RUNNING HEAD: LANDFILLS & RURAL ENVIRONMENTAL INJUSTICE

Introduction

Landfills are a major environmental hazard linked to water contamination, greenhouse gas emissions (e.g. methane), and the accumulation of toxins in human and natural ecosystems (Elliott and Frickel, 2011; 2013). Hazardous waste landfills have been shown to be a form of environmental inequality potentiating adverse health outcomes disproportionately experienced by poor communities and communities of color (e.g., Bullard, 1990; Mohai and Saha, 2006; Pellow and Brehm, 2013; Taylor, 2014; Mohai and Saha, 2015a; 2015b) and by rural communities (Ashwood and MacTavish, 2016). However, little research has investigated the effects of all other landfills, construction and demolition (C&D), industrial, and municipal, which comprise 93% of landfills in the U.S. (see McKinney, Kick, and Cannon, 2015). Research has begun to show adverse health effects, such as high asthma rates and low birth weights, due to proximity to C&D, municipal, and industrial landfills (see for instance, Mattiello et al., 2013; Porta et al., 2009; World Health Organization, 2007), though these facilities are not regulated as hazardous waste. Moreover, recent scholarship has suggested that disasters caused by natural hazards may have indirect impacts on landfills in rural areas due to the necessity of clearing disaster debrief quickly (McKinney et al., 2015). The current analysis examines effects of landfills on rural areas. Specifically, this research analyzes key linkages among C&D, industrial, municipal, and hazardous waste landfills and ruralness, sociodemographic characteristics, disaster occurrences, and segregation, questions previously unexplored on a national scale within the academic literature.

Two key areas of background literature are used to frame the current study. First, I present a short description of landfills by type in the US. Second, I present an overview of academic research that suggests potential link of landfills as an environmental hazard, driven by debris from disasters affecting rural counties filling an identified gap in the literature (Kelly-Reif and Wing, 2016).

Landfills

Modern production processes generate numerous kinds of waste that are disposed of in multiple containment apparatuses and regulated differently. Hazardous waste generally refers to waste that is ignitable, corrosive, reactive, or toxic. This category includes wastes from industrial processes, such as those to refine petroleum, and unused hazardous commercial chemical products, such as agricultural insecticides. Treatment, storage, and disposal of this category of wastes is federally regulated by the Resource Conservation and Recovery Act (RCRA; 1976).

However, this is not the only kind of waste modern life produces. In fact, much of the waste produced in the U.S. is not regulated as hazardous waste although it may be hazardous to human health and ecological systems. The majority of waste produced, treated, stored, and disposed of is regulated as municipal, C&D, or industrial waste (EPA, 2008). While hazardous waste is regulated federally, individual states are responsible for establishing operating criteria for these other landfill types. The U.S. Environmental Protection Agency (EPA) regulates the location, operation, design, control, monitoring, closure, post-closure maintenance, and financial solvency criteria for municipal solid waste landfills under subtitle D of the RCRA. However, states are tasked with ensuring that municipal solid waste landfills meet the federal criteria (EPA, 2019). "Industrial waste landfill" is a kind of catchall term that can include any landfill other than a municipal solid waste landfill, a RCRA hazardous waste landfill, or a hazardous waste landfill regulated and monitored through the Toxic Substances Control Act (EPA, 2019). C&D landfills receive construction and demolition debris, which typically consists of roadwork material, excavated material, demolition waste, construction/renovation waste, and site clearance waste (EPA, 2019). C&D landfills are not subject to the federal mandates that would require protective liners, control leachate, and collect runoff. As with industrial waste landfills, it is up to the state to define what constitutes C&D waste.

These non-hazardous waste—C&D, industrial, and municipal—landfills make up 93% of all landfills in the U.S. Although not regulated as hazardous waste, recent scholarship suggests that these landfills pose a threat to human health and environment (WHO, 2007; Porta et al., 2009; Mattiello, 2013). As such, these landfills warrant further consideration.

Rural Environmental Injustice

Racial/ethnic and socioeconomic inequities in the distribution of various environmental hazards and risks in the U.S. have led to vibrant policy debates and a substantial amount of research during the last few decades. Under this rubric of environmental justice, numerous studies have focused on identifying whether environmental hazards are distributed evenly across people and places, or if minority and lower class communities are disproportionately exposed to such pollution and hazards (e.g., Bullard, 1990; Mohai and Saha, 2006; Brulle and Pellow, 2006; Adeola 2012; Taylor 2014; Mohai and Saha 2015a; 2015b). More specifically, a strand of environmental justice research has investigated the disproportionate impact of environmental injustice on rural communities (see Ashwood and MacTavish, 2016), such as hydraulic fracturing (Malin and DeMaster, 2015), coal impoundments (Greenberg, 2017), coal production (Bell and York 2010), and hazardous waste facilities (Hunter and Sutton, 2004). In turn studies of ruralness have broadened the environmental justice framework (e.g., Van Wagner, 2016; Masterman-Smith, Rafferty, Dunphy, and Laird, 2016). Several studies indicate that racial/ethnic minorities and low-income individuals experience disproportionate residential exposure to technological hazards such as air pollution (Grineski, Bolin, and Boone, 2007), toxic releases from industrial facilities (Pastor, Sadd, and Morello-Frosch, 2004), and inactive hazardous waste sites (Cutter and Solecki, 1996). Although there is extensive literature on what constitutes "the rural" (see for instance Cloke, Marsden, and Mooney, 2006; Flora, 2018) as well as research into the terms "rurality" (Cloke, 2006) and "locality" (Appadurai, 1995), the term ruralness is employed here to capture the multiple levels of rural using the Rural Urban continuum code developed by the US Department of Agriculture (USDA) (see also Hunter and Sutton, 2004 for an extensive discussion on ruralness).

To better understand the understudied effects of C&D, industrial, and municipal landfills on communities across the U.S., particularly rural ones, this study investigates relationships of social and environmental injustice by performing logistic binary regression. In their efforts to understand general social determinants of environmental injustice, analysts should theoretically specify and empirically analyze how socioeconomic, racial/ethnic, *and* gender statuses contribute to unequal risks to environmental hazards. This research aims to do just this through the specified analytic techniques and unique data set of social and environmental indicators for all counties of the 48 contiguous United States. Lastly, this research answers calls by scholars to utilize a sub-national level of analysis to understand socio-environmental linkages across the U.S. (Pellow and Brehm, 2013).

Landfills and Environmental Injustice

There are two major theories within environmental justice research that are used to explain the co-location of hazardous waste landfills in predominantly rural, poor communities of color. These theories have attempted to distinguish between whether landfills are sited in areas into which minorities move or whether landfills are sited in areas with high concentration of minorities (Mohai et al., 2009; Banzhaf et al., 2019). For instance, Robert D. Bullard (1990) argues that hazardous waste landfill siting follows the path of least political resistance because low-income and minority communities, particularly those in rural areas, lack the societal power and resources to influence siting decisions. Moreover, African Americans living in rural areas, in particular, may be overrepresented in neighborhoods with a high risk of environmental hazard because they are more likely than whites to have low levels of income, education, and wealth. The current study seeks to ascertain whether similar socio-environmental dynamics occur with siting of C&D, industrial, and municipal landfills.

In addition to the path of least political resistance, scholars argue that environmental hazards are disproportionately located in minority neighborhoods because racial housing discrimination constrains the residential choices of racial minorities and confines them to neighborhoods with high levels of environmental hazard (Bullard, 1993; Mohai and Saha, 2006; Pais, Crowder, and Downey, 2014). A series of overt discriminatory factors are theorized to reinforce and perpetuate racial disparities in the distribution of hazards. Overt factors include locating public housing in high-pollution areas, institutionalized racial discrimination in the buying and selling of homes, and racial real estate steering (Logan and Molotch, 2007; Gotham, 2014). These factors lead to racial-environmental inequality, but not all factors are the direct byproduct of overt racial discrimination.

Similarly, Bullard, Mohai, Saha, and Wright (2007) (see also Bullard and Wright, 2012) found a disproportionate number of toxic waste sites in rural, poor, African American communities. Situated in a theoretical framework of environmental justice, environmental inequality, and a "race to the bottom" economic modality to maximize profits, land use, and cheap labor, the authors hypothesized that race and income predict the location of hazardous waste facilities. They also found that race was a robust predictor of commercial hazardous waste facility locations when socioeconomic and non-racial factors are considered. Recent scholarship has found support for both theses. For instance, Mohai and Saha (2015b) in their subnational-level research employing distance-based methods investigating hazardous waste transfer, storage, and disposal facilities (TSDFs) find support for both the racial discrimination and the path of least political resistance theories. Although there is support for both race and socioeconomic status and environmental pollution as evidenced in this review, there is no clear understanding on the mechanism driving this relationship yet. Lastly, empirical research has difficulty disentangling which are the drivers and which are the outcomes of this dynamic relationship among hazardous waste facilities and social inequality.

However, environmental justice research has not yet investigated which sociodemographic relationships are significantly associated with the presence of the 93% of landfills in the U.S not categorized as hazardous. The current study fills this gap in knowledge by examining key linkages among ruralness, sociodemographic characteristics, and presence of non-hazardous waste landfills in a county across the U.S.

Landfills, Environmental Inequality, and Gender

In recent years, gender has emerged as a key analytical focus in research on environmental inequality as scholars increasingly examine how environmental hazards can affect women differently than men (e.g., Rocheleau et al., 1996; Taylor, 2014). In addition, scholars have begun to analyze how gender intersects with other aspects of social life including age, immigration status/citizenship, and indigeneity to influence disproportionate exposure to hazards (e.g., Merchant, 1980; Mies and Shiva, 1993; Linder el al., 2008; Collins et al., 2011). Women are often physically and socially relegated to some of the most toxic residential and occupational spaces in communities and workplaces—an undertheorized example of environmental inequality (for an overview, see Pellow and Brehm, 2013).

In a study of ethnic disparities in cancer risks from air toxics in El Paso County, Texas, Collins and colleagues (2011) find that gender disadvantage (measured by percent female-headed households) revealed a significant risk disparity, one that related to the lower socioeconomic status of female-headed households. Similarly, Downey and Hawkins (2008) find in their tract-level study of different family structures across the U.S. (i.e., female-headed households, male-headed households, married couple-headed households without children), controlling for socioeconomic status and race, that female-headed households were overrepresented in tracts with high concentration of air toxics. This finding diverges from Linder et al.'s (2008) study, in which they found no risk disparity between the highest and lowest quartiles of percent female-headed households. Though Collins (2011) and Linder et al. (2008) examine relationships between gender and cancer risks from air toxics, there have been few studies that have examined the impact of gender on environmental hazards (i.e., landfill presence) prior to this research.

The relative poverty of women the world over also creates greater barriers in the face of environmental hazards, since women tend to experience poorer nutrition, limited health care, and, in the case of single, divorced, and widowed women, fewer sources of social support (see Rocheleau et al., 1996). Consistent with gender inequality theories, women and, in particular, rural, poor women of color may be overrepresented in communities with a high risk of landfill presence. This effect may be because they are more likely than white people to have low levels of income, education, and wealth (Taylor, 2014), leaving them less able to afford higher-quality housing in safer, less polluted communities.

In addition, environmental hazards may be disproportionately located in minority neighborhoods with a concentration of female-headed households since institutionalized racial housing discrimination impedes housing choices, restricts residential movement, and concentrates poor women and racial minorities to neighborhoods with high levels of environmental hazard (Downey, 2005; Gotham, 2014). Such research provides a socioeconomic explanation for gender discrimination and inequality. Building on this line of research, the current study includes the gender indicator of percent female-headed households in order to ascertain the unique relationship between gender and environmental inequality (i.e., landfill presence).

Ruralness, Landfills, and Disasters

Recent research has shown the indirect impacts of disasters on driving waste management in rural areas. For instance, McKinney and colleagues (2015), in their quantitative analysis of C&D, industrial, and municipal landfills in the Southeast, found that debris from disasters in more urban areas created a pipeline of waste to more rural areas. This pipeline of sorts creates additional indirect effects from disasters that are not quantified or categorized when discussing impacts and effects of disasters, particularly on coastal cities (i.e., New Orleans, LA; New York City, NY). As the frequency and magnitude of extreme weather events is expected to increase due to global climate change (IPCC, 2015), it is necessary to examine the effects of such natural hazards on important problems, such as managing societal waste. Understanding effects of natural hazards on landfills is an important site of study since clearing waste and debris is one of the major challenges to a community's successful recovery (Brown et al., 2011; Luther, 2010). There exists a feedback loop of climate change, natural hazards, and landfills. The accumulation of waste in landfills increases the production of greenhouse gases (e.g., methane, carbon dioxide), which contribute to climate change, which in turn generates more frequent and extreme natural hazards producing more and more landfill waste (McKinney, Kick, and Cannon, 2015; EPA, 2013).

A disaster is understood here as "a non-routine event that exceeds the capacity of the affected area to respond to it in such a way as to save lives; to preserve property; and to maintain the social, ecological, economic and political stability of the affected region" (Brown et al., 2011). Disaster debris is a large category with potential impacts on all types of landfills including. Research has shown that the faster disaster debris can be removed, the sooner recovery can occur (Luther, 2010; Brown et al., 2011). Debris removal then is paramount to a community's resiliency to disasters. To hasten the removal of debris, most regulations that govern what kind of waste can go where are suspended, leading to higher incidences of the comingling of various types of waste. Furthermore, this comingled waste is likely to end up in landfills not designed to house such toxic materials.

Although it is clearly important to disaster recovery efforts to understand the links between disasters and waste management, it is unclear how debris produced by disasters affects communities and which communities are most adversely affected. Moreover, disaster debris may pose a human and ecological threat due to the necessity of quick disposal and the likely suspension of regulations to accommodate a speedy recovery (McKinney, Kick, and Cannon, 2015). The current analysis seeks to test this thesis to ascertain if and to what extent there is a relationship between disaster occurrence and landfill presence.

Research Questions and Hypotheses

Given the theoretical orientation elucidated above, this research addresses five central questions regarding relationships among socio-environmental inequality and the distribution of landfills across the U.S., with a focus on impacts on rural counties: (1) Do rural areas have an increased likelihood to host a non-hazardous waste landfill compared to urban areas? (2) Do C&D, industrial, and municipal landfills (i.e., non-hazardous waste landfills) have similar relationships to sociodemographic characteristics as hazardous waste landfills? (3) Is there a significant relationship between gender and environmental inequality? (4) Is there a significant relationship between federally declared disasters and landfill presence? (5) Is there evidence that supports the path of least resistance or racial discrimination theory, or both, when investigating non-hazardous waste landfills?

The following hypotheses are drawn from the literature reviewed above.

H1: Counties hosting non-hazardous waste landfills tend to be more rural compared to non-hosting counties, holding all other variables constant).

H2: C&D, industrial, and municipal landfills (i.e., non-hazardous waste landfills) will have sociodemographic relationships similar to those that previous studies have found with hazardous waste landfills.

H2-A: Counties hosting non-hazardous waste landfills contain greater percentages of racial/ethnic minorities compared to non-hosting counties, holding all other variables constant.

H2-B: Counties hosting non-hazardous waste landfills contain greater percentages of lower socioeconomic status compared to non-hosting counties, holding all other variables constant.

H3: Counties hosting non-hazardous waste landfills contain greater percentages of single-female headed households compared to non-hosting counties, holding all other variables constant.

H4: Counties hosting non-hazardous waste landfills tend to have fewer federally declared disasters compared to non-hosting counties, holding all other variables constant.

H5: Counties hosting non-hazardous waste landfills will have greater segregation than non-hosting counties, holding all other variables constant.

Data and Methods

A combination of data from several sources is necessary to answer the above research questions. Data are reviewed below.

C&D, Industrial, and Municipal Landfill Data, 2012

Waste generated from households and through construction and demolition processes, particularly as driven by redevelopment of urban areas, must be disposed of somewhere. This is regulated and maintained at different levels of government (e.g., local, state, and federal), Location of landfills maintained by the state are recorded by each state's environmental regulatory agency (e.g. Environmental Management, Natural Resources, Environmental Quality, Environment and Natural Resources, Health and Environmental Control, Environment and Conservation, etc.). Since C&D, industrial, and municipal landfills are regulated and maintained by the states, there is a great degree of variance across landfill records with respect to fill size, accepted materials, and address. Given the variation across state records, data collection took an extensive amount of time (3 years) and necessitated going to each state's environmental agency to build a dataset of landfill by type and county. Collecting data from individual states, although more time-intensive, proved to be more accurate and thorough than using data from national databases (e.g., U.S. EPA's Toxic Release Inventory), which often lacked the most current and complete data available. Additionally, federal databases are not comparable due to inconsistent data collection procedures across federal agencies. As such, this dataset represents the first of its kind to the author's knowledge. All landfills that were listed as open in 2012 are used in the dataset for all 3,111 counties in the 48 contiguous states.

Determination of Ruralness 2013

Counties are classified into levels of ruralness based on a rural/urban continuum coding scheme developed by the United States Department of Agriculture (USDA). Nine classification codes designate counties by degree of urbanization and proximity to metro areas. Each county in the U.S. is assigned one of the nine codes. This coding scheme allows researchers to use county data to move beyond metro and nonmetro areas and into finer residential groups, particularly in analyzing trends of nonmetro areas. Higher values (i.e., 9) mean more rural counties (see Table 1).

Table 1. Rural Urban Continuum Codes for counties across the U.S. (USDA, 2013)

Code	Description	Example (County, State)
Metro counties:		
1	Counties in metro areas of 1 million population or more	Dallas, TX
2	Counties in metro areas of 250,000 to 1 million population	Fresno, CA
3	Counties in metro areas of fewer than 250,000 population	Tuscaloosa, AL
Nonmetro counties:		
4	Urban population of 20,000 or more, adjacent to a metro area	Athens, GA
5	Urban population of 20,000 or more, not adjacent to a metro area	Clinton, NY
6	Urban population of 2,500 to 19,999, adjacent to a metro area	Los Alamos, NM
7	Urban population of 2,500 to 19,999, not adjacent to a metro area	Jackson, OK
8	Completely rural or less than 2,500 urban population, adjacent to a metro area	Marquette, WI
9	Completely rural or less than 2,500 urban population, not adjacent to a metro area	Billings, ND

Within the multivariate models, I use indicators of ruralness to yield insight into C&D, municipal, and industrial landfill presence in U.S. counties. Rural/urban continuum codes from 2013 are used in the analysis. Since the RUCC codes are at the county level of analysis, this study uses the county as the level of analysis. [1]

Disaster Data, 2013

Disaster data are taken from the Federal Emergency Management Agency (FEMA) for each county and include tropical storms, hurricanes, floods, tornadoes, earthquakes, fires, freezes, landslides, droughts, volcanoes, blizzards, water shortages, and tsunamis for the time period 1961-2011 (see FEMA, 2013). To determine key relationships between total number of declared disaster occurrences and landfills, I employ total number of federally declared disasters from 1964-2011 (see McKinney et al., 2015) to test research hypotheses.

Dissimilarity Indices, 2000

To test hypotheses related to compositional network of host counties and to ascertain if host counties are segregated, dissimilarity indices are used in the analyses. The most prevalent indicator for measuring segregation is dissimilarity indices (Massey and Denton, 1993).

[1] While county-level analyses may have the potential for errors related to aggregation, such geography is necessitated here due to the requirement of socio-demographically detailed C&D, industrial, and municipal landfill data. Moreover, given that no research has examined the effects of these landfills at the subnational scale, such level of aggregation is an important contribution to our understanding of the associations between social inequality and non-hazardous waste landfills.

Dissimilarity indices measure the evenness with which two groups are distributed across census tracts. Although critiqued (see for an overview Brown and Chung, 2006), dissimilarity indices remain the most commonly used measure for segregation in the U.S. The minimum value of an index is 0 and the maximum value is 100. If a census tract were to be perfectly segregated, the dissimilarity index would equal 100; conversely, if two groups were randomly assigned to a census tract the dissimilarity index would equal 0. Dissimilarity indices are statistically independent of the size of the two racial groups used in the index. It is not independent of the geographic units used in the index. The dissimilarity indices are taken from ICPSR University of Michigan Population Studies and are calculated for the year 2000. These are the latest available indices for all counties for the U.S.[2] Given that racial segregation has shifted only somewhat in the 12 years since 2000 (Logan, 2013), this measure gives a reliable estimate of key relationships between segregation and landfill presence. Moreover, since landfills tend to have a 50-year life cycle (from when they are established to when they are capped), the lag of twelve years in the dependent variable provides a sense of this snapshot in time. To answer the above research questions, two dissimilarity indices are utilized in the analyses: that of group comparisons between Whites and Blacks and that of Whites and Hispanics, which represent the two largest racial/ethnic minorities across the country.

Analytical Approach

This analysis was conducted at the county level, nationwide. Given the novelty of these data and the use of rural urban continuum codes, the county level of analysis is an important first step to answering the research questions outlined above. The unit hazard coincidence method, wherein analysts investigate the relationship between sociodemographic characteristics of a unit (i.e., county) and the occurrence of a hazard in that unit (i.e., landfill), is used in this analysis. Although critiqued (e.g., Mohai and Saha, 2006), utilizing the unit hazard coincidence method is an important initial step in analyzing these novel data; future studies should incorporate distance-based methods to better understand relationships between proximate populations and non-hazardous waste landfills. Multivariate logistic regression models were estimated to predict presence of landfill type as a function of various county-level socioeconomic characteristics, with a focus on associations among race/ethnicity, class, gender, ruralness, disaster occurrence, racial segregation, and landfill presence by type (i.e., C&D, industrial, municipal, and hazardous). To answer the above research questions, I employ logistic binary regression to test for significant and robust associations between social and environmental inequality. This analytic technique is appropriate given that logistic binary regression does not require assumptions of multivariate normality, linearity and homogeneity of variance for independent variables and equal variance-covariance across groups. Thus, logistic regression is more adept at handling the high co-variance among independent variables than other sorts of techniques, such as OLS regression (Osborn, 2014).

In addition, total population and population density, or people per square mile (see Smith 2009), are used as predictors in order to statistically control for variations in population size while controlling for the physical size of the county. Other independent variables found in the

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[2] Note indices of similarity were calculated as follows: Dissimilarity index measuring segregation of whites from blacks= $[.5\sum(b_i/B - w_i/W)]*100$, where b_i = the black population of the i^{th} geographic unit (i.e., census tract); B = the total black population of the large geographic area for which the index is being calculated (i.e., county); w_i = the white population of the i^{th} geographic unit; and W = the total white population of the large geographic area for which the index is being calculated (Population Studies Center, University of Michigan).

environmental justice hazardous waste landfill literatures (Mohai and Saha, 2015a) include percent white, percent black, and percent Hispanic as measures of race and ethnicity. To test the path of least political resistance theory, socioeconomic variables commonly used in the field and included here are percent of population with a bachelor's degree, median household income, and percent of families living below the poverty line. Level of education is used to test the hypothesis that people of color have limited access to resources to prevent environmental hazards in their communities, thus increasing their risk of adverse effects due to nearby hazards (Mohai and Saha, 2006; Mohai and Saha, 2015b; Kosmicki and Long, 2016). To ascertain a unique effect of gender on landfill presence, following research by Downey and Hawkins (2008) and Collins et al. (2011), I use percent of female-headed households as a measure of gender. All sociodemographic data comes from the American Community Survey (ACS) 5-year estimate (2009-2013) in order to have data for all areas regardless of population size (US Census 2013). In addition to ruralness, a region variable is incorporated to ascertain differences across regions (Alldred and Shrader-Frechette, 2009). Counties were categorized as being in the South, Northeast, Midwest, or West based on Census divisions.

Discussion of Results

Summary statistics are reported in Table 2.

Table 2. Descriptive Statistics for independent and dependent variables.

	Mean	SD	Min	Max
Dependent variable				
Landfill host county	1.84	2.78	0	37
C&D host county	.79	1.48	0	18
Industrial host county	.37	1.13	0	21
Municipal host county	.62	1.23	0	18
Independent and control variables				
Population density (sq. mile)	258.39	1,724.93	.12	69,468.42
Total population	98,479.18	314,016.51	82	9,818,605
Region				
Northeast	0.7	.25	0	1
Midwest	.34	.47	0	1
South	.46	.5	0	1
West	.13	.34	0	1
Ruralness				
Rural Urban County Continuum	4.99	2.7	1	9
Race				
Percent White	83.27	16.32	2.92	99.22
Percent Black	8.96	14.54	0.00	85.68

Percent Hispanic	8.33	13.25	0	95.74
Socioeconomic				
Percent below poverty	11.97	5.53	0	40.19
Median Household Income	45,457.85	11,775.64	19,624	122,844
Bachelor's degree or higher	12.55	5.32	1.95	42.18
Gender				
Percent female headed households	11.33	4.28	1.68	38.01
Total disasters 1964-2011	9.18	4.64	0	27
Dissimilarity indices				
White/Black	35.88	35.11	0	100
White/Hispanic	25.29	53.84	0	100
N = 3,111				

Multivariate binary logistic results are presented in Table 3. In the following sections I discuss odds ratios of primary variables of interest in the logistic regression models. Logistic regression results are organized as follows. To test research hypotheses, I ran five models with a different landfill type (i.e., C&D, industrial, municipal, or hazardous) as the outcome variable with the same set of indicators. These five models investigate the unique relationships among region, ruralness, race, socioeconomic status, gender, dissimilarity indices for White/Black and White/Hispanic, and occurrences of disasters from 1964 to 2011 on a C&D landfill host county (Model 1); industrial landfill host county (Model 2); municipal landfill host county (Model 3); a county that hosts a non-hazardous waste landfill (Model 4); and a hazardous waste landfill host county (Model 5).

Table 3 presents odds ratios for a series of logistic regression models to test hypotheses 1-5. Taken together, these models show unique effects of socio-demographics, ruralness, and total number of disasters on the probability of living in a county with a landfill. Below, I interpret statistically significant estimates in the five models.

Control variables

For Model 1, the control variables, population density, and total population are significant in the expected direction (Smith, 2009). The likelihood of living in a county that hosts a C&D landfill decreases if one lives in the Northeast compared to living in the West. Model 2 indicates a decreased likelihood of living in an industrial host county for those living in the Northeast, Midwest, and Southern regions of the US compared to living in the West. In Model 3, the control variable, total population, is in the expected direction: the greater the total population in a county, the greater the likelihood of a municipal host county. There is a decreased likelihood of a county hosting a municipal landfill if it is located in the Northeast, Midwest, and South when compared to being located in the West. In Model 4, counties located in the Northeast, Midwest, and South have a decreased likelihood of hosting a non-hazardous waste landfill compared to the West. Region variables are not statistically significant for hazardous landfill hosting counties.

Table 3. Multivariate logistic regression analysis examining the effect of socio-demographic variables, disasters, degree of segregation, and categorical ruralness on the probability of living in a county that hosts a C&D, industrial, municipal, and hazardous landfill.[3]

	Model 1	Model 2	Model 3	Model 4	Model 5
Independent variables	C&D host	Industrial Host	Municipal Host	Landfill Host	Hazardous Host
Population density (sq. mile)	1.000***†	1.000	1.000***	.999***	1.000*
Total pop[a]	1.146***	1.07**	1.146***	1.146***	1.105***
Region[b]					
Northeast	.617*	.241***	.278***	.361***	.631
Midwest	1.061	.357***	.384***	.589**	.866
South	.854	.320***	.423***	.465***	.855
West	--	--	--	--	--
Race					
% White	.997	1.019*	1.006	.995	1.019
% Black	1.03***	1.002	.999	1.022**	1.001
% Hispanic	.995	.999	1.02***	1.01*	.999
Socioeconomic					
% below poverty	1.000	.945**	.932***	.957**	.936*
Median Household Income[c]	.991	.979*	.993	.991	.988
Bachelor's degree or higher	1.008***	1.04**	1.031*	1.065***	1.061**
Gender					
% female headed households	1.02	1.13***	1.084**	1.065*	1.209***

[3] **Note:** Odds ratios are reported for all logistic regression tables. Odds ratios are estimated to the nearest thousand. The results include pseudo-R^2 even though statisticians disagree over the usefulness of this measure of goodness of fit. Therefore, the low R^2 should not be taken as indicative of incomplete or inaccurate models (see Ramseyer and Rasmusen, 2010). One measure of goodness of fit that can be used is the proportioned by chance accuracy rate—that is does the model estimate the model correctly 25% better than chance. These models meet these criteria. Multicollinearity was assessed using variance inflation factor (VIF) values. Although there is no formal cut off value for VIF, the accepted standard is VIF<10. All explanatory variables have VIF measures below 10. Finally, I have also conducted a series of models within regions, the conclusions remain the same. Due to the scope and space limitations of this article, they are not included. The author will share the results with any reader who requests them.

Total disasters 1964-2011	.985	1.019	.968**	.99	.985
Dissimilarity indices					
White/Black	.998	1.005	1.008**	1.001	1.017***
White/Hispanic	1.000	.997	.999	1.000	1.002
Ruralness (RUCC-code)					
Metro>1 mill (1)	.882	3.098***	1.019	.904	9.985***
Metro 1 mill-250k (2)	1.503*	3.103***	1.814**	1.823**	10.271***
Metro < 250k (3)	1.6**	3.501***	2.128***	1.885**	10.175***
Nonmetro urban>20k metro adj (4)	1.425	3.972***	2.542***	2.62***	7.72***
Nonmetro urban>20k not metro adj (5)	1.564	5.146***	4.38***	4.939***	6.007**
Urban 2.5k-20k metro adj (6)	1.261	2.706***	1.59**	1.599**	4.078**
Urban 2.5k-20k not metro adjacent (7)	1.382*	2.621***	2.089***	1.73**	2.705
Rural metro adj (8)	.861	.954	.612*	.692*	2.159
Rural not metro adj (9) (Reference)					
Constant	.303	.029**	.362	1.361	.000***
Pseudo-R^2					
Cox&Snell R^2	.099	.07	.169	.155	.111
Nagelkerke R^2	.134	.107	.228	.212	.217
Model χ^2 (df)	320.84*** (23)	233.847*** (23)	568.105*** (23)	516.744*** (23)	361.045*** (23)
N = 3,111					

* p<0.05, **p<0.01, ***p<.001

† The number is so small that even at the thousandth place, it was rounded.

[a] Total population is reported in the hundreds of thousands.

[b] Effect of region with West as referent category.

[c] Median income is reported in the thousands.

Socio-demographics, ruralness, segregation, and disasters on landfill presence

For Model 1, significantly, percent population African American increases the likelihood of living in a C&D host county. This result is expected, given longstanding environmental justice research that evidences people of color, particularly African Americans, are disproportionately affected by environmental hazards (Bullard, 1990; Bullard and Wright, 2012; Mohai and Saha, 2015a; 2015b). Median household income is also significant in the expected direction: that is, the greater the median household income, the less likely to live in a C&D host county. Surprisingly, the percentage of the population with a bachelor's degree has a greater likelihood to live in a C&D host county. This result is contrary to what is expected given the theory that people living near an environmental hazard will have less access to political resistance. It is supported by some research into socio-demographics and environmental inequalities (Kosmicki and Long, 2016). Similar to McKinney et al.'s (2015) findings and with a similar magnitude of effects, the fewer number of disasters declared in a county (cumulative 1964-2011), the greater likelihood of a county hosting a C&D landfill, providing some evidence for the transfer of waste from disaster-hit areas to landfills elsewhere. Region variables, Midwest and South, along with ruralness, percent white and percent Hispanic, percent of families living below the poverty line, and percent female-headed households are not significant determinants of being located in a C&D host county.

In Model 1, of the eight levels of ruralness, three are statistically significant. For metro counties with a population of 1 million or less there is an increased likelihood of hosting a C&D landfill compared to the most rural counties. For urban counties with a population of 2,500 to 19,999 (not adjacent to a metro area) there is an increased likelihood to host a C&D landfill compared to the most rural counties. These results indicate the intricate relationship between ruralness and hosting C&D landfills. Given that C&D landfills are often used for development and redevelopment, particularly of residential spaces and smaller-scale businesses, it makes sense that C&D landfills have a greater likelihood of being in mid-size US cities (such as Birmingham, AL). Interestingly, small urban areas that are not near a metro area also have an increased likelihood of hosting C&D landfills.

In Model 2, the same set of predictors for Model 1 were used to predict an industrial host county. Model 2 shows that more rural counties have a decreased likelihood of hosting an industrial landfill. This result is somewhat surprising, given the industrial processes that occur in rural areas of the U.S., particularly industrialized agriculture (Stuart, 2008). Yet research shows that other sorts of industrial processes, particularly urban development, tend to occur in peri-urban spaces (Simon, 2008). Model 2 shows that the greater the percentage of white people in a county, the greater the likelihood of a county hosting an industrial landfill. The greater the percentage of families living below the poverty line in a county, the lower the likelihood of a county to host an industrial landfill. The higher the median household income, the lower the likelihood of a county to a host an industrial landfill. Although race and socioeconomic indicators are not in the expected direction, these findings do support Kosmicki and Long's (2016) similar results in studying coal and nuclear host tracts in the U.S. Little research has investigated location of industrial landfills and sociodemographic characteristics (e.g., Wakefield and Elliott, 2003), though some research suggests that industrial landfills may be a particularly pernicious environmental hazard due to their less rigorous regulation and the substances that are disposed there (Lee and Lee, 1994).

Similar to Model 1, the greater the percentage of the population with a bachelor's degree in a county, the greater the likelihood of a county hosting an industrial landfill. The greater percentage of families with female-headed households, the greater the likelihood of a county hosting an industrial landfill. This finding provides support for the relationship between gender and environmental injustice with similar magnitude of effects (Downey and Hawkins, 2008; Taylor, 2014). Contrary to results for C&D landfills in Model 1, the greater number of total disasters from 1964-2011 declared in a county, the greater the likelihood that a county hosts an industrial landfill. Population density, total population, percent African American, percent Hispanic, and dissimilarity indices White/Black and White/Hispanic are not statistically significant.

In Model 2, of the eight levels of ruralness, seven are statistically significant. There is little variation in the outcome across different levels of ruralness. There seems to be a robust relationship between presence of an industrial landfill and nonmetro counties, regardless if those counties are adjacent to a metro area or not. Similarly, there is an increased likelihood for metro counties with a large population (greater than 250,000 people) to host an industrial landfill compared to the most rural counties. Nonmetro counties with small urban populations (i.e., 2,500 to 19,999) both adjacent to metro areas and not adjacent to metro areas, also have an increased likelihood of hosting an industrial landfill compared to the most rural counties. This finding shows that industrial landfills seem to be located across metro and nonmetro counties of differing population sizes regardless of ruralness. More research is necessary to further understand how industrial landfills are regulated to better account for their presence.

Model 3 shows, similar to findings from Model 2, the more rural a county, the lower the likelihood of a county hosting a municipal landfill. The greater the percentage of the population that identifies as Hispanic, the greater the likelihood that a county hosts a municipal landfill. Mohai and Saha (2015b) similarly found a significant relationship between percent Hispanics and commercial hazardous waste treatment, storage, and disposal facilities (TSDFs). Similar to Model 2, the greater the percentage of families below the poverty line, the lower the likelihood of a county hosting a municipal landfill. Median household income is in the expected direction: as median household income increases, the likelihood of a municipal host county decreases. Similar to both Models 1 and 2, the greater the percent of population with a bachelor's degree, the greater the likelihood of a county hosting a municipal landfill. As expected, given literature reviewed above on gender and environmental injustice, the greater the percent of female-headed households in a county the greater the likelihood of a county hosting a municipal landfill. Similar to Model 1 and contrary to Model 2, counties with a greater number of total declared disasters have a decreased likelihood of hosting a municipal landfill. Although there is some research that shows that leachate from municipal landfills may impact groundwater (Longe and Enekwechi, 2007), there is not much research on where these landfills tend to be located and who may be most affected by them. The dissimilarity index of whites and African Americans indicates that the greater the segregation in a county the greater the likelihood of a county hosting a municipal landfill. It may be the case that municipal landfills tend to be located in highly segregated peri-urban spaces. Additionally, more segregated counties may have less ability to organize political resistance to landfills. Such lack of political resistance may be important for permit extensions for landfills already in operation. Percent white, percent African American, and dissimilarity index for White/Hispanic are not statistically significant.

In Model 3, of the eight levels of ruralness, seven are statistically significant. There is an increased likelihood of metro counties with populations of 1 million or less hosting a municipal landfill compared to the most rural counties. Similarly, for non-metro counties with populations of 2,500 and greater, regardless of adjacency to a metro area, there is an increased likelihood of hosting a municipal landfill compared to the most rural areas. This finding points towards the use of municipal landfills for most populations at the county-level, at least, as an important containment strategy for waste. Additional research is necessary to ascertain if and to what extent municipal landfills are the predominant form of waste management for municipalities in the U.S.

Taken together, Models 1-3 do not offer support for hypothesis 1 that non-hazardous waste landfills have an increased likelihood to be rurally located. There is support for hypothesis 2-A that similar to hazardous waste landfills, non-hazardous waste landfill-hosting counties will have a greater percentage of racial/ethnic minorities compared to non-host counties. There is mixed evidence for hypothesis 2-B in that while median household income was consistently statically significant in the expected direction, percentage of the population living below the poverty line was not in the expected direction. This finding may suggest that counties hosting non-hazardous waste landfills may be more likely to have working class or middle-class residents. There is strong support for hypothesis 3 that gender is a significant and robust indicator of landfill presence. More research is necessary to further understand the mechanisms that relate gender to landfill presence. There is mixed support for hypothesis 4; the greater number of disasters declared in a county, the lower the likelihood of that county to host both C&D and municipal landfills. Similar to McKinney et al.'s (2015) findings, there seems to be an internal transportation of waste from declared disaster areas. Interestingly, the more federally declared disasters in a county, the greater the likelihood for industrial landfill host counties. There seems to be a difference of the effect of declared disasters depending on landfill type. There is limited support for hypothesis 5 that shows that municipal landfill hosting counties have an increased likelihood of being more segregated between whites and African Americans compared to non-hosting counties.

Given that subnational environmental justice research has focused primarily on hazardous waste landfills and accompanying storage and treatment facilities (for review, Mohai and Saha, 2015a), I ran two logistic regression models to determine if there are differences in social demographics predicting a host county of a non-hazardous waste landfill and those hosting a hazardous waste landfill (hypothesis 2). The first model (Model 4) has as the dependent variable a dichotomous measure of non-hazardous waste landfill (i.e., presence of one of the non-hazardous waste landfill types). The second model (Model 5) has as the dependent variable a dichotomous measure of hazardous waste landfill.

In Model 4, as ruralness increases, the likelihood of hosting both a non-hazardous waste landfill and a hazardous landfill decrease. As expected, counties with a greater population of African Americans have an increased likelihood of hosting a non-hazardous waste landfill. Similarly, counties with a greater population of Hispanics have an increased likelihood of hosting a non-hazardous waste landfill. Surprisingly, neither of the race /ethnicity variables are statistically significant for hazardous landfill hosting counties. Although ample research suggests there are racial disparities with the presence of hazardous waste facilities (Mohai and Saha, 2015a; 2015b), the non-significance of these indicators may be due to the limitations of this scale of analysis (i.e., subnational). The greater the percentage of families below the poverty line the decreased likelihood of a county hosting either a non-hazardous waste landfill or hazardous landfill. As expected, the greater the median household income, the lower the likelihood a county hosts either a non-hazardous waste landfill or hazardous landfill. The greater the percentage of bachelor's degree the greater the likelihood a county hosts either or non-hazardous waste or hazardous waste landfill. Total disasters from 1964-2011 were not significant in either Model 4 or 5.

Results from Model 5 indicate hazardous waste landfills have a greater likelihood of being in urban and metro areas than non-hazardous waste landfills (referent: most rural areas). For instance, for metro counties with a population of 250,000 to one million, there is a 10.2 times increased likelihood of hosting a hazardous waste landfill compared to the most rural counties. Whereas, there is a 1.8 times increased likelihood of hosting a non-hazardous waste landfill for the same level of ruralness. Non-metro counties with urban populations of 20,000 or greater also have a greater likelihood of hosting a hazardous waste landfill than non-hazardous waste landfill. Even for non-metro counties with an urban population of 2,500 to 19,999 (adjacent to a metro area) there is a greater likelihood of hosting a hazardous waste landfill than a non-hazardous waste landfill when compared to the most rural counties. Interestingly, hazardous waste landfills then are not an environmental hazard that just affects populations in urban, metro or nonmetro rural areas, but across almost all levels of ruralness. Levels of ruralness for populations of 19,999 and fewer were not statistically significant indicators of hazardous waste landfill presence.

Although hazardous waste landfills make up 7% of all landfills in the U.S., these landfills seem to be spread across ruralness—stretching from urban areas to more rural ones. Additionally, the findings presented here necessitate the continued study of different types of landfills beyond hazardous waste landfills. Given that non-hazardous waste landfills make up 93% of all landfills in the U.S., future research may use a count outcome or continuous ratio variable to further investigate key relationships between sociodemographic characteristics and landfills. Lastly, future research should endeavor to further understand the spatial distributions and key relationship between sociodemographic characteristics and landfill type as they vary across space.

Generally, when models 1-5 are taken together, they offer support for Hypothesis 2: that non-hazardous waste landfills tend to have similar relationships to sociodemographic characteristics as hazardous waste landfills. The dissimilarity index for whites and African Americans indicates the greater the segregation between these two groups the greater the likelihood of a county hosting a hazardous waste landfill. This result supports Smith's (2009) finding in his analysis of Superfund sites that racial discrimination is a factor in environmental inequality. The total number of declared disasters and the dissimilarity index for White/Hispanic were not statistically significant in either models. Future research should consider using interactive effects in order to better account for estimates within one model to compare non-hazardous and hazardous waste landfills.

Limitations

There are several limitations to this study that suggest important avenues for future research. First, this study is a cross-sectional analysis of secondary data. Secondly, the county-level unit of analysis is not as fine-grained as tract level analyses. More specifically, the scope at the sub-national level and the scale at the county might affect the estimated relationship (see Baden, Noonan, & Turaga, 2007). Similar to many geographic units of analysis, there are limitations of this method to account for differences across the unit of analysis (i.e., counties) (see for analysis, Ringquist, 2005). For example, there may be more within-county variation for certain variables (i.e., race/ethnic minority percentages) than other variables (i.e., ruralness). Future research should extend the identified relationships here among socio-demographics, ruralness, and landfills to this more fine-grained level of analysis. Doing so may also further illuminate relationships between segregation and environmental inequality. Third, there are limitations to logistic regression as a statistical technique, specifically the assumption that the relationship between the dependent and independent variables is uniform (Ranganathan, Pramesh, and Aggarwal, 2017). Environmental justice research has shown the effectiveness of using distance-based methods (i.e., geographically weighted regression, hotspot analysis) to ascertain key relationships among race, class, and hazardous waste sites. Future research should employ these methods in investigating non-hazardous waste landfills to further our understanding of environmental inequalities at multiple scales of analysis (e.g., block group, states, regions, etc.).

Conclusion

I endeavored to understand if and to what degree previously analyzed relationships among socio-demographics, ruralness, disasters, segregation, and hazardous waste landfill presence were the same when investigating non-hazardous waste landfills. To this end, my empirical results of secondary data reveal similar and differing relationships between these social dynamics of concern to hazardous and non-hazardous waste landfills.

These findings provide some of the first evidence that sociodemographic relationships, such as along race, class, and gender axes, to hazardous waste landfills are similar to those of non-hazardous waste landfills. I found that there is a difference in relationships between social indicators and landfill presence depending on the type of a landfill (i.e., C&D, industrial, municipal, hazardous). However, there are important differences between hazardous waste landfills and non-hazardous waste landfills with respect to ruralness. Hazardous waste landfills are more likely to occur in urban areas, whereas C&D, industrial, and municipal landfills are more likely to occur in different areas along the ruralness spectrum. For instance, industrial landfills are most likely located in peri-urban, possibly suburban areas, whereas municipal landfills may also be located in peri-urban areas that are segregated between whites and African Americans. This research adds to recent scholarship investigating rural environmental injustice (see Ashwood and MacTavish, 2016; Kelly-Reif and Wing, 2016) through its analyses of landfills a form of socio-environmental inequality.

This research has shown that gender is a significant and robust predictor of landfill presence across landfill types. More socio-environmental research should include gender variables in order to better understand the unique role of gender in environmental injustice. Particularly given intersecting axes of oppression, gender, as well as its intersections with race and class, must be further explored in future research. Both qualitative and quantitative approaches can add valuable insight to the role gender plays in environmental inequality. Additionally, there are implications for gender inequality theories on the role the environment may play in exacerbating gender disparities. More research is necessary to understand specific mechanisms, such as distribution of health and social impacts, among gender, the environment, and social inequality. Moreover, research into rural environmental injustice should investigate the intersections of race, class, gender, and ruralness. There is evidence that supports both racial discrimination and socioeconomic inequality theories, which argue that poor people and people of color disproportionately experience environmental inequality on account of their race and economic status. The current study contributes to this robust literature through an analysis that extends research on hazardous waste landfills to non-hazardous waste landfills. Importantly, although not assessing siting decisions of landfills, this research demonstrates those in society who are disproportionately affected by landfill presence. Landfill presence, more than an unwanted land use, poses multiple threats to human health (Porta et al., 2009) and ecological systems (Elliott and Frickel, 2013). Adding to research into disasters, social locations, and landfills, the current research finds support for McKinney et al. (2015), who argue that there is internal migration of waste from the places where disaster strikes elsewhere. More research, particularly tract-level analyses, is necessary to ascertain what communities are affected by this movement of disaster waste.

There is an intricate and complex relationship between ruralness and hosting landfills. For instance, since industrial landfills are most likely to be in non-metro areas, it may be useful to think of waste miles, or the number of miles waste travels to its disposal site. Since transportation is a leading contributor to greenhouse gas emissions, it is important to understand how much of these emissions are contributed by waste miles. Future research should measure waste miles and investigate relationships between waste miles or waste transportation more generally with climate change. Lastly, given the findings presented here, such future research should ascertain if and to what extent rural populations are adversely affected by waste transportation.

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