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Research paper

Viewing urban decay from the sky: A multi-scale analysis of residential vacancy in a shrinking U.S. city

Chengbin Deng*, Junjie Ma

Department of Geography, State University of New York at Binghamton, PO Box 6000, Binghamton, NY 13902, United States

HIGHLIGHTS

- Perform comprehensive analyses of residential vacancy using VHR geospatial products.
- Mean lot NDVI is an effective measure of residential landscape management behaviors.
- Proximity variables indirectly characterize a number of socioeconomic variables.
- Neighborhood vacancy prevalence was proposed to capture neighborhood blight effect.
- Residential vacancy can be modeled adequately at both aggregate and fine levels.

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ABSTRACT

Demographic shifts result in not only urban sprawl but also urban decay. Although urban vacant land is a sign of economic decline, it is beneficial to the improvement of urban ecology since it provides a variety of critical ecosystem services. It is unclear how socioeconomic/ecological drivers collectively affect the emergence and dynamics of vacant land within the urban context of population decrease and economic decline in different shrinking cities. To address this issue, this research performed comprehensive analyses to examine and quantify the impacts of social processes, economic conditions, urban ecological and spatial proximity factors on residential vacant land at both the block group level and the parcel level through incorporating high spatial resolution multispectral aerial photographs and GIS datasets. Results indicate three major conclusions. First, the mean lot NDVI is found to be a consistently effective measurement of residential landscape management behaviors at both levels, which is significantly and positively related to residential vacancy. Second, proximity factors indirectly and partially characterize a number of socioeconomic variables. Third, a ratio index called neighborhood vacancy prevalence was proposed to capture the neighborhood blight effect, and a potentially optimal neighborhood size was obtained among different neighborhood radii. By considering different categories of variables, residential vacancy can be explained and modeled adequately at both the aggregate and fine levels. Urban planners, geographers and social scientists could benefit from the explanatory and predictive model at the fine scale to yield the most updated parcel data with acceptable estimation accuracy for various practical applications.

1. Introduction

Approximately 54% of the world's population is living in urban areas in present days (United Nations, 2014). This trend is projected to continue in the upcoming decades. Most existing urban studies usually place an emphasis on a variety of relevant social and environmental issues caused by urban sprawl, such as transportation congestion, air pollution, water quality degradation, food insecurity, and poor health care, etc. (Byomkesh, Nakagoshi, & Dewan, 2012; Dewan, Kabir, Nahar, & Rahman, 2012a; Dewan, Yamaguchi, & Rahman, 2012b; Dewan & Corner, 2014; Dewan & Yamaguchi, 2009). Unlike urban sprawl, demographic shift is also associated with other stages of urban transitions, such as urban decay. In addition to population loss caused by aging population and population migration, other factors such as economic decline, environmental degradation, as well as social and political shifts collectively contribute to urban shrinkage (Haase, Haase, & Rink, 2014). With such common characteristics, these cities are also termed shrinking cities or legacy cities (Nassauer & Raskin, 2014). Most of such cities can be found in post-socialist Eastern Europe

* Corresponding author. Tel.: +1 607 777 6791.
E-mail address: cdeng@binghamton.edu (C. Deng).

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and in the Great Lakes watershed in the U.S. The latter ones are also known as "Rust Belt" cities (Haase et al., 2014; Lorance Rall & Haase, 2011; Schilling & Logan, 2008).

Apparent phenomena in shrinking cities are a large amount of vacant lands and abandoned properties across the entire urban area. While most of the attention from local government has been put on the tax revenue loss of the abandonment and vacancy as well as its financial solutions, a number of potential social and ecological benefits of vacant land have long been neglected (Burkholder, 2012; Nassauer & Raskin, 2014). The retention of urban lawn grass, shrubs, trees and woods on vacant land provides a variety of critical ecosystem services. This is due to the fact that a lack of management and maintenance after the exodus of people generally results in dense and overrun vegetation on the formerly occupied land. For example, vacant land affects urban landscape hydrology: stormwater infiltrates and redistributes on vacant land with pervious vegetated covers, which can effectively reduce stormwater volume in sewer systems. Consequently, not only can it lower the possibility of combined sewer overflow as well as flooding, but also it can prevent soil erosion and improve water quality (Shuster, Dadio, Drohan, Losco, & Shaffer, 2014; Turner & Daily, 2008). Further, vegetation as well as the retention of grass clippings and leaves on vacant land are found to enhance carbon storage potential. As a result, they can stabilize urban climate, mitigate urban heat island, and reduce air pollution (Davies, Edmondson, Heinemeyer, Leake, & Gaston, 2011; Deng & Wu, 2013a; Fissore et al., 2012; Nassauer et al., 2014; Pickett et al., 2011; Turner & Daily, 2008; Visscher, Nassauer, Brown, Currie, & Parker, 2014; Zipperer, 2002). Another impact of vacant land is the increase of social capital, such as social contact with neighbors in public space (Burkholder, 2012; Nassauer & Raskin, 2014; Schilling & Logan, 2008).

Although the importance and significance of vacant land has been highlighted and discussed in some recent studies, the influence of social and ecological processes on the residential vacancy has rarely been examined. A few studies focus on the relationship between socioeconomic status and residential landscape of vacant land. For example, Emmanuel (1997) studied vegetation change at the Census tract level in Detroit, MI, a classic case of shrinking city studies using Landsat Multispectral Scanner (MSS) imagery. By comparing the greenness component of Tasseled Cap transformation over two years, he found that urban vegetation can serve as an ecological indicator to characterize physical environmental qualities as well as an effective proxy for unusual social change. Also with Landsat Thematic Mapper (TM) images, it is found that the decrease in urban vegetation in the inner city of Detroit was correlated to social and demographic shifts at the Census tract level, such as percent population change and fertility, etc. (Ryznar & Wagner, 2001). The influence of lifestyle factors from socioeconomic variables were also tested at the same level in other studies, and similar findings were reported with the same study site (Hoalst-Pullen, Patterson, & Gatrell, 2011; Pearsall & Christman, 2012). Despite the significance of these works, there are still some questions to be further studied. First, it is not clear how socioeconomic/ecological drivers collectively affect the emergence and dynamics of vacant land. As such, more relevant variables should be examined. Second, it is still unclear whether the relationship between these factors and vacancy status remains the same at finer scales than the Census tract level, e.g., the Census block group level and even the parcel level. Third, it is worth exploring such a relationship in other different shrinking cities.

In addition to the necessity of a more comprehensive understanding, other major issues in existing vacant land research are related to data: data acquisition, data update and data quality. Geographers, environmental/social scientists and urban planners may have complications with existing parcel data for environmental analysis and planning applications in shrinking cities due to the lack of timely data updates and poor data quality in these areas. To further understand current parcel data availability in these less prosperous areas, we performed an online search of the County's Geographic Information System (GIS) data website of the top 20 fastest shrinking cities in the U.S. in 2013. The online search result of digital parcel data availability is illustrated in Table 1.

As shown in Table 1, as of November 2014, public access to digital parcel data varies considerably from one to another among these shrinking cities. Only 2 out of 21 cities provide free access of digital parcel data to the public, and 6 of them charge for such GIS data, while the rest 13 cities do not specify either the acquisition or the price of parcel data on their websites. Further, only 6 cities update their GIS dataset at least once per year, and only 2 of them have monthly updates; some of the other shrinking cities might even lack a digital format of parcel data (i.e., only paper maps). This online search result specifies that it is of great necessity to develop cost-effective methods to update existing data and improve data quality at the parcel level for various research and planning practices in shrinking cities.

This paper therefore attempts to answer a general question: what is the relationship between both socio-economic and environmental factors, and residential vacancy status? To address this issue, we performed a comprehensive analysis at both the aggregate scale (i.e., the Census block group level) and the fine scale (i.e., the parcel level). Following the definitions from New York State Department of Taxation and Finance and U.S. Census Bureau, we defined residential vacancy as an uninhabited/unoccupied residential parcel with or without abandoned structures (New York State Department of Taxation and Finance, 2014; U.S. Census Bureau, 2014). Specifically, two objectives of this research include: (1) to explore, quantify and explain the association among residential vacancy, various socioeconomic, spatial and ecological factors, and (2) to analyze, predict and update residential occupancy status in a shrinking city with the timely and accurate information so as to assist policy makers in making new urban redevelopment policies to aid economic recovery.

2. Study area and data

2.1. Study area

The study site of this research is the Greater Binghamton Area in the southern tier of New York State, U.S., which is also known as the triple-cities area (see Fig. 1). As the major statistical metropolitan area of Broome County, this region encompasses the city of Binghamton and its two adjacent villages, i.e., Johnson City and Endicott. Historic Census files show that the entire triple-cities area has been declining during the past five decades. According to the most recent 2013 American Community Survey (ACS) data from U.S. Census Bureau, the population in this study area decreased .70% between 2012 and 2013. As of August 2014, the data from U.S. Department of Labor, Bureau of Labor shows that the unemployment rate of Binghamton is 7.4%, and is higher than the level of Broome County and the whole New York State (6.4% for both areas). For digital parcel data, even the most recent data of this study area is not updated until April of each year, and its acquisition time is merely for the previous year rather than the current year.

2.2. Data

In this research, a variety of geospatial datasets were used to extract numerous variables for statistical analyses. For geographic boundary data, digital parcel data were provided by Broome County GIS and Mapping Services. Careful examination on this data finds that only the parcel occupancy status is complete and available