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Moving Beyond Cleanup: Identifying the Crucibles of Environmental Gentrification

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This paper reviews the distributional impacts associated with "environmental gentrification" following the cleanup and reuse of Superfund sites, brownfields, and other locally undesirable land uses (LULUs). By making a neighborhood more attractive, cleanup and reuse of LULUs may drive up local real estate prices. Renters in the neighborhood would have to pay higher rents. Although they would also reap a capital gain, homeowners too would face higher housing costs, including perhaps higher tax bills. Moreover, existing residents may not value the removal of the disamenity as much as other households, creating a mismatch between their priorities and the new character of the neighborhood. Thus, even if they do not move, existing residents, especially renters, may be harmed by the gentrification effects of cleanup. If many former residents do move, to be replaced by wealthier households, the character of the neighborhood would change further, feeding the gentrification. Such environmental gentrification is a key concern of local stakeholders. Nevertheless, the extent of environmental gentrification, if any, following cleanup and reuse of LULUs has not been solidly confirmed in the empirical literature. This paper seeks to fill that void by reviewing the evidence to date.

We find limited evidence for rising real estate prices following cleanup of LULUs. We find stronger evidence for increased housing density and increasing incomes, but no evidence for racial impacts. Our review also uncovers a variety of factors that are likely to temper the adverse consequences of gentrification for residents.

Key words: land cleanup, reuse, gentrification, brownfields
Subject Area Classifications: Hazardous Waste, Land Use, Distributional Effects

Moving Beyond Cleanup:
Identifying the Crucibles of Environmental Gentrification

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I. Introduction

The protection of land and the cleanup of Superfund sites, brownfields, and other locally undesirable land uses (LULUs) is a core part of the mission of the Environmental Protection Agency. To achieve the full benefits of cleanup, "reuse," the next step of restoring these sites to productive uses, is increasingly an emphasis as well (Vitulli et al. 2004). In evaluating the success of such programs, benefit-cost analysis naturally can play a central role, and accordingly EPA has recently reviewed the benefits of cleanup and reuse of Superfund sites (E2 Inc. 2005, US EPA 2006a,b). However, net economic benefits cannot be the only criterion for planning. Over 40 years ago, writing in the context of water programs, Maass et al. (1962) noted that there might be other important policy objectives, such as the distribution of net benefits. They suggested that multiple objectives, rather than a single measure such as net benefits, be given weight in policy-making. In some cases multiple objectives may be combined (as traditional benefit-cost analysis would seek to do), but in other cases incommensurable impacts are best left separate.[2]

In that spirit, this paper reviews the distributional impacts associated with "environmental gentrification" (Sieg et al. 2004) following the cleanup and reuse of LULUs. By making a neighborhood more attractive, cleanup and reuse of LULUs may drive up local real estate prices. Renters in the neighborhood would have to pay higher rents. Moreover, existing residents may not value the removal of the disamenity as much

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[2] The same consensus was recently reached by members of a workshop on reuse of contaminated properties (Probst and Wernstedt 2004).

as other households, creating a mismatch between their priorities and the new character of the neighborhood. Thus, even if they do not move, existing residents, especially renters, may be harmed by the gentrification effects of cleanup.[3] If many former residents do move, to be replaced by wealthier households, the character of the neighborhood would change further, feeding the gentrification. Such environmental gentrification is a key concern of local stakeholders, as emphasized in a recent report from the National Environmental Justice Advisory Council (NEJAC) on "Unintended Impacts of Redevelopment and Revitalization Efforts" (2006). Nevertheless, the extent of environmental gentrification, if any, following cleanup and reuse of LULUs has not been solidly confirmed in the empirical literature. This paper seeks to fill that void by reviewing the evidence to date.

Wernstedt (2004) has recently identified a range of such impacts that might arise from cleanup and reuse of LULUs, but which would not be classified as standard economic benefits, and has carefully reviewed the studies and data that speak to them. Unfortunately, as he notes, most studies to date have not distinguished between cleanup and reuse. Moreover, few have provided insights into the distribution of the costs and benefits of cleanup and reuse. Indeed, Wernstedt writes in his conclusion that, of fourteen studies on land reuse, none

> examines in any great detail the distributional effects of reuse with respect to different segments of a community. Yet, many contaminated properties lie in disadvantaged areas, where site reuse has the potential to address long-standing issues of local environmental and economic inequities. Future work to clearly identify the communities and subpopulations that are supposed to benefit from the reuse of contaminated land—and to assess where the beneficial effects of reuse actually go—could both make explicit what often appears to be an implicit objective of site reuse as well as improve program initiatives to accomplish this objective. Such work would require baseline documentation of the socio-economic composition of the communities hosting reuses and systematic tracking of changes in this composition and general community well-being.

[3] Viewed in these terms, the logic of environmental gentrification is somewhat the reverse of the logic of the "environmental justice" literature. If households chose to live in dirtier neighborhoods because they prioritized cheap housing over environmental amenities, cleaning up adverse land uses and causing prices to increase may work against their greatest needs.

Although the situation is not quite as bleak, much the same could be said of our state of understanding of the distributional effects of cleanup as well.

To overcome some of these limitations, in this paper we review a wider literature that allows us to garner insights into potential impacts. We first take a closer look at what sociological and economic theories say we might expect too happen under various conditions. We then look to empirical studies of the correlation of both land prices and demographics—key aspects of gentrification—with land uses. We also review a more recent economic literature that, while not necessarily connected to land use per se, has begun to quantify the connection between land prices and demographics with other social forces such as crime and education.

We first find that even a simple economic model does not yield clear predictions on neighborhood effects following cleanup, except for the initial effect of rising housing values. In the empirical literature, we actually find conflicting evidence of rising real estate prices following cleanup of LULUs. We find somewhat stronger evidence for increased housing density and increasing incomes, but no evidence for racial impacts. Our review also uncovers a variety of factors that are likely to minimize the likelihood of gentrification or temper its adverse consequences.

This report is divided into six sections. Section II explores what, exactly, is meant by the term "gentrification" as understood from diverse perspectives and academic disciplines. Section III encapsulates some of these insights into an economic model that yields predictions about the most likely impacts from local land use changes associated with cleanup and reuse. (A more formal version of the model is provided in an appendix.) Section IV begins a review of the relevant empirical literature, starting with “partial equilibrium studies” which capture one aspect of gentrification at a time. Section V extends the review to “general equilibrium” studies, which have tried to capture multiple aspects of gentrification simultaneously. Section VI concludes.

II. What is Gentrification?

Ruth Glass, a sociologist, is credited with coining the term "gentrification." Describing the metropolitan center of London in the 1960s, Glass (1964) portrayed gentrification as a process of *invasion* whereby

> one by one, many of the working class quarters of London have been invaded by the middle classes-upper and lower. Shabby, modest mews and cottages—two rooms up and two down—have been taken over, when their leases have expired, and have become elegant, expensive residences. Larger Victorian houses, downgraded in an earlier or recent period…have been upgraded once again….Once this process of 'gentrification' starts in a district it goes on rapidly until all or most of the original working class occupiers are displaced, and the whole social character of the district is changed. (xviii-xix)

Thus, class and class change are at the center of Glass's work and remain so in contemporary definitions and studies of gentrification. Nevertheless, contemporary definitions and popular understandings have evolved and expanded over the years.

Hallmarks of Gentrification

Today, the concept of gentrification has spread into many disciplines and into popular discourse. Writers across disciplines, and even within them, would not agree on everything that is meant by the term "gentrification." Nevertheless, most would agree on three hallmarks: rising property values and rental costs; new construction or renovation upgrading the housing stock and perhaps converting it from rental to owner-occupied units; and a turnover in the local population, bringing in residents with a higher socioeconomic status.[4] Their new economic status also may bring changes in the racial or ethnic composition of the neighborhood, sometimes creating tensions along these lines (Levy et al. 2006).

Economists have generally stressed the market forces that link many of these characteristics together. As a neighborhood becomes more desirable for some reason, more households, including wealthier ones, desire to live there. This increased demand

[4] This may be accompany abnormal rates of turnover in a rapidly changing neighborhood, but not necessarily. Nationally, almost half of all households move within a five-year period. Such a baseline rate of mobility may be sufficient to bring about a changing character.

for space increases real estate prices to a level that the wealthier households can afford, but that previous residents might not. The wealthier households, in turn, can also afford to improve their living environments in both size and appearance, and so they renovate their property. This renovation then further increases housing costs, reinforcing the trend.

Sociologists emphasize these market forces as well, but also describe an aesthetic process. Sharon Zukin (1987), in an excellent introduction to the topic, notes that while gentrification can involve new development, often it involves the renovation or rehabilitation of historic buildings. As with Glass's Victorian mansions, this renovation reflects the preferences of specific demographic groups for the architecture in the gentrifying neighborhood. Furthermore, historic preservation ordinances may solidify the process.

Where various depictions of gentrification differ the most is in their understanding and description of the indirect effects that new demographic groups, with their new aesthetic tastes, have on the characteristics of the neighborhood. At the simplest level, the demographic changes themselves may represent a new aesthetic. If racial or socioeconomic groups have differing preferences for the racial or socioeconomic makeup of the neighborhood (perhaps preferring to live with people like themselves), initial demographic changes would fuel further changes in the demographic composition. (See the economic literature on “endogenous” racial amenities and sorting, e.g. Bayer et al. 2003, 2005, Sidon 2005, Schelling 1969.)

Sociologists tend to stress the character of the community that different groups create, giving more content to the economists' model. Some highlight gentrification as the arrival of yuppies. Others stress the arrival of a more bohemian culture. For instance, Zukin (1987) describes gentrification as a radical break with suburbia, “a movement away from child-centered households toward the social diversity and aesthetic promiscuity of city life” (p. 131).

These new groups may have tastes for different private goods. Thus, another aesthetic aspect of gentrification is the change in the character of local retail and other services. O’Sullivan (2005) develops an economic model in which low- and high-income

residents consume distinctive private goods. As more high-income residents move in, local provision of their good increases (more coffee shops, florists, book stores), making the neighborhood more attractive to those households and again reinforcing the demographic shift.[5] O'Sullivan calls this the "Starbucks effect."

Other indirect affects of demographic changes in the community may include changes in the crime rate or quality of local public schools. Crime may first increase following gentrification, as increased inequality creates more tension (associated with violent crime) and new targets for property crime. The former effect in particular appears strong in the data (Blau and Blau 1982, Morgan 2000). Consistent with these findings, some have suggested that the first wave of gentrifiers has a high tolerance for crime (Skogan 1986, Zukin 1987).[6] In the longer run, as the gentrification process continues, crime would be expected to decrease. Likewise, local school quality might improve, via the peer-group effect in which the higher educational attainment of wealthier families spill over to other children as well.[7]

A Case Study of Portland, Oregon 1990-2000 highlights many of these changes, including changes in racial composition, income composition, and housing prices. Specifically, the average number of blacks per central city tract decreased, while elsewhere the number of black persons increased; simultaneously, households with at least twice the poverty income increased. Median housing prices increased by a factor of 3.4 in the inner city and 2.6 in the rest of the city. In addition, crime decreased by 49% in the inner city but only 5% in the rest of the city (O'Sullivan, 2005). A case study of Boston from 1970 to 1998 found influxes of college-educated households in gentrifying areas, but found city-wide increases in land values. It concluded that the effects had

[5] Although these are private goods for all practical purposes, technically small economies of scale in production induce some publicness, with the goods only provided if local demand is high enough.
[6] This finding is confirmed by information on residents' reactions and opinions to their newly resettled homes and neighborhoods as solicited in both the Mount Pleasant and Capitol Hill neighborhoods in Gale's (1976-77) survey of Washington DC. Even with a majority of respondents, within each of these area studies, reporting personal victimization, in or related to a criminal incident and unease pertaining to the level of criminal activity, "most saw it as a necessary price to pay in order to enjoy the attributes of inner-city living" (Laska and Spain, 1980, p. 102).
[7] But, as Vigdor (2002) notes, if gentrifying households do not have children they would have little impact on schools.

more to do with metro-wide changes in the income distribution than with local amenities (Vigdor 2002).

While this study has examined a generally gentrifying city, one final part of gentrification is the fate of other areas that do not gentrify. Gentrification's contribution to increased homelessness and trends in displacement has long been a contentious area of study (Zukin 1987). One of these displacement phenomena is termed the mismatch hypothesis, in which a mismatch of skills of previous blue-collar residents and the requirements of new white-collar jobs leads to unemployment or migration (Frey, 1979). Zukin (1987) emphasizes that gentrification can take place alongside areas that continue to deteriorate. Glass (1964) similarly saw, in 1960s London, "pockets of blight" (p. xx) growing more dense and areas where "change and stagnation exist side by side" (p. xxv). On this reading, as low-cost neighborhoods gentrify, poorer residents have fewer options, and so pack into remaining poor neighborhoods more densely.

Theories of Neighborhood Change

These various hallmarks of gentrification receive greater or less weight, or are described in different terms, according to different theories of neighborhood change. In addition to neoclassical economics, five social theories of neighborhood change serve as paradigms for descriptions of gentrification (Liu 1997 and Zukin 1987). The five theories are the invasion-succession model, the neighborhood life-cycle model, the push-pull model, the institutional theory of neighborhood change, and a Marxist-materialist perspective. Most of these theories have components that resonate with neoclassical economics as well; accordingly we discuss economic theories along side the sociological.

Associated with the Chicago school of human ecology, the classical invasion-succession model is based on an ecological process in which a new plant invades a habitat and replaces previous plants as the dominant species, only to be itself replaced by a later invasion. This process, according to the theory, is mirrored in human society, with succeeding demographic waves cascaded over a neighborhood. This may well be what Glass (1964) had in mind when describing gentrification as an "invasion." In Liu's (1997) analysis of the theory, the invasion-succession model implies that relationships between races will be characterized by competition, conflict, and accommodation.

The neighborhood life-cycle model, originally formulated by Hoover and Vernon (1959), as cited in Liu, also views neighborhood change as a natural process. Here, the analogy is to generational succession rather than ecological succession. As housing stock ages, it becomes less desirable, leading to successive in-migration of lower socioeconomic groups that are willing to occupy it at reduced costs. Eventually, when it deteriorates to a critical point, the housing stock is recycled and renewed. Economists will recognize in this perspective a "filtering" model or a model of the optimal timing of investment (e.g. Brueckner and Rosenthal 2005, Rosenthal 2006, Somerville and Holmes 2001). As a young housing stock first begins to age, renovating it requires high fixed costs and only modest returns. Eventually, as it continues to age, it reaches a point at which investment is economical. This process has been confirmed in empirical work by Helms (2003), who finds age a significant factor in the prediction of housing renovation.

This life-cycle perspective is important for understanding the potential consequences of decontamination and reuse of LULUs. If local land prices and the socioeconomic status of local residents are correlated with LULUs primarily through mutual correlation with the age of a neighborhood, removal of the LULU would not reverse the basic phenomenon, and gentrification would be less likely to occur.

A third theory, the so-called push-pull model, focuses on two related forces. The pushing force includes neighborhood disamenities that make a neighborhood less desirable for residence, such as existing (or planned) LULUs. The pulling forces are amenities, those things that might draw a person to reside in a given neighborhood, for example parks or employment opportunities. The push force motivates households to relocate, and they then choose a new neighborhood based on its pulling factors (e.g. Frey 1979). Applied to land uses, this theory interprets the cleanup of a LULU as pulling in those who are attracted to the new set of amenities and pushing out those who cannot afford to stay (see Liu 1997). Clearly, the sociologists' push-pull model is quite close to neoclassical economic models of neighborhood choice, in which households choose where to live based on the balancing of prices and desirable and undesirable features. One difference, however, is that economists would tell a story of simultaneous push and pull forces. Households may decide to relocate based on changing pull factors elsewhere, even without new push factors in their current neighborhood. This increases the

prospects for environmental gentrification, since cleanup and reuse will be a pull factor for many residents.

Fourth, the institutional theory indicates that institutions, including universities, banks, and insurance companies, play a large role in the status of a neighborhood as they make their location, economic, and political decisions. Banks, for example, can consign a neighborhood to decline through the practice of "redlining," in which they refuse to finance mortgages or home equity loans in a neighborhood, a practice emphasized by NEJAC (2006). According to the institutional theory, amenities or push-pull factors have only a minor role to play. Thus, LULUs would not necessarily be obstacles to neighborhood stability and do not necessarily lead to neighborhood decline. Reuse, on the other hand, would not be expected to occur in redlined areas, as it is often connected to large investments, in some cases backed by public subsidies or insurance (Wernstedt, Meyer, and Yount 2003).

A fifth and final perspective comes from Marxism, where gentrification is a manifestation of the propensity for capital to reproduce itself. Zukin (1987) writes that, according to this perspective,

> in our time, capital expansion has no new territory left to explore, so it redevelops, or internally dedifferentiates, urban space. Just as the frontier thesis in US history legitimized an economic push through 'uncivilized' lands, so the urban frontier thesis legitimizes the corporate reclamation of the inner city from racial ghettos and marginal business uses. (Zukin, 1987, p. 141)

From the materialist viewpoint, such expansion might also partly explain conversion of rental units to owner-occupied units. Again Zukin:

> As a form of homeownership, gentrified dwellings are both a means of accumulation and a means of social reproduction for part of the highly educated middle class. Moreover, as a reference to specific building types in the center of the city, gentrification connotes both a mode of high status cultural consumption and the colonization of an expanding terrain by economic institutions [and employment] associated with the service sector. (Zukin, 1987, p. 144)

Thus, the expansion of capital into the neighborhood may represent the accumulation of wealth, or it may represent the social expansion of capitalists. In any case capitalists are simply doing what capitalists do.

Although there are many perspectives and ways of describing gentrification, most authors appear to agree on the main signs and indicators. Thus, an operational and widely accepted definition of gentrification might read as follows. Gentrification is a phenomenon with many reinforcing characteristics, incorporating three hallmarks of community change: rising property values and rental costs; renewal or creation of housing stock corresponding to the appreciation of housing values; and changes in demographic composition, especially economic status but perhaps affecting race, education, and household size as well. A fourth set of issues, differing more widely from case to case and writer to writer, is the formation of new amenities, including the aesthetic feel of a neighborhood, its crime rate, and its school quality.

III. A Conceptual Framework for Gentrification

Many of the most salient features of gentrification can be captured in an economic model of household choice for communities. In particular, models that follow the insight of Tiebout (1956), in which households "vote with their feet" and select communities providing their preferred level of amenities and housing costs, can predict community impacts following changes in public goods, such as the cleanup and reuse of LULUs. Of this class of models, we use one introduced by Epple, Filimon, and Romer (1984), a more general version of which has been estimated econometrically by Epple and Sieg (1999) and applied to environmental improvements by Sieg et al. (2004) and Walsh (2004). Banzhaf and Walsh (2006) and Vigdor (2006) use this model to gain insights into environmental gentrification. The results presented here are derived in Banzhaf and Walsh. In the appendix to this paper, we represent this model formally and derive mathematically the key insights discussed here.[8]

[8] This section and the appendix are written in parallel. Thus, readers wishing to skip the mathematical details may safely read this section and skip the appendix; those interested in the mathematical version may do the opposite.

In this model, households differ by their income and by their tastes for public goods/bads, including contamination or visual disamenities like brownfields. Consequently, they also differ by their willingness to pay, in terms of higher housing prices, for bundles of public goods. However, they do not differ in how they value one *particular* public good (like parks and green spaces, say) relative to another (like public safety). Because of the latter simplifying assumption, households agree on their rankings of "most desirable" communities. Because of the higher demand for housing there, housing prices are highest in the most desirable communities; likewise, they are lowest in the least desirable. And because households do differ in their willingness to trade off housing prices for public goods, these price differentials lead households to select different communities. Holding tastes constant, richer households will be in the nicer communities and poorer households in the less desirable communities.

Figure 1 illustrates the situation. The figure shows two demographic types (differing by race, for example, or educational attainment) with different income distributions. The two curves in the figure are their respective density functions, with Type 2 being wealthier on average than Type 1. Type 2 households may be white for example and Type 1 minority; or Type 2 may be college-educated and Type 1 not.

Holding tastes constant, the income threshold $\overline{Y}$ separates them into two different communities: all those with incomes above $\overline{Y}$ are in the more desirable of two communities, all those with incomes below $\overline{Y}$ are in the less desirable. In the case depicted, the more desirable of the two communities also has more Type 2 households. This follows logically in the case of symmetric distributions and will be true in practice in most cases. However, it is not guaranteed. If the Type II pdf had a thicker tail and $\overline{Y}$ were moved to the left, one could imagine the less desirable community, while still poorer, having more Type II people. This case would represent an upper-middle class minority neighborhood for example.

The question we seek to answer with this model is what happens to a community, and to other communities, when its public goods improve, as when LULUs are cleaned up and returned to productive uses. Consider an improvement in Community 1. After the improvement, households who were somewhat indifferent before will now clearly

prefer Community 1. As depicted in Figure 2, $\bar{Y}$ will shift to the right. All the people who preferred Community 1 will continue to prefer it, but now additional people (represented by the shaded area in the figure) will as well. In other words, the demand for housing in Community 1 will increase and the demand for housing in Community 2 will fall. This will have the effect of increasing the population of Community 1 and decreasing the population of Community 2.[9] Other things equal, it will also have the effect of increasing housing prices in Community 1 and lowering them in Community 2. We thus have two clear hypotheses: Housing prices and population will both increase following cleanup and reuse of LULUs. The former, at least, is one hallmark of gentrification.

What about the demographic composition of the communities? Note that the people in the shaded area, those who previously preferred Community 2 but now prefer Community 1, are richer on average than the original residents of Community 1. When they move in following the cleanup of the LULU, they will thus increase the average income of Community 1. However, note that these people were poorer on average than those who remain in Community 2. Accordingly, the average income of Community 2 will increase as well![10] While we can thus hypothesize an increase in income following cleanup and reuse of LULUs, another hallmark of gentrification, this hypothesis is harder to test in the data, since the process involves movement of supposedly "control" communities in the same direction. However, as discussed by Banzhaf and Walsh (2006), it should be possible to detect this effect in some special cases.

Finally, we cannot say anything about the change in the composition of Community 1 with respect to other demographic variables. Common sense seemingly suggests that as income increases, demographic groups associated with higher incomes should increase as well. However, that need not be the case. If the ratio of Type 1 households to Type 2 households among those moving into Community 1 (the gray area) is greater than the ratio among those previously living in Community 1 (to the left of the

[9] This increase in population density could follow the development of undeveloped land, rezoning developments for more dense uses, and/or changes in vacancy rates. To the extent these mechanisms are restricted, changes in population density likewise would be restricted and price effects would be greater.
[10] If Community 2 were improved, so it becomes even more desirable than before, all the opposite effects would occur. Both communities would get richer on average.

original $\overline{Y}$), then Community 1's share of Type 1 households could increase, even while getting richer. Thus, this additional hallmark of gentrification—where it is associated with certain demographic groups, whether it be whites, more educated individuals, "urban" sophisticates, Yuppies, or something else—is the least likely to result from cleanup and reuse of LULUs and the least likely to be found in empirical studies.

To summarize this section, even a fairly simple Tiebout model does not yield clear predictions about the effects on a neighborhood of cleanup and reuse, except for rising population densities and housing prices and, to a lesser extent, rising incomes if the cleanup occurs in poor neighborhoods. More complicated models are likely to be even less definitive. For example, in reality, households do differ in their tastes for different public goods. Some dislike brownfields more than others, others fear crime more, others value good schools more. Intuitively, cleaning up and reusing brownfields and other LULUs would then make the neighborhood more attractive to those who most disliked them and who are most attracted to the new use. Of course, just who these demographic groups are is an empirical question. Second, as we discuss below in Section V, models in which groups have preferences for the endogenous makeup of the neighborhood (i.e., where people prefer to live with other people like themselves) can lead to some surprising outcomes through the indirect effects of these preferences.

Before turning to those more complicated issues, however, we first review empirical studies of the basic issues, in particular studies connecting changes in land uses to one of two of the hallmarks of gentrification: increases in real estate prices and changes in demographic composition. We then turn to studies that look at more than one hallmark, including the indirect effects on other public goods, aesthetics, and feedbacks through group preferences.

IV. Empirical Evidence of Gentrification: Direct Effects

As described in Section II and in the model of Section III, gentrification is a multifaceted phenomenon featuring housing price increases, demographic changes, and other aspects. Very few empirical papers have looked at even two of these faces simultaneously, still fewer more of them. However, in many cases one aspect or another has been separately

studied in a distinct literature, often without a self-conscious connection to gentrification. To see how these literatures connect to the larger whole, consider the illustration in Figure 3. This figure shows a pyramid, with each of its four points representing one salient feature of environmental gentrification. At the top is the urban environment itself, which can be improved by cleaning up a LULU and converting it to a healthier and more aesthetic use (public open space, for example). This improvement would be the starting point in the process of environmental gentrification. Directly underneath this point is a second point that represents the demographic composition of the neighborhood. During gentrification, the neighborhood might become wealthier, more white, more educated, or younger. To the right is a third point representing real estate prices. As the community becomes more desirable first because of the cleaning up of the LULU, and perhaps later because of other indirect effects, rental prices and real estate prices would increase, another component of gentrification. Finally, and most speculatively, to the left is a fourth point representing other, endogenous urban amenities and public goods. These may include the aesthetics of the gentrified housing, public safety, local school quality, and the sets of private goods offered in the neighborhood. These are *additional* changes in public and private goods responding to the cleanup of the LULU.

Each line segment in the pyramid represents a correlation between two of these aspects. When accompanied by a theory of a causal direction between the two, they become theories tested in various literatures. The arrows drawn in the figure represent some of the most important cases. The hedonic literature connects both environmental and other amenities to real estate prices, viewing the amenities as influencing prices. The environmental justice literature connects demographics to environmental quality, viewing the demographics as a potential determinant of pollution. Some economic critiques of this literature, on the other hand, would point to an indirect effect of environmental quality on housing prices and housing prices on demographics. This latter line segment, between housing prices and demographics might be described simply as differing housing demand elasticities held by differing groups. The connection between demographics and other amenities includes those cases where the new populations change the aesthetic character of the housing stock, are associated with lower crime rates, bring a new peer group to the public schools, or attract new retail (the "Starbucks effect").

Last, and most speculatively, LULUs might have some direct connection to amenities such as crime if there is a "broken windows" effect, wherein the decay represented by a brownfield engenders social disconnectedness and disregard (e.g., Kelling and Coles 1996).

Again, although environmental gentrification is a complex process involving the interaction of all these factors, insights can still be obtained from the literature exploring some of these links independently. In particular, there is a fairly large literature documenting the consequences of land uses on both housing prices and demographics, probably the two most important aspects of gentrification. As price increases and demographic changes are each two key features of gentrification, evidence of these effects taken separately is a necessary, though not sufficient, condition for the presence of gentrification.

The ideal empirical evidence of these partial connections would be observed effects on each following randomized cleanup and reuse of LULUs. Such randomized treatments being rare or nonexistent in social science, however, the next-best evidence comes from comparisons of changes before and after cleanup and reuse (or before and after the announcement of cleanup) with changes over a similar time frame with a control group. A third tier of evidence comes from simpler cross-section regressions comparing areas with and without brownfields. Although these regressions do not document the effects of land use changes per se, they do provide important evidence about the likely effects of reuse. Cleanup and reuse of a LULU changes an area so that it looks like other areas that have never had a brownfield. However, there may still be the memory or stigma of the old LULU to hold back gentrification. In addition, as we discuss below, the existing demographic makeup and aesthetic feel of the community may be self-reinforcing, acting as a force for stability. Thus, the largest possible gentrification effects of cleanup would be to elevate prices and incomes to the level of control communities. Consequently, if cross-sectional regressions show no substantial difference between neighborhoods with LULUs and control communities, we would have no reason to

expect changes after cleanup.[11] In this way, even cross section regressions provide important empirical tests of gentrification.

We review studies that fall under each of these three categories in the remainder of this section, looking first at evidence of effects on land prices and second at effects on income and other demographic variables. We briefly consider other amenities as well.

Land Prices

There is a large literature regressing real estate prices on the proximity of LULUs, or changes in the status of LULUs (Boyle and Kiel 2001, EPA 2006, E2 Inc. 2005, Farber 1998, Kiel and Williams 2007). Typically, this "hedonic" literature is used in policy analyses to evaluate the benefits of cleanup and reuse. Such an application to benefits requires additional assumptions about the structure of markets and household behavior, so that the difference in prices with or without LULUs, ceteris paribus, equals the willingness to pay to be without a nearby LULU. This "benefits" interpretation is not required for our present purpose, however, which is only to show the effect on prices.

As past literature reviews of these studies have concluded, the clear consensus in the literature is that, looking cross-sectionally, LULUs are associated with lower housing prices (Boyle and Kiel 2001, EPA 2006, E2 Inc. 2005, Farber 1998). More recently, Kiel and Williams (2007) have looked at 57 Superfund sites and found what they interpret as evidence of heterogeneity in effects. Of the 57 sites, 18 had significantly lower prices nearby, 32 had insignificant effects, and 7 had significantly higher prices. In a meta-analysis, they found that bigger sites and sites with more data (and where estimates are more precise) were more likely to have statistically negative impacts, as one might expect. We thus view these findings as consistent with the conventional wisdom.[12]

The existence of cross-sectional differences, while consistent with such an outcome, does not necessarily imply that gentrification would follow from cleanup. Thus, signs of changes following discovery and, especially, cleanup are especially relevant. The largest literature in this area is applied to Superfund and other hazardous

[11] The reuse of the land could elevate prices higher if it involves an especially attractive use, one making the community even more attractive than the comparison communities.
[12] Moreover, Cameron (2006) has recently demonstrated that the failure of studies to date to account for directional effects (stronger effects downwind, for example) can bias results downward.

waste sites.[13] In one of the first such studies, Kohlhase (1991) finds that, in Houston, land prices were no lower nearer Superfund sites until after sites were listed on the National Priorities List (NPL) (1986, as compared to 1980 and 1976). One site was cleaned up by 1986, and it does not show the same relationship, suggesting cleanup can raise housing prices. In a similar study of hazardous waste sites in Boston, Michaels and Smith (1990) find a positive effect of distance on prices, but again that it is only significant after discovery and publication. Interestingly, they find these effects in all but the lowest tiered market, as defined by local real estate agents.

In a study designed to further explore these information effects, Gayer, Hamilton, and Viscusi (2000) look at properties surrounding seven Superfund sites in Grand Rapids, Michigan. They find that housing prices increase about 1 percent for every mile in distance from the closest Superfund site. They find, however, that these effects decline after the US EPA released information on objective health risks, illustrating that the markets react to changes in perceptions (see also Gayer, Hamilton, and Viscusi 2002). This suggests that they might react to objective changes from cleanup and reuse as well.

Two sets of researchers have studied housing prices around the RSR lead smelter in Dallas. After many years of operation, the plant closed in 1984. During cleanup, lead was abated from the soil at homes within a half-mile of the facility. A court ruled in 1986 that cleanup was complete, but new concerns later arose and the site was finally placed on the Superfund NPL in 1993. A second round of cleanup was completed in 2002.

In the first study of this site, Dale et al. (1999) find that during operation and through the initial cleanup, housing prices were significantly lower near the smelter, by about 2% per mile. This trend reversed itself in the period following the first cleanup, becoming higher near the smelter by 4 to 5% per mile, suggesting cleanup of such sites can reverse previous depressing effects on housing prices. McCluskey and Rausser

[13] Others have looked at sites that might be viewed as sources of air pollutants or themselves adverse land uses. Kiel and McClain (1995) look at the effect of the siting of an incinerator in North Andover, MA. They find that housing appreciation slowed in North Andover during construction of the incinerator and during operation, compared to the Boston metro area. However, they do not find that it had a systematic relationship with distance to the facility. Bui and Mayer (2003) and Oberholzer-Gee and Mitsunari (2006) find conflicting evidence of the effect of information disclosure about polluting facilities (the TRI program) on nearby property values.

(2003a) further explored subtleties in the relevant area around the site and extend their work into the period of new concerns. Using linear splines (a flexible functional form), they find a significant price gradient up to 1.2 miles, and find that this gradient is lowest in the 1979-80 period before initial identification and in the 1987-90 period following the first clean up. The gradient is highest in the 1981-86 period of initial concern and the 1991-5 period of subsequent concern. This is precisely what one would expect, and again suggests that housing prices can rebound and increase following cleanups. But in an extension of this work, McCluskey and Rausser (2003b) find that housing appreciation rates continue to lag nearest the facility.

In an earlier study of three Superfund Sites in Woburn, Massachusetts, Kiel (1995) also finds that housing prices increase with distance from the nearest sites, finding a somewhat higher gradient of 2 to 5 percent. Unlike the studies reviewed above, however, she does not find an obvious pattern in these effects from pre-discovery, through several phases from discovery to cleanup. Messer et al. (2006) have also recently cast doubt on the hypothesis that housing prices rebound after cleanup. They study neighborhoods around Superfund sites in Montery Park, CA, northern New Jersey, and Woburn. At least in these three cases, where cleanup at the sites was delayed for 10 to even 20 years, property prices do not seem to rebound relative to more distant controls. Messer et al. suggest this may be because, during the period of delay, the sites became increasingly stigmatized and that this stigma was not reversed by cleanup and its related activities.

Ihlanfeldt and Taylor (2004), meanwhile, have found somewhat mixed evidence of the effects of cleanup. Instead of looking at residential property, they explored the effects of hazardous waste sites on five classes of commercial and industrial property in Atlanta: apartment, office, retail, industrial, and vacant.[14] They find that price gradients with distance increased after discovery and listing of a hazardous waste site. After listing, they find that prices continue to rise to a distance of at least 2 miles, and are generally 10-25 percent higher at that distance than at 0.5 miles, and as much as

[14] Howland (2000, 2004) similarly studied industrial sites in Baltimore, looking at sales of actual brownfield sites. She finds that such sites sold for 55% less per acre than clean sites, but that the contamination and associated regulatory uncertainty did not otherwise limit the operation of land markets. Contaminated properties continued to sell, but at lower prices.

36 percent higher for office space but only 3 percent higher for industrial sites. However, looking at sites that were subsequently delisted, they find no statistically significant effect of this delisting. Moreover, surprisingly, these sites did not show the same systematic effect at the time of discovery and listing as the other sites.

Throughout this literature, distance and time effects are crucial. In a study of property values surrounding a former copper smelter in Tacoma, WA, McMillen and Thorsnes (2003) refine the treatment of these dimensions by modeling them non-parametrically. In particular, they estimate a smooth but otherwise arbitrarily varying derivative of price with respect to distance from the smelter. Moreover, they allow this derivative to vary with time, which runs from 1977 to 1998. On average, they find that there is a positive effect of distance on price in the early years, but an effect that is steadily declining in time. At about 1986 or 1987, after the smelter was closed, the effect reverses itself and distance to the smelter—correlated with distance to the city center and to the bay—is given a premium. This effect occurs well before cleanup began in 1995.

These conflicting results raise several questions about conventional hedonic techniques. For example, are areas further from adverse land uses systematically different in terms of other factors that cannot be observed or controlled in multivariate regression? Are sites that are cleaned up relatively quickly (as in the Ihlanfeldt and Taylor study) smaller or less dirty than other sites? And likewise, are sites that take many years to clean up (as in Messer et al.) systematically worse?

To address these problems, Greenstone and Gallagher (2005) employ a natural experimental design that allows cleanup of Superfund sites to be treated as an exogenous variable. They also improve upon earlier work by employing a national sample. This sample includes all census tracts near the 690 hazardous waste sites that were finalists for Superfund's National Priority List. These sites were given a score using a Hazardous Ranking System, with a score of 28.5 in this system being the original cut-off for listing. Although other sites were later added, the score remains a major factor in the pattern of listings. By using the score as an econometric "instrument," Greenstone and Gallagher remove the effect that land values may have had on listing via a political process for listing. Moreover, by focusing only on sites with scores just above or just below the

threshold of 28.5, sites with similar objective risks but with different policy treatments can be compared.

By using these strategies, Greenstone and Gallagher provide the strongest empirical design to date in this literature.[15] They find little evidence that NPL listing affects housing prices relative to other CERCLA sites that are not listed. However, note that they studied the effect of listings, including any subsequent cleanup, but not the isolated effect of cleanup or reuse. The effect of listing is ambiguous in theory. On the one hand, it might have been expected to increase prices, as cleanup follows listing. On the other, it might be expected to lower prices, as it is an informational signal to households about risks and may perhaps create a permanent stigma. To help distinguish these effects, Greenstone and Gallagher also analyze housing *rents*, with differential effects for listing and for actual cleanup. Again, there is little consistent effect.

Taken as a whole, this literature yields conflicting findings for a property value effect following cleanup. As a final comment, we note that most of these studies, and our discussion of them to this point, have essentially been framed in terms of the presence or absence of a LULU. However, the reuse of a cleaned up LULU, that is, the land use that replaces it, may be just as important an issue. For example, one-third of reused Superfund sites have been converted to green spaces (Vitulli et al. 2004), as have many brownfields (IEDC 2001, De Sousa 2003). Hedonic studies have generally confirmed that such land uses increase nearby property values (see McConnell and Walls 2005 for a recent review, and Irwin and Bockstael 2001 and Irwin 2002 for excellent examples.) Areas where land reuse involves conversion to amenities like parks or other open spaces, then, might be especially prone to gentrification. On the other hand, if the land is used for residential developments, the increase supply of housing may actually lower housing prices. While this possibility should be kept in mind, most studies appear to support the idea that cleanup increases property values.

[15] Although one limitation is that they are constrained to analyze data at the census tract level. It should also be noted that a crucial assumption in their design is that non-NPL sites are not cleaned up under other, state programs. If they were, the comparison would be merely between sites cleaned up under one program vs. sites cleaned up another program.

Demographics

Just as a large literature has analyzed the direct connection between LULUs and real estate values, a separate (and for the most part quite distinct) literature has focused on the direct connection between LULUs and local demographics. In particular, the so-called "environmental justice" literature has explored correlations in the presence of LULUs and poor or minority populations. See Pastor (2002), Ringquist (2003), Bowen (2002), and Noonan (2005) for recent reviews and Ringquist (2005) for a meta-analysis.[16]

Most of this literature has addressed the question of whether there is racism or other injustice in the siting of hazardous facilities. However, just as we were not primarily concerned with the benefits interpretation of hedonics, but merely the correlation and the causal connections, so too here our concern is merely with evidence for or against demographic gentrification—changing populations that are richer and perhaps more white—following cleanup and reuse of a site.

Since early work by the United Church of Christ (1987), most researchers have found that LULUs are located in poor and minority neighborhoods.[17] In a recent meta-analysis, Ringquist (2005) finds the location of noxious facilities and/or Superfund sites had a statistically significant relationship with minority populations across 33 studies, even controlling for various levels of geographic aggregation and measures of study quality.[18] A weak correlation is present for income and poverty, but it is not very robust to study details. A number of individual studies have found an inverted u-shape, with LULUs present near low-middle class neighborhoods, so the interpretation of Ringuist's results is less clear in this case.

There are two non-mutually exclusive hypotheses explaining these correlations. One possibility, stressed by environmental justice activists, is that firms and local

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[16] Engel (1997-98) discusses the potential conflict between the goals of the environmental justice movement and the movement to reuse brownfields. In conflict with the former, the latter often involves easing cleanup requirements. See also The Environmental Law Institute (2002).

[17] Anderton et al. (1994) is one exception.

[18] Although they are more numerous, less work has explored such correlation for brownfields. The Council for Urban Economic Development (1999) found that a sample of 107 brownfield *projects* had higher concentrations of minority populations and poverty levels within a 1-mile radius than statewide averages. However, this may simply be because they are in more urban areas than the rest of the state. Heberle and Wernstedt (2005) found in a sample of nearly 50 developers that their brownfield projects were in census tracts where the median income was 25 percent less than the median income of the wider metropolitan area.

governments are discriminatory in their siting practices. An alternative possibility is that the siting, or perhaps later revelations of hazards at the site, triggers neighborhood decay. Under this scenario, demand for land in the neighborhood declines, richer households leave, and poorer (perhaps minority) households attracted to lower housing costs move in.[19] Essentially, this process following siting is the reverse of the gentrification story following cleanup.

Several papers have tested these dynamics in various settings, with conflicting findings. Been (1994, 1997) was the first to articulate such a reverse gentrification story in the environmental justice literature. In her most extensive empirical analysis, Been (1997) studies a national sample of census tracts with Toxic Storage and Disposal Facilities (TSDFs) compared to a control group of all other tracts. She finds that, in 1990, Black and Hispanic populations are correlated with the presence of a TSDF. When she looks at the demographics of those tracts *at the time the TSDF was sited*, she continues to find some evidence of a correlation, especially for Hispanics. The probability of hosting a TSDF is also an inverted-U shape function of income. Moreover, when she looks at changes in demographics between 1970 and 1990 at those tracts that hosted new TSDFs in the 1970s, she finds that their share of minorities grew *less* than control tracts. Thus, despite having introduced it, Been's findings suggest that gentrification processes have not been important in shaping existing correlations between demographics and TSDFs.

Pastor et al. (2001) similarly study TSDFs in Los Angeles. They give greater attention to issues associated with the scale of impacts than did Been, looking at all tracts within ¼ mile or 1 mile of a TSDF. They also look only at tracts without a TSDF as of 1970. They find that the probability of a tract having a facility located within these distances between 1970 and 1990 is a positive and significant function of 1970 minorities. Again, it is also an inverted-U shaped function of income. Like Been, Pastor et al. also find that 1980-90 changes in minority populations is not a function of TSDF sitings in the 1970s.

[19] For a discussion of this process, see Been (1994, 1997), Baden and Coursey (2002), Bowen (2002), and Banzhaf and Walsh (2006).

Those two papers thus find no evidence of reverse-gentrification following siting of a LULU. Other papers have found more evidence of reverse gentrification. Baden and Coursey (2002) studied environmental hazards (CERCLA and large RCRA sites) in Chicago. They found that although these LULUs were correlated with Hispanic populations in 1990, there was no correlation with minority groups as of 1960, presumably before they were understood as hazards. This pattern holds up under a variety of specifications and hazard types.

Wolverton (2002) improves upon the econometrics of these papers by explicitly modeling firm decisions using a conditional logit model. Specifically, she models the siting of polluting plants listed in the Toxic Release Inventory in Texas as a function of land prices, local wage rates, the existence of other facilities, and local demographics. Like Baden and Coursey (2002), she does not find evidence that minority populations contributed to firm location decisions, although like Been (1997) and Pastor et al. (2001) she finds evidence for the inverted-U shape with respect to income.

Thus, studies thus provide conflicting evidence about the historical pattern after siting. Recently, Cameron and Crawford (2004) and Cameron and McConnaha (2006) have conducted careful and focused evaluations of a small number of case studies, over periods which include the cleanup of some sites. Cameron and McConnaha look at four Superfund sites: the Old Bethpage Landfill on Long Island, Tacoma's copper smelter, the RSR lead smelter in Dallas, and Love Canal. Cameron and Crawford (2004) study seven Superfund sites.

Both studies report the evolution, from 1970 to 2000, of a number of socioeconomic, demographic, and mobility indicators around these sites as a function of distance to the site. They find heterogeneous patterns. In some cases, the share of whites decreased closer to the sites, in other cases it increased. Interestingly, given the role of childless households in some of the gentrification literature, they also consider a variety of household structures, although, again, consistent patterns do not emerge. They also find no clear patterns in mobility (as proxied by the number share of people in the same house as five years ago). They do find, however, that the percent of households above the regional median income either declined or was statistically insignificant over the three

decades. They also find some evidence of rebound effects in some indicators. In particular, Cameron and McConnaha (2006) note that the Bethpage landfill, which was listed early and which was cleaned up in 1993 (though not de-listed) had the strongest signal of a rebound. Households with income above the regional median, for example, increased in the 1990 to 2000 period nearer to the site, after declining from 1970 to 1980. The fact that the strongest evidence for this aspect of gentrification occurred near this site, where there was the most time post-cleanup, suggests that gentrification may occur with some lag, and that it may still occur at the other sites.

Banzhaf and Walsh (2006) have focused on gentrification-type responses to the entry and exit of polluting facilities in California, as recorded in the Toxic Release Inventory (TRI). Although these facilities are active polluters, they point out that households may be reacting more to a locally undesirable land use than to local air quality. They find strong evidence for decreasing population density from 1990 to 2000 near both old and new (post-1990) facilities, and increasing density following closure. They also find weak evidence of decreasing incomes near both older and new facilities. They find that both affects occur at one-half mile from the TRI sites, but at a weaker level than one-quarter mile. Greenstone and Gallagher (2005), discussed above in the context of property values, find similar results in looking at demographic responses to Superfund cleanups. In particular, they find that in 2000, tracts near cleaned up NPL sites had increasing population density over 1980, relative to other hazardous waste sites. They find some weak evidence of increasing incomes after cleanup, but no meaningful evidence of other demographic effects.

In summary, the evidence of demographic effects associated with gentrification is roughly consistent with the theoretical model described above. There is preliminary evidence of an increase in the number of households and the population density of a cleaned up neighborhood. Such revitalization represents an increase in the demand for real estate, and in this sense is connected to the hedonic literature reviewed above. There is also some weak evidence of an increase in the share of wealthier and non-minority households in Banzhaf and Walsh (2006), Greenstone and Gallagher (2005), and perhaps in Cameron and McConnaha (2006) (at the Bethpage landfill). Studies have not found consistent racial, family, or other group effects.

Crime and other amenities

As noted in the earlier discussion, decreasing crime and increasing changes in the set of urban amenities, including the type of public spaces, the type of retail (the "Starbucks effect") or the feel of the community ("aesthetic promiscuity"), are all hallmarks of gentrification. O'Sullivan (2005) found that in Portland, changes in crime, housing prices, and the income and educational attainment of the population moved together.

Most of these types of effects of cleanup, if present at all, are likely to be the indirect result of changes in demographics (lines 2 and 5 in Figure 3). Reuse, while also having these indirect effects, might be more likely to directly affect some other amenities, but this would be highly case specific. As a rule, then, we do not expect to see many direct effects on other amenities. The one reasonable exception is crime. As brownfields and other LULUs are located in high-crime areas, crime reduction is often cited as one goal of cleanup and reuse.

One plausible mechanism for cleanup of LULUs to reduce crime is the “broken windows” effect (Wilson and Kelling 1982, Kelling and Coles 1996). The broken windows theory is that small changes in the physical environment, such as fixing broken windows and removing graffiti, can reduce the rates of more serious violent and property crimes. Cleaning up pollution, removing abandoned buildings, and so forth may fit into this category. An intriguing potential second mechanism has been suggested by Kuo and Sullivan (2001). They point to psychological evidence that brain activity differs when people are in green spaces, in a way that is more restful and reduces stress. They hypothesize that this psychological effect, as well as the congregation of people around green spaces, may reduce crime. In support of this theory, they find that crime rates are lower in greener sections of a major Chicago public housing development, even though residents were randomly assigned to apartments. If brownfields and other LULUs have the opposite effect, cleaning them up may reduce crime rates. If the land is reused as a park or other green space, the effect would be more direct.

These effects remain speculative. Apart from a small number of qualitative case studies,[20] we have not found any documentation of improved crime rates following cleanup and reuse of LULUs.

V. General Equilibrium Effects

So far, we have discussed direct connections between land uses and the character of nearby communities, with an emphasis on land prices and demographics. Although these are probably the two most important features, various perspectives on gentrification all describe a cascade of effects that interact, perhaps reinforcing, perhaps dampening, these direct effects. As a starting point, changes in land prices and changes in demographics occur simultaneously. If different groups have differing demands for land, then changes in land prices will further influence demographic composition. At the same time, if people have preferences for the demographic composition of their neighborhood, demographic changes can affect the demand for land and hence prices.

In addition, these changes may bring about other changes in the character of the neighborhood. Wealthier households may replace or rejuvenate the housing stock, further affecting housing prices. New residents may vote for, or organize to create, different levels of public goods (or just different kinds of public goods). They may be associated with lower crime rates. They may also bring differing levels of educational attainment to the school system and otherwise alter the nature of the student peer group. They may have differing tastes for private goods, and so new retail may move in to cater to those tastes (the “Starbucks” effect). And so on.

Recently a family of new "equilibrium sorting models" has emerged in the economics literature, which model some of these simultaneous effects through economic structures (preferences, public good "production functions," and so on). Very few of these models address environmental issues at all, let alone cleanup and reuse of LULUs. Nevertheless, we can gain insights on the importance of these indirect effects for gentrification processes, even if a change in local land uses is not the precipitating factor in the studies.

[20] See, e.g., http://www.epa.gov/brownfields/success/bridgeport_wentfield.pdf.

In the first application of this literature to an environmental issue, Sieg et al. (2004) and Smith et al. (2004) study the simultaneous effects of changing populations and changing land prices in response to changes in air quality in Los Angeles. They estimate an empirical version of the model introduced in Section III, in which households differ by income and tastes for public goods. They find that in general equilibrium, although average ozone improved by 6 to 20 percent across the 5 counties, the equilibrating change in average prices was -6% to 20%.

For our purposes, one of the most important take-home messages from these papers is that local residents can be made worse off after an improvement in neighborhood amenities, even though they have some value for it. Because of below-average tastes for public goods and/or below average incomes, the households who live in an initially dirty community have lower (though still positive) willingness-to-pay for the amenity.[21] When the community is cleaned up and amenities improve, other, outside residents compete to live there, bidding up the price of land to their own, higher willingness to pay for the amenities. Poorer residents are forced to pay these higher rents, or move. Even if they move elsewhere, they are not likely to find as good an alternative as their original community, which they had chosen over other alternatives. Moreover, in reality they would have to pay both the out-of-pocket and the psychological costs of moving, an issue overlooked in the model. However, note that housing prices did fall in some communities where air quality improved, though by less than other areas. These residents are likely to be made better off, as housing prices fall and public goods improve.

In an application closer to the cleanup and reuse issues addressed in this paper, Walsh (2004) uses the same basic model to study the provision of new open space in Raleigh, NC. In his model, households have preferences for fixed green spaces like parks, but also for the population density, which serves as a proxy for "greenness" insofar as larger lots help maintain a more open and rural character. When new open space is provided in a neighborhood, increased demand for living in the neighborhood drives up population density, along with new construction, decreasing that aspect of open space and

[21] In the Tiebout logic of the model, this is revealed by their choice to live in that community in the first place. Relatively speaking, they weight the advantages of affordable housing over those amenities.

thus counter-acting some of the effects of the original policy. Again, Walsh finds that local residents can be made worse off after the provision of green space in their community. Even though they have some value for green spaces, their value is not as high as others, who, with a relative high willingness to pay for the amenity, bid up rents high enough to offset the direct gain of the green spaces to the initial residents.

Although these papers offer important insights into the distributional effects of public good improvements, two limitations suggest reason for caution before applying their empirical findings too literally. First, mobility is costless in the models, and households have no tastes for home and no connection to a specific job location. In short, they have no connection to "place" beyond its description by a vector of public goods and prices. As a result, the models predict an unrealistic level of turnover from changes in public goods.[22] This high turnover, in turn, allows prices to change more than they otherwise might in some communities. On the other hand, as noted above, abstracting from moving costs also implies that the negative welfare impacts on those initial residents who do move are understated (see Vigdor 2006 for discussion).

Second, all households are renters in the model, with increases in rents being captured by absentee landlords outside the model. Homeownership will have different implications for the general equilibrium welfare effects, with homeowners reaping the capital gain in their house rather than paying out higher rents. However, allowing for homeownership probably would only increase the inequity of the welfare impacts. On average, poorer households would be the renters in a neighborhood experiencing cleanup and reuse of a LULU, so it is the poorer households who would pay out the higher rents, while (on average) richer homeowners would capture the gains in their property assets.[23]

A second strand of this equilibrium sorting literature accounts for households' preferences for racial homogeneity or diversity and more generally socioeconomic

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[22] For example, Sieg et al. (2004) find in their policy simulation a 97% turnover in one community following a 9% improvement in ozone concentrations. Seventy-five percent of the new residents came from two communities that were close substitutes.

[23] Of course, along with their higher housing values homeowners would also face higher tax assessments. If new residents have a higher demand for public goods, they might also raise tax rates (e.g. Epple et al. 2001). However, homeowners should still be better off, unless they are highly immobile (so they cannot cash out and move) *and* liquidity constrained (so they cannot tap into higher values to pay current taxes with, e.g., a reverse mortgage).

composition of communities, which naturally develop endogenously. In a recent theoretical paper, Sidon (2005) explores conditions under which two neighborhoods, one clean and one dirty, are segregated by race or income. Generally speaking, Sidon finds that when environmental preferences are strong and racial preferences are weak, the communities will be segregated by income, with richer households outbidding poorer households for the clean community. Wealthier minorities will join wealthy whites in the clean community. As racial tastes increase in intensity, segregation is more likely to occur along racial lines, with the wealthy minorities now joining their poorer peers in the dirty community. As those tastes strengthen even further, it is even possible to support an equilibrium in which the minorities are in the clean community and whites in the dirty community.

Sidon's model is particularly relevant to this review because he analyzes the effect of cleaning up the dirty community, such as by decontamination and reuse of a LULU. The effect of this shift is similar to the effect of lowering the relative weight on environmental preferences. Income sorting becomes less likely, because rich minorities, previously attracted to the clean community (or repelled by the dirty community), need no longer sacrifice environmental quality in order to join their peers. Racial sorting then becomes *more* likely. Since the dirty community had an initially higher level of minorities in the model, as observed empirically for communities near LULUs, we would consequently predict clean up and reuse to *increase* the proportion of minorities in the neighborhood.[24]

In recent empirical work, Bayer and McMillan (2005) have confirmed Sidon's intuition. Using a sorting model of locational choice in San Francisco, they estimate households' preferences for the racial, income, and educational composition of a community, preferences that individually vary by those same socioeconomic factors. They then simulate a counterfactual in which such sociodemographic tastes are not present. Although they do not look at land uses or other environmental amenities, they

[24] Note that this reinforces the message from Banzhaf and Walsh (2006), presented in Section III, where increasing incomes was predicted more strongly than changes in racial composition. It is also consistent with their empirical findings as well as those of Greenstone and Gallagher (2005).

find that the black-white gap in other public goods such as school quality and crime falls by about one-half.

Others have argued that school quality and crime are themselves endogenous functions of local sociodemographics (e.g. O'Sullivan 2005). Bayer, Ferreira, and McMillan (2003) allow for this possibility in additional simulations using a similar model. Again, they do not look at environmental amenities, but they do consider an exogenous change in a local public good, namely school quality. When racial preferences are ignored, the average school zone experiences a $1,000 increase in mean income when its test score is increased by one standard deviation. When racial preferences are accounted for, income increases $1,600. And when further endogenous increases in school quality are allowed to follow from the new peer group in the school, and when crime rates are similarly allowed to fall, the effect rises to $1,800.

In the simulation of Bayer et al., the presence of racial preferences accelerated the gentrification process. However, this need not necessarily be the case. The most fundamental insight of these models and simulations is that the introduction of racial and other group-preferences creates the possibility for a "tipping point," above which gentrification may be accelerated but below which it may be slowed (Schelling 1969, 1972). That is, one important implication of these models and simulations is that, when multiple equilibria are possible, cleanup of a LULU may not automatically transition a community to look like communities that never had one. In some cases, demographic preferences may be a force keeping the previous demographic composition relatively stable. Absent any history of a LULU, a neighborhood may be just as likely to be predominantly white as it is to be predominantly minority. With the introduction of a LULU, it is more likely to become a predominantly minority community. With the removal of LULU, either outcome is supportable in theory as an economic equilibrium. However, the existing equilibrium of predominant minority makeup is an obvious focal point and so may remain stable and even become more dominated by the minority group. If they are directly or indirectly related to any of these demographic effects, housing prices would be expected to reflect them concomitantly.

Cameron and McConnaha (2006) make this precise point when they note that

> Studies that have failed to find that housing prices rebound to pre-contamination levels may be assuming, implicitly, that socio-demographic characteristics of the affected neighborhoods were unaffected by events surrounding the discovery and remediation of an environmental hazard. If households were immobile, if the environmental risk was transitory, and if there was no permanent taint associated with a Superfund site, then restoration of prior housing prices might be expected. However, if the character of the neighborhood is fundamentally changed by these events, and reverse migration is asymmetric compared to out-migration, we might see prolonged effects upon housing prices. (p. 286)

Thus, the importance of other aesthetic amenities and public goods created by neighborhoods may make them somewhat more resilient to gentrification. This may be one reason why before-and-after comparisons of cleanup of LULUs have found weaker demographic responses than cross-sectional comparisons, and that Cameron and McConnaha (2006) found the strongest evidence in the case where there was the most time for a response.

We conclude this section on general equilibrium effects with a paper that takes a very different modeling approach, but that applies it to a policy question of direct relevance to this review. Noonan et al. (2006) model the change in local housing prices following the cleanup of Superfund sites, allowing for endogenous changes in the housing stock and in local demographics. They look at changes in mean housing values as reported in the 1990 to 2000 census years in a national sample of census block-groups, with the variable of interest being an indicator variable for the presence of a Superfund site that has been deleted from the National Priority List, either in the block-group or an adjacent block-group.

Changes in housing prices are also a function of changes in endogenous housing quality (e.g. age, number of rooms, utilities, density) and neighborhood demographics (e.g. income, percent white, percent college graduates, percent poor, and percent blue collar workers.) These in turn are modeled as functions of changes in one another and housing prices, as well as the deletion from the NPL. Noonan et al. take a traditional reduced-form simultaneous equations approach, with lagged levels and changes of each of these factors serving as instruments.

In their preliminary results, Noonan et al. find little evidence for a direct effect of housing appreciation following cleanup, except for with the most restrictive models. They do find evidence for upgrade in the housing stock, with younger and bigger houses appearing after cleanup. They do not find demographic effects. Taking the joint effects of all the relevant interactions, Noonan et al. find slightly positive effects (on the order of 1% to 5%) on housing *values* (pure price effects and quality upgrades).[25] Taken as a whole, there is thus some suggestive evidence of gentrification, but as with the other empirical work not definitive.

VI. Summary and Conclusions

Unfortunately, there are really no rigorous empirical studies that have looked at the full picture of gentrification in the context of the appearance, cleanup, or reuse of LULUs. In this paper, we have tried to gain insights into the issue by looking at theoretical models and empirical studies that have looked at at least one aspect of gentrification at a time, plus others that have looked at multiple aspects in settings that are similar to the cleanup of LULUs. In this final section we summarize our findings from the literature by responding to a series of questions about environmental gentrification.

What are the characteristics of gentrification?

There are three principle hallmarks of gentrification in virtually every perspective on the subject: rising property values and rental costs; new construction or renovation upgrading the housing stock; and a turnover in the local population bringing in residents with a higher socioeconomic status. Various perspectives emphasize other features as well, but most involve some sense of the creation of a new amenity, based on architecture, retail, lifestyle, or just common peer groups. These new endogenous amenities further drive gentrification.

Do cleanup of LULUs and/or reuse trigger gentrification?

The literature yields conflicting signals on whether cleanup is likely to trigger gentrification. A simple Tiebout model predicts price effects following an increase in demand for living in the neighborhood. It also predicts richer households under

[25] As of the time of this writing standard errors are not available for this estimate.

restrictive circumstances, but has no predictions for other demographic groups, even those differing by mean income. Introducing group preferences can lead to counterintuitive effects, where populations of minorities or other groups with lower average incomes can increase following cleanup. If housing prices are also a function of these demographics, one would expect attendant indirect effects on real estate values as well.

Consistent with these surprisingly vague theoretical predictions, the empirical literature has found only weak or conflicting evidence of gentrification. First consider land prices. Cross-sectional work has consistently found lower housing values near a variety of LULUs. In addition, early work found lower housing prices near Superfund sites after discovery, and rebounding prices following cleanup. But more recently, Messer et al. (2006) suggest this need not happen in every case, especially where prolonged cleanup activities have created a potential stigma. Greenstone and Gallagher (2005) likewise find no effect in a national sample of NPL sites compared to other CERCLA sites.

With respect to demographics, again, cross-sectional studies consistently find poorer or minority households near LULUs. Studies are conflicted as to whether these are the result of reverse-gentrification following siting of the LULU, with Been (1997) and Pastor et al. (2001) suggesting not, but Baden and Coursey (2002) and Wolverton (2002) suggesting so. After cleanup, the evidence is again mixed. Banzhaf and Walsh (2006) and Greenstone and Gallagher (2005) both find evidence of increased density following improved land uses, weak evidence for increases in income, and little to no evidence for a decrease in minorities. Cameron and McConnaha (2006) find little effect on income, except perhaps at the first site to be cleaned up (in 1993), and again no effect on either racial or family composition.

Finally, recent work by Noonan et al. (2006) looking at a set of simultaneous effects of Superfund cleanup finds no direct effect on prices, no consistent effect on demographics, but some effect on the quality of the housing stock, which increases housing values. These joint effects are consistent with the partial effects found in other studies.

We find no papers looking at the further effect of specific *reuses* of land following cleanup. However, evidence that some converted land uses such as greenfields are associated with higher neighborhood land prices (Walls and McConnell 2005) is suggestive. In addition, the sociological description of gentrification as a new aesthetic emphasizing recent construction or renovated properties and urban culture hints at another way that reuse might trigger gentrification. In particular, if cleanup, and especially a particular reuse, of a LULU changes the aesthetic "feel" of a community, it may be more likely to trigger gentrification by attracting a new type of resident. Yet this is mere speculation.

What is the potential geographic extent of gentrification?

If gentrification occurs, its geographic extent is likely to be very local. Glass (1964) and Zukin (1987) stress that gentrified neighborhoods can exist side-by-side with deteriorating ones. Most hedonic price studies of Superfund sites have focused on very local areas, with effects extending to 2 miles or so at most. Studies with the most flexible functional forms (using rings around a LULU or splines, for example) find the strongest effects within about a mile (e.g. Ihlanfeldt and Taylor 2004, McCluskey and Rausser 2003).

With respect to demographics, Banzhaf and Walsh find that income responses to TRI sites are still present one-half mile away, but weaker than one-quarter mile. The cleanup and reuse of smaller LULUs, such as brownfields, are likely to have even more local effects.

To what extent do residents and businesses turn over following decontamination or reuse?

As emphasized earlier, turnover is not necessary for pre-existing residents to be harmed by cleanup and reuse of LULUs. Housing prices may still increase, and immobile households may simply have to pay these higher costs. On the other hand, when they are mobile and have good substitutes to move to, households may escape these costs (see Banzhaf and Walsh 2006, Vigdor 2002, 2006). Moreover, if baseline turnover rates are high enough, gentrification and demographic changes may occur even without an increase in the turnover rate.

Simulation models of general equilibrium responses to changes like cleanup of a LULU have generally predicted quite high—indeed, unrealistic—turnover (e.g. Sieg et al. 2004). However, these models impose no monetary or psychological costs of moving, and incorporate no sense of place (a "home" or job location). Empirical studies of mobility have generally found no evidence of increase in turnover following cleanup. In particular, Cameron and McConnaha (2006) find no pattern to the change in the percentage of households at the same house as five years ago following either discovery or cleanup of four Superfund sites. Somewhat removed from these land use and environmental applications, Vigdor (2006) finds that renters are no more likely to move in neighborhoods experiencing lower rates of abandoned housing and barred windows.

Although more work would be needed before reaching definitive conclusions, these two studies suggest that turnover is not likely to increase following cleanup and reuse of LULUs. However, this does not imply that there is no gentrification. The studies do not show a decrease in turnover either. Even if it occurs at an ordinary, typical pace, if the turnover involves replacing one demographic group with another, gentrification might still occur. As discussed above, there is some evidence supporting increases in income following cleanup, although little evidence for changes in other demographic groups.

What factors and policies can mitigate gentrification, and what role can they play?

The literature suggests several factors that might minimize the probability of any gentrification occurring or mitigate its effects. First, given the importance of aesthetic amenities, reuse projects that fit the existing character of the community are less likely to trigger gentrification. Consistent with this point, the NEJAC (2006) report on unintended consequences stresses the importance of community involvement in planning reuse projects.

Second, given the role of racial and other demographic preferences in maintaining an equilibrium, targeting more homogenous communities may be less likely to trigger gentrification as well. This is because these communities are probably further from a "tipping point" at which they would switch over to a new demographic composition.

Third, the work of Sieg et al. (2004) and Smith et al. (2004) suggests that when large policies target several communities within a metro area, gentrification effects are likely to be smaller. While improving a single community is likely to increase its attractiveness relative to all other communities, creating incentives for other households to move in and driving up its housing prices, improving many communities would neutralize this effect, lifting all boats equally.

Finally, we have also noted that communities with owner-occupied housing are less likely to suffer from the adverse effects of rising land prices, although taxes remain a concern. A recent report from the Urban Institute (Levy, Comey, Padilla 2006) suggests three strategies that can be used to help low-income residents afford housing when gentrification threatens. Strategies that have been observed to be successful for providing or assuring affordable housing include: production of affordable units, retention of existing affordable housing units, and asset building for current residents and neighborhood families. Strategies for the production of affordable units include creating housing trust funds, inclusionary zoning ordinances, and the federal Low-Income Housing Tax Credit, in addition to split-rate tax structure and tax-increment financing. In the studies completed, it was found that retention of the affordable housing stock can be encouraged through the enforcement of code, rent control, and the preservation of federally subsidized affordable housing. Thirdly, strategies to build resident assets may be effective in mitigating displacement. As used by Levy, Comey, and Padilla, asset building includes individual development accounts, homeownership education and counseling, limited equity housing co-ops, community land trusts, location efficient mortgages, and the Section 8 homeownership program. These three strategies were found to be effective in six case studies examined by Levy et al. (see also Kennedy and Leonard 2001).

Given these empirical findings, and given these policy options, there seems ample hope for cleanup and reuse of contaminated properties that is a true Pareto improvement for all households—not just a "potential" improvement.

Appendix: A formal model of gentrification

As noted in the text, to gain insight into gentrification following cleanup and reuse of LULUs, we employ a model of vertically differentiated communities introduced by Epple, Filimon, and Romer (1984), a more general version of which has been estimated econometrically by Epple and Sieg (1999) and applied to environmental improvements by Sieg et al. (2004) and Walsh (2004). Banzhaf and Walsh (2006) and Vigdor (2006) use this model to gain insights into environmental gentrification. This appendix is based on Banzhaf and Walsh.

Consider a continuum of households that are characterized by their income y and demographic group t. The joint distribution of types and income is given by $f(y,t)$. The marginal distribution of income is given by $f_y(y)$ and the distribution of income conditional on type t is given by $f_y^t(y)$. Household preferences are defined over housing with price P, a numeraire whose price is normalized to 1, and environmental quality G. Household i's preferences are represented by the indirect utility function

$$V_i = V(y_i,P,G). \tag{1}$$

Each household chooses to live in a community $j \in J$ and, conditional on community choice, chooses a quantity of housing D_i. Each community is characterized by its supply of housing S_j and level of environmental quality G_j, both of which are exogenously determined. To facilitate a characterization of the equilibrium sorting of households across communities, we further assume that household preferences satisfy the "single crossing" property. This condition requires that the slope of an indirect indifference curve in the (G,P) plane be increasing in y.[26] Although household demand for public goods in this simple model is differentiated only by differences in income, the model can be extended to include heterogeneity in tastes without altering the key insights derived here.

Given the assumption of single crossing, equilibrium can be characterized by an ordering of communities that is increasing in both P and G. That is, there is a clear ordering of communities from low price, low quality communities to high price, high

[26] For a discussion of the single crossing property in this context see Epple & Sieg (1999).

quality communities. Further, for each pair of "neighboring" communities (as sorted by this ranking), there will exist a set of boundary households (defined by an income level) that are indifferent between the two communities. Households whose income is below the boundary income will prefer the lower ordered community and those whose income is above the boundary income will prefer the higher ordered community. This leads to perfect income stratification of households across communities.[27] Equilibrium prices P_j and boundary incomes $\overline{Y}_{j,j+1}$ are implicitly defined by the equilibrium conditions of equation (2):

$$V(\overline{Y}_{j,j+1}, P_j, G_j) = V(\overline{Y}_{j,j+1}, P_{j+1}, G_{j+1}) \quad \forall j \in \{1,...,J-1\} \tag{2}$$

$$M \int_{y \in C_j} D(y, P_j, G_J) f_y(y)\, dy = S_j \quad \forall j \in \{1,...,J\},$$

where M is the total mass of households, D(.) is housing demand, and C_j is the set of incomes locating in community j. These equations formalize the J-1 boundary indifference conditions and the requirement that the land markets clear in each of the J communities, yielding 2J-1 equations to identify the 2J-1 endogenous variables.

We use the model to consider two issues important for the analysis of migration and environmental gentrification. First, we consider the implied distribution of households across communities for demographic groups with different income distributions, $f_y^t(y)$. Second, we evaluate how the predicted demographic composition of communities changes, in response to changes in environmental quality. Consider two demographic groups, Type 1 and Type 2. Assume that their conditional income distributions $f_y^1(y)$ and $f_y^2(y)$ are such that the mean income for Type 1 individuals is less than the mean income for Type 2 individuals. Figure 1 provides a graphic representation of the distribution of these demographic types in a system of two communities, with Community 1 having the lower (P, G) pair and Community 2 the higher. All households to the left of $\overline{Y}_{1,2}$ sort into Community 1, all to the right sort into

[27] It is straightforward to relax this assumption by introducing heterogeneity in tastes, so that there is heterogeneity of income within each community, but perfect stratification by tastes for each income (see Epple and Sieg 1999 and Sieg et al. 2004). Accordingly, this assumption is not critical for the following implications of the model.

Community 2. Obviously, Community 1 has a lower average income than Community 2. As shown in the figure, in this example Community 2 will have a much higher concentration of Type 2 individuals and Community 1 a much higher concentration of Type 1 individuals. Thus, Tiebout sorting with heterogeneity in income can induce correlations between other demographic groups (like race) and pollution. (Nevertheless, while this correlation is guaranteed under the central case where the two distributions have identical higher moments, it need not occur in general.)

The above results are completely expected given the model. However, the comparative statics associated with a change in environmental quality in one of the communities is more subtle. Consider the impact of cleaning up and reusing LULUs in the lowest G community in a system of two communities. Evaluating the resulting demographic responses requires identifying the shift in the income boundary, $d\overline{Y}_{1,2} \big/ dG_1$. To evaluate this shift, we assume that housing demand is separable from G and apply the implicit function theorem to the boundary indifference condition and two market clearing conditions from equation (2). This yields the following comparative static relationship:

$$\frac{d\overline{Y}_{1,2}}{dG_1} = \frac{-V_{G_1}{}^{1}}{(V_y{}^{1} - V_y{}^{2}) - f_y(\overline{Y}_{1,2})\left[\dfrac{D(P_1,\overline{Y}_{1,2})V_{P_1}{}^{1}}{\int_0^{\overline{Y}_{1,2}} D_{P_1}(P_1,y)f(y)dy} + \dfrac{D(P_2,\overline{Y}_{1,2})V_{P_2}{}^{2}}{\int_{\overline{Y}_{1,2}}^{\infty} D_{P_2}(P_2,y)f(y)dy}\right]}, \tag{3}$$

where

$$V^1 = V(\overline{Y}_{1,2}, P_1, G_1),$$

$$V^2 = V(\overline{Y}_{1,2}, P_2, G_2).$$

D(.) is the household demand function, and subscripts denote partial derivatives.

The key to signing the derivative in equation (3) is to recognize that the single crossing property implies that $(V_y^{\,1} - V_y^{\,2}) < 0$ implying that $d\overline{Y}_{1,2} \big/ dG_1$ is positive.[28] Figure 2 illustrates the impact of an increase in G_1 on the equilibrium sorting. In response to the change, the indifference boundary $\overline{Y}_{1,2}$ moves to the right and the set of households in the shaded region A relocate from Community 2 to Community 1. If G_1 were to fall instead, or if G_2 were to increase instead of G_1, an opposite shift would occur. At the aggregate level this change leads to an increase in population for Community 1 and a decrease in population for Community 2 (and to an increase in prices in Community 1 and decrease in Community 2).

What is the change in community 1's composition relative to community 2? Surprisingly, the model does not offer clear predictions. Consider first the effect on income distributions. As the bordering households move from Community 2 to Community 1, Community 1 gets richer. (This follows from the fact that the moving households, shaded in Figure 2, are richer on average that the original residents of Community 1.) We call this an absolute composition effect. But meanwhile Community 2 loses its lowest income residents and therefore also experiences an increase in average income. Thus, we have the counter-intuitive result that increasing the level of G_1 leads to an increase in average income *for both communities!* So the *relative* composition effect is indeterminate. Not surprisingly, the effect on relative racial composition is also indeterminate. In fact, so is the absolute effect: As Community 1 increases in average income, it does so by gaining the richer type I individuals as well as poorer type II individuals. In general, the ratio of new type II to new type I individuals can be either greater or lesser than the existing ratio, so that the percent of type I individuals can increase or decrease.[29]

We thus have three propositions.

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[28] By the definition of $\overline{Y}$, $V(\overline{Y}_{1,2}, P_1, G_1) = V(\overline{Y}_{1,2}, P_2, G_2)$. Since all those with incomes higher than $\overline{Y}$ prefer Community 2, $V(\overline{Y}_{1,2} + \varepsilon, P_1, G_1) < V(\overline{Y}_{1,2} + \varepsilon, P_2, G_2), \forall \varepsilon > 0$.

[29] As an example, consider a set of three minorities with incomes {10k, 30k, 50k} and a set of Whites with incomes {40k, 60k, 80k}. These are two symmetric distributions differing only in the location parameter, with a higher mean for Whites. Yet if $\overline{Y}_{1,2}$ is initially at \$45k and shifts to \$55k, the composition of Community 1 will change from two-thirds minorities to three-quarters minorities.

Proposition 1 (Scale Effect). For any two communities, a marginal increase in public goods in one community relative to the other will cause population to rise in the community experiencing the improvement and to fall in the other community.

Proposition 2 (Absolute Composition Effect). Ceteris paribus, a marginal increase in public goods in any community will increase its average income. The effect on the share of racial or other demographic groups is indeterminate.

Proposition 3 (Relative Composition Effect). The change in the average income, or mean share of demographic groups positively correlated with income, in a community experiencing a marginal increase in G, relative to another community, is indeterminate.

These results suggest that for small changes in Community 1's environmental quality, there are no clear predictions for the relative change in community compositions. The interpretation is even more complicated by the possibility that sometimes it is the nicer community, Community 2 in this example, which improves. In that case, both communities would become poorer on average.

These negative conclusions are mitigated by three factors. First, in most cases it will be the less desirable communities (like Community 1) which host LULUs. Second, if we consider a larger change—one that raises the level of environmental quality in Community 1 above that of Community 2—clearer predictions arise. Such a change will cause the populations in Communities 1 and 2 to switch places, resulting in an increase in average income in Community 1, while average income drops in Community 2. Third, when we consider many communities instead of just two, the affect of a change in public goods in Community 1 will intuitively have the largest effects on the composition of close substitutes, with effects on other communities dampening out in the rank ordering (a pattern we have confirmed in simulations). If these more distant communities act as a control group, we would expect to find a relative composition effect. Thus, despite our inability to predict relative composition effects in general, there remain plausible reasons for expecting an increase in income among communities experiencing an exogenous improvement in public goods. One might also expect a similar increase in the share of demographic groups correlated with income, such as race, but this remains purely an empirical matter.

Figure 1. Density of income for two household types and community income boundary.

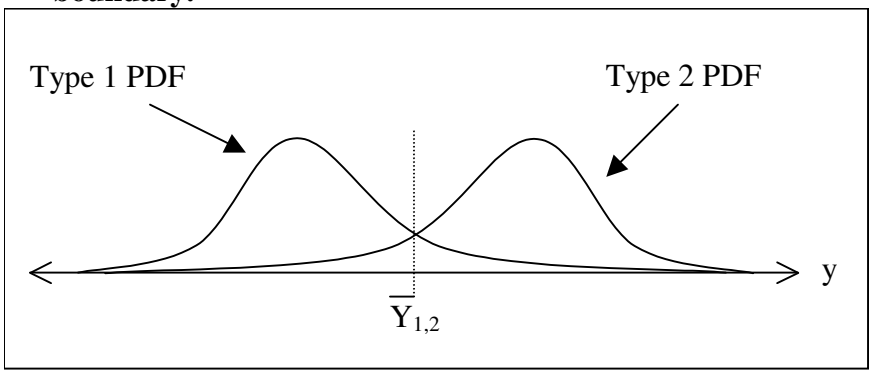


Figure 2. Shift in community income boundary after improvement in G_1.

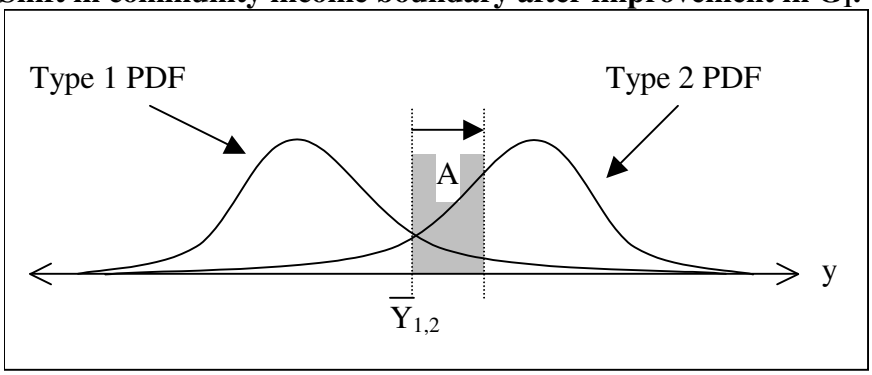
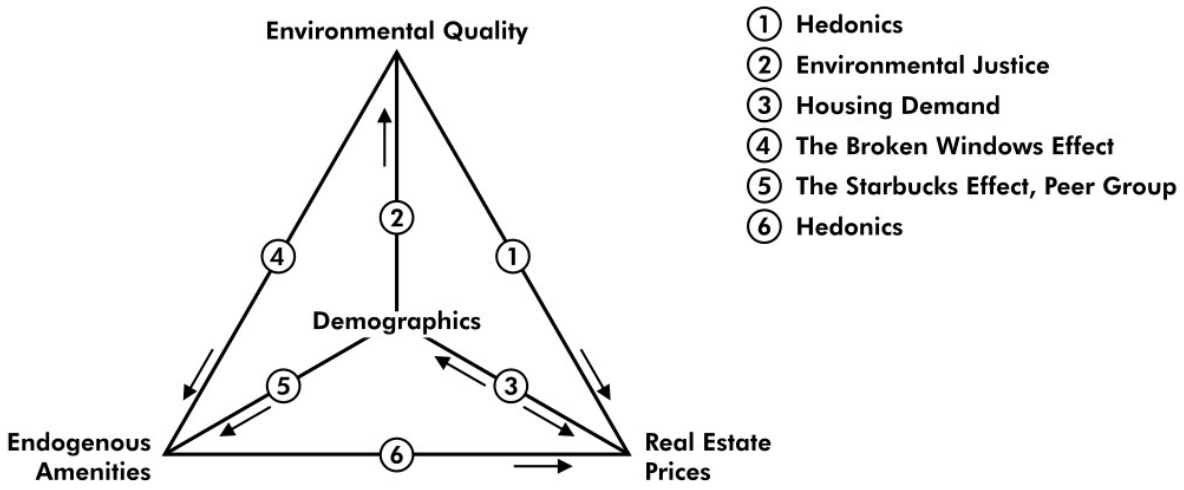


Figure 3. The Four Sides of Environmental Gentrification



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