The spatio-temporal impacts of demolition land use policy and crime in a shrinking city

Amy E. Frazier*, Sharmistha Bagchi-Sen, Jason Knight

University at Buffalo – State University of New York, Geography Department, 105 Wilkeson Quad, Buffalo, NY 14261, USA

Keywords:
Shrinking cities
Human–environment interactions
Demolition
Crime
Cluster analysis
Regional planning
Policy
Buffalo

Abstract

Land use change, in the form of urbanization, is one of the most significant forms of global change, and most cities are experiencing a rapid increase in population and infrastructure growth. However, a subset of cities is experiencing a decline in population, which often manifests in the abandonment of residential structures. These vacant and abandoned structures pose a land use challenge to urban planners, and a key question has been how to manage these properties. Often times land use management of these structures takes the form of demolition, but the elimination of infrastructures and can have unknown and sometimes unintended effects on the human–environment interactions in urban areas. This paper examines the association between demolitions and crime, a human–environment interaction that is fostered by vacant and abandoned properties, through a comparative statistical analysis. A cluster analysis is performed to identify high and low hot spots of demolition and crime activity, specifically assault, drug arrests, and prostitution, over a 5-year period. Results show that there is an association between the area targeted for significant demolition activity and the migration of spatial patterns of certain crimes. The direction of crime movement toward the edges of the city limits and in the direction of the first ring suburbs highlights the importance of regional planning when implementing land use policies for smart decline in shrinking cities.

Introduction

Land use change, specifically in urban areas, is one of the most severe forms of global environmental change (Grimm et al., 2008). Urbanization is a human-dominated process that has lasting impacts on biodiversity and ecosystem processes (Tian, Ouyang, Quan, & Wu, 2011), and therefore many urban land use studies focus on the human–environment interactions fostering these changes. In these studies, humans are studied as the agent of land use change (e.g., the destroyer of forests, paver of roads, etc.), and the environment is typically studied from the perspective of the ecosystem processes affected by land use changes (see Alig, Kline, & Lichtenstein, 2004; Lambin, Turner, Geist, & others, 2001; Turner, Meyer, & Skole, 1994). While the global trend is urban intensification through infrastructure growth and population increases, a subset of cities is experiencing a different phenomenon — population shrinkage. This reversal is associated with a different type of land use change, the elimination of infrastructure, which in turn is affecting human–environment interactions in urban areas.

Shrinking cities are urban areas that are experiencing population decline and along with it an inability to maintain previous levels of infrastructure and services. These cities typically result from a combination of deindustrialization, suburbanization, and/or demographic shifts (Hollander & Nemeth, 2011; Hollander, Pallagst, Schwarz, & Popper, 2009; Schilling & Mallach, 2012; Wiechmann & Pallagst, 2012), and the decline in population manifests itself through vacant and abandoned residential structures (Schilling & Mallach, 2012). These properties pose a challenge to the city because they discourage economic development, deter people and businesses from locating to the city, and require a substantial amount of public resources for maintenance and safety.

Studies have also found that neighborhoods with vacant properties have higher rates of certain types of crime including assault (Boyle & Hassett-Walker, 2008), drug activity (Cohen, 2001; Yonas, O’Campo, Burke, & Gielen, 2007), prostitution (Spelman, 1993), fires (Thomas, Butry, & Prestemon, 2011), and homicide (Suresh & Vito, 2009). Abandoned buildings represent urban decay and signal to criminals that crime monitoring and apprehension rates are lower than in well-maintained neighborhoods, i.e. the Broken Windows theory (Wilson & Kelling, 1982). Additionally, vacant properties provide criminals with a rent-free space in which to carry out drug or prostitution transactions.
The key question for many urban municipalities is how to manage these vacant properties because maintaining them and paying the municipal and school taxes is a burden. Some cities have turned to demolition in order to regulate the ill effects of these vacant properties. Demolition of a residential structure transforms the land use of the property from residential to vacant or open space. This type of land use change, while atypical in most urban areas, has become a powerful mechanism for shaping American cities in the 21st century (Mallach, 2011). Demolitions are especially common in shrinking cities and have implications for two types of human—environment interactions rarely addressed in urban geography studies. First, the removal of built-up infrastructure represents an aberrant human—environment interaction whereby humans actively reverse the trend of urbanization. Second, these land use changes affect human—environment interactions in the form of the criminal activity promoted by the cultural landscape of vacant and abandoned structures.

The objective of this paper is to study the association between demolitions and criminal activity through a comparative statistical analysis. We hypothesize that the patterns of human—environment interactions (i.e. criminal activities) typically associated with vacant and abandoned structures will disperse from the areas where significant demolition activity is occurring. The objective will be tested through the following specific aims: (1) analyze the local spatial clustering of demolition activity over a period of time in a shrinking city using geographic clustering techniques, (2) analyze the local spatial clustering of certain crimes associated with vacant structures, (3) determine whether there are any shifts in the magnitude and direction of the clusters of those crimes, and (4) discuss whether these changes have implications for urban land use policy. To our knowledge, no studies have attempted to look at whether these changes have implications for urban land use policy.

Urban geography: theoretical and policy traditions

Human—environment interactions in developed urban areas

The human—environment tradition in urban geography has historically focused on site selection and the possibilities a site afforded for population and economic growth (Tower, 1905; Ullman, 1941). For example, sites adjacent to deep water ocean ports supported different outcomes for city growth compared to sites located in rugged mountain terrain. As cities grew rapidly throughout the 19th and early 20th centuries, certain spatial patterns of growth came to characterize the expansion of the city and suburbs as people migrated outward in search of better opportunities and quality of life. In these scenarios, the central business district (CBD) usually remained active while suburban areas or ‘sub-cities’ developed in distinctive growth patterns such as rings, corridors, or edge cities (Garreau, 1991; Newton, 2000). The human—environment investigations of urban geography progressed accordingly through the 20th century to explore the emerging evolution of the city-suburb dichotomy, along with its spatial and demographic patterns.

In recent years, the focus of most human—environment research in urban areas has been on the conversion of rural lands in order to extend metropolitan aggregations (Lambin et al., 2001). These land use changes have a range of environmental impacts, but most typically they are studied in terms of their effect on traffic and transportation management (Antrop, 2004), environmental quality (Carle, Halpin, & Stow, 2005; Ren et al., 2003; Song, Webb, Parmenter, Allen, & McDonald-Buller, 2008), public health (Moore, Gould, & Keary, 2003; Young et al., 2012), and disaster management (Nirupama & Simonovic, 2007; Sheng & Wilson, 2009).

However, a growing stream of literature suggests that the traditional city-suburb dichotomy that models a declining central city surrounded by growing, vibrant suburbs or suburbs is no longer the only relevant metropolitan model (Hanlon, 2008, 2009; Hanlon, Short, & Vicino, 2010; Lee & Leigh, 2007; Mikelbank, 2004; Puente & Orfield, 2002). In contrast to the ring, corridor and edge scenarios discussed above, shrinking cities experience population decline in the city center. This decline manifests in a ‘hollowing out’ of the city as the physical and cultural landscape adjusts to comply with the loss and is sometimes referred to as the ‘donut effect’. While shrinking cities are a widespread phenomenon of the late 20th and early 21st centuries, urban geography studies rarely focus on the unique land use changes taking place in these cities. Nor do they address policies for managing excess land and infrastructure or the human—environment relationships that result from those excesses. The key question is how does altering the physical landscape in shrinking cities affect human—environment interactions and what are the implications for urban policy?

Land management strategies in the U.S.

Urban planning has traditionally focused on managing growth (Pallagst, 2008) through promoting major economic development plans and strategies (Bradbury, 1982; Dewar, 1998). The focus on growth has been so pervasive that shrinking cities have typically maintained pro-growth policies, assuming that increases in development will bring back population, jobs, and taxes thereby halting the shrinkage problem. Unfortunately, this planning strategy has had minimal impact in reversing decline and disinvestment or spurring growth (Dewar, 1998).

During the past decade, policies have begun emerging that plan for decline rather than growth in shrinking cities. These approaches, known as ‘smart decline’ (Popper & Popper, 2002), represent a shift from growth-based economic development strategies to a ‘better not bigger’ approach that explicitly recognizes decline and its manifestations (e.g., neighborhood decline, housing vacancy, and foreclosures). Smart decline in the US was first codified by the City of Youngstown, Ohio in its 2010 City Plan advocating a “better, smaller Youngstown” that accepted population loss and focused on improving quality of life (City of Youngstown, 2005).

While smart decline is not yet a widely accepted policy objective, many cities have implemented smart decline approaches such as residential relocations, land banks, green infrastructure, and demolitions. In particular, demolition has a long history as a policy response to urban and neighborhood decline. In the case of shrinking cities, demolition is a viable, yet socially and politically challenging tool to address vacancy and abandonment. Demolitions have received little attention in the literature (Mallach, 2011), so there is very little knowledge regarding the effect of demolition policies on the physical landscape of the city as well as the effect on the human—environment interactions within that landscape. The purpose of this research is to contribute to this knowledge gap.

An exemplary shrinking city: Buffalo, NY

Buffalo’s preeminent place in U.S. urban history is directly attributed to its site advantage, making it exemplary in the human—environment tradition of urban geography. Located on the eastern shores of Lake Erie, along the Niagara River, Buffalo was able to capitalize on the shipping benefits of the Great Lakes and Erie Canal as well as railroad systems and enjoyed sustained economic growth through the mid-1950s. Similar to other mid-sized and large rust-
belt cities, Buffalo’s deindustrialization was fueled by more geographically desirable transportation logistics in southern and mid-western states as well as better labor relations in states without unionized workforces (Crandall, 2002). Between 1950 and 2010, the population decreased from over 580,000 to 266,000, and the vacancy rate now stands at 17.2%, the seventh-highest in the country (U.S. Census Bureau, 2010), with an estimated 25,000 vacant units.

Currently, Buffalo ranks 4th on Microsoft News’ (MSN) Real Estate list of the top 10 shrinking cities in the U.S. (Fulmer, 2012). Of the top 10, seven are located in the north (Flint, MI, Cleveland, OH, Buffalo, NY; Dayton, OH; Pittsburgh, PA; Rochester, NY; and Syracuse, NY), and New York claims three of the top 10, more than any other state. Buffalo is representative of other shrinking cities because it encompasses the myriad crises that have affected other ‘old and cold’ shrinking cities such as economic-infrastructure shifts, nationwide migration to sunbelt cities, racial segregation, and globalization. Buffalo has also experienced another characteristic artifact of shrinking rust-belt cities — suburbanization of the surrounding county. While population in the city declined from 1950 to 1970, the rest of the County gained population, indicating growth in the suburbs. The development of housing units in the surrounding county continues to draw residents into suburban neighborhoods.

Buffalo is among an innovative group of shrinking cities using demolition as a community development tool, which also includes Cleveland, Dayton, Flint, and Rochester (Favro, 2006; Streitfeld, 2009). Cleveland and Dayton used federal funding through the Neighborhood Stabilization Program to implement demolition plans (City of Cleveland, 2011; City of Dayton, 2011), while Flint used foreclosure law changes to make demolition work (Streitfeld, 2009). Buffalo’s demolition plan was initiated in August 2007 to address the high vacancy rate, which was causing ‘dangers and blight’ and attracting certain types of crime (DAFPU, 2007, pp. 1–4).

The ‘5 in 5 Demolition Plan’ (hereafter referred to as the ‘5 in 5’ plan), aimed to demolish 5000 structures in 5 years (DAFPU, 2007, pp. 1–4) in order to reduce the number of vacant structures and thereby reduce certain types of crimes.

### Methodology

#### Study area and data

The study area is the city of Buffalo, NY, located in Western New York on the shores of Lake Erie. The city is situated within the larger Buffalo-Niagara metropolitan area (Fig. 1a), which is an international gateway for commerce and trade between the U.S. and Canada and a tourist destination for Niagara Falls. The ‘5 in 5’ plan was initiated in August 2007, therefore September 1, 2007 was chosen as the start date and August 31, 2012 as the end date for the study. The time period is broken into five one-year analysis periods, with each year running from September 1st through August 31st of the following year. The spatial mapping units for the study are the 2000 block groups (U.S. Census Bureau, 2000). We elected to use the 2000 block groups because the majority of the ‘5 in 5’ plan took place during the period for which those block groups were available and valid. However, block groups were redrawn in 2010, causing some changes to the number and size of the units. To ensure that this mapping change did not impact our results, we tested our analysis (discussed in Section 3.3) using both 2000 and 2010 and determined there was no significant difference in outcome. Therefore, all analyses use the 2000 block groups. A complete list of all demolitions occurring during the 5-year period from September 1, 2007 through August 31, 2012 was obtained from the city of Buffalo. The location of each demolition was geocoded to the Erie County land parcel GIS shapefile, which is maintained by the Erie County GIS Department. All 2814 demolitions that occurred during the 5-year period were successfully matched to a land parcel (Fig. 1b).

Crime data for assault, drug arrests, and prostitution were acquired from the Buffalo City Police Department for the period September 1, 2007 through August 31, 2012. These crimes were specifically selected because they have been found to increase with the Broken Window theory. Additionally, drug and prostitution activities are attracted to vacant buildings, which offer free, private spaces in which to conduct illicit business. Crime locations were
geocoded to the Erie County GIS database, and in each case, over 97% of the crimes were able to be successfully matched to a parcel or road centerline. Since the spatial units for the study are areal block groups, a count of the number of demolitions and each type of crime were assigned to each block group to form analysis data.

Cluster analysis using the Getis—Ord \( G_i \) statistic

Statistical tests for the detection of clusters are frequently performed in order to identify ‘hot spots’ of activities when nothing is known about their locations (Besag & Newell, 1991; Ord & Getis, 1995). Such ‘hot spots’ will emerge from the surrounding locations if their values are unusually high or low (Ord & Getis, 1995). Hot spot analyses can take the form of global or local tests. Global tests summarize the degree to which a spatial pattern deviates from the specified null hypothesis, producing a single value describing that deviation for each map. Global statistics are limited because they cannot provide information regarding the size or location of specific pockets of raised incidence (Rogerson & Yamada, 2009, 322 pp.).

Local, or focused, statistics measure and test for spatial association for a variable within a geographic neighborhood. Local measures of spatial association are widely used in exploratory spatial data analysis and are particularly relevant for urban planning applications because they allow for detection of sub-regions, or clusters, within a spatial dataset and can provide the location and extent of aggregations of extreme values or give an indication of the clusters, within a spatial dataset and can provide the location and extent of aggregations of extreme values or give an indication of the phenomenon in an area or location of interest, and are commonly used in criminology and epidemiology research (Aldstadt, 2010; Wu & Grubesic, 2010; Ye & Wu, 2011). The benefit of local clustering tests over global statistics is that they may be able to identify significant, but smaller, pockets of clustering.

The Getis—Ord general (local) \( G_i \) statistic is frequently used for this purpose and derives from the Getis and Ord’s Global (\( G \)) Statistic (Getis & Ord, 1992; Ord & Getis, 1995), which is computed as:

\[
G(d) = \frac{\sum_{i=1}^{m} \sum_{j=1}^{m} W_{ij} (d)(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{m} \sum_{j=1}^{m} W_{ij} (d)(x_i - \bar{x})^2}
\]

(1)

The \( G \) statistic measures spatial association using all pairs of \((x_i, y_i)\) where the distance between \(i\) and \(j\) is \(d\). The local form of the statistic, \( G_i \) (Getis & Ord, 1992; Ord & Getis, 1995) allows for analysis of local pockets of increased or decreased incidences, and is computed as:

\[
G_i = \frac{\sum_{j=1}^{m} W_{ij} (d)x_j - W_i'^{\bar{\chi}}}{s \left[ mS_i'^{\bar{\chi}} - W_i'^{\bar{\chi}} \right]^{1/2}} \text{ all } j
\]

(2)

Where \( W_{ij}(d) \) is a symmetric one/zero spatial weight matrix with ones for all links defined as being within distance \(d\) of a given \(i\). All other links are zero. In the standardized version of the statistic used here (\( G_i \)), the target region \(i\) is included in the computation of the statistic. Therefore, \( W_{ii} \neq 0 \). The variables \( \bar{\chi} \) and \( s \) are the sample mean and standard deviation of the observed set of \(x_i\), respectively.

\( G_i \) will produce high values along with a high positive z-score when there is a dominant pattern of high values near other high values and will produce low values when there is clustering of low values (Rogerson & Yamada, 2009, 322 pp.). The benefit of the \( G_i \) statistic over other commonly used measures of global spatial association, such as Moran’s I (Moran, 1948), is that it can find both ‘hot’ and ‘cold’ spots. It also eliminates the biases that can arise when specific areas are selected for testing based on preconceptions about their existence (Ord & Getis, 1995).

Neighborhood search distance

Prior to implementing \( G_i \), we first determined the appropriate neighborhood scale at which there were significant relationships in the number of housing demolitions. Many applications adopt a default definition of ‘geographic neighborhood’ from the software without considering the scale of the process generating the data. These types of arbitrary definitions of ‘neighborhood’ can lead to inaccurate results and can possibly identify significant relationships when no meaningful associations exist (Rogerson & Kedron, 2012). Several methods have been proposed for determining the optimal neighborhood distance and an associated weights matrix using empirical approaches to scan multiple scales (Rogerson, 2010; Rogerson & Kedron, 2012) or use local varigrams to identify scales of spatial association (see Lloyd, 2011; Sampson, Damien, & Guttorp, 2001).

We determined the appropriate neighborhood scale for analysis by calculating the global \( G \) statistic in ArcGIS 10.1 (Esri, 2012) for the entire set of demolitions at distance thresholds every 500 ft from 1000 to 7000. The centroid of each block group served as that block’s geographic location, and each block group was assigned a value for the total number of demolitions that had been performed during the 5-year period. At 500 ft there were no neighbors for any block groups, which warranted the use of 1000 as the minimum threshold distance. At each distance the z-score was computed and plotted against neighborhood distance (Fig. 2). The positive significance of raised incidences of demolitions levels off at 3500 ft, and this distance was therefore selected as the most appropriate scale at which to perform the analysis.

\( G_i \) calculations were implemented in ArcGIS 10.1 (Esri, 2012) using a fixed distance (Euclidean) band for locating spatial relationships. Each feature within the 3500 ft neighborhood boundary received a weight of 1 and exerted influence on the computations for the target feature. Features falling outside of the 3500 ft threshold received a weight of zero and exerted no influence on a target features’ computation. After testing the clustering for each year of demolitions separately, it was determined that the results changed minimally from year to year. Therefore, a single \( G_i \) analysis was run for the complete set of demolitions. For the crime data, separate \( G_i \) analyses were run for each type of crime for each year in order to observe the change in hot spot locations over time.

It is important to note that block groups located on the edge of the city may not have as many regional neighbors as interior block groups. The block groups on the western side of the city border Lake Erie, which is an unavoidable physical boundary. However, the block groups along the northern, eastern, and southern edges of the

![Fig. 2. Plot of distance threshold (ft) vs. z-score for the global G statistic (Getis & Ord, 1992; Ord & Getis, 1995) for all demolitions performed during the 5-year period.](image-url)
city share a boundary with Erie County, which envelopes the city of Buffalo, and the restriction of cluster growth due to these limits can affect the analysis and detection of true clusters. The implications of these edge effects are addressed in Section 5.

Distance and direction of change

The second part of the analysis examines whether there were changes in the location and intensity of criminal activities, specifically in areas targeted for demolitions, during the 5-year period. We hypothesize that the spatial clustering of certain human–environment interactions (i.e., crimes including prostitution and drug activity that are attracted to vacant structures) will migrate away from the areas where significant demolition of vacant and abandoned structures is occurring.

The mean center statistic was used to quantify the distance and direction of the change for crime clusters across the 5-year period. First, the mean center was computed for the demolition clusters by selecting all block groups with a positive significant z-score ($p < 0.05$). The mean center of those block groups was computed using the z-score as the weight. Next, mean centers were computed for the crime clusters using the same method. The distance and direction of change in the mean crime centers were then compared to the mean center of demolition activity.

Results

Demolitions and crime statistics

A total of 2814 demolitions were performed during the period from September 1, 2007 to August 31, 2012 (Table 1). In the 12-months prior to the start of the initiative, only 380 residential structures were demolished, so while the overall goal of the ‘5 in 5’ plan to demolish 5000 structures was not achieved, there was an increase in the number of demolitions each year. However, demolition activity begins to decline in Year 3, and by the final year of the initiative (Year 5), only 384 structures were demolished, which is only slightly above the pre-plan number.

The overall number of crimes also decreased during the 5-year period, with some minor fluctuations between years (Table 1). Most notably the number of prostitution arrests declined by approximately 70% between Year 1 and Year 5. Overall, drug arrests declined by 14% while assaults declined only slightly (0.01%).

Despite the differences in the degree of decline, the overall trends indicate that during the 5-year period there is a reduction of these types of crimes across the city of Buffalo. This information is important in terms of interpreting the cluster analysis in the following section because no large increases in the number of any type of crime were observed, which may have impacted the cluster analysis results.

Cluster analysis

The $G_i$ analysis for demolitions identified a single, large hot spot of significantly raised incidences on the eastern side of the city (Fig. 3). The single region of high demolition activity is completely surrounded by an area with no raised or lowered areas of incidence (neutral color). This neutral region is then bordered by a broken ring of significantly lower incidences of demolitions (blue and gray tones) located toward the northern, western, and southeastern areas of the city.

The $G_i$ analyses for crime were completed for each year in order to observe the shift in patterns over time. The zone of significant demolition clustering has been superimposed on the crime mapping results for reference. This zone includes all block groups with positive significant ($p < 0.05$) z-scores and is hereafter referred to as the ‘demolition zone’. The results for assault identify several pockets of raised and lowered incidences, with distinct pattern changes across the 5-year period (Fig. 4). In Year 1, there are two main clusters of raised incidence in the vicinity of the demolition zone, a third large cluster bordering the west side, and a small cluster in the northwest corner of the city. By Year 3, the two clusters in the demolition zone have decreased in size and separated, and the western cluster has become less intense, indicated by lower z-scores. By Year 5, the larger of the two clusters in the demolition zone is clearly migrating north, while the smaller cluster in the center of the zone continues to de-intensify.

The results for drug arrests (Fig. 5) show two major hot spots of raised incidence, one on the east side and one on the west side. Additionally, there is a large cluster of low significance in the north-central part of the city, and some smaller clustering of low significance between the two high clusters. Across the five years, the cluster on the west side of the city remains fairly stable. However, the cluster on the east side, corresponding to the demolition zone, shows obvious movement to the north and east along with a de-

<table>
<thead>
<tr>
<th>Table 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of demolitions and crimes for each year of the ‘5 in 5’ plan.</td>
</tr>
<tr>
<td>Year</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Year 1</td>
</tr>
<tr>
<td>Year 2</td>
</tr>
<tr>
<td>Year 3</td>
</tr>
<tr>
<td>Year 4</td>
</tr>
<tr>
<td>Year 5</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Fig. 3. $G_i$ cluster analysis results for all demolitions completed during the ‘5 in 5’ plan period.
intensification, particularly in the southern-most block groups of the cluster. These results are similar to the results for assault indicating that a cluster of raised incidence is present on the east side of the city, near the demolition zone, and that cluster shifted north and east during the study period.

The results for prostitution (Fig. 6) show two major clusters and one minor cluster of raised incidences each year. The temporal trend shows a shift in the location of the east side cluster near the demolition zone and de-intensification, particularly in Year 3. However, unlike with assault and drug arrests, the prostitution hot spot appears to be shifting south in relation to the demolition zone. There are no significantly low areas of prostitution in any of the three years depicted.

**Magnitude and direction of change**

Since the demolition clustering analysis indicated only a single cluster of raised incidences (see Fig. 3), crime clusters corresponding to the demolition zone were evaluated for distance and direction of change. Results of the mean center analysis show that hot spots of all three crimes dispersed from the demolition zone (Table 2). The mean center of the drug arrest hot spot (Fig. 7) was nearly coincident with the demolition zone mean center in Year 1 and moved nearly 3600 ft over the study period. The assault mean center began the study the farthest from the demolition zone mean center and moved an additional 2300 ft to the northeast over the five years. The prostitution mean center shifted approximately 1100 ft to the south from its Year 1 starting point.

**Discussion and implications**

**Urban geography**

The implications of decline and city shrinkage for urban geography need further attention. The same logic that causes us to associate sprawl with expansion of development-related problems is also likely the reason that shrinkage is associated with a condensation of issues toward the city center. However, this is not the case. It is necessary to begin to realize that the problems associated with decline (e.g., crime, lack of economic development, decline in real estate values, etc.) do not necessarily shrink along with the physical infrastructure when decline policies, such as...
demolition, are performed. Political boundaries do not contain the effects of decline, and the effects of decline are difficult to contain without knowing all of the parameters. Along with effects often associated with city shrinkage (e.g., reduced economic opportunities), there can also be shifts in other activities (e.g., crime, etc.). Urban geography theories concerning the city-suburb dichotomy and land use models require particular attention when decline is involved, and they are discussed below.

First, the city-suburb dichotomy, which is often characterized by bona fide political boundaries and a fragmentation of governance, can hide certain spatial patterns of human–environment interactions that are impacting economic and social development. For example, in our crime analysis results, during the period of significant demolition activity, there was also a shift in the hot spots of assaults and drug arrest clusters, which both migrated toward the northeastern boundaries of the city. While the impacts of the ‘5 in 5’ plan appear to be reducing certain crimes within the city limits, it is highly probable that these crimes are moving over the boundary and into the eastern first ring suburb of Erie County (Cheektowaga, NY). However, because the city of Buffalo and the municipality of Cheektowaga operate under separate governing bodies, they have differing data management policies, and we were unable to obtain demolition data for Cheektowaga in order to assess whether these spatial patterns of human–environment behavior do in fact extend across the boundary. Ultimately, this fragmentation of governance prevents a comprehensive analysis of social and economic development, which could potentially lead to a better quality of life in both municipalities.

An important premise of the ‘5 in 5’ plan was that vacant and abandoned properties attract crime. While fragmentation of data collection prevented us from analyzing demolitions outside the city, we were able to obtain housing vacancy rates for Buffalo and the first ring suburbs through the U.S. Census. There are slight differences in block groups between 2000 and 2010 (discussed in Section 2.1), but the overall pattern shows an increase in vacancies in the southern part of the city and the northeastern suburbs over time (Fig. 8). While these maps alone cannot explain why crime shifted, they may help inform the planning process by aiding policy makers in the city and first ring suburbs to target high vacancy areas for future demolitions. It is also unclear why prostitution shifted south while assault and drug arrests shifted to the northeast since both areas showed increases in vacancy rates. The processes influencing these specific, localized effects should be examined in a future study.

The city-suburb dichotomy also has implications for land use management. Land use models need to account for the removal or demolition of residential structures. The ability to pack up and move out defines the American city (Kaplan, Wheeler, & Holloway, 2009), and with this spatial freedom comes the likelihood that structures will be vacated or abandoned. It is imperative for land use models to consider the physical, social, and economic consequences of the demolition of such structures, such as how they will affect housing prices or alter the need for transportation and other services. It is also necessary to consider how the removal of certain structures will change the urban form, and in turn affect certain human–environment interactions. For example, in the analysis presented here, the removal of buildings in the east side of Buffalo coincided with a significant decrease in prostitution activities city-wide and a shift of high clusters to the south. While these results may initially imply that prostitution has been significantly reduced, the results are more likely the combined effect of demolitions along with a shift in practice which has led prostitutes to abandon ‘street walking’ in favor of using the internet to find clients. As fewer prostitute stroll the streets looking for business and more use

### Table 2
Distance and direction of change for the mean center.

<table>
<thead>
<tr>
<th></th>
<th>Distance to demolition zone mean center (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assault</strong></td>
<td></td>
</tr>
<tr>
<td>Year 1</td>
<td>5580</td>
</tr>
<tr>
<td>Year 3</td>
<td>6509</td>
</tr>
<tr>
<td>Year 5</td>
<td>7882</td>
</tr>
<tr>
<td>Total shift</td>
<td>2302</td>
</tr>
<tr>
<td><strong>Drug arrests</strong></td>
<td></td>
</tr>
<tr>
<td>Year 1</td>
<td>1171</td>
</tr>
<tr>
<td>Year 3</td>
<td>2399</td>
</tr>
<tr>
<td>Year 5</td>
<td>4818</td>
</tr>
<tr>
<td>Total shift</td>
<td>3647</td>
</tr>
<tr>
<td><strong>Prostitution</strong></td>
<td></td>
</tr>
<tr>
<td>Year 1</td>
<td>2138</td>
</tr>
<tr>
<td>Year 3</td>
<td>2351</td>
</tr>
<tr>
<td>Year 5</td>
<td>3247</td>
</tr>
<tr>
<td>Total shift</td>
<td>1109</td>
</tr>
</tbody>
</table>

Fig. 6. $G^*_i$ z-score results for prostitution. The demolition zone is shown for reference.
online resources, it is much harder for police to catch offenders (Watson, 2007), thereby increasing the need for police resources to monitor these crimes. This increase in service needs is an example of an unintended consequence that might occur as buildings are demolished, and highlights the need for considering the consequences of shrinkage in land use models.

**Methodologies for analyses in shrinking urban areas**

A spatio-temporal approach is critical for implementing methodologies to examine shrinkage in urban areas. By examining the location of the spatial clusters of certain crimes over a temporal scale (1 year) that was finer than the temporal scale of the demolition policy initiative (5 years), we were able to determine that the spatial location of crime hot spots were trending in certain directions. This would not have been possible using a static analysis. The focus in urban geography is indeed shifting to spatio-temporal approaches for both theory and empirical tests (Portugali, 2000), largely to address the primal question of the human–environment tradition in urban geography of how cities form over time. New contributions to urban theory have determined that the processes of diffusion and coalescence, such as those that occur within a shrinking city, can clearly be identified in the spatial–temporal development of the urban area (Dietzel, Herold, Hemphill, & Clark, 2005). However, these spatio-temporal approaches have typically been applied to urbanizing areas, and it is necessary to begin to transfer these methods to the shrinking cities phenomenon.

There are several limitations of statistical tests for the detection of clusters that require attention. First, scale is a major consideration that must be addressed in any type of spatial statistic study. Particularly in cluster analyses, the spatial and temporal scales at which the analysis is completed will influence the detection of hot spots (Eck, Chainey, Cameron, Leitner, & Wilson, 2005). By first performing exploratory spatial data analysis to determine the most appropriate neighborhood threshold distance, we were able to eliminate many of the biases that can affect a study. However, the use of block groups as the areal unit for the study also has implications. As discussed, we tested both 2000 and 2010 block groups and found no significant difference in the location of the demo cluster. However, the different sized spatial units can impact neighborhood distance thresholds, and therefore careful

Fig. 7. Location of mean geographic centers of the crime hot spots.

Fig. 8. Vacancy rates in the city of Buffalo and the inner suburbs in 2000 and 2010. Data are from the U.S. Census. Buffalo city limits depicted by thick, black line.
consideration of the mapping unit must be given prior to implementing a study.

A second limitation of this type of analysis in an urban area is the impact of city boundaries on cluster detection. Most geographic studies take place within a finite region, but restricting analysis to a specific window can cause two types of edge effects to occur (Baddeley, 1999). The first is sampling bias, which occurs when the probability of observing an object depends on its shape or size. These biases can usually be remedied by weighting observations (Roberson & Yamada, 2009, 322 pp.). The second type is censoring effects, which occur when the full extent of an object that lies partially within the window cannot be observed in full. Remedies for censoring effects typically involve delineation of internal or external ‘guard’ or ‘buffer’ areas, which are used for boundary estimation but are not presented in results or used in subsequent analysis (Van Meter et al., 2010; Vidal Rodeiro & Lawson, 2005).

External guard areas are particularly useful for areal cluster analyses because they allow full estimation of internal measures. Unfortunately, information external to the city is not always available. In our study, data limitations prevented us from delineating an external buffer zone because we were unable to obtain demolition data from Cheektowaga. Since the cluster of high demolition data spans this municipality (see Fig. 3), without additional information it is difficult to know whether the cluster stops at the city limits, or whether it spreads across the boundary. If the cluster does in fact expand into the inner suburb, then the location of the mean center of the cluster would also change accordingly, as would the locations of the mean centers for the associated crime clusters. These issues concerning the limitations of the spatial power of the statistical technique as well as the limitations of the data must be explicitly stated for this type of analysis.

Policy implications for shrinking cities

City government has historically usurped county, state, or federal regulations, and city governments gradually took control of service functions such as safety, education and infrastructure through the 20th century, including the tax base to fund these activities (Kaplan et al., 2009). This dominance of the city above even its parent county leads to policy fragmentation implications for city management. This is especially evident in Buffalo, where Erie County will not foreclose on properties located within the Buffalo city limits, even though it is within their jurisdictional right. Additionally, in many cases city services such as police and fire departments are duplicated in each municipality with little policy collaboration across political boundaries.

The effect of these fragmented policies has several implications for regions experiencing decline. First, as areas in shrinking cities are targeted for demolition, it is possible that activities such as crime will migrate away from the city center toward the first ring suburbs. This shift will pose challenges for police and firefighters who may experience increased incidences. A second impact is that policies to manage vacant and abandoned structures may actually create additional problems within the region. In our analysis of Buffalo, crime did not dissipate (as evidenced by relatively stable numbers of drug arrests and assaults across time) it simply shifted toward other areas. It is speculated that this shift in crime, especially toward the inner suburbs, could likely impact housing prices and economic development in those areas as well. The key finding is that the land use management policy implemented to manage population shrinkage will likely have long-term, unknown consequences in the inner suburbs.

One possible solution to minimize these ‘unknown’ consequences of land management policies in shrinking cities is for regional governance. This analysis has shown that shrinkage is a problem that affects the entire region, not just the city. Regional planning is already widely accepted for transportation planning, sewer and water systems, and park and recreation facilities due to the geographic scope and shared nature of these networks. Land use management in contrast is typically conducted at the local level. In many areas, regional planning is a significant political challenge as local governments are unwilling to give up their power, even to address significant regional challenges (Levy, 2011). However, with the undisputed effects of land use on quality of life and the need for more effective partnering across sectors in order to reduce the impacts on several quality of life indicators including human health (Moore et al., 2003) and crime (Grubesic, 2010), cross-jurisdictional coordination for land management is a necessity.

In conclusion, shrinkage is a problem of the region, not just the city. The city proper is the geographical focus of the typical problems of shrinkage today, however, as land uses are managed, associated problems such as crime, decreased economic development, and declining home prices will gradually shift to the inner suburbs, and eventually to the entire metropolitan area. Therefore, land use management in shrinking cities is yet another urban planning factor that requires an integrated, regional approach. This study found that a particular land use policy solution that was intended to manage population shrinkage may have resulted in simply shifting the problem to other areas.

Acknowledgements

We would like to thank the Buffalo Police Department, particularly the Erie Crime Analysis Center and the Division of Criminal Justice Services for providing data as well as the comments from three anonymous reviewers, which helped to improve this manuscript greatly.

References


DAPUR: Department of Administration, Finance, Policy and Urban Affairs, City of Buffalo, Janet Penksa, Commissioner. (2007). Mayor Brown’s “5 in 5” demolition plan. In