Research Paper

Urban vacancy and land use legacies: A frontier for urban ecological research, design, and planning

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HIGHLIGHTS

- Highly vacant urban landscapes do not "return to nature" regardless of appearance.
- Contaminant and infrastructure legacies introduce uncertainty at fine scales.
- Landscapes that look well-cared-for discourage abandonment and crime.
- Social capital may be nurtured by and also promote physical evidence of care.
- Management choices affect health, ecosystem services and development potential.

ABSTRACT

Around the world, many urban districts and some entire cities are dominated by vacant and abandoned property. Former uses of these properties range from heavy industry to residential neighborhoods, and each bears many potential legacies of past uses, including: introduction of contaminants that may threaten the health of humans and other species, engineering of land and infrastructure that may undermine hydrological ecosystem services, and introduction of species including invasives. While the ecological functions that characterize vacant urban lands have been only partially investigated, the legacies associated with their past uses are known to affect ecosystem services. In addition, changed industries, weakened economies, arcane financial systems, population migration, and aging resident populations have left many people living in the midst of this vacancy, with clear implications for human health and safety. Since market demand is weak in highly vacant districts, social capital may be particularly important to protecting quality of life and ecosystem services. New design and planning approaches should be informed by urban ecological knowledge that is synthesized with social and cultural understanding of residents' perceptions and values. Interest in urban agriculture, green infrastructure, and open space planning for vacant urban lands is burgeoning. However, without adequate knowledge of highly vacant districts as socio-ecological systems, design and planning may have unintended consequences for human health, water quality, adaptation to climate change, and a panoply of other ecosystem services. Research questions and design and planning applications require a transdisciplinary approach to address highly vacant urban districts with legitimacy and relevance.

1. Introduction

As population growth rates have declined globally, aging populations and population migrations have left vacant and abandoned properties dominating many urban districts, towns and villages. In every part of the world, entire cities have been affected by post-industrial economic decline, real estate financial miscalculations, or natural disasters (Martinez-Fernandez, Kubo, Noya, & Weyman, 2012; Tacoli, 2009), and this has been associated with falling standards of living, ineffective governance, racism, and growing rates of crime and insecurity (Beauregard, 2009; Meurs & Ranasinghe, 2003; Vassilev, 2003). In the United States (US) in 2000, 21 of the 200 largest cities had lost more than a quarter of their residents since 1950 (Dewar & Thomas, 2012). To describe these cities, we use the term “legacy cities”, which Mallach and Brachman (2013) operationalize as cities with populations less than 20% of peak but larger than 50,000. Detroit, MI, is the largest US city to lose more than half its population – shrinking from over 1.8 million in 1950 to under 714,000 in 2010 (US Census Bureau, 1950, 2010). More than a

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quarter of all Detroit properties are abandoned or vacant, and these approximately 100,000 properties occupy about 20 square miles, which is about 14% of the land area of the city and an area larger than all parks and open spaces in the city combined (Detroit Future City, 2013). Even in China, India, and South Africa, where cities are growing rapidly, vacant buildings and abandoned landscapes dominate certain urban districts (Martinez et al., 2012). While the etiology of abandonment, cultural expectations for urban form, and types of governance vary from place to place and time to time, all highly vacant urban landscapes have these conditions in common:

1. They combine occupied structures, abandoned structures, and vacant, formerly occupied, land in a dynamic, patchy pattern.
2. They bear the legacies of past human uses, including contamination, altered hydrologies, altered soil profiles, and introduced species, including invasives.
3. In the near term, they have limited potential to attract financial investment: the real estate market is weak in highly vacant districts.

More specific factors that are believed to have historically affected legacy American cities include: economic restructuring from manufacturing to a service economy, suburbanization, constrained annexation of regional landscapes by local governments, declining quality and support for public services and schools, racism, and longtime infrastructure disinvestment (Beauregard, 2009; Mallach & Brachman, 2013). Age of housing, sewer, water, transportation, and communication infrastructure also affect the dynamics of vacant land.

Many American cities with high proportions of vacant land are located along navigable waters in the Great Lakes watershed (e.g., Milwaukee, Detroit, Cleveland, Buffalo, Rochester) or are coastal port cities (e.g., New Orleans) (Beauregard, 2009; Mallach & Brachman, 2013). Consequently, vacant properties’ potential ecosystem services related to climate change and water quality are highly relevant. In the short term, weak market demand for vacant land reduces the opportunity cost for providing land extensive ecosystem services like flood protection, carbon storage, and habitat. In the longer term, maintaining or enhancing ecosystem services may enhance market values and potential for economic development in these cities (e.g., Turner & Daily, 2008).

However, quality of life for people who live in highly vacant landscapes is of immediate concern. An understanding of relationships among associated social, institutional, and ecological processes associated with vacant urban land is vital to framing actionable research (Doussard, Peck, & Theodore, 2009; Etherington & Jones, 2009). Neighborhood dynamics and social capital, and stakeholder values and preferences may be critical to both environmental and social processes (Kruger, 2008; Nassauer, Wang, & Dayrell, 2009; Schilling & Mallach, 2012), affecting flows of materials, energy, and species, as well as the health, safety, and welfare of residents.

Social capital may be even more essential to the environmental health and human well-being of legacy cities and districts than it is to urban areas that are growing in the 21st century. Social capital refers to the value of support that people provide for each other through their networks, norms, sanctions, and mutual trust – distinct from financial capital (Schuller, 2007). It may affect maintenance, perceptions of safety, and crime in highly vacant neighborhoods. It has been described as including both bonding capital and bridging capital. Bonding capital may exist among people who are similar in some way – for example, they may live in the same neighborhood and they may undertake neighborhood activities together. Bridging capital links people across more hierarchical relationships – for example, neighborhood residents and local public safety providers may develop bridging capital with each other (Baum & Ziersch, 2003; Brisson & Usher, 2005). People who live in a highly vacant neighborhood may establish bonding capital among each other, and they may establish bridging capital with governments and institutions that contribute to management of and investment in the city.

2. Transdisciplinary research questions

This paper examines how physical evidence of social capital may have particular implications for understanding and management of highly vacant urban landscapes, with implications for their current and future ecosystem services. It examines this issue in the context of three key transdisciplinary research questions about vacant urban land:

1. What spatial and temporal characteristics particular to the process of urban land abandonment and vacancy might affect social and environmental systems?
2. How might the legacies of past land uses as well as land abandonment and vacancy affect social and environmental systems?
3. What aspects of human well-being and environmental function should be considered when managing vacant urban lands?

2.1. The dynamic, patchy landscape of urban property abandonment

The dynamic of urban landscape abandonment and vacancy is both social and environmental, and understanding it requires a temporal perspective. In this paper, we define abandonment as the phenomenon of uninhabited structures. We define vacancy as the phenomenon of land from which structures have been removed. While some parts of a highly vacant city may be uniformly occupied, almost none are uniformly vacant, and the transformation from uniform occupancy to abandonment and high vacancy can be rapid or it can take many years. Neighbors may be surprised when the occupants of a well-tended home nearby are suddenly gone. Maintenance stops when a property is abandoned, and a vacant house may be quickly vandalized. In Detroit, abandoned houses are subject to fire, and arson is common. Demolition of abandoned properties is relatively expensive, and demolitions typically are spatially disaggregated. Consequently, patterns of vacancy are patchy and highly dynamic.

After land becomes vacant, new materials are released into the environment and new disturbance regimes begin, but these vary greatly. Specific material flows are uncertain and unpredictable. For example, some vacant properties may be mown in whole or part several times annually, some only annually or less because of limited financial resources. Urban ecology recognizes the central relevance of patch dynamics and offers substantial knowledge of some of the environmental effects of urban settlement (e.g., Grimm et al., 2008; Jenerette & Wu, 2001; Pickett et al., 2008, 2011), but the environmental characteristics of the patchy, and often surprising patterns and flows of vacant urban land have received little scientific attention to date (Ramalho & Hobbs, 2011; Ryan, 2012). Yet, the coupled human and natural processes initiated by abandonment are likely to have profound effects on subsequent human health, economic development opportunities, and ecosystem services. Importantly, some ecological designers paid particular attention to the potentials of vacant land in urban neighborhoods decades ago. Spinn (1984, 2005) in particular pointed to the vexing reality of urban contaminant legacies and raised essential questions of environmental justice. But the link between the history of design innovations that address the dynamics of cities, and research in urban ecology or coupled natural and human systems remains underdeveloped. Furthermore, the most vacant
neighborhoods in America’s legacy cities today are vacant at scales and in contexts novel to recent North American urban experience (Mallach & Brachman, 2013).

One of the biggest challenges for understanding and managing these landscapes is that people do and will continue to live in highly vacant neighborhoods; they are not empty places or places that have “returned to nature”. The novel ecosystem functions set in motion in vacant urban land are paralleled by novel social phenomena experienced and affected by the people who live in this dynamic landscape matrix (Figs. 1 and 2) as well as by property owners who may be speculators or live in remote locations (Thomson, 2012). In a process that Mallach and Brachman (2013) describe as “disinvestment”, property rapidly declines in value in neighborhoods characterized by abandonment and vacancy. Demand plummets. Poverty often characterizes highly vacant neighborhoods, and property may be lost to mortgage or tax foreclosure. Real estate speculators and remote international financial institutions may come to own substantial proportions of property, acquired at low prices or by loan default. However, people continue to live in highly vacant neighborhoods. Some have invested their savings to buy a home and are not able to afford a sale in which they would lose the equity they have invested. Some simply do not want to leave a place where they have lived their lives, despite the changes all around them. Some are attracted to live in the neighborhood by relatively low rental prices. Some choose to stay or are drawn by their personal values to move into highly vacant neighborhoods (Mallach, 2010). All face challenges related to the patchy, highly dynamic pattern of occupancy and vacancy.

Across the broader scale of the city, abandonment and vacancy upset the balance between infrastructure services and revenues. The area serviced per rate payer increases for many services like police and fire protection, or street and sidewalk maintenance, and efficiencies of scale are lost in a patchy pattern of citizen demand (Johnson, Turcotte, & Sullivan, 2010). Other services, like municipal storm sewer, sanitary sewer and water supply are sunk capital assets, investments that were previously made to serve a larger population but that cannot be withdrawn from use without affecting the remaining population. For these assets, the number of rate payers citywide may decline below a minimum threshold for repaying capital bonds or for maintaining and operating plants that were scaled to larger populations. At the same time, the amount of property that local governments own and are responsible for maintaining dramatically increases in cities under the local government property tax structure typical in the United States, whereby failure to pay local property taxes ultimately results in foreclosure in lieu of taxes. Consequently, cities facing a declining property tax base that is inadequate to pay for existing infrastructure and maintenance acquire the additional burden of maintaining additional publicly owned land (Keating, 2010).

A recent OECD report characterizes cities with consistently declining populations as “shrinking cities” (Martinez et al., 2012), adopting the language of an influential exhibition and book series (Oswalt, 2005) that responded to the vanguard post-industrial redevelopment policies of a reunified Germany. However, the report’s broad array of case studies demonstrates how the spatial metaphor, “shrinking”, may lead to an inaccurate conceptualization of urban areas with declining populations. Since cities cannot and do not shrink spatially (reducing the size of all their parts in unison), a pressing question is how to reduce and spatially redistribute some of government’s more malleable services and perhaps the homes of some city residents while the city framework of sunk capital assets (Table 1) remains unchanged.

This question implies that some parts of a shrinking city will have many fewer residents, inviting attendant reductions in malleable public services. A more subtle implication is that even highly vacant areas are laced with infrastructure that represents sunk capital and that may be necessary to the function of infrastructure networks extending throughout the city. Even the areas of the city that may appear to be entirely vacant may be vital links in the city’s infrastructure networks. However, financial and governance stresses contribute to outdated engineering and general disrepair of these systems, and that may have environmental effects. For example, the problem of combined sanitary and storm sewer over-flows polluting downstream waters is typical in industrial cities of the US, including Chicago, Detroit, and New York City. In addition, leakage from aging water system pipes alters the hydrology of legacy cities (Pickett et al., 2011).

At the same time, highly vacant areas are subject to other ecosystem processes, including successional changes. Vacant urban landscapes in forest biomes tend to increase in forest cover over time (Emmanuel, 1997; Zipperer, 2002) with implications for ecosystem services including reduction of urban heat island effects, improved downstream water quality, reduced downstream erosion and flooding, and increased carbon storage (Currie & Bass, 2008; Grimm et al., 2008; Pickett et al., 2011). In a study of the urban forests of Syracuse, New York, vacant landscapes had higher rates of carbon sequestration in vegetation than any other urban forest type (Zipperer, 2002). Depending upon composition and configuration, forest patches also enhance biodiversity (e.g., Grimm et al., 2008; Pickett et al., 2011; Sandström, Angelstam, & Mikusinski, 2006).

### Table 1

<table>
<thead>
<tr>
<th>Malleable services</th>
<th>Sunk capital assets</th>
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<tr>
<td>Paving of local streets, alleys, sidewalks</td>
<td>Electric, gas, phone, cable utilities</td>
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<tr>
<td>Garbage pick-up, recycling</td>
<td>Sanitary sewer</td>
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<td>Street lighting</td>
<td>Storm sewers</td>
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<td>Snow, ice removal</td>
<td>Municipal water</td>
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<td>Emergency responder ratios</td>
<td>Arterial roads</td>
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<td>Tree planting/landscape maintenance</td>
<td>Highway system</td>
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<td>School class size/School services</td>
<td>Rail-based public transport</td>
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<td>Library services</td>
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<td>Bus public transportation</td>
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2.2. Landscape legacies of past uses and abandonment processes

Vacant urban landscapes embody not only infrastructure but also the contaminant legacies of past uses and the abandonment process. Abandoned structures decline from a lack of maintenance and from vandalism by scavengers, squatters, and arsonists. Because of the risks of fire, vandalism, and personal and property crimes, neighbors and public administrators typically advocate for demolition of abandoned structures (Béauregard, 2012; Ehrenfeucht & Nelson, 2012). But demolition is costly for financially stressed local governments. For example, almost a quarter of the residential structures in Detroit are vacant – approximately 80,000; demolition would cost roughly US$12500 per house (Detroit Future City, 2013). With new financial assistance under the federal Neighborhood Stabilization Program, 2008, the rate of residential demolitions increased dramatically in Detroit in 2010 (Thomson, 2012), and is planned to accelerate further in 2014 with a $52.2 million federal grant for 4000 residential demolitions. However, demolition replaces one set of highly visible safety risks with other more subtle environmental uncertainties.

Structures that have been abandoned have life cycle histories that affect site hydrology and soil characteristics. On vacant property, contaminants and species typically have been introduced as well (Burton & Pitt, 2001; Li, Lee, Wong, Shi, & Thornton, 2004; Pickett & Cadenasso, 2009; Pickett et al., 2011). The effects of these disturbances remain even after a well-executed demolition. The process of demolition itself has been shown to expose nearby people to airborne contaminants at potentially toxic levels (Farrel et al.,...
In addition, vacant properties are subject to illegal dumping. Unless the vacant landscape it is visibly maintained, it does not appear to be “watched”. Dumping of unknown materials, including household chemicals, construction debris, oil and gas products, and tires and vehicles is a common phenomenon on vacant property in the United States (Beauregard, 2012). The effect is to increase uncertainty about the identity and presence of potential contaminants after abandonment.

Contaminants incorporated in structural materials may include asbestos, PCBs, lead, zinc and copper. In addition, past occupants of the structures may have introduced contaminants into the landscape by their own activities. Such contaminants could include: PAHs from gasoline and oil, several heavy metals from tires and vehicle part repair, and organochlorides and pesticides from pest control (Burton & Pitt, 2001). The landscape context of vacant property also may contribute to its contaminant burden. For example, location near an arterial street or highway would likely increase lead in the soil, a legacy of the decades in which lead was added to gasoline (Li et al., 2004; Molina & Molina, 2004). Location near a long-time industrial site would increase the likelihood that other airborne contaminants may have been deposited in soils (Molina & Molina, 2004). In addition, industrial sources including massive plumes downwind of coal-fired power plants have increased soil mercury (Edgerton, Hartsell, & Jansen, 2006; Pickett et al., 2011). Mercury releases from coal-fired plants continue in much of the world, including the United States and China. Longer histories of landscape exposure are likely to increase soil concentrations of this neurotoxin (Astrom et al., 2010).

Over time, a vacant property sometimes takes on the appearance of “nature”, at least to the uneducated eye (Fig. 3). For example, large contiguous blocks of vacant small residential parcels in the city of Detroit frequently have been described as “prairie” in the popular, design and planning press (e.g., Mallach & Brachman, 2013; Rubin, 2007; Sommer, 2012). But this appearance of nature belies uncertainties about the contamination legacy of vacant urban landscapes. Even in known contaminated sites, landscapes that look “natural” may harbor contaminants that may be subject to bioaccumulation up trophic levels. For example, “nature” is an intentional contaminant remediation strategy in Germany. In the post-industrial Emscher Valley, a strategy for some heavily contaminated areas is to employ forests for very slow, but inexpensive contaminant attenuation (Dettmar, 2005; Hamm, 2006). In Leipzig, Schetke and Haase (2008) proposed linking vacant patches of the city into networks by reforestation.

The immediate stewardship of vacant urban landscapes will affect their contaminant legacies and the availability of ecosystem services for the present and future, and ultimately, the economic development potential of the larger metropolitan region. Inadequate or misguided stewardship could affect the health of humans and other organisms as well as long-term soil and water quality.
biogeochemical cycling, and capacity to adapt to climate change. While addressing the question of how to spatially redistribute some services calls for innovation in public administration and civil engineering, it also demonstrates that highly urban vacant landscapes are socio-ecological systems that call for transdisciplinary approaches to urban ecology, design, and planning. Ecosystems of vacant urban landscapes may host novel organisms and ecological processes that develop from their landscape legacies. The history of increasingly stringent regulation of contaminants for land reuse on designated brownfield sites illustrates that future and current uses of vacant landscapes should be attentive to what science suggests about risks inherent in the contaminant legacies of past uses, regardless of current regulations (Erdem & Nassauer, 2013). The behavior of current residents – including whether they move into the neighborhood or stay there – is at least partly contingent on how they perceive this landscape that is redolent with uncertainty. Addressing these questions in the context of the larger socio-ecological systems of which they are a part and in tandem with on-the-ground problem-solving could build a more solid and sustainable foundation for future economic development.

2.3. Managing vacant lands: physical evidence of social capital

In the dynamic of vacant urban lands, both ecosystems and social capital will be affected by actions taken by residents and institutions that shape the visible landscape (Gobster, Nassauer, Daniel, & Fry, 2007; Nassauer, 2012). Residents’ behavior to make their neighborhood landscapes looks more well-cared-for, more safe, or more sociable, or to be more productive or useful may also change flows of contaminants, water, or species. At the same time, institutional investments to manage flows of water (e.g., green infrastructure), disinvestment in infrastructure maintenance, or removal of malleable services may affect residents’ perceptions of neighborhood maintenance, safety, or sociability. In each of these relationships, the landscape is the shared medium – changed for a specific intended purpose but having unintentional additional effects. Transdisciplinary urban research and practice frameworks could aim to ensure that these unintentional effects are consistent with enhanced human well-being and long-term ecosystem services (Wang et al., this issue).

While residents’ behavior may very seldom be intended as environmental stewardship, it may have environmental effects. This behavior may be intended to maintain or beautify their landscapes by mowing or trimming, to establish secure boundaries around their own landscape, to fence their dogs, to light the neighborhood at night, to ensure privacy from the view of passersby, to watch who is moving in and out of the neighborhood nearby, to accommodate play or recreation, to allow for vehicles to be repaired or maintained, to dispose of garbage or landscape debris, or to grow food. But this behavior may also discourage dumping, disrupt succession, introduce new species and new materials (including pesticides can contaminants associated with oil, gas, and tires), and alter flows of species and materials. From the standpoint of social capital, these behaviors may build bonding capital by signifying the presence of watchful people who care about their neighborhood and by enhancing perceptions of safety.

Both bonding and bridging social capital affect quality of life in highly vacant urban areas (Sampson & Raudenbush, 2004). However, the patchy, dynamic character of vacancy presents particular challenges to forming the formal and informal social networks that can nurture social capital (Schuller, 2007). People living in homes surrounded by large vacant areas are physically isolated from remaining neighbors. Furthermore, the fires and crime associated with abandoned structures cause people living or walking nearby to have legitimate concerns for their safety (Branas et al., 2011; Galster & Raleigh, 2012). People who are more vulnerable in some way (e.g., the elderly, children, single parents) may feel particularly at risk.

In addition to social isolation and fear of being near abandoned structures, the disorderly appearance of vacant landscapes also could undermine formation of social capital. Wilson and Kelling’s (1982) “broken windows” hypothesis asserted that physical evidence of incivility in urban landscapes signified that an area may not be effectively巡逻ed or guarded, and, consequently, invited crime. While subsequent studies have not found a consistent relationship between perceived disorder and crime, they have found a relationship between perceived disorder and perceived risk of crime (Hong & Farley, 2008; Maxfield, 1984; Perkins, Meeks, & Taylor, 1992; Sampson & Raudenbush, 2004). That is, a disorderly abandoned landscape (characterized by graffiti, litter, unmown grass, abandoned cars and broken glass) may look like a dangerous place regardless of the actual record of crime there. Certainly, vacant structures are dangerous places and pose real risks of fire. However, the risk of specific types of crime varies, partly depending upon the stages of abandonment and vacancy that are present, the types of landcover associated with each stage, and by contextual factors – like whether liquor is sold nearby (Galster & Raleigh, 2012). In addition to the fear of crime, disorder in the physical environment...
environment may burden residents with other stressors including increased feelings of hopelessness, stigmatization, and a sense of isolation, which undermine neighborhood social capital (Curley, 2010; Mair, Kaplan, & Everson-Rose, 2012).

In contrast, landscape characteristics that signify order, care, neighborliness, and an ongoing human presence may nurture social capital, possibly by helping to encourage social networks and social cohesion. At the same time, social capital may affect perception of the neighborhood. Sampson and Raudenbush (2004) demonstrated that diminished social networks were stronger predictors of perceived disorder than objectively rated neighborhood disorder in Chicago. In the Netherlands, social cohesion was found to strongly correlate with both perceived safety and objective esthetic characteristics of an urban neighborhood (Kamphuis et al., 2010, Wood and Giles-Corti (2008) reviewed the social capital literature and concluded that it suggests linkages between and social capital and the following landscape characteristics:

- Incivilities and disorder
- Esthetic appearance
- Housing design
- Private and public property upkeep
- Feelings of safety
- Access to nature and greenery

Their study suggested that lack of physical evidence of strong social capital may increase residents’ propensity to move, feeding a vicious cycle of abandonment and vacancy.

Landscape characteristics that visibly demonstrate human presence to care for the landscape and imply a broader attention to societal or neighborhood norms have been called “cues to care” (Nassauer, 1995, 2011). In highly vacant neighborhoods of US industrial cities, cues to care are likely to include:

- Mown turf
- Trimmed trees and hedges
- Canopy trees
- Plants in neat rows
- Food gardens
- Lawn ornaments
- Colorful flowers
- Fences
- Structures in good repair
- Neatness and order (no litter, no weeds, no stray items)
- Visible and crisp edges of different patch types including gardens
- Furniture for sitting on front steps or porches

A neat appearance including mowing and trimming has consistently been found to be preferred in residential neighborhoods in the US and Europe (Colyer, Sullivan, & Kuo, 1997; Donovan & Prestemon, 2012; Hong & Farley, 2008; Jorgensen, Hitchmough, & Dunnet, 2007; Kuo & Sullivan, 2001; Kuo, Sullivan, Coley, & Brunson, 1998; Nassauer et al., 2009; Nassauer, 1988; Zheng, Zhang, & Chen, 2011). In a low-income neighborhood in New Orleans, physical characteristics such as housing condition, property upkeep, low frequency of abandoned buildings, and neighborhood cleanliness were associated with higher levels of neighborhood satisfaction (Basolo & Strong, 2002). While food gardens often look neat and well-cared for, some forms of food production may not be appropriate on vacant properties, which sometimes harbor contaminants that could compromise human and environmental health (Kruger, 2008). In a declining low-income neighborhood of Salt Lake City, Utah, US, physical cues were strongly related to residents’ levels of place attachment, which promotes neighborhood stability and security. Positive place attachments were more prevalent on blocks with more homeowners, fewer incivilities, higher neighborhood cohesion, and less fear of crime. Respondents’ experiences of place attachment were rooted within their immediate physical and social context, implying that perceptions can be influenced at a relatively fine scale, block-by-block (Brown, Perkins, & Brown, 2003). This scale is consistent with findings for other residential neighborhoods, that choices about the appearance of one’s own home landscape are strongly influenced to be similar to the choices of nearby neighbors (Hunter & Brown, 2012; Nassauer et al., 2009).

Several cues are specifically associated with a greater sense of safety, or lower actual crime rates. Mown turf and shrubs are associated with lower fear (Jorgensen, Hitchmough, & Calvert, 2002; Kuo & Sullivan, 2001). Barriers such as fences, boundaries defined by gardens or shrubs, and signs of personalization such as outdoor property maintenance or beautification were correlated with lower crime rates and reduced fear in Baltimore, MD, USA (Taylor, Gottfredson, & Brower, 1984). In Penang, Malaysia, intentional landscaping, personalization of landscapes, lighting, surveillance, and physical barriers were associated with reduced fear of crime (Hedayati, Abdullah, Razak, & Tilaki, 2012). A Philadelphia Horticultural Society project to clean and maintain vacant lots throughout Philadelphia removed trash and debris, degraded land, planted grass and trees, and installed low wooden post-and-rail fences. These landscape changes were associated with reduced rates of vandalism and other criminal activities (Branas et al., 2011) because the landscape signaled that “someone in the community cared and was potentially watching over the space” (p. 1302). Higher percentages of tree canopy, particularly on public land or easements, were related to lower crime rates for US Census block groups in Baltimore (Troy, Grove, & O’Neill-Dunne, 2012). However, they noted that this relationship might not hold for large areas of abandoned land, in which large wooded areas might be seen as unsupervised spaces for criminal activity.

Visible landscape cues that are associated with care and safety may have a halo effect in which landscape appearance shapes assumptions about the people who tend to the land, and these assumptions extend beyond immediate cues to care to the nearby landscape (Nassauer, 2011). A perception of good landscape care may suggest that the caretakers are good neighbors with adequate time and money to express personal pride in the landscape. Evidence of neglect in landscape may imply troubled caretakers, and has been associated with compromised perceptions of safety. By implying characteristics of residents, landscape care can be seen as supporting and communicating social capital. Curley (2010) explicitly links landscape appearance to social networks and interactions in Boston, MA, USA, where she found landscape appearance to contribute to the loss of social capital in a low-income HOPE VI housing project. She found that the following aspects of the “look” and “feel” of exterior and public spaces shaped interactions with outsiders, and ultimately perpetuated a sense of isolation and stigmatization:

- Groups of people hanging out
- Graffiti
- Lack of outdoor lighting
- Trash in parking lots, sidewalks, and lawns
- Unattractive common outdoor areas
- Lack of recreational space
- ‘Ominous’-looking structures, particularly in terms of ‘barracks-style’ development
- Physical isolation from transportation, stores, facilities, and other conveniences.

The literature clearly suggests that appearance of the landscape affects neighborhood residents’ perceptions of safety, desirability, and neighborliness within their neighborhoods, and sometimes actual crime rates as well. However, individuals who live in highly

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vacant neighborhoods can establish physical evidence of social capital with little need for financial capital. At the same time, institutional investments also can establish physical evidence of social capital, especially as part of capital improvement projects, which may be primarily intended to achieve goals of stormwater management or transportation improvements. This underscores the strong links between landscape characteristics that are evidence of social capital and landscape characteristics that affect environmental functions.

3. Implications for new frontiers in urban ecology, design and planning

Landscape characteristics that are perceived as physical evidence of social capital, or the lack of social capital, are essential elements in the dynamic of highly vacant urban landscapes as socio-ecological systems. They affect the well-being of urban residents as well as the functioning of urban ecosystems. They are determined by human behavior as well as by inherent environmental properties of highly vacant landscapes. Importantly, links between human behavior that produces physical evidence of social capital and the environmental effects of that behavior may not be immediately apparent to either stakeholders or science. Below are some possible links that have implications for landscape design and planning and urban ecology, as well as for choices by neighborhood residents:

- Building demolition may improve perceived neighborhood safety and neatness, but building demolition may expose nearby organisms to airborne contaminants, which also may be deposited in nearby soil, or as dust on surfaces.
- Individual properties that exhibit strong physical evidence of social capital may have a halo effect – increasing the degree to which nearby properties are perceived as “watched” and reducing dumping of unknown substances on those properties. This halo effect may also reduce the propensity of neighbors to move, maintaining a more spatially cohesive pattern of neighborhood care and perceived safety. Conversely, abandoned properties may produce a destructive halo, inviting destructive activities into the neighborhood and “driving” neighbors to move.
- Keeping residential landscapes neat may nurture social capital, but people who live near abandoned and vacant property may have a high perceived need to control insect and rodent pests and consequently use larger amounts of pesticides.
- Using vacant property for food gardens may be a cue to care and increase social capital, but it also may expose food consumers to legacy contaminants in the soil or shallow ground water.
- Fences can be a strong cue to care and help residents feel safe, but some fence designs may reduce desirable flows of materials and species. On the other hand, fences that contain dogs and cats that could become feral may enhance habitat quality on vacant land, especially for ground-nesting species.
- Using large contiguous areas of vacant land as habitat may provide patch sizes adequate for uncommon “interior dwelling” species, but this habitat may expose wildlife to legacy contaminants, which may move through trophic levels and be transported to other landscapes and regions. It may also provide patch sizes adequate to allow for unwatched human activity, including criminal activity.
- Expansion of urban forests on vacant urban land may reduce downstream stormwater event peaks and CSOs and mitigate flooding; reduce nitrogen, phosphorous, and sediment loads and improve downstream water quality; and increase storage of carbon and help to mitigate climate change. However, expansion of urban forests on vacant urban land may reduce perceived safety or increase crime rates by reducing visibility in urban neighborhoods.

This list, while speculative and incomplete, demonstrates the importance of transdisciplinary research in urban ecology, design and planning for highly vacant urban landscapes. It also suggests that certain issues will be important to transdisciplinary approaches to addressing the research questions we raised at the beginning of this paper:

1. What spatial and temporal characteristics particular to the process of urban land abandonment and vacancy might affect social and environmental systems?

Post-industrial economic changes, real estate financial uncertainties, natural disasters and climate change, racism, poverty, ineffective governance, crime and perceptions of insecurity affect the patch dynamics of urban land abandonment and vacancy, and distinguish it from other ecosystem dynamics, including the dynamics of other urban ecosystems. In addition, the spatial scales and temporal processes of abandonment and vacancy in the most highly vacant cities may present thresholds representing socio-ecological dynamics that call for novel planning and design approaches. For example, the new wave of residential demolitions in Detroit will be targeted to neighborhoods that are the most intact, in which abandoned properties might have a destructive halo effect on well-functioning neighborhoods. This is one signal that the most vacant neighborhoods of the city have crossed a threshold into a socio-ecological regime of landscape matrix dominated by vacancy and characterized by novel dynamics of contaminants, species, and people. Another implication of a vacancy threshold is that ecosystem services may overshadow social effects in landscape management decisions in highly vacant neighborhoods. For example, land-based green infrastructure for distributed stormwater management is well-suited to large contiguous areas of vacant land. However, if design and planning of green infrastructure fails to recognize how vacant neighborhoods as social systems, both long-term stormwater benefits and potential social benefits are at risk. Even highly vacant urban landscapes should be conceptualized as socio-ecological systems in research and practice.

2. How might the legacies of past land uses as well as land abandonment and vacancy affect social and environmental systems?

The history of changes to soil and water, including stormwater, groundwater, sewer and water infrastructure, other utility infrastructure, and introduction of species sets vacant urban landscapes on novel ecological trajectories, and raises fundamental questions about the stewardship of abandoned lands with uncertain contaminant legacies. What is a sufficiently precautionary approach to protect the health of humans and other species against contaminants introduced by past or current land uses, including abandonment and vacancy? Contaminant transport may place constraints on demolition practices, as well some forms of urban agriculture. Even vacant land that is used as open space will benefit from design that is attentive to contaminant effects through trophic levels, and monitoring of these effects. How can long-term soil and water quality be protected or even improved by management of highly vacant lands? To the extent that vacant land appears to be “natural” or “returning to nature”, appearances are misleading. Rather, highly vacant landscapes invite transdisciplinary interventions to enhance ecosystem services and human well-being.

3. What aspects of human well-being and environmental function should be considered in managing the landscapes of highly vacant neighborhoods?

While financial capital for management of vacant urban lands is limited, social capital may be more available. Nurturing social
capital for remaining residents should be a consideration. This may be achieved partly by recognizing and respecting physical evidence of neighborhood bonding social capital. It also may be achieved by leveraging public capital investments to be recognizable as physical evidence of bridging social capital at neighborhood scales. Ensuring that vacant land does not appear to be unwatched and unmaintained is particularly important to perceptions of safety and neighborliness. While increasing forest cover on vacant land provides needed ecosystem services including stormwater management, the design of forest, especially its grain and extent, is essential to perceptions of safety. Designing and planning to ensure physical evidence of social capital and to allow for ecosystem services on vacant land may require special consideration of physical cues to care, safety, and neighborliness.

Highly vacant urban lands present a frontier for transdisciplinary research in urban ecology, design, and planning. The issues described above are affected by management of vacant lands, whether or not that management is influenced by available science. In highly vacant neighborhoods today, people are exposed to personal safety and environmental risks, demolitions are underway, gardens are being tended, and novel ecosystems have emerged. Legitimate transdisciplinary approaches to addressing the questions above will probe the highly dynamic and patchy pattern of vacant landscapes while being attentive to the health, safety and welfare of the people who live there and respecting the extraordinary value of the social capital they contribute to their communities and metropolitan areas.

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