our interviewees for systems we had missed.

We identified three types of websites that explore neighborhood issues: (1) neighborhood indicator maps (typically of development, such as local educational attainment or housing construction, or quality of life, often represented by amenities), (2) opportunity maps, and (3) racial/economic change maps (including gentrification).³ To narrow our focus, we chose just the sites focusing on gentrification within this last category, which included projects in Chicago, Minneapolis-St. Paul (two projects), Portland, San Francisco, and Washington, DC. We excluded several sites that depict neighborhood change without an explicit focus on gentrification or assessment of risk.⁴ We then added projects from several cities—Charlotte, North Carolina; Houston, Texas; Los Angeles; Seattle/Puget Sound, Washington; and St. Louis, Missouri—that had produced recent assessments of gentrification or displacement risk with a report, rather than a web interface, as the final product. Again, we excluded recent gentrification reports that were not framed as risk assessments.⁵

From the 11 projects, we interviewed 9 of the system creators and attended a presentation of 1; the last site is our own. Most of the interviews occurred via telephone and lasted 45 to 60 minutes, using a semistructured format; one interview was by e-mail. The analysis also draws from a survey of users (n = 33) of the University of California, Berkeley's Urban Displacement Project toolkit.⁶

The projects generally fall into two broad categories: (1) those developed by universities, with online map interfaces, and (2) those developed by cities as reports for internal use (exhibit 2). Perhaps because of the role of city government in many of the projects, most of the analyses examine neighborhood change within city, rather than regional, limits. The most common audience, both intended and actual, is city government and community organizations; others specified regional agencies, community members, and elected officials as their target audience. All the sites rely primarily on U.S. census data at the tract level, typically using the data with standardized census tract boundaries provided by GeoLytics, Inc., or Brown University. Most of the projects span at least two decades (1990 to 2010 or 1990 to 2014), and two projects (Chicago and St. Louis) use 1970 as the starting year. Two sites (Portland and San Francisco) also add parcel-based data on recent home sales, and two (San Francisco and Washington, DC) add data from the U.S. Census Bureau's Longitudinal Employer-Household Dynamics program on job accessibility and also add a rail transit station layer. One site (San Francisco) also uses data about amenities (parks, transit, walkability), property characteristics (from the tax assessor), and nonprofit organizations.

³ Our scan identified 24 of these websites, but we suspect that many more exist.

⁴ These sites include HUD's Affirmatively Furthering Fair Housing Assessment Tools (huduser.gov/portal/affht_pt.html#affhassess-tab); Code for Boston's Ungentry (<http://codeforboston.github.io/ungentry/>); and sociologist Michael Bader's racial/ethnic change maps for New York, Los Angeles, Chicago, and Houston (<http://mikebader.net/media/neighborhoodtrajectories/map.html?city=newyork>).

⁵ These reports include the 2016 New York University Furman Center for Real Estate and Urban Policy annual report on New York City housing (<http://furmancenter.org/research/sonychan>) and two reports on Philadelphia by the Federal Reserve Bank (Ding, Hwang, and Divringi, 2015) and the Pew Charitable Trusts (2016).

⁶ The Urban Displacement Project solicited survey responses from a list of 395 stakeholders in the nine-county Bay Area, including housing policy advocates, planning directors, and elected officials. After two e-mail solicitations, the project received 33 responses (a response rate of 8 percent). The survey asked users 10 questions about how they used the site (maps, case studies, and policy inventory) and also asked how the site could be improved.

Exhibit 2

Neighborhood Early Warning Systems for Gentrification and Displacement (1 of 2)

City/Region	Type of Project	Host	Geography	Goal	Users	Format	Policy Influence?
Charlotte, North Carolina	Neighborhood change analysis	City of Charlotte	City	Tactical: Understand how to do equitable and inclusive development	City, some community organizations	Internal report	NA
Chicago, Illinois	Gentrification index	University of Illinois at Chicago	City	Tactical and empowering: Measure change and provide tools	Community organizations	Report and maps on line	Yes
Houston, Texas	Gentrification index and at-risk indicator	Local Initiatives Support Corporation	City	Strategic, tactical, empowering: Use as advocacy tool for LISC	LISC, community organizations	Internal report	Yes
Los Angeles, California	Gentrification index	City of Los Angeles	City	Strategic: Help city target initiatives within a large grant program	Mayor's office	Internal report	NA
Minneapolis, Minnesota	Housing market index	University of Minnesota Twin Cities	Twin Cities	Strategic, tactical, empowering: Start a conversation, inform policymakers and residents	Community organizations, city	Report and maps on line	Yes
Minneapolis-St. Paul metropolitan area, Minnesota	Gentrification index and at-risk indicator	Minnesota Center for Environmental Advocacy	Region	Strategic, tactical: Spark conversation, implement mitigations, obtain funding	Community organizations	Report and interactive maps on line	No
Portland, Oregon	Gentrification index and at-risk indicator	Portland State University (hosted by <i>The Oregonian</i>)	City	Tactical, empowering: Show where gentrification is happening in Portland	City, community organizations	Report and maps on line	Yes
St. Louis, Missouri	Index of "neighborhood vitality"	University of Missouri-St. Louis	City	Tactical and empowering: Show which neighborhoods are "rebounding"	Community organizations	Report on line	Yes
San Francisco Bay Area, California	Gentrification index and at-risk indicator	University of California, Berkeley	Region	Tactical and empowering: Describe current patterns of neighborhood change and city policies	Local government, community organizations, elected officials	Report and interactive maps on line	Yes

Exhibit 2

Neighborhood Early Warning Systems for Gentrification and Displacement (2 of 2)

City/Region	Type of Project	Host	Geography	Goal	Users	Format	Policy Influence?
Seattle-Puget Sound, Washington	Neighborhood typology and at-risk indicator	Puget Sound Regional Council	Region	Strategic and tactical: Provide jurisdictions a tool for station-area plans	Local government, community members	Report on line	Yes
Washington, DC	Gentrification index and at-risk indicator (not yet released)	University of Maryland, College Park	Region	Tactical: Understand change primarily around transit (Purple Line on the Metrorail system)	Local government	Maps on line	NA

LISC = Local Initiatives Support Corporation. NA = not applicable.

Analyzing Risk

The first generation of reports analyzing gentrification and displacement risk generally all followed the same methodology; that is, run correlations or regressions to identify predictors of gentrification and/or displacement and then assign each factor a value to come up with a susceptibility score (Atkinson et al., 2011; Chapple, 2009; Turner and Snow, 2001). The analyses behind the current set of early warning systems—in Chicago, Houston, Portland, the San Francisco Bay Area, and Seattle/Puget Sound, as described further below—have improved on this methodology by looking at the dimension of time (that is, past and present neighborhood change dynamics in addition to the extent of vulnerability). Many analyses also make a useful analytic distinction between gentrification and displacement, while still analyzing both.

The Chicago gentrification index (Nathalie P. Voorhees Center, 2014) determined relevant factors based on a literature review. It provided a “score” for each “community area” in 1970, 1980, 1990, 2000, and 2010, based on a composite index that compares the community area to the city at large for 13 indicators. Then, a neighborhood change typology (displayed in maps) was constructed not just from these scores but also from their change between 1970 and 2010. A separate toolkit identified housing, land use, and other tools appropriate for each of three stages: (1) before gentrification, (2) midstage gentrification, and (3) late-stage gentrification (Nathalie P. Voorhees Center, 2015).

Building off the same methodology as Chapple (2009), Local Initiatives Support Corporation (LISC) researchers constructed a model predicting gentrification in neighborhoods of Houston, using a slightly narrower definition of gentrifying neighborhoods (Winston and Walker, n.d.). The LISC researchers used the regression coefficients and continuous independent variables in predicting susceptibility to gentrification.

In Portland, Bates (2013) predicted market changes based on vulnerability to displacement, demographic changes, and housing market conditions, a method that was replicated in the Twin Cities gentrification risk assessment performed by the Minnesota Center for Environmental Advocacy. Tracts were vulnerable to displacement in 2010 when they had higher-than-average populations

of renters and communities of color, few college degrees, and lower incomes. For housing market conditions, Bates defined neighborhood market typologies as (1) adjacent tracts (low/moderate 2010 value, low/moderate appreciation, next to high-value/appreciation tract); (2) accelerating tracts (low/moderate in 2010 with high-appreciation rates); and (3) appreciated tracts (low/moderate 1990 value, high 2010 value, high 1990 to 2010 appreciation). Combining this information with demographic shifts for vulnerability factors between 2000 and 2010, the study identified six neighborhood types ranging from early to mid- to late-stage gentrification. Bates then used these typologies to recommend how to tailor policy approaches to the specific characteristics and needs of neighborhoods.

In the San Francisco Bay Area, the Urban Displacement Project provided a typology analysis that characterizes Bay Area neighborhoods (census tracts) according to their experience of gentrification and risk of displacement.⁷ This early warning system was based on a gentrification index that adapts the methodologies of various researchers (for example, Bates, 2013; Freeman, 2005; Maciag, 2015) to characterize places that historically housed vulnerable populations but have since experienced significant demographic shifts and real estate investment.

The loss of low-income households between 2000 and 2013 was used as a proxy for displacement. On average, Bay Area census tracts' low-income population grew by 59 households between 2000 and 2013. The typology therefore assumes that any neighborhood that experienced a net loss of low-income households while stable in overall population is a result of displacement pressures.⁸ After constructing regression models to estimate the predictors of both gentrification and loss of low-income households/displacement, the project developed place typologies for risk of either gentrification-related displacement or exclusion-related displacement (which occurs in higher-income neighborhoods). Unlike the other studies, results were vetted via several workshops with a project advisory committee and also via community forums. Based on these interactions, tracts were divided into low-income and moderate- to high-income tracts to capture the displacement pressures occurring in nongentrifying neighborhoods that are also losing low-income households. Exhibit 3 presents the resulting typology. The Urban Displacement Project's website also includes an inventory of policies available in each jurisdiction (exhibit 4).

The Puget Sound Regional Council project, conducted with the Center for Transit-Oriented Development, used descriptive methods to construct a typology of neighborhoods based on risk factors (the "people profile") and market strength (the "place profile"), which then formed the basis for suggesting policy responses (PSRC, 2013). For the people profile, one axis consisted of social

⁷ This project was a side product of a larger study funded by the California Air Resources Board and the Metropolitan Transportation Commission (via HUD's Sustainable Communities Initiative) that involved extensive qualitative and quantitative regional analysis to better understand the nature of neighborhood change and displacement in the Bay Area and their relationship to transit.

⁸ We assume that a tract that lost low-income households during this period underwent some process of displacement when combined with other indicators such as a loss of market-rate affordable units or a decline of the in-migration of low-income population into that tract beyond the regional median. Although the change in low-income households could be because of income mobility (for example, low-income households moving into middle- or upper-income categories, or vice versa), from our analysis of data from the Panel Study of Income Dynamics, we estimate that there would have been a net increase in low-income households in most places likely because of the Great Recession (December 2007 to June 2009); therefore, our estimates of displacement are likely an underestimate.

Exhibit 3

Displacement/Gentrification Typologies^a

Lower-Income Tracts (> 39% of households are considered low income)	Moderate- to High-Income Tracts (< 39% of households are considered low income)
<p>Not losing low-income households or very early stages</p> <ul style="list-style-type: none"> Does not fall within any of the following categories 	<p>Not losing low-income households or very early stages</p> <ul style="list-style-type: none"> Does not fall within any of the following categories
<p>At risk of gentrification or displacement</p> <ul style="list-style-type: none"> Strong market In TOD Historic housing stock Losing market-rate affordable units Employment center 	<p>At risk of displacement</p> <ul style="list-style-type: none"> Strong market In TOD Historic housing stock Losing market-rate affordable units Employment center
<p>Undergoing displacement</p> <ul style="list-style-type: none"> Already losing low-income households and naturally affordable units In-migration of low-income residents has declined Stable or growing in size 	<p>Undergoing displacement</p> <ul style="list-style-type: none"> Already losing low-income households Either naturally affordable units or in-migration of low-income residents has declined Stable or growing in size
<p>Advanced gentrification</p> <ul style="list-style-type: none"> Gentrified between 1990 and 2000 or between 2000 and 2013 based on— Neighborhood vulnerability Demographic change Real estate investment 	<p>Advanced exclusion</p> <ul style="list-style-type: none"> Very low proportion of low-income households Very low in-migration of low-income households

TOD = transit-oriented development.

^a Tracts with 0 population in 2010 were excluded from the analysis (8 tracts). In addition, tracts where more than 50 percent of the population in 2010 was in college were excluded from the analysis (11 tracts).

Exhibit 4

Policy Inventory on Urban Displacement Project Website



Source: <http://www.urbandisplacement.org>

infrastructure and access to opportunity. The second axis—change/displacement—measured risk of displacement resulting from recent neighborhood change, current community risk factors, and current and future market pressure. The place profile also consisted of two dimensions: (1) urban form that supports a dense and walkable transit community and (2) the likelihood that the community will change in response to real estate market strength. Combining the people and place typologies, they identified eight general typologies; for each typology, they identified implementation and policy approaches.

Thus, in an attempt to predict change more accurately, early warning systems and related projects are gradually improving in methodology. Notable methodological shifts include the analysis of multiple stages of both gentrification and displacement, building on the approach of Bates (2013); the shift to a regional, rather than municipal, framework; and the mixing of quantitative and qualitative approaches. Conceptualizing gentrification and displacement as a long-term, multistage process, rather than a binary state or on/off switch, has helped build local buy-in into the early warning systems. Looking at many different cities within a region helps localities understand regional housing market dynamics and learn about different policies. Checking results with local residents and key informants helps ensure that the maps represent conditions on the ground.

Methodological problems remain, however, particularly in terms of the predictive ability of the models. Methods are still far from transparent: models are not readily replicable, and the scores can be hard to understand. The next section describes how stakeholders are using the models in practice and also the effectiveness of the new approaches.

The Use and Impact of Neighborhood Early Warning Systems

This section examines the use and impact of these projects, looking at those that assess gentrification and/or risk (in Chicago, Houston, Minneapolis-St. Paul, Portland, San Francisco, St. Louis) and also examines the other neighborhood change reports (in Charlotte, Los Angeles, Minneapolis, and Seattle/Puget Sound).⁹ We assess first how internal actors, and then external stakeholders, use early warning systems. We then examine what impact the projects have had on policymaking and how accurate they are at predicting change.

Internal Use

One obvious use for early warning analyses is in strategic planning for housing and neighborhoods. Maps that show how neighborhoods are changing and that anticipate future change can help stakeholders bring attention to imminent problems and target resources. If the map suggests that change is in very early stages, the neighborhood can strategize about actions to take during the long term; for example, the Houston systems architect said, “. . .in Houston, we are a few years or a decade behind other metropolitan areas in terms of the waves of gentrification and things coming. So what we realized is that by doing research now, we could get ahead of that.” The gentrification analysis showed where change was anticipated yet land was still cheap, so that intermediaries could target land acquisition funds strategically.

⁹ Because the Washington, DC site has not yet been launched, it is too early to assess its use and impact.

The Houston project was strategic, not just in terms of timing but also in policy approach and ownership. Before the analysis, stakeholders had expressed some disagreement about how to spend disaster recovery money. Having the data helped advocates to say, "...if we're doing this investment, let's also create and preserve affordable housing opportunities in places at risk of gentrification"—but without making enemies by specifically endorsing certain policies within the report itself.

The Houston system creator said—

We had a strategically placed piece of analysis that could help community stakeholders on our side make a point about what policy ought to be. Not a distraction, not something that came out of Washington, DC, saying this is what y'all ought to do. Because that would have been suicidal.

Another strategic, internal use of maps is targeting resources, as with the Housing Market Index (HMI) in Minneapolis, which helps determine the blocks where funds to fix vacant property can be most effectively spent. One developer on the Minneapolis project said, "It has been very, very, very useful.... When you're involved in politics, and competition for scarce resources, the more facts you can provide, the better you are. The HMI are facts. And that speaks much louder than any political will."

In Charlotte, where the use of the report remained internal to the city government, the analysis became a tactic to broaden the framework and discussion of neighborhood change. The initial referral from the city council had been to look at gentrification, but instead the city "looked more broadly at neighborhood change and the challenges that can arise in the context of gentrification across all neighborhoods, plus the close ties that this issue has with economic opportunity and the historic patterns of economic and racial segregation in Charlotte—consequently, we looked at a broad range of indicators."

The analysis in Charlotte ultimately supported the development of a much broader housing strategy than anticipated, with a wide array of tools and strategies to manage neighborhood change.

Once the analysis is in place, it can create its own momentum. In Seattle, the Puget Sound Regional Council analysis established—after considerable debate with advocates—that four neighborhoods in southeast Seattle were at high risk. Years later, planners working on the update to the Seattle Comprehensive Plan used the analysis as a background document to show that the community was at risk. Developers of the gentrification typology in Minneapolis-St. Paul have a similar intent—to create the momentum to fund and implement the mitigations for neighborhood preservation and equitable development in St. Paul's Central Corridor Development Strategy.

External Use

The most common use of early warning indicators and maps is as a *tactic* to spark a conversation, generate new ideas, or show how to implement solutions. The survey of users of the Urban Displacement Project in the San Francisco Bay Area suggested that this was the primary use of that warning system. Users volunteered that it was a tool to start dialogue: "I've used the maps to show policymakers that my neighborhood is at risk of displacement."

In the Bay Area, the tool also serves to legitimize other work—

My organization provides legal research, advice, education, and advocacy to support communities in developing community-owned economic structures. This data has been useful in better understanding the dynamics of displacement internally, as well as in communicating about the importance of our work to the public.

It also lets advocates know where cities lack antidisplacement policies, so they can push for implementation. A user of the Urban Displacement Project in the Bay Area reported using the site “to assess which areas have been most impacted in order to identify mitigation strategies for nonprofits that lease in those areas.” Users reported using it “to check on what policies have been implemented by Bay Area jurisdictions to produce more housing” and “assessing opportunity for preservation strategies and making the case for funding.” Because the maps are regional, advocates use them to advocate at the regional level: “[We] identify which cities are performing well and which are not. [We] advocate for MTC [Metropolitan Transportation Commission] to use this info to guide funding through OBAG [a regional grant program to encourage density] to incentivize better local policies.”

In St. Louis, the release of the index of “neighborhood vitality” also brought new attention to “rebounding” neighborhoods, helping to spark a conversation about how reinvestment occurs. Researchers at the University of Missouri–St. Louis sponsor a morning panel that highlights “come back” neighborhoods, with a panel of people from the neighborhood that tell the story of what was done to strengthen the community.

Maps of neighborhood change at a regional scale can help bring perspective to communities that had considered themselves immune to affordable housing need. In Seattle, the conversation took a new turn—

Roosevelt community...is ‘Improve Access’ [type]...[it is one of the] station areas that were predominantly white, affluent station areas in a wealthier city. When having conversations about what to do with surplus lands the transit agency will have, I was able to go in and talk about the typology exercise, which highlighted that adopting tools to ensure affordable housing was a central need for places like Roosevelt... [which] helps counter some of the community members who want to use those for parks and open space.

The Twin Cities gentrification typology is also meant to educate the suburbs, developers, and others who do not comprehend the extent of housing pressure on the urban core. The developer said, “It’s like driving down the road using your rearview mirror, and all of this demographic change is in front of you. You’re going to end up in the ditch.”

The maps often serve to validate disenfranchised perspectives. One place where such validation occurred was Portland, where many planners did not understand the issues—

And then there was this big explosion around a bike lane project...historically black part of Portland. That was the first wave of displacement. So it’s on the bike boulevards plan...they were not going to do any of the pedestrian safety stuff that black folks had asked for. Huge conflicts between bike lanes and buses. So all the transportation planners were like, ‘Wait what is this gentrification thing people are talking about?’ so that was one of the first goals was to get people on the same page of what are we talking about.

The maps made the issues more real: “So for the [National] Urban League, and some other black [organizations, it was like]: ‘See this thing we told you was happening, has happened, is real. It’s in the data.’”

When the city sponsors the project, as in Portland, it can help legitimize the entire conversation. The system creator in Portland said, “One of my first conversations with them in talking was, ‘you should all stop saying that you’re trying to gentrify stuff. It’s not going over well.’ They would routinely say that. ‘Oh this area needs gentrification...’ with no comprehension of what they were saying... I think it was really important that there was an acknowledgment on the part of the city that this was not a purely market accident. So that started happening more in the popular conversation.”

Likewise, a creator of the Chicago maps argues that depicting how neighborhoods are changing, even where the gentrification process is just barely starting, is effective because users can recognize themselves—and their own economic struggles—in the maps.

Inequality perpetuates this narrative of gentrification, the fear of gentrification, even if it’s not really happening. When you can’t get into the middle, when you’re middle income and you can’t buy a house, then there are structural forces at work. But you want something to blame, and so the narrative about how gentrification is occurring feels right.

In Chicago, the active dissemination of the index into communities by the University of Illinois at Chicago researchers helped locals shift into action and policy design. As communities looked at the new index, they wanted to deconstruct it and shift into figuring out strategies: “Communities are looking for that sweet spot, where they can prevent excessive development but still get enough to have resources.” Part of this conversation was spurred by media attention, a radio reporter who became interested in the issue because of her own neighborhood, Bronzeville. The interest led the university to add the policy toolkit, which then spurred many new conversations in different communities.

Another way to use data analysis and maps is to organize or empower a constituency. In Portland, the housing advocates formed a new coalition and reframed it around displacement, broadly defined—an umbrella that could include those fighting gentrification, or for renter protections, or to stabilize communities. For the projects being used by community organizations, all the interviewees reported empowerment and capacity building as outcomes. From Minneapolis-St. Paul to the San Francisco Bay Area, community organizations use the maps to organize their constituencies. The data do not show only that “it’s real”; the data provide evidence that advocates point to in meetings with and letters to policymakers.

In St. Louis, the analysis revealed that every rebounding neighborhood had strong civic engagement—

My main surprise is that when we go out to the neighborhoods that we identified as these rebound neighborhoods, that there really is a—groups on the ground that are talking about this. About what they can do to help the neighborhood. And it’s sort of, they find it extremely gratifying to be identified as a neighborhood that’s coming back. There seems to be a very upbeat conversation about these neighborhoods.

Interacting with communities about the early warning maps helped creators realize that locals needed to be equipped to deal with different stages of gentrification. In Chicago: “We quickly realized that we needed to show people how different tools are appropriate for different stages of gentrification.” For instance, when gentrification is late stage, as in East Pilsen, the strategy should be to preserve the diversity and stabilize the community by building coalitions across different groups.

Policy Impact

Many of these early warning systems and reports are in the public domain and have become established resources in the ongoing civic conversation about housing. This social context may have aided the process of policy learning, as policy communities construct shared definitions and debate ideas (Bennett and Howlett, 1992). Most of the interviewees can point out different ways that the analyses have shaped the policy conversation, though it is hard to know how pivotal a role they played in the passage of specific policies. Even the cities using their new neighborhood change tools internally, such as Los Angeles and Charlotte, reported shifts in how their governments thought about housing needs and targeting resources.

In St. Louis, the report influenced conversations by the Ferguson Commission about the siting of Low-income Housing Tax Credit housing in poor areas. Also, the report found that no rebounding neighborhoods were in the north of the Delmar area, which helped spur a new conversation about using tax increment financing to fund infrastructure. In Houston, the analysis of gentrification risk “kept the drumbeat going” at city hall and also helped convince Houston Endowment Inc. to provide \$1 million for a loan fund in a transitioning neighborhood. In Chicago, the maps likely contributed to the passage of the Single-Room Occupancy Preservation Ordinance. Portland has a new focus on housing policy throughout the civic arena, with the declaration of a housing emergency and many different new policies, such as the redistribution of tax increment finance revenues to affordable housing.

The evidence of policy influence is clearer in the Bay Area, where displacement and gentrification pressures are particularly acute and the Urban Displacement Project has garnered considerable media attention (more than 50 articles). Several policymakers responded to the user survey and said that they use the early warning system to design policy. One local councilmember said, “[I use the site] to assist in writing public policy for the city I represent as a public official. It is very valuable and useful.” Another official said, “For my work with the City of Oakland, I used these to understand how our existing anti-displacement policies could be improved.” San Francisco’s Mission 2016 Interim Zoning Controls requires developers of new projects in the Mission District to write a report on their project’s displacement potential, drawing from the early warning system. City councilmembers in several cities, including San Mateo and San Rafael, California, have referenced the project during council meetings to confirm the city’s displacement risk, show what policies neighboring municipalities have adopted, and justify passing new antidisplacement policies. The Berkeley, California mayor used the policy inventory to identify new policies to incorporate into his comprehensive housing plan. The Metropolitan Transportation Commission is considering incorporating more stringent antidisplacement targets in its next long-range plan. Affordable housing producers have used the maps to target sites for subsidized housing development. Unintended audiences also are using the tools; for example, real estate brokers have reported using the assessment of gentrification risk to identify profitable areas for investment.

It is clear that many users point to the early warning systems to validate their claims that the neighborhood is gentrifying. The tools also seem to be spurring policy changes (though it is impossible to know whether the new policies would have appeared in the absence of the maps). The methodological improvements in the new generation of toolkits have likely helped make policy more effective. By identifying neighborhoods in early stages of gentrification and displacement, they put the issue on the radar of local stakeholders; by extending the analysis to the region, the systems clarify that housing markets operate regionally, affecting peripheral and core areas; and, by incorporating users into the development of the tools, early warning systems have become more accurate—but with limitations, as the next section discusses.

Using Early Warning Systems for Prediction

In general, the system developers interviewed did not encourage the use of systems for prediction but found that policymakers and residents were eager to do so. One expert explained, “Either the analysis is not very helpful—it is not revolutionary, like predicting change near the metro—or it is very weak. We can’t predict the [new stadium].” Another pointed to the challenge of accounting for “sites of reserve,” or property that landlords hold for decades in anticipation of future profit. As they lay fallow for decades, warning systems may suggest disinvestment, but locals know better.

One interviewee said that developers would generally prefer that the maps be used as a “wake-up call”—

I did not expect that people—especially people in the city—the planning people—to view it as a predictive model. Or try to keep using it as a predictive model, given that the whole point was to have very minimal data and simple concepts. So that surprised me. Was their interest in doing that more so than creating and developing the policy part? Like, how much more studying of data do you need?

Likewise, in Los Angeles, policymakers describe their tool as a first step. Once they identify areas that have the potential to change, they can add more qualitative knowledge of the neighborhood in order to do “prediction”—

We use it as a way to say ‘we can choose between these neighborhoods for the first [project], and between these for the second one; and then within it, we can focus on a sub-area, block, commercial corridor, and then we pull in a lot more information. So it’s definitely not something where you can just enter in some basic search parameter and then it’ll tell you exactly where to do it... every policy item will have different things to consider, different political ramifications, and other factors that go well beyond just describing what’s happened.... And once you have a few good candidates, you have to take in all these additional considerations. Where are different community groups working in this particular space that you could partner with?

Even if the developers advise caution, users are eager for more explicit prediction. One expert explained:

The precise numbers would be valuable in influencing the city. We are now to the point where we’re hearing the city is ready to have a comprehensive housing plan, and cohesive housing policy. So precision in numbers would be useful for that. In terms of how we’re allocating resources.

Few developers have systematically assessed the validity of their gentrification and displacement predictions. The exceptions are Houston and the San Francisco Bay Area. Validating their Houston model using 2007 (2005–2009) American Community Survey data, LISC researchers found 86 percent accuracy for highly susceptible tracts (that is, those that the model predicted were 75 percent likely to gentrify) and 60 percent accuracy for moderate susceptibility (that is, between 50 and 75 percent likelihood). The Urban Displacement Project found that its analysis from 1990 to 2000 correctly predicted 86 percent of the 85 tracts that gentrified from 2000 to 2013 (Chapple et al., 2016). The rate of false positives, however, was extremely high: of the 512 tracts that did not gentrify, the model predicted that 79 percent of the tracts would experience moderate or high gentrification. The analysis of household displacement risk revealed the same pattern: a high degree of accuracy in predicting displacement, but also a high rate of false positives (Chapple et al., 2016).

Both the Chicago and Portland projects used 2010 as the end date for the analysis, so it is possible to validate those models by checking their results against neighborhood change from 2010 to 2014. Looking at Portland, we found that the extent of vulnerability had changed very little, but the number of gentrifying or gentrified tracts doubled, from 15 to 30; the model seems to have underpredicted gentrification, which is occurring very rapidly. In Chicago, we found a near-perfect correlation (0.94) between the risk score from 2000 to 2010 and that from 2010 to 2014. If anything, the extent of gentrification has slowed in Chicago; the original analysis found that 11.7 percent of neighborhoods were gentrifying by 2010, but the 2014 update (using tracts rather than the original neighborhoods) finds just 8.8 percent.

Given that most developers are skeptical of the accuracy of their own risk assessments, the call of Pettit and Greene (2016) for better predictive analytics seems warranted. A disinvested neighborhood that receives a false positive “at risk” categorization may resist new market-rate development or even other forms of revitalization. To the extent that they offer a wake-up call, early warning systems are helpful for community organizing. Without more precision, however, systems may actually hinder efforts to develop appropriate policy responses.

Next Steps

Although the first generation of online neighborhood early warning systems has disappeared, a new set has emerged, now measuring the risk of gentrification and displacement. Policymakers, community residents, and other stakeholders are actively using these early warning systems strategically, tactically, and for empowerment. Although it is unknown the extent to which the analyses have actually caused policy shifts, they clearly have influenced the urban debate about housing and neighborhood change.

The state of predictive analytics is poor, however. Despite methodological advances in the new generation, the systems are not yet reliable enough to use to design for specific policies. For instance, they are not able to predict the displacement impacts of specific developments or to identify which of the many antidisplacement policies is useful in different contexts.

For the most part, the early warning systems studied are not well integrated into the smart cities movement, potentially missing an opportunity for analytic improvement and long-term sustainability.

None incorporate real-time data on neighborhood change or crowd-sourced data. Unlike the smart systems that are improving the efficiency of city operations, neighborhood systems have a potential that is not yet clear—apart from raising awareness and building momentum for policy change. The smart cities movement has not yet fully grappled with issues of inclusion, instead focusing primarily on efficiency (Pettit and Greene, 2016). One expert said, “Getting the open data movement to address equity is like moving a big boat.”

The durability of these efforts remains an outstanding question. Of the projects profiled in this article, a few are planning minor updates, but none have long-term plans to institutionalize this work. The nonprofit organizations and universities that sponsor much of the work have little capacity to continue it without a significant influx of resources, and foundation funders come and go. Although city government is a logical home for early warning systems, especially given new technological capabilities, the case has yet to be made for why cities should pursue tools and strategies for more equitable, inclusive neighborhood change. Likewise, the private sector has not yet engaged in neighborhood change debates. Absent such intervention, these early warning systems will most likely vanish, just as the first generation disappeared.

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References

- Atkinson, Rowland, Maryann Wulff, Margaret Reynolds, and Angela Spinney. 2011. *Gentrification and Displacement: The Household Impacts of Neighbourhood Change*. Melbourne, Australia: Australian Housing and Urban Research Institute.
- Bates, Lisa. 2013. *Gentrification and Displacement Study: Implementing an Equitable Inclusive Development Strategy in the Context of Gentrification*. Portland, OR: Portland State University.
- Baud, Isa, Dianne Scott, Karin Pfeffer, John Sydenstricker-Neto, and Eric Denis. 2014. “Digital and Spatial Knowledge Management in Urban Governance: Emerging Issues in India, Brazil, South Africa, and Peru (reprinted from vol. 44: 501–509),” *Habitat International* 44 (October): 501–509.
- Bennett, Colin J., and Michael Howlett. 1992. “The Lessons of Learning: Reconciling Theories of Policy Learning and Policy Change,” *Policy Sciences* 25 (3): 275–294.

- Chapple, Karen. 2009. *Mapping Susceptibility to Gentrification: The Early Warning Toolkit*. Berkeley, CA: Center for Community Innovation.
- Chapple, Karen, Paul Waddell, Dan Chatman, Miriam Zuk, Anastasia Loukaitou-Sideris, Paul Ong, Karolina Gorska, Silvia Jimenez Ramos, and Chhandara Pech. 2016. *Developing a New Methodology for Analyzing Displacement*. Draft report. Sacramento, CA: California Air Resources Board.
- Craig, William, and Sarah Elwood. 1998. "How and Why Community Groups Use Maps and Geographic Information," *Cartography and Geographic Information Systems* 25 (2): 95–104.
- Ding, Lei, Jackelyn Hwang, and Eileen E. Divringi. 2015. Gentrification and Residential Mobility in Philadelphia. Federal Reserve Bank of Philadelphia Working Paper No. 15-36. <https://ssrn.com/abstract=2675379>.
- Freeman, Lance. 2005. "Displacement or Succession? Residential Mobility in Gentrifying Neighborhoods," *Urban Affairs Review* 40 (4): 463–491.
- Galster, George, and Peter Tatian. 2009. "Modeling Housing Appreciation Dynamics in Disadvantaged Neighborhoods," *Journal of Planning Education and Research* 29 (1): 7–22.
- Ghose, Rina. 2011. "Politics and Power in Participation and GIS Use for Community Decision Making." In *The SAGE Handbook of GIS and Society*, edited by Timothy Nyerges, Helen Couclelis, and Robert McMaster. Thousand Oaks, CA: Sage: 423–438.
- Goldsmith, Stephen, and Susan Crawford. 2014. *The Responsive City: Engaging Cities through Data-Smart Governance*. New York: Jossey-Bass.
- Goodchild, Michael F. 2007. "Citizens as Sensors: The World of Volunteered Geography," *GeoJournal* 69 (4): 211–221.
- Gorr, Wilpen L., and YongJei Lee. 2015. "Early Warning System for Temporary Crime Hot Spots," *Journal of Quantitative Criminology* 31 (1): 25–47.
- Hillier, Amy E., Dennis P. Culhane, Tony E. Smith, and C. Dana Tomlin. 2003. "Predicting Housing Abandonment With the Philadelphia Neighborhood Information System," *Journal of Urban Affairs* 25 (1): 91–106.
- Lees, Loretta, Tom Slater, and Elvin K. Wyly. 2008. *Gentrification*. New York: Routledge/Taylor and Francis Group.
- Maciag, Mike. 2015. "Gentrification in America Report," *Governing the States and Localities Magazine*. <http://www.governing.com/gov-data/gentrification-in-cities-governing-report.html>.
- Marcuse, Peter. 1986. "Abandonment, Gentrification, and Displacement: The Linkages in New York City." In *Gentrification of the City*, edited by Neil Smith and Peter Williams. New York; Oxford: Routledge: 153–177.
- Nathalie P. Voorhees Center. 2015. *Gentrification and Neighborhood Change: Helpful Tools for Communities*. Chicago: University of Illinois, Chicago.

- . 2014. *The Socioeconomic Change of Chicago's Community Areas (1970–2010): Gentrification Index*. Chicago: University of Illinois, Chicago.
- Oleske, Denise M. 2009. "Health Risks from the Environment: Challenges to Health Service Delivery." In *Epidemiology and the Delivery of Health Care Services*, edited by Denise M. Oleske. New York: Springer: 211–233.
- Pettit, Kathryn, and Solomon Greene. 2016. *What If Cities Used Data to Drive Inclusive Neighborhood Change?* Washington, DC: Urban Institute.
- Pew Charitable Trusts. 2016. *Philadelphia's Changing Neighborhoods: Gentrification and Other Shifts Since 2000*. Philadelphia: Pew Charitable Trusts. <http://www.pewtrusts.org/philaresearch>.
- Puget Sound Regional Council (PSRC). 2013. *The Growing Transit Communities Strategy*. Seattle, WA: Puget Sound Regional Council.
- Ramasubramanian, Laxmi. 2011. "PPGIS Implementation and the Transformation of Planning Practice." In *The SAGE Handbook of GIS and Society*, edited by Timothy Nyerges, Helen Couclelis, and Robert McMaster. Thousand Oaks, CA: Sage: 411–422.
- Sampson, Robert J. 2011. *Great American City: Chicago and the Enduring Neighborhood Effect*. Chicago: University of Chicago Press.
- Snow, Christopher W., Kathryn L.S. Pettit, and Margery Austin Turner. 2003. *Neighborhood Early Warning Systems: Four Cities' Experience and Implications for the District of Columbia*. Washington, DC: Urban Institute Metropolitan Housing and Communities Policy Center.
- Treuhaft, Sarah. 2006. *The Democratization of Data: How the Internet Is Shaping the Work of Data Intermediaries*. Institute of Urban and Regional Development working paper. Berkeley, CA: University of California, Berkeley.
- Turner, Margery, and Christopher Snow. 2001. "Leading Indicators of Gentrification in D.C. Neighborhoods." Presentation at the Urban Institute D.C. Policy Forum, Washington, D.C., June 14, 2001. Washington, DC: Urban Institute.
- Waddell, Paul. 2002. "UrbanSim: Modeling Urban Development for Land Use, Transportation, and Environmental Planning," *Journal of the American Planning Association* 68 (3): 297–314.
- Williams, Sonya, George Galster, and Nandita Verma. 2013. "Home Foreclosures as Early Warning Indicator of Neighborhood Decline," *Journal of the American Planning Association* 79 (3): 201–210.
- Wilson, William J. 1987. *The Truly Disadvantaged: The Inner City, the Underclass, and Public Policy*. Chicago: University of Chicago Press.
- Winston, Francisca, and Chris Walker. n.d. *Predicting Gentrification in Houston's Low- and Moderate-Income Neighborhoods*. Unpublished paper.
- Zuk, Miriam, Ariel H. Bierbaum, Karen Chapple, Karolina Gorska, Anastasia Loukaitou-Sideris, Paul Ong, and Trevor Thomas. 2015. *Gentrification, Displacement, and the Role of Public Investment: A Literature Review*. San Francisco: Federal Reserve Bank of San Francisco. <http://www.frbsf.org/community-development/files/wp2015-05.pdf>.