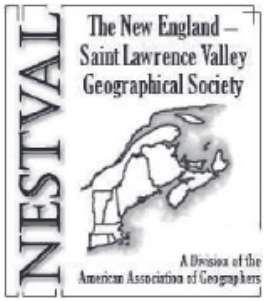

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Edited by

Steven E. Silvern,
Department of Geography, Salem State University
Email: negeog@salemstate.edu

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BURGLARY RATES AND NEIGHBORHOOD Contextual Characteristics: A Case Study in Hartford, Connecticut

Yunliang Meng
Central Connecticut State University

ABSTRACT

There is a long-standing interest in the spatial relationship between neighborhood contextual characteristics and crime in the U.S., since such relationship allows police and neighborhood stakeholders to better understand the spatial distribution of crime and design prevention programs to reduce crime risk. The objectives of this research are to 1) examine the relationship between burglary rates and contextual characteristics at the neighborhood-level in the city of Hartford, Connecticut and 2) account for spatial spillover effects of burglary crime penetrating neighborhood boundaries. The analysis results of this research show that predictors such as poverty, tenure of housing, residential mobility, and racial/ethnic diversity are significantly associated with burglary rates across the city. Additionally, the use of the Geographically Weighted Regression model for the spatially weighted burglary rates helps better reveal the spatial relationships between burglary crime and contextual factors, since it explained 68.1 percent of the variances of burglary crime, compared with 60.2 percent using the raw burglary rates. The results are discussed, and implications are given in the context of Hartford.

Key words: Burglary, Contextual Characteristics, Hartford, Geographically Weighted Regression

Introduction

A burglary, also called breaking and entering, is committed when someone enters an inhabited dwelling without permission and with the intent to steal or rob property. Although Connecticut has had a dramatic reduction in violent and property crimes over the past decade, burglary is still a common offense in the City of Hartford. According to the Uniform Crime Report (UCR) statistics, Hartford had 738 reported burglaries in 2017, making them the second most common felony offense after larceny (Federal Bureau of Investigation 2017). In 2017, the burglary rate in Hartford was 5.9 per thousand people which was more than twice the Connecticut rate (2.49 per thousand people). In addition, when a household member is present, burglaries can often lead to violent crimes such as assault (15.0 percent), robbery (7.0 percent),

and rape (3.0 percent) (Catalano 2010). To better understand burglaries in Hartford, it is worthwhile to examine the burglary crime explanatory factors in different neighborhoods.

As a multi-disciplinary field of research, criminology research always has a wide range of perspectives and often competing theoretical foundations. Its mainstream research has focused on the issue of crime causation or in other words: what produces crime and the criminal? Traditionally, criminologists have long noticed the importance of place in understanding crime. Criminology research has shown that burglary offenses are not spatially randomly distributed, but instead tend to be geographically patterned (Bernasco and Luykx 2003; Malczewski and Poetz, 2005). The spatial patterns of burglaries can be explained by several theories in the criminology field (Brantingham and Brantingham 1984; Evans 1989, Hartnagel 2004; Evans and Herbert 2013).

Some research suggests that burglaries can be explained by crime opportunity theory and, consistent with this argument, criminological studies employ the routine activities hypothesis (Cohen and Felson 1979; Kennedy and Forde 1990; Koening and Linden 2004). The routine activity argument highlights the tendency of burglars to commit offenses inside or near their neighborhoods (Malczewski and Poetz 2005). It suggests that vulnerable neighborhoods are more likely to be located near areas where offenders reside (Herbert and Hyde 1985; Wright Logie and Decker 1995; Wiles and Costello 2000). By contrast, some theories suggest that crime control is directly or indirectly related to the creation of general community instability (Sampson and Groves 1989; Bursik and Grasmick 1993). The area variability hypothesis suggests that neighborhoods with high levels of mixture or heterogeneity are the most vulnerable to crime (Ceccato, Haining, and Signoretta 2002). On the other hand, the local social control hypothesis suggests that well-integrated and socially cohesive neighborhoods with a strong sense of community identity tend to have less crime (Bursik and Grasmick 1993; Hancock 2001). Given the various crime theories, empirical research is needed to investigate the spatial differences in burglary rates and identify neighborhood contextual characteristics that underlie existing spatial differences.

Numerous empirical studies have examined the spatial aspects of urban crime at the neighborhood level using Geographic Information Systems (GIS) techniques and quantitative methods (Sampson, Morenoff, and Gannon-Rowley 2002; Cahill and Mulligan 2003; Townsley 2009). However, the previous studies of neighborhood-level crime are often criticized due to the artificial boundary problem that often arises when aggregating individual crime incidents to neighborhood units using the containment approach (Murray et al. 2001; Ratcliffe 2010; Zhang, Suresh, and Qiu 2012). The issue of this approach is that it completely ignores the impact of crimes committed on or near the border but fall within adjacent neighborhoods (McCord and Ratcliffe 2007; Zhang, Suresh, and Qiu 2012). This paper attempts to tackle the issue by designing a spatial weighting method to count incidents within the boundary of each neighborhood, along with those in close proximity in a case study, using data on burglary crime collected by the Hartford Police Department.

Literature Review

Crime Theories and Ecological Measures

Various research has been done in the criminology field on the socio-economic factors contributing to the level and type of crime experienced in a community. This study of the socio-economic characteristics of burglary criminals and victims can be then extended to a critical analysis of the role of location. As a theoretical foundation in the criminology field, criminal opportunity assumes that opportunity is the necessary condition for crime and that the growing amount of goods in stores and homes and the sharp rise in personal wealth has provided increasing opportunities for criminal activities. Closely related to this concept is the routine activities theory of crime, in which demographic or social class factors contribute to particular activity routines. The theory emphasizes that the occurrence of a burglary requires the simultaneous existence of three elements: 1) the presence of a motivated offender (such as an unemployed person), 2) a suitable target (such as a residential dwelling containing goods which could be easily resold) and, 3) the absence of a capable guardian (homeowner, watchful neighbor, friend or relative) (Clarke and Felson 1993, 9; Knox 1995, 256; Hackler 2000, 169). The routine activities approach "stems from rational choice assumptions and emphasizes the circumstances under which crime is most likely" (Wilcox, Land, and Hunt 2003, 22). While a small number of burglary offenders may choose targets or victims far from their homes, most of them tend to commit crimes in areas that they are familiar with (Ainsworth 2001).

Shaw and McKay (1942) proposed social disorganization theory in their study of communities with high levels of crime. Their study in the City of Chicago illustrates that crime rates were not randomly distributed throughout the city and that the so-called Zone of Transition that is close to the city center has the highest crime rate. The neighborhoods in the Zone of Transition tend to have low socio-economic status, high numbers of ethnic/racial minorities, and high residential mobility (Wilcox, Land, and Hunt 2003, 28). As a result, Shaw and McKay (1942) suggested that the high crime rates were not a function of the personal attributes of the groups residing in the neighborhoods, but rather that "the structural factors of poverty, high heterogeneity, and high mobility created 'social disorganization', and it was community-level social disorganization that was presumed to cause crime" (Wilcox, Land, and Hunt 2003, 28). The area variability and local social control hypotheses have their roots in social disorganization theory (Herbert and Hyde 1985). The area variability hypothesis argues that 'mixed' or heterogenous areas are more likely to experience higher crime rates. The local social control hypothesis suggests that neighborhoods in which social cohesion is low and there is little sense of community are more vulnerable to crime (Bursik and Grasmick 1993; Hancock 2001). In contrast, ordered and well-organized neighborhoods with a strong sense of community identity experience less crime (Sampson, Raudenbush, and Earls 1997).

Empirical research suggests that burglary offences can be explained by variables that quantify "offender" and "target" characteristics. The socio-economic conditions of neighborhoods where offenders live can be characterized by: 1) high unemployment rates (Rountree and Land 2000; Hartnagel 2004), 2) high proportions of low-income households

(Kennedy and Forde 1990; Bursik and Grasmick 1993; Kitchen 2007), 3) low levels of education (Ehrlich 1975; Kitchen 2007), 4) lone-parent families (Bottoms and Wiles 1988; Bowers and Hirschfield 1999), 5) transient populations (Bottoms and Wiles, 1988; Bernasco and Luykx 2003), and 6) ethnicity and race variables measuring the degree of ethnic/race heterogeneity (Miethe and Meier 1994; Bowers and Hirschfield 1999; Ceccato, Haining, and Signoretta 2002). In addition, criminology research suggests a variety of neighborhood attributes that can be used to characterize the risk of burglary, such as the value of dwellings (Kennedy and Forde 1990; Bursik and Grasmick 1993; Paternoster and Bushway 2001), tenure and type of housing (Neustrom and Norton 1995; Ceccato, Haining, and Signoretta 2002), household income (Bursik and Grasmick 1993; Rountree and Land 2000), and residential mobility (Ceccato, Haining, and Signoretta 2002; Hartnagel 2004).

Previous Research on Burglary Crime

Rengert (1991) proposed a model which assumed that most property criminals have a choice between several alternative opportunities and considered site characteristics in relation to all possible alternatives within the system. In the study, most of the Philadelphia burglars lived in the central parts of the city and most of the burglaries were committed there. Rountree and Land (2000) presented a study that addresses the potential generalizability of empirical relationships from multilevel (individual- and neighborhood-level) models of burglary victimization across three cities by comparing the effects of individual-level sociodemographic and routine-activity variables, neighborhood-level social disorganization and concentration-of-poverty variables, and micro–macro interactions using data from Rochester, St. Louis, and Tampa-St. Petersburg. The study shows that 1) mean burglary victimization risk changes significantly across neighborhoods in all cities examined, but the individual-level covariates of risk do not vary in their effects across neighborhood or city contexts; and 2) much of the variability in burglary risk across neighborhoods is accounted for by the inclusion of neighborhood-level covariates. Chamberlain and Hipp (2015) examined how variations in inequality across larger areas might impact crime rates in neighborhoods. The research shows that disadvantage in the focal neighborhood and nearby neighborhoods increase neighborhood violent crime, which is consistent with social disorganization theory. Johnson et al. (2007) analyzed space–time patterns of burglary in ten areas, located in five different countries. In this study, while the precise patterns vary, for all areas, houses within 200 meters of a burgled home were at an elevated risk of burglary for a period of at least two weeks. Frith and Johnson (2017) modeled burglary offender spatial decision-making at the street segment level. In the research, as predicted by crime pattern theory, novel metrics concerning offender familiarity and effort are significant predictors of residential burglary location choices.

Crime Aggregation and Artificial Unit Problems

In crime research, census boundaries (e.g., census tracts or census block groups) are widely used as the approximation of neighborhoods, but they don't exactly match the underlying

patterns of urban crime (Brantingham 2009; Zhang, Suresh, and Qiu 2012). Additionally, point-in-polygon aggregation of crime points is often used to calculate the total number of crime incidents inside each urban neighborhood (Ratcliffe 2010). The method is an easy and convenient way to link crime incidents to corresponding areal units, but the distribution of crime does not necessarily correspond to those predefined neighborhood boundaries (Eck 2005; Paulsen and Robinson 2009; Zhang, Suresh, and Qiu 2012). As a result, it is questionable to use the point-in-polygon spatial operation to summarize crime incidents in urban neighborhoods, because the method completely ignores the influence of crime incidents committed on or near neighborhood borders but fall in adjoining neighborhoods (Zhang, Suresh, and Qiu 2012). In other words, the point-in-polygon spatial operation significantly underestimates the real risk of neighborhood crime (McLafferty, Williamson, and McGuire 1999; Zhang and Song 2014). To quantify the real risk of neighborhood crime, recent studies created buffer rings around urban neighborhoods to count the total number of crime incidents (McCord and Ratcliffe 2007; Zhang, Suresh, and Qiu 2012). However, the buffering method overestimated the real risk of neighborhood crime, since crime incidents can be repeatedly counted by adjoining neighborhoods (Zhang, Suresh, and Qiu 2012). In addition, Zhang and Song (2014) proposed a method to calculate the risk of crime for each areal unit by taking crime incidents in adjacent units into consideration. The research results were generated based on a queen-based spatial contiguity weight matrix which only considers spatial units as neighbors when they share a common edge or vertex. As shown in Figure 1, Unit A will not be considered as a neighbor for Unit D if neighbors are defined by a queen-based spatial contiguity algorithm, since they don't share a common edge or vertex.

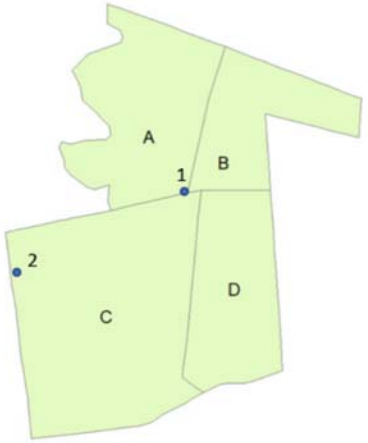

Figure 1: An example of four hypothetical neighborhoods

By using this algorithm, although the Crime Incident #1 is much closer to Unit D than Crime Incident #2, the Crime Incident #1 is not taken into consideration in the calculation of the real risk of crime for Unit D, but Crime Incident #2 is. In other words, the real crime risk for Unit D is underestimated to some extent when a queen-based spatial contiguity weight matrix was used in the calculation, because the crime risk from nearby Unit A is excluded from the analysis. Additionally, Zhang and Song's (2014) study aggregates crime incidents at the centroids of neighboring units and assumes that their physical distances to the target unit are the same in the process of calculating the spatial weights. To address these weaknesses, this study proposes a new and improved method to quantify burglary risk for each areal unit by taking crime occurrences in adjacent units into consideration.

Methodology

Study Area

The City of Hartford, located at the center of Connecticut (Figure 2), is one of America's oldest cities. Founded in 1635, it is currently the capital city of Connecticut and has the nickname "Insurance Capital of the World" as it hosts many headquarters or large offices of insurance companies (i.e. The Hartford and Travelers) and insurance is the region's major industry. The 2020 U.S. Census shows that Hartford is the fourth-largest city in Connecticut with a total population of 121,054, behind the coastal cities of Bridgeport, New Haven, and Stamford (U.S. Census Bureau 2020). Hartford is home to some of the largest corporations in Connecticut that provide over 65,000 jobs. The city provides the widest range of housing options – from a historic Victorian home in the West End to a converted factory loft apartment in the southwest of the city; from a luxury downtown apartment to a starter home beside the University of Hartford; or from townhouses in South Downtown to two- and three-family homes in the South End.

The city of Hartford has a total area of 18.0 square miles, of which 17.3 square miles is land and 0.7 square miles is water. The Connecticut River, located on the east side of the city, forms the boundary between Hartford and East Hartford. The Park River originally divided Hartford into northern and southern sections and was a major element of Bushnell Park, but the river was nearly completely buried by flood control projects in the 1940s. The intersection of Highway I-84 and I-91 is located in downtown Hartford. In addition, two other highways service the city: CR-2, an expressway that runs from downtown Hartford to Westerly, Rhode Island, and the Wilbur Cross Highway segment of CR-15, which skirts the southeastern part of the city near Brainard Airport. The City of Hartford is an important study area for burglary crime for two reasons. First, its crime rate in 2017 was higher than 95.0 percent of all U.S. cities (Federal Bureau of Investigation 2017) and the high crime rate led to the population loss in the past (Sauter, Stebbins, and Comen 2017). Second, burglary crime in Hartford was the second highest felony offense in 2017.

Data Preparations

This study is based on the Hartford Police Department's datasets for each year in the five-year period between January 1st, 2013 and December 31st, 2017 (Hartford Data 2019). The five-year crime data is used in this study, because it not only provides insights on recent burglary offenses in Hartford, but also aligns with the most recent American Community Survey five-year estimates for 2013-2017 (U.S. Census Bureau 2017). The data consisted of 3,523 burglary incidents in the City of Hartford, Connecticut during the five-year period. Each incident was added into ArcGIS 10.6.1 (Environmental System Research Institute 2018) based on the x and y coordinates included in the dataset. The burglary point layer was spatially joined with a shapefile consisting of ninety-six Census Block Groups (CBGs) in Hartford. This enabled the

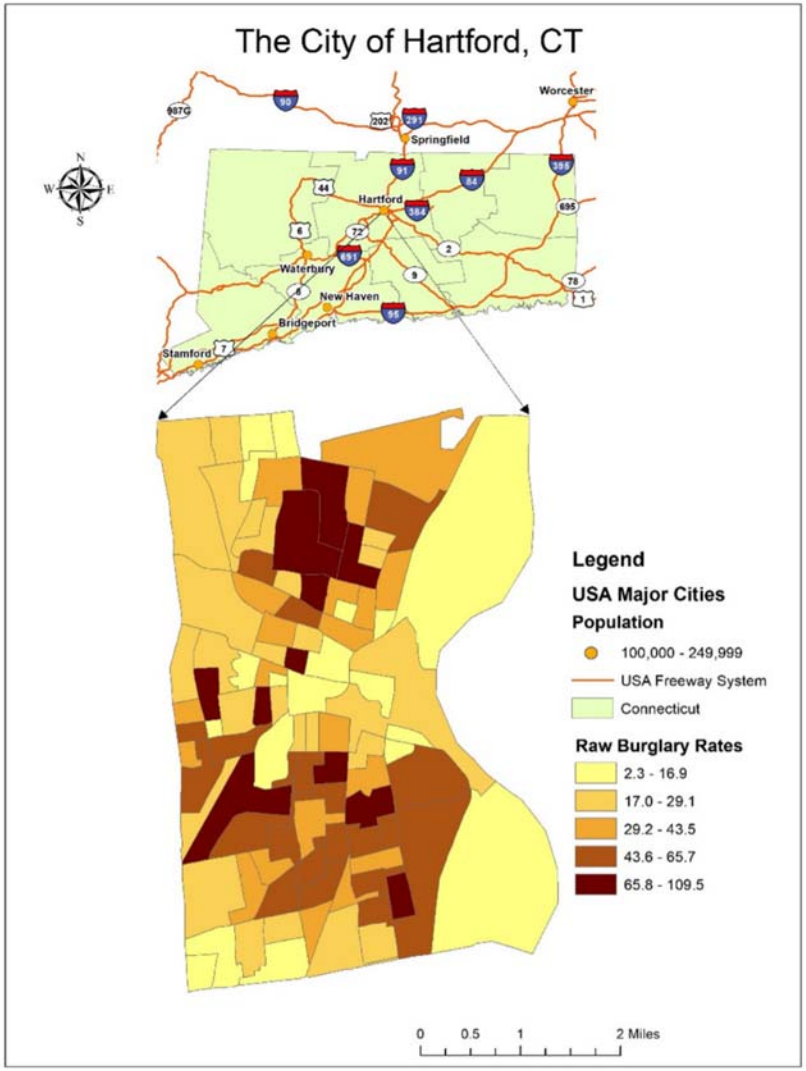

Figure 2: Study Area

computation of the total number of burglaries for each CBG. In this research, CBGs are used as the approximation of neighborhoods, since Hartford does not have well defined neighborhood boundaries, and CBGs are one of the most widely used geographic boundaries which can be used to compile the burglary data and neighborhood demographic and socio-economic characteristics data. A CBG usually contains between 600 and 3,000 people and its boundary never crosses the boundaries of different states or counties (Iceland and Steinmetz 2003). In addition, CBGs are used to represent neighborhoods, since they are designed to be relatively homogeneous with respect to population demographics and socio-economic characteristics.

In this study, the raw counts of burglaries in each CBG were added to those of adjacent CBGs in order to account for the spillover crime risk from adjoining CBGs. This calculation is necessary, because the actual risk of burglary crime in a given CBG is determined not only by its own frequency of crime incidents, but also affected by crimes in neighboring areas (Bernasco and Luykx 2003; Downey 2003; Zhang and Song 2014). Consequently, when small geographic units such as CBGs are used, a more accurate measure of the risk of crime for each areal unit needs to take crime occurrences in adjacent units into consideration (Wang and Arnold 2008; Zhang and Song 2014). A new measure for spatially averaged counts of burglaries was calculated below.

$$B_i^w = \frac{B_{io} + \sum_{jk}^{mn} B_{jk} SW_{ijk}}{1 + \sum_{jk=1}^{mn} SW_{ijk}}$$

where B_{io} is the observed number of burglaries in a CBG i and it is calculated by using ¬the point-in-polygon approach (Ratcliffe 2010). It should be noted that $i \in C1 = \{1,2,...,q\}$ which is the index set of locations of q observations (i.e. all CBGs in Hartford). B_{jk} is the kth observed burglary incident in neighboring area j. m is the number of neighboring CBGs for a CBG i which is determined by distance-band (GeoDa 2020), so $j \in C_2 = \{1,2,...,m\}$. n is the number of observed burglaries in neighboring area j, so $k \in C_3 = \{1,2,...,n\}$. It this study, 0.5 mile is used as the critical distance in the search of neighboring CBGs. The critical distance of 0.5 mile was chosen, because the distance from the typical American's house to the edge of its neighborhood is between 520 and 1,060 meters with an average of 790 meters or about 0.5 mile according to the U.S. Census Bureau's research on the perceived size of a typical U.S. neighborhood (Donaldson 2013). Accordingly, Wijk is a spatial weight based on the spatial relationship between area i and the observed burglary incident k in neighbor unit j. Wijk = 0, if an area j is outside of a critical distance band from the target area i. If an area j is within the critical distance band – 0.5 mile – from i, W_{ijk} is calculated below:

$$w_{ijk} = \frac{\frac{1}{d_{ijk}}}{\sum_{jk=1}^{mn} \frac{1}{d_{ijk}}}$$

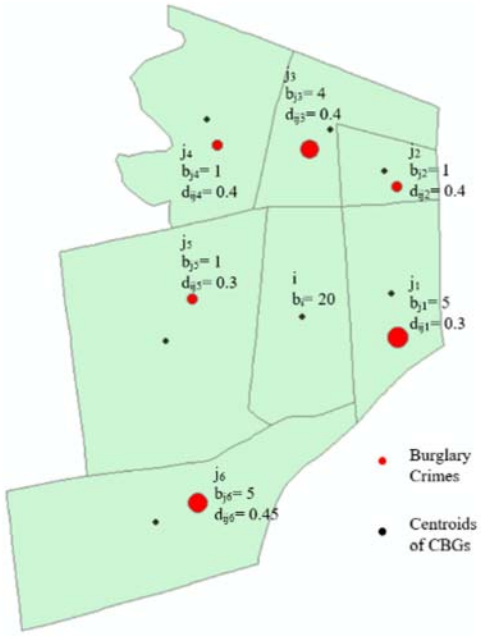

Figure 3. An example of seven hypothetical neighborhoods

Where d_{ijk} is the straight-line distance from the centroid of target area neighborhood i to the kth observed burglary incident in the neighboring area j and it was calculated using point distance function provided by ArcGIS10.6.1 (Environmental System Research Institute 2018). An inverse-distance weighting method was used to give the closest burglary incident the highest weight. Thus, the level of burglary risk in target neighborhood i is positively associated with each burglary incident in an adjacent area, but negatively affected by the physical distance (d_{ijk}) between target neighborhood i and observed burglary incident B_{jk}. To illustrate the new method, a simplified example is given in Figure 3 for demonstration purposes.

It should be noted that in reality, there can be multiple burglaries in multiple locations in a neighboring unit. The target area i has six neighborhood units which was determined by distance-band (GeoDa 2020). Each of which has an observed number of burglaries (B_{jk}) and a different crime-to-centroid distance to the target neighborhood i. The observed number of burglaries within the target neighborhood was twenty. In this example, the spatial weight of adjacent observed burglary crime j_1 was computed as

$$w_{ij1} = \frac{\frac{1}{0.3}}{\frac{1}{0.3}+\frac{1}{0.4}+\frac{1}{0.4}+\frac{1}{0.4}+\frac{1}{0.3}+\frac{1}{0.45}} = 0.203$$

The spatial weights of other five adjacent observed burglary crimes were calculated in the same way, with $W_{ij2} = 0.153$, $W_{ij3} = 0.153$, $W_{ij4} = 0.153$, $W_{ij5} = 0.203$, and $W_{ij6} = 0.136$. The spatially averaged number of burglaries for target area i was then calculated as:

$$B_i^w = \frac{20 + 5 * 0.203 + 1 * 0.153 + 4 * 0.153 + 1 * 0.153 + 1 * 0.203 + 5 * 0.136}{1 + (0.203 + 0.153 + 0.153 + 0.153 + 0.203 + 0.136)} = 22.81$$

Then, the burglary rates were calculated by dividing the total raw counts and spatially averaged counts by residential population in each CBG and multiplying by 1,000. The descriptive statistics for the two dependent variables – raw burglary rates and spatially weighted burglary rates are shown in Table 1 below.

	Min	Max	Median	Interquartile Range	Standard Deviation
Raw burglary rates: raw burglary counts per 1,000 people	2.8	109.5	26.0	16.5	16.2
Spatially weighted Burglary rates: spatially weighted burglary counts per 1,000 people	3.1	114.5	27.2	16.8	15.6

Table 1. Descriptive Statistics for the Dependent Variables – Burglary Rates

This study considers ten socio-economic characteristics as the potential explanatory variables (see Table 2). The ten contextual variables at CBG level were chosen to reflect the key dimensions underlying the variation in the risk of burglary as suggested by the crime theories as well as variables used in previous empirical research (see literature review for detail). The demographic and socio-economic variables such as residential population, education, income, poverty, house price, tenure of housing, type of housing, residential mobility, racial and ethnic population, and household type were taken from the American Community Survey five-year estimates for 2013-2017 (U.S. Census Bureau 2017). The education variable was quantified by the percentage of people aged twenty-five to sixty-four without a college degree or above. The income variable was determined by the median household income. The poverty variable was calculated as the percentage of people living under the poverty line. The home price variable was measured as the median house value. Tenure of housing was quantified by the percentage of renters in the population. Type of housing was calculated by two measures: 1) Percentage of single unit dwellings and 2) Percentage of multiple unit dwellings. Residential mobility was determined by the percentage of people lived elsewhere twelve months ago. The household type variable was calculated by the percentage of single female headed households. The racial/ethnic diversity variable was measured using Shannon equitability index (Shannon and Weaver 1949) based on eight racial/ethnic groups' population in CBGs in Hartford, including Hispanic, Non-Hispanic White alone, Non-Hispanic Black alone, Non-Hispanic Asian alone, Non-Hispanic American Indian and Alaska Native alone, Non-Hispanic Native Hawaiian and Other Pacific Islander alone, Non-Hispanic other race alone, and Non-Hispanic two or more races. Population data for these eight racial/ethnic groups were collected from American Community Survey five-year estimates for 2013-2017 (U.S. Census Bureau 2017). Shannon's index, which originated in ecology research, not only accounts for both abundance and evenness of the species present, but also has implications for the relative racial/ethnic heterogeneity of human populations (White 1986). The Shannon diversity index is calculated using the following equation in Excel:

$$H = -\sum_{l=1}^{S} p_l \ln p_l$$

Where S is total number of racial/ethnic groups in the community, p_l is the proportion of the l_{th} racial/ethnic group to the total population.

Then, the Shannon equitability index (E_H) can be then generated by dividing H by H_{max}, which has a value between 0 (no diversity or a neighborhood is completely dominated by one racial/ethnic group) and 1 (perfectly diverse or all racial/ethnic groups are equally represented in the neighborhood). Then, the demographic and socioeconomic datasets were joined with the CBGs file and stored for further analysis using ArcGIS 10.6.1 (Environmental System Research Institute 2018). There is one data problem with using census block groups for analyzing neighborhood socio-economic characteristics. One census block group in Hartford has no reported demographic and socio-economic data. This potentially is a data suppression issue, since the census bureau does not report all sub-national data if the American Community Survey estimates have a disclosure risk or an unacceptable level of statistical reliability. As a result, this census block group was excluded from further analysis. The descriptive statistics for each explanatory variable and the correlation among them are shown in Table 2 and 3 respectively. An analysis of the Pearson's correlations indicates that all independent variables were statistically significantly (at least at 0.05 level) correlated with the two dependent variables (i.e., raw burglary rates and spatially weighted burglary rates).

Variables	Min	Max	Median	Interquartile Range	Standard Deviation
Education: percent of people aged twenty-five to sixty-four without a college degree or above	8.2	90.2	62.8	19.1	16.3
Income: median household income	11,140	100,526	31,809	23,750	19,507
Poverty: percent of people living under the poverty line	1.7	66.5	29.8	22.8	15.6
House price: median house value	74,684	289,144	122,985	72,581	41,254
Tenure of housing: percent of renters in the residential population	0.0	100.0	78.9	30.6	24.9
Type of housing I: percent of single-unit dwellings	0.0	100.0	12.6	23.7	25.9
Type of housing II: percent of multiple-unit dwellings	0.0	100.0	87.3	23.7	25.9
Residential mobility: percent of people who lived elsewhere twelve months ago	0.0	40.1	13.2	10.3	9.2
Racial/ethnic diversity **Index**: Shannon equitability index	6.0	82.3	39.7	26.7	21.5
Household type percent of single female headed households	4.5	42.4	29.8	18.1	19.3

Table 2. Descriptive Statistics for the Explanatory Variables.

Variables	Education	Income	Poverty	House price	Tenure of housing	Type of housing I	Type of housing II	Residential mobility	Racial/ ethnic diversity	Household type
Raw burglary rates	-0.25*	-0.40**	0.54**	-0.48**	-0.42**	-0.22*	0.35*	0.46*	0.52**	0.28*
Spatially weighted Burglary rates	-0.31**	-0.45**	0.62**	-0.52**	-0.53**	-0.26*	0.47**	0.51**	0.65**	0.37*
Education		0.38**	-0.46**	0.32**	-0.30*	0.41**	0.03	0.125	-0.39**	-0.42**
Income			-0.51**	0.41**	-0.35*	0.36**	-0.15	-0.31*	-0.36**	-0.47**
Poverty				-0.46**	0.30*	-0.33*	0.10	0.34**	0.49**	0.51**
House price					-0.40**	0.37**	0.12	-0.43**	-0.45**	-0.57**
Tenure of housing						-0.34*	0.44**	0.46**	0.51**	0.38**
Type of housing I							-0.31*	-0.38**	-0.45**	-0.51**
Type of housing II								0.40**	0.30*	0.32*
Residential mobility									0.46**	0.54**
Racial/ethnic diversity										0.58**

* $p < 0.05$; ** $p < 0.01$

Table 3. A Pearson's Correlation Matrix of Dependent and Independent Variables

Geographically Weighted Regression Model Building

Many early contextual studies on crime patterns are criticized for their use of global regression modeling techniques, such as Ordinary Least Squares or OLS regression (Malczewski and Poetz 2005), because the regression method violates some basic assumptions when spatial data is used (e.g., independence of observations and spatial stationarity of the relationship between independent and dependent variables). Geographically Weighted Regression or GWR (Brunsdon, Fotheringham, and Charlton 1996; Fotheringham, Brunsdon, and Charlton 2002) relaxes these assumptions and enables the analysis of spatially clustered data. GWR is often considered as an extension of OLS regression, since it allows local parameters instead of global parameters to be estimated, hence making it possible to model spatial variations within the data (Fotheringham, Brunsdon, and Charlton 2002). Unlike OLS regression, which produces a single global model across space, GWR simultaneously conducts multiple regressions for different data units so that there is one regression model per spatial data unit (e.g. a census block group) (Hipp and Chalise 2015). In a GWR model, observations near a particular data unit will have more influence in the estimation than observations further away (Hipp and Chalise

2015). Given the weaknesses of OLS regression and strength of GWR, this research uses GWR for analyzing the spatial non-stationarity relationship between burglary rates and neighborhood contextual characteristics in the City of Hartford.

The first step is to examine the spatial heterogeneity of the dependent variables: raw burglary rates and spatially weighted burglary rates. If the burglary rates are not spatially clustered, there is no need to build a spatially explicit model. The Moran's *I* Index (Anselin 1995) provided by ArcGIS 10.6.1 (Environmental System Research Institute 2018) was used to identify the clustering of burglary rates across CBGs in the City of Hartford. Moran's *I* ranges from −1.0, perfectly dispersed (e.g., a checkerboard pattern), to a +1.0, perfectly clustered. In this research, Moran's *I* scores (0.246 and 0.348) and *p* values (0.0002 and 0.0001) were generated, indicating burglary rates are spatially clustered and the result is statistically significant. A Local Moran's *I* Cluster Analysis of burglary rates was conducted, and the results are shown in Figure 4 below.

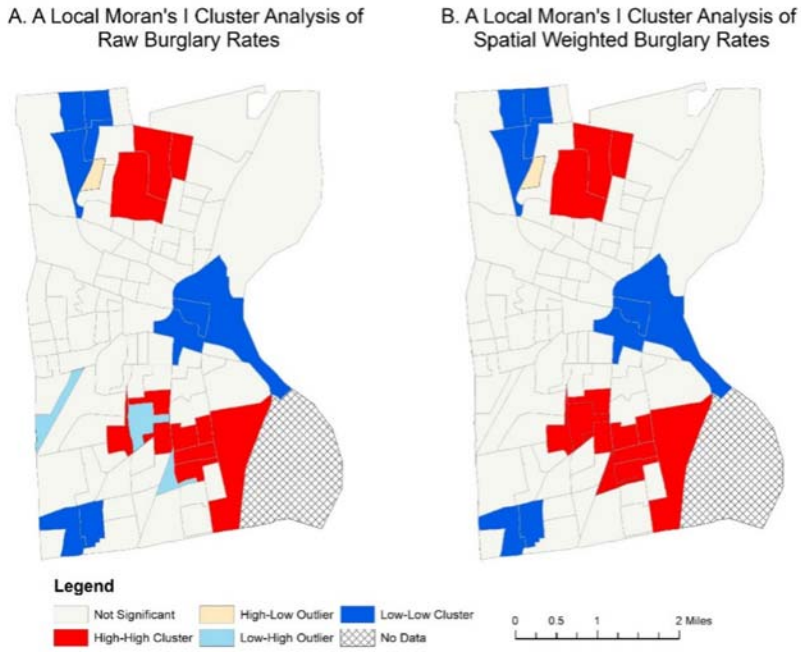

Figure 4. A Local Moran's *I* Cluster Analysis of Burglary Rates

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In Figure 4, the maps demonstrate five different types of spatial clustering: (1) high-high, for neighborhoods with high burglary rates that are in close proximity to neighborhoods with high burglary rates; (2) low-low, for neighborhoods with low burglary rates that are in

close proximity to neighborhoods with low rates; (3) high-low (known as spatial outliers), for neighborhoods with high burglary rates, but are proximate to neighborhoods with low rates; (4) low-high (also known as spatial outliers), for neighborhoods with low burglary rates, yet are in close in proximity to neighborhoods with high rates; (5) not significant, for neighborhoods where there is no significant spatial clustering. As shown in Figure 4, low-low spatial clusters were found in neighborhoods located in the east, northwest, and southwest of Hartford, while high-high spatial clusters are overlapped with CBGs located in the southeast and north of the city.

The OLS multivariate model (Aiken and West 1991) in SPSS 25 was then used to conduct initial data exploration and model specification. Two factors motivated the decision to first specify the OLS model: 1) to identify explanatory variables significantly correlated with the dependent variable (burglary rates) before specifying the GWR model; and 2) the GWR software used for spatial analysis does not provide a variance inflation factor (VIF) to measure multicollinearity. If the standard regression equation in the investigation of burglary rates is given by:

$$Y_i = \beta_0 + \sum_p \beta_p x_{pi} + \varepsilon_i$$

where Y_i is the burglary rate at CBG i, β_0 is a constant term (i.e., the intercept), β_p measures the relationship between the independent variable x_p and Y for the set of i CBGs, and ε_i is the error associated with CBG i. It should be noted that $i \in C_1 = \{1,2,...,q\}$ which is the index set of locations of n observations (i.e. all CBGs in Hartford).

It should also be noted that the above equation "results in one parameter estimate for each variable included" (Cahill and Mulligan 2007). The summary of the OLS analysis results is presented in Table 4 below. In the OLS regression, only variables significantly correlated with the dependent variables were included. The OLS models are significant (F = 16.859 and 19.756, $p < 0.05$). The adjusted R^2 values are 0.389 and 0.446 which means that the models explained 38.9 percent and 44.6 percent of the variance in neighborhood-level burglary rates. The VIF for all variables was less than 3.0, a commonly used cutoff point, suggesting no severe multicollinearity issue was detected among the explanatory variables (Table 4).

As shown in Table 4, there is a positive and significant relationship between burglary rates and the following variables: the percent of people living under the poverty line, percent of the renters in the residential population, percent of people who lived elsewhere twelve months ago, and Shannon equitability index. In other words, the burglary rates tend to be higher in a neighborhood where the percent of people living under the poverty line, the renters in the residential population, and people who lived elsewhere twelve months ago are also higher. In addition, the higher the Shannon equitability index in a neighborhood, the higher the burglary rates in that neighborhood. The rest of the explanatory variables are insignificantly related to burglary rates in this study. The residuals of the OLS model were spatially auto-correlated (Moran's $I = 0.18$ and 0.23; $p < 0.05$). In other words, the OLS model overestimated burglary risks for some neighborhoods, while it underestimated the risks for some others.

Variables	OLS model – raw burglary rates			OLS model – spatially weighted burglary rates		
	β	**SE value**	**VIF**	***β***	**SE value**	**VIF**
Intercept	-1.057	1.886	-----	2.231	1.754	-----
Poverty: percent of people living under the poverty line	0.492*	0.141	2.794	0.622**	0.126	1.992
Tenure of housing II: percent of renters in the residential population	0.401*	0.031	1.589	0.461*	0.012	2.857
Residential mobility: percent of people who lived elsewhere twelve months ago	0.284*	0.121	1.357	0.354*	0.100	1.557
Racial/ethnic diversity Index: Shannon equitability index	0.621**	0.219	2.478	0.761**	0.115	2.048

Table 4. Results from Ordinary Least Square Model of Neighborhood-Level Burglary Rates

Then, the same set of variables was then used to specify a GWR model using the GWR4 software (GWR4 2015). GWR is a modeling technique used to explore spatial non-stationarity (Brunsdon, Fotheringham, and Charlton 1996). The "main characteristic of GWR is that it allows regression coefficients to vary across space, and so the values of the parameters can vary between locations" (Mateu 2010, 453). In other words, instead of estimating a single parameter for each variable, GWR estimates local parameters. By estimating a parameter for each data location (i.e. neighborhood) in the City of Hartford, the GWR equation would only alter the OLS equation as follows:

$$Y_i = \beta_{0i} + \sum_p \beta_{pi} x_{pi} + \varepsilon_i$$

where Y_i is the burglary rate at CBG i, β_{0i} is the constant term at CBG i, x_{pi} is the explanatory variable (i.e. poverty, tenure of housing, residential mobility, racial/ethnic diversity) at CBG i, β_{pi} is the value of the parameter for the corresponding explanatory variable at CBG i, and ε_i is the error term at CBG i. It should be noted that $i \in C_1 = \{1,2,...,q\}$ which is the index set of locations of n observations (i.e. all CBGs in the City of Hartford).

GWR becomes useful when "a single global model cannot explain the relationship between some sets of variables" (Brunsdon, Fotheringham, and Charlton 1996, 281). In the

GWR model, a continuous surface of parameter values is estimated under the assumption that locations closer to i will have more influence on the estimation of the parameter $\hat{\beta}_i$ for that location. Consequently, GWR allows researchers to explore "spatial non-stationarity by calibrating a multiple regression model which allows different relationships to exist at different geographical locations" (Leung, Mei, and Zhuang 2000). The GWR model was used to explore the macro-level spatial non-stationarity of the statistical relationship among burglary rates and the predictors including poverty, residential mobility, tenure of housing, racial/ethnic diversity.

While conducting the GWR, the continuous (Gaussian) model and the adaptive kernel were used, which was produced using the bi-square weighting function. The adaptive kernel uses varying spatial areas, but a fixed number of observations for each estimation. It is the most appropriate technique when the distribution of observations varies across space. In this case, observations (neighborhoods) are much smaller and closer together in the center of the city than they are at the edge. Finally, a process that minimizes the Akaike Information Criteria (AIC) was used to determine the best kernel bandwidth. The parameter estimates and t values produced by the software were exported and mapped using ArcGIS 10.6.1 (Environmental System Research Institute 2018).

Results

Summary statistics of the two GWR models are presented in Table 5. Compared with the results of the OLS models, using GWR significantly improved the explanatory performance by much larger adjusted R2 values (for both measures). The GWR model that adopted spatially weighted burglary rates explained 68.1 percent of the total variation in the dependent variable and it was a much better fit than using the measure of raw burglary rates which accounted for 60.2 percent of the variance (Table 5). A Local Moran's I cluster analysis (Anselin 1995) was conducted for the residuals of the two GWR models as a diagnostic for the collinearity in GWR residuals. There were no violations of residual independence (Table 5). The GWR models generated β coefficients for each neighborhood (see Table 6,Figures 5 A-D, and Figures 6 A-D), adjusted local R^2 value (see Figures 5E and 6E) and t values for each neighborhood (see Figures 7 and 8).

Statistics	GWR model – raw burglary rates	GWR model – spatially weighted burglary rates
Adjusted R^2	0.602	0.681
Akaike Information Criterion(AIC)	851.63	749.18
Moran's *I* for residuals	0.02	0.01

Table 5. Results from Geographically Weighted Regression

Variables	**β coefficients of GWR model – raw burglary rates**		**β coefficients of GWR model – spatially weighted burglary rates**	
	Min	Max	Min	Max
Intercept	-0.641	1.761	-0.523	2.413
Poverty: percent of people living under the poverty line	-0.681	1.922	-0.415	2.626
Tenure of housing II: percent of renters in the residential population	-1.382	2.375	-1.121	3.025
Residential mobility: percent of people lived elsewhere twelve months ago	-1.245	1.644	-1.021	2.315
Racial/ethnic diversity Index: Shannon equitability index	-1.465	2.231	-1.204	2.615

Table 6. β coefficients from GWR Models of Neighborhood-Level Burglary Rates in Hartford

Variables	**GWR model – raw burglary rates**			**GWR model – spatially weighted burglary rates**		
	-1.96 ≤ t^* ≤ 1.96	1.96 ≤ t^* ≤ 2.58	t^* > 2.58	-1.96 ≤ t^* ≤ 1.96	1.96 ≤ t^* ≤ 2.58	t^* > 2.58
Intercept	-----	-----	-----	-----	-----	-----
Poverty: percent of people living under the poverty line	75.8	18.9	5.3	69.5	22.1	8.4
Tenure of housing II: percent of renters in the residential population	62.1	34.7	3.2	55.8	33.7	10.5
Residential mobility: percent of people lived elsewhere twelve months ago	65.2	27.4	7.4	52.7	35.7	11.6
Racial/ethnic diversity Index: Shannon equitability index	85.2	9.5	5.3	74.8	18.9	6.3

* 1.96 and 2.58 are the cut-off values for t-test. When $|t| > 1.96$, the β coefficient estimate for a variable is significant at a significance level of 0.05. When $|t| > 2.58$, the β coefficient estimate for a variable is significant at a significance level of 0.01.

Table 7. Percentage of Neighborhoods by 95.0 percent of t Statistics in Hartford

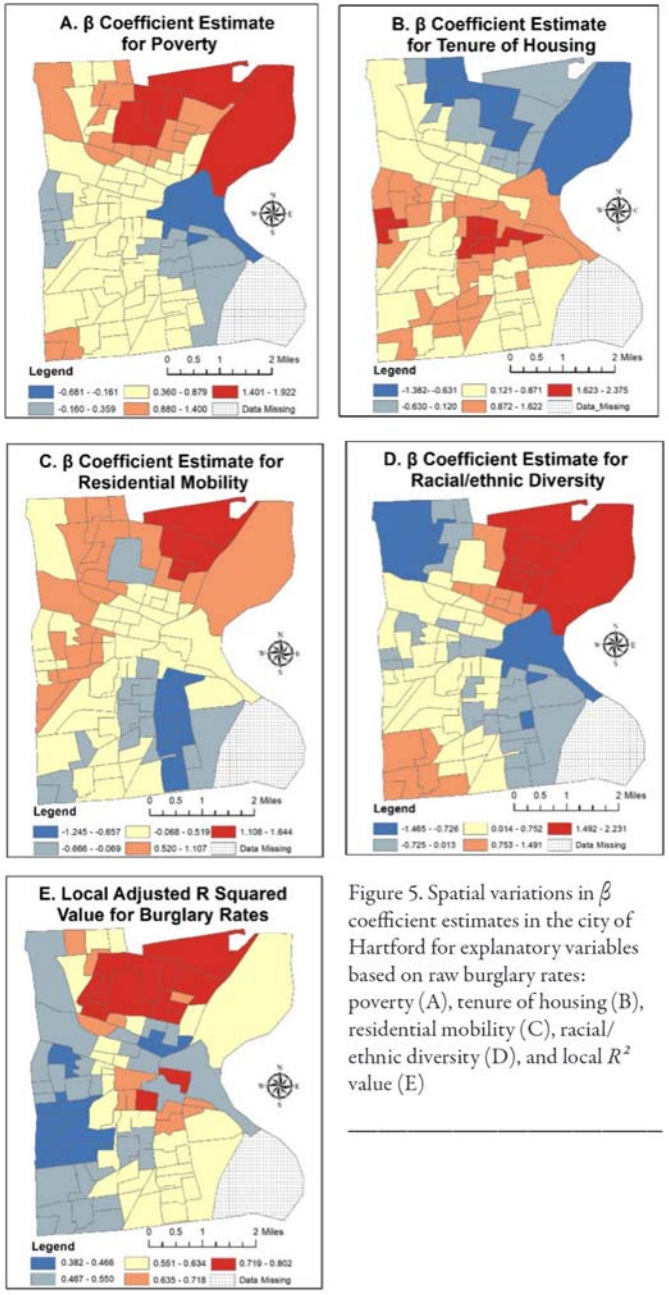

Figure 5. Spatial variations in β coefficient estimates in the city of Hartford for explanatory variables based on raw burglary rates: poverty (A), tenure of housing (B), residential mobility (C), racial/ethnic diversity (D), and local R^2 value (E)

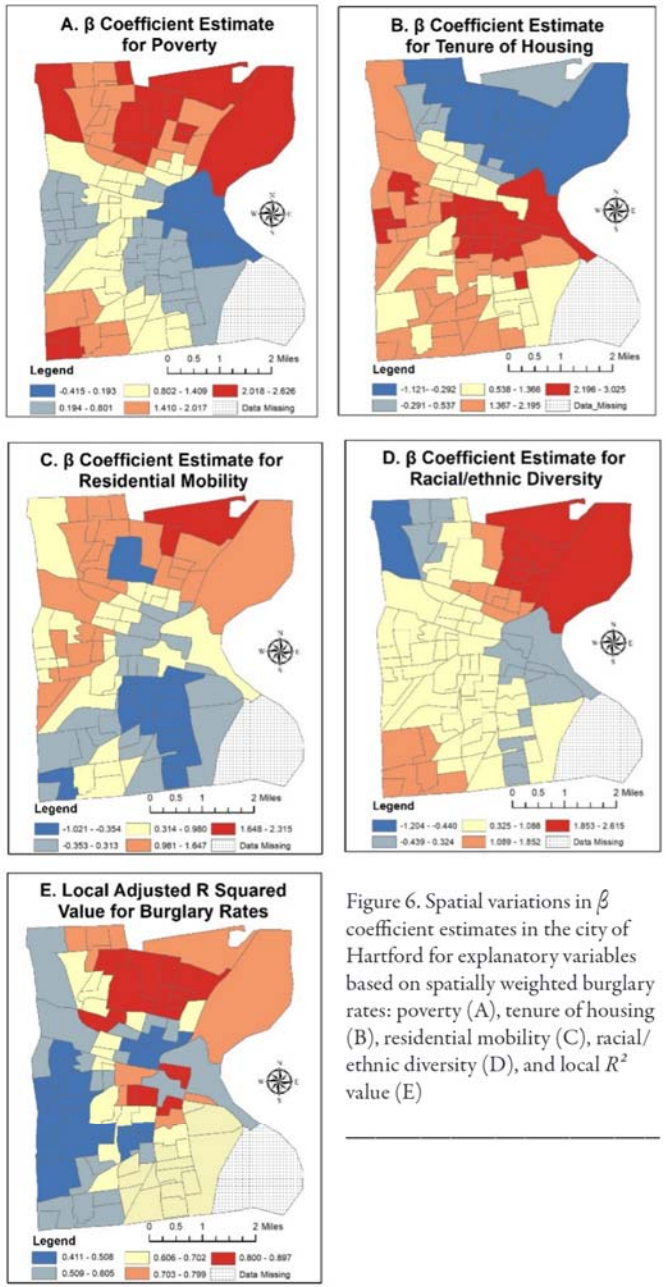

Figure 6. Spatial variations in β coefficient estimates in the city of Hartford for explanatory variables based on spatially weighted burglary rates: poverty (A), tenure of housing (B), residential mobility (C), racial/ethnic diversity (D), and local R^2 value (E)

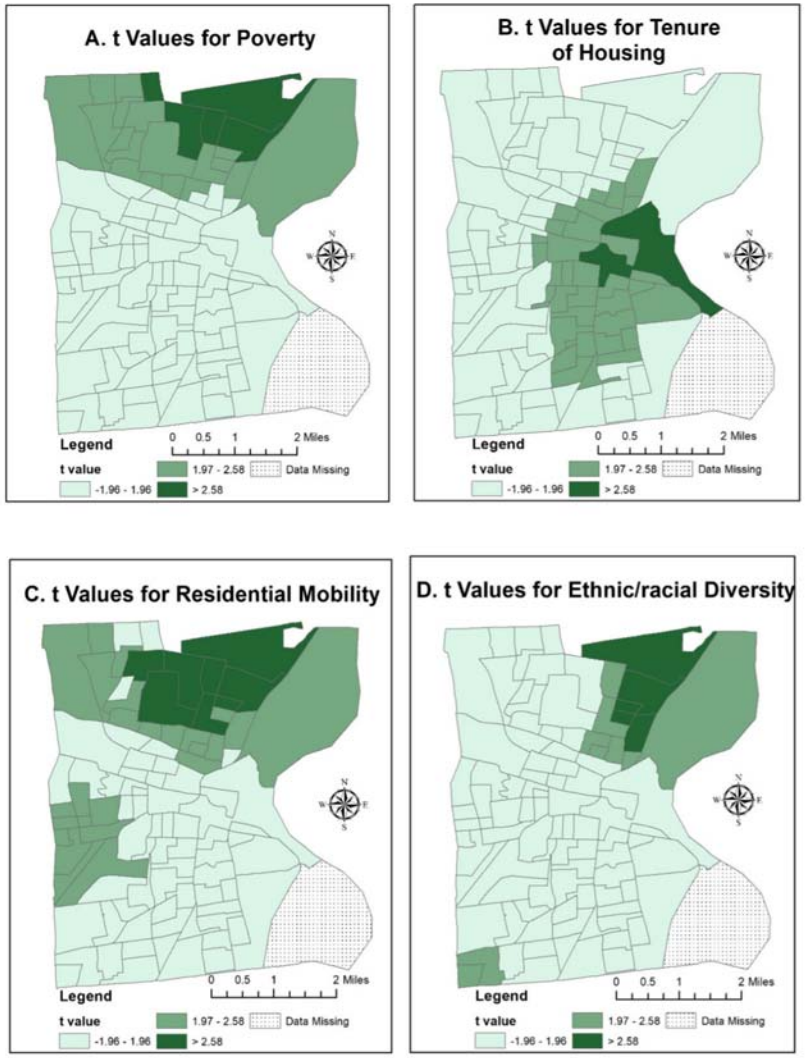

Figure 7. Spatial variations in t values in Hartford for explanatory variables based on raw burglary rates: poverty (A), tenure of housing (B), residential mobility (C), racial/ethnic diversity (D). Note: 1.96 and 2.58 are the cut-off values for t-test. When $|t| > 1.96$, the β coefficient estimate for a variable is significant at a significance level of 0.05. When $|t| > 2.58$, the β coefficient estimate for a variable is significant at a significance level of 0.01.

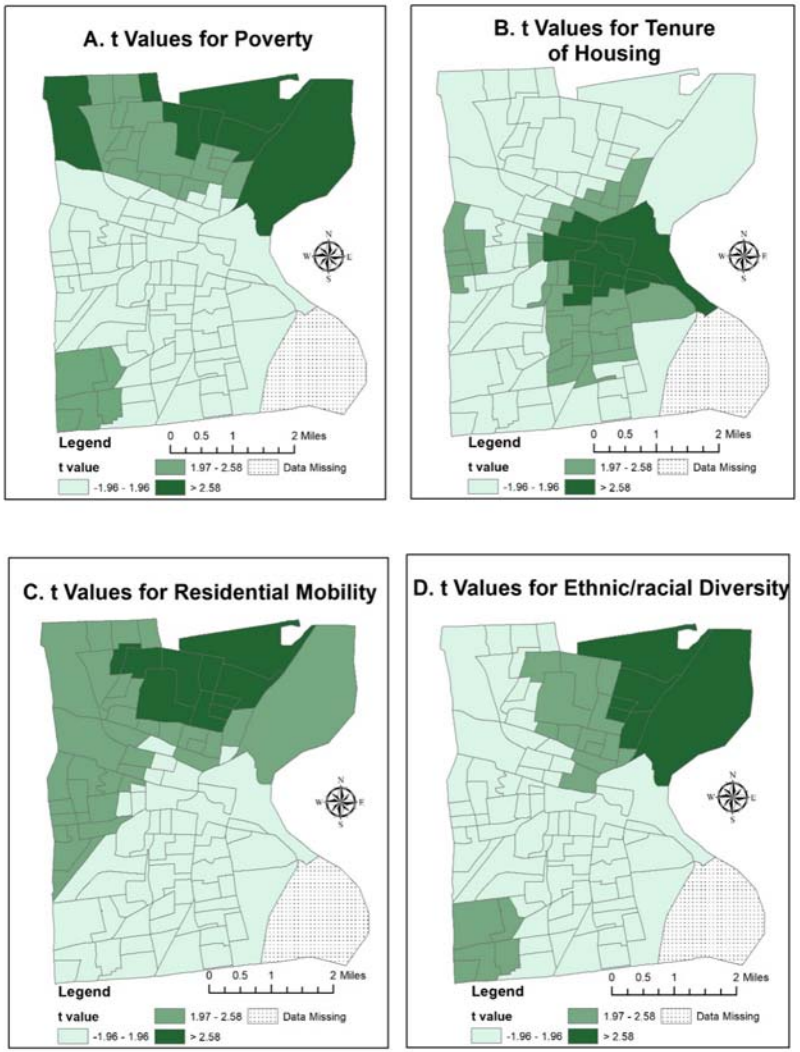

Figure 8. Spatial variations in *t* values in Hartford for explanatory variables based on spatially weighted burglary rates poverty (A), tenure of housing (B), residential mobility (C), racial/ethnic diversity (D). Note: 1.96 and 2.58 are the cut-off values for *t*-test. When $|t| > 1.96$, the β coefficient estimate for a variable is significant at a significance level of 0.05. When $|t| > 2.58$, the β coefficient estimate for a variable is significant at a significance level of 0.01.

Discussion

As shown in Table 6, Figure 5A, and Figure 6A, poverty, defined by the percentage of people living under the poverty line, is mainly positively associated with neighborhood-level burglary rates across the city. However, there are some outliers demonstrating that the predictor is negatively but insignificantly associated with burglary rates at the west and southeast ends of the city (Figure 5A and 6A). This finding supports previous research which shows that households with low income suffer a 60.0 percent greater chance of burglary than high-income ones (Levitt 1999) and property crimes like burglary are also more prevalent in poor neighborhoods than their wealthy counterparts (Dong 2020). Given the high poverty rate in Hartford and its positive association with burglary rates, regeneration initiatives and antipoverty programs aimed at re-allocation of economic resources and job creation should be established in the high poverty neighborhoods in Hartford.

As shown in Table 6, Figure 5B, and Figure 6B, tenure of housing, defined by the percentage of renters in the residential population, is mainly positively associated with neighborhood-level burglary rates across the city. However, there are some outliers demonstrating that the predictor is negatively but insignificantly associated with burglary rates at the north ends of the city (Figure 5B and 6B). This finding supports previous research which suggests that renters are 85.0 percent more likely than owners to be burglary victims (National Crime Prevention Council 2019). In Hartford, just 24.0 percent of the homes are occupied by a homeowner, compared to 67.0 percent statewide. In the center of Hartford, almost 100.0 percent of the residents are living in a rental home, so the area is highly and significantly correlated with raw or spatially weighted burglary rates (see Figures 5B, 6B, 7B, and 8B).

As demonstrated in Table 6, Figure 5C, and Figure 6C, residential mobility, defined by the percentage of people who lived elsewhere twelve months ago, is mostly positively associated with neighborhood-level burglary rates across the city, although there are some outliers demonstrating that the predictor is negatively but insignificantly associated with burglary rates in southern Hartford (Figure 5C and 6C). As illustrated in Table 6, Figure 5D, and Figure 6D, racial/ethic diversity, defined by Shannon equitability index, is largely positively associated with neighborhood-level burglary rates, although there are some outliers demonstrating that the predictors are negatively but mostly insignificantly associated with burglary rates in northwestern and eastern Hartford (Figure 5D and 6D). These findings are consistent with previous research findings which suggest that residential instability and racial/ethnic heterogeneity weaken residents' attachment to the neighborhood and impedes informal social control and order maintenance, so crime rates are high in neighborhoods where residential mobility and racial/ethnic heterogeneity are high. For example, Sampson, Raudenbush, and Earls (1997) suggest that residential instability and racial/ethnic heterogeneity are major structural conditions that undermine collective efficacy, in turn fostering increased crime. Additionally, empirical research shows that poverty and disorder tend to be highly correlated with racial/ethnic diversity (Sampson and Groves 1989; Sampson, Raudenbush, and Earls 1997). Disorder and poverty negatively influence individuals' ability and willingness to engage in social activities with neighbors, so they could exacerbate the feeling of powerlessness

and mistrust, and worsen inter-personal relationships (Sampson, Raudenbush, and Earls 1997; Marschall and Stolle 2004) which undermines collective efficacy for people living in neighborhoods with high level of racial/ethnic diversity and in turn boost crime in the neighborhoods. To enhance collective efficacy, comprised of social cohesion and control, in neighborhoods with high residential mobility and racial/ethnic diversity in Hartford, stakeholders from local communities should first be engaged to identify burglary problems, craft solutions and assess responses. Then, intervention measures should be focused on 1) surveying local residents to learn how they feel about their neighborhoods; 2) involving stakeholders to use the data gathered in community surveys to identify problems and common targets, craft solutions, and assess responses; 3) encouraging the local residents to participate in neighborhood watch or citizen patrol programs; and 4) avoiding racial profiling practice in high crime neighborhoods. Guided by problem-oriented policing strategies, crime statistics would dictate that a relatively greater number of residents will be stopped, searched, and/or eventually arrested in neighbourhoods with concentrated disadvantage, high residential mobility, and high racial/ethnic diversity in the future. This practice can lead to a vicious cycle that even the strictest law enforcement advocates would admit is patently unfair.

As shown in Table 6 and Figures 5-8, the change in magnitude and direction of the coefficients suggests spatial non-stationarity of the relationship between the burglary rates (i.e. both raw burglary rates and spatially weighted burglary rates) and the predictors. The variation in parameter estimates from GWR suggests the necessity of applying this spatial statistical tool to future crime studies that would be restricted by using global OLS models, since GWR provides insights on how a particular explanatory variable influences the crime rates across the study area. For example, as shown in Figures 6B and 8B, tenure of housing, defined by the percentage of renters in the residential population, had the greatest effect in neighborhoods located in the center-eastern Hartford. As illustrated in Figures 6D and 8D, in neighborhoods located in the northeastern and southwestern of Hartford, the racial/ethnic diversity variable had a greater association with burglary rates.

The importance of using spatial statistical tools such as GWR in future crime studies can also be confirmed by the local R^2 value (see Figure 5E and 6E). The adjusted R^2 for the two GWR models ranged from 0.382 and 0.802 and from 0.411 to 0.897, with an average of 0.602 and 0.681 respectively, while the adjusted R^2 in the OLS models were 0.389 and 0.446. The OLS R^2 values mask a wide distribution of local associations between the explanatory variables and burglary rates. In other words, without GWR, the OLS model would be unable to estimate the variance of local associations. For example, in the northern and center Hartford, the GWR model explained up to 89.7 percent of the variance in the spatially weighted burglary rates, indicating the measures of social disorganization theory better explained the variances in the burglary rates there. However, among neighborhoods clustered in the west of the city, the model did not explain much of the variance (about 41.1– 50.8 percent), suggesting social disorganization theory measures were not effective in explaining the patterns of burglary crime in the suburban neighborhoods in western Hartford. Such spatial variation would have been neglected with the OLS model alone. Likewise, as shown in Table 5, the GWR model adopted spatially weighted burglary rates generates a much smaller Akaike information criterion (AIC)

value (i.e. 749.18) than the one adopted raw burglary rates (i.e. 851.63), indicating a significant improvement in predicting the variation of burglary crime.

It should be noted the spatially weighted count method not only leads to a better fit GWR model than using the measure of raw crime counts, but it also has two major advantages compared with the ones proposed by past research (Zhang, Suresh, and Qiu 2012; Zhang and Song 2014). First, it uses a pre-defined critical search distance band instead of queen-based spatial contiguity (i.e. sharing either sides or common vertices with the focus area) to search for neighboring units. The rationale behind this change is that the crime risk of spatial spillover effect should be accounted based on a physical distance, not spatial connectivity. Second, it directly weights burglary incidents in adjoining units based on the inverse distance from the incidents to the targeting neighborhood, where the previous research aggregates burglary incidents into the centroids of adjoining units (Zhang, Suresh, and Qiu 2012; Zhang and Song 2014) and weights them based on the inverse distance from the centroids of adjoining neighborhoods to the targeting neighborhood. This new method allows different burglary incidents in an adjoining unit to pose a different level of risk to the targeting unit based on their distances to the unit rather than assuming different burglary incidents in an adjoining unit pose the same level of risk to the targeting unit. Additionally, the calculated *t* statistics (see Table 7) for the local parameters indicate that the GWR model for spatially weighted burglary rates has more significant coefficients (i.e., *t* values were larger than 1.96 or 2.58, the critical value for the significance level of 0.05 and 0.01) than the model for raw burglary rates. In other words, spatially weighted burglary rates are better correlated with the explanatory variables with a high confidence level in the GWR model than raw burglary rates. It is worthwhile to note the fundamental differences between the spatially weighted count method used in this study aiming to account for the spillover crime risk from adjoining CBGs and a spatial lag or spatial error used in the spatial regression model. A spatial lag averages the neighboring values of a location and accounts for autocorrelation in the spatial regression model with the weight matrix. However, the spatially weighted count of crime in this study is used as a dependent variable to account for the negative crime spillover effect from adjoining neighborhoods.

This study is not without limitations. The first group of limitations is associated with geographic boundary effect, such as edge effect. It should be noted that the statistical relationships drawn from areal data must be carefully interpreted. Robinson (1950) long ago suggested the data scale/boundary problem and clearly explained that inferring individual level relationships from macro-level correlations is inappropriate. In this study, CBG boundaries were used as an approximation of neighborhoods and the relationships between burglary rates and contextual characteristics at the neighborhood-level thus cannot be interpreted as and/or applied to individual-level relationships. In addition, the GWR model is restricted by the edge effect, whereby CBGs located on the edges of Hartford do not have the 360° influence of CBGs in the city's interior.

The second group of limitations is related to crime data. It should be noted that the crime dataset prepared by Hartford police may underestimate the burglary offenses to some extent, because only the most serious offenses are recorded per incident of crime according to the UCR classification rule. For example, if there was a burglary with a murder involved, the incident

would then be classified according to the crime that carried the longest maximum sentence, which would be the murder offense. Such a classification rule results in an underrepresentation of less serious offenses such as the burglary in the above example. In addition, the local R^2 values accounted for up to 89.7 percent of neighborhood-level burglary rates, which means that other risk factors associated with burglary crime need to be added into the GWR model.

Conclusions

This research analyzed the spatial distribution and correlations of burglary rates in Hartford. Specifically, this study incorporated demographic and socio-economic correlates with burglary rates. The relationship between the crime rate and predictors is not new (i.e. Sampson, Raudenbush, and Earls 1997; Rountree and Land 2000; Malczewski and Poetz 2005; Zhang and Song 2014)), but little research has been done to investigate the spatial heterogeneity of the relationships in the City of Hartford. Additionally, there are a few studies attempting to quantify for each areal unit by taking crime incidents in adjacent units (or spillover effect) into consideration. This research contributes to the existing literature in two ways. First, it uses a distance-based approach to search neighboring units and quantify the risk of burglaries in each CBG by adding those of adjacent CBGs to account for the spillover crime risk from adjoining CBGs. The GWR model for the spatially weighted burglary rates explained 68.1 percent of the variances of burglary crime, proving that it fits much better than using the raw burglary rates. Second, it shows that there is a significant correlation between burglary rates and the explanatory contextual variables, and this relationship has a spatial but nonstationary association in the City of Hartford. This study presents an initial and exploratory step towards better understanding of burglary, but much more in-depth work remains before criminology researchers and law enforcement understand why these spatial variations exist and why explanatory factors, such as poverty, tenure of housing, residential mobility, racial/ethnic diversity have very low explanatory effects in some neighborhoods but explain up to 89.7 percent of burglary rates in others in Hartford.

Dr. Yunliang Meng is Associate Professor at the Central Connecticut State University, Geography Department. His research interests lie in the field of GIS, Urban Geography, Quantitative Analysis, Social and/or Environmental Justice. His publications cover a wide range of topics including participatory planning, racial profiling/crime pattern analysis, and disease pattern modeling. Email: mengy@ccsu.edu.

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DENSITY AND THE SPATIAL ANALYSIS of Principal Components Derived from Mobility-Related Socio-Economic Variables in New England

Devon Lechtenberg
Capitol Region Council of Governments
Hartford, Connecticut

ABSTRACT

Principal component analysis (PCA) is a widely used multivariate data analysis technique for variable reduction and analysis of variable relationships, among other purposes. In this current study set in New England, PCA is used together with local indicators of spatial autocorrelation (LISAs) to examine regional patterns of spatial dependence between population density and synthetic variables (i.e. principal components) derived from mobility-related socio-economic variables. A secondary analysis using geographically weighted principal component analysis (GWPCA) is used to identify which of the original contributing variables are most important for different locations within the region. Using a local bivariate indicator of spatial autocorrelation, overall results show that most resulting principal components are positively spatially correlated with population density, although this correlation is not a direct point-to-point one and instead relates the principal component to the spatial lag of density for a given location. These findings are relevant for understanding the relationship between agglomeration (as represented by density) and the triad of mobility, accessibility, and connectivity. The results of this study could aid and inform future research and efforts at modeling travel behavior.

Key words: Mobility, Population Density, Principal Component Analysis, Geographically Weighted Principal Component Analysis, Bivariate Local Moran's I, New England, NCHS 2013 County Typology

Introduction

Regional travel-to-work patterns are shaped through the conceptual triad of accessibility, mobility, and connectivity, which is anchored by agglomeration. Agglomeration, which can be represented by population density, is understood here to include the geographic concentration of people, jobs, infrastructure, shopping, institutions, and recreation that form urbanized areas. Given the many factors encompassed by agglomeration, the positive correlation between density on the one hand and accessibility and connectivity on the other hand comes as no surprise.

The relationship between agglomeration and mobility is somewhat more difficult to articulate as some mobility measures are evidence for *previous* travel such as vehicles miles traveled (VMT) or indications of potential travel, such as the numerous socio-economic variables used in transportation analyses. Additionally, the number and diversity of socio-economic variables complicate efforts to understand the relationship between these variables and density (agglomeration). As these socio-economic variables shape mobility, they thus also affect, and can be affected by, accessibility and connectivity. Furthermore, socio-economic variables have both attribute values (quantitative or qualitative) and spatial properties (georeferenced locations). Within multivariate data analysis, a standard method of variable reduction in the face of many potentially interrelated variables is principal component analysis (PCA). Synthetic variables (known as principal components) are created out of the original group of variables and have the important property of explaining high levels of variance within the original data set (while using fewer variables) and being mutually orthogonal and unrelated. Traditional PCA is non-spatial but can be used in tandem with measures of global and local spatial autocorrelation to understand their patterns of geographic distribution (see Anselin 2020a). Geographically weighted principal component analysis (GWPCA), a relatively new method, combines analysis of both attribute and spatial heterogeneity (as opposed to autocorrelation), thus highlighting the variability of attributes across space. This study uses a combination of traditional PCA and indicators of spatial (auto-) correlation as well as GWPCA in an exploratory analysis of mobility-related socio-economic variables and their relationship to population density in New England.

New England offers a unique case study for several reasons: Firstly, the region is well-defined and largely self-contained, bordered by New York state and Canada while consisting of the six states of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont. Secondly, New England states have almost no unincorporated land, which enables the straightforward designation of contiguity regimes between (town) boundaries, a key part of spatial analysis. Thirdly, New England offers an almost textbook example of a coastal dense pattern of urban development contrasting with the low-density hinterland, which obviously lends itself to a density-based analysis. In fact, this contrast may be the most prominent feature of the population distribution in New England (see Figure 1). The density gradient runs diagonally from just north of Boston down to the Connecticut-New York State line, with the ten largest regional urban populations all located to the south of the gradient. Nevertheless, there are isolated population centers in northern New England, notably the Burlington, VT area (home to the three largest Vermont towns) and the scattered patterns found in Maine. Settlement and mobility patterns are also related to topography: New England is characterized by mountains, hills, rivers, and extensive coastline and not only is the population concentrated in comparatively flat, low-lying areas (e.g. coastal plain, Connecticut River valley, Champlain Valley in Vermont), but travel between locations, especially more remote ones, are impeded by difficult terrain even though modern paved roads are found everywhere in the region.

This study is concerned with understanding spatial and attribute patterns of mobility-related socio-economic variables and their relationship to density within New England but must employ a means to reduce the number of variables and simplify the analysis. The principal components derived from these variables can be used in a spatial analysis that more efficiently

gets at the relationship between the original socio-economic factors — now combined in the form of synthetic variables and essentially representing multifaceted socio-economic profiles — and density. Thus, the concrete research question for this study is: ***Are the principal components derived from the original socio-economic data (positively) spatially dependent with population density? And if so, where?*** In other words, do spatial patterns of density impact the spatial patterns of these socio-economic variables? It would be expected with accessibility and connectivity, but it is less clear with socio-economic variables and takes on significance if these synthetic variables were to be used in comparative and/or predictive analyses involving measures of accessibility and connectivity. The primary analysis described above has the limitation that it is still global in nature, meaning in this case that the relationship between contributing socio-economic variables within a PCA is determined for the entire study area and is not sensitive to local variations. As a complement to the primary analysis, a secondary analysis consisting of a GWPCA provides a needed local view within this study since there is every reason to believe that these relationships are not static over space.

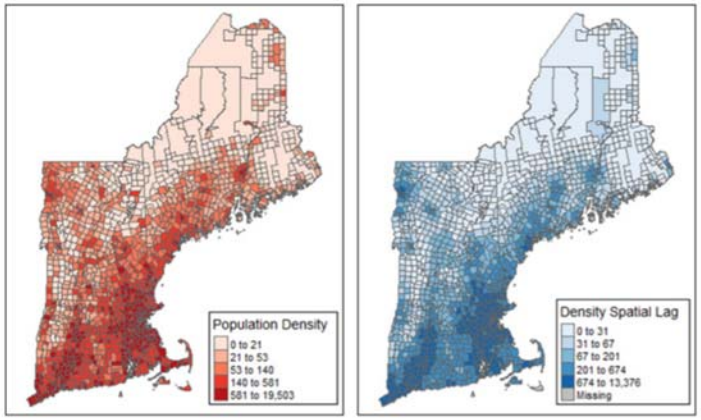

Figure 1: Population Density and Its Spatial Lag in New England.
(Source: Author using 'tmap' package in R).

Results from the traditional PCA, used together with univariate and bivariate local indicators of spatial autocorrelation (LISAs), show that there is positive spatial correlation between the synthetic variables and population density in all cases but one. The intensity of the spatial correlation is low but is nevertheless statistically significant. The subsequent GWPCA demonstrates that the importance of original contributing variables within individual principal components was not spatially constant, with different variables being the most important contributors in different locations, something that is unknowable from traditional "global" PCA methods. The practical significance of these findings are as follows: 1) it strongly suggests the role of agglomeration in shaping mobility via the spatial dependence between density and mobility-related socio-economic characteristics, 2) the derived synthetic

variables (principal components) can be used in subsequent analyses involving variables that may be highly correlated with density without the risk of major complications stemming from multicollinearity, 3) there is clear variation between low density (rural) locations and higher density (urban) locations with respect to these synthetic variables, and 4) results of GWPCA offer clues as to which contributing variables are the most important in shaping their principal components in given locations. There are several caveats to this study. Firstly, no list of socio-economic variables is complete, and variable reductions comes at the price of potentially omitting relevant variables. PCA results can vary significantly depending on which variables are included, although some relatively stable patterns emerge. Secondly, these results from an aggregate level analysis are not directly transferable to individual-level analyses. Thirdly, any formal articulation of relationships between these principal components and measures of accessibility and connectivity will have to wait for more rigorous future modeling analyses. Thus, the socio-economic profiles created by each principal component and their relationship to transportation patterns are a potential future avenue of research. This research is of potential interest to transportation geographers, planners, spatial scientists, and those with a regional interest in New England.

Literature Review

For the last thirty years, Paul Krugman's (1991) new economic geography has had considerable influence over debates surrounding the unequal allocation of industry, populations, and attendant phenomena such as infrastructure within and between regions. This massing of interrelated things rooted in a spatial concentration of industry and population can be termed ***agglomeration***. New economic geography holds that regions can develop into core and peripheries as a result of agglomeration creating beneficial economies of scale, transport costs being reduced, and a certain distribution of manufacturing. Krugman (1991) noted that there was general agreement that economic production concentrates or 'localizes' in part because of access to common labor pool and information spillovers, which were first discussed as causes by the English economist Alfred Marshall in the late 1800s. These benefits of agglomeration, generally held to be positive, combined with economies of scale are captured in the term economies of agglomeration (or agglomeration economies). From a transportation perspective, one very important observation put forth by Krugman (1991) was that decreasing transport costs can in fact reinforce the consolidation of core and peripheral areas. Lafourcade and Thisse (2011) echoed this point. Agglomeration manifests itself as urban form and one of the most basic and indeed common means of measuring this is ***population density*** (Clifton, Ewing, Knaap, and Song 2008). Density is usually positively correlated with jobs, infrastructure, trip generation, and higher levels of various socio-economic indicators. Thus, density can justifiably be treated as a stand-in for agglomeration.

Density strongly impacts the relative accessibility of a location, as can be seen in the fact that accessibility tends to reflect the spatial distribution of population density (Sohn 2005). This is illustrative of ***place-based accessibility***, which as a concept can be defined as "the ease of reaching desired locations" (Clifton et al. 2008, 28). Both elements of mass (a desired

location, usually made attractive by its size) and frictions (in the form of transportation costs and their inversely proportional relationship) are present in this definition. This sort of conception of accessibility is derived from the gravity model, which arose as an analogy to Isaac Newton's mathematical description of gravity. Alan G. Wilson (1967, 2001) reformulated the classic gravity model into a spatial interaction model (SIM) which is a far more flexible implementation of the gravity concept. The SIM has three potential forms, production-constrained, destination constrained, and doubly (production and destination) constrained. Alternatively, another place-focused conception of accessibility is given by Bruinsma and Rietveld (1996), where it represents "the potential opportunities for interaction" for regional economic purposes. This definition is attractive as it broadens the ways in which place-based accessibility can be defined. In contrast to both place-focused definitions discussed above, there is also ***people-based accessibility***, which refers to "how easily a person...can reach activity sites" (Hanson 2004, 5). People-based accessibility is fundamentally shaped by factors of location and socio-economic attributes, which are in the first instance measures of mobility. Thus, socio-economic attributes, more properly categorized as measures of mobility, can influence people-based accessibility. They could also influence place-based accessibility when included in a spatial interaction model as additional variables.

Mobility can be thought of as the ability of people to physically move around in space. In the context of commuting, mobility attributes represent the either the aggregate or individual capacity to travel to their place of work. Socio-economic attributes tend to be best thought of as factors that affect mobility as opposed to observed (or sometimes estimated) measures of mobility, such as vehicle miles traveled (VMT). A number of factors influence trip production among individuals, including income, vehicles owned, household characteristics, family size, land value, residential density, and accessibility (Ortuzar and Willumsen 2011, 126), although more could certainly be added. These factors can be stratified into groups such as income brackets in order to further differentiate the population. Scholarly research has as well identified other important factors such as gender, race/ ethnicity, level of education, and transit availability. Susan Hanson, for example, has published extensively on the role of gender in mobility (Hanson 2010). Race and ethnicity as factors are also causes of differentiated mobility, including when they are compounded by gender differences (Hu 2020). For example, ethnic and racial minority groups often face long (duration) and complex commutes involving multiple transit connections owing to spatial mismatch, i.e. the residence of these groups far away from their places of work. Thus, they face serious challenges not only related to mobility, but also to accessing the benefits from connectivity and accessibility that would be available were it not for a lack of mobility. The intersection of transit-usage and low-income status takes on special significance where the absence of a public transportation option decisively curtails the person mobility of low-income persons (see Giuliano 2005). The type of employment and level of education can also significantly influence mobility patterns, with high-income, highly educated individuals often commuting much longer distances to work, or alternatively, being in the economic position to afford expensive urban housing closer to their work. The connectivity (or lack thereof) of transportation infrastructure can severely impede personal mobility, even where socio-economic factors are otherwise favorable (Bjarnason 2014). Mobile phone data has been

increasingly used in the last decade to produce detailed observational data of personal mobility. Some research has managed to couple this observational data together with socio-economic data to create especially solid analyses of travel behavior (Xu et al. 2017). What is exceedingly clear is that there are a very large number of potential socio-economic variables to choose from when performing an analysis. However, it can be unclear as to which ones are the most important for various analyses.

The concept of ***connectivity*** is the last part of the triad whose first two elements are accessibility and mobility. Connectivity is the measure of 'linkages' between origins and destinations and is best understood in terms of networks, which fundamentally consist of nodes and links, each with their own attributes. Network connectivity is generally described by measures such as degree of node, centrality index, etc... Transportation infrastructure is a particular type of physical network where both nodes (i.e. intersections, interchanges, major transshipment points) and links (i.e. roadways, railways) are tangible and exist to facilitate movement people and goods. ***Transportation infrastructure*** contrasts with commuter flow networks where nodes and links are not both tangible[1] . Transportation networks arise and densify in the presence of agglomeration. The densification of the network leads to greater accessibility as the transportation costs are lowered by better infrastructure. However, although accessibility and infrastructure are generally correlated positively, Marcińczak and Bartosiewicz noted that at some point, increasing the density of the built environment actually decreases accessibility as it forms an impedance (2018). Greater transportation network connectivity does not stymie the benefits of personal mobility as would be the case in conditions of low connectivity, which limit options of people desiring to travel even if they are otherwise able (Vickerman 1996). Strategically chosen new transportation infrastructure can even improve mobility of the population (see Bjarnason 2014). Thus, transportation network connectivity, place-based accessibility, and personal mobility enter a self-reinforcing cycle. Despite the seemingly positive returns of increasing connectivity, regional inequalities resulting from agglomeration can be exacerbated by new and better infrastructure, as workers will move out of the hinterlands to towards urbanized areas but retain easy access to family and friends back home facilitated by said infrastructure. Transportation infrastructure networks can be measured in a number of ways including: total length of facilities in a given area, density of facilities, total length of facility types (i.e. Interstates), interchanges, intersections, among others. Black (2003) details many applicable measures from graph theory, while Labi et al (2019) go further and include additional measures that combine characteristics of network connectivity with accessibility and mobility measures.

Tools are needed that lend greater structure and clarity to the analysis of multiple variables that characterize accessibility, mobility, and connectivity. ***Principal component analysis (PCA)*** is a standard method of multivariate data analysis wherein variable reduction creates uncorrelated (orthogonal) synthetic variables from linear combinations of potentially related *real* variables. These synthetic variables are called *principal components* (PCs) and are equal to the number of original real variables. PCs are in fact eigenvectors given in reverse rank order of most variance explained to least (signified by eigenvalues), with the first few PCs usually explaining the vast majority of variance within the dataset. The steps and their corresponding

mathematical notations are lengthy and are only briefly summarized in Appendix A. However, more complete explanations can be found in Joliffe (2002) or Abdi and Williams (2010). Demšar et al. (2013) offer a thorough review of the use of PCA within geography over the last century. The unique qualities of spatial data were discussed as well. Although there have been notable periods of interest in PCA as an analytical tool in its own right, such as during the 'quantitative revolution' of the 1960s, substantial scholarly interest in PCA among geographers has never remained consistent. This is regrettable given the specific analyses which can be performed with PCA as described by Jeffers (1967), cited in Harris et al. (2011, 1717):

1) examination of the correlations between variables of a selected set;
2) elimination of variables that contribute relatively little information;
3) examination of the group of individuals in n-dimensional space;
4) determination of the weighting of variables in the construction of indices;
5) allocation of individuals to previously demarcated groups;
6) recognition of misidentified individuals;
7) orthogonalization of regression calculations; and
8) reduction of the basic dimensions of variability in the measured set.

Furthermore, PCA's multiple potential applications for geographic subject matter are identified by Gould (1967)[2], and also cited in Harris et al. (2011). Standard PCA is a non-spatial global analysis, as it takes neither spatial autocorrelation nor spatial heterogeneity directly into account. Although this can be partly remedied by a spatial analysis performed on the PCs, the analysis would remain fundamentally global as local variations in the data are not addressed.

Geographically weighted principal component analysis (GWPCA), a method for incorporating spatial heterogeneity, was first briefly introduced by Fotheringham et al. (2002) and presented in more detail by Harris et al. (2011), who as seen above, strongly endorsed the use of PCA as an analytical technique based on the justifications provided by earlier scholars. Gollinni et al. (2015) detailed an R package, *"GWmodel"*, which could perform GWPCA, among many other novel geographically weighted analyses. In contrast to the geographically weighted approach of dealing with spatial heterogeneity, a PCA accounting for spatial autocorrelation was developed by Jombart et al. (2008). The use of traditional PCA with spatial data has also been featured in online documentation for GeoDa software, where local indicators of spatial autocorrelation (LISAs) are presented as tools for analyzing principal components (Anselin 2019). There have been several recent examples of PCA and/ or GWPCA being used in the analysis of regional economic development, including a combined standard PCA-GIS approach by Petrişor et al. (2012) for different sets of variables in various Romanian regions, a GWPCA used by Li, Cheng, and Wu (2016) for Jiangsu Province in China, and a very recent effort by Cartone and Postiglione (2020) to augment PCA using spatial filtering to account for both spatial autocorrelation and spatial heterogeneity in regional development in the Italian province of Rome. This methodological flexibility when using PCA is well-suited for describing the complex relationships between mobility-related socio-economic variables and population

density. The use of PCA and spatial analysis to better understand the relationship between socio-economic characteristics of mobility and the spatial organizing influence of agglomeration would be a methodological contribution to transportation studies, geography, and other spatial sciences.

Methods

The data analyzed in this study consist of 2018 American Community Survey (ACS) 5-year estimates. Shapefiles for minor county divisions (MCDs, equivalent to towns for most of New England), counties, and state boundaries were obtained from the U.S. Census Bureau's website. The 2013 six-way classification typology for U.S. counties by National Center for Health Statistics (NCHS) researchers (see Ingram and Franco 2014) was utilized. Using ESRI ArcGIS, separate shapefiles for MCD in the six New England states were merged into one large shapefile for the whole region, containing 1606 locations. Census data from the ACS were reformatted in Microsoft Excel, where appropriate, to be expressed as population proportions so as to prevent size effects from dominating the data. In the rare cases where there were missing data, the proportion for the variable for the county to which the MCD belongs was substituted, something that mostly occurred in far-northern Maine near the geographically large but sparsely populated towns. A GAL (GenePix Array List) for queen-contiguity adjacency of all towns in New England was obtained using GeoDA, an open-source exploratory spatial econometrics software (see Anselin et al. 2006, Anselin and Rey 2014). The GAL file serves as a portable spatial weights file for determining neighboring spatial unit and being relevant to spatial analysis in multiple methodological approaches. The analysis was carried out using R for the Pearson correlations, traditional PCA, and GWPCA, GeoDA for both the global and local versions of univariate and bivariate Moran's indices for spatial correlation, and R for final mapping of the results.

Thirty-two variables (see Table 1) were selected from an initial list of nearly fifty candidates. Variables were eliminated based on a number of criteria, including: negligible attribute correlation with population density, negligible and statistically insignificant spatial autocorrelation as measured by the Global Moran's I, and anticipated redundancy with other variables. Correlation with density and individual spatial autocorrelation were considered important criteria owing to the central role played by both in this study. If potential variables were not expected to react (either positively or negatively) with density, then there was little point to retaining them in this analysis. Also, a lack of statistically significant positive or negative spatial autocorrelation (clustering) would make these variables difficult to analyze utilizing the methods proposed below. An initial PCA was performed, and variables found to be making little contribution to any of the selected PCs were also used to inform individual decisions. There were some exceptions made even when the aforementioned criteria seemed to warrant removal. Variables removed included: service and sales occupations, educational attainment levels of some college and associate degree, median age, age dependency, old age dependency, and child dependency ratios, female and male age groupings of 0-25, 25-65, and 65 and up, desktop and laptop ownership (not exclusive of other devices such as smartphones and tablets),

Variables	Global Moran's I	Pearson Correlation with Density
HHNoVehcle	0.196	0.514
HH1Vehcle	0.152	0.235
HH2Vehcle	0.120	-0.257
HH3mVehcle	0.294	-0.217
LongCommute	0.478	0.042
MedMinutes	0.466	0.037
Leaves5to7	0.263	-0.149
Leaves7to9	0.382	0.118
Transit	0.764	0.686
HH1Person	0.127	0.110
HH2Person	0.330	-0.296
HH3Person	0.206	0.050
HH4Person	0.293	0.041
Femaleto25	0.286	0.177
Female25to65	0.110	0.043
Female65andUp	0.216	-0.128
Maleto25	0.290	0.196
Male25to65	0.163	0.080
Male65andUp	0.296	-0.201
NonWhite	0.419	0.663
MedAge	0.332	-0.349
Below150PvThr	0.260	-0.116
MedHomval	0.317	0.251
OCC_MBASO	0.396	0.141
OCC_NRCM	0.243	-0.202
OCC_PTTM	0.284	-0.086
HSorEqvInt	0.492	-0.175
DegreeBA	0.520	0.100
DegreeAdv	0.570	0.166
Smartphone	0.602	0.203
Tablet	0.491	0.135
Broadband	0.464	0.106

Table 1: Description of Basic Socio-Economic Variables Used in Analysis. (Source: Author)

lack of computer ownership, and finally dial-up Internet. The resulting data set consisted of 1,606 observations (towns in New England) of 32 variables. Of note is the definition of the variable LongCommute as the percentage of workers with a forty-five minute or longer commute. The occupation variables OCC_MBASO, OCC_NRCM, OCC_PTTM represent the respective summary census categories of management, business, arts, and science; natural resources, construction, and maintenance; and finally production, transportation, and material moving.

A traditional principal component analysis (PCA) was performed on the thirty-two variables (seen in Table 1) with the *"FactoMineR"*, *"factoextra"*, and *"corrplot"* R packages[3] . The most important principal components were chosen by consulting the Kaiser criterion (1961), which selects components based on those having an eigenvalue of greater than 1. The selected PCs were analyzed for spatial correlation using both global and local versions of univariate and bivariate Moran's I for identifying spatial clustering (see Appendix B for Equations) in GeoDA. The resulting cluster patterns could then be mapped in R using the *"tmap"* package by Tennekes (2018). The local univariate and bivariate spatial clustering patterns of the selected principal components were then analyzed and interpreted. Use of the NCHS county typology also contributed to the analysis. Owing to the limitations of traditional PCA, even when accompanied by spatial indices of autocorrelation, a geographically weighted principal component analysis in the *"GWmodel"* package in R was performed on the data set as well. The GWPCA output of the localized "winning" variable for each selected principal component was especially helpful here.

Results

The results section consists of two parts: a traditional principal component analysis (PCA) accompanied by a spatial analysis of the selected principal components and a brief geographically weighted principal component analysis (GWPCA) to add to the findings.

	PCA Measure	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Summary	*Eigenvalue*	*8.2495*	*4.7503*	*3.7810*	*3.4107*	*1.7250*	*1.1508*	*1.0395*
	Perc. Variance	*25.78*	*14.84*	*11.82*	*10.66*	*5.39*	*3.60*	*3.25*
	Cumulative Variance	*25.78*	*40.62*	*52.44*	*63.10*	*68.49*	*72.09*	*75.33*
Variable Loadings	*Variables*	*PC1*	*PC2*	*PC3*	*PC4*	*PC5*	*PC6*	*PC7*
	HHNoVehcle	-0.0319	0.0743	-0.6334	0.3510	0.1590	0.3362	0.1037
	HH1Vehcle	-0.2440	-0.0889	-0.5136	0.5936	0.1794	-0.0803	-0.2293
	HH2Vehcle	-0.2292	0.2670	0.6101	-0.2300	-0.1979	0.2164	0.2948
	HH3mVehcle	-0.4247	0.6591	0.2635	-0.2776	-0.0206	-0.0917	-0.2333
	LongCommute	0.1546	-0.0219	0.1917	-0.5164	0.7113	-0.1376	0.0327
	MedMinutes	0.2148	0.0464	0.1945	-0.5130	0.7032	-0.1693	0.0028
	Leaves5to7	0.0167	-0.5620	-0.1254	-0.5281	0.1395	-0.0975	-0.0286
	Leaves7to9	0.7275	-0.0295	0.1018	0.2760	-0.2115	0.0149	-0.1541
	Transit	0.4083	0.2709	-0.1417	0.2144	0.5040	0.3993	0.1260
	HH1Person	-0.2686	-0.1558	-0.3933	0.6486	0.1888	-0.2419	-0.2340
	HH2Person	-0.4395	-0.2040	0.5967	-0.0732	-0.1186	0.3944	0.1167
	HH3Person	-0.2801	0.7389	-0.0751	-0.1611	-0.0307	0.0214	-0.1963
	HH4Person	-0.3181	0.8709	0.0110	-0.1629	0.0053	0.0029	-0.0192
	Femaleto25	0.5323	0.1620	-0.4461	-0.2426	-0.1185	-0.3070	0.3251
	Female25to65	0.5003	-0.4964	-0.1217	-0.3704	-0.0907	0.2467	-0.3242
	Female65andUp	-0.0834	-0.5646	0.3401	0.5076	0.1503	-0.1542	0.2539
	Maleto25	0.5588	0.1785	-0.4769	-0.1676	-0.1855	-0.2638	0.2765
	Male25to65	0.4884	-0.5204	-0.1452	-0.3387	-0.0074	0.2838	-0.2971
	Male65andUp	-0.0691	-0.5829	0.4568	0.3842	0.0858	-0.1345	0.2088
	NonWhite	0.3274	0.2049	-0.4995	0.1949	0.2118	0.4104	0.2034
	MedAge	-0.3060	-0.4570	0.6539	0.2765	0.1436	0.0158	-0.1778
	Below150PvThr	-0.4366	-0.3010	-0.1636	0.0154	-0.0748	0.0792	0.2999
	MedHomval	0.6357	0.3681	0.3154	0.2692	0.1939	0.0796	0.0026
	OCC_MBASO	0.5876	0.3790	0.3371	0.2782	0.0652	-0.0362	0.0087
	OCC_NRCM	-0.6357	0.1038	0.0098	-0.0733	-0.0915	-0.0136	-0.0583
	OCC_PTTM	-0.7896	0.3130	0.0049	-0.0494	0.0983	0.0630	0.0998
	HSorEqvInt	-0.6486	-0.3865	-0.2577	-0.3235	0.0390	0.0400	0.0878
	DegreeBA	0.6426	0.3422	0.3776	0.2591	-0.0486	-0.0672	-0.1187
	DegreeAdv	0.6361	0.3774	0.3317	0.3595	0.0552	-0.0341	0.0433
	Smartphone	0.8891	-0.0712	-0.0058	-0.1605	-0.0982	0.0235	0.0106
	Tablet	0.8455	-0.0719	0.0790	-0.1865	-0.1222	0.0478	0.0239
	Broadband	0.8584	-0.2929	0.0895	-0.1328	-0.0966	-0.0286	0.0407
Correlation Indices	*Moran's I*	0.6550	0.3860	0.2050	0.3970	0.4570	0.2370	0.1010
	Pearson Correlation with Density	0.2787	0.1928	-0.4014	0.2057	0.3534	0.4226	0.1286
	Bivariate Moran's I with Density	0.305	0.206	-0.164	0.147	0.297	0.29	0.059

Table 2. Summary of Traditional Principal Component Analysis. Interpretation Notes: Variable loadings may be either positive or negative and it is rather the absolute value, i.e. its distance from 0 that is most important. Thus, negative loadings can just as strongly characterize a principal component as a positive loading. The choropleth scheme is employed to reinforce this point. Correlation summaries are given at the bottom. (Source: Author)

Part 1: Results of Principal Component Analysis

Seven out of thirty-two principal components (PCs) were initially selected for further analysis based on the Kaiser criterion of having an eigenvalue of greater than one. These seven PCs collectively explain 75 percent of the variance in the data set. These PCs are in effect synthetic variables to which the original thirty-two variables are correlated either positively or negatively, over a range of magnitudes. The higher the absolute value of a loading, the more closely identified with the PC a given variable is. A complete summary of the seven PCs, including their variable loadings, is given in Table 2, which additionally contains correlation indices for the PCs. These indices show global spatial autocorrelation (i.e. spatial correlation of a PC with itself), attribute correlation with density, and global spatial correlation between the PCs and density, or rather, the spatial lag of density. Since multiple variables can be strongly correlated with a single PC, it is useful to think of these PCs as complex socio-economic profiles. A description of these profiles is given in Table 3 for future reference and for the sake of brevity, *PC 1*, *PC 2*, *PC 3*, etc... will mostly be used instead of the descriptor in the rest of the results section.

Principal Component	***Description***
PC 1	Tech-Ed-MBASO
PC 2	Larger Professional Households
PC 3	Older, 2-Person, 2-Vehicle Households
PC 4	Older, 1-Person Households
PC 5	Long Commutes
PC 6	Non-White, 2-Person Households, Transit
PC 7	Economically Distressed, 2-Vehicle Households, Non-White

Table 3. Brief Descriptions of Selected Principal Components. Interpretation Notes: Consult Table 2 for Explanation of Principal Component Characteristics (Source: Author).

The initial interpretation of the seven principal components has been informed both by a careful reading of the PCA summary provided in Table 2 and the mapped clusters of spatially autocorrelated PCs in Figure 2. PC1 accounts for over a quarter (25.78 percent) of the variance in the original data set, and showing significant spatial autocorrelation, with statistically significant high-high value clustering near large urban areas and in some rural settings where several higher education institutions are located (i.e. the Five Colleges area in western Massachusetts). PC1's spatial clustering patterns are not surprising given its profile (refer back to Tables 2 and 3). PC2 is moderately spatially autocorrelated and clustered *near* the major cities of Boston and New York City (along the "Gold Coast" of Connecticut). PC3 is weakly autocorrelated and far more geographically dispersed in its clustering, as it is in fact more representative of lower density and even some rural areas than urban ones. PC4 shows an interesting pattern of dispersal across the region that is harder to interpret, as it

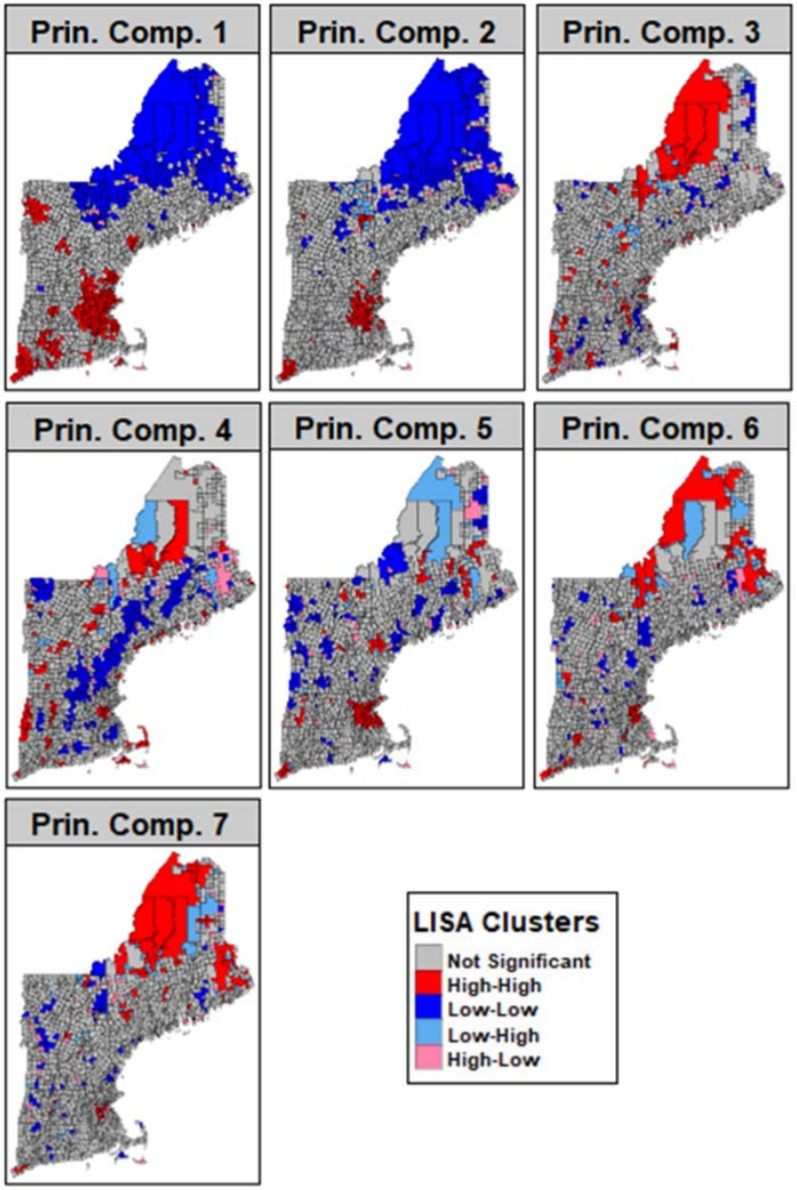

Figure 2. Spatial Autocorrelation of First Seven Traditional Principal Components from PCA. (Source: Author using GeoDA software, Results mapped in 'tmap' package in R).

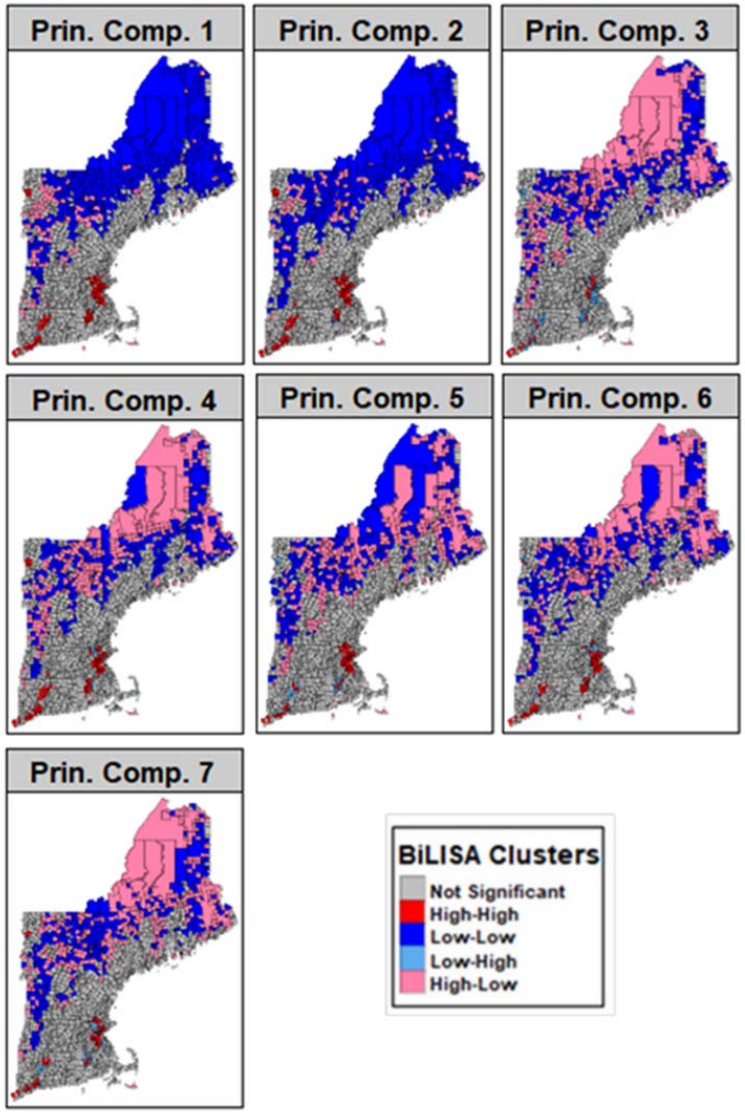

Figure 3. Bivariate Local Moran's I of First Seven Traditional Principal Components from PCA and Population Density. Interpretation Notes: The spatial correlation seen below are between the principal components and the spatial lag of population density. It does not represent a one-to-one spatial correlation analysis between a principal component and density. Rather, it shows the spatial relationship of spatial dependence between the PC in question and general area conditions of density as measured by the lag at each location. (Source: Author using GeoDA software, Results mapped in 'tmap' package in R).

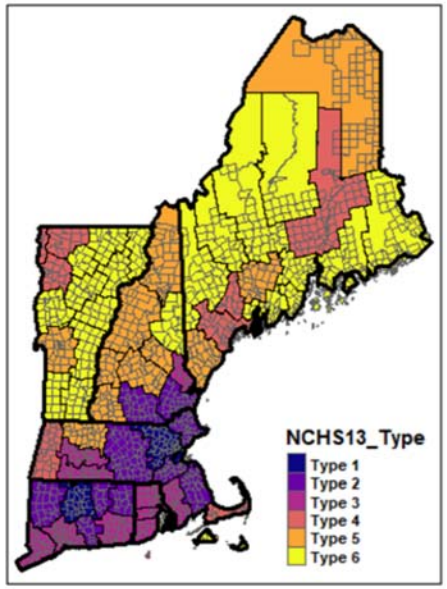

Figure 4. National Center for Health Statistics (NCHS) 2013 Six-way County Typology. (Source: Author using 'tmap' package in R).

appears in both in some urban areas as well as more rural tourist destinations such the Berkshire mountains, Cape Cod, and the White Mountains of New Hampshire. PC5 is squarely defined by longer commuting behavior and thus can be found both on the periphery of urban areas as well as rural ones. PC6 is clustered in urbanized areas but does not register as being strongly spatially autocorrelated, perhaps an artefact concentration of its profile in a relatively small number of towns vis-à-vis the whole of New England. PC7's pattern of clustering is very difficult to discern given its only negligible positive autocorrelation.

Local Spatial Dependence between PCs and Population Density

The principal components' profiles (Table 3) and patterns of spatial autocorrelation (Figure 2) have described internal relationships between original variables and their geographic concentration. Given the known spatial patterns of density, particularly the spatial lag of density (refer back to Figure 1), and the measured spatial patterns of autocorrelation among the PCs, it was mostly anticipated that there would be identifiable clustering of high values of the PCs with high values of population density. In fact, the PCs' statistical relationships demonstrate mildly positive relationships with density in all but one, PC3. *The Pearson's correlation coefficient and the bivariate global Moran's indices given above (see Table 2) establish that a statistical and spatial relationship exists* but does not demonstrate exactly where this correlation is found. The bivariate local Moran's I of the PCs and population density is mapped in Figure 3. A cautious summary and interpretation of the spatial dependency between the PCs and what amounts to the spatial lag of density follows. PC1 and PC2 are clearly positively spatially correlated with the general density characteristic of urbanized areas and have a conversely negative correlation with low density areas of rural northern New England. High-High correlation clusters between PC3 and density are rather scant, with more mixed but statistically significant clustering occurring in the north. The remaining PCs demonstrate a pattern that has more emphasis on High-High clustering in urbanized areas while at the same time having mixed clustering in the north.

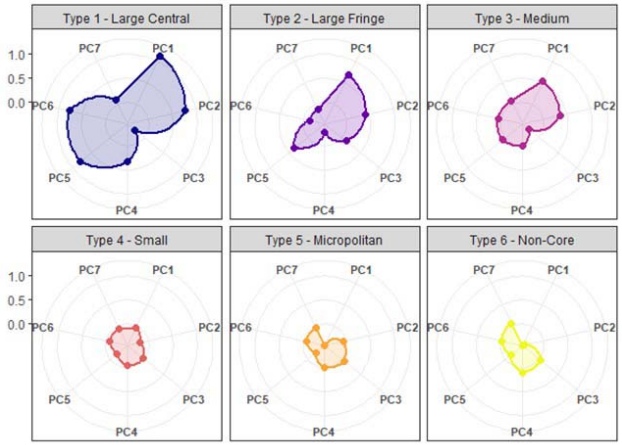

Figure 5. Polar Coordinates Chart of Relative PC Importance for Six NCHS County Types (Refer to Figure 4) in New England. (Source: Author using 'ggplot2' package in R).

Geography has been related *to* principal components as part of the analysis thus far. Conversely, the perspective can be reversed, and multiple PCs related to a geography type. Using the 2013 NCHS County Typology (see Figure 4), the relative importance of PCs to towns falling within a given county type can be assessed (see Figure 5). Large metropolitan counties (Type 1) such as Hartford County in Connecticut and Suffolk County (home of Boston) in Massachusetts, are highly defined by PC1, PC2, PC5, and PC6. Briefly considering these PCs' profiles: there is a prominent role played by educated professionals, their families, technological consumption in urban and suburban areas. Long commutes and non-white, transit using, two-person households (PC6) are also typical, although presumably with slightly different spatial distributions within each county (outer suburbs vs inner suburbs and central city). It can be seen PC1, PC2, and PC5 retain at least some measure of their importance through all but the smallest county types. PC3 and PC4 have alternating levels of relative importance in larger county types but stabilize into moderate importance in smaller ones. As the relative influence of PC1 and PC2 recede in Small (Type 4), Micropolitan (Type 5), and Non-core (Type 6) counties, the relative influence of other PC profiles, such as PC7, begins to be felt. An interesting observation is that small metro counties (Type 4) combine many characteristics of all PCs in moderate fashion but appear to skew to a slightly younger cohort (PC1 vs PC2). These counties are located, for example, around Bangor, Maine, Berkshire Mountains in western Massachusetts, the Burlington, Vermont area, the Cape Cod peninsula, and near Lewiston, Maine. All these counties have notable colleges and universities.

The principal components analyzed above are "global" in nature and reflect a set of constant relationships between contributing variables and their representative principal components. Although these PCs and their relationship to density display spatial

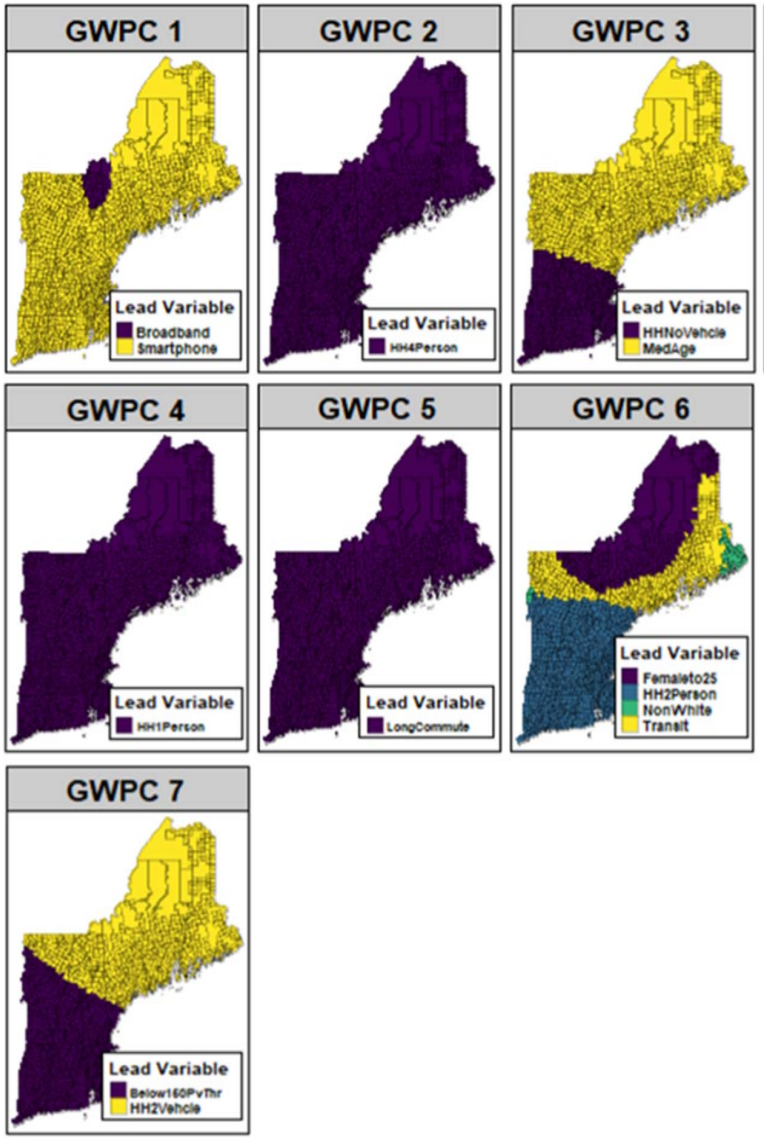

Figure 6. Winning Variable Results for Each Principal Component in Geographically Weighted Principal Component Analysis. (Source: Author Using 'GWmodel' package in R, Mapping Results using 'tmap' package in R).

dependence, this analysis was not fully spatial in the sense that it does not provide for a means of identifying heterogeneity in attribute values across space. One possible approach to this problem is by extending the PCA fully into the spatial domain using a geographically weighted principal component analysis.

Part 2: Geographically Weighted Principal Component Analysis (GWPCA)

A GWPCA offers a more complex analysis of the spatial patterns underlying the PCs and their contributing mobility-related variables than traditional PCA. The GWPCA was performed using the "GWModel" package in R on the same set of variables as the traditional non-spatial PCA above. All data were scaled (z-score normalization) before being put in the model. A non-adaptive kernel function of "exponential" was chosen. A GWPCA consists of both a traditional PCA (that should yield nearly identical results to any other PCA on the same data set) and a spatial one. The outputs of GWPCA include ranges of variance across space as well as the contribution of variables. In effect, each location has its own local PCA, with the "local area" being determined by the kernel function. Despite the sophistication of the analytical tool, the visual output is rather simple. Several types of maps can be produced, including one that displays the *spatial variation* of total cumulative variation of PC1 to a subsequent PC, and the second type displays the "winning" variable for each location, something that helps address the question of which contributing variable for a given PC matters the most for a location. Only "winning" variable maps will used in this analysis.

The results of GWPCA (especially when viewing their mapped patterns) must be treated with caution as they are greatly affected by which variables are included (just as is the case with traditional PCA) but also by the bandwidth selection. Given the potential for variability, it is best to use this method as an exploratory one. With this precaution in mind, the mapped results of the GWPCA on the thirty-two variables in this analysis will be discussed as an additional consideration to the traditional PCA rather than formally analyzed in their own right (see Figure 6). In contrast to global PCA where the "winning" variable for a PC would remain constant, in GWPCA the "winning" variable is allowed to vary over space. The variable with the highest absolute loading for a given location is mapped. As such, it is all the more telling that for GWPC1, GWPC2, GWPC4, and GWPC5 one variable dominates (or very nearly so...) the whole region. GWPC3, GWPC6, and GWPC7 see greater spatial variability in which contributing original variable is the most important. The winning variables from this GWPCA are all important in their corresponding traditional PC, being at or nearly at the top ranking as determined by their absolute value. Substantively they show that these variables were regionally significant in the analysis of the data set used here.

This GWPCA discussion demonstrates that the relative importance of variables can change over space and adds to the discussion of the traditional PCA by confirming the importance of top contributing variables. However, there are two caveats to bear in mind: 1) is the aforementioned potential for instability in geographically weighted results (owing to which variables are included and bandwidth), and 2) is the fact that there may be little quantitative difference between, for example three candidate variables (say, A, B, C) for being the "winner"

with hypothetical loadings of 0.7356, -0.7451, 0.7196, respectively, but the variable with the highest absolute loading (e.g. variable B with | -0.7451|) will be named the winner. There is a strong possibility that many important variables would not be considered as a result. Despite these concerns, GWPCA is a valuable addition to the analytical toolkit of multivariate spatial analysis since it highlights the diversity relationships between variables across space.

Discussion

The seven selected principal components all displayed statistically significant spatial dependence with population density. A closer look at their profiles makes this unsurprising. University-educated, technologically connected, professionals and students in their younger and working years comprised PC1. They lived in more expensive homes and are able to begin their commute to work at a reasonable hour as distances traveled and time spent commuting are not that great. This profile is significantly concentrated around urban areas and college towns in New England. A similar profile was seen in PC2, only it is associated with larger families and can be understood as suburban professional families with children. These two profiles were among the most associated with the higher general density of urbanized areas. Thus, even where the original contributing variables were selected to be related to density, but not too closely as would have been the case with a measure of place-based accessibility or commuter network connectivity, the top two PCs are clearly marked by an affiliation with density. The mildly negative correlation of PC3 consisting of older, two-person, and -vehicle households and density stands out among the other PCs, but not decisively so. Long commutes (PC5) are found in both urban and rural areas but do not constitute an especially weighty PC overall. The GWPCA highlighted that a number of contributing variables can be considered the most influential vis-à-vis their PC depending upon location. Smartphones and broadband Internet could both claims to be the most important contributing variable for different areas within the PC1 profile. Other GWPCA results on winning variables can be interpreted and informative towards the traditional PCA analysis in a similar manner. A number of conclusions can be drawn from the forgoing analysis: 1) Even for socio-economic variables selected for the purpose of not being too closely associated with density, density still matters a great deal. 2) There appears to be a more dynamic relationship between urbanized (cities, suburbs, and urbanized corridors) areas and socio-economic indicators dealing with education, occupation, wealth than is the case with areas with far lower density. 3) Variables may be more important in some locations than others.

The usefulness of a PCA analysis lay in identifying important variables and creating new synthetic ones that can be used in regression modeling or the creation of indices. The seven PCs created from this analysis could certainly be used for this purpose. Additionally, the traditional PCA could also act as a filter of potential variables to include in a model and be aided in this effort by the results of a GWPCA that would explicitly name “winning” variables for given locations. Both of these applications are directly related to fitting regression models and future research could pursue them, especially in the context of travel behavior. A third benefit of PCA is in exploring the relationships between variables within the data set, performed on both a

geographic and attribute level in this analysis. This is the more immediate contribution of this research as large numbers of socio-economic variables are used in modeling transportation behavior and sometimes the relationship between them is far from clear. A PCA is only a snapshot of these relationships for a given set of specific inputs, yet nevertheless, some trends in the data relevant to the relationship between mobility, accessibility, and connectivity, all anchored by agglomeration (represented here by population density) do emerge. Although the close relationship of density to place-based accessibility (derived from a SIM) is well known, the most important socio-economic variables within this data (selected for their association with mobility) are also highly related to density, since they are most frequently found in dense, urbanized areas. All of these areas also happen to have reasonably high measures of accessibility and connectivity. It may be unclear as to how much population attributes such as wealth (home value), level of educational attainment, occupation would directly translate into higher observed levels of mobility (such as VMT), but they would certainly augment existing advantages of highway network connectivity and accessibility, thus affecting a measure such as VMT. It is clear that the spatial element of studying principal components cannot be minimized or ignored. There is pronounced spatial variation in where different PCs are important. Likewise, there is pronounced spatial variation in where constituent variables with a single PC are important. In the realm of transportation studies, this would reaffirm that the spatial distribution of socio-economic factors contributing towards mobility must be studied just as spatial variance in accessibility and connectivity.

Conclusion

The relationship between the socio-economic variables that influence mobility and population density was shown to be statistically significant. Principal component analysis allowed for a faster, unified, and more comprehensive analysis of these variables as they were too numerous to study individually and their combined influence in the form of individual PCs pointed to larger impacts that could not be described by one variable alone. Both the improved understanding of these socio-economic variables as well as the direct outputs of PCA such as the PCs and variables identified by their importance can be put towards efforts to model transportation behavior and transportation systems in future research. One specific avenue may be how socio-economic variables can help model connectivity within a regional commuter-flow network when place-based accessibility does not adequately explain this alone. Another would be to investigate the cumulative variance of geographically weighted principal components across a region and how it relates to the spatial clustering found in global principal components. This research should be of interest to scholars engaged with the study of travel behavior, especially at larger regional scales. Some practitioners in the field of transportation planning and modeling may be interested as well as this points towards methods of reducing the number of potential variables to be including in customized travel demand models. Finally, it may also be of interest to geographers with an interest in the New England region as it addresses important socio-economic patterns across the region that have application both within and beyond travel-to-work matters.

Appendix A: Traditional and Geographically Weighted Principal Component Analysis

Principal component analysis involves complex matrix operations and will only be very briefly summarized here using notation found in Harris et al. (2011). All input data considered in PCA can be summarized in *m* (number of variables) *by n* (number of observations) matrix **X**. The subsequently derived variance-covariance matrix **Σ** has dimensions *m by m* and is calculated from $\frac{\mathbf{X}\mathbf{X}^{\mathbf{T}}}{n-1}$, after original variables in **X** have been mean centered, and ideally standardized so as to eliminate size effects and distortions caused by different units of measurement, where T is the matrix transpose function. The variance-covariance matrix **Σ** is described by the equation $\mathbf{L}\mathbf{V}\mathbf{L}^{\mathrm{T}}=\mathbf{R}$ where **R** = **Σ** and is a positive definite matrix, **L** is a matrix containing eigenvectors (in this case, the loadings of each variable on the corresponding principal component), and **V** is a diagonal matrix of eigenvalues. The matrix product of **XL** creates the component scores for each observation *n*.

In contrast to the single global nature of traditional PCA, geographically weighted regression (GWPCA) enables *n* local PCAs across the study area. Each observation in the data set matrix **X** is a geographic location *i* (a point or centroid within an areal unit) with coordinates (*u, v*). A weights matrix **W** is calculated for each location i and its neighbors using a kernel function, in the case of this analysis: $w_{ij}=exp(-d_{ij}/r)$ where the weighting w_{ij} is equal to the exponentiated quotient of negative distance $-d_{ij}$ (between locations i and j) and the bandwidth r. Thus, in calculating the variance covariance matrix **Σ** in GWPCA, the weight matrix **W**, as defined above, is used in the equation:

$$\mathbf{\Sigma}(u, v) = \mathbf{X}^{\mathrm{T}}\mathbf{W}(u, v)\mathbf{X},$$

Having obtained the geographically weighted variance covariance matrix, eigenvalues and eigenvectors can be calculated for each location *i* as:

$$\mathbf{L}\mathbf{V}\mathbf{L}^{\mathrm{T}}|(u_i, v_i) = \mathbf{\Sigma}(u_i, v_i),$$

Given that each location *i* has a small PCA, it is impractical to communicate GWPCA in the same way as traditional PCA. Outputs such as local cumulative variance and identification of "winning" original variables are provided instead.

Appendix B: Indicators of Spatial Autocorrelation

The global version of Moran's index of spatial autocorrelation, referred to here as Global Moran's I, is expressed by the following equation (using notation borrowed from Anselin 2019):

$$I = \frac{\sum_i \sum_j w_{ij} z_i . z_j / S_0}{\sum_i z_i^2 / n},$$

Where the index *I* is equal the sum of the cross-product of observations of variable *x* at location *i* $(x_i - \bar{x}) = z_i$ with observations of variable *x* at location *j* $(x_j - \bar{x}) = z_j$ over the variance at location

i, $\sum_i z_i^2 / n$, where n is the number of observations. The binary (0,1) weights matrix w_{ij} filters out cross products of locations that are not classified in advance as neighbors, either through contiguity measures or some other scheme, by multiplying the cross product of location pairs either by a 1 if they are designated neighbors, or 0 if they are not. The sum of all the locational weights $\sum i \sum j\ w_{ij} = S_0$ which weights the deviation scores of z_j. Owing to the filtering of neighbors vs non-neighbors, this measures is essentially one of the correlation of variable x to the spatial lag itself.

The Global Bivariate Moran's I is similarly calculated as the univariate Moran's I above, however it differs in that it is instead a correlation between variable x and the spatial lag (average of neighbors) of variable y. The formula is given as:

$$I_B = \frac{\sum_i (\sum_j w_{ij} y_j . x_i)}{\sum_i x_i^2},$$

Where the index I_B is the sum of the filtered (by weight matrix w_{ij}) cross product of observation i of variable x with the spatial lag of variable y over the variance of x_i.

Anselin (1995) devised local variants of these global measures of spatial autocorrelation so that the clustering of statistically significant like values could be viewed on a map. The equation for the univariate Local Moran's I is given as:

$$I_i = c z_i \sum_j w_{ij}\, z_j,$$

Where the index I at location i is equal to the product of $(x_i - \bar{x}) = z_i$ and the weighted sum of $(x_j - \bar{x}) = z_j$, i.e. the spatial lag of x. The variance, $\sum_i z_i^2$, is abbreviate to c. Similarly, the Bivariate Local Moran's I is given as:

$$I_i^B = c x_i \sum_j w_{ij}\, y_j,$$

Where the index I^B at location i is equal to the product of $(x_i - \bar{x}) = x_i$ and the weighted sum of $(y_j - \bar{y}) = y_j$, i.e. the spatial lag of y, and the variance $\sum_i z_i^2$ abbreviate to c. Statistically significant clusters of index values for both I_i and I_i^B can be mapped according to the scheme of high-high, low-low, low-high, and high-low to reflect the relationship between a observation at location i compared to its neighbors, high value of x at i surrounding by low values etc.

Devon Lechtenberg is a Senior Transportation Planner at the Capitol Region Council of Governments in Hartford, Connecticut. Email: dlechtenberg@crcog.org. He holds a PhD in Geography from the University of Illinois at Urbana-Champaign (2014) and a professional Master of Urban Planning & Policy from the University of Illinois at Chicago (2017). He has professional and research interests in the application of spatial statistics and econometrics to regional transportation and land use issues.

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Disclaimer

The research presented here is my own and does not represent the opinion, position, or intentions of my employer, the Capitol Region Council of Governments (CRCOG).

Endnotes

[1] The nodes are physical locations (i.e. residential origins and work destinations) but the links are conceptual (i.e. mapped straight-line flows of commuters of varying volume reaching work by some indeterminate physical route).

[2] These applications were first stated by Gould (1967) but were cited in Harris et al. (2011) as: "(a) measures of terrain roughness; (b) the varying spatial nature in the connectivity of towns; (c) orientations of physical features and transport networks; (d)characteristics of mean information fields (Hägerstrand 1967); (e) classification; (f) homogeneity of architectural features; (g) measures of residential desirability; and (h) the interpretation of mental maps." (1718).

[3] The "FactoMineR" package was developed by Le Sebastien and Husson (2008). It contains the algorithms for PCA. Kassambara and Mundt (2020) specifically developed "factoextra" to work alongside "FactoMineR" and visually communicate the complex PCA output. The R package "corrplot" (Wei and Simko 2017) is also used for visualization. Kassambara (2017) encouraged and demonstrated the coordinated use of these three packages in a practical introductory text to multivariate analysis.

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STATISTICAL ANALYSIS OF RISK FACTORS Contributing to Chronic Obstructive Pulmonary Disease Prevalence In The Southeast United States

Erick Bora
Colorado School of Mines

ABSTRACT

Chronic Obstructive Pulmonary Disease (COPD), currently the fourth leading cause of death worldwide, is projected to become more problematic by 2030 unless appropriate actions are taken to reduce the major risk factors that contribute to COPD. However, the spatial distribution of individuals with COPD and the many potential factors that contribute to this disease make prevention methods difficult to discern at a national level. Thus, COPD must be evaluated at a local scale. This study analyzed the spatial distribution of COPD prevalence per county for the area south of the Ohio River and east of the Mississippi River which has experienced the highest COPD prevalence in the United States. Additionally, this study statistically analyzed the significance of socioeconomics, air quality, physical inactivity, household size, smoking, and occupation in predicting observed rates of COPD. Results show that high COPD rates clustered in eastern Kentucky, western Virginia, and southern Missouri, which correlated with areas of high smoking rates. Smokers, age, construction workers, healthcare workers, and physical inactivity were statistically significant in predicting high COPD prevalence. Thus, medical and healthcare professionals should focus on addressing these issues in this area of the country to reduce the risk of COPD.

Keywords: Chronic Obstructive Pulmonary Disease, Geographic Information Systems (GIS), Occupation, Regression, Risk Factors

Introduction

Chronic Obstructive Pulmonary Disease (COPD) is an umbrella term used to describe the progressive deterioration of lung strength and function due to a broad range of lung diseases, which include emphysema, chronic bronchitis, and asthma. COPD is a progressive respiratory disease, thus its severity increases overtime. Individuals affected by COPD suffer from the airways in their lungs becoming inflamed and thickened, thereby destroying the tissues where oxygen is exchanged, which makes it hard to breathe. Symptoms of COPD include shortness

of breath during everyday activities, a lingering cough (dyspnea), and fatigue (American Lung Association 2019). Additionally, overtime COPD weakens the rest of the body, increasing the likelihood for the individual to develop other serious chronic diseases including heart attacks and strokes.

According to the most recent Global Burden of Disease Estimate, approximately 174.5 million individuals worldwide have been diagnosed with COPD, which equates to approximately 2.3 percent of the world's population (Hart et al. 2018). In 2015, approximately 3.2 million deaths were caused by COPD (Hart et al. 2018). As of 2018, COPD is the fourth leading cause of death worldwide, behind cancer, heart disease, and stroke (Kauhl et al. 2018). By 2030, COPD is projected to become the third leading cause of death unless necessary steps are taken to reduce the underlying risk factors of COPD, specifically reduce smoking (WHO 2018).

COPD prevalence is higher in the Americas more than any other region of the world. In the United States, almost 15.7 million individuals have been diagnosed with COPD, which is approximately 6.4 percent of the country's total adult population (Wheaton et al. 2015). Within the United States, the area with the highest age adjusted prevalence of COPD is in the region to the south and east of the Mississippi and Ohio Rivers (Wheaton et al. 2015).

Many factors affect the severity and prevalence of COPD. Of most significance is cigarette smoking; approximately 80 percent of all COPD cases worldwide are caused by cigarette smoking (Liu et al. 2018). Cigarette smoke releases over 7,000 harmful chemicals and substances into the lungs which weakens the lung's defense against infection, narrows airway passages, causes swelling in air tubes, and destroys air sacs – all of which are contributing factors to COPD (American Lung Association 2019). Another contributor of COPD is air pollution and exposure to particulate matter or secondhand smoke. Nearly 20 percent of all COPD cases are among people who are non-smokers (Olloquequi et al. 2018). Biomass smoke, smoke caused from the burning of organic matter, is referred to as the main cause of COPD among non-smokers (Olloquequi et al. 2018). Particulate matter in the atmosphere caused by air pollution or biomass smoke has a similar effect on the lungs as smoking cigarettes in that the toxic particles clog lung airways and weaken the lungs' defense against infections.

COPD is most common in individuals aged 55 years old or older, which accounts for approximately 35 percent of all COPD cases in the United States (Wheaton et al. 2015). This is mainly because individuals are not diagnosed with COPD until after they have lost 50 percent of their lung function (Wheaton et al. 2015). Overtime, the lungs start to weaken, and individuals become more prone to other significant respiratory diseases. COPD causes progressive damage to a person's lungs which increases an individual's chance of developing other chronic diseases (Gaunt 2020). COPD tends to affect females (specifically elderly) more so than males – 8.9 million to 6.7 million cases in the United States – due to higher use of tobacco among women in higher income countries, like the United States (Wheaton et al. 2015). Women also have a higher risk of exposure to indoor air pollution from biomass smoke created from cooking or heating, which has caused female COPD cases to increase in recent years (WHO 2019). Female lungs are also more susceptible to lung damage from cigarette smoke and particulate matter because they are smaller than male lungs (American Lung Association 2019).

Additional factors that influence the likelihood of developing COPD include physical activity and living conditions. It has been well documented that increased physical activity in COPD patients can lead to fewer hospitalizations and reduce mortality rate (Boeselt et al. 2016). Due to progressively decreased lung strength, COPD patients have significantly reduced duration, intensity, and step count numbers due to the associated muscle weakness and limited mobility from COPD (Boeselt et al. 2016). While physical activity may be challenging for COPD patients, exercise is an important component of pulmonary rehabilitation to increase lung strength and function (Wheaton et al. 2015). Additionally, average household size may contribute to COPD. A study conducted in Germany (Kauhl et al. 2018) found that persons residing in a living community or shared apartments of unmarried people in steady relationships were at a high risk for exposure to secondhand smoke, and thus at higher risk for developing COPD.

Race has also played an important role in COPD prevalence. Between 2000 and 2014, the age-adjusted rates of death due to COPD declined by 21.1 percent in Non-Hispanic White (NHW) males and by 24.4 percent in black males, but increased in black females by 4.2 percent with no change in rates for NHW females (Ejike et al. 2019). It is believed that COPD prevalence in African American individuals will increase in the coming years if the prevalence of smoking continues to remain high in black individuals than white individuals (Ejike et al. 2019). In a study conducted by Chatila et al. (2004), showed black patients who were diagnosed with COPD were younger and had lower cumulative tobacco smoke exposure with similar lung function to their white counterparts. This is attributed to varying socio-economic factors including household size and median income. A study conducted by Hankinson et al. (1999) indicated that black individuals tend to have lower lung function than white individuals of the same age. This difference has been attributed in part to smaller trunk/leg ratios in black individuals. On average, black individuals smoke fewer cigarettes and start smoking at an older age than white individuals, but black individuals are more likely to die of smoking related diseases (i.e. COPD) than white individuals. It is still unclear what causes this trend, but black individuals appear to have greater nicotine intake from tobacco smoke and lower renal clearance of cotinine, which indicates recent exposure to tobacco smoke (Ejike et al. 2019). By comparison, in a U.S. study conducted by Wheaton et al. (2015), Asian individuals had the lowest age-adjusted COPD prevalence of any race (2.0 percent) compared to white (6.3 percent) and black individuals (6.5 percent).

The effect of industry and job status on COPD prevalence has yet to be considered as a contributor to COPD in the United States. Larger urban areas are characterized by higher pollution levels, including particulates. A study in Germany indicates that a strong correlation exists between mining or steel manufacturing industries and air pollution (Aschan-Leygonie et al. 2013). Urban areas, which are more developed, generally have more industries and thus will likely have more particulate matter in the atmosphere compared to a rural setting. Therefore, certain occupations could be at a higher risk for developing COPD depending on exposure to higher levels of particulate matter in occupations where most of the time is spent outside (farmer, construction worker) and/or likelihood to smoke due to stress from an occupation (nurse or teacher).

Medical service involves care-taking of individuals who are sick or injured and any mistakes or errors could be costly and sometimes fatal (Familoni 2008). Not only are medical professionals prone to the same stresses as the general population, but these individuals must also cope with increased stress from their professions. According to a report published by the American Foundation for Suicide Prevention, on average, death by suicide is 70 percent most likely in male doctors than among other professionals and 250-400 percent higher among female doctors, with the major causes by stress and depression caused by the jobs (Familoni 2008). Early individual behavioral reactions among medical students may include onset or increased smoking or alcohol use as a way to cope with the increased stress (Familoni 2008). Medical students and professionals can also become "burnt out" which consists of emotional exhaustion, depersonalization of patients and colleagues, and low productivity/achievements which leads to an increase in stress and potential increase in smoking and alcohol use, deterioration of physical and mental health, and premature deaths (Familoni 2008).

Even though many educators feel their work is important and rewarding, a high degree of stress and "burn-out" is common in this profession. Occupational stress among teachers is associated with several factors including time pressure, discipline problems, lack of resources, lack of professional recognition, lack of support and the diversity of tasks required (Skaalvik & Skaalvik 2015). A majority of teachers tested and interviewed by Skaalvik & Skaalvik (2015) reported that workload and time pressure were extremely stressing. A typical day for a teacher can involve lesson planning, grading, meetings, and communication with students, parents and staff members. These factors accompanied by the low financial compensation can all contribute to added stress for educators who look to smoking as a form of stress release.

Both farmers and construction workers predominantly work in the outdoors, increasing their risk of exposure to harmful particulates in the atmosphere, the other major cause of COPD. A typical farmer can be subjected to various respiratory exposures on their farm including organic and inorganic dusts, bacteria, toxic gases like ammonia and hydrogen sulfide, and endotoxins (Elliot and Von Essen 2016). These particulates can enter the lungs and lead to COPD and other respiratory diseases overtime. The same is true for construction workers, who are exposed to various chemicals and particulates at a job site. According to Borup et al. (2017), the occupational exposure limit (OEL) for respirable dust is set at 5 mg/m3 in the United States, but this exposure limit was exceeded by 11 percent in the construction industry. As such, farmers and construction workers were included in this study given their association with a primary risk factor of COPD diagnosis.

Beneficiaries of this study include medical professionals and the health science communities who will gain a better understanding of which risk factors are most likely to contribute to COPD prevalence in certain areas of the United States. Knowing this information will allow doctors to better mitigate these risk factors and lower the risk of people developing COPD in the future. Understanding what major risk factors contribute to COPD development will allow medical professions to take the necessary precautions to reduce the severity of their disease and prescribe the proper treatment procedures.

The distribution of individuals suffering from COPD is high in the United States and previous research has shown that COPD prevalence is concentrated south and east of the Ohio and Mississippi Rivers. Unfortunately, the research to explain why COPD levels are high in these areas is limited. Therefore, the objective of the study was to analyze the spatial distribution of COPD prevalence and statistically determine the significance and spatial relationship of age, gender, smoking habits, air pollution, physical activity, household size, and job status to better understand the distribution patterns of COPD across the southeastern United States.

The United States is one of the most developed nations in the world, yet a limited number of studies have been conducted in the United States. Boeselt et al. (2016) evaluated the effect of physical activity as a treatment for COPD, rather than considering physical activity, or lack thereof, as a contributor to COPD prevalence. Additionally, COPD prevalence studies have used drastically variable sample sizes, with some studies as low as 20 patients (Boeselt et al. 2016). Studies that use larger sample sizes, such as this study, and use data on the general public (not just individuals with COPD) will increase the precision or confidence level in our conclusions regarding COPD prevalence distributions. Estimates always have some level of uncertainty, but a larger population size accounts for more variability, and will be more reflective of the entire population (Littler 2019).

Methods

Data for this study was collected from a variety of sources. Demographic data including population, gender, age, physical activity and household size were collected for each county from the U.S Census Bureau (2016). County data for adult smoking rates was collected from Data U.S.A (2017). Smoking data from 2017 was considered for this study, as it was the most recent data provided. In order for an individual to be included in this analysis, they must be considered a consistent smoker, to better understand the relationship between tobacco smoking and COPD crude rate. Crude COPD rates (COPD cases per 100,000 people) was provided by the Center for Disease Control (CDC) Wonder (2016). Average particulate matter (2.5 micrometers) was obtained from the U.S. Environmental Protection Agency (2018). Occupation data which included the total number of farmers, healthcare workers, construction workers, and education professionals per county were obtained from the U.S. Census Bureau (2018). County data was used for this analysis as the data was readily available through the U.S. Census Bureau and other sources. The goal of this analysis was to spatially and statistically determine where in the southeast United States COPD crude rates were created by various socioeconomic factors and county data better shows which regions of the county are affected rather than city data, as much of the population of the southeast U.S. resides in rural areas. According to the Centers for Disease Control and Prevention (CDC) (2019), adults living in rural areas are also more likely to be heavy smokers (more than fifteen cigarettes per day) than adults living in urban areas. Demographic, physical activity, smoking, COPD crude rate, particulate matter, and occupational data was organized and spatially analyzed by county using ESRI ArcGIS software.

The Tobacco Nation States are a 13-state region in the southeastern and Midwest United States stretching from Alabama to Michigan where tobacco smoking rates are higher than the rest of the nation. In the Tobacco Nation States, 21 percent of the adult population smokes, compared to 15 percent of adults in the rest of the U.S. These states have a lower household income (25 percent less than the typical U.S. resident) and cigarettes are cheaper compared to the rest of the country (Galvin 2019). Cigarettes are also cheaper in the Tobacco Nation States: $5.69 per pack compared with $7.05 in the rest of the United States (Galvin 2019). Particulate matter is also high in these states, specifically in the Appalachia region where the mountains were exposed to mountaintop removal mining which destroys the top of mountains to reach profitable coal seams. As a result, tons of particulate matter get released into the atmosphere. (Appalachian Voices 2017) Tobacco smoke and exposure to particulate matter are the most significant factors that contribute to COPD prevalence and are the reason why COPD rates are higher in the southeastern United States.

The study area assigned for this analysis encompassed eight of the thirteen Tobacco Nation States: Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Missouri, South Carolina, and Tennessee. The other five Tobacco Nation States (Michigan, Indiana, Ohio, Oklahoma, and West Virginia) were not included in this analysis as the goal of this study was to focus on the southeastern United States. The other states included in this analysis were Florida, Georgia, North Carolina, and Virginia. As mentioned, smoking is not the only cause of COPD. Particulate matter is also higher in the southeast United States than other areas of the country. According to the World Health Organization (2018), the guideline for annual average fine particulate matter is 10 $\mu g/m^3$. Much of the southeastern United States sits above these levels, with the average reading for a county in the southeast United States at 12.3 $\mu g/m^3$ (Data U.S.A. 2017).

According to the U.S. Census Bureau (2018) the total population of the twelve states included in this analysis is 89,247,684. 72.45 percent of this region is comprised of white individuals, 21.53 percent are African American, and 3.04 percent are Asian (U.S. Census Bureau 2018). The average adult smoking rate for this region is 20.01 percent (Data U.S.A. 2017). The average COPD crude rate by county is 55.01 percent (CDC 2016). Missouri (67.08 percent), Kentucky (67.01 percent) and Tennessee (61.82 percent) had the highest COPD crude rates by state in the region (CDC 2016). Every state in the region was above 41 percent, with Louisiana as the lowest in the region with a 41.69 percent crude rate (CDC 2016).

All demographic and occupational data was normalized in Esri ArcGIS. Percent of individuals over 55 years of age, those most at risk for COPD was calculated by dividing the total number of individuals over 55 years of age for each county by the county population. Since females have been more affected by COPD in recent years, percent of females were considered and calculated by dividing the total number of females (in all age groups) by the total population of the county. Physical activity data was normalized by dividing the total number of people deemed physically inactive (reporting no physical activity in last 30 days) by the total population of the county. Household sizes of three or more individuals were considered for this study as it is greater than the national average of 2.53 persons (Statista 2019). Rented and owned households with more than three individuals were divided by the total number of

housing units per county. Occupational data included the total number of individuals working as farmers, construction workers, healthcare workers and educational professionals which was divided by the total number of individuals employed over the age of sixteen to calculate the percentage of individuals employed as farmers, construction workers, healthcare workers and educational professionals for each county in the southeast United States.

To determine if COPD rates per county were clustering in the southeastern United States, the Hotspot Analysis tool was used. Results spatially identify where high and low COPD crude rates cluster at the 95 percent confidence interval. To determine the proper distance for the Hotspot Analysis, the Incremental Spatial Autocorrelation Tool was used, which relates different distance values to identify the peak z-score where spatial processes promote clustering.

Kauhl et al. (2018) conducted a spatial analysis to explain which populations were at greatest risk for COPD across northeast Germany. The factors tested included: age, migration background, household size, and area deprivation. Kauhl et al (2018) concluded that a global regression model was effective and therefore was used here. To explain the observed COPD crude rates per county, the Ordinary Least Squares Regression tool, which determines which explanatory variables were significant in predicting COPD crude rates per county at the 95 percent confidence interval. The global model produced coefficients for each explanatory variable in relation to the dependent variable. P-values were the probability that the spatial pattern was created by a random process (the null hypothesis). R^2 value (percentage of the dependent variable proven by the explanatory variables), Variance Inflation Factors (signify redundancy), the Jarque-Bera Statistic, which tests the distribution of the residuals from the regression and the Koenker Statistic which determines which factors were more significant in specific locations in the study area were all obtained through the OLS. The Spatial Autocorrelation tool plotted the residuals (errors) of the analysis and generated a Z-score and P-value to determine if the error was normally distributed or clustered.

The study conducted by Kauhl et al. (2018), used a Geographically Weighted Regression (GWR) to spatially analyze which regions of northeastern Germany were at greatest risk to COPD. A GWR local regression model was successful in predicting COPD cases in Northeastern Germany and therefore was used here. The Geographically Weighted Regression tool was used to construct a linear regression model on a local scale for each county within the southeastern United States to determine which explanatory variables were most significant at predicting COPD crude rates in certain regions of the southeast United States. In order to determine whether the residuals of the local model were random or clustered, the ESRI Spatial Autocorrelation tool was run again using the results of the GWR. A random distribution of the residuals was ideal in proving the validity of the analysis.

Results

High COPD crude rates with above 90 cases per 100,000 people were observed in Kentucky (Floyd, and Harlan counties), Missouri (Wayne and Hickory counties), and Arkansas (Woodruff and Fulton counties). Tampa, FL also had COPD crude rates above 90 (Figure 1). The thirteen risk factors tested to predict COPD crude rates yielded unique statistical results,

summarized in Table 1. The percentage of educators were well dispersed across the southeast United States. Counties with more than 9 percent of employed adults as educators were high in Missouri (Boone and Pulaski counties), Virginia (Abermarle and York counties), and Florida (Alachua and Lafayette counties) (Figure 2A). Healthcare workers were most numerous (greater than 9 percent) along the Mississippi River, in Missouri (Randolph and Madison counties), Mississippi (Rankin and Monroe counties), and Arkansas (Craighead and Saline counties) (Figure 2B). Farmers were not very numerous in the southeast United States (most of the area was less than 3 percent), but there were some counties with higher values namely in Georgia (Colquitt and Appling counties) Florida (Hardee county) and Arkansas (Lee county) where more than 9 percent of employed adults were farmers (Figure 2C). High levels of construction workers were more clustered, specifically in Louisiana (Cameron and De Soto counties), Arkansas (Stone and Montgomery counties) and Mississippi (Clark and Kemper counties) all had more than 9 percent of working populations as construction workers (Figure 2D).

Variable	Coefficient	P-Value	Robust_Pr	VIF
Intercept	-54.588846	Not Significant	0.000037	---
Average Particulate Matter (μg/m3)	-0.185737	Not Significant	0.407148	1.032230
Percent Smokers	2.235644	$p < 0.05$	0.000000	1.341076
Percent Healthcare Workers	0.714083	$p < 0.05$	0.004177	1.121923
Percent Farmers	0.501076	$p < 0.05$	0.027002	1.245767
Percent Construction Workers	0.154842	Not Significant	0.466612	1.197040
Percent Educators	-0.044576	Not Significant	0.856858	1.156721
Percent Households 3 or More	-0.176197	Not Significant	0.084837	2.458239
Percent Over 55	1.142801	$p < 0.05$	0.000000	3.423692
Percent Females	-0.108189	Not Significant	0.556365	1.586516
Percent White	0.918431	$p < 0.05$	0.000139	43.327382
Percent Black	0.053261	Not Significant	0.655329	39.880672
Percent Asian	-0.102691	Not Significant	0.241646	1.974076
Percent Physically Inactive	0.037783	Not Significant	0.385825	1.025974

Table 1. Raw data statistics for COPD Crude Rate and dependent variables tested in analysis.

The highest rates of households with three or more individuals were highest in northeast Virginia (Chesapeake, York, and Loudoun counties), Georgia (Coweta, Walton, Bartow, and Chattahoochee counties) and southern Louisiana (Cameron and Plaquemines counties) was also among the highest rates for above average household sizes (Figure 3A). Across the entire southeast United States, a large majority of the counties had between 50 percent and 52 percent females. Some counties did have higher levels of females, mainly in Mississippi (Attala, Holmes, and Smith counties) (Figure 3B). Average particulate matter (2.5 μm) was highest (greater

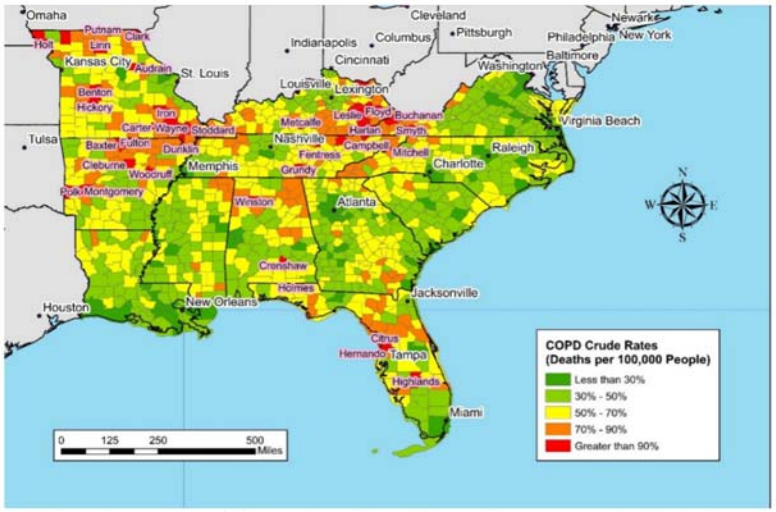

Figure 1. COPD crude rates in 2016 for southeast United States. Major cities are highlighted in white and counties within the highest class break are highlighted in pink.

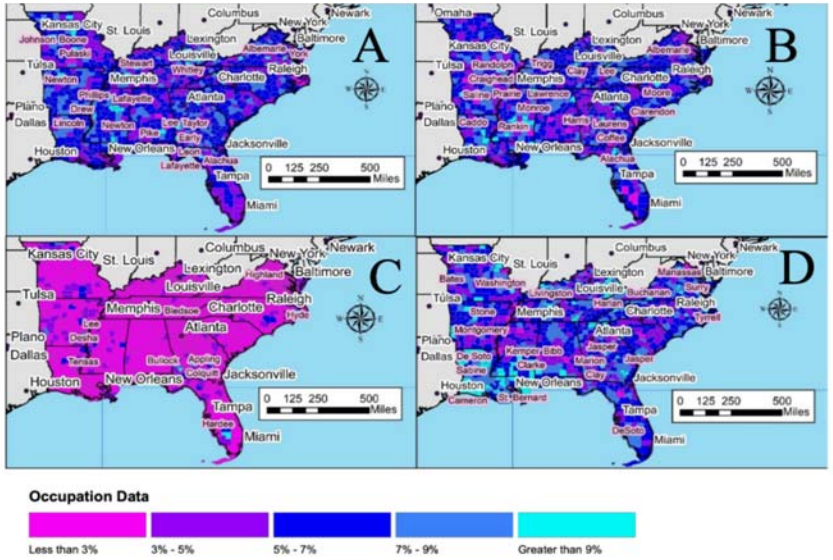

Figure 2. Distribution of occupations for educators (A), healthcare workers (B), farmers (C), and construction workers (D) in the southeast United States. Major cities are highlighted in white and counties within the highest class break are highlighted in pink.

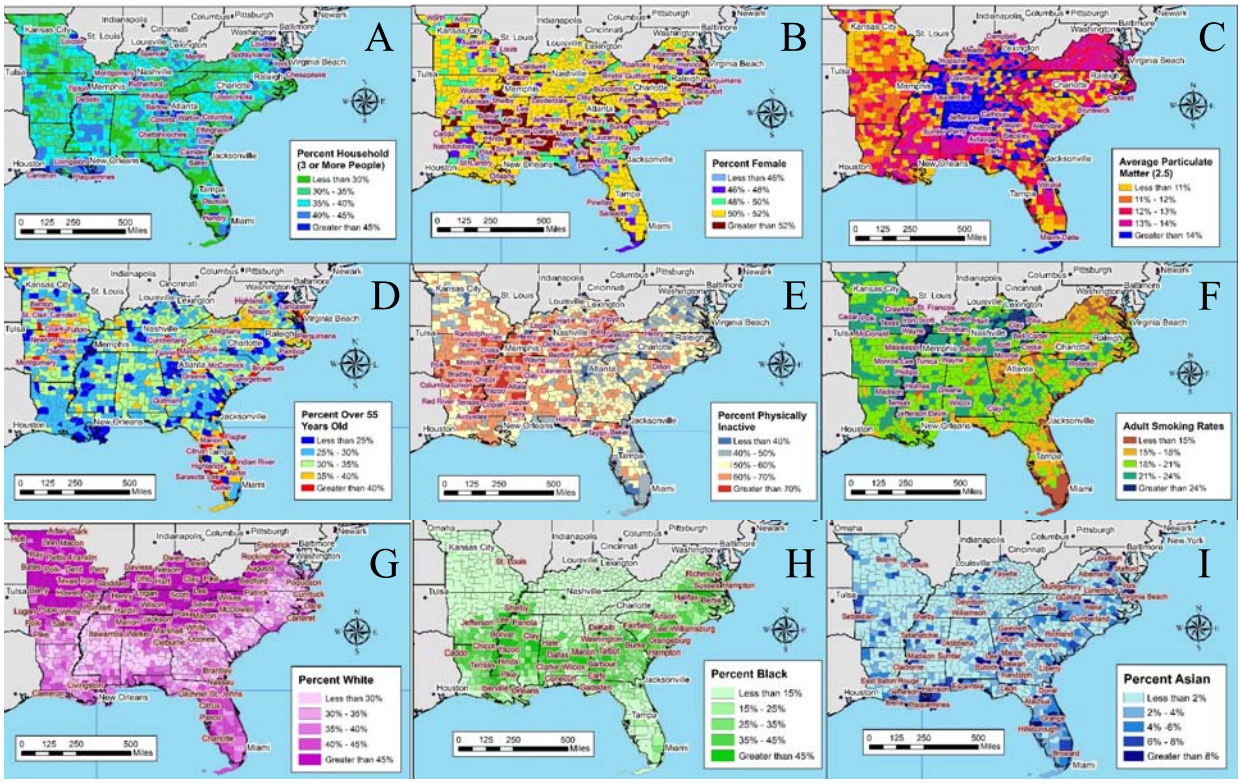

Figure 3. County data for percent of households with 3 or more individuals (A), percent females (B), average particulate matter (C), percent of people over 55 years (D), percent of people physically inactive (E), adult smoking rates (F), percent white (G), percent black (H), and percent Asian (I). Major cities are highlighted in white and counties within the highest class break are highlighted in pink.

than 14 percent) in northern Alabama (Jefferson and Perry counties) and Georgia (Calhoun and Jasper counties) (Figure 3C). The highest levels of individuals 55 years old and older were located in Florida (Sarasota and Marion counties), Missouri (Benton and St. Clair counties) and Arkansas (Ozark and Montgomery counties) (Figure 3D). The highest levels of physical inactivity in the southeast United States was clustered in Mississippi (Yazoo, Panola, and Attala counties), Louisiana (River, Tensas, and Union counties), and Arkansas (Polk, Monroe, and Stone counties) with more than 70 percent of individuals considered physically inactive (Figure 3E). The highest levels of adult smoking rates occurred in Kentucky (Clay, Hart, and Grayson counties) and along the Mississippi River in Louisiana (Madison county), Mississippi (Holmes county), Arkansas (Lee county) and Missouri (Wayne and Crawford counties) (Figure 3F).

The highest levels of white individuals were found in the northern region of the study area, namely Missouri (Linn, Iron, Franklin, and Perry counties), Kentucky (Stoddard, Hart, and Clay counties), Tennessee (Logan, Scott, and Wilson counties) and Virginia (Bedford and Rockingham counties). (Figure 3G) The lowest levels of white individuals were clustered in a band stretching from eastern Virginia, along the coastal Carolinas, into south-central Georgia, Alabama, and Mississippi with counties in this region showing populations where less than 30 percent of the individuals are white. The highest levels of black individuals occurred in nearly the same region of the lowest percentages of white individuals: North Carolina (Halifax and Anson counties), South Carolina (Lee and Orangeburg counties), Georgia (Dekalb and Talbot counties), Alabama (Dallas and Conecun counties) and Mississippi (Yazoo and Hinds counties (Figure 3H). The highest levels of Asian individuals were more scattered than the other two races. Populations with more than 8 percent Asian included Louisiana (Plaquemines and Iberia counties), Florida (Orange and Broward counties), and Georgia (Gwinnett and Fulton counties) (Figure 3I).

Clustering of high COPD crude rates were observed in eastern Kentucky, western Virginia, Orlando, Florida, Nashville, Tennessee, northern Arkansas, and northern/southeastern Missouri. (Figure 4) Areas where low COPD crude rates clustered include southern Louisiana, eastern Virginia, Miami, Florida, Atlanta, Georgia, Montgomery, Alabama and the coastal Carolinas (Figure 4).

The first trial of the global model explained 59.179 percent of observed COPD crude rates ($R^2 = 0.591790$), which may be indicative of key factors absent from the analysis (Table 2). This was further supported by the significance of the Jarque-Bera statistic, which indicated that the analysis was biased. However, the Variance Inflation Factors (VIFs) for percent whites and percent blacks were very high (Table 2), indicating redundancy between the two variables. This redundancy was likely attributed to a majority of the counties in the southeastern U.S. having similar percentages of white and black individuals, as observed in Figure 3G and Figure 3H. Percent blacks was removed from the second trial of the global model as there were a higher number of white individuals living in the study area. The second trial of the global model explained 59.1734 percent of observed COPD crude rates ($R^2 = 0.591734$), again indicating key factors may be absent (Table 3). The four most significant factors (given by the lowest robust probability values) were percent white, percent smokers, percent physically inactive and percent of people over 55. Percent smokers also had the highest coefficient in the global model, meaning percent of smokers was the most influential factor considered (Table 3).

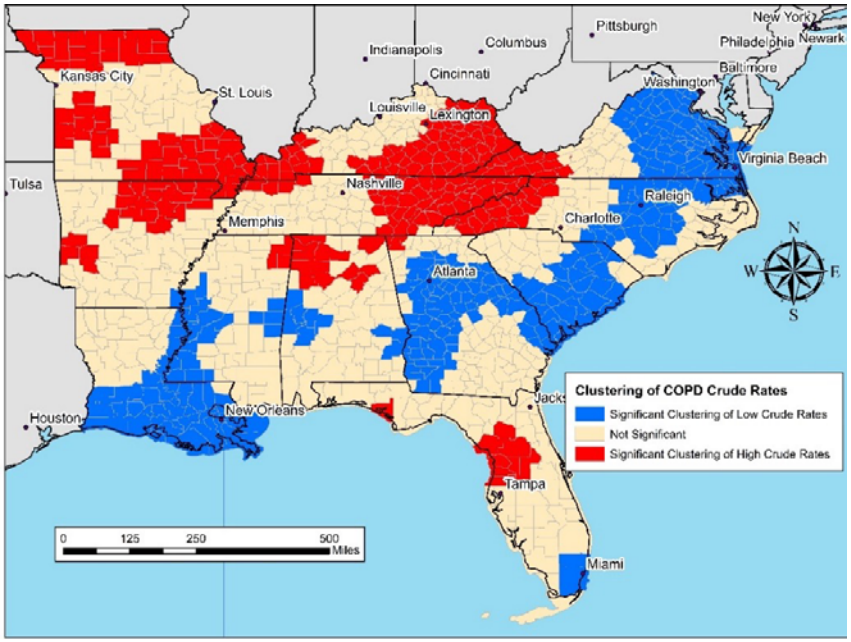

Figure 4. Identification of locations within the southeast where high and low COPD crude rates cluster significantly.

The global regression model determined percent smokers, percent healthcare workers, percent farmers, percent of individuals over 55 years old, and percent of white individuals were statistically significant in predicting COPD crude rates (Table 3). Average particulate matter (2.5μm), percent educators, percent of households with three or more individuals, percent females, and percent of Asian individuals had negative correlations to COPD crude rates (Table 3). Percent smokers, percent healthcare workers, percent farmers, percent construction workers, percent of individuals over 55 years old, percent white, and percent of people physically inactive were positively correlated (Table 3). All five significant variables had positive correlations with COPD crude rates. Interestingly, average particulate matter, a well-known risk factor of COPD in non-smokers was not identified as significant for the global model.

Results of the Spatial Autocorrelation yielded a Z-score of 19.3837 ($p < 0.05$). The high positive Z-score indicated that the distribution of the residuals from the global model were not a result of random chance; clustering of residuals of the global model was evident and further supports the need for additional independent variables to explain COPD crude rates.

The Geographically Weighted Regression was conducted using only the variables determined to be statistically significant in the global model. The local regression model explained 58.719 percent of observed COPD crude rates ($R^2 = 0.58719$), a slight increase

Intercept	-54.588846	Not Significant	0.000037	---
Average Particulate Matter (µg/m3)	-0.185737	Not Significant	0.407148	1.032230
Percent Smokers	2.235644	$p < 0.05$	0.000000	1.341076
Percent Healthcare Workers	0.714083	$p < 0.05$	0.004177	1.121923
Percent Farmers	0.501076	$p < 0.05$	0.027002	1.245767
Percent Construction Workers	0.154842	Not Significant	0.466612	1.197040
Percent Educators	-0.044576	Not Significant	0.856858	1.156721
Percent Households 3 or More	-0.176197	Not Significant	0.084837	2.458239
Percent Over 55	1.142801	$p < 0.05$	0.000000	3.423692
Percent Females	-0.108189	Not Significant	0.556365	1.586516
Percent White	0.918431	$p < 0.05$	0.000139	43.327382
Percent Black	0.053261	Not Significant	0.655329	39.880672
Percent Asian	-0.102691	Not Significant	0.241646	1.974076
Percent Physically Inactive	0.037783	Not Significant	0.385825	1.025974

R squared value = 0.576677

Table 2. Results from first trial of global multivariable regression analysis to explain observed COPD crude rates.

Variable	Coefficient	P-Value	Robust_Pr	VIF
Intercept	-52.323667	Not Significant	0.000013	---
Average Particulate Matter (µg/m3)	-0.173642	Not Significant	0.431911	1.016677
Percent Smokers	2.244506	$p < 0.05$	0.000000	1.311216
Percent Healthcare Workers	0.730434	$p < 0.05$	0.003062	1.092990
Percent Farmers	0.487461	$p < 0.05$	0.029833	1.220925
Percent Construction Workers	0.151874	Not Significant	0.000000	1.195379
Percent Educators	-0.042335	Not Significant	0.474297	1.156172
Percent Households 3 or More	-0.177144	Not Significant	0.864065	2.457263
Percent Over 55	1.150987	$p < 0.05$	0.000000	3.342736
Percent Females	-0.063669	Not Significant	0.694669	1.108897
Percent White	0.813894	$p < 0.05$	0.000000	1.280710
Percent Asian	-0.123118	Not Significant	0.094169	1.594279
Percent Physically Inactive	0.037136	Not Significant	0.393827	1.024749

R squared = 0.576604

Table 3. Results from second trial of global multivariable regression analysis to explain observed COPD crude rates.

Variable	Min. Coefficient	Max. Coefficient
Percent Farmers	0.336424	0.819818
Percent Healthcare Workers	0.504432	0.813643
Percent White	0.784995	0.892700
Percent Over 55	1.215704	1.496303
Percent Smokers	1.929614	2.634295

Table 4. Results from local multivariable regression analysis for observed COPD crude rates in the southeastern United States.

from the global model (Table 4). This improvement is likely attributed to the United States and the southeast region in particular having higher rates of adult smokers, particulate matter, and other factors influencing COPD prevalence compared to other areas of the world. The local model was produced to observe the correlation between percent of farmers, percent of healthcare workers, percent of white individuals, percent of people over 55 years old, and percent of adult smokers with COPD crude rate. The model showed percent farmers and percent healthcare workers had the weakest correlation with COPD crude rate in the study area as evidenced by the lower coefficients, while percent of individuals over 55 years old and percent smokers had the highest coefficients, indicating the strongest positive correlation (Table 4). For percentage of farmers, only Missouri and northern Arkansas exhibited a coefficient above 0.6 (Figure 5A). Percentage of healthcare workers was slightly more strongly correlated with COPD crude rate. The entire eastern half of the study area exhibited a coefficient between 0.6 and 0.8 (Figure 5B). Percent white exhibited a more positive coefficient between 0.8 and 1.0 in nearly the entire study area except northern Missouri, northern Kentucky, and northern Virginia, which all had coefficients between 0.6 and 0.8 (Figure 5C). Percent of individuals over 55 years old was more strongly correlated, with the entire study area having a coefficient between 1.2 and 1.4, except Missouri, Arkansas and western Louisiana, which had coefficients between 1.4 and 1.6 (Figure 5D). The model showed adult smoking rate had a very strong positive correlation in the entire study area, with every county exhibiting a coefficient above 1.6. (Figure 5E).

Discussion

Areas of clustering of low COPD crude rates occurred in cities including Atlanta, Miami, New Orleans, and Raleigh (Figure 4). These urban areas have easier access to hospitals and medical facilities than rural areas requiring less travel to receive proper treatments. These cities typically have hospitals that serve a larger number of people; more people may result in the hospitals more likely to conduct spirometry tests to diagnose patients with COPD and provide the proper treatments. Although the global model to explain COPD crude rates determined average particulate matter (2.5) was not statistically significant, particulate matter is considered to be the most likely risk factor of COPD in nonsmokers (Olloquequi et al. 2018). The insignificance of particulate matter in this study could be attributed to the fact that nonsmokers comprise a small population of COPD patients.

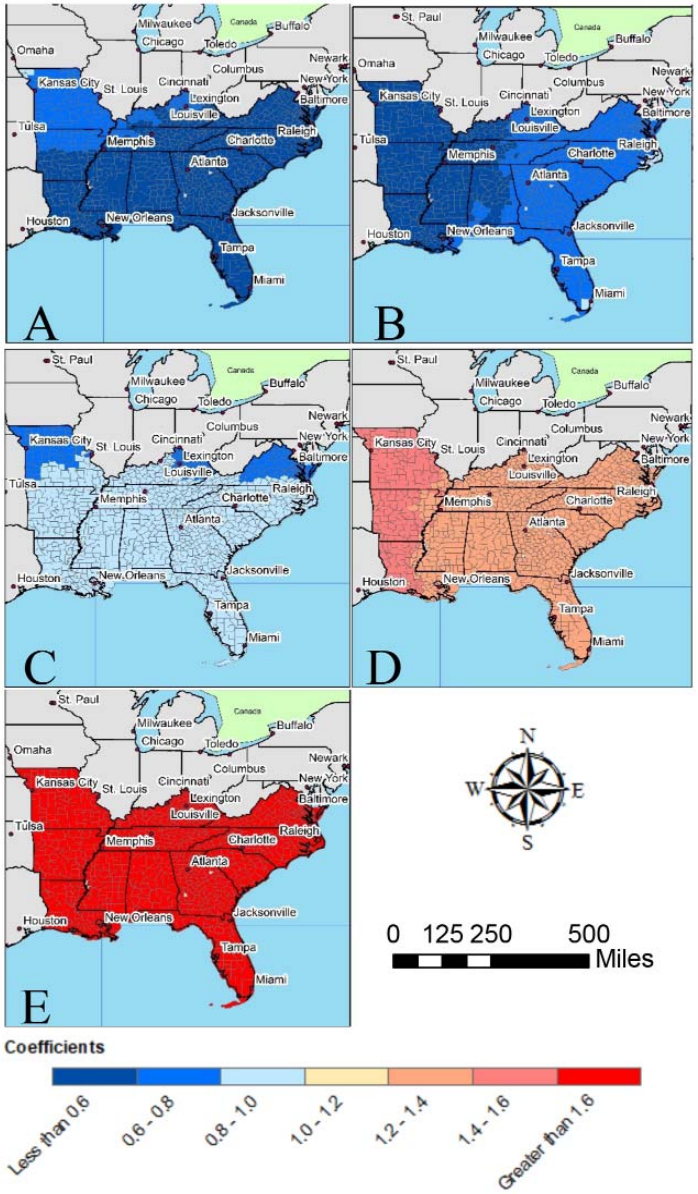

Figure 5. Results of the local regression analysis to show the correlation between COPD rates and farmers (A), healthcare workers (B), white individuals (C), individuals over 55 years of age (D), and adult smokers (E).

Another potential explanation for the insignificance of particulate matter is the wrong type of particulate matter was tested, specifically for farmers and construction workers. As mentioned, farmers and construction workers are exposed to particulates specific to their industry including asbestos, sulfides, construction dust, and other chemicals. COPD is still relatively high in these populations compared to other industries and percent of farmers was determined to be a significant factor in prediction of COPD prevalence in both the global model (Table 3) and the local model (Figure 5A), even though the correlation is the weakest among the five significant risk factors. A study in the United States concluded that the lifetime risk of COPD was twice as high among construction workers as among non-construction workers (Borup et al. 2017). A French study conducted by Guillien et al. (2015) concluded that in a study of 4,704 individuals and 3,787 farmers determined the population of farmers had a higher percentage of COPD prevalence than non-farmers. However, COPD prevalence depended on the farming activity and region. The same can be true for the United States and more data must be collected to develop a more definitive explanation for the relationship between farmers and construction workers with COPD prevalence.

Healthcare workers had a significant positive relationship with COPD crude rate in the global model (Table 3). In addition, there was a moderate positive correlation with COPD crude rate in the local model (Figure 5B). Nurses and doctors are among the most stressful professions, which can lead to increased smoking levels. Healthcare workers are also exposed to sick individuals on a daily basis. The likelihood of a healthcare worker catching an infection or disease is higher than other individuals. An infection can weaken the immune system and potentially increase the likelihood of that individual experiencing deteriorated lung function and becoming diagnosed with COPD. Instituting measures for medical professionals to take more frequent breaks or work shorter shifts could reduce their stress levels and hopefully reduce COPD prevalence. Better protection against the spread of infection should be given for healthcare workers including more personal protective equipment (PPE) and more frequent handwashing. More attention given to following organizational guidelines including knowledge, awareness and practice when treating patients for diseases is vital to protection of both the patient and the caretaker.

Percent whites had a significant positive relationship with COPD crude rate in the global model (Table 2) and had a moderately strong positive correlation with COPD crude rate in the local model for the southeastern United States (Figure 5D). This indicates race does play a factor in COPD prevalence, to an extent. It is somewhat surprising that white individuals were one of the more significant factors in predicting COPD crude rate given that black individuals in the United States have a higher prevalence and morbidity due to various biological, socioeconomic, and cultural factors (Ejike et al. 2019). This analysis tested only three races (with blacks being eliminated due to redundancy in the global model). An individual can be a variety of races or even multiracial. There is likely more substantial evidence to determine how race predicts COPD crude rates, but more research must be done to conclude this hypothesis.

In Missouri, Arkansas and Louisiana, individuals over 55 years of age were more strongly correlated with COPD crude rates than the rest of the study area (Figure 5C). Therefore, measures to ensure older individuals receive the proper diagnosis and treatments is necessary

to reduce COPD prevalence in this region and the southeast United States entirely. The most efficient way to diagnose COPD patients is using a spirometry test. Spirometry is a simple, noninvasive test that measures how strong an individual's lungs are and indicates the severity of airflow limitations (Skolnik et al. 2018). Underuse of spirometry is one of the largest contributors to underdiagnosis. Making spirometry tests mandatory during physical examinations for older individuals will help diagnosis those who may be affected with COPD and receive proper treatment. Another way older individuals can better protect themselves from developing COPD is by eating healthier and getting exercise, either self-enforced or with a caretaker. Taking medication properly helps as well because COPD is a progressive disease and can complicate with other diseases such as diabetes and asthma.

According to Figure 3F, adult smoking rates were highest in Kentucky, Missouri, and along the Mississippi River and lowest in Florida and the extreme southeast United States, however smoking rates in adults are high throughout most of the southeastern United States. The results of the local model identified similar trends in that COPD crude rates in the entire southeast United States correlated very strongly with adult smoking rates (Figure 5E). Smoking was determined to be the strongest risk factor influencing COPD crude rate in both the global model (Table 2) and local model (Figure 5F), as evidenced by the highest coefficients of all variables tested. Tobacco smoking is by far the most important risk factor in developing COPD (Liu et al. 2017). This is consistent with developing COPD; COPD weakens lung strength and leads to shortness of breath, which makes it harder to do everyday activities and contribute to physical inactivity (Liu et al. 2017). From the results of this analysis, medical professionals can determine which areas of the southeast United States where COPD is most prevalent, are affected from certain risk factors. In order to reduce the levels of smoking, certain measures should be taken to increase the tax on cigarettes to discourage people from buying them.

Future Experiments/Error

Future experiments should consider different types of air pollutants significant in COPD development considering particulate matter (2.5) was not significant on the global or local scale. Adjusting the age scale from 55 years and over to a smaller range could result in more significant results on the local scale. This is evident by the average prevalence rate for COPD being for people 75 years and older, the highest prevalence for any age group (Wheaton et al., 2015). Households with more than 3 individuals were grouped together in this study as a potential risk factor. A future experiment could yield promising results as a previous spatial and statistical analysis conducted by Kauhl et al. (2018), determined household size was a significant risk factor for a study in northeastern Germany. Studying other occupations could lead to future experiments and possibly determine which occupations are most at risk for COPD development, specifically in the southeastern United States where COPD is a large problem for the population. Testing other types of races and multiracial individuals would also yield more complete results in the relationship between race and COPD prevalence. A study analyzing how individuals already diagnosed with COPD cope with the disease as well as studying if these individuals develop more severe health problems from their diagnosis would help better understand the long-term effects of COPD.

Limitations

Data for this study was collected from several different years., due to the availability of the data. County data was not available for the same year of each risk factor, therefore data from years as close to the year of COPD crude rate was used for this analysis. While this does slightly alter the statistics for the risk factors, the discrepancy was kept as minimal as possible to conduct a study with valid results. County data was used in this analysis rather than individual or city data because county data was easily obtained for a large region like the southeastern United States. Individual data would have been more difficult to collect and analyze given the large population tested and major changes that could occur on a case-by-case basis. While this does essentially negate the effect of genetics, the third major predictor in COPD prevalence, a separate study focusing on how genetics predict COPD prevalence would yield better results. In addition, genetics would have been difficult to manipulate in a quantitative statistic to use in an OLS or GWR.

This study only provides a snapshot of COPD and its risk factors in the southeastern United States for one specific year. In order to best determine the risk factors and effects of COPD in any region, multiple years must be considered to assess the risk factors overtime, as well as follow how the health of an individual changes throughout their lifetime. People relocate constantly and therefore affect the demographic data of the places they live, distorting the data. For this reason, a study focusing on individual or household cases is imperative to assessing COPD prevalence.

Conclusions

This study is one of the first to test the spatial relationship between occupation and COPD crude rate in the United States. The selection of the occupation tested was determined by their relationship with the well-known causes of COPD (smoking and atmospheric particulate matter). While this study yielded important results, such as further validating smoking and old age contributes to COPD prevalence and indicating occupation does indeed help predict COPD prevalence, more research needs to be done to determine how particulate matter and other factors contribute to COPD prevalence. The methodology of this study proved useful in determining which risk factors helped predict COPD in the southeastern United States, which is important in understanding this disease, which will only continue to increase in cases unless certain measures are taken to prevent the deterioration of lung function. This study provides a useful starting point for assessing the effects of many risk factors to predict COPD in one of the most severely affected regions of the United States.

Erick Bora received his Bachelor of Science from Eastern Connecticut State University, Willimantic, CT. He is currently a Master's Degree Student at the Colorado School of Mines, Golden, Colorado. Email: ebora@mines.edu. His research interests include Proterozoic structural geology, geomorphology, and geographic information systems.

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ESTIMATING ABOVEGROUND CARBON STOCK at Franklin Pierce University

Amanda Suzzi-Simmons
Fitchburg State University

ABSTRACT

With the increasing concentration of carbon dioxide in the Earth's atmosphere as the result of fossil fuel combustion (leading cause) and deforestation (secondary cause), there is a pressing need to estimate carbon pools in local forests. The present study was aimed at classifying forest types on Franklin Pierce University's campus and estimating above ground biomass and carbon stock using allometric equations. The Jenkins method of allometric equations was used to relate tree components obtained by non-destructive measurements to the oven dry biomass for trees in the United States. The results indicated that the Spruce Swamp had lower mean aboveground biomass (33.5 mt/ac) than the Deciduous forest (37.7 mt/ac) and Mixed Forest (45 mt/ac), while Coniferous Forest had aboveground biomass of 59.42 mt/ac. The type of forest did not have a significant effect (p=0.0597) on the amount of carbon stored because there is a lot of variation within each forest type and not a lot of variation between the forest types. The number of species sampled ranged from 2 to 10 per plot and the overall mean stand density was 389 stems/acre. Acer rubrum (31.23 percent), Picea rubens (29.15 percent), and Pinus strobus (9 percent) were the most dominant species. Most of the tree species belonged to the diameter at breast height class of 10–20 cm. The total aboveground carbon stock of the forest in the study area in 2018 was estimated at 40,679.66 metric tons.

Keywords: Aboveground biomass; Allometric equations; Forest Inventory, New Hampshire

Background

Global warming is caused by the continuous accumulation of greenhouse gases (GHG), especially carbon dioxide (CO_2), in the atmosphere driven primarily by the burning of fossil fuels and exacerbated by deforestation worldwide. Deforestation contributes to global warming because trees are cut down and burned, releasing carbon into the air, with tropical deforestation responsible for about 10 percent of all GHG which amounts to a yearly average of 3.0 billion tons of carbon dioxide or the equivalent of 600 million cars (Union of Concerned Scientists 2013). The Intergovernmental Panel on Climate Change (IPCC) Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security,

and Greenhouse Gas Fluxes in Terrestrial Ecosystems (2019) confirms that deforestation is a significant contributor to the current greenhouse gas (GHG) emissions problem and that forest loss causes warming in temperate zones. The increased CO_2 emitted needs to be sequestered to strike an ecological balance and reverse global warming trends.

Fortunately, forests are natural carbon sinks with live biomass, detritus, and soil organic matter storing roughly half of the world's terrestrial carbon (Anderson-Teixeira et al. 2016). There is a decline per decade of the carbon sink in South America (-0.69 Pg C), increase in Africa (0.25 Pg C), and increases in the temperate forests (0.87 Pg C ha^{-1}) globally and boreal forests of North America (0.49 Pg C ha^{-1}) with an alarming 1.12 Tg C of emissions in one year over 23,613 hectares in the Peruvian Amazon due to gold mining while deforestation caused by gold mining and logging concessions accounted for carbon emissions of 0.42 Tg C yr^{-1} between 2006 and 2009 (Asner et al. 2010, Xu et al. 2019, Ovidiu and Asner 2020). There is an estimated potential of 0.4 to 5.8 gigatonnes of carbon dioxide sequestered per year from reducing deforestation and forest degradation (IPCC 2019).

Therefore, forests play a critical role in regulating the future increase of CO_2 levels by sequestering atmospheric carbon through the process of photosynthesis and converting excess carbon into the growth of woody biomass (Brown and Pearce 1994). Tree carbon sequestration rates vary widely with forest type, tree species, climate, forest stand age, and location, but younger and faster growing forests generally have higher annual sequestration rates or net primary productivity (NPP). This is the reason that afforestation on abandoned agricultural land, like that of the study location, acts as a carbon sink and continues to sequester carbon (Woodbury et al. 2007).

The Northeastern United States is largely covered by a transition zone of trees that is positioned between the northern hardwood - conifer forests to the north and oak - pine forests to the south (Prasad et al. 2014). The growth and distribution of forests has an important impact on atmospheric carbon dioxide concentrations and is a central issue in global change research. Fossil fuel burning, deforestation, and other human activities have driven a 25 percent increase in atmospheric carbon dioxide (CO_2) since 1900 (Thompson et al. 2013). Humans cut down a lot of trees, making deforestation the second biggest source of the 36 billion metric tons of CO_2 emitted annually from over 7,500 large CO_2 emission sources (Le Quéré et al. 2018, IPCC 2005). IPBES' 2019 Global Assessment Report on Biodiversity and Ecosystem Services, the first global biodiversity assessment since the Millennium Ecosystem Assessment (2005), confirms that terrestrial ecosystems became a net sink for carbon emissions around the middle of the last century, with a gross sequestration of 2.8 gigatons of carbon per year (the equivalent of some 30 percent of global anthropogenic emissions). In addition, it mentions that deforestation has been much more intensive in temperate regions historically (IPBES 2019). The Northeastern United States is specifically afflicted with past and continued deforestation.

The history of forests in the northeast is one of colonization and anthropocentric land use change. Though the United States was heavily forested at the beginning of European settlement, much of it was cleared for farmland in the 19th century. In 1630, Northeastern forests occupied over 117,940,000 acres (Kellogg 1909). It is estimated that by the 1920s at least 50 percent of

the eastern forest had been cleared (Whitney 1994). Farmland abandonment, beginning in the mid-1900s and continuing through the study period, has led to a natural regrowth of forest. Unfortunately, there has been an increase in forest clearing over the last few decades for housing, coal mining and energy development associated with fracking, with approximately nine million acres cleared since the 1970s (Biello 2010). Today, while the forest area has grown to 84,796,000 acres in the Northeast, less than one-tenth of a percent of these forests are undisturbed with very few old growth forests remaining (Biello 2010).

Forests in the Northeastern United States are currently a major recovering carbon sink. U.S. forests capture about 2 billion tons of carbon every 10 years and counteract 10 percent of our fossil fuel emissions (Smith 2008). Through photosynthesis, live trees emit oxygen in exchange for carbon dioxide, a greenhouse gas, they pull from the atmosphere. As a tree grows it stores carbon in cellulose, hemicellulose, lignin, and other compounds that form the wood above and below ground. The amount of carbon in the biomass varies from between 35 to 65 percent of the dry weight, depending on species ranging from 41.9–51.6 percent in tropical species, 45.7–60.7 percent in subtropical/Mediterranean species, and 43.4–55.6 percent in temperate/boreal species, with 50 percent often used in equations as a default value (Karsenty et al. 2003, Thomas and Martin 2012). As forests grow over time, the amount of sequestered carbon increases. Carbon storage in vegetation represents an important reservoir within the global carbon cycle, and changes in carbon uptake by and storage within vegetation and soils can have a significant impact on the global carbon balance.

While forest carbon stocks in the United States are estimated at a national level using data from the United States Department of Agriculture (USDA) Forest Service, Forest Inventory and Analysis (FIA) program, there is a significant difference in estimates of carbon stocks at the local and national scales, according to Domke et al. (2012). They further reported those national scale estimates by individual U.S. states for the entire 1990-2019 time series, with New Hampshire storing 481 million metric tons of carbon dioxide equivalent in 2019, 144 million of which is aboveground biomass. Therefore, it is important to estimate local forest carbon stock based on field measurements for accuracy and precision. The FIA program uses a set of generalized allometric regression models to predict oven-dry biomass in tree components for all tree species in the U.S. (Jenkins et al. 2003). The Jenkins method was developed using a version of meta-analysis where more than 1,700 regression predictions were refitted for more than 100 species and groups of species.

The objective of this study was to estimate tree aboveground biomass (AGB) and carbon storage in the forests at Franklin Pierce University to provide a benchmark with which the university can track the change in carbon stocks to reduce net emissions from deforestation and degradation and to track enhanced carbon sequestration through campus tree harvest planning. Aboveground biomass includes all living biomass above the soil including stem, stump, branches, bark, seeds, and foliage. While it is easy to visualize the carbon stored in AGB, a substantial proportion of forest net primary production (NPP) is directed toward maintenance and accumulation of belowground biomass (BGB). Belowground biomass can be estimated as a percentage of AGB. Santantonio et al (1977) conclude that there is a consistent relationship

between root-system biomass and stem diameter at breast height with a BGB of at least 20 percent of AGB (sometimes up to 30 percent). Understory herbaceous vegetation rarely is a significant factor in the ecosystem carbon budget. Soil estimates require more data than covered in this study.

Research Methods

The study site is located in N'dakina (Abenaki word for their ancestral territory). The boundaries of the study area are the property lines of the university as determined by the 2018 Town of Rindge Plat map and sales history (Figure 1). Located in the southwestern New Hampshire section of the Hillsborough Inland Hills and Plains within the U.S. Forest Service's Vermont-New Hampshire Uplands, Franklin Pierce University's campus (42°46'45.0"N 72°03'20.7"W) in Rindge, New Hampshire is dominated by small rocky hills and moist depressions. The average annual temperature in Rindge is 7.36 °C (45.24°F) and average annual rainfall is 1206.245 mm (47.49 in).

The land is situated within both the Millers River and Contoocook River watersheds and makes up the headwaters of both which flow into the Connecticut and Merrimack rivers, respectively. Wetlands can be found at the margins of most forests in this area. These include peatlands, scrub-shrub marshes, and a red maple basin swamp, not included in this study. In addition, there is a large spruce swamp, which is explored in this study.

Upland soils in this region are mostly well-drained, shallow, stony and formed from glacial tills and glacio-fluvial deposits as a result of the Laurentide glacial retreat approximately 5,000 years ago. The terrain is hilly, having a range in altitudes from 315m to 360m above mean sea level.

The study site lies within the hemlock-white pine-northern hardwood forest system with the dominant natural community in this system being the Hemlock-Beech-Oak-Pine forest (HBOP), a very common, broadly defined transitional community found on glacial till in mid elevations in central and southern New Hampshire. There are several other natural vegetation community types covering these 1120 acres, including but not limited to: Semi-Rich Mesic Sugar Maple Forest, Hemlock-Beech Northern Hardwood Forest, Dry Red Oak and White Pine, Hemlock-White Pine Forest, Black Spruce Larch Swamp, and Red Maple Swamps. Most of the area is currently used as a college but formerly for grazing livestock as evident on antique maps.

Thirty-nine 20-m x 20-m plots were measured in 2003, 2008, and 2017-2018. These plots were previously established by Singleton and Koning in 2003 for a buckthorn study based on forest type and former land use (Koning and Singleton 2013). Plots were categorized into forest type based on species distribution and dominance and prior land use. These plots were then recategorized into generalized forest types. Four generalized forest types were represented by these plots – deciduous, coniferous, mixed, and spruce swamp. For example, A1C consists of 18 trees with Sugar Maple and White Ash as the dominant species (relative abundance is > 10 percent). This would categorize the forest as Semi-Rich Mesic Sugar Maple Forest and then recategorize it as a deciduous forest. Using this method resulted in twenty-two mixed forest

plots, one coniferous forest plot, seven deciduous forest plots, and nine spruce swamp plots (one was not included in calculation due to missing data).

All live trees in the sample plots greater than 10 cm diameter at a height of 1.4 m above the ground (DBH) were measured using a dbh measuring tape during the Fall 2017/Spring 2018 semesters. Trees with DBH < 10 cm were not measured since they normally contribute a small amount of biomass. Aboveground biomass in respective measurement plots was calculated with the following allometric equation: $[ln(biomass) = b_0 + b_1 ln(dbh)]$, using coefficients based on species identification developed by Jenkins et al. (2003) for individual aboveground tree biomass estimation. Estimated AGB in each plot was converted to AGC stock using the conversion factor of 0.5.

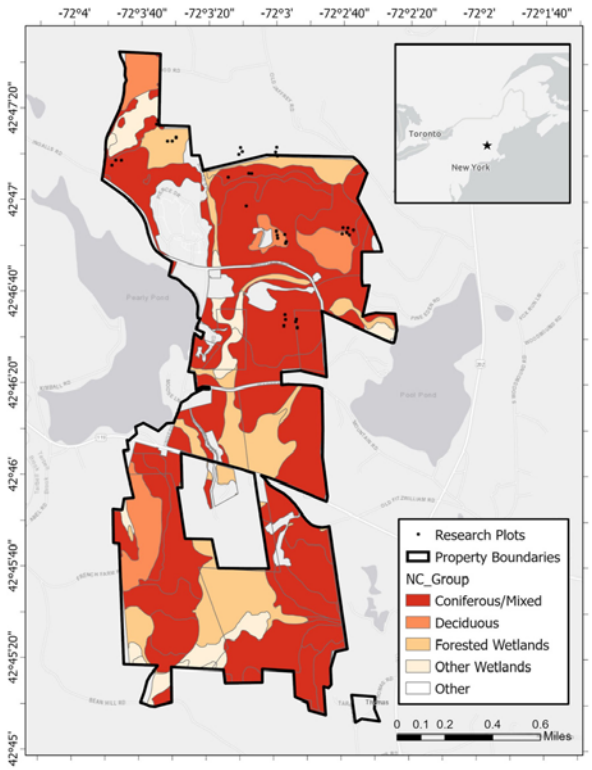

Figure 1. Map of property boundaries and plot locations.

The available aboveground carbon stock was estimated by applying allometric equations to the inventoried individual trees, averaging the Carbon per plot per forest type, and extrapolated to the entire area. Plot totals were calculated and combined into totals for the forest type. This total was divided by the number of plots to get the average Carbon per plot per forest type. Each plot is roughly one-tenth acre, so this was multiplied by 10 to get average carbon per forest type per acre. Plots were extrapolated to the full-acre area, which was then applied to the total number of acres of this kind of forest, as determined by remapping (Figure 1) in a geographic information system to produce carbon-stock estimates in each of the stratified forest types.

The map to determine forest type acreage was created based on examination of the 2011 New Hampshire land use land cover maps, a natural community classification map, and aerial photography interpretations. Aerial photography (0.30-meter, 4-band) was sourced from the

2015 High Resolution Orthoimages for New Hampshire by the U.S. Geological Survey on GRANIT captured on May 6, 2015 with Microsoft UltraCam and Eagle (UCE) large format digital camera and corrected for atmospheric errors (New Hampshire GRANIT 2001).

Results

Fifty-eight acres of FPU land are deciduous Sugar Maple/Beech/Birch, including plots A1C, A1M, A1T, B1C, B2T, B3M and B3T; 238 acres are coniferous Hemlock-Spruce Hardwood, including plot D3T; 153 acres are Spruce Swamp, including all of the E plots; 427 acres are mixed Hemlock/Beech/Oak/Pine, including all remaining plots; and the remaining 244 acres are developed land, or wetlands (Figure 1).

Nineteen canopy tree species were recorded in the forest, 80 percent of which are deciduous. Among the study species, red maple (n = 361), spruce (n = 337), white pine (n = 104), hemlock (n = 88), and sugar maple (n = 57) were the five most abundant trees, collectively representing more than 80 percent of the total sample. Mean dbh ranged from 10.9 cm to 39.85 cm for species in the study with white pine having the largest mean dbh followed by hemlock (25.9 cm), yellow birch (26.6 cm), white ash (24.1 cm), and red oak (30 cm). The range of dbh values varied widely by species in the analysis, with white pine showing the largest variation across its respective range.

In this study, all live trees with a dbh >10 cm were included in the analysis. A total of 1,156 individual live trees were sampled throughout 39 plots. Of the 1,156 individual trees, 27.71 percent were Red Maple and 30.70 percent were Spruce. Table 1 shows the total aboveground carbon per species. For example, Red Maple as a species has the most aboveground carbon at 52,235.90 kg due to it being the most populous species. Table 1 also shows the average aboveground carbon per individual. For example, Red Oak averaged the most at 229.24 kg and Grey Birch averaged the least at 19.48 kg.

TREE SPECIES	C (KG)	#	AVERAGE C (KG) STORED PER TREE
BALSAM FIR	844.41	19	44.44 ± 31.62
BEECH	781.21	20	39.06 ± 20.47
BLACK BIRCH	2578.51	31	83.18 ± 122.45
BLACK CHERRY	4465.81	35	127.59 ± 122.16
GRAY BIRCH	38.95	2	19.48 ± 0.9
HEMLOCK	10507.01	88	119.40 ± 144.35
HORNBEAM	95.82	4	23.95 ± 4.25
OSTRYA	200.60	4	50.16 ± 13.69
PAPER BIRCH	815.62	9	90.62 ± 70.91
RED MAPLE	52235.91	361	144.69 ± 165.09
RED OAK	4584.86	19	229.24 ± 233.71
SPRUCE	15733.66	337	46.69 ± 35.13
SUGAR MAPLE	6997.55	57	122.76 ± 140.14
WHITE ASH	10649.75	47	226.59 ± 235.65
WHITE PINE	43649.76	104	416.71 ± 387.21
YELLOW BIRCH	4013.29	18	222.96 ± 179.31

Table 1. Total Aboveground Carbon stored per tree species.

Calculations were made two ways. First, the total carbon stored in living aboveground biomass as of 2018 in each forest type was calculated. Table 2 displays the average and total per generalized forest type. The mixed forest contains an average of 4,500.68 ± 1,217.85 kg of aboveground carbon per plot for a total of 99,014.99 kg C in 22 plots. Figure 2 graphs the carbon per plot and the means. Extrapolated out over 427 acres, the mixed forest type on campus totals 19,217.91 metric tons of carbon stored. The coniferous forest plot contains a total of 5,942.42 kg C (n=1). While this is the highest average carbon per plot stored, the low sample number and fact that this plot has never been harvested could influence the results. Extrapolated out over 238 acres, the coniferous forest type on campus totals 14,142.97 metric tons of carbon stored. The spruce swamp contains an average of 3,353.37 ± 1,305.73 kg of carbon per plot with a total of 26,826.93 kg C in 8 plots. Extrapolated out over 153 acres, the spruce swamp forest type on campus totals 5,130.65 metric tons of carbon stored. The deciduous forest contains an average of 3,772.63 ± 10,68.84 kg of carbon per plot from a total of 26,408.41 kg C in 7 plots. Extrapolated out over 58 acres, the deciduous forest type on campus totals 21,88.13 metric tons of carbon stored. This equals a grand total of 40,679.66 metric tons of carbon stored in the aboveground biomass of the forests on campus.

Forest Type	Total C (kg)	# of Plts	C (kg)/plot	Acres	C Tot (metric tons)
Mixed	99014.9	22	4500.68 ± 1217.85	427	19217.91
Conifer	5942.42	1	5942.42	238	14142.97
Spr Swamp	26826.9	8	3353.37 ± 1305.73	153	5130.65
Deciduous	26408.4	7	3772.63 ± 1068.84	58	2188.13
TOTAL	158192.62	38		876	40679.66

Table 2. Carbon storage in each forest type.

Next, the total carbon in the 38 research plots was calculated at 1581.93 metric tons; that is a carbon density of 41.63 metric tons per acre. Extrapolating that out over the 876 forested acres leads to a total of 36,467.88 metric tons on campus. While this is a generalized calculation, it is important for comparison to see if there is a difference in doing it by straight acreage or by forest type. The difference between the calculations is 4,211.78 metric tons of carbon with a higher number accounting for the forest type method.

However, an analysis of variance (ANOVA) test shows there is not a strong significant difference ($p = 0.0597$) among the four generalized forest types. There is a 5.97 percent chance that the differences between the average carbon stored in each forest type is due to random chance. This supports preliminary research that suggested aboveground live carbon is not significantly different between coniferous and deciduous stands around this location (Suzzi 2017). The type of forest did not have a significant effect on the amount of carbon stored because there is a lot of variation within each forest type and not a lot of variation between the forest types ($F=3.67$).

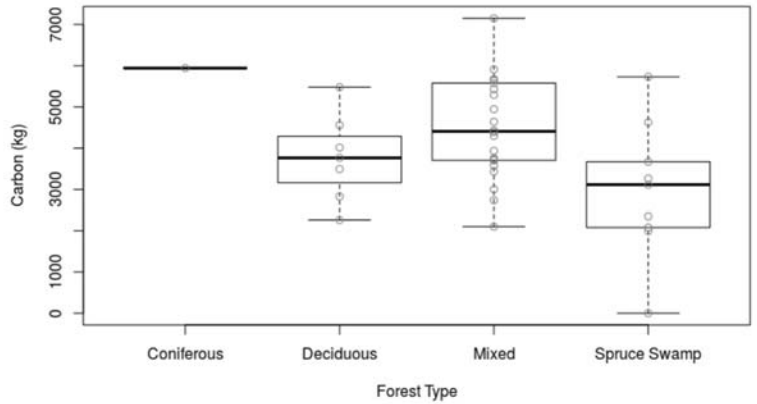

Figure 2. Carbon in each plot, grouped per generalized forest type.

Discussion

The average old growth forest in northern New England contains total carbon stocks of approximately 79 metric tons per acre for northern hardwoods and 98 metric tons per acre for softwoods, of which 54 percent and 47 percent was in aboveground biomass, respectively (Hoover et al. 2012). The carbon density at Franklin Pierce University at 46.44 (forest type) - 41.6 mt/ac (straight acreage) is less than the average old growth northern New England forest. Extrapolating Hoover's AGC calculation out over 876 acres gives an estimate of 38,544 mt – overestimating the actual storage by 2,135 mt if using the forest type calculation or underestimating the actual storage by -2,076.12 mt if using the straight acreage calculation. Therefore, using Hoover's estimate to calculate the carbon storage of local forests would give fairly accurate results.

Limitations of this study include the forested wetland South of Rt 119 which is listed as Spruce Swamp on the map; however species composition information is not available. Furthermore, the logged areas South of Rt 119 have no plot data. These areas were estimated based on aerial photography, however plots located in this area would provide more accurate data. In addition, developed areas and non-forested wetlands were not included in this study, but are still important in the carbon budget with wetlands storing large amounts of carbon in the soil because anoxic conditions slow decomposition and lead to the accumulation of organic matter.

In addition, soil and detritus are globally important reservoirs of carbon, containing three times more carbon than the atmosphere (Lal 2004). While these numbers were not calculated for this study, the soil carbon can provide an important source or sink because soil disturbance releases CO_2. Interestingly, forest floor carbon is significantly different between hardwood and softwood forests (Hoover et al. 2012). Therefore, calculating soil carbon based on forest type would be an excellent continuation of this study.

Factors discussed in this study that affect forest carbon budgets include region and forest type. Other factors that could influence the tree growth and subsequent carbon storage include the past land use, site conditions (including soil and other abiotic factors), forest age, and the neighboring trees. Neighborhood traits that impact competition include root and crown distributions, wood density, specific leaf area, and maximum height (Kunstler et al. 2016). Additionally, clearing and abandonment have favored well-dispersed early successional species (such as red maple) and an associated decline in longer-lived shade-tolerant species (Dyer 2006).

The obtained results may have some practical significance for forest management. Carbon accumulation slows after 200 years, which means the forests on campus are still accumulating carbon but will start to slow down if not managed. While past studies found that prior land use and forest succession in this area does not change the amount of carbon storage (Rodrigues 2017), changing and current land use does affect carbon storage. Specifically, reforestation of the land on Ingalls Road since the 1940s increased the amount of carbon sequestered on campus. To further increase sequestration, the University could allow afforestation of grassy areas, prevent conversion of forests to non-forest, and improve forest management practices. Afforestation of grassy areas will show significant gains in sequestered carbon in 20-30 years. Increasing productivity through forestry practices can include weed control, fertilization, and stocking choices.

Forests play an important role in sequestering atmospheric carbon dioxide (CO_2). This study set out to quantify the carbon stored in the forests on Franklin Pierce University's campus. The total aboveground carbon stock of the forest in the study area in 2018 was estimated at approximately 40,679.66 metric tons. While this study answered the original question, it creates more questions. What about the carbon storage of the 244 other acres of land? What about the carbon sequestered belowground? How can researchers use emerging remote sensing to validate this data? This research lays the foundation for further forestry and carbon storage research to be conducted within this region, and this baseline may serve as a valuable reference guide to not only track the change in carbon stocks to reduce net emissions from deforestation and degradation, but also to enhance carbon sequestration through campus tree harvest planning.

Amanda Suzzi-Simmons is part-time faculty in the Department of Earth and Environmental Science at Fitchburg State University, Fitchburg, MA and an instructor in the Departments of Geography and Environmental Conservation at the University of Massachusetts Amherst. E-mail: asuzzi@umass.edu. Her research interests include quantitative ecology, spatial statistics, remote sensing, and conservation.

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DESTINATION IMAGE AND STUDENT PERCEPTIONS
Of Tourism in China, India, and Thailand

Taylor J. Ouellette
Central Connecticut State University

William R. Price
Ball State University

Timothy J. Garceau
Central Connecticut State University

ABSTRACT

China, India, and Thailand have the highest number of tourist arrivals in their respective sub-regions of Asia. Many people have formulated images about these countries without any first-hand experience. With social media on the rise, potential travelers are exposed to destination imagery from personal and industry sources. This research assesses the positive and negative perceptions among Connecticut college students about traveling to these three countries. A survey utilizing Likert Scale and open-ended questions was administered to 111 students in 2018. Results indicate that perceptions of friendly locals and high-quality transportation were correlated with strong tourism demand amongst the students sampled. Of the three countries, Thailand had the most positive overall image, as college students in Connecticut associated it with the beach and a distinctive culture. India's cultural and experiential amenities were also positively viewed. China was more negatively perceived, linked with overpopulation and unsafe conditions. It still had appeal, however, as a global destination with a blend of heritage and modern culture. Overall, students interested in a specific destination were drawn by cultural heritage and natural attractions, showing that these attributes should be marketed as part of each country's brand. One strong variation worth additional research was that males surveyed were less interested in traveling to India and Thailand than their female counterparts. Language, cost, flight time, and distance were commonly identified barriers to travel. Tourism professionals targeting college students should consider how to market these countries in ways that reduces these concerns or eliminate the barriers themselves.

Keywords: Tourism Geography, Destination Image, Asia, Tourism Demand

Introduction

Asia has been among the fastest growing international destination regions since the start of this millennium (UNWTO/GTERC 2017). At the forefront of this trend, China was the leading international tourism generator in 2019 and among the top five destinations, receiving 66 million international tourists (UNWTO 2021). Yet, circumstances may change in the aftermath of a global pandemic that originated in Asia and brought international travel to a standstill in 2020 (Gössling et al. 2020). As rising vaccination levels foretell a likely return of large-scale international tourism, it is necessary to consider not only what has made Asia an attractive destination, but also what barriers predate pandemic-related concerns.

This study investigates how a sample of college students at a regional university in Connecticut perceive traveling to China, India, and Thailand, the most visited destinations in each of Asia's three World Tourism Organization (UNWTO) sub-regions: North-East, South-East, and South (see Table 1). The goal of the study is to discover the similarities, differences, and general perceptions that students have about traveling to Asia's most visited countries.

North-East			South-East		South	
1	China	65.7	Thailand	39.8	India	17.9
2	Japan	32.2	Malaysia	26.1	Iran	9.1
3	Hong Kong	23.8	Vietnam	18	Sri Lanka	1.9
4	Macao	18.6	Indonesia	15.5	Maldives	1.7
5	South Korea	17.5	Singapore	15.1	Nepal	1.2

Table 1. International Tourist Arrivals by Asian Sub-Region in 2019 (in millions of visitors)
Source: World Tourism Organization 2021

Tourism demand, the interest of people in engaging in tourism, is shaped by multi-scalar factors, including motivation, leisure time, discretionary income, culture, and life stage. Specific considerations for college students include available financial resources (Carr 2005) and institutional opportunities for travel (Rodriguez et al. 2012). A crucial component of demand is place perception (Cho 2010; Skinner and Theodossopoulus 2011); in tourism studies, referred to as "destination image" (Pike 2002). Tourism is driven, in part, by people's imaginations about places, culminating in a desire to experience them firsthand (Salazar 2012).

Destination image is subject to a range of influencing factors, including personal experiences, spatial proximity, societal factors, news, and popular media (Tasci 2007). The initial image formation stage is the most influential in the destination selection process (Baloglu and McCleary 1999) and perceptions may be difficult to change once ingrained for potential travelers. Rather than considering the destination's specific characteristics, the overall image is often what most influences tourists (Tapachi and Waryszak 2000). Destination image is interconnected with tourism marketing. Those involved with destination development attempt to create a desirable image through a process termed "branding" (Morgan et al. 2007). For

example, Las Vegas' familiar refrain of "what happens in Vegas..." is an effective marketing ploy to draw tourists looking for an exciting place to vacation. Such slogans do not happen by accident; tourism marketing agencies perform extensive research in formulating their brands (Morgan et al. 2003). Destinations may focus on positive imagery and ensure that their realities match peoples' perceptions or attempt to remedy negatives (Almeyda-Ibanez and George 2017).

Destination images may also hinder potential tourist demand. Negative perceptions of some regions are partially rooted in the era of European colonization (Bandyopadhyay and Morais 2005) and the West's view of other cultures as exotic and inferior – as famously highlighted in Said's (1978) landmark research on Orientalism – still manifests. Studies have also found, for example, that associations with terrorism and other forms of risk reduce tourist interest (Arana and Leon 2008).

This research focuses on college students as they are often more educated, youthful, and open-minded than the general tourist population, providing an ideal sample for discussing international destinations. Many types of tourism cater to the young and affluent (Field 1999; Barron and Arcodia 2002; Sakakida, Cole, and Card 2004). Additionally, the current generation of American college students grew up in an age of social media and convenience, making them the first young adults to have their travel perceptions and experiences shaped primarily by these things. As a cohort inclined to adventure and risk taking (Kim et al. 2007; Lesjak et al. 2015), they also promise to be among the first to travel internationally again in the aftermath of the pandemic. Insight into the attitudes of college students may thus be important to destinations seeking to attract the wider U.S. tourist market. For example, perceived barriers identified by college students may be exacerbated for those in older, more risk averse, demographics.

While research has been conducted on various Asian destinations (e.g., Choi, Chan and Wu 1999; Mercille 2005; Yusuf 2014; Hader, 2017), investigation into the most visited countries in three of the UNWTO's sub-regions of Asia is lacking, specifically as it relates to college students. This research seeks to fill two gaps: expanding tourism geography research on China, Thailand and India; and studying perceptions of travel to those countries by a sub-set of American college students.

Influences on Destination Image

Consideration of the interactions between peoples and places has long been a central theme in geography. People develop a "sense" shaped by their interactions with a place (Tuan 1977; Relph 2009); these may be especially nuanced for the places where people live. Due to the processes of time-space compression, sense of place is ever more global (Massey 2008). Reflecting these complexities, tourists perceive and interact with places in distinct ways (Hughes 1992). Urry and Larson (2011) refer to this perspective as the "tourist gaze." This section considers the literature focused on influences on destination image.

"Destination image" is defined by Lopes (2011, 307) as "a subjective interpretation of reality by the tourist." Destination images traditionally consist of related components: product, behavior, and environment (Milman and Pizam 1995). Ideally, destinations aim to

make tourists' experiences coincide with a positive destination image. This consistency creates relationships and encourages positive feedback, revisitation, and giving of recommendations (Chavelier and Mayzlin 2006; Chen and Tsai 2007; Jacobs, Potgeiter, and Geldenhuys 2016). Several recurring concepts may be detected in the literature on destination image. First, many authors attempt to define "destination image" (i.e., Milman and Pizam 1995; Ryan and Cave 2005; Nadeau et al. 2007). Second, destination image formation has been analyzed with widespread recognition that the information gathering process, consciously or subconsciously, plays a role in how a traveler chooses a destination (Gartner 1994; Kim and Richardson 2003; Frias, Rodriguez, and Castaneda, 2008). A third theme is destination images' impact on tourism considerations such as marketing and visitor arrivals (Milman and Pizam 1995; Chen and Tsai 2007).

Formation of destination image is based on knowledge and familiarity. Travel experience has a significant impact on destination image (Beerli and Martin 2004). Two main sets of perceptions are combined, the "organic" and the "induced." Organic images often develop first, from the exposure to information in daily life; perception then evolves into an induced image with contributions from advertising and other pitched material (Milman and Pizam 1995). Though the organic image is always present, to reach the induced image, the consumer must seek out information regarding the destination because they are motivated to travel. With more research by the traveler, their destination image becomes more nuanced.

Destination image is influenced by many social processes, including culture, history, and politics. These factors have been considered by a range of literature (i.e., Beerli and Martin 2004; Ooi 2004). Such considerations also fall within the wider realm of geographic imagination (Gregory 1994). Perceptions of places are shaped by discourses of marginality, identity, and exclusion (Shields 1991; Sibley 1995, Price 2004; Massey 2005). As Said (1978) illustrated, geographic imagination is complex in its creation and the associated ideas often long enduring. Contemporary geopolitics also affects destination image (Rowen 2016). For example, perceived risk has been repeatedly linked with lessoned tourist demand (Saint Akadiri et al. 2020; Lee, Olasehinde-Williams, and Saint Akadiri 2021).

Tourism marketing has been researched for decades (Coltman 1989; Lumsdon 1997; Jamrozy 2007; Kolter, Bowen, and Makens 2009). Branding is used to create a "personality" for a destination, which shapes both how an attraction is perceived and the expectations and behavior of tourists. As technology has evolved, so too have the most common tourism marketing mediums. The internet has made information available at the traveler's fingertips (Olmeda and Sheldon 2002; So and Morrison 2004; Lin and Huang 2007), including websites offered by attractions and destinations, social media, and word of mouth platforms such as TripAdvisor (Choi, Lehto, and Morrison 2007; Nielson 2013). Other common sources include personal experience, peer conversations, travel books (Echtner and Ritchie 1991), television, and movies (Chalip, Green, and Hill 2003; Govers, Go, and Kumar 2007).

Destinations often cater specifically to college students since they are a diverse group, comprised of all types of Cohen's (1974) travelers, from those craving novel experiences to those seeking familiarity in their destination. They travel in high numbers, enabled by short-term

and semester-long study abroad programs (Kim et al. 2007; Rodriguez et al. 2012). Students comprise an important cohort for the industry, fostering their travel fever early and maintaining it throughout their lives. They have also been more exposed to different lifestyles, cultures, and people than high school students; making them a prime candidate for studies on destination image (Sirakaya and McLellan 1997; Gibson, Qi, and Zhang 2008; Wang and Hsu 2010).

Destination Image and Asia

Researchers have studied how the Asia Pacific region compares to other regions and competition within the region itself (Enright and Newton 2005). Asia has been considered collectively (Mak and White 1992; Winter 2007; Singh 2009) and on a country-by-country basis (Peleggi 1996; Lew 2003; Chon et al. 2003; Jackson 2006; Crooks 2011). Asia has also been a dynamic focus in the literature regarding destination images of developing nations (Lee et al. 2005). Researchers have yet to compare the countries with the top arrivals based on sub-region – China, India, and Thailand – making this research especially pertinent as a juxtaposition of Asia's three largest sub-regional tourism players.

After the active exclusion of most foreigners during the era of Mao Zedong, the Chinese government first embraced tourism as an integral part of their development vision in the 1980s (Xiao 2006). Tourism was further designated as a growth point of the national economy in the late 1990s (Lew et al. 2003) and China's government has subsequently used tourism to generate revenue and promote positive images to travelers. One of the focuses of China's tourism development has been designation of sites on the UNESCO World Heritage List, an approach that is also tied into the government's geopolitical agenda (Li et al. 2008). Much of the literature on China's destination image centers on the 2008 Summer Olympic Games in Beijing (i.e., Gibson, Qi, and Zhang 2008). Overall, destination images of China tend to be positive (Tasci and Gartner 2007; Choi, Chan, and Wu 1999, Xiao and Mair 2006), with both strengths and weaknesses considered by tourists (Shani et al. 2009). However, the complex geopolitical relationship between the U.S. and China – as well as lingering attitudes from the Cold War – may also exert influence on the perceptions of American college students (Yee and Storey 2004; Ambrosio, Schram, and Heopfner 2020).

Tourism in India has grown recently with interest in sites including the Taj Mahal, the Red Fort, and the city of Mumbai. After improvement to other sectors, such as agriculture, housing, and water (Kaur and Johari 2011), India began dedicating resources to uplifting their economy with tourism in the 1990s (Taqi et al. 2018). Relatively little research has been done regarding India's destination image. Based on the literature, potential travelers deem India's culture as exotic and their food, arts, and language as intriguing, but express concerns about overcrowding and safety (Kale and Weir 1986; Ahmed and Krohn 1992; Chaudhary 2000; Crooks 2011).

Thailand made a concerted effort at growing their tourism sector in the 1990s to increase foreign export earnings (McDowall and Wang 2009) and is now one of Asia's top destinations. Following the Korean and Vietnam Wars, Thailand was associated with sex tourism, with demand shifting from GIs on leave to the wider tourist market (Garrick 2005). Though

prostitution is illegal, sex tourism remains a primary lure for many visitors. To expand their market, Thailand has purposefully focused on cultural, gastro, and medical tourism. To date, there has not been extensive research on Thailand's destination image, with studies focused on the aforementioned products (e.g., Wilson 2011; Pullphothong and Sopha 2012) and the influence of films (Law, Bunnell, and Ong 2007; Mostafanezhad and Promburum 2018).

Methods

This research focuses on how destination-related perceptions impacts college students' choices about traveling to Asia. To better understand any connection, we surveyed college students at Central Connecticut State University (CCSU), a regional comprehensive public university, regarding their perceptions and willingness to travel to the most visited countries in the three Asian sub-regions: China in North-East Asia; Thailand in South-East Asia; and India in South Asia. Overall, we sought to answer the following questions:

1) What positive or negative perceptions do Connecticut college students (who have never been to China, India or Thailand) have about these countries?
2) Does knowing someone who has traveled to one of the subject countries influence their own perceptions?
3) Is there stronger demand to travel to one of the countries? Does gender influence travel demand?

Survey Design

Surveys are commonly used in tourism geography research. The literature related to destination image and visitation numbers have ascertained results based on surveys (Chen and Tsai 2006; Chi and Qu 2007; Chen and Phou 2013). In research on destination image and visitation to China, Gibson, Qi, and Zhang (2008) surveyed college students to assess their travel experience, travel intentions, and perceptions of risk, among other factors. They primarily used a Likert Scale survey, giving participants a five-point scale to express how strongly they agree or disagree with certain statements. As the Likert Scale survey was effective for their research questions, which are comparable to ours, we sought to emulate their methodology to assess students' destination knowledge, access to promotional images, and plans to travel. The survey administered for this research had four main sections:

a) *Respondent Background*: Respondents were asked their age, gender, if they knew anyone who had been to China, India or Thailand and, if so, if that person's experience was positive.
b) *Likert Scale Questions*: Questions assessed the likelihood, interest, or agreeability with certain statements (1 to 5 Scale). Early questions assessed interest in traveling internationally and to Asia. The remaining 11 question sets were then asked specific to each country (thus each question was answered three times; once per country). Effectively, upon completion of this section, students had submitted 35 Likert responses (first 2 plus 11x3).

c) *Open Response*: Open questions sought to identify common perceptions by asking students to provide three keywords that come to mind to describe each country and then identify the biggest appeals and barriers for traveling to each country.

d) *Ranking of Travel Media Information*: The final section sought a ranking of the importance and reliability of travel information sources. Due to confusion from this section's design, response approaches were inconsistent and conflicting. Thus, no results were discernible, and this survey section is omitted from the research.

Survey Administration

Since the research relates to college students' perceptions, the survey was explicitly targeted to "traditional" college students (those attending shortly after high school, aged 18-25), since they are a desired market for tourism research due to study abroad, break travel, and long-term travel plans. The other prerequisite was that participants had not visited any of the three countries, as our research intended to capture preconceptions. To understand variations by gender, we sought a roughly even split between male and female respondents. Besides age, gender split, and whether someone had visited a subject country, no other individual characteristics were used to filter or identify survey respondents. Through random canvassing on campus and administering the survey in two general education courses, we sought a diversity of ethnic backgrounds and fields of study; however, we did not explicitly ask for respondents to identify such characteristics. The survey was administered in 2018 at Central Connecticut State University's main campus in New Britain, CT. Students confirmed to be in the target sample group were asked to complete the survey. Ultimately, 111 CCSU students anonymously completed the survey and provided consent to include their responses.

Data Preparation & Analysis

The first analysis step generated descriptive statistics to compare countries and see how perceptions impact the willingness to travel to each country. The next analysis stage compared subset respondent populations using t-Tests: first comparing male and female respondents to see if gender impacts perceptions or travel intentions and, second, comparing respondents who knew someone that had been to one of the countries to the population that did not. A final group of t-Tests compared how perceptions of a country impact one's interest in traveling there. For this analysis, those interested in traveling to a specific country (indicated by a 4 or 5 response) were one population compared to those NOT interested in traveling to (indicated by a 1 or 2 response). Any neutral respondent (reporting a 3 for that country) was omitted from those t-Tests. Open-ended responses were reviewed to identify common replies. Keywords were grouped by whether they were positive, negative, neutral, or miscellaneous. Research analysis ultimately focused on the positive and negative keywords to shed light on polarized destination imagery.

Field	Count	Percent
Total Respondents	111	
Male	34	30.6%
Female	77	69.4%
Respondents' Age		
Average Age	20.5	
Minimum	18	
Maximum	25	
Knows someone who has traveled to China, India or Thailand	63	56.8%
If knows someone, number who had positive experience	61	97% (of 63)

Table 2. General Information about the Survey Respondents

Results

The survey was completed by 111 students: 77 were females and 63 people (56.8 percent) knew someone who had traveled to one of the countries (See Table 2). Of those 63 people, 61 (97 percent) reported that their acquaintance's experience was positive.

General Results of Likert Scale Survey Responses

Of the 111 respondents, interest in traveling internationally was strong (mean 4.75; mode 5) but when asked about traveling specifically to Asia, there was markedly less interest (mean 3.77; mode 5; See Table 3). Since the mode was still 5, however, it appears that what is reflected is not an overall decrease in interest but rather much lower interest level among those not finding Asia to be an appealing region to visit. Interest in traveling to the three subject countries varied from country to country, but all three generated lower interest by respondents than the "traveling to Asia" question, potentially indicating interest in traveling to a different country than one of these three. Thailand scored the highest (mean 3.70; mode 4), China was second (mean 3.49; mode 4) and India was lowest (mean 3.13; mode 3).

The idea that travelers were likely to encounter overcrowding in China (mean 4.55) and India (mean 4.39) were quite high (modes for both countries were 5's). Thailand's perceived overcrowding was lower (mean 3.68; mode 4). There were strong perceptions of poverty in India (mean 4.21) and Thailand (3.95) with "5" as the most frequent response. China's poverty was perceived to be lesser (mean 3.66; mode 3). Oppositely, however, China was expected to have higher pollution (mean 4.29; mode 5) while Thailand was thought to have the lowest pollution among the three (mean 3.58; mode 3).

Respondents did not think the culture of the subject countries were similar to the United States (means ranging from 2.19 to 2.60). When asked about cultural heritage, responses show that China (mean 3.95) has a higher rate of cultural heritage appeal than India (mean 3.69) or Thailand (3.82) but both China and India had 5's as their most common response. The questions regarding the appeal of the subject countries' natural environments showed that Thailand is perceived to have an attractive natural environment (mean 4.03; mode 5) among surveyed college students, especially compared to India and China (mode 3 for both). Thailand and China were both perceived to be more welcoming to tourists than India (medians and

modes of 4 compared to India's 3's). Despite these variations in perceived welcomeness, all three countries scored closely on the level of difficulty to interact while in each country (means ranging from 3.48 to 3.55). Regarding perceptions of safety, the modes and medians for all three countries were right in the middle at 3; however, China's average (3.50) was slightly higher than India (3.09) and Thailand (3.19) and therefore perceived to be safer by many respondents.

Likert Question	*Mean*	*Median*	*Mode*	*Mean*	*Median*	*Mode*	*Mean*	*Median*	*Mode*
How interested are you in traveling:	Internationally						to Asia		
	4.75	5	5				3.77	4	5
How interested are you in traveling:	to China			to India			to Thailand		
	3.49	4	4	3.13	3	3	3.7	4	4
Likelihood to encounter overcrowding:	in China			in India			in Thailand		
	4.55	5	5	4.39	5	5	3.68	4	4
Likelihood to encounter visible poverty:	in China			in India			in Thailand		
	3.66	4	3	4.21	4	5	3.95	4	5
Likelihood to encounter pollution:	in China			in India			in Thailand		
	4.29	5	5	4.02	4	5	3.58	3	3
Perceive US culture to be similar to:	China			India			Thailand		
	2.60	3	3	2.21	2	2	2.19	2	2
How tourist-friendly is transportation:	in China			in India			in Thailand		
	3.49	4	4	3.01	3	3	3.24	3	3
How welcoming to tourists are they:	in China			in India			in Thailand		
	3.56	4	4	3.37	3	3	3.75	4	4
How difficult will it be to interact:	in China			in India			in Thailand		
	3.55	4	3	3.51	4	4	3.48	4	4
How appealing is the cultural heritage:	in China			in India			in Thailand		
	3.95	4	5	3.69	4	5	3.82	4	4
How appealing is the natural environment:	in China			in India			in Thailand		
	3.64	4	3	3.58	4	3	4.03	4	5
How safe for tourists is it:	in China			in India			in Thailand		
	3.50	3	3	3.09	3	3	3.19	3	3

Table 3: Select Summary Statistics of Likert Scale Survey Responsess

Results of t-Tests Part 1: Influence of Gender on Destination Perception

To understand how gender influences perceptions and preferences, a series of t-Tests were performed comparing male (n=34) survey responses to those by females (n=77). Of the 35 t-tests, 29 had no significant difference between male and female responses. With respect to perceptions of poverty, pollution, difficulty of interactions, and safety for tourists, there were no significant differences between how men and women perceived all three countries. Similarly,

there were no differences between female and male respondents about comparison to U.S. culture, receptiveness to tourists, or ease of transportation for tourists.

Generally, both genders had similar responses about interest in traveling internationally, traveling to Asia, and to China. Regarding travel to India and Thailand, however, women were significantly more interested in visiting those countries than men (See Table 4). Women found the cultural heritage more appealing than men did for both countries as well. In addition, Thailand was perceived by women to be overcrowded but yet to offer an appealing natural environment. There were no significant differences in women's and men's responses about China's cultural heritage or overcrowding or the natural environment in India and China.

Nature of Question	Country	Pop. A Mean	Pop. B Mean	Mean Diff.	t Stat	Two-tail P-value	Lower Conf. Interval	Upper Conf. Interval
		Males	*Females*					
Interest in Traveling to	India	2.76	3.29	-0.52	2.10	0.04	-0.03	-1.01
Interest in Traveling to	Thailand	3.24	3.91	-0.67	2.92	0.00	-0.22	-1.13
Perceived Overcrowding in	Thailand	3.33	3.83	-0.50	2.56	0.01	-0.11	-0.88
Appeal of Cultural Heritage in	India	3.29	3.87	-0.57	2.46	0.02	-0.11	-1.04
Appeal of Cultural Heritage in	Thailand	3.38	4.01	-0.63	2.94	0.00	-0.21	-1.06
Appeal of Natural Environment	Thailand	3.71	4.17	-0.47	2.28	0.02	-0.06	-0.87
		Does NOT Know Anyone	*Knows Someone ...*					
Interest in Traveling to	Internationally	4.57	4.88	-0.30	2.57	0.01	-0.07	-0.53
Interest in Traveling to	India	2.85	3.33	-0.48	2.06	0.04	-0.02	-0.94
How Difficult to Interact in	China	3.81	3.35	0.46	2.16	0.03	0.04	0.88
How Difficult to Interact in	India	3.81	3.29	0.52	2.57	0.01	0.12	0.93
How Difficult to Interact in	Thailand	3.79	3.25	0.53	2.58	0.01	0.12	0.94
Appeal of Natural Environment	Thailand	3.76	4.22	-0.46	2.40	0.02	-0.08	-0.84
Interest in Traveling to	China	*Low Interest*	*High Interest*					
Tourist-Friendly Transport in	China	3.00	3.69	-0.69	-2.64	0.01	-1.17	-0.22
How Welcoming to Tourists in	China	3.22	3.83	-0.61	-3.37	0.00	-1.02	-0.20
Appeal of Cultural Heritage in	China	3.04	4.42	-1.38	-5.32	0.00	-1.82	-0.94
Appeal of Natural Environment	China	2.83	4.00	-1.17	-4.86	0.00	-1.65	-0.70
Interest in Traveling to	India	*Low Interest*	*High Interest*					
Tourist-Friendly Transport in	India	2.62	3.05	-0.43	-2.06	0.04	-0.84	-0.01
How Welcoming to Tourists in	India	3.03	3.52	-0.49	-2.53	0.01	-0.87	-0.12
Appeal of Cultural Heritage in	India	2.71	4.36	-1.66	-7.52	0.00	-2.09	-1.22
Appeal of Natural Environment	India	3.20	3.95	-0.75	-3.36	0.00	-1.20	-0.31
Interest in Traveling to	Thailand	*Low Interest*	*High Interest*					
Appeal of Cultural Heritage in	Thailand	2.88	4.19	-1.30	-4.29	0.00	-1.83	-0.78
Appeal of Natural Environment	Thailand	3.12	4.37	-1.25	-4.81	0.00	-1.72	-0.79

Table 4. Results of Significant t-Tests

Results of t-Tests Part 2: Influence of Knowing Someone who has been to the Country

Another factor tested was whether respondents who know someone that has been to one of the countries (n=64) have different perceptions and preferences compared to someone who does not have such "word-of-mouth" knowledge on these places (n=47). Interestingly, as with gender, there was no significant difference on 29 of the 35 survey question responses. The six questions that were significantly different between the two tested populations differed from the six for the gender-based t-Tests, however. Firstly, people who knew someone who had been to one of these three countries were significantly more interested in traveling internationally and going to India specifically (no significant variation was present for travel to Asia, China, or Thailand). Respondents who knew someone also had a higher view of Thailand's natural environment. Across the board, respondents who did not know anyone that had been to these countries were significantly more likely to perceive it to be difficult to interact in all three countries. Conversely, those who did know someone had a better idea about interactions in that country and were less likely to perceive that to be an issue. Interestingly, there were no other significant variations between people that knew someone and those that did not for the range of questions on pollution, culture, safety, and other factors.

Results of t-Tests Part 3: Influence of Interest in Traveling to a Specific Country

The final set of t-Tests were to understand how an interest in traveling to one of the countries relates to perceptions about that country. For all three countries, those expressing high interest in visiting had significantly higher views of both the natural environment and cultural heritage of that country. In other words, a positive view of culture and nature is associated with a higher interest level, whereas those without such positive perceptions are significantly less likely to want to visit. Those interested in visiting China or India perceived those countries to be much more welcoming to tourists and have easier-to-use transportation than their fellow respondents with low or no interest in visiting those countries.

Results of Open-Ended Questions: Destination Image Keywords

As part of the survey, students were asked to record three keywords that come to mind when thinking about the destination image of the three subject countries. China's destination image among this sample is overwhelmingly negative. Overall, there were 59 distinct keywords; the most common response was that China is too populated (n=34) or overcrowded (n=24). Being "busy" (n=15) and polluted (n=18) were also frequent associations. Common positive responses include "culture" (n=15) and "interesting" (n=10). Overall, India had 78 distinct keywords. While India also had common negative keywords (e.g., overpopulated, n=23, and crowded, n=21), there were generally more positive associations. India's culture (n=30) and food (n=13) were frequent responses, as well as descriptors like beautiful (n=9), colorful (n=8), and interesting (n=4). Thailand generated a range of 84 distinct keywords. Perceptions were largely positive with keywords like beautiful (n=24), culture (n=18), and beaches (n=14)

dominating the responses. Populated (n=8) and different (n=8) were also common responses, but otherwise the keywords were wide-ranging from cheap alcohol and prostitution to meditation and waterfalls.

Results of Open-Ended Questions: Appeals for Visiting

When asked specifically about the appeals for traveling to the three countries, culture and food were the most common draws for students. For China, food (n=31) and culture (n=36) were the strongest, with historic places (n=13) also appealing (especially as it relates to The Great Wall, n=28). Food (n=23) and culture (n=11) were the most frequent responses for India, with all the other appeals only mentioned by one or two respondents. The range of appeals for India was everything from low cost and beauty to religion and traditions. Like China and India, culture (n=30) and food (n=17) were the most favored aspects of traveling to Thailand. In addition, there was a strong appeal of Thailand's natural landscapes (n=12) and environment (n=9).

Results of Open-Ended Questions: Barriers to Visiting

When asked about barriers to traveling to these countries, language and the different aspects of getting to the countries were by far the biggest perceived challenges. Language was the most frequently reported barriers for all three (China n=45, India n=31, and Thailand n=32). The cost of travel was perceived to be just as much a barrier in China (n=45), while less so in India (n=19) and Thailand (n=20); however, India and Thailand had many more respondents citing the distance (Thailand n=15) or the flight (India n=11). China split that with 9 respondents each reporting the flights or distance as issues.

Barriers unique to each country were cultural differences (China n=9), overcrowding (India n=12), and general safety (Thailand n=6). Variations of political concerns also evidenced themselves in China with government (n=7) as a common response.

Full Survey & t-Tests Results

Since the outcomes from t-Tests and the lists of keywords are lengthy, full results are not able to be included here but are available from the authors upon request.

Analysis

With college students as a major source of would-be travelers, it is critical to understand what shapes their perceptions and willingness to travel. We found a strong demand among surveyed college students to travel internationally and to travel to Asia, specifically. Students were less interested in traveling to China, India, or Thailand than they were to Asia overall, so it is possible students were more interested in other Asian countries. While demand was strong to travel internationally, the perceived barriers of going to one of the three subject countries are clearly hampering their appeal to college students in Connecticut. Concerns about language barriers, different cultures, and political differences are all considerations when it comes to

whether they would like to visit these countries or not. Analysis of survey results will be framed by the three core research questions:

1) What positive or negative perceptions do Connecticut college students (who have never been to China, India or Thailand) have about these countries?
2) Does knowing someone who has traveled to one of the subject countries influence their own perceptions?
3) Is there stronger demand to travel to one of the countries? Does gender influence travel demand?

What Perceptions do Connecticut College Students have about China, India, and Thailand?

While Connecticut college student perceptions vary across the three countries, there are several pervasive images common across all three. Most students identified the countries as having cultures that are very different from American culture. This cultural difference, however, creates a surprising split: some seeing distinct cultures as a major appeal, and others seeing this as a barrier and possible cause of anxiety. So, while distinct cultures may be a specific appeal to bring some students, this very attribute may also serve to deter others altogether. All three countries were also perceived to be overcrowded by many of the respondents.

Whether culture was appealing or not, many surveyed students saw all three countries as offering a variety of natural amenities. Students indicating a desire to visit a specific country often seemed attracted to the combination of distinct cultural and natural offerings. The surveyed college students who knew someone that had been to Asia were drawn by Thailand's natural scenery. Thailand has marketed its natural environment extensively in recent years, often showing off stunning islands. Based on this survey, Thailand has been doing an excellent job, as those who heard any word of mouth about Asia were excited by the country's landscape. As culture, and specifically food, were frequently offered as appealing attributes about a country, it raises questions about student knowledge of these countries and if there is any connection to or limitation from eating frequently at Chinese, Indian or Thai restaurants in the United States.

For all three countries, the cost of the trip and the flight itself hampered the demand to visit. The challenge of long flights is not something easily overcome, especially for college students, who are limited by university breaks. Even in a scenario where travel costs to Europe are comparable, shorter travel distances will allow more sightseeing time in Europe than in Asia, particularly during a tight schedule. Therefore, Asian tourism agencies may be better served to market themselves as winter and summer break or travel abroad destinations to allow for longer trips. It may behoove countries to work collaboratively rather than competitively in marketing themselves to American students so that the time and money spent on flights could include multiple stops in Asia over a several week span.

Due to the prevalence of China in American news and politics, there was some confusion about whether Americans are welcome in China and, once there, whether you can use technology (phone/internet) or not. It is evident from our research that the geopolitical relationship between the U.S. and China is impacting student perceptions, though not to what

extent. India's opportunities include needing to better market its cultural sites, as many students strongly saw cultural heritage as a draw, but only the Taj Mahal was specifically mentioned as a key site to visit. Strong appeal related to culture, religion, and history suggest there is room to build upon these by marketing additional landmarks and places that combine these strengths. In addition, despite having beautiful beaches and coastlines, India seems to be losing out to Thailand on being perceived as a beach destination. Indeed, India could market itself as a combination of history, culture, and beach relaxation.

Are Perceptions Influenced by Knowing Someone who has been to China, India or Thailand?

Receiving firsthand information about a country from a friend or family member can play a huge role in one's perceptions and willingness to travel. In comparing perceptions and interest, those who knew someone that had been to one of the countries were significantly more interested in visiting as well. These students perceived the country to be more welcoming to tourists, easier to navigate, and having more appealing attractions. Oppositely, those who had not received firsthand knowledge from an acquaintance were significantly more negative in their perceptions and less likely to want to visit; indicating concerns about communicating and the ability to interact in those countries.

Is There Stronger Demand to Travel to One of the Countries? Does it Vary by Gender?

Generally, China and Thailand were more appealing to these college students than India. When looking at women respondents, however, India and Thailand were seen as more attractive to visit. Thailand had the biggest variation by gender and, based on some of the key words reported, seems tied to female perceptions of Thailand as a place of beaches and relaxation with good food, spas, and an eclectic night life. This situation creates an interesting question for Thai tourism officials: are they missing out on the college male demographic, or should they play up these perceptions in marketing directed to college women? Just as Central Florida appeals to families and Las Vegas markets itself as a playground for adults, there is the possibility that Thailand could build a niche market as well.

Those expressing interest in visiting China, India, and Thailand had significantly better views of both the cultural heritage and natural environments of those countries. In other words, a positive perception of culture and nature seems to be associated with demand. Those with demand for China or India also perceived those countries to be much more welcoming to tourists and have easier-to-use transportation than their counterparts with low or no interest in visiting. This finding represents an opportunity for marketing to students: if you can increase students' understanding of cultural/natural offerings and accessibility, you could significantly shift students' willingness to visit these places.

Conclusion

China, India and Thailand are the dominant tourist destinations in their respective sub-regions of Asia. Despite this, research on the three countries is limited regarding tourism geography and destination image, especially for Thailand and India. This paper builds on existing research in focusing on a group of college students' perceptions and preferences for traveling to these countries. Many types of tourism cater to young people since they are often more flexible in their ability to travel and potentially more open to it (Field 1999; Barron and Arcodia 2002; Sakakida, Cole, and Card 2004). Therefore, understanding how they perceive certain places can inform industry specialists about building on positive imagery and overcoming negative perceptions; especially when considering the role of social media in current times.

A primary finding of our research as it relates to international travel, and particularly to countries in Asia, is that the influence of knowing people who have been to those locations is significant. College students, such as those surveyed, are typically more open to new experiences and to traveling (Kim et al. 2007; Lesjak et al. 2015). Therefore, American college students may serve as a "canary in the coal mine" for international destinations seeking to attract American tourist dollars. Places viewed as unwelcoming or difficult to navigate by college-aged Americans would potentially be even less attractive to those traveling in later life stages with families or health considerations. Therefore, one might expect an even more significant dichotomy among other would-be travelers in later life stages regarding the impact of knowing someone who has been to that country or not.

A major piece within the purview of the tourism industry is whether to specialize in serving a targeted population or to instead appeal to a broader market. Based on our research, Thailand exhibits more attraction to women than men. Hence, Thailand may consider more targeted marketing towards men or, alternatively, playing-up their identity as a premier destination for a "girls' getaway." Similarly, if immersion into an authentic culture is a major draw for American students to visit China, India, or Thailand, commodifying the culture could ultimately push the culture-seekers to visit other places instead. Building on the reality that knowing someone who has visited can make-or-break demand, Asian countries may want to consider marketing campaigns that include first person testimonials or encouraging visitors to share their experiences via social media or other mediums with friends and family.

This research identified many common perceptions, appeals, and deterrents for college students in Connecticut to visit China, India, and Thailand. A limitation of this research is that it surveyed only students at one university. It created, however, an easily replicated survey that can be administered at college campuses throughout the United States. Since the "Travel Media Information" section of our survey caused confusion amongst respondents, this section needs to be revised. Future research could also directly explore the role of geopolitics in informing American college student perceptions of the leading Asian destinations. As knowing someone who had visited Asia is clearly impactful, the survey could be expanded to achieve more detailed responses on the topic. For example, is social media a major avenue of information? And, to what degree does it matter if the person who has visited is a close friend or distant acquaintance?

Also, is this pattern of knowing someone more influential as it relates to Asian countries only or do comparable trends emerge for other international destinations or even domestic sites? If college-aged potential travelers are getting most of their information from peers on social media, the tourism industry would be well-served to ramp up imagery of their country via social media platforms. If, however, the main conduit of information is indeed word-of-mouth diffusion from trusted friends and family, it is unclear how the tourism industry could overcome this limitation.

Consistent with prior studies (Kale and Weir 1986; Ahmed and Krohn 1992; Chaudhary 2000; Crooks 2011), participants in our survey expressed anxiety about traveling to China and India due to overcrowding. Taken together, China and India's destination images particularly seem to suffer from negative preconceptions. These country-specific impediments may be exacerbated by the COVID-19 pandemic, with dense populations and poverty viewed as contributing factors to outbreaks. As this research was completed prior to the COVID-19 pandemic, it will be pertinent to do a follow-up survey to see how the pandemic has impacted travel preferences. In the meantime, the negative perceptions identified in this research can be a guide to tourism officials on how to improve access to information and generate positive destination images in their respective countries.

Taylor J. Ouellette has a Master's degree in Geography from Central Connecticut State University. Email: taylor.ouellette@my.ccsu.edu. Her research interests are tourism and destination image.

William R. Price is an Assistant Professor in the Department of Geography and Meteorology at Ball State University. Email: wrprice@bsu.edu. His research centers on tourism, cultural heritage, and sustainability.

Timothy J. Garceau is an Associate Professor of Geography and Planning at Central Connecticut State University. Email: tgarceau@ccsu.edu. His research focus areas are sustainable transportation and urban redevelopment.

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FROM THE MOUNTAINS TO THE SEA:

Protecting Nature in Postwar New Hampshire

K.A. Jarvis
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Reviewed by Jonathan Leonard
University of Connecticut
Department of Geography

From the Mountains to the Sea: Protecting Nature in Postwar New Hampshire explores the underlying *sense of place* that led residents to band together in preserving their way of life. The author introduces three distinct areas in New Hampshire with varying challenges associated with their conservation, as they each invoke a different sense of meaning and importance to the people of the *Granite State*. The author, Dr. Kimberly A. Jarvis, is a professor of history at Doane University and specializes in women's studies, and the conservation movement in the United States. Dr. Jarvis is also the author of the book, *Franconia Notch and the Women Who Saved It*, and several journal articles and conference papers.

From the book's introduction to the second chapter, the author introduces Franconia Notch, a region in the White Mountains, and follows the campaigns to save the area from excessive timber harvesting practices, and the proposed construction of an interstate highway. The battle, generally between official entities and the people who live there, lasted decades. The purpose of the proposed interstate was to connect the *north country* to the rest of southern New Hampshire, in the interest of increasing economic development in the more rural northern part of the state. In addition, an interstate would also increase tourism to the notch, as vacationers from the more urban parts of New England and New York were a major source of income for many inhabitants in the region. The author does a wonderful job extrapolating the details and local politics that took place over this decades-long debate. Dr. Jarvis emphasizes that the will of the people was not necessarily to preserve the notch *as is* and *untouched*, but rather it was the recognition that economic development is needed, yet it must be done in a way that ensures that the character of their land is maintained. At the time, a natural land feature in Franconia Notch, the Old Man of the Mountain, was regarded as the very soul of the Granite State. The Old Man was a large granite cliff edge in the shape of a face that appeared to *watch over the land*. By the late 20th century, in what can be seen as one of the greatest compromises between economic development and environmental conservation, a gentler *scenic parkway* was built through the notch, instead of the more environmentally destructive interstate highway.

Chapters 3 and 4 explore the campaigns to save Sandwich Notch, a region also in the White Mountains, in the town of Sandwich which is fifteen miles southeast of Franconia. While it is natural to assume that the reasons to save the notches of Franconia and Sandwich are similar, they are different cases with differing physical and human geographies. The campaign

efforts in Franconia Notch were focused mainly on saving the area from the construction of an interstate highway, while Sandwich Notch residents rejected the commercialization of their town. By the early 20th century, Sandwich Notch was becoming a popular destination for the establishment of summer homes by wealthy city slickers in nearby cities. This was viewed by the locals as ruining the identity of the area. New Englanders are known for being nostalgic and place great emphasis on concepts such as history and tradition. That being the case, Sandwich Notch was seen as a place in the region which represented the *old New England* way of life, and it must be preserved. Efforts to save Sandwich Notch were focused on the area along Sandwich Notch Road, one of the first roads built in the area in the 17th century. Besides the value of the road itself, there are several features that have historical importance such as old foundations, cellars, and stone walls. This section of the book, like previous chapters, explains the long process with regard to conservation and that baby steps were often necessary. For example, the first success in the process of Sandwich Notch conservation was the simple, yet drawn out, act of making Sandwich Notch Road a *scenic road* in order to protect the natural and anthropogenic features that are along it.

In Chapter 5, the book's final chapter, the author leaves the mountains of the central and northern part of the state for the coastal region. The state of New Hampshire has the shortest coastline in the United States with just over eighteen miles of seashore. If we include the Great Bay Estuary, which is adjacent to the town of Durham, that coastline more than doubles. With such a limited shoreline, it is expected that residents living there would fight fiercely to the prospect of any possible environmental hazard. Unlike the previous two regions, Durham is not a wild and sparsely populated area as it has been well populated since the 17th century due to its proximity to the coast. In 1973, a new company called Olympic Refineries developed plans to build what would have been the world's largest oil refinery in Durham, but the town's residents mobilized to prevent what they viewed as a threat to their town. Here the argument was not necessarily about preserving the untouched beauty of the seashore, but more so to preserve a way of life that residents have known for generations. For example, many in the town were aware of catastrophic oil spills in other parts of the country and feared that if this happened in their town, what would become of the fishing industry that so many have relied on for generations? Most agreed that an oil refinery was necessary for the economy; however, the common concern was simply that it shouldn't be built *here*. What I found interesting about this chapter is how the author provides some background connecting the events in small-town America to the world stage and the 1973 OPEC Oil Embargo in the Middle East. Following the passing of legislation, the residents of Durham used the concept of "Home Rule" to combat the to combat the oil executives of New York City, the publisher of the state's only daily newspaper, and even their own governor.

The merits of this book are considerable. The author uses a wide array of sources which helped to paint an honest picture of the modern histories regarding three distinct towns in New England. It is enjoyable to see old newspaper clippings and flyers created by several environmental organizations included. Although, the only examples shown in all three conflicts are from the perspective of the preservationists. For instance, if there were Sandwich Notch real estate advertisements or information flyers in support of Olympic Refineries, it would have been

an entertaining contrast to include in this book. However, those were the losing parties after all, and history is commonly written by the victor. Also, Dr. Jarvis does an excellent job in showing that, while concepts like ethics and moral duty are commonly mentioned as principal driving forces for environmental conservation, the *sense of place* made up of personal connections such as nostalgia, identity, and sentimentality are also powerful factors.

Overall, I highly recommend this book as it gives us an intimate look at the struggles of residents in rural New England in the 20th century. It isn't explicitly stated in the book but, what is also refreshing is how the author effortlessly weaves concepts from different fields such as history, political science, geography and more, in order to give an honest picture of the happenings in small-town America. In addition, it is intriguing how the author captures what might be the leading motivation that convinced the majority of the people to support the protection of the land: the New Englander's deep and undeniable *sense of place*.

HOME NOW: HOW 6,000 REFUGEES

Transformed an American Town

Cynthia Anderson
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Reviewed by Pablo S. Bose
Department of Geography
University of Vermont

For the past thirty years I have been intrigued by the dynamics of refugee resettlement outside of major metropolitan areas across the world, and especially in the United States. Like labor and other migrants, refugees have in recent decades increasingly settled in secondary cities, smaller towns, and rural regions, including in the South, in the Midwest, and in the Rustbelt. Unlike other immigrant populations, refugees have little say on their initial placement, and are relocated primarily due to decisions made by the federal government and its resettlement agency partners and their networks. The fate of refugees who end up in disparate communities across the United States. has become a topic of much political debate and controversy in recent years. What happens to those who go not to more traditional immigrant destinations like New York City, Miami or Los Angeles but rather are placed in small towns in California and Massachusetts, in rural Georgia or Idaho, or in rustbelt cities in Ohio and Pennsylvania? And what happens to the communities who have welcomed newcomers into their midst? Have they changed and if so, how?

It is with such interests in mind that I picked up Anderson's *Home Now*. Its title and blurb promise a focus on refugee resettlement in Lewiston, Maine and the ways in which that process has played out through the turbulence of the recent past. The book does tell that story, but this is less a tale about Lewiston and more about (some of) those who live in it. In many ways the town is really a backdrop to the accounts of a handful of individuals whose lives, struggles, and successes Anderson illuminates over the course of five years – and how these personal narratives shed an intimate light on the debates regarding immigration, identity, integration and belonging that are roiling the United States as well as the world. I was curious to return to the story of Lewiston in particular. Within immigration and especially refugee resettlement studies, the tale of the town in the Northeast is notable and somewhat notorious. In 2002, in response to ongoing (primarily secondary) migration by Somalis into Maine and into Lewiston in particular, the then-mayor penned an open letter to newcomers advising them not to come and warning that city services would be overwhelmed by their arrival. This act spurred a furious set of responses and counter-responses, with white hate groups cheering the stance and a much larger number of immigrant rights supporters and the Somali community itself pushing back against the xenophobic rhetoric.

In her book, Anderson takes the reader back to Lewiston more than a decade later to see how Lewiston has emerged from such tensions. In particular, *Hope Now* is focused primarily on the Trump years, between 2015-2019 and on the months leading up to and including the U.S. presidential election and the first year of Trump's presidency. The author takes the reader through election rallies and campaign promises, travel bans and the suspension of the refugee program, and more locally, the controversy surrounding a proposed bill to ban Female Genital Mutilation (FGM) in the Maine legislature. Anderson also shows us the events that frame the lives of people living through these moments – jobs sought, taken and left, education pursued (and endured), relationships explored, nurtured, ended and begun, weddings, funerals, trips, purchases, and plans, all the many decisions and outcomes of daily life that happen regardless of the drama taking place on the national stage.

Anderson's book is not a scholarly take on resettlement, though an increasing number of academic texts take up this question of immigrants and refugees outside of the major cities. Examples include studies of immigrant settlement in places like Nashville (Winders 2013), the US south (Ehrkamp and Nagel 2017), rural areas (Nelson and Nelson 2011), Fargo (2020), Utica (Kraly and Vogelaar 2011), Minneapolis-St. Paul (Chambers 2017), and my own research on Vermont (Bose 2020). Such work has sought to complicate many of the standard narratives and well-worn tropes of immigration and integration – what such journeys look like and what outcomes they produce. Thus, while there are many similarities one finds in the stories of resettlement whether in Boston or Chicago, Turlock or Twin Falls, there are also specificities and unique contexts that can be brought to life through a book like *Home Now* that does a deep dive into a particular case.

Anderson is well-positioned to tell this particular case, having grown up in the Lewiston area and having covered the region extensively in several previous news articles. She has returned more recently for both personal and professional reasons to live part of the year in Maine and takes up the tale in a particularly fraught moment, as locals (newer and older) question the value, purpose and outcomes of settling mostly African refugees in a mostly white, aging post-industrial small town. Anderson's background as a journalist and a non-fiction writer is reflected in the cadences and norms of *Home Now*. This is no academic treatise; there are no long discussions of methodology, no discussion of how she gained access to the main subjects of her book, no explanation of how she processed or analyzed their stories, no account of how she gained their trust to retell such intimate details of their lives, and no mention of whether those who are featured in the book received any backlash or criticism for opening up in the way that they did. Indeed, this is one of the things I found most jarring in the book – that it is so open and candid about the central figures, with their names, lives and even images featured prominently throughout. Especially in the field of refugee/resettlement studies, the tendency is much more common to mask or obscure identities for all kinds of reasons.

But of course, this is a journalistic account, not a research article or a scholarly monograph. And being so does not diminish from the depth of Anderson's work, which is clearly based on extensive and meticulous ethnographic research including repeated long-form interviews and participant observation within communities with which she is intimately familiar. Her familiarity with Lewiston is on display throughout the book and she intersperses the narrative

with her own memories and attachments to the place itself. The central characters in *Home Now* are a number of resettled refugees and asylum seekers in Maine, mostly from the Somali, Somali Bantu and Congolese communities. They include men and women, parents, high school and college students, and activists and community leaders. Anderson also features a number of other secondary and tertiary characters – others within the resettled communities, several local advocates who support them, and a few who have been active in opposing refugee resettlement in Maine. All are presented not as representative of their particular politics or communities, but rather as illustrative of the complicated and often contradictory nature of the dynamics of resettlement.

Overall, I found *Home Now* to be an engrossing read – in many ways it felt more like a serialized podcast or documentary than a book. In this sense the book feels like a series of vignettes where the reader returns repeatedly to each of primarily five lives and sees how each of Anderson's central and supporting characters are reacting to changes in their own lives and to the swirl of politics and culture all around them. How does the asylum seeker react to new changes in visa rules? What do the refugees think of the Trump rallies in Maine that demonize them directly? How do the proponents of the anti-FGM bill respond to the failure of their legislation? I was left wanting more context for all of these stories – in some ways it felt like just a small window into a particular moment, and I felt like the introduction in particular did not do enough work to set the stage for the book to come. A mere handful of pages introduce Lewiston, even less detail is presented about the author herself and precious little time is devoted within the book to introducing Anderson's relationships and connections within the community. This last would have been especially helpful because the reader is left wondering how indeed she managed to make inroads into communities (especially the Somali and anti-refugee groups) that generally show significant amounts of distrust of outsiders. I also would have liked to have seen a reframing of the introduction; as mentioned earlier the title and introductory chapter sets up an expectation that Lewiston will be the centerpiece of the book, but it rather quickly fades into the background and the central characters rise to prominence. This is not a failing in the book – it is the stories of Abdikadir, Carrys, Fatuma, Jamilo and Nasafari that are the most compelling and captivating in *Home Now*. Having been able to anticipate this trajectory from the outset of the book might have made it a little less unexpected as a reader however. *Home Now* would make an excellent complementary reading for researchers and especially undergraduate students interested in the lived experiences of refugees in smaller locations – though I would recommend pairing it with more scholarly works that introduce and contextualize the reasons for those placements in the first place.

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UNSUSTAINABLE INEQUALITIES:

Social Justice and the Environment

Lucas Chancel
Translated by Malcolm DeBevoise
Cambridge: Harvard University Press, 2020. vi, 175 pp.
cloth, ISBN: 9780674984653

Reviewed by Elizabeth A. Carlino
Department of Geography
Texas A&M University
College Station, TX

In the English translation of his 2017 book, *Unsustainable Inequalities*, French economist Lucas Chancel takes on the subject of inequality and seeks to understand it in the context of environmental sustainability. Exploring the relationship between sustainability and socioeconomic inequality, he brings attention to the policies developed at global climate summits over the last thirty years to understand how these goals, agreements, and policies might work to reduce inequality while still adequately protecting the environment. The author notes that there has always been a sense of tension between reducing socioeconomic inequality and protecting the environment and this tension has revealed itself in the way policies are created and acted upon. He uses this work to show that this tension need not be—that there are ways to achieve both pursuits simultaneously without detriment to the other. Drawing on some of his own previous work and data collected for the World Inequality Database (WID.world), Chancel paints a clear portrait of how unequal access to resources, exposure to risk, and responsibility for pollution ultimately cost us more in the long run. With ample data presented from several case studies, he clearly and effectively demonstrates that reducing these inequalities through data-driven policy making can help us achieve true sustainability and equity by placing environmental resiliency and socioeconomic equality at the forefront of our global policy strategies.

Throughout the book, he explains why the need to reduce inequality is inextricably linked with the need to protect the environment. He successfully argues that these two pursuits are not mutually exclusive—in fact, we cannot pursue one and ignore the other without serious long-term consequences. He lays out his argument carefully in the course of the work; first, looking at the relationship between economic inequality and unsustainability—namely, what trends and policies drive these inequalities and what does this mean for the environment? He then tackles the vast intricacies of environmental and social inequality at the global scale to understand how these drive unsustainable practices and he teases out the historical precedents which laid the foundation for these inequalities to fester quietly until they would eventually explode in the face of a global pandemic. Finally, he lays out the policy implications of reducing inequality

and expanding environmental protection and shows how this might usher in a paradigm shift in how we address climate change for both people and the environment. Most importantly, however, he demonstrates a degree of optimism throughout, showing the reader that though the data are grim, all is not lost. We have a unique opportunity to begin the process of reversing the environmental, social, and economic ills of previous decades in order to forge a clearer, more resilient path for ourselves and future generations. Written clearly and concisely, this is an accessible book for those with or without a background in economic analysis and will prove to be highly relevant in the months and years ahead as existing socioeconomic and environmental inequalities are further exacerbated by the COVID-19 pandemic.

In Part One, Chancel begins with describing how economic inequality is inherently bound up with unsustainable environmental practices. In describing the trends and drivers of economic inequality he identifies the principle causes and shows that while no one cause has overriding importance, each one represents a series of very specific and purposeful policy choices meant to maintain the status quo. A running theme throughout the work is that economic inequality has merged into political debates because of the threat it poses to global capitalism. The burgeoning political influence of those with increasingly vast amounts of private wealth subsequently drives the creation of policies which reinforce unsustainable practices and increase economic inequality. Bolstered by a good deal of country data detailing wealth and income disparities over the past several decades, the author shows us that these are not new problems and are, instead, the result of years of power-driven policy making. More importantly however, Chancel reminds the reader that because the driving forces behind unsustainability and inequality are policy *choices*, with the right political and moral will, these can be offset or overturned with more sustainable and more equitable policies.

In Part Two, the author sheds light on the ways pervasive social and environmental inequalities dampen our ability to fully realize the potential of achieving the Sustainable Development Goals (SDGs) set in 2015 by the United Nations General Assembly. He argues that unequal access to resources, exposure to risk, and responsibility for pollution have created a situation where those living in poverty increasingly become more vulnerable to shocks—he refers to a "vicious circle" where these economic, social, and environmental inequalities are mutually reinforced. The author cites the need for the implementation of better social and environmental public policies which specifically work to interrupt these vicious cycles. He uses Part Three to provide an overview of potential policy strategies which, when successfully implemented, have the power to begin the process of reversing these inequitable and unsustainable policies. He argues that reducing disparities in exposure and risk at all scales is inseparable from the need to protect the environment and he draws a clear line for the reader between the evolution of these inequalities and how current policies and strategic frameworks continually work to exacerbate these problems.

Overall, this work is highly comprehensive and covers a great deal of ground without burying the reader in mounds of complicated datasets, which is so often the case when we delve into large amounts of country-level wealth and income statistics. It is interesting, however, that the author did not spend more time underscoring the effects of systemic and institutionalized racism while discussing the trends and drivers of socioeconomic inequality. He briefly touches

upon the effects of education inequality on Black student test scores in the United States and he mentions that Black Americans are far more likely to be exposed to lead and ambient air pollution than white Americans but he does not dig deeper into the historic zoning policies which worked to create these outcomes. The spatial remnants of redlining still have very real implications for people of color today. A deeper discussion of the evolution of systemic racism would have strengthened his argument that the trends and drivers of inequality are deeply ingrained in our policy making processes and represent decisions made by those in power to remain in power. Disaggregating the data by race would reveal an entirely new story, possibly one even more dire than what is told here but still crucial if we are to take the author's advice and tackle these wicked problems with better data and smarter policy choices. The decision to not include disaggregated data certainly does not lessen the importance of the work at hand, rather it provides fertile ground for future work that is focused on reducing inequality with even sharper data for stronger policy recommendations. Chancel finds a great deal of success in this work with his ability to get to the essence of social and environmental policies created at various scales and demonstrates how even small adjustments could make a true difference to the very real individuals who suffer the inequalities we tend to discuss so broadly. Ultimately, we must remember that when we talk about "inequality" as a concept, this is, in fact, the lived reality for billions of people worldwide and the consequences of inaction are and will continue to be catastrophic. The author carries this understanding throughout the book, letting the reader know that the reality we currently face can be changed for the better when we are armed with sharp data and the right amount of political and moral willpower.

DANGEROUS YEARS: CLIMATE CHANGE,

The Long Emergency, and the Way Forward

David W. Orr
New Haven, CT: Yale University Press, 2016. 320 pp.
paper, ISBN: 9780300222814

Reviewed by Prajjwal Panday
Department of Environmental Science
Nichols College
Dudley, MA

To anyone who has been paying attention to the mounting evidence of climate change and planetary destabilization, David W. Orr's book comes as no surprise. Orr, a leading environmentalist, is the Paul Sears Distinguished Professor of Environmental Studies and Politics Emeritus as well as a senior advisor to the president of Oberlin College. He is the author of eight books, a founding editor of the journal Solutions, and the founder of the Oberlin Project, a joint venture in the City of Oberlin working towards creating a thriving, resilient, and sustainable community.

Orr has been sounding the alarm on climate change for decades while devoting his entire career to the issues of sustainability and education. The central theme of the book is that this period of rapid climate destabilization is simply the manifestation of deeper systemic and structural problems embedded in our economy, politics, education and philosophy. In this book, Orr rallies the call for a radical approach of reform that is required in our governance, economy, and education for us to have any hope for the planet to recover from the political, economic, and social impacts of current climate crisis in the coming years.

In the prologue, Orr cautions the reader that the journey to sustainability will be a long and arduous transition through uncharted territory. Although humans will face challenges of immense scale and complexity, Orr believes that "with foresight, hard work, and luck, it could also be a story about the transition to an ecologically sustainable world" (p. xvii). In chapters 1 and 2, Orr points out climate change and ecological deterioration, nuclear proliferation, and artificial intelligence as three inextricably linked challenges to the long-term viability of human civilization. However, he argues that the climate emergency poses the biggest and the most urgent challenge to sustainability as it will magnify each and every political, ecological, and economic problem.

In Chapter 3, Orr introduces the need for resilience to create sustainable systems which are able to make ongoing adjustments to changing conditions. Resilience could be easily integrated in the economy, urban systems, electrical grids, and other infrastructure via technological solutions and design. However, he emphasizes that the real challenge lies in improving the resilience by tackling and reforming deeper structural issues of governance and political

processes. In Chapter 4 "The Problem of Denial", Orr laments how we have failed to act given the overwhelming evidence on the magnitude and severity of planetary destabilization and the impending crisis that lies ahead. The web of climate denial laid out by entities with large stakes in fossil fuel industries has sown confusion regarding climate change. Orr adds that "we have so far failed to act in ways commensurate with the scale and projected duration of the crisis and the extent of death and suffering further procrastination will cause" (38). At the same time, Orr also raises concern about strategies that offer delusional optimism that evade the harsh long-term consequences and realities of climate destabilization.

In Chapters 5 to 8, Orr details the shortcomings of the current economic system, governance, educational system, and philanthropic giving, and the systemic changes necessary in these areas to tackle the planetary emergency. In Chapter 5 "Economy", Orr details the historical roots of the current mainstream neoclassical economic theory and discusses why it is flawed and hence unsustainable given that it is divorced from biophysical reality and principles. This economic model was built "on the foundations of self-interest not sympathy, individual desires not public interest, private wealth not commonwealth, and the present not the future" (46). It has adopted assumptions of endless growth and infinite substitutions for resources on a finite planet. Orr also defines the role corporations have played in laying the political and legal foundations for an industrial-extractive economy, particularly in the case of fossil fuels. Orr calls for a version of economic theory which is more closely grounded within the principles of ecology and seeks to preserve the basic rights of present and future generations. In particular, he recommends that the current economy must conform to the larger system which takes into account limits to unchecked growth and externalities to reflect the full costs of human activities. Orr also urges the need for our economy to be non-violent by diverting current extractive resource practices in favor of more nonviolent and natural methods.

In Chapter 6 "Governance", Orr discusses the lack of action by governments in Western democracies in tackling the climate crisis. He views the crisis as "a massive political and governmental failure" (77). He states that "climate change is the perfect problem: scientifically complex, politically divisive, economically costly, and morally contentious" (77). Orr explains that a main part of this problem stems from how the regulatory power of governments in improving public goods and services has been diminished in recent decades in favor of corporations, market, and financial institutions. He is also critical of the lack of creativity, action, or capacity shown by governments at the scale and complexity required in dealing with systemic problems owing to climate destabilization. In the context of the United States, Orr details the flaws of the U.S. Constitution in how it does not provide a strong foundation for federal environmental protection law, while giving too much power to private rights as opposed to public goods. Despite the limitations of the government to manage the challenges ahead, Orr argues that a strong, transformed democracy remains our best hope for governance during this long emergency. This climate crisis requires a properly led and funded government with participatory democracy of its engaged citizens that demands collective action on an unprecedented scale.

In Chapter 7 "Mind", Orr reminds us that our contemporary model of education, which is only offering skills for a job market fitted for an industrial-technology world, is inherently

incapable of training the coming generations to be caring stewards of the planet. A sustainable global civilization is only possible with an education that prepares the younger generation for planetary emergency and connects learning with appreciation of the natural world and its physical system. The greening of higher education has mostly been successful and transformative in reducing energy, water, and material waste in physical infrastructures and buildings across educational institutions. However, Orr suggests that only a transformed liberal education and curriculum that is reflective and thought-provoking can reform the current educational model if "education is to play a positive role in a 'Great Turning' toward a sustainable global civilization" (104). Orr's proposed solutions include the need for colleges and universities to be fertile grounds for institution-wide conversations on complex questions beyond the conventional silos of thought and research, to become a learning organization by which they become more responsible and sustainable, and to graduate students who are ecologically literate. In Chapter 8 "Heart", Orr criticizes the response of foundational grants and programs that have vastly ignored the enormity of the issues stemming from climate destabilization. Although they may have the right intentions, he argues that the efforts necessary to confront the current climate crisis lacks priority among philanthropic networks. In Orr's view, true philanthropy is one that requires good judgment and investigation, protects the natural systems, and provides stewardship to secure the planet for future generations.

In Chapter 9 "The Long Revolution", Orr details the required knowledge for the long transition as we head into this period of climate destabilization. Owing to the multidimensional nature of this crisis, Orr's proposed solutions also include a multi-pronged approach of rapid expansion of renewable energy, educational reform, competent governments, and ecological governance. However, all of this is only possible with what he calls a metanoic transformation "by which we come to our senses causing a tectonic shift in moral consciousness" (149). At the societal scale, he envisions slow tectonic shifts in thought and behavior "until they spark social movements and revolutionary behavioral and political change" (163). Orr also reviews some of the major challenges governments will face in the long emergency which will entail ensuring social stability amidst environmental and economic crises, improving efficiency, accountability and transparency, and leading research and innovation during this transition. In Chapter 10, he reiterates his belief that a competent national government rooted in local democracy is critical in laying down the foundations for effective policy innovation, public engagement, and regulations. One facet of the government Orr is very critical towards is excessive military spending and the supply chain of violence which supports the military-corporate complex in what he refers to as the "American security state" (177). Orr stresses that the transition to a non-violent world, along with the abolition of nuclear weapons, is also equally important in creating a sustainable civilization.

In Chapters 11 and 12, Orr provides a glimpse of what some of the proposed solutions at the community and city-wide scale looks like. He cites the revitalization of the city of Chattanooga, Tennessee into a green city as an example of green urbanism pioneered by David Crockett (to whom the book is also dedicated). In doing so, Orr adds his voice to others before him such as Donella Meadows and Jay Forrester who have argued for systems thinking and analysis for urban as well as regional governance. The book ends with a summary of the Oberlin

Project, an exemplary effort of regional collaboration of the City of Oberlin, Oberlin College, and private and institutional partners. The project was formed to improve food systems, sustainability, resilience, and the economy as an integrated response to the challenges posed by the climate crisis and provides a blueprint for other cities and regions with a bottom-up catalyst in our transition to sustainability.

While Orr is a proponent of radical systemic changes, he rests our best hopes on grassroots movements, organizing, and gradual shifts in thinking that eventually leads to political change. Although these sorts of movements are ultimately what is required, it is less clear whether they will occur with the speed and immediacy required to divert our current pathway from the crisis. Such fundamental changes which would include a radical reset to our economy and has also been deemed necessary by others. One of them is Naomi Klein, a Canadian author and social activist, who has thrown her full support behind the Green New Deal (Klein, 2020). It is a holistic vision and bold agenda championed by progressive Democrats that proposes federal policies and a 10-year national mobilization of massive societal resources to curb carbon emissions and create a fair and just economy. Although Orr does not specifically discuss the Green New Deal in this book, he makes a case here that suggests that success for any reform depends first and foremost on a competent government and sustainable democracy. The book is written mostly in the context of Western countries, in particular the United States, and Orr's recommendations are mostly applicable to the rest of the world. However, for weaker democracies in the developing world, a lack of capital and technology and poor governance over the economy and resource exploitation pose a much steeper challenge.

This book reflects the dedication of Orr's lifelong scholarship and passion and his vision of the necessary changes for humankind to transition into a sustainable planet. This is an excellent book for an introduction to the long-term challenges owing to our collective failure in foresight and leadership thus far in handling this climate crisis. It also provides a philosophical, thoughtful, and hopeful manifesto of the urgency we must show to overcome it. Orr emphasizes time and time again that we require radical changes in governance, the economy, and education systems to have any chance of self-correction against this crisis. This book could be a required text in an undergraduate classroom which provides a foundation for discussions in disciplines of environmental sciences, geography, and economics. It is also a great resource for scholars, students, policymakers, practitioners and anyone looking for guidance, solidarity, and a call to action as we head into the dangerous years ahead.

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PATCH ATLAS: INTEGRATING DESIGN PRACTICES

Ecological Knowledge for Cities as Complex Systems

Victoria Marshall, Mary Cadenasso,
Brian McGrath, and Steward Pickett
Yale University Press, 2020, 128 pp.
PB-Flexibound, ISBN: 9780300239935

Reviewed by Joseph Drake
Organismal & Evolutionary Biology Interdepartmental Program
Department of Environmental Conservation
University of Massachusetts Amherst

Patch Atlas is a well written foray into a novel landcover classification scheme that tries to meld design principles and ecological research from the outset. This approach, the authors argue, is a needed advancement of urban geospatial research which should help a wider audience interpret the landscape more holistically. This co-production aims to produce an approach greater than the sum of its individual parts, providing a more equitable and synthesized understanding of a human dominated landscape. Victoria Marshall, Mary Cadenasso, Brian McGrath, and Steward Pickett strive to use each of their greater than 17-year accumulation of knowledge to develop a classification of land cover that does not necessarily separate human-created structures from their biological and geological counterparts. They try to avoid such land use dichotomies that can ultimately lead to faulty interpretation and understanding of the role humans play among the complex ecologies developing in the increasingly urban world. In *Patch Atlas* they present the motivation and convey the need for such a novel interpretation presented in a clever design aesthetic reminiscent of Edward Tufte (for better and worse). While this reader feels that the authors fell slightly short of their described aims, this well thought out work provides a novel exploration of how the design and research collaborative process could be, and potential should be, enacted to push the understanding of urban ecologies further.

While the authors acknowledge traditional land cover classification schemes are still pertinent, they also argue that such approaches conflate land use and land cover. Such a distinction may seem arbitrary to some, but the inherent valuation of activity carried out on landscapes can *and do* mask patterns of land cover. The authors present a working case of an alternative classification scheme called *High Ecological Resolution Classification for Urban Landscapes and Environmental Systems (HERCULES)*. With this peer reviewed model of landscape classification, they examine the Gwynns Falls Watershed, an area in Maryland that stretches across Baltimore County and Baltimore (the city). This slice of the Greater Baltimore area includes a diversity of land covers and land uses. This watershed is exemplar of many urban areas that defy the urban-to-rural gradient that is often used to in urban ecological modeling and land use planning. Instead, this area is a mosaic of patches of various land covers that

emerge from a long history of urban development, abandonment, and land use succession. The HERCULES land cover model allows the truly mosaic nature of the landscape to be described, assorting the study area into contiguous patches with interiors more similar than to those patches neighboring them.

A prominent feature of *Patch Atlas* is the visual representation of the land cover composition of the Gwynns Falls Watershed. While clever and novel, this Tufte-esque design aesthetic left me wanting for more. While this may be on purpose, it (in this reader's opinion), does not achieve the desire to make the patch data "intelligible at a glance". For example, they describe the use of white space as an essential element to the visualization of the patch distribution across the watershed. This is a clever way to show isolation of bare soil, fragmentation of homogenous vegetation patches, flow through neighborhoods based on heterogeneous vegetated and paved patches, etc. However, the white space trick is hampered by a lack of context as each set of patches is placed on a white page, leaving the reader unsure if the white space they are looking at is within the watershed or just on the page.

As each chapter unfolds, describing a different pattern found within the landscape patches, the authors provide a bounty of visual data. Their demonstration of such a novel way to classify such data and the potentially useful new approach to amassing these data is defined as a "periodic table" of patches, based on patch composition. Though the gradients of land covers explored through this system is likely exceptionally useful for statistical analysis for the audiences they hope to provide it too (such as ecologists, engineers, architects, and anthropologists), the visual representation of this data results in a lifeless representation of the dynamism the authors hoped to convey.

While the work is intriguing and highly readable, the authors missed an opportunity with this project. They rightly describe the urban-to-rural complex of modern cites as a complicated narrative derived from historical intricacies that influence the current state of an urban patches' ecology. Unfortunately, they only but briefly touch on the historic legacies that inform our current context. Such landscape sized view of the processes of social and economic trends leaves a desire for a local scale compliment. A personal narrative of a neighborhood and the residents (or current lack thereof) would have provided a welcome local-scale approach, giving context to the wider watershed view. Such a thread could have given power to the story as motivated by the historical dynamism and the "flux of energy and matter" that is a changing city. Thus, a multi-scale approach would have been achieved, providing information that would have been a boon to the wider audience of urban planners, designers, architects, engineers, community activists and natural resource managers the authors hoped would gain from this new collaborative approach to research. Such a resource would provide an example of how to extrapolate from current conditions to anticipate better how our land cover patterns may be altered for the betterment of the city-organism and the participants that reside within.

All critiques aside, I enjoyed this book. I also think it is an important and timely contribution to the study of urban systems. I wish that it had taken more than an evening to read, yet as I return to look at its pages, I am enthralled with the maps and figures provided. The authors achieved their goal of demonstrating that moving beyond a "land-use" classification is possible. This, in and of itself, is a success. And their work does go beyond this: they lay an

intentionally loose and flexible blueprint for others hoping to achieve a eco-design collaboration success. And hopefully, their work continues to achieve their goal to “inspire maps that have yet to be drawn” so that there is increased speculation of the “city yet to come” through a more holistic and equitable design approach.

VACANT TO VIBRANT: CREATING SUCCESSFUL

Green Infrastructure Networks

Sandra L Albro
Washington, D.C.: Island Press. 2019. 190 pp.
paper, ISBN: 9781610919005

Reviewed by Judith Otto
Department of Geography
Framingham State University

The hypothesis of this empirical study is that scattered vacant lots in post-industrial cities can improve urban environments through green infrastructure that combines recreation with stormwater management. The project, Vacant to Vibrant (V2V), is a portfolio of nine repurposed vacant lots in three cities in the Great Lakes region; the project team was led by staffers from the Cleveland Botanical Garden. This is an ambitious project, because recreation and stormwater management have generally not been considered compatible land uses at this scale, nor do they have shared constituencies or methodologies. The primary value of this study is that it exposes, in highly specific detail, the systemic barriers to improving both environmental sustainability (stormwater management) and quality of life for residents in troubled neighborhoods (aesthetic and recreational amenities). For me, this book also implicitly raised deep and disturbing concerns about the limits of green design in addressing social and economic inequalities.

The book is organized chronologically, following the project from the concept stage, to research fieldwork, to design and construction, to maintenance, to "lessons learned." Chapter 1, "Green stormwater infrastructure on vacant lots," provides historical context: it summarizes the trajectory of urban development and decline in Midwestern industrial cities, from population growth due to the Great Migration and European immigration, to redlining and block-busting, to de-industrialization, de-population, and shrinking municipal revenues and capacity to provide services. This is familiar history for those who teach or have studied American urban geography, but is nevertheless helpful in establishing the social and cultural contexts in which the Vacant to Vibrant project was situated. Particularly useful are the descriptions of three sets of stakeholders whose missions to revitalize these cities often work at cross-purposes: non-profit land banks, which aggregate vacant parcels for future use; the U.S. Environmental Protection Agency, which has threatened consent decrees to improve water quality in the Great Lakes (mainly by requiring cities to reduce combined sewer overflows, or CSOs); and residents, who (often justifiably) lack trust in government institutions.

Chapter 2, "City dynamics that shape vacant land use," describes the process of selecting the three cities; the similarities and differences of their urban development history; and the characteristics of the neighborhoods that were chosen (West Side in Buffalo, Woodland

Hills in Cleveland, and Aetna in Gary). The criteria for selecting cities included those with an abundance of vacant lots; a sense that the project would be welcomed in the community; and a mix of geographical similarities and differences that would yield useful lessons about the design variables. The chapter describes the neighborhoods, including their demographics, cultural history, urban form, and physical geography, with a special focus on soil types (both native and modified by humans) and their implications for groundwater recharge. All three neighborhoods were connected to the steel industry, and all have similar demographic profiles.

Chapter 3, "Vacant to Vibrant Planning," explains the parcel selection design and review processes. The project team used a multi-scalar approach (city, neighborhood, block group, and parcel) with a mix of quantitative and qualitative criteria at each scale. Parcels or neighborhoods that had other ongoing projects or investment were given higher priority to increase overall neighborhood impact. When the parcels had been selected, preliminary plans were drawn for each one before seeking community input. For stormwater management, the primary criterion was that the rain gardens should retain stormwater runoff on the parcel at a minimum, and should collect it from abutting parcels and the street where possible. For recreation, a typology was developed along a continuum dependent on neighborhood context, from passive recreation (sitting, birdwatching) to active recreation (a handball court, play equipment). A limited palette of mostly native plants was developed; and modest hardscaping included inexpensive materials and some salvaged materials.

The design team struggled with neighborhood outreach when the preliminary designs were presented. Poor or elderly residents often did not have internet access or email, so they could not receive notices about meetings. Survey response rates were very low. One-on-one meetings on residents' stoops tended to get better input, as well as to build some trust. Where it was possible to meet with members of an existing community organization, the design team received more feedback, but Albro also notes the ethical problems that arise when leaders of such groups are, *de facto*, asked to support projects that they and their organizations have not been involved in conceiving of or designing.

The design team also struggled with buy-in. Residents were primarily concerned with making the vacant lots safe and preventing crime and vandalism, which pushed design revisions in some interesting directions. For example, connecting the vacant lots to each other or to other public space (a common principle in open space planning) was viewed by residents as a negative, as it would allow alleged perpetrators of crimes to escape capture. Residents wanted conventional play equipment geared towards younger children, to prevent teens from loitering. They also wanted familiar shrubs and flowers, rather than the less showy native plants promoted by the designers.

Perhaps surprisingly, then, as detailed in Chapter 4, "Vacant to Vibrant Implementation," permitting and construction proceeded on time and on budget. The average construction cost per parcel was $18,000, with sites ranging from 3,200 to 9,300 square feet. During construction, the designers consulted with landscape contractors to ensure that the projects would be low- maintenance in the future. Over the seven-month growing season, each group of three parcels was estimated to need six hours of maintenance per month, which is very low. Thus, it was difficult to find skilled contractors who would take such small jobs: Albro offers (in

Chapter 5, "Sustaining urban greening projects") a variety of possible solutions to maintenance needs, including creating a teen or adult workforce training program; educating contractors and residents about native plants (they tended to be mistaken for weeds); and allowing the parcels' amenities to change organically over time consistent with users' needs and wants.

In Chapter 6, "Scaling up networks of small green infrastructure," Albro evaluates the effectiveness of the nine designs with respect to stormwater reduction and recreation benefits. This is the weakest chapter, because it both conflates and incompletely discusses findings and analysis. For example, Albro states that the project retained 749,000 gallons of stormwater over a six-month period in 2015. However, there is little attempt to place this number in context, and no comparison with the control group of parcels. Second, Albro asserts that there has been little research on quantifying plant evapotranspiration and its role in stormwater management; a cursory database search shows that this is simply untrue. Last, there is only indirect, anecdotal discussion of how the projects affected residents' quality of life and no discussion at all of the projects' effect on stabilizing or increasing real estate values in the neighborhoods.

Where the book is much stronger, by contrast, is in identifying structural barriers to integrating recreation and stormwater management. Chief among these is the patchwork of missions, regulatory priorities, and investment between stakeholders, including non-profit land banks, city planning agencies, sewer districts, and state and federal agencies. Each of these types of agencies values green infrastructure differently, and there is little coordination between them. Likewise, municipal zoning regulations often work against green infrastructure: for example, Albro recommends that municipalities remove prohibitions against downspout connections and other barriers to green infrastructure.

Albro also recommends the adoption of cutting-edge regulatory and collaborative strategies to boost green infrastructure. She describes stormwater fees and stormwater credits as means to incentivize landowners to create green infrastructure. She suggests that health organizations (hospitals and insurers) should be brought into the conversation to help raise awareness of the health and wellness benefits of green infrastructure. She suggests more extensive neighborhood education to make residents aware of the benefits of using native plants and decrease the stigma of "low maintenance" landscaping. Finally, she argues for increased neighborhood density -- not through infill development, as is currently popular in urban planning circles -- but by increasing density of existing built parcels while maintaining vacant lots permanently as green infrastructure.

This book, because it is so very city-specific, has limited use in the geography or environmental studies university classroom as a textbook. However, it is an excellent resource for undergraduate students working on community service projects, with much practical information about working with diverse constituencies and adjusting designs to meet their needs. The book could have been published simply as a research article in an academic journal or as a planning report on an institutional website, but I am very glad that the author chose the extra work of publishing it as a book.

The book contains black-and-white photographs with a "before and after" view of each of the nine sites. They are small and not high-quality, but they can be viewed in combination with a set of very readable, attractive design plans in the Appendix, in order to reach a fuller

understanding of how the sites look and function. (There are no people in any of the photos, which seems like a missed opportunity.) The bibliography, although compact, lists useful references to research studies on the economic, health, and community benefits of green infrastructure.

One final note: this study makes disturbingly clear how low the bar is set for high quality public open space, especially in poor or minority neighborhoods. As a landscape designer, I have experience preparing plans for heavily used sites. Never have I encountered the kinds of setbacks mentioned here: the theft of desirable shrubs (which was one of the arguments for using less well-known native species); the perception that trees would provide hiding places for criminals and thus must not be used; the constant repair of swing-sets after casual destruction; and the vandalism of bird houses, lighting, and soil moisture monitoring equipment, to showcase only a few. Is the solution more education on the benefits of green infrastructure? It seems necessary – but completely insufficient.

THE IMMIGRANT-FOOD NEXUS:

Borders, Labor, and Identity in North America

Edited by Julian Agyeman and Sydney Giacalone
Cambridge, Massachusetts: The MIT Press, 2020. 344 pp.
paper, ISBN: 9780262538411

Reviewed by Nicolas Parent
Department of Geography
McGill University

In the introductory chapter of this edited volume, Julian Agyeman and Sydney Giacalone outline an ambitious project to bring together an eclectic yet focused collection of contributions exploring the intersection of immigration and food. Describing the immigrant-food nexus as the crossroads between food systems, immigration policy, and immigrant foodways, the editors propose three necessary approaches to its study: multi-scalar thinking, intersectionality, and critical analysis. They illustrate this need by showcasing a bifurcation in food studies, split between the food sustainability movement (also known as the 'alternative food movement') and those who make up the food justice community. To the editors, the former too often embodies a white colonial imaginary of what constitutes 'good', 'healthy', and 'sustainable' food, leading to somewhat of a tête-à-tête with other food choices and practices of immigrant communities. This same imaginary is constitutive to the expected identity of farmers, farm owners, and more broadly to the agricultural industry in North America. As one would expect, this has a marginalizing effect for immigrants that both consume and produce food; one that the food justice community seeks to address. In its exploration of these issues, this edited volume is divided into three sections, as is suggested in the title. Section 1 – 'Borders' – looks at some of the physical and imagined borders that define the limits of immigrant belonging within agricultural space. Contributions in section 2 – 'Labor' – focus on the lived experience of immigrant farm workers and farm owners. And lastly, section 3 – 'Identity' – explores narratives around and politics of identity at the intersection of immigration and foodscapes.

A notable strength of this edited volume is its groundedness. By this, I mean that all (at the exception of one) contributions are based on empirical evidence. More than this, a wide breadth of methodological approaches are employed. Through interviewing, Curtis (Chapter 1) explores world making at the Arizonan borderland, Huang (Chapter 5) provides nuance between local food and food from home amongst immigrant and refugee farmers in Alaska, Minkoff-Zern & Sloat (Chapter 7) explore legibility and access barriers for farmers looking for support within USDA programs and resources, and Ostenso, Dring, & Wittman (Chapter 11) examine the extent of cultural inclusion within food policy councils in Vancouver. In their chapter on Hmong American foodways, Alkon & Vang (Chapter 13) use survey data to demonstrate that translocality intersects with food practices to produce identities that

are hybridized yet still distinctly Hmong and American. In two chapters, content analysis is used to draw out narratives and discourses about food and immigrants within predominantly white agricultural spaces. Here, Neubert (Chapter 2) looks at the racial politics surrounding the building of a new slaughterhouse in Iowa, and Linton (Chapter 10) confronts Canada's mythology of multiculturalism by demonstrating color blind agrarian narratives in Ontario. In-depth personality profiles also play an important role in this edited volume, where Valdez (Chapter 9) features the life of four women who feed dairy workers and recreate a home away from home, and Passidomo & Wood (Chapter 12) profile the work of three women who are leading food businesses in the *Nuevo* American South, building "familial and community 'wealth' beyond the monetary" (249). Finally, ethnography also plays within the methodological arc of this collection. In Schmid (Chapter 8), the intimate qualitative data collected from Mexican American farming families in Southern Appalachia reveals the central role women play in organising cooperative community networks to 'move' fresh produce. In the final chapter, the anonymous Situational Strangers (Chapter 14) report their observations at a shared-use commercial kitchen in Connecticut, delving into the processes of crossing, cooking, cultivating, and culture as they relate to community formation and individual futurity.

Moving on, I have selected what I believe is the strongest chapter for each of the three sections of this edited collection. This is certainly subjective, but I have tried to align my choice with the intended goals articulated by editors Julian Agyeman and Sydney Giacalone. I have also selected these chapters based on the different geographies (or spaces) in which they investigate. For the first section (Borders), I found Joassart-Marcelli & Bosco's (Chapter 3) contribution to be the best executed. Focusing on San Diego's 'ethnic foodscapes' of Barrio Logan and City Heights, defined as the physical places, people, objects, discourses, and sensual elements "associated with the foodways of ethnic groups in particular places" (61), the authors explore the nexus of food and gentrification. Interviews with shop keepers, residents, and consumers supplement a rich analysis displaying the tension between urban discourse and foodscapes, where ethnic enclaves are often qualified as 'food swamps' or 'food deserts' while also standing as the site of exoticisation and excitement by foodies, tourists, and developers. The latter dimension serves as a force to propel gentrification, where the authors examine the use value of food and appropriation from a Marxian economics perspective, contrasting this to local forms of resistance that seek to preserve the symbolic value of ethnic foodways. Within the 'Labor' section, it is Minkoff-Zern & Sloat (Chapter 7) that struck me as particularly interesting. Here, the authors use James Scott's concept of 'legibility' to examine why immigrant farmers are not accessing (or being granted) USDA financial resources to the same extent as their white counterparts. It is shown that racial discrimination has long existed within the USDA, showcased though the experience of black farmers during the civil rights era. With immigrants, discrimination is subtly anchored in questions of legibility. This can be a relatively simple question of linguistic barriers, where immigrant farmers are asked to read and understand financial program requirements and write application documents exclusively in English. It also trickles to the more complex issue of agricultural practices, where immigrant farmers' diverse crops (i.e., agroecological variety) are at odds with contemporary industrial practices of monocropping; the latter being more persuasive in competitive bids for USDA

support. Beyond the interesting arguments this chapter provides, it is also 'backed up' by an impressive study involving seventy interviews with immigrant farmers and another forty-seven with staff in government and non-profits. For the last section, 'Identity', it was the chapter by the anonymous 'Situational Strangers' (Chapter 14) that I found most riveting. Here, the nuance between 'authentic' and 'original' food takes on a metaphoric life throughout, where authentic is understood as objective cultural legitimacy and original stands as its subjective kin, drawing on authenticity but remixing it to create something new. Through anonymity, the authors de-centre the ego of ethnographers. They do this in an acknowledgement that only 'original' knowledge is reached via co-production, subverting the claims of authenticity often held by those writing ethnographies. Drawing on the lives and voices of immigrants working through CLiCK, inc., a shared-use commercial kitchen, the authors show that there is no universal recipe for authentic immigrant lives. And while both authentic and original life often coexist, this tired binary is perhaps unreflective of the in-between of both conceptual categories of cultural embodiment.

This edited volume provides a wide breath and deep wealth of content beyond what I have presented. The multi-scalar aims of Agyeman and Giacalone are certainly met, with chapters spanning North America and exploring geographies that go beyond the agricultural. Contributions specific to Mexico, however, would have strengthened this collection. The aim of intersectionality is relatively well achieved as a whole, but in terms of individual chapters, it is seldom described in these terms and only a few chapters take this up successfully (Ostenso, Dring, & Wittman; Schmid; Valdez). The aim of producing a volume that critically examines the connection of food and immigration, however, is a bit of a miss. While the editors don't go in detail about what they mean by 'critical' or 'critical approach', this volume lacks the edge that seasoned critical scholars may be hoping for. From a theoretical and conceptual standpoint, there is almost no mention of how postcolonial, decolonial, or critical race theories enrich and push forward conversations on food and immigration. Marxist and anarchist approaches, often standard in critical studies, are also absent (For an exception, see Joassart-Marcelli & Bosco). And besides the contributions by Linton (Chapter 10) and Ostenso, Dring, & Wittman (Chapter 11), this volume grossly glazes over how food and immigration intersect with settler colonialism and the contemporary livelihoods of indigenous peoples. To reiterate a previous point, the strength of this edited volume lies predominantly in its empiricism and geographic reach. Its primary weakness, however, is that it falls short in developing conceptual knowledge. While I can appreciate that this is perhaps an inevitable compromise when writing in chapter form, many recurring concepts to which contributions gravitate to – hybridity, translocality, race, place, home, power – are largely taken-for-granted and remain relatively static. Even the vernacular of food studies – foodmaps, foodways, foodscape – does not receive a critical treatment. All in all, though, I believe this edited collection does two important things. First, by focusing on the centrality of immigrants, immigrant farm workers, and immigrant farm owners in the North American foodscape, this book subverts the white, male, and middle-class agricultural imaginary. Second, this book's wide and deep exploration of immigrant livelihoods shows us that this group is leading the way in agricultural and food system alternatives.

BATTLES OF THE NORTH COUNTRY: WILDERNESS POLITICS

and Recreational Development in the Adirondack State Park, 1920-1980

Jonathan D. Anzalone
Amherst and Boston, Massachusetts:
University of Massachusetts Press, 2018. x and 279 pp.
paperback, ISBN: 978001623543642

Reviewed by Thomas A. Rumney
Department of Geography
Plattsburgh State University

On many maps of New York State, a clear "Blue Line" stands out that encompasses a vast expanse of the upstate portion of the state. Located within this "Blue Line" is the massive upland and mountainous region known as the Adirondacks. This ancient highland region has long been a source area for resources used by humans. First, it was a hunting and fishing territory for Native Americans. Later, Europeans obtained furs, lumber, and iron from these vast spaces. Although Native Americans didn't live in the area, Europeans did settle here, building farms, clearing lands, founding villages, and making lives. By the turn of the 1800s and with the formation of a newly independent United States and New York State, the region developed into an urbanized, industrial, and technologically advanced collective. One of the changes arising from these modernizing processes was the increase of wealth and leisure time for more people. Outdoor recreational activities became more common by New York's growing urban populations. Conservationists and many of the wealthy who wished to protect their properties and exclusive recreational activities advocated for protection of the region. As a result of these social and political forces, the state created what was called the Adirondack State Park in 1892. This territory, encircled by "the Blue Line," was based on the idea of "forever wild." Therein lies the source of the acrimonious and convoluted conflicts that would occur well into the twenty-first century.

The author begins his discussion of the conflicts over the uses of Adirondack lands in the 1920s. By then, the massive extractive industries that had exploited the region's iron and lumber resources for nearly a century and a half had begun to fade. Farming was, and still is, an undertaking for some in the area, it could never replace iron and lumbering in importance for the regional economy. At the same time, a growing urban population in the state that had more leisure time and financial resources desired more outdoor recreational opportunities, such as camping, hiking, and hunting. With newly available means of transportation in the form of automobiles and better roads, people could now get to more isolated wilderness areas such as the Adirondacks. Ironically, many of the places they wanted to visit were already either owned by the wealthy or were being protected by conservationists. This set the stage for conflict and rancor.

Two major events would roil this already existing conflict over land use. New York State,

along with building a more extensive and usable road network in this region, undertook a major road-building effort up the side of one of the iconic peaks of the area, Whiteface Mountain. This sparked multiple battles within state government circles, and between public and private land owners and uses. The state was making the region "less forever wild." These roads were augmented by campgrounds and recreational spots along the newly built roads. Many of these spots were quickly overrun by eager vacationers, producing problems of pollution, trash, and overuse of local resources. These problems continue to the present day, as do the disagreements about who is responsible maintaining the sites and how much development should take place. These conflicts were made worse by the 1932 Winter Olympics and all the construction associated with it.

The second major event was the 1980 Winter Olympic Games held in Lake Placid. New and more elaborate sporting facilities had to be built and maintained for the Games. Likewise, further road and other transport systems, housing, dining, and (some) entertainment establishments were added, mainly in and near the village of Lake Placid. The Games brought a sudden rush of people into the region. Those Games were a success, but they created a problem. What was to be done with all the facilities after the Games were finished? Generally, the decisions were to keep using them for further events and both public and private recreation, vacationing, and service functions. This is what is occurring now; with additional big events like an Ironman Triathalon event, more stores, motels, and restaurants. The conflicts between public and private land and business owners have continued.

Who would have thought that having fun and finding rest and regeneration in a beautiful natural setting would cause such turmoil? Yet, that turmoil has been a part of the human and natural landscapes of the Adirondacks for a century and a half. Parts of these problems derive from the fractious results of having both public and private landownership within the park, and the government regulatory agencies that have been at work in the region, especially since 1980. The author has captured the essential ingredients of these dilemmas for the peoples and areas of the Adirondacks.

This book is organized with an introduction, seven "content" chapters, and a conclusion. The chapters are presented in a chronological order that identity, elaborate, and discuss the evolution of land use problems, conflicts, and events in the region from the early 1920s to the end of the 1980s Olympic events. The book is written in direct, clear, and expressive prose, and has few writing problems. Although not a long book, it provides the basics of a complex and dynamic situation in a large portion of New York State. It is well researched, using a large collection of local newspaper articles, varied academic works, and government documents as references and sources. A few more maps showing the developing infrastructures and facilities, plus the connections with the outside world, would have enhanced the narrative, though. There is one additional thought that occurred after finishing this volume. What has happened since the end of the 1980 Olympics in the region in most recent days? This is a continuing story, and would seem to be a logical sequel to this first volume.

Anne Hayden
Manomet

A Collaborative Approach to River Herring Restoration in New England

River herring are recognized as a keystone species, and efforts for restoration of their habitats have been advanced across New England. The Passamaquoddy, a native tribe with close ties to river herring, refers to the species as "the fish that feeds all" because of its importance in the food web. These small diadromous fish are also food sources for humans, and are used as bait for other fisheries. One of the biggest threats to river herring survival is dammed rivers, which prevents river herring from reaching their spawning grounds. A new effort seeks to bring together researchers, state and federal managers, and community members with an invested interest in river herring restoration, with the stated goal of improving communication among the parties. Researchers use new technologies such as eDNA to determine the presence of river herring through water samples; many towns collect data through fish counts and scale sampling; and managers use available data to ensure compliance with management goals. A recent meeting affirmed communication gaps, and revealed that among research organizations, there is a lack of transparency regarding research projects and limited access to data or information. It was also evident that citizen participation is an important aspect of river herring restoration and that integration of local knowledge and research capacity into programs would improve outcomes. Community input into the design of research projects could help address local interests and concerns. Participants from all groups agreed a collaborative approach would improve restoration. *Keywords: alewives, blueback herring, citizen science, eDNA, keystone species*

James Cooke
University of Maine at Farmington

Campus Garden Project: Fostering Connections between Campus, Community and the Environment while Combating Rural Food Insecurity

A project many years in the making, the University of Maine at Farmington's community garden represents an opportunity for students and community members to connect with the source of their food, with one another, and with the natural world. A campus green space designed, built, and maintained by students, the garden represents a tactile, inclusive, and physically accommodating learning space in an increasingly online and remote world. This

interdisciplinary project involved data collection, design drafting, cost estimation, carpentry, community outreach, and organic gardening methods. In its first season, the garden produced over 100 pounds of produce that was donated to local food closets and directly to UMF students. Multiple UMF courses already have used the community garden for research, class projects, meeting space, and as a topic of discussion. Job loss as a result of the pandemic has lead to the exacerbation of rural food insecurity, making food banks in our area become an even more essential resource. According to the U.S. Department of Agriculture's Economic Research Service, 13.6% of Maine residents are food insecure. Of this population, a large portion (37%) does not qualify for public assistance. Food banks in Maine and throughout the country provide an undervalued and vital service. Community gardening provides a multi-purpose opportunity to support Maine's food insecure residence while fostering greater connections between members of the community, their food, educational objectives, and the natural world at large.
Keywords: community garden, experiential education, food insecurity

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Olivia Houde
Westfield State University

Greening Westfield State University Campus: Recommendations for New Student Orientation

Extending off of a previous study that assessed the Westfield State University campus' attitudes towards sustainability, this research provides a framework for presenting the topic of sustainability in the context of new student orientation (NSO) programming. Introducing students to sustainability during NSO is beneficial because it is when students get an idea of what the university prioritizes, essentially setting the tone for the rest of their college career. Since Westfield State does not have an active strategic approach to sustainability, NSO programming focused on promoting it on the campus could potentially lead to other advances in the realm of sustainable development. Ten universities were contacted via email to gain insight into how sustainability is presented at their school's orientation sessions. Three schools were available to participate, and each of them had various approaches to teaching sustainability. All of the universities made an effort to expose their students to it in some way, making a case for including these teachings in WSU's orientation stronger. Due to the variety of methods employed by the other universities, the recommendations made for WSU vary in intensity. They include options such as having upperclassmen sustainability representatives lead students in a presentation of the sustainable features of the university, tabling in the Dining Commons that promotes the university's composting program, and awarding money to use towards the local farmer's market as a prize during orientation activities. These features will ensure that WSU provides the foundation necessary for students to succeed in a sustainably developing world.
Keywords: Sustainability, higher education, orientation, sustainable development, education for sustainability

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Zachary Serino
Salem State University

Hazards from the Shipwrecks of Massachusetts

Throughout the world, there are thousands of sunken vessels slowly corroding at the bottom of the ocean. Many of these vessels have hazardous materials on board such as liquid fossil fuels, munitions, and other dangerous materials. Massachusetts has also been a major maritime hub with treacherous waterways in time of peace or war. After these vessels sink or are lost at sea they are largely lost or forgotten, then over the years the water slowly corrodes these vessel's hull leading to "mystery oil spills". These spills are not only environmentally hazardous to nearby marine life but for hundreds of miles as the oil coats the ocean's surface. This cripples commercial fishing and other ocean based recreational activities as well.
The use of GIS to analyze known shipwrecks of Massachusetts to analyze what vessels pose a high or low risk. I used an Arc GIS model builder to score each vessel by rank, vessel type, condition, and date sunk. Then by use of the Arc Model builder, it calculated scores and gave vessels a rank from 1-10, ten being the worst and one being nearly harmless. Through this analysis local or federal government can be aware of this threat to mitigate the impact of hazardous materials leaking into the oceans and causing harm to the ocean, people, animals, and the economy. *Keywords: poster, hazards, coastal, shipwrecks*

Sheida Serafat
Salem State University

Land Surface Temperature Change Between Coastal and Inlands Areas: A Case Study from the Persian Gulf

When we think of our changing climate, the first thing that likely comes to mind is extreme weather swirling about in the atmosphere. But focus on the oceans, they ultimately control our climate destiny. Coastal areas generally have more moderate temperatures than inland areas because of the greater heat capacity of the oceans. This research uses satellite imagery and geographic data to study temperature changes in coastal and inland areas between 2003 and 2019. Land surface temperature data from the MODIS sensor aboard the AQUA satellite and digital census data were analyzed and combined in a geographic information system to study temperature changes in these two areas. The coastal and inland areas surface temperature was calculated using parameterizations from the NOAA land surface model with inputs from MODIS 500-m. Spatial variations in the parameterized temperature were assessed using a GIS-based grid. To avoid anomalous years, temperature data were aggregated into 4year averages at the beginning of the time series (2003, 04, 05, 06) and at the end of the series (2016, 17, 18,19). After the end years were aggregated, a univariate differencing was undertaken where

the mean temperature values of the early years were subtracted from the later years and then the differences between the coastal areas and the inland areas were analyzed. The Persian Gulf provided a geographic area of interested as a case study. Observations have shown that in this particular location, the temperature has become colder in the coastal areas and warmer in the Inland areas. *Keywords: Land Surface Temperature, Temperature Zones, Coastal and Inlands Areas, Persian Gulf*

Michael Levesque, Julia Alterio, Owen Austin, Zach Berliner, Michael Chavez, Tom Dolman, Richard Down, Haley Kerin, Zack Laflamme, and Matt McCourt
University of Maine at Farmington

Lovejoy Pond Watershed Survey

Lake ecosystems are jeopardized due to eutrophication from erosion and nutrient inputs occurring along the shoreline of the water. Through different forms of erosion, phosphorus and other contaminants from development are able to make their way into bodies of water and create large algae blooms that negatively affect the life in and around lakes and ponds. Lakes that are the victim of eutrophication also suffer decreased property values around the water. Tracking locations where erosion occurs can make a difference in protecting a lake from possible contamination and maintaining its health. The Maine Department of Environmental Protection, with the help of volunteers from the University of Maine Farmington, the 30 Mile River Watershed Association, and the Lovejoy Pond lake association, launched a watershed survey program for this purpose. This survey uses components of Geographic Information Systems to help document high risk lakes and take steps towards preventing erosion along their shorelines. These surveys are completed on the ground by identifying characteristics of erosion and categorizing their severity. Lovejoy Pond, in central Maine, is one of the high risk bodies of water where a watershed survey was completed. The goal of this survey was to retrieve high quality data about nonpoint source erosion around Lovejoy Pond with careful consideration to special guidelines due to the Covid19 pandemic. This poster reports on the unique process and results of this survey and describes practices that other watershed programs may consider when addressing eutrophication problems related to erosion. Keywords: erosion, eutrophication, nonpoint source sites, watershed. *Keywords: erosion, eutrophication, nonpoint source sites, watershed*

Peter Wamburu
Salem State University

Mapping the Urban Heat Islands of City of Salem, Massachusetts

Urban heat island is a part of the metropolitan area that is warmer than the surrounding rural areas and are highly noticeable during winter or summer periods. According to EPA, heat island describes built-up areas that are hotter than nearby rural areas. The annual mean air temperature of a city with 1 million people or more can be 1.7-5.4 f warmer than the surroundings. The major cause of heat island is the increased urbanization of our cities. Paved and impermeable surfaces, low albedo materials, thermal mass and dark surfaces that absorb more energy into the buildings. Also, the lack of vegetation in cities helps increase the heat island effect. Increased urban heat in coastal cities adds to the increased temperatures in the surroundings thus bringing changes in local wind patterns, the formation of fog and clouds, precipitation rates and humidity. This in effect increases the impacts of sea level rising.
This paper maps the urban heat island of the City of Salem in two epochs. This will help in highlighting the areas under the risk of increased temperatures, and thus help the city to take necessary mitigation measures to curb the spread. The city being a coastal city is prone to climate change effects like sea level rising and storm surges. The study is done using the geospatial technologies of Remote sensing and GIS, which are powerful in identifying and analyzing spatial patterns of different phenomena. *Keywords: urban heat island, climate change, sea level rising, coastal city*

Kayla Dorey
Salem State University

Measuring Volumetric Change of Constructed Marsh on Collin's Cove in Salem, Massachusetts using Drone-derived Digital Surface Models

The City of Salem received $216,550 from the Massachusetts Office of Coastal Zone Management's Coastal Resilience Grant program that was used to construct a salt marsh on the eroded shoreline of Collin's Cove. Salem State University is now assisting Salem Sound Coastwatch to monitor the success of the project since its completion in June 2019. This report outlines a method of quantifying volumetric change in the restored marsh using drone-derived LiDAR (Light Detection and Ranging) in order to detect erosion and deposition over time. Digital Surface Models created in Drone2Map from the 2018 and 2020 elevation data were adjusted to sea-level and differenced in Terrset/Idrisi to calculate the change in sediment volume. The resulting image shows the degree of sediment erosion and build up between the two dates with a fair amount of accuracy as determined by error statistics. This analysis process

may be replicated in the future to see if the constructed marsh can withstand and protect against flooding and storm surge due to climate change and sea level rise. *Keywords: remote sensing, drone, digital surface models, LiDAR, erosion, coastal resilience*

Julia Stevenson[a], Miriah Russo Kelly, Ph.D.[a], and Joanna Wozniak-Brown[b], Ph.D.[b]
Southern Connecticut State University[a] and University of Connecticut[b]

Multi-Dimensional Stakeholder Assessment: Connecting Stakeholder Systems to Climate Resilience

The Resilient Connecticut project was created in response to hurricane disaster relief funding designed to build coastal resilience in Connecticut. The program seeks to provide regional support for decision-making through technical tools and capacity building efforts. To effectively attain these goals, the program has developed mechanisms to reach out to stakeholders in different ways. Through the use of data collection, analysis, and communication, program leaders are able to understand the extent to which they are reaching desired goals, and may uncover ideas for how to overcome engagement barriers. *Keywords: Resilient Connecticut, coastal resilience, climate change, stakeholder systems*

Sydney Moser[a], André Viau[a], and Matthew Peros[b]
Department of Geography, Environment, and Geomatics, University Of Ottawa[a] and Department of Environment and Geography, Bishop's University[b]

Paleoclimatological Analysis of an 8500 year-long Sediment Core from Baie des Baradères, Haiti

Growing coastal populations in underdeveloped Caribbean countries face increasing risk due to stressors such as climate change and sea level rise. In Haiti, 40% of the population lives in urban areas, including slums, located in coastal plains prone to flooding. Furthermore, the metropolitan region, Port-au-Prince, lies directly along the boundary of two tectonic plates, and the country falls within the migration envelope of the ITCZ, meaning that it is potentially sensitive to droughts and changes in hydrological regimes. Moreover, hurricanes are among the most catastrophic and costly environmental phenomena along Atlantic coasts, but the factors that control their patterns are poorly understood. Despite this, long timescale (millennial) paleoclimatic records, which are used to establish important environmental baseline data and information on the variability of these phenomena, are rare. This project aims to help resolve this gap by using geological and geochemical proxies (grain-size, x-ray fluorescence (XRF) core scanning data) to identify long time-scale climate and/or hurricane trends in a coastal

Caribbean setting. The focus of the study is a nine-meter-long sediment core collected from a Blue Hole (an underwater Karst basin), approximately one kilometer from the Baradères River Delta on Haiti's southwestern coast. Radiocarbon dating revealed that the core contains close to 8500 years of sediment data. This graduate thesis project is currently in the analysis phase, but preliminary results are promising: principal component analysis of grain size and geochemical data reveals a dynamic local paleoclimate during the last 3000 years, possibly related to changes in climate or tectonic activity. *Keywords: Climate change, paleoclimate, coastal environment, Caribbean, Haiti, hurricanes, sea level rise, tectonic activity, ITCZ*

Kyle Zajaczkowski
Salem State University

Study of GIS Techniques and Applications in Response to Climate Change on North Shore of Massachusetts

This poster is an examination of the plans and preparations of five, MA, medium-sized coastal town and city governments for the challenges of climate change, notably sea level rise (SLR). Of most interest in these plans and preparations are those using geospatial technology. Sea level rise and the flooding associated with it are increasing becoming a major issue for coastal towns and cities in Massachusetts. As we begin to feel the effects of climate change, the only options available to us are to take measures to prevent it from getting worse as well as measures to mitigate and deal with what we are already experiencing. These mitigation solutions come in a variety of ways and methods and this project specifically examines those oriented to the geospatial technologies. The coastal cities in the study were found to have performed basic and in a few cases advanced analyses (for example: The City of Gloucester used hydrodynamic modeling vs bathtub modelling for its analysis) to determine the impacts of SLR on their communities. There were also several different data sets commonly used. The city of Lynn took special interest in an area of the city called Strawberry Brook for green infrastructure planning as it most of its surface is impermeable. Upon completion of the study, suggestions are made in regards to other methods and models for SLR analysis as well as other areas of concern that should be examined by these five cities. *Keywords: GIS, North Shore, climate change, sea level rise, resiliency*

Stephano Tabi
Salem State University

Wind Energy Assessment as A Mitigation to Climate Change: A GIS-Based Approach Case of The Atlantic OCS Region, US

Wind energy refers to the process of creating electricity using the wind, or air flows that occur naturally in the earth's atmosphere. Considered as a free and low-carbon energy, wind energy source has handy the attention of decision makers around the world. Wind energy has the possibilities of reducing the world's dependence on fossil fuels and has a very huge potential to impart sustainable development of both climate and energy. This paper is focusing on the wind energy potentials of the Atlantic Outer Continental Shelf Region of the United States, as a strategic location to develop wind farms that would help mitigate climate change. We used a GIS based approach in identifying suitable locations for wind farms and assessing wind energy potentials as a mitigation to climate change by using a weighted overlay of geospatial layers corresponding to these criteria. Results showed that a wind turbine runs practically emissions-free for 20 years, a viable alternative to burning polluting fossil fuels that offset all emissions within the first 6 months of operation. The Atlantic OCS Region present us with enormous wind energy potentials. Findings in this paper projects that from 2020, wind power alone would save 9.25 billion tons of CO2 every year. On average, each kWh of wind power generated would avoid 600 grams of CO2 (Global Wind Energy Council). Renewable energy would help mitigate climate change in an excellent way. However, we need sustainability in order to ensure a sustainable future for generations to come. *Keywords: Mitigation, Climate Change, Wind Energy, Renewable Energy, GIS, Sustainability, Wind Energy Potentials*

Gabriela E Triay
Southern Connecticut State University

A Meta-Analysis Of Coastal Zone Climate Change Impacts and the Greening of Ports: Growing Blue Economy and Greening Ports

Recently, ports and port authorities, across the world, have experienced increased pressure to reduce their impacts on the coastal environment (Bjerkan and Seter 2019). With a rapidly changing climate, and impacts already occurring in the coastal zone, ports are being pressed to find ways to adapt and grow (Yang et al. 2018). Adaptation responses by some ports include making the transition to becoming "green ports". Along with that, over the past 20 years, many ports have begun to initiate "Green Ports" (Abood 2012). This literature review will investigate what this transition process would look like for ports. It will review how it can become more environmentally sustainable while also, including social justice considerations in this transition. In this presentation, we will share key findings from a review of literature on the greening of ports across the U.S. This meta-analysis will develop a deeper understanding of the implications of climate change and growth in the blue economy on the greening of ports, and will later be used as a foundation for future interview research to be conducted at the local scale.
Keywords:Green Port, Blue Economy, Just Transitions

Alexandre V Pace[a], Jeannine M St Jacques[a], Duane Noel[a], and Guillaume Fortin[b]
Concordia University[a] and University of Moncton[b]

A Tree Ring Based Moisture Reconstruction of the Last 211 Years for the Mountains of Gaspésie, Québec.

To determine whether anthropogenic climate change is significantly affecting a region, long records of instrumental data are needed. The interior Gaspésie is a mountainous region likely to be sensitive to anthropogenic climate change but continuous instrumental records are brief, starting only in the 1960s. The only practical method to supplement the lack of climate records in this region is to reconstruct annual data through the analysis of tree rings. Here we present a 211 year moisture reconstruction of a major river in the region. The reconstruction is based on six white cedars chronologies (Thuja occidentalis) in a river valley and three sites at the tree line, two black spruce (Picea mariana) and one white spruce (Picea glauca). Collectively, the

data spans 456 years. Analysis of the chronologies reveal an energy-limited snowpack system controlling tree growth. This reconstruction is the fourth river reconstruction in eastern North America, filling an important geographical gap in paleoclimatic records. Climatic and hydrological reconstructions could be useful for the management of the flora and fauna of Gaspésie National Park, particularly for the region's endangered caribou population and for the Atlantic salmon fisheries of the Sainte-Anne River. *Keywords: moisture reconstruction, tree rings, Gaspesie, paleoclimate*

Emma Cross[a], Miranda Holland[a], C. Patrick Heidkamp[a], Annette Govindarajan[b], Erin Frates[b], Sarah Stover[b], Sara Gerckens[a], Dan Martino[c], Lauren Brideau[d] (co-author)
Southern Connecticut State University[a], Woods Hole Oceanographic Institution[b], Cottage City Oysters[c], and University of Virginia[d]

Building Environmental and Economic Resilience for the Shellfish Aquaculture Industry Through Transdisciplinary Action Research Involving Industry and Academia

Multi-species ocean farming is an emerging aquaculture technique that produces sustainable food sources whilst potentially aiding in mitigating ocean acidification and hypoxia impacts. This ocean farming model co-cultures seaweed and shellfish, and can potentially lead to increases in pH and oxygen that offset acidification and hypoxia. Transdisciplinary action research has emerged as a dynamic pathway to encompass sustainable blue economy transitions. Here, we present an update on our coastal transdisciplinary action research that incorporates the co-production of knowledge between industry and academia to address the need to build environmental and economic resilience to the shellfish aquaculture industry. To determine environmental resilience, we are measuring the impact of multi-species ocean farming on water quality and local biodiversity through the use of continuous unattended logging multi-probes and environmental DNA (eDNA) analysis, respectively. Go-Pro footage and plankton tows are also being used to supplement our biodiversity analysis. The potential development of a highly marketable sustainable ecolabel for aquaculture products from multi-species ocean farms will be used to build economic resilience for the shellfish aquaculture industry. This applied research initiative has connected natural science academics with expertise in water quality and environmental DNA (eDNA) analyses, social science academics with expertise in the blue economy, and industry stakeholders who are experienced multi-species ocean farmers. This presentation details that while sectors can value independent departures and prioritize different needs in a transdisciplinary action research process, supporting a shared objective holds potential to support ocean sustainability. *Keywords: Aaquaculture, shellfish, ocean sustainability*

Melissa Veitch
University of Maine at Farmington

Building Maine's Food Processing Infrastructure: A Circular Food Systems Map for Maine

My internship, for the last few months, has allowed me the privilege to work for the UMaine Mitchell Center for Sustainability Solutions. A few years ago at the Mitchell Center, they identified that eliminating food waste was the most important issue to solve in order to create a more sustainable waste system for Maine. In order to accomplish the goal of eliminating food waste, they created six solutions that strive to also achieve the "Triple Bottom Line"; People, Planet, and Profit. My specific solution is Solution 4: to Build Maine's Food Processing Infrastructure. My focus in this specific solution is on creating a GIS map that can be used as a tool to help create this processing infrastructure. I aim to do this by building relationships between farmers, producers, and consumers through the map. In order to accomplish the creation and initial building of this map, our team has researched and met with stakeholders to see if there is a need for this map; if there is this need, then what the map should look like. I also found previous maps that had been created (by suggestion and research) to find out what some of the "best practices" are, in regards to mapping a food processing system in any aspect. We have used this research moving forward to identify the need for a map like this in Maine, and are looking to start creating this map very soon. Our overall goal for this map is to help reduce food waste. *Keywords: Maine, food, food waste, food processing*

Yunhe Cui, Xiang Chen, Xurui Chen, and Chuanrong Zhang
Department of Geography, University of Connecticut

Competition, Integration, or Complementation? Exploring Dock-Based Bike-Sharing in New York City

The bike-sharing system has advanced urban transportation by enabling more flexibility for short-distance travel. However, there has been a paucity of knowledge about the relationship between the bike-sharing system and the public transit system. In this paper, we solicit a one-year biking trip data consisting of approximately 17 million trips from Citi Bike, the largest dock-based bike-sharing system in New York City. Then, we analyze the bike usage patterns by applying the K-means clustering method based on three clustering variables: the start trips, end trips, and station empty status. Lastly, we identify three relationships between bike-sharing and public transit: competition, integration, and complementation. The results show that the bike-sharing system is well integrated with the public transit system to enhance urban ridership and solve the "last mile problem." The paper also portrays the unequal distribution landscape of the bike-sharing system, which is concentrated on transportation hubs but has relatively limited coverage in low- to medium-density residential areas. Thus, the study would help stakeholders

to better understand the different roles that the bike-sharing system plays in the city. It can guide the development and expansion of the system to improve spatial equity in urban and transportation planning . *Keywords: bike-sharing, public transit, K-means clustering, mobility, mode switching*

Talia G. Lent
Southern Connecticut State University

COVID-19 Implications for Sustainable Lifestyles in New Haven, Connecticut: An Exploratory Study

COVID-19 has had substantial detrimental impacts on the global environment, economy, and society. Consequently, the pandemic - and the resulting mitigation efforts to control it - has influenced multiple fabrics of everyday life including food consumption, energy usage, and transport dynamics. Despite the widespread impacts of the pandemic and subsequent lockdowns and quarantine measures, very few studies have explored in detail the repercussions that COVID-19 has had on sustainable lifestyles. This exploratory study therefore addresses a need to understand the regional impacts of COVID-19 on sustainable lifestyles in Connecticut and the disparities that have arisen between diverse socio-economic segments of the population. This presentations' aims are two-fold. Firstly, this study outlines the ways in which the pandemic has shaped sustainable practices. Secondly, a methodological approach for gathering first-hand accounts of the disruptive changes to everyday lifestyles and sustainability in New Haven, Connecticut is presented. *Keywords: Sustainable Lifestyles, COVID-19, Racial Justice, Climate Justice, Inequity*

Emma Sweeney
Southern Connecticut State University

COVID-19 Transmission in Connecticut: GIS Mapping of the First Three Months of the Pandemic

As the COVID-19 virus made its way across the United States in the spring of 2020, Connecticut was among the most severely impacted states. Previous theories have suggested that these initial impacts can be attributed to Connecticut's close proximity to New York State, the epicenter of the disease during this time. Prior to the pandemic, there were close to 50,000 Connecticut residents commuting into New York for work with many claiming to use a railroad system as their primary means of travel. This study was established to investigate COVID-19 transmission trends in Connecticut. Specific interest was given to the possibility that transmission was coming from New York State, especially New York City. The primary

question during this study was does it appear that COVID came to Connecticut via New York and if it did, how did it happen. From this study, a gradual increase in COVID-19 cases was seen beginning in the Western portion of the state, suggesting transmission came from New York. The rapid rise in cases in the Stamford, Norwalk, and Danbury areas, which are known to have many commuters going into New York, further confirmed New York transmission likelihood. Continual case increases in areas surrounding well-known railroad and highway routes into New York City demonstrated the great impact that transportation had in aiding the spread of COVID-19. Results also conclude that by mid-May, COVID-19 was fully established in Connecticut causing any patterns after this point to be inconclusive when aiming to establish an initial source of transmission. *Keywords: COVID-19, Connecticut, transmission trend, New York, pandemic*

Charlotte M. Whyte[a], Leeli Amon[a], Jeannine-Marie St-Jacques[a], and Matt Peros[b]
Concordia University[a] and Bishop's University[b]

Deglaciation and Early Holocene Fire Record from Scotstown Bog, Eastern Townships, Québec, Canada

During the end of the last glaciation, the final retreat of the Laurentide Icesheet affected the landscape and vegetation across vast regions of Canada and the eastern United States. Sedimentary deposits at Scotstown Bog, Eastern Townships, Québec, are among the few sedimentary sequences studied at high resolution from this period. A sediment core of six meters was taken from the site. The bottom layer consists of a silty clay deposited during the years the site was a pro-glacial lake; this is surmounted by layers of gyttja (organic lake mud), then peat from riparian marshes, and finally bog sediments deposited as lake was filled in. The bottommost Scotstown Bog sediments date back ~12,800 years BP. The bottom 105 cm were analysed for the presence of micro-charcoal at high resolution (using contiguous 1 cm subsamples) to gain information about the occurrence and frequency of forest fires in the region. Surprisingly, the proglacial lake sediments contained little micro-charcoal, even though the northern border of the boreal forest was only ~100 km to the south. The transition from the silty clay of the proglacial lake to gyttja was very rapid, occurring over 2 cm. This shift is accompanied by a transition from a near-complete lack of micro-charcoal to substantial amounts. Hence, we conclude that the lack of micro-charcoal at the bottom of the core is likely due to the nearby Laurentide Ice sheet suppressing fires in the nearby boreal forests, until it recedes far enough northward that it no longer affects the local pyro-climate. *Keywords: fire regimes, deglaciation, Québec, Holocene, micro-charcoal, post-glacial vegetation*

Daniel J Kraemer
University of Connecticut

EARLY-STAGE REAL ESTATE DYNAMICS IN THE COVID-19 PANDEMIC: A GEOSPATIAL ANALYSIS OF NEW YORK'S MSA

COVID-19 has affected all aspects of global activity and has since reshaped and restructured society itself. In particular, real estate has experienced numerous changes in composition since March of 2020. This study examined the effects of this pandemic on the real estate market in one of the world's most influential metropolitan areas, New York. Real estate value dynamics in New York City's metropolitan statistical area (MSA) were investigated through geographically weighted regressions (GWRs) on the six time intervals following the outbreak in the United States. The analysis indicated that certain characteristics, including population density and distribution, racial diversity, transportation accessibility, and education provide indications of the effect of an external shock such as COVID-19 on real estate dynamics of a given group or area. This analysis also suggested that urban exodus could be a response to an external shock like the pandemic. This study helps develop a better understanding of external shocks similar in nature to COVID-19 and helps better prepare society for the ramifications of such events in the coming future. *Keywords: COVID-19, Real Estate, GWR, New York, New York City, MSA*

Antoine Lachance[a], Jeannie-Marie St-Jacques[a], and Matt Peros[b]
Concordia University[a] and Bishop's University[b]

Establishing the Chronology of Paleo-Storms During the Holocene on the Magdalen Islands, Eastern Canada, Using Peat Cores

Tropical cyclones and winter storms are pervasive dangers to coastal communities in eastern Canada. To better understand the impact of climate change on these events, two peat sequences of 3.25 and 7.00-meter long were recovered from two ombrotrophic peat bogs on Île du Havre-Aubert, the southernmost island of the Magdalen Islands archipelago, in eastern Canada. The samples cover the entire peat sequence, with the base of the cores ending in sediments of glacial or marine origin. The cores were sampled to be dated by 14C. The bottommost peat sediments date back to ~ 8500 years for the 7.00-meter core and ~ 4200 years for the 3.25-meter core. Both cores were analysed with high resolution X-ray microfluorescence (μ-XRF) and computerized-tomography (CT) scans to detect the presence of allochthonous material from the ocean and surrounding beaches and sandstone cliffs deposited in the peatbogs during extreme weather events. Preliminary analyses show high frequency variability in bromine and chlorine, which may be associated to sea-spray, and terrigenous elements (potassium, titanium,

manganese, iron), which may be associated to surrounding beaches and cliff sediments. Ultimately, Holocene past-storminess will be established by combining μ-XRF geochemistry, CT-scan-derived density measurements, and aeolian sand influx measurements derived from loss-on-ignition (LOI) analysis. *Keywords: paleotempestology, Holocene, tropical cyclones, extratropical cyclones, Quebec*

Shannon O'Lear[a], Ken Foote[b], Deborah Thomas[c], Emily Skop[d], Jeffrey Lash[e], and Fernando Bosco[e]
University of Kansas[a], , University of Connecticut[b], University of North Carolina at Charlotte[c], University of Colorado at Colorado Springs[d], and San Diego State University[e]

Healing in Leadership

This session considers how leaders can cultivate a practice of healing. Healing can involve observing the overall well-being of the people around us, validating their concerns, and being available and present; healing is focused on empowering teams and making space for new voices. In a recent piece in Inside Higher Ed, Annmarie Caño observes, "...if part of our job is to develop and sustain the vitality of our units, then we also need to care about the health and wellness of our people as they work to create a healthy future for themselves and for others. That sounds like healing to me." In this session, we invite leaders, both in leadership positions and in spirit, to participate in small group conversations about healing practices that contribute to departmental, collegial, and personal well-being. We will collect and share observations about actions that contribute to healing in our workplaces that range from interpersonal communication to disrupting unhelpful structures when necessary. *Keywords: leadership, professional development, well-being*

Xiang Chen
University of Connecticut

How Does Social Distancing Change Covid-19 Diseasescape: Case Modeling Across Connecticut Towns in the Early Outbreak

In the early development of COVID-19, large-scale preventive measures, such as border control and air travel restrictions, were implemented to slow international and domestic transmissions. When these measures were in full effect, new cases of infection would be primarily induced by community spread, such as the human interaction within and between neighboring cities and towns, which is generally known as the meso-scale. Existing studies of COVID-19 using mathematical models are unable to accommodate the need for meso-scale modeling, because of the unavailability of COVID-19 data at this scale and the different timings of local intervention

policies. In this respect, we propose a meso-scale mathematical model of COVID-19, named the meso-scale Susceptible, Exposed, Infectious, Recovered (MSEIR) model, using town-level infection data in the state of Connecticut. We consider the spatial interaction in terms of the inter-town travel in the model. Based on the developed model, we evaluated how different strengths of social distancing policy enforcement may impact future epidemic curves based on two evaluative metrics: compliance and containment. The developed model and the simulation results will establish the foundation for community-level assessment and better preparedness for COVID-19. *Keywords: COVID-19, modeling, social distancing, epidemiology*

Jesse Minor
University of Maine at Farmington

Invasive Species Control Through Expanded Culinary Markets

Non-native European Green Crabs (Carcinus maenas) have been present in New England since the mid-1800s and in Maine since 1900. Recent and rapid warming in the Gulf of Maine has contributed to the explosive population growth of green crabs, to the detriment of important eelgrass habitat, to valuable shellfish industries, and with potential harm to the iconic lobster industry. Eradication policies have not worked and are increasingly unlikely to succeed, so the Maine is shifting its policy focus toward green crab population control via harvesting. This set of policy changes is complex, but does provide economic growth opportunities for harvesters, processers, and related markets. One potential green crab control mechanism is an expanded culinary market. In this presentation, I describe several attempts to create a culinary market for invasive green crabs in Maine, including an ongoing course-based pilot project at UMaine that seeks to introduce green crabs into the college dining hall. *Keywords: green crabs, invasive species*

Eve Fischer[a], Jesse Minor[a], and Marissa McMahan[b]
University of Maine at Farmington[a] and Manomet[b]

Investigating Policy Solutions to Support Culinary Green Crab Market Development in Maine

Invasive species are a growing global problem under climate change that have severe impacts on local ecosystems and economies. The invasive European green crab, Carcinus maenas, has had a presence in the United States since the 1800s, and in Maine since the early 1900s. Due to the warming of the Gulf of Maine and green crabs' ability to rapidly reproduce and spread, their populations have exploded in recent years. Green crabs relentlessly prey on soft shell clams, destroy important ecosystem features like eelgrass beds, and outcompete native crab species. As a result, Maine's lucrative clamming industry has suffered and clam landings continue to

fall each year. Since a species as prolific as the green crab is essentially impossible to eradicate, it is necessary to adapt to them as a part of our new climate reality. The clearest way to do this is by making use of green crabs as a culinary resource, which both serves to balance out their population and to diversify Maine's fishery resources. The state can support this goal through a combination of regulation changes and support for the market as it develops. Maine can also look at approaches to the green crab invasion in other places and how other invasive species have been utilized in culinary markets to guide us in this endeavor. As the climate continues to change, it is vital that we learn to adapt and tailor public policy to benefit people and the environment as much as possible. *Keywords: Shellfish, aquatic invasive species, soft shell clam, lobster, fishery management, green crab*

Eve Vogel
University of Massachusetts Amherst

Legacies of Electric Restructuring for a New Electric Transition: Neoliberal Paths for Canadian Hydropower?

The current transition in our electric systems away from fossil fuels is shaped by a previous electric system transition, electric restructuring. Can the neoliberal tools we built some two decades ago—and the regulatory remnants and responses—achieve the deep environmental and social change we now seek? This paper summarizes the institutional, political-economic, and geographical effects and legacies of electric restructuring, focusing on Massachusetts and New England. It shows how the legacies of these changes shape Massachusetts's approach to importing Hydro-Québec power. Today's main market tools in the electric sector are inadequate to fund long-distance transmission in the United States, as investors cannot tolerate the high financial risk. Massachusetts's approach to importing Québec hydropower unfolded in four steps: 1) the 2016 Energy Diversity Act; (2) a Request for Proposals to fund a transmission line through northern New England; (3) the selection of a winning proposal, and 4) the addition of clean energy credits to the state renewable portfolio standard. These put the cost of a new line onto Massachusetts's electric customers, guaranteed profits to the transmission owner and the state's still-regulated utilities, and offered multiple income streams to Hydro-Québec. The proposal competition favored projects that externalized costs onto other people and places, and into the future—leading to political opposition, escalating costs, and implementation delay. This history helps reveal key legacies and limits of electric restructuring and its role in decarbonization. *Keywords: hydropower, Canada, New England, restructuring*

Adam Gallaher[a], Marcello Graziano[b], and Maurizio Fiaschetti[c]
University of Connecticut[a], Southern Connecticut University[b], University College London[c]

Legacy and Shockwaves: A Spatial Analysis of Strengthening Resilience of The Power Grid in Connecticut.

Grid resilience and reliability are pivotal in the transition to low and zero carbon energy systems. Tree-trimming operations (TTOs) have become a pivotal tool for increasing the resilience of power grids, especially in highly forested regions. Building on recent literature, we aim at assessing the temporal and spatial extents of the benefits that TTOs produce on the grid from three perspectives: the frequency, extent, and duration of outages. We use a unique dataset provided by Eversource Energy, New England's largest utility company, with outage events from 2009-2015. We employ spatial econometrics to investigate both the legacy and spatial extent of TTOs. Our results show TTOs benefits occur for all three metrics for at least 4 years, and benefits spillover to up to 2km throughout the treated areas, with significant spatial spillovers across the state greater than direct effects. Implications lead to supporting TTOs as part of the hardening policies for utility companies, especially as home-based activities increase in importance in a post-COVID19 world. *Keywords: Spatial modeling, electricity, vegetation management, trimming, outages, energy transitions.*

Eric Fournier[a], Trushna Parekh[b], Jing Li[c], and Ken Foote[d]
Washington University St. Louis[a], Texas Southern University[b], University of Denver[c], and University of Connecticut[d]

Pandemic Silver Linings: An Open Discussion of How Covid Has Helped Us Improve Our Teaching

In a good way, the pandemic forced us to focus on our teaching more than we have for years. We suddenly moved into an online environment where we had to reinvent our classes almost overnight. What have we learned from this experience? Of the experiments we tried, which ones will we continue to use when the pandemic recedes? This session is organized as an open, small-group discussion in which all participants will be able to share their ideas and strategies with the help of four facilitators. *Keywords: teaching, learning, pandemic, professional development*

Miriah Kelly and Stephen Axon
Southern Connecticut State University

Questioning Climate in Connecticut: An Exploratory Thematic Analysis of Questions for State Leaders

Understanding collective inquiry themes derived from public audiences can better inform educational, outreach, and engagement efforts for sustainability and climate action. This is especially true in the coastal resilience sphere, where climate change impacts are occurring and mitigation and adaptation efforts are already being implemented. In this presentation, we share findings from an exploratory thematic analysis of questions posed to state leaders during the Solve Climate by 2030 public event that was jointly hosted by Southern Connecticut State University and the University of Connecticut. The online webinar featured state leaders and was presented live on YouTube, where it remains available for continued viewing. Questions posed during, and following, the event indicate a plethora of perspectives and attitudes towards how climate action is advancing in the State of Connecticut. These questions are analyzed using a thematic analysis framework (after Braun and Clarke, 2006) that categorizes the main factors that shape public perspectives towards Connecticut state leadership on climate action. The themes arising from this research can be assimilated within state-level action to guide efforts to more meaningfully integrate public audiences into the climate narrative evolving in Connecticut, and the larger region of the Northeast United States. *Keywords: Climate Action, State Leadership. Public Engagement, Climate Governance*

Faith Kim
Southern Connecticut State University

Racing to the Polls: The Voter Demographics of New Haven, CT

The political landscape, at both the national and local levels, has experienced a resurgence of citizen participation. Rather, the desire to participate and be represented has been rekindled, fueled by the growing inequality of the nation; an inequality so great that it is impossible to ignore. However, barriers to achieve a truly inclusive democracy are quietly and consistently being constructed. While New Haven does not engage in such explicitly unequal practices, it remains that inequality is inarguably present. This was most prevalent during the mayoral candidate campaigns leading up to the last mayoral election in 2019. In the face of the 2021 municipal election – another mayoral election – this research examines if there are any relationships between race, income, and voter registration that exist at this scale. To do so, the 2020 Official Check List from the New Haven Registrar's Office and the income and racial data acquired from the 2019 American Community Survey and 2020 decennial census, respectively, are added to ArcGIS software for spatial analysis. Preliminary results show a clear relationship between income and race, and a weaker, but still positive, relationship between the number

of registered voters and either income or race. Because of the complexity around how race is categorized and calculated on the census, as well as the further generalization of this research, further statistical analysis as well as a deeper investigation is encouraged. *Keywords: registered voters, voter eligibility, race, income, census, New Haven, GIS*

Aaron M. Adams, Debs Ghosh, Adam Gallaher, Ashley Benitez Ou, Diego Cerraic, and Chuanrong Zhang
University of Connecticut

Relation Between Mobility, Extreme Weather Events, and Health: A Cases Study of Covid-19 Outbreaks

This paper aims to understand whether outbreaks of Covid-19 cases may increase after major storms due to the displacement and movement of a large number of people affected by fallen trees, power lines, and resultant power outages. After Tropical Storm Isais caused widespread power outages in Connecticut (CT), we compiled hourly power outage data, and daily COVID-19 cases for 21 days before and after the storm. First, we identified towns with statistically significant increasing trends of daily COVID-19 cases before and after the storm using time series functions. Using a retrospective space-time scan statistic, we further identified COVID-19 space-time clusters that were active (i.e., more observed than expected cases) before and after the storm. Second, we measured the movement of people from cell phone data aggregated by Safegraph. Third, we measured statistical associations between power outages and movement of people with the increase in COVID-19 cases. Results showed positive associations between power outages and COVID- 19 cases increase. It may be possible to predict the location of future outbreaks after major storms using power outage information. We can estimate times to power restoration by locations using outage predictions and then direct appropriate public health interventions such as increased testing and contact tracing when people return to their homes and businesses to prevent future disease outbreaks. This paper has the potential for advancing the understanding of coupled human-environment systems through an investigation of the relationships between extreme weather events, environmental management, and human health. *Keywords: COVID-19, storms, power outages, mobility, environmental management, spatial analysis*

Matthew McCourt
University of Maine at Farmington

Scaffolding Student Learning with Project Management Tools for Project-Based Learning

Project-based learning (PBL) provides an effective way for integrating high impact practices into a sustainability seminar aimed at professionalization and geospatial competencies. At the same time, PBL poses challenges for both students and instructors. For students, PBL can present group collaboration, self-management, and active learning challenges. For instructors, PBL can require adaptive management of diverse student activities and careful maintenance of relationships with community partners. This presentation reports on the use of project management tools (e.g., a scoping process, scheduling tools, a reflective project log) to improve project-based learning process and outcomes. The project management tools were developed out of readings in GIS project management and intended to support a distributed model of project management in an authentic trail mapping project in Farmington, Maine. *Keywords: education, project-based learning, project management, GIS*

Shaina Sadai
University of Massachusetts - Amherst

Sea Level Rise and Multispecies Climate Justice

Physical changes to the earth system resulting from anthropogenic greenhouse gas emissions are already having myriad impacts on all parts of our shared planet. Sea levels have risen significantly over the past century and are projected to continue to increase for centuries to come, and to stay elevated for millenia. Determining the impacts that sea level rise has on biodiversity conservation, ecosystem functioning, and the wellbeing of individual humans and nonhuman animals is an important avenue to assess as we seek to confront the climate crisis in a way that centers climate justice. Multispecies climate justice allows us to look deeper into the interrelated ecologies of climate impacts by shifting away from a sole focus on humans to a broader assessment of interrelated beings and ecosystems. This talk will draw from political ecology, animal geographies, and biological and ecological sciences literature to present a preliminary framework for considerations of multispecies climate justice particularly as it relates to sea level rise drivers, impacts, and adaptations. *Keywords: climate justice, sea level rise, biodiversity*

C. Patrick Heidkamp[a], Michaela Garland[b], Celine Germond-Duret[c], Matthias Kokorsch[d], and John Morrissey
Southern Connecticut State University & IJSBERG[a], University of Connecticut & IJSBERG[b], Liverpool John Moores University & IJSBERG[c], and University Centre of the Westfjords & IJSBERG[d]

Situating Just Transitions: Sustainability, Innovation and Inclusion in the Blue Economy?

The emerging Blue Economy (BE)—a concept championed by the United Nations—is seen as a promising low carbon driver of sustainability transitions. On the premise of wanting to effect not only a sustainable but also a just transition, this paper argues for the need to analyze the more hidden interactions and relationships of the BE (subsistence activities, illegal activities, barter, etc.) rather than only focusing on capitalist enterprise, market exchange, and wage labor. Essentially, a just transition is dependent on assuring distributive, recognitive, and procedural justice. The paper proposes a quadruple helix approach to stakeholder engagement and a Transdisciplinary Action Research (TAR) methodology as a promising avenue in which the diversity of such stakeholder groups can mutually engage to envision and co-create BE futures that realize these three dimensions of justice. *Keywords: Blue Economy, Just Transitions, Transdisciplinary Action Research, Alternative Economies*

Ailing Jin
University of Connecticut

Storefront Transparency Evaluation in Commercial Areas Using Google Street View (GSV) and Deep Learning

In recent years, governments have emphasized the importance of storefront transparency in commercial areas and proposed the local storefront design guide. However, only a handful of research have studied the storefront transparency evaluation. Previous research assessed storefront transparency by fieldwork and measuring data, which is time- consuming and limited to small study areas. To resolve these problems, this study proposed a deep learning based method to evaluate storefront transparency from GSV images. In this paper, each commercial area will be classified into one of three classes, which are Good, Fair, and Low, based on its transparency level. Three popular Convolutional Neural Networks (CNNs) are employed to extract features from GSV and Fully connected neural networks are used to classify levels of storefront transparency. The performance of VGG19 and Resnet 18 for storefront transparency

classification are compared. The result shows that VGG19 can classify GSV images with better precision compared to Resnet 18. The result transparency map is created using VGG 19. Finally, linear regression analysis is conducted to reveal the relationship between generated transparency and housedhold income at Census tract level. The result suggests that the sum of commercial parcels classified as Good has the most important effect on household income. *Keywords: Convolutional Neural Networks (CNNs), Google street view (GSV)images, Image classification, Storefront transparency evaluation, Household income*

Brian D Pollard, Eve Fischer, Chy'anne Cray, and Richard Down
University of Maine at Farmington

The Austin Way Project: Supporting Local Greenways Creation

Greenways are lands set aside for recreation, alternative transportation, and environmental protection. They add a great deal of value to communities for both people and the environment. Austin Way is a 15-acre trail network being developed in Farmington, Maine, that fits within a broader regional greenways vision. Students in a Geography and Environmental Planning seminar designed a project to support the Austin Way trail network by creating a series of maps that show Austin Way's key features and provide an accurate depiction of the trail network. This work will help the property owners develop their greenway and use it for nature-based events, thereby creating a valuable asset for the community. In this presentation, we share a set of maps we created that display different key features of the trail system. These include story maps that provide thematically organized multimedia information about Austin Way, printed trail maps for practical use on the land, and a brochure highlighting the beautiful natural features visitors will see at Austin Way. The project highlights the myriad benefits local greenways offer, but it has also enabled our class to learn project management skills through the process of working directly with our Austin Way client, as well as the extensive preparation and project scoping work we did prior to our engagement. *Keywords: greenways, trails, project-based learning, GIS*

Scott M. Graves and Megan Hill
Southern Connecticut State University

The Curious Case of Perched Beaches @ Guilford Connecticut

A small collection of naturally occurring (non-engineered) perched beaches occur along a short stretch of salt marsh fronted shoreline in Guilford Connecticut. These "perched" sandy deposits sit atop and back from the salt marsh fronted shoreline and appear to be stranded storm surge lag deposits in episodic landward migration over the backing/underlying salt

marsh. They occur in a very small stretch of the Connecticut shoreline between Guilford's Grass Island and Mulberry Point, a linear distance of ~2km. Only 2 other examples of similarly perched beaches occur along the Connecticut shoreline - just eastward and around the corner from Hammonasset's Meigs Point. Close viewing of the entire New England and mid Atlantic shoreline (in google Earth) reveals no other examples of similarly perched/stranded, salt marsh fronted beaches. All other beaches are of the typical form: resting in the Intertidal/supratidal zone and composed of sandy material liberated by erosion of older glacial coastal bluff and weathered bedrock. Since 1990 the largest of Guilford's perched beaches at Chaffinch Island has migrated landward over the upper salt marsh by as much as 45m. Extended periods of fair weather see the uppermost portions of these stranded berms progressively vegetated by dune grasses. Intervening extreme surges uproot or bury these incipient dunes and the entire stranded/perched deposit may migrate landward (washover lobes) by as much as 5m. Chaffinch Island's perched beach has been mapped in detail with a μUAS/drone - employing Structure from Motion and its internal anatomy investigated by trenching across the feature. *Keywords: perched beach, storm surge lag deposit, salt marsh shoreline*

Barry S. Zellen[a], Katherine Donahue[b], Mary K Bercaw Edwards[c], Tracy Romano[d], and Fred Calabretta
United States Coast Guard Academy[a], Plymouth State University[b], University of Connecticut, Avery Point[c], and Mystic Aquarium[d]

The Enduring Southeastern CT/Arctic Geographical Nexus

Southeast Connecticut has a long and proud connection to the Arctic region dating back several centuries to the eras of commercial whaling and polar exploration, where local residents forged enduring relationships with indigenous peoples of the Arctic, resulting in the emergence of a small Inuit community in Groton in the 19th century. Our region's connection to the Arctic continued through the mid-20th century's Arctic defense modernization efforts of the Cold War, including the advent of long-distance capable nuclear submarines in Groton which cruised beneath the polar ice, and numerous Arctic research, educational, and policy activities across the Thames River at the Coast Guard Academy. More recently, there has been a renewal of interest in the region's connection to the Arctic through our shared maritime history at the Mystic Seaport Museum and the Mashantucket Pequot Museum and Research Center, and to Arctic marine mammal research and conservation at Mystic Aquarium (with its beluga whale research program) - with this unique, and fascinating, cluster of local organizations fostering the renewal of the region's ties to the indigenous peoples of the Arctic who had long interacted with earlier generations of residents from New London, Groton and Mystic. I, along with my co-authors, will discuss our respective organizations' current efforts to sustain this fascinating geographical nexus connecting Southeastern CT with the Arctic region via our shared maritime heritage

for generations to come, and to reflect on the unique geographical dimensions of our enduring Southeastern CT/Arctic geographical nexus. *Keywords: Arctic exploration, commercial whaling, nuclear submarines, Coast Guard Arctic heritage, beluga whale research*

Caitlin McLaughlin
Southern Connecticut State University

Using the Past to Paint The Future: The Sustainability Potential of Organic Pigment Processing and Creation

The arts, particularly paint, have evolved alongside humanity in both functional and creative ways. Historically, paints were created using pigment products found in nature. As part of the mass-produced paint industry, there has been a shift away from these resources in favor of synthetic replacements that pose health and environmental risks. However, within niche communities a return to more sustainable and naturally based pigments has seen a revitalization. This demonstrates that not only do these processes work, but that the products produced from them are actively sought out as a replacement for commercial products. By implementing these processes on a larger scale, the paint industry can meet the needs of these individuals while introducing paint products that are more sustainable to a wider range of consumers. This incorporates the need to find natural materials that are easy to harvest pigment material from with a consideration to the economic cost of processing them into a usable form. In addition, it is vital to consult the individuals within these specialized painting communities in an equitable way. This presentation reports on findings that examined both these dimensions. It highlights the growing interest in natural pigments across painting ability, the challenges that home-growers face when trying to grow plants for pigments, and the variability in the quality of the end paint result. The presentation concludes with an evaluation of the sustainability potential of organic pigment processing and creation to move the paint industry towards a sustainable future. *Keywords: Paint Industry, Organic Pain Processing, Plant Material, Pigment Creation, Sustainability*

Brad Dearden
University of Maine at Farmington

Visualizing Economic Juxtapositions of Urbanicity in the 21st Century

Relevant literature suggests that photographs communicate both literal and nuanced meanings of human activities and place. Visual forms of advertising that situate within commercialized city-space, for instance, convey an essential 'branding' of places associated with globalized interests. Importantly, these myriad visual artifacts increasingly occupy select spaces in urban geographies, often concomitant with a trajectory that encourages development under a scenario

of brisk 21st century capitalism. In analyzing these manifestations and the interpretations they evoke, this study contextualizes the author's still photographs of Beijing, Kathmandu and Boston's Chinatown, places exhibiting fundamental differences but imprinted with activities reflective of ambitious development. The outgrowth of this research infers that visual media forms offer a productive means to document this phenomenon – namely, the expansive, recurrent commercial forms that prosper in urban areas amidst local spaces of deprivation or gentrification, and the consequent social landscape juxtapositions they elicit. *Keywords: urban development, globalization, visual media*

Taylor S. Price
University of Connecticut

Zoning Overlays in Lexington, KY

Zoning has a significant impact on our built environment. Overlay zoning, an additional form of restrictive zoning, is a tool that municipalities utilize to control development and neighborhood density. This study analyzes the impact that historic district (H-1) and neighborhood character (ND-1) overlays have on home sale price in Lexington, KY. Results suggest that overlays have a significant positive impact on home sale price and that overlays exhibit positive price spillover on non-overlay homes. Results also suggest that whiter wealthier neighborhoods choose to implement overlays compared to the average neighborhood.
Keywords: Zoning, Housing, Historic District, Housing prices, Overlay districts

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A typical manuscript should be between 12 and 20 double-spaced pages of text. The journal will consider both shorter and longer pieces depending on their appropriateness. Articles submitted for consideration must be typewritten using Times New Roman 12-point font, double-spaced, 1-inch margins and with a minimum of special formatting. Electronic submission is preferred as a Word document. Do not place any identifying information in your manuscript or your file names to ensure a blind review. This includes names of authors, their affiliations or acknowledgments.

Articles MUST contain the following:

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An abstract of no more than 250 words with 4-5 keywords
The body of the paper
Separate pages for notes
Separate pages for references
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Electronic submissions should go to the editor: Dr. Steven Silvern
Email: negeog@salemstate.edu