urban science

MDPI

Article

Reuse Choice, Flood Risk and Resilience, and Characteristics of Counties with Brownfield Cleanups

Ann M. M. Carroll * and Norma F. Kanarek

Department of Environmental Health and Engineering, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD 21205, USA; NKanarek@jhu.edu
* Correspondence: Acarrol9@jhu.edu or annmmcarroll@gmail.com

Received: 1 August 2018; Accepted: 28 August 2018; Published: 4 September 2018

check for updates

Abstract: Limited research has examined brownfields clean-up, reuse choice and associations with flood risk or resilience. This cross-sectional analysis examines counties with U.S. Environmental Protection Agency (EPA) funded brownfield cleanups initiated from 2005 through 2009 and assesses the county-level relationship of green reuse with flood risk while accounting for county factors of resources, environmental stressors, race and ethnicity, location, and structural characteristics, as modified from the Gee and Payne-Sturges conceptual model of community environmental health. Flood plain designation predicted a three-fold odds of green reuse alone (OR = 2.96 [95% CI, 1.31–6.66]) and green with other reuses (OR = 2.88 [95% CI, 1.07–7.75]). Green reuse alone was influenced negatively when a county had an eastern or western US location or a larger proportion of population aged 5–24 and positively when population education levels were higher. Among counties with green and other reuse, low education was predictive. Conceptually, decisions for green reuse alone were driven by resources and location while decisions for green and other reuse were driven by resources, location and environmental stressors.

Keywords: brownfields; flood plain; green reuse; community remediation; United States; counties

---

1. Introduction

Brownfields, abandoned or underused industrial, commercial or real properties known or suspected to be contaminated, have been a focus of case studies and articles in environmental policy, planning and economic development literature focused on financial, market and liability risks since the mid-1990s and more recently considered in planning and sustainability studies in domestic and international literature [1–4].

Limited research has examined reuse choice following brownfield clean-up and ways reuse choices contribute to community cumulative environmental risk. Cleanup and reuse of brownfields is achieved through local, state, or federal agencies partnering with a cadre of business and community partners assembling an array of resources for revitalization [5,6]. To succeed, it is important to educate the public and local leaders about how green or sustainable reuse of brownfields can reduce exposure to hazardous substances, improve degraded lands, minimize urban sprawl, and lessen flood risk—thereby improving the general quality of life in the local area [7,8].

We describe here a conceptual model for evaluating factors associated with cumulative stress that builds on the U.S. Environmental Protection Agency (EPA) and community investments in brownfield assessment, cleanup and revitalization. This research finds significant regional differences in choices of green reuse of cleaned brownfields associated with location and neighborhood resources of community age distribution and educational characteristics. Increasing the estimated 4 to 5% of brownfields that have been converted to greenspace for low-impact development or green infrastructure will assist with storm-water management, contribute to distributed storm water management systems and expand restoration of the degraded land and habitat needed to introduce other health and ecosystem benefits [8–15].

1.1. Environmental Protection Agency Brownfields Program

In the mid-1990s, the United States (US) EPA launched pilot brownfield projects to assist communities, states and other stakeholders in the identification, cleanup and redevelopment of brownfield sites. At that time, estimates of the number of brownfields across the United States ranged from below 150,000 to more than 450,000 sites [16,17]. Many identified brownfields were former industrial and commercial sites with known or suspected soil or structural contamination. Investing in their cleanup for reuse was found to create jobs and improve property values which contributes to increases in local tax bases while site assessment and cleanup improves and protects the environment according to the EPA and local research [18–20]. A brownfield can be reused or recycled in several different ways following cleanup, including residential, commercial, or mixed-use redevelopment projects, or as parks, community gardens or 'transitional uses' in shrinking cities or weak market areas [21–23]. When brownfields are converted to unpaved natural areas, they can be designed to absorb, filter, and manage storm water, thereby helping to prevent floods, whereas other types of reuse may magnify flood risk as an example.

The 2002 Small Business Liability Relief and Brownfields Revitalization Act (Public Law 107–118, the "Brownfields Law") bolstered the EPA's ability to promote sustainable brownfields cleanup and reuse. This law defines a brownfield as "real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant" [24]. This law expanded the definition of brownfields to include low-risk petroleum-contaminated sites, mine-scarred lands, and sites contaminated with controlled substances (such as former methamphetamine labs), while excluding: more severely contaminated Superfund sites or those proposed for the National Priorities List; sites undergoing emergency removal of hazardous substances; any federal properties; and contaminated sites undergoing law enforcement. Under the new definition, additional brownfields became eligible for federal funding, including sites posing community hazards in urban and rural areas [24–27].

1.2. Land Reuse

The revitalization of brownfields through cleanup and reuse has been and will continue to be advanced and accelerated by research that seeks: (1) to better understand developer and other stakeholder perspectives and the barriers to investment; (2) understand impacts on local government and communities; and, (3) to identify effective and appropriate incentives for brownfield redevelopment [26,28–35]. Drawing on decades of remediation experience at the state, tribal, and federal level, brownfield cleanup takes a risk-based approach—meaning that the cleanup goals are based on anticipated exposure risks to human health and the environment—informed by the plan for subsequent reuse [34–39]. As with other developments, successful reuse has been associated with brownfield site size and location, incentives for developers, community support and integration of reuse with neighborhood plans, whereas conflicting land uses and unimproved infrastructure impede redevelopment efforts [31,35,39]. Research on the effect of cleanup on property values nationally showed a 5.0–11.5% average increase in property values within 5.0 kilometers of a brownfield cleanup while local studies found housing price increases of 2.7% in Minneapolis and 11.4% in Milwaukee [40,41]. Case studies also cite job creation and tax base improvement among the outcomes of industrial and commercial brownfield reuse [18]. Whereas brownfields can be a source of neighborhood stress, with proper land-use planning, the cleanup and revitalization of vacant sites and abandoned buildings can reduce known and perceived environmental hazards, diminish community fears, and create neighborhood spaces for social interaction that increase resilience [42–45].

Local and national brownfield reuse research has long focused on economic development and policy actions to reduce barriers to investment and examine project economic impact. One locality, Milwaukee County, showed higher commercial (31%), industrial (19%), and residential reuse (20%), as compared to the national United States Conference of Mayors (USCM) survey responses from 99 cities, which reported 25% commercial, 18% industrial, and 14% residential reuse [8,17,22]. Despite the USCM's lead in confronting climate change locally, there has been a dearth of attention to adaptation needs and natural hazard vulnerabilities to inform cleanup priorities, bolster resilience and add greenspaces to meet community needs [46–53]. As a community-driven process, creating the vision for a healthier environment with brownfields reused as spaces for skills development, training or settings to foster community, employment, and civic participation, can also strengthen attention to flood-risk vulnerability [23,53–56].

1.3. Flood Risk and Resilience

Urbanization and development in flood plains leads to the paving and compaction of soils, which, in turn, impairs the ecosystem functions necessary for flood prevention [9,11,23,57]. Most U.S. counties are affected by floods, the costs of which have quadrupled in recent decades. Over time, law and policy have moved from the creation of dam and levee structures to integrate structural and non-structural measures, including land-use planning to prevent floods and reduce loss of life and property damage. Flood plain development continues, despite the increased risk of exposure to natural hazards, although the training of land-use planners in development alternatives such as low-impact development (LID) and its' adoption can reduce these hazards. Flood risk is buffered by natural spaces, including those created through green reuse of brownfields and where green conversion of brownfields near flood plains can create and connect green infrastructure, it can enlarge flood water storage for management and reduction of flooding, while restoring blighted areas [58–60]. As an environmentally preferable and more equitable alternative to sprawled development in flood plains and "greenfield" (or previously undeveloped) areas, the redevelopment of brownfields can be a sustainable development strategy for resilience [34,60–63].

1.4. Conceptual Model of Community Environmental Health Disparities

Community environmental stressors, neighborhood resources that buffer stress, structural factors such as population density, residential location such as region and flood plain proximity, hazard exposure, race, and ethnic composition are all factors theorized to contribute to cumulative impacts on cumulative community stress shown in Figure 1 (adapted from Gee, Payne–Sturges) [64]. Collectively these factors further understanding of the "geographies of exposure and vulnerability" and area "riskscapes where both environmental exposures and social stressors are present" [65]. This conceptual model illustrates links between race and ethnicity, residential location, and neighborhood and structural resources that may increase or reduce exposures to environmental hazards and pollutants, and it provides a context for many of the forces that influence community-level vulnerability to hazards [44,45,66,67].

The Gee and Payne-Sturges' model of cumulative community environmental risk was used in this study to identify the critical factors that may influence green reuse choice. Location reflects the risks of proximity to environmental and natural hazards, and to regional variation (illegal dumping, mine waste, fill and burn sites near ports and rivers) and thus conceptually includes flood plains, our independent variable.

Operating at different spatial scales, location is often synonymous with race and Hispanic ethnicity that have been associated with disproportionate hazard exposures and spatial inequities in amenities and opportunities (waste transfer stations, parks and recreational areas) and may exhibit its effect in an interaction with other location variables [67,68].

Community environmental stressors are additive, cumulative environmental stressors of known and suspected abandoned brownfields, hazardous-waste Superfund sites, transportation, storage and disposal facilities, leaking underground storage tanks, and toxic release reporting facilities [67–70].

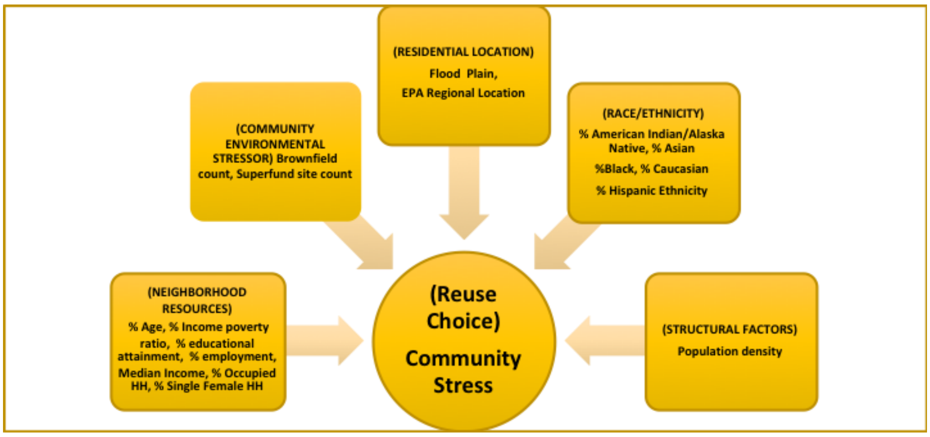

Figure 1. Community-Level Vulnerability: An Exposure–Stress Model (modified from Gee, Payne-Sturges, 2004).

Neighborhood resources, as adopted in the model, represent the demographic, educational, employment, population characteristics, and economic strengths and social ties that mediate risk. Research has documented differential exposures to economic, educational, and occupational opportunities and amenities in many communities. Social ties and social trust can be built in parks and public areas, strengthening neighborhood resources that contribute to an ability to respond to, meet and assist neighbors and provide social support, which helps buffer other stressors associated with preparing for and recovering from natural hazards [53,54,59,64] (for example, libraries).

Structural factors include population density, built environment investments or policies that sustain disproportionate exposures to hazards in low-income and minority communities or that reinforce flood-hazard vulnerability from inadequate flood management [11–14]. Brownfield cleanup and revitalization at a neighborhood scale can contribute to resilient revitalization (land-use planning, population density and development, infrastructure investment, etc.). Brownfields and contaminated sites not only contribute to community stress regarding known and suspected hazard exposures, but they also stifle area investment, available services, and employment prospects, thereby adding to the adverse impacts.

Inventories can be quite extensive, as seen by Litt and colleagues who examined 182 of 480 vacant and underused industrial sites in Southeast Baltimore for environmental hazards and pollutants. Historic industries in this area included smelting, oil refining, paint, plastic, chemical, and metal manufacture, warehousing, and transportation, and were associated with heavy metals, solvents, polycyclic aromatic hydrocarbons, and hazardous substances that can cause cancer, reproductive or developmental effects, and other target-organ effects [71]. In another example, McCarthy's examination of state environmental site registries for Milwaukee brownfield analysis included underground storage and waste tanks and dry-cleaning sites [46].

To accelerate and prioritize brownfield reuse, researchers and the EPA developed tools to inventory, map, and characterize sites for sustainability and economic impact [4,23,60,61,63]. It remains unclear how often practitioners use general vulnerability assessment or hazard planning tools in specific site or area-wide brownfield assessment and cleanup practices [34,44,51,52].

1.5. Proposed Study

Examination of former brownfield reuse will advance brownfield practice [72–76]. To date, limited national analysis has examined brownfield reuse choices as incremental actions for improving equity and resilience [77–84]; this study examines counties and additional factors contributing to actual reuse choices. This is appropriate, given the county role in planning, public health, environmental protection, economic development, and preparedness, as well as the county's frequent role as a brownfield grant recipient or partner to local recipients. This research focuses on reuse choice associations with county flood-plain location and characteristics, in addition to racial and ethnic minority population, population density, population age, educational attainment, employment, median income, income poverty ratios, and brownfield or Superfund site counts.

This retrospective cross-sectional county-level analysis examines EPA-funded brownfield cleanups initiated in one five-year period and completed in an additional five-year period. This research analyzes green reuse associated with flood risk while accounting for other county characteristics.

2. Results

2.1. Counties Included/Excluded

Table 1 tabulates characteristics of counties included in the study and those excluded.

Table 1. County race/ethnicity, residential location, neighborhood resources, community environmental stress, and structural factors by study inclusion status.

	Counties Included (min, max or %) (N = 181)	Counties Excluded (min, max or %) (N = 88)	Test of Significance
Race/Ethnicity			
Race (%) Median			
American Indian/Native Alaskan	0.26 (0.007, 17.12)	0.32 (0.032, 61.57)	$F_{(268)} = 5.57$, $p = 0.019$
Asian	1.55 (0.01, 27.73)	1.25 (0.039, 31.24)	$F_{(268)} = 0.12$, $p = 1.680$
Black	4.6 (0.018, 63.09)	3.87 (0.018, 56.03)	$F_{(268)} = 4.26$, $p = 0.0401$
White	81.25 (4.6, 98.66)	82.99 (12.75, 98.29)	$F_{(268)} = 0.05$, $p = 0.8239$
Hispanic Ethnicity (%) Median	3.78 (0.49, 94.45)	4.82 (0.61, 94.45)	$F_{(268)} = 0.09$, $p = 0.7651$
Residential Location			
Aggregate EPA Regions [1] [Number (%)]			
Atlantic/Gulf Coast **Mid-West** **Mountain/Pacific Coast**	77 (42.5) 58 (32.0) 46 (25.4)	42 (47.7) 17 (19.3) 29 (33.0)	Chi Square$_{(2)} = 5.008$, $p < 0.082$
Flood Plain Designation			
Yes **No**	74 (40.9) 107 (59.1)	22 (25.0) 66 (75.0)	Chi Square$_{(1)} = 6.509$, $p < 0.011$
Neighborhood Resources			
Age (%) Median			
<5	6.3 (0.700, 12.99)	6.44 (4.69, 10.70)	$F_{(268)} = 1.92$, $p = 0.1672$
$5 \leq 25$	26.8 (12.99, 40.30)	27.2 (16.70, 39.00)	$F_{(268)} = 0.27$, $p = 0.6055$
$25 \leq 45$	26.3 (3.30, 40.50)	25.4 (16.70, 39.20)	$F_{(268)} = 0.05$, $p = 0.8317$
$45 \leq 65$	26.5 (17.29, 42.29)	26.3 (16.99, 34.60)	$F_{(268)} = 0.84$, $p = 0.3593$
$65 \leq 85$	12.79 (4.89, 23.19)	13.09 (6.49, 27.69)	$F_{(268)} = 0.86$, $p = 0.3557$
≥ 85	2 (0.40, 7.80)	1.9 (0.40, 5.30)	$F_{(268)} = 0.75$, $p = 0.3872$

Table 1. *Cont.*

	Counties Included (min, max or %) (N = 181)	Counties Excluded (min, max or %) (N = 88)	Test of Significance
Household Income Poverty (%) Ratio Median [2]			
<100%	12.67 (3.71, 29.84)	13.2 (4.46, 38.32)	$F_{(268)} = 1.37$, $p = 0.2434$
100 ≤ 125%	3.93 (1.46, 10.22)	4.39 (1.77, 10.33)	$F_{(268)} = 6.83$, $p = 0.0095$
125 ≤ 200%	13.03 (6.33, 23.63)	14.56 (6.24, 23.56)	$F_{(268)} = 7.10$, $p = 0.0082$
≥200%	67.79 (40.97, 87.68)	66.97 (31.91, 85.78)	$F_{(268)} = 6.39$, $p = 0.0121$
Median Household Income ($) Median	47,766 (28,410, 81,113)	45,601 (29,482, 92,213)	$F_{(268)} = 5.08$, $p = 0.0250$
Occupied Housing Units (%) Median	87.39 (12.70, 96.09)	84.59 (33.09, 96.60)	$F_{(268)} = 0.08$, $p = 0.7834$
Female Head of Household (%) Median	10.01 (1.79, 30.82)	9.99 (3.96, 22.93)	$F_{(268)} = 0.44$, $p = 0.5078$
Educational Attainment (%) Median [3]			
<9th Grade	4.1 (0.00, 23.69)	4.24 (1.59, 16.60)	$F_{(268)} = 0.50$, $p = 0.4801$
Some High School	39.89 (16.99, 57.20)	41.39 (19.00, 62.79)	$F_{(268)} = 1.91$, $p = 0.1684$
Some College	54.89 (35.80, 79.49)	52.74 (31.59, 76.30)	$F_{(268)} = 2.42$, $p = 0.1213$
Employment (%) Median [4]	61.49 (40.79, 89.70)	59.14 (44.30, 73.09)	$F_{(268)} = 3.11$, $p = 0.0709$
Community Environmental Stress			
Brownfields Sites (Number)			
1	79 (43.6)	66 (75.0)	Chi-Square$_{(3)} = 24.23$, $p < 0.000$
2	37 (20.4)	10 (11.4)	
3	24 (13.3)	3 (3.4)	
≥4	41 (22.7)	9 (10.2)	
Superfund Sites Number			
0	82 (45.3)	48 (54.5)	Chi-Square$_{(2)} = 2.90$, $p < 0.234$
1	43 (23.8)	21 (23.9)	
≥2	56 (30.9)	19 (21.6)	
Structural Factors			
Population Density Median [5]	286.09 (0.83, 71,151)	141.89 (0.87, 32,818)	$F_{(268)} = 4.70$, $p = 0.0310$
Population Total Size Median	188,411 (686, 9,785,282)	110,274 (1481, 3,855,534)	$F_{(268)} = 1.90$, $p = 0.1692$

[1] Aggregate EPA Regions—Atlantic/Gulf Coast = EPA Regions 1, 2, 3, 4, 6; Mid-West = EPA Regions 5, 7; and Mountain/Pacific Coast = EPA Regions 8, 9, 10. [2] Poverty-guideline levels for a family of four in the 48 contiguous states and Washington, D.C. were $19,350 (2005), $20,000 (2006), $20,650 (2007), $21,200 (2008), and $22,050 (2009); poverty guidelines for a family of four in Alaska were $24,190 (2005), $25,000 (2006), $25,820 (2007), $26,500 (2008), $27,570 (2009); and poverty-guideline levels for a family of four in Hawaii were $22,260 (2005), $23,000 (2006), $23,750 (2007), $24,380 (2008), and $25,360 (2009). Sources: Federal Register, Vol. 70, No. 33, 18 February 2005, pp. 8373–8375, Federal Register, Vol. 71, No. 15, 24 January 2006, pp. 3848–3849, Federal Register, Vol. 72, No. 15, 24 January 2007, pp. 3147–3148, Federal Register, Vol. 73, No. 15, 23 January 2008, pp. 3971–3972 and Federal Register, Vol. 74, No. 14, 23 January 2009, pp. 4199–4142. [3] Educational attainment for those over 25 years of age. [4] Employment rate for those over 16 years of age. [5] Population density per square mile calculated using 2005–2009 American Community Survey (ACS) total population and 2005–2009 county land areas.

Examination of race and ethnicity showed included counties had significantly higher median population percentages of Blacks ($p = 0.0401$) and lower median population percentages of American Indians/ Native Alaskans ($p = 0.019$). There were no differences by Hispanic ethnicity.

Borderline significant and significant regional location differences were found: excluded counties were less often located in the Mid-West ($p = 0.082$) and less often located in flood-plain designated areas ($p < 0.011$).

Among neighborhood resource measures, only income poverty median was statistically significant though employment proportions were borderline ($p = 0.0709$) higher among included counties. Age did not differ significantly between included and excluded counties. Excluded counties had significantly higher household income in the poverty ratio categories of 100–124% ($p = 0.0095$) and 125–199% ($p = 0.0082$), while included counties had significantly higher income poverty ratios over 200% ($p = 0.0121$). Average median household income was significantly ($p = 0.0250$) higher among counties included in this analysis.

No differences were seen in the percentage of occupied housing units, the percentage of female head of household, and educational attainment. Employment was of borderline significance ($p = 0.0709$) and higher among the counties included.

Community environmental stress measures differed significantly with higher numbers of brownfields among excluded counties ($p < 0.000$) but did not differ in number of Superfund sites ($p < 0.234$).

On structural factors, included counties had significantly higher median population density ($p < 0.0008$), yet did not differ statistically from excluded counties in total population ($p = 0.1692$).

2.2. Structural and Community Factors

Brownfield counties were categorized dichotomously above and below median population density and they differed significantly by race and ethnicity. Low density areas had significantly higher median population percentages of American Indians/Native Alaskans ($p = 0.0002$) and whites ($p = 0.0066$), while high density areas had significantly higher percentages of Asians ($p < 0.0001$), blacks ($p < 0.0001$), and those of Hispanic ethnicity ($p = 0.0002$) (Table 2).

Regional measures differed significantly between high- and low-density counties; there were greater proportions of high density counties in the Atlantic/Gulf Coast ($p = 0.005$). Flood-plain was more common among high density flood-plain counties though the comparison did not reach statistical significance.

Neighborhood resource measures compared by population density differed by age distribution, poverty levels, median income, education and employment. No differences were observed in percentage of occupied housing units or households with a single female head of household.

High population density counties had significantly higher percentages of children under five ($p = 0.0070$) and those 25–44 ($p = 0.0005$), and smaller proportions of those 45–64 ($p = 0.0001$) years of age.

High population density counties had a significantly higher percentage of population at 200% or more income poverty ratio ($p < 0.0001$), whereas low-density counties had significantly higher population percentages of income poverty ratios between 100–124% ($p < 0.0001$) and 125–200% ($p < 0.0001$). No differences in population density were seen in population percentages for those <100% poverty. Median household income differed positively and significantly by population density ($p < 0.0001$).

Percentage educational attainment of some college was significantly more common in high-density counties ($p < 0.0001$), while the proportion of some high school was significantly higher in low-density counties ($p < 0.0001$). Employment percentage differed with significantly higher median employment in high population density counties compared to low-density counties ($p = 0.0014$).

Structural factor, population size, was significantly higher ($p < 0.0001$) in high density counties.

As to differences in community environmental stressors, high population density counties had significantly higher numbers of counties with four or more brownfields, while low-density counties were more likely to have only one brownfield ($p < 0.0001$). Similarly, significant excesses in Superfund sites were observed in high-density counties ($p < 0.0001$).

Table 2. County race/ethnicity, residential location, neighborhood resources, community stress, and structural factors by population density.

	Population Density		
	High (Min, Max or %) (N = 99)	**Low (Min, Max or %) (N = 82)**	**Test of Significance**
Race/Ethnicity			
Race (%) Median			
American Indian/Native Alaskan	0.22 (0.05, 4.21)	0.39 (0.007, 17.12)	$F_{(180)} = 14.87$, $p = 0.0002$
Asian	2.45 (0.32, 24.44)	0.71 (0.01, 27.73)	$F_{(180)} = 76.25$, $p = 0.0000$
Black	8.35 (0.66, 63.09)	1.31 (0.01, 39.62)	$F_{(180)} = 66.40$, $p = 0.0000$
White	73.47 (18.05, 94.41)	89.66 (4.60, 98.66)	$F_{(180)} = 7.54$, $p = 0.0066$
Hispanic Ethnicity (%) Median	5.5 (0.89, 61.35)	2.55 (0.049, 94.45)	$F_{(180)} = 14.75$, $p = 0.0002$
Residential Location			
Aggregate EPA Regions [1] (Number (%))			
Atlantic/Gulf Coast **Mid-West** **Mountain/Pacific Coast**	51 (51.5) 31 (31.3) 17 (17.2)	25 (30.5) 28 (34.1) 29 (35.4)	$Chi^2_{(2)} = 10.6752$ Pr = 0.005
Flood Plain Designation **Yes** **No**	 59 (59.6) 40 (40.4)	 39 (47.6) 43 (52.4)	 $Chi^2_{(1)} = 2.6165$ Pr = 0.106
Neighborhood Resources			
Age % Median			
<5	6.49 (4.10, 9.09)	6.15 (0.70, 12.99)	$F_{(180)} = 7.44$, $p = 0.0070$
$5 \leq 25$	26.89 (19.29, 40.30)	26.24 (12.99, 39.89)	$F_{(180)} = 1.48$, $p = 0.2252$
$25 \leq 45$	27.39 (3.30, 38.20)	24.59 (12.79, 40.50)	$F_{(180)} = 12.48$, $p = 0.0005$
$45 \leq 65$	25.7 (20.80, 30.20)	27.64 (17.29, 42.29)	$F_{(180)} = 15.20$, $p = 0.0001$
$65 \leq 85$	12.39 (5.40, 23.19)	13.6 (4.89, 22.19)	$F_{(180)} = 2.51$, $p = 0.1148$
$\geq$85	2 (0.40, 15.15)	2.2 (0.60, 15.15)	$F_{(179)} = 3.60$, $p = 0.0593$
Household Income Poverty (%) Ratio Median [2]			
<100%	12.25 (4.07, 24.41)	13.98 (0.58, 30.63)	$F_{(180)} = 0.48$, $p = 0.4889$
$100 \leq 125$%	3.71 (1.46, 6.58)	4.27 (1.49, 10.22)	$F_{(180)} = 18.27$, $p = 0.0000$
$125 \leq 200$%	11.89 (6.33, 16.51)	14.85 (7.49, 23.63)	$F_{(180)} = 47.96$, $p = 0.0000$
$\geq$200%	71.19 (52.90, 87.68)	65.6 (40.97, 85.09)	$F_{(180)} = 19.92$, $p = 0.0000$
Median Household Income ($) Median	53,538 (33,062, 81,113)	43.305 (28,410, 72,988)	$F_{(180)} = 38.97$, $p = 0.0000$
Occupied Housing Units (%) Median	88.7 (12.70, 96.09)	84.39 (47.39, 95.30)	$F_{(180)} = 0.95$, $p = 0.3321$
Female Head of Household (%) Median	10.01 (1.79, 30.82)	9.87 (2.55, 21.29)	$F_{(180)} = 0.06$, $p = 0.8029$

Table 2. *Cont.*

	Population Density		
	High (Min, Max or %) (N = 99)	**Low (Min, Max or %) (N = 82)**	**Test of Significance**
Educational Attainment (%) Median [3]			
<9th grade	3.99 (1.59, 13.99)	4.4 (1.70, 23.69)	$F_{(180)} = 1.16$, $p = 0.2827$
Some High School	36.8 (16.99, 51.50)	43.49 (21.50, 57.20)	$F_{(180)} = 29.43$, $p = 0.0000$
Some College	57.89 (42.19, 79.49)	50.74 (35.80, 76.80)	$F_{(180)} = 37.06$, $p = 0.0000$
Employment (%) Median [4]	61.79 (50.90, 70.59)	59.74 (40.79.0, 81.19)	$F_{(180)} = 10.51$, $p = 0.0014$
Structural Factors			
Population Density Median [5]	837.24 (285.83, 71,151.02)	64.18 (0.84, 282.04)	$F_{(180)} = 261.38$, $p = 0.0000$
Population Total Size Median	491,757 (73,031, 9,785,282)	57,114 (686, 990,217)	$F_{(180)} = 193.35$, $p = 0.0000$
Community Environmental Stressors			
Brownfields Sites (Number)			
1	39 (39.4)	62 (75.6)	Chi $Square_{(3)} = 32.02$, $p < 0.000$
2	25 (25.3)	9 (11)	
3	9 (9.0)	9 (11)	
≥4	26 (26.3)	2 (2.4)	
Superfund Sites (Number)			
0	25 (25.3)	57 (69.5)	Chi $Square_{(11)} = 46.45$, $p < 0.000$
1	24 (24.2)	19 (23.2)	
≥2	50 (50.5)	6 (7.3)	

[1] Aggregate EPA Regions Atlantic/Gulf Coast = EPA Regions 1, 2, 3, 4, 6; Mid-West = EPA Regions 5, 7; and Mountain/Pacific Coast = EPA Regions 8, 9, 10. [2] Poverty-guideline levels for a family of four in the 48 contiguous states and Washington, D.C. were $19,350 (2005), $20,000 (2006), $20,650 (2007), $21,200 (2008), and $22,050 (2009); poverty guidelines for a family of four in Alaska were $24,190 (2005), 25,000 (2006), $25,820 (2007), $26,500 (2008), $27,570 (2009); and poverty-guideline levels for a family of four in Hawaii were $22,260 (2005), $23,000 (2006), $23,750 (2007), $24,380 (2008), and $25,360 (2009). Sources: Federal Register, Vol. 70, No. 33, 18 February 2005, pp. 8373–8375, Federal Register, Vol. 71, No. 15, 24 January 2006, pp. 3848–3849, Federal Register, Vol. 72, No. 15, 24 January 2007, pp. 3147–3148, Federal Register, Vol. 73, No. 15, 23 January 2008, pp. 3971–3972 and Federal Register, Vol. 74, No. 14, 23 January 2009, pp. 4199–4142. [3] Educational attainment for those over 25 years of age. [4] Employment rate for those over 16 years of age. [5] Population density per square mile calculated using 2005–2009 ACS total population and 2005–2009 county land areas.

2.3. County Factors by Flood-Plain

Examination of brownfield counties by flood-plain designation shown in Table 3 found significantly higher population percentages of Asians in flood-plain brownfield counties, but no other differences by race or by Hispanic ethnicity.

There were no region-based flood-plain differences.

Among neighborhood resource measures, flood-plain counties had significantly higher percentages of those 25–44 years of age ($p = 0.0145$), compared to all other age groups.

Apart from significantly higher population percentages with income poverty ratios of 125–199% ($p = 0.0027$) in brownfield counties with no flood designation, there were no differences in population percentages with income poverty ratios below 100%, at 100–124%, or above 200% (borderline significance, $p < 0.10$). Median household income was significantly higher in flood-plain counties ($p < 0.0133$).

Structural factors of population density ($p < 0.0001$) and population size ($p < 0.0001$) were significantly higher in flood-plain counties.

Flood-plain counties did not differ in other neighborhood resource measures: percent occupied housing units, female head of household, or educational attainment. Employment among those age 16 years and older was of borderline statistical significance (p = 0.0561).

Among community environmental stressors, flood-plain counties had higher numbers of brownfields (p < 0.0070) and Superfund (p < 0.0074) sites per county.

Table 3. County race/ethnicity, residential location, neighborhood resources, community stress, and structural factors by flood-plain designation.

	Flood-Plain		
	Designation N = 98	**No Designation N = 83**	**Test of Significance**
Race/Ethnicity			
Race (%) Median			
American Indian/Native Alaskan	0.24 (0.03,13.10)	0.27 (0.007, 17.12)	$F_{(180)}$ = 2.77, p = 0.0981
Asian	1.9 (0.08, 24.44)	1.13 (0.01, 27.73)	$F_{(180)}$ = 9.03, p = 0.0030
Black	5.15 (0.01, 63.09)	3.34 (0.03, 40.59)	$F_{(180)}$ = 1.77, p = 0.1846
White	81.1 (4.60, 97.00)	85.29 (28.89, 98.66)	$F_{(180)}$ = 1.94, p = 0.1653
Hispanic Ethnicity (%) Median	4.21 (0.83, 94.45)	3.4 (0.49, 48.00)	$F_{(180)}$ = 0.83, p = 0.3636
Residential Location			
Aggregate EPA Regions [1] [Number (%)]			
Atlantic/Gulf Coast	43	33	$F_{(180)}$ = 0.4405, p = 0.802
Mid-West	30	29	
Mountain/Pacific Coast	*25*	*21*	
Neighborhood Resources			
Age (%) Median			
<5	6.3 (1.30, 12.99)	6.3 (0.70, 9.70)	$F_{(180)}$ = 0.76, p = 0.3830
5 ≤ 25	26.64 (17.30, 37.89)	26.89 (12.99, 40.30)	$F_{(180)}$ = 0.14, p = 0.7040
25 ≤ 45	26.64 (19.80, 40.20)	25.49 (3.30, 40.50)	$F_{(180)}$ = 6.10, p = 0.0145
45 ≤ 65	26.39 17.29, 42.29	26.5 (20.80, 41.09)	$F_{(180)}$ = 1.08, p = 0.3002
65 ≤ 85	12.64 (5.40, 22.19)	13.09 (4.89, 23.19)	$F_{(180)}$ = 0.01, p = 0.9082
≥85	2.09 (0.40, 15.15)	2.09 (0.60, 15.15)	$F_{(180)}$ = 1.05, p = 0.3070
Household Income Poverty (%) Ratio Median [2]			
<100%	12.25 (4.59, 30.63)	13.84 (0.58, 23.13)	$F_{(180)}$ = 0.22, p = 0.6386
100 ≤ 125%	3.84 (1.46, 8.04)	4.13 (1.79, 10.22)	$F_{(180)}$ = 2.71, p = 0.1014
125 ≤ 200%	12.39 (7.06, 20.90)	13.94 (6.33, 23.63)	$F_{(180)}$ = 9.23, p = 0.0027
≥200%	70.6 (40.97, 86.24)	67.2 (48.59, 87.68)	$F_{(180)}$ = 3.00, p = 0.0848
Median Household Income ($) Median	49,272 (28,410, 81,113)	45,848 (30,166, 78,422)	$F_{(180)}$ = 6.25, p = 0.0133
Occupied Housing Units (%) Median	88.15% (32.90, 96.09)	86.99% (12.70, 96.09)	$F_{(180)}$ = 1.01, p = 0.3158

Table 3. *Cont.*

	Flood-Plain		
	Designation N = 98	**No Designation N = 83**	**Test of Significance**
Female Head of Household (%) Median	*10.23 (1.79, 21.84)*	9.23 (1.88, 30.82)	$F_{(180)} = 1.27$, $p = 0.2606$
Educational Attainment (%) Median [3]			
<9th grade	3.9 (1.80, 23.69)	4.69 (1.59, 15.49)	$F_{(178)} = 0.62$, $p = 0.4305$
High school	38.89 (16.99, 57.20)	41.79 (21.50, 56.90)	$F_{(180)} = 1.28$, $p = 0.2597$
College	56.84 (38.30, 79.49)	53.79 (35.80, 76.80)	$F_{(180)} = 1.52$, $p = 0.2187$
Employment (%) Median [4]	61.84 (43.69, 81.19)	60.8 (40.79, 72.50)	$F_{(180)} = 3.70$, $p = 0.0561$
Structural Factors			
Population Density Median [5]	384.99 (0.90, 69,468.59)	231.7 (0.91, 12,415.59)	$F_{(180)} = 6.64$, $p = 0.0108$
Population Total Size Median	264,530 (686, 2,976,831)	98,142 (1077, 9,785,282)	$F_{(180)} = 10.69$, $p = 0.0013$
Community Environmental Stressors			
Brownfields Sites (Number)			
1	44 (44.9)	57 (68.7)	Chi Square$_{(3)}$ = 12.1278, $p < 0.007$
2	20 (20.4)	14 (16.9)	
3	13 (13.3)	5 (6.0)	
≥4	21 (21.4)	7 (8.4)	
Superfund Sites (Number)			
0	35 (35.7)	47 (56.6)	Chi Square$_{(2)}$ = 9.8046, $p < 0.007$
1	24 (24.5)	19 (22.9)	
≥2	39 (39.8)	17 (20.5)	

[1] Aggregate Regions-Atlantic/Gulf Coast = EPA Regions 1, 2, 3, 4, 6; Mid-West = EPA Regions 5, 7; and Mountain/Pacific Coast = EPA Regions 8, 9, 10. [2] Poverty-guideline levels for a family of four in the 48 contiguous states and Washington, D.C. were $19,350 (2005), $20,000 (2006), $20,650 (2007), $21,200 (2008), and $22,050 (2009); poverty guidelines for a family of four in Alaska were $24,190 (2005), 25,000 (2006), $25,820 (2007), $26,500 (2008), $27,570 (2009); and poverty-guideline levels for a family of four in Hawaii were $22,260 (2005), $23,000 (2006), $23,750 (2007), $24,380 (2008), and $25,360 (2009). Sources: Federal Register, Vol. 70, No. 33, 18 February 2005, pp. 8373–8375, Federal Register, Vol. 71, No. 15, 24 January 2006, pp. 3848–3849, Federal Register, Vol. 72, No. 15, 24 January 2007, pp. 3147–3148, Federal Register, Vol. 73, No. 15, 23 January 2008, pp. 3971–3972 and Federal Register, Vol. 74, No. 14, 23 January 2009, pp. 4199–4142. [3] Educational attainment for those over 25 years of age. [4] Employment rate for those over 16 years of age. [5] Population density per square mile calculated using 2005–2009 ACS total population and 2005–2009 county land areas.

2.4. Unadjusted Relationship of Flood-Plain and Reuse

Table 4 presents brownfield county reuse choices by flood designation. Whether assessing differences in green reuse, green reuse in combination with other reuse, and non-green reuse, or any green reuse compared to non-green reuse, there is a statistically significant and positive influence of flood-plain (respectively, $p = 0.031$ and $p = 0.008$) on green reuse choice.

2.5. Adjusted Relative Risk Ratios

Prior to assessing all other variables and their contribution, interactions of race and Hispanic ethnicity were evaluated in the full model and none were found to be significant despite race differences and a conceptual hypothesis of location and race working in combination rather than independently.

This research finds significant regional differences in green reuse of cleaned brownfields associated with regional location and neighborhood resources associated with community age distribution and educational characteristics. By multinomial logistic regression modeling, the relationship between flood-plain and green reuse only choice found a significantly higher relative risk compared to the choice that included non-green reuse shown below (Table 5). The fully adjusted model relative risk for flood-plain designation was 3.11 [95% CI: 1.14–8.50]). The fully adjusted and final, parsimonious model (2.88 [95% CI: 1.07–7.75]) of this comparison each yielded a relative risk of about three. The final model included the confounders of EPA region, Hispanic ethnicity, household income, race and age distribution, percent occupied housing units, percent female head of household, and more than one brownfield site in the county, and the covariate, education (some college) (Table 5).

Table 4. County flood-plain designation by brownfield reuse.

	Green Reuse [a]	Green and Other Reuse [b]	Other Reuse [c]	Test of Significance
	(N = 64)	**(N = 38)**	**(N = 79)**	
Flood-Plain Designation				
Yes	40	24	34	Chi Square$_{(2)}$ = 6.9680 *
No	24	14	45	
Flood-Plain Designation RRR (CI)	2.20 (1.12, 4.32)	2.26 (1.02, 5.02)	(Reference)	
	Any Green Reuse		**Other Reuse**	**Test of Significance**
	(N = 102)		**(N = 79)**	
Flood-Plain Designation				
Yes	64		34	Chi Square$_{(1)}$ = 6.9638 **
No	38		45	
Flood-Plain Designation RRR (CI)	2.22 (1.22, 4.05)		(Reference)	

* $p < 0.05$, ** $p < 0.005$, *** $p < 0.000$. [a] Green reuse as defined in this analysis includes greenspace alone as a category of reuse reported by brownfield grantees. This category can include: agriculture, fields, forests, nature trails, parks, playing fields, playgrounds, ponds, recreational areas, storm-water-management areas, green roofs, urban forest canopies, wetlands, or wildlife refuges. Revised 28 June 2017. [b] Green reuse and other reuse as defined in this analysis includes the creation or expansion of greenspace as defined in conjunction with other residential, commercial, or industrial redevelopment and reuse. [c] Other reuse as defined in this analysis includes residential, commercial, or industrial redevelopment and reuse that does not include any greenspace creation or expansion.

Table 5. Multivariable-interaction model of county brownfield green reuse.

	Full Model		**Final Model**	
	Green Reuse Only	**Green and Other Reuse**	**Green Reuse Only**	**Green and Other Reuse**
	RRR (CI)	**RRR (CI)**	**RRR (CI)**	**RRR (CI)**
Residential Location				
Flood-Plain Designation				
Flood	**3.11 (1.14, 8.50)**	2.76 (0.82, 9.32)	**2.96 (1.31, 6.66)**	**2.88 (1.07, 7.75)**
No Flood	(Reference)	(Reference)	(Reference)	(Reference)
Aggregate EPA Regions [1] (Number)				
Atlantic/Gulf Coast	0 (0.00, 2.94 $\times$ 10^{10})	2.27 $\times$ 10^{17} (0.00, 8.00 $\times$ 10^{46}) (Reference)	**0.29 (0.11, 0.73)**	1.52 (0.47, 4.88)
Mid-West	(Reference)	0	(Reference)	(Reference)
Mountain/Pacific Coast	0.07 (0.00, 3.70 $\times$ 10^{17})	(0.00, 1.75 $\times$ 10^{33})	**0.25 (0.07, 0.89)**	2.18 (0.47, 10.16)
Race and Ethnicity				
Race (%) Median				
American Indian/Native Alaskan	0.61 (0.30, 1.25)	0.67 (0.14, 3.24)	0.88 (0.61, 1.28)	0.91 (0.58, 1.44)
Asian	0.62 (0.27,1.46)	0.92 (0.24, 3.64)	0.66 (0.37, 1.19)	0.68 (0.35, 1.34)
Black	0.74 (0.25, 2.24)	1.77 (0.32, 9.89)	0.89 (0.64, 1.23)	0.94 (0.64, 1.39)
White	0.17 (0.00, 433.25)	12,743.55 (0.01, 2.09 $\times$ 10^{10})	(Reference)	(Reference)
Hispanic Ethnicity (%) Median	0.44 (0.13, 1.49)	7.82 (0.81, 75.08)	0.9 (0.53, 1.51)	1.29 (0.66, 2.53)

Table 5. *Cont.*

	Full Model		Final Model	
	Green Reuse Only	**Green and Other Reuse**	**Green Reuse Only**	**Green and Other Reuse**
	RRR (CI)	**RRR (CI)**	**RRR (CI)**	**RRR (CI)**
Residential Location and Race or Ethnicity				
American Indian/Native Alaskan X				
Atlantic/Gulf Coast [1] **Mid-West** **Mountain/Pacific Coast**	1.78 (0.67, 4.73) (Reference) 0.61 (0.17, 2.19)	2.11 (0.38, 11.70) (Reference) 1.02 (0.14, 7.54)		
Asian X				
Atlantic/Gulf Coast [1] **Mid-West** **Mountain/Pacific Coast**	0.93 (0.30, 2.89) (Reference) 0.81 (0.18, 3.65)	0.99 (0.16, 6.01) (Reference) 0.48 (0.06, 3.85)		
Black X				
Atlantic/Gulf Coast [1] **Mid-West** **Mountain/Pacific Coast**	1.14 (0.38, 3.39) (Reference) 1.48 (0.37, 5.87)	0.46 (0.07, 3.15) (Reference) 0.87 (0.12, 6.38)		
White X				
Atlantic/Gulf Coast [1] **Mid-West** **Mountain/Pacific Coast**	9.06 (0.00, 20,698.39) (Reference) 1.32 (0.00, 14,730.52)	0.00 (0.00, 1017.80) (Reference) 13,093.05 (0.00, 8.91×10^{14})		
Hispanic Latino X				
Atlantic/Gulf Coast [1] **Mid-West** **Mountain/Pacific Coast**	2.43 (0.56, 10.53) (Reference) 0.80 (0.11, 5.95)	0.10 (0.01, 1.38) (Reference) 1.35 (0.04, 42.64)		
Neighborhood Resources				
Age % Median				
<5	0.58 (0.01, 25.14)	0.52 (0.00, 349.95)	1.85 (0.24, 14.30)	0.65 (0.07, 5.99)
5 ≤ 25	0.03 (0.00, 50.08)	295.55 (0.00, 1.74×10^{8})	**0.02** **(0.00, 0.97)**	1.74 (0.03, 100.45)
25 ≤ 45	221.75 (0.41, 118,812.70) 0.04	304.02 (0.01, 6.39×10^{6})	(Reference)	(Reference)
45 ≤ 65	(0.00, 885.25) 1.36	77.06 (0.00, 3.17×10^{10})		
65 ≤ 85	(0.11,16.47) 0.95	31.68 (0.86, 1167.32)		
≥85	(0.27, 3.35)	0.15 (0.02, 1.26)		
Household Income Median ($)	201.33 (0.00, 1.22×10^{7})	0 (0.00, 54,043.95)	0.96 (0.07, 13.27)	0.25 (0.01, 6.86)
Educational Attainment (%) Median				
<9th grade	0.16	0.05	1.2	**0.1**
Some High school	(0.02, 1.36) 0	(0.00, 0.99) 0.05	(0.33, 4.42) (Reference)	**(0.02, 0.58)** (Reference)
Some College	(0.00, 30.14) 0.01 (0.00, 24,177.46)	(0.00, 90,715.50) 0 (0.00, 1.02×10^{6})	**200.33** **(2.88, 13,912.01)**	0.36 (0.00, 63.88)
Occupied Housing Units (%) Median	1.69 (0.12, 23.30)	21.47 (0.80, 579.84)	1.46 (0.24, 8.85)	2.07 (0.26, 16.66)
Single Female Head of Household (%) Median	1.28 (0.36, 4.57)	0.40 (0.10, 1.64)	1 (0.35, 2.89)	0.44 (0.14, 1.35)

Table 5. *Cont.*

	Full Model		Final Model	
	Green Reuse Only	Green and Other Reuse	Green Reuse Only	Green and Other Reuse
	RRR (CI)	RRR (CI)	RRR (CI)	RRR (CI)
Household Poverty (%) Median				
<100%	2.74 (0.10, 74.79)	0.99 (0.00, 266.47)		
$100 \leq 125\%$	6.15 (0.24, 160.97)	1.82 (0.01, 227.12)		
$125 \leq 200\%$	1.29 (0.01, 232.18)	0.16		
		(0.00, 701.03)		
$\geq$200%	0.83 (0.00, 1.01×10^9)	3.29 (0.00, 5.67×10^{13})		
Employment (%) Median [2]	0.01 (0.00, 101.43)	32.97 (0.00, 3.31×10^6)		
Structural Factors				
Population Density Median	0.55 (0.27, 1.10)	1.82 (0.69, 4.82)		
Population Density				
Low				
High	(Reference) 1.92 (0.35, 10.53)	(Reference) 0.32 (0.04, 2.48)		
Population Total Size Median	1.04 (0.46, 2.32)	1.14 (0.35, 3.67)		
Community Environmental Stressors				
County Brownfield Sites				
One **More than One**	(Reference) 1.33 (0.49, 3.63)	(Reference) 5.10 (1.38, 18.83)	(Reference) 1.31 (0.57, 3.01)	(Reference) 4.19 (1.54, 11.39)
County Superfund Sites				
None			(Reference)	(Reference)
One or More	(Reference) 0.95 (0.33, 2.72)	(Reference) 0.35 (0.10, 1.26)	0.83 (0.35, 1.96)	0.48 (0.17, 1.30)

[1] Aggregate EPA Regions—Atlantic/Gulf Coast combines EPA Regions 1–4 and 6; Mid-West (Reference) combines EPA Regions 5 and 7; Mountain/Pacific Coast combines EPA Regions 8, 9, and 10. [2] Employment rate for those over 16 years of age.

Comparing green reuse plus other reuse to no green use choice yielded a similar relative risk of about three to that for the green reuse only compared to no green reuse; the full model for this comparison found a statistically significant estimate of 2.96 [95% CI: 1.31–6.66]. The relative risk for the parsimonious model, however, did not reach statistical significance (2.76 [95% CI: 0.82–9.32]) (Table 5).

Green reuse alone did not differ by region, though green reuse in combination with other reuse choices was significantly less likely in the aggregated region of the Atlantic/Gulf Coast and Mountain/Pacific Coast as compared to the Mid-West. No differences in green reuse or green reuse in combination with other reuse was seen by race and ethnicity, our initial hypothesis.

On the other hand, green reuse alone was significantly less likely based on percent population age $5 \leq 25$ as compared to green reuse combination and non-green reuse which were not significant. No differences were seen in age ranges 25 and older. Thus, the final model uses all older age groups combined as the comparison.

Educational attainment—specifically, population percentage with college educational attainment—was significantly associated with increased odds of solely green reuse as compared to other reuse choices in the final model. By contrast, significantly reduced odds of green reuse with other reuse was associated with educational attainment below ninth grade. As educational attainment may vary by race and ethnicity, educational attainment may be serving as a proxy for race and ethnicity in this analysis and confounding any relationship.

Counties with more than one brownfield cleanup had significantly higher odds of green reuse in combination with other reuse as compared to counties with only one brownfield. The relative risks for the green reuse only were in the same direction but were not statistically significant.

No significant association between reuse choice and counts of Superfund sites was seen.

Reuse choice did not differ by median household income, percent occupied housing units, or percent single female head of household. No differences in reuse choice by race and ethnicity of brownfield county populations were observed. Nevertheless, these variables were retained in the final model because they were confounding (Table 5)

3. Discussion

3.1. Green Reuse

Despite recognition of the risks of development in flood plains and information documenting increasing damages, development in flood risk areas continues [11,44]. The significant relationship between flood risk and green reuse only or green reuse in combination with other reuses provides evidence of progress in incorporating green reuse into brownfield development. This is of increasing importance as urbanization trends increase population density in potential risk areas and risk ranges expand [77–83]. Changes in extreme regional precipitation increases risks beyond those identified in past flood plain measures and places greater pressure on local governments and communities to consider community needs as part of revitalization activities [12,14,50,53,84–88]. Increased emphasis on green infrastructure as a surplus land-management program in the Mid-West and emerging interest in urban agriculture may explain increased green reuse as compared to the Atlantic and Gulf Coast and Mountain Pacific Coast [10,23,89–91]. Regional variation observed may also reflect differences in urbanization and population density and different development pressures for residential, commercial or other economic development and land use.

Green reuse alone was significantly negatively associated with younger ages, namely the 5–24-year age bracket, while it was positively associated in combination with other reuse. This suggests demographic-driven differences where developers do not pursue solely green reuse for younger populations. The lower likelihood of green reuse counters growing research documenting the health benefits of green space creation and the need for parks, greenspaces, and nature for respite, recreation, health, and other benefits for youth, young families, and others [10,89–98]. The association of green reuse only with college educational attainment while green and other reuse was associated with educational attainment below 9th grade highlights a differential land use by educational class that reflects concerns of environmental justice advocates but may also foreshadow differences that may contribute to longer term resilience with the introduction of green reuse. Green and other reuse in areas of lower educational attainment may introduce commercial or other development that does not bolster resilience and may introduce risk when redevelopment occurs in flood risk areas.

3.2. Update to Our Knowledge

Few studies have examined brownfield reuse in the United States. A 2004 brownfield review of redevelopment estimated 5% brownfields in studied communities were converted to greenspace, comparable to the estimated 4.8% of brownfields converted to parkland in Ontario brownfield projects from 2004–2015 examined by De Sousa et al. [7,8,88]. A survey of brownfield area residents about brownfield reuse found parks and green reuse preferred to commercial or industrial redevelopment [91]. A study of three brownfield-to-greenspace conversions found 90% of the 475 respondents agreed that greenspace creation and recreational trails were a good use of brownfields. Brownfield conversion to green reuse can contribute to mitigate flood risk in areas with higher populations of young families, children, elderly, and residents with reduced economic resources, a finding we were unable to confirm [10,12,15,52,89,90].

In this study, green reuse alone was significantly associated with college educational attainment, while green reuse combined with other reuse was significantly negatively associated with educational attainment less than ninth grade. This suggests the need for resilience investment that diminishes inequities and brings other benefits, including investments for green reuse alone in lower educational attainment areas [91–99]. Other community resources such as median household income and percent occupied housing did not add to the model independently and were dropped from the final model.

No differences in reuse choice associations between flood risk and race and ethnicity were observed. However, this study derived a flood risk category with existing information that may not reflect true risks, given growing extreme weather and limitations in flood risk mapping, despite research showing that 88% of U.S. counties have been flood impacted in the past five decades even as sea level rises, coastal storm surges and increased precipitation result in more nuisance flooding in areas not considered flood risk areas [100–106]. A lack of national publicly available flood risk information and outdated updates impedes sound planning, investment, and good governance. The emphasis on updating flood maps in primarily greater population areas ignores the needs of rural communities and tribal lands with fewer prevention and response resources, as well as rural or recreational areas where the lack of development and preservation of wild and natural areas attract visitors that may not be familiar with local flood hazards.

Reasons for developer and community decisions to choose green reuse are unknown but are important areas for future study. Surveys of developers and residents have documented successful project incorporation of green reuse as well as green reuse preferences that may require less investment [7,8,10,35,50–52]. As an example of a stressor exerting a positive influence, the presence of more than one brownfield may motivate green reuse combined with other reuse. This effect was not observed in green reuse only, nor associated with counties Superfund sites.

3.3. Potential Limitations

There may be limitations that affected the study results reported here. First, administrative record reporting to EPA may have included errors in project status or location. Errors in reported reuse, address, parcel and locational information used in determining flood locations may result in misclassification. Colloquial locational information (i.e., northwest of the intersection) rather than an address was common for historical industry, mine, quarry, railroad sites, tribal areas and illegal dumpsites, and if these properties are more likely to be in or not in flood plains, locational and mapping errors may bias results. Brownfields were attributed to counties in which they lay because local jurisdictions are likely managers of redevelopment, relegating brownfields to a larger geography where flood risk planning and response occurs. The conceptual model calls for areal measures, and factors other than reuse were measured at the county level. Additionally, organizational capacity to consider brownfields and to secure resources and investors for redevelopment vary and do not reflect all county brownfields in need of cleanup or community willingness to seek EPA funding or communities interested in addressing stigma, risks, and environmental contaminants.

The availability, age, and accuracy of county flood information varied by location, with less flood information being available for low-population density areas. Flood-plain location based on a 1% and 0.2% probability of flood-risk return is a fraught concept, as flood-plain maps, where available, span 2006 to 2016 yet may not reflect newer local or upstream development or lands behind levees not considered flood plains [100–102]. Though out of date, existing maps concentrate on developed areas rather than tourist areas, campgrounds, or recreational areas where development may occur where visitors or tourists may congregate unaware of flood risks. In this analysis, the median distance to water bodies was a proxy flood-plain measure of risk distances for flood-risk category in areas with no data.

Second, brownfields are not randomly distributed, nor are operations associated with brownfields. While the EPA's 2002 brownfield definition encompasses urban and rural brownfield locations, certain industries in brownfield inventories are more likely to be near railroads and waterways. This recognition is reflected in 23 March 2018 legislative changes which reauthorizes the EPA brownfield program through the Brownfield Utilization, Investment and Local Development (BUILD) Act and directs EPA to consider brownfield location in a flood plain or proximity to waterways as a new selection criteria to consider in evaluating applicants for brownfield grants in future grant competitions and award decisions [20,24].

Third, reuse determines cleanup and may be influenced by factors beyond those examined in this research, including location-specific factors such as land cost, property size, location, the extent of contamination, greenfield or “clean land” availability, developer interest and available financing [10,34,35,99]. For example, reported data does not detail contaminant levels so no risk inferences can be made. These site-specific factors were not accounted for, though the analysis did include community variables (such as population density) that may correlate with these considerations.

This 2005 to 2014 retrospective analysis spans the decade following data improvements and the brownfield amendments providing new authorities to EPA for regarding cleanup in the brownfield program. While there was greater confidence in brownfield practice entering the second decade of brownfield policy and practice, the recession and reduced project financing, staff resources or available credit, may have altered reuse choices after the recession and during recovery.

The analysis used 2005–2009 ACS data, whereas the Superfund site information is from 2014. The U.S. Federal Emergency Management Agency FEMA flood-map information was accessed in 2016 and 2017 to map brownfield locations; however, as the accessed flood-map information spanned updates from 2006 to 2016, this information may reflect the times under study. However, these maps may not reflect current flood risks or anticipated higher risks, as we have seen a continued increase in the number and intensity of extreme weather events associated with global environmental change or other contributors to flooding. Future research will consider maps, site location and characteristics of floodplain development, impervious surfaces, structural and non-structural flood management, river-channel size and depth, sedimentation, and groundwater level associated with flooding risks, which may contribute to flood risk but that were not included in this analysis.

The EPA brownfields program’s goal is to support the assessment and cleanup of properties for their return to safe reuse. Exclusion of brownfield counties with no reported reuse may have omitted reuse that is currently underway, represent incomplete reporting or may reflect weaker market conditions, more complex sites, or areas with less economic investment. If excluded sites were more likely to be redeveloped with different reuse choices, exclusion may have biased our results. Excluded counties may be subject to community and natural-hazard vulnerabilities that require attention yet were not included in this analysis, largely because of timeliness of reporting. Future analysis should examine all projects and additional administrative records for reuse status to better inform brownfield analyses.

The 1% and 0.2% probability (or 1-in-100-year- and 1-in-500-year-flood-return) periods need new attention, as the cost, frequency, and extremity of flood hazards and damages mount [44,45,100–104]. Research regarding resident misperceptions of flood risks near levees and the important role of homeowners in preparedness and in purchasing flood insurance adds new urgency to the need for communities to revisit flood-mapping procedures, information gaps and structural and non-structural flood management approaches and to discuss flood risks facing residents, businesses, and critical facilities, outside of extreme events, to build the trust needed for effective communication and action. In this analysis, the median distance to water bodies in flood-plain locations served as a proxy flood-plain measure to estimate and categorize flood risk. Future analyses should explore other flood metrics, flood damage assessments, and watershed or county flood-risk planning, to examine flood risks to brownfields at different scales [105,106].

Since 2007, the U.S. EPA has strongly encouraged local and state governments to integrate systems to manage storm and waste water and to adopt green infrastructure to reduce storm-water pressure on established combined sewer overflow systems. Sustainable redevelopment choices, such as green reuse, can help manage extreme precipitation within a system context to protect drinking water and waste water systems. Though funded differently, complementary investments in green infrastructure, drinking and waste water infrastructure can encourage climate-responsive reuse and discourage flood-zone investment that doesn't add to resilience functions. Regional differences in risk, climate vulnerability, and customer demand may spur regional differences in reuse in areas with more brownfields.

4. Materials and Methodology

4.1. Study Observations: Brownfield Counties

This retrospective study examines counties with brownfield cleanup projects initiated between 2005 and 2009 and completed by 2014. As the second decade of EPA's brownfield program, 2005–2014, is marked by improved data collection. Brownfield data were acquired (February 2017) from the U.S. EPA's Cleanups in My Community website, a public repository of contaminated site information that contains brownfield administrative records reported by grant recipients to the EPA's Brownfield Assessment, Cleanup and Redevelopment Exchange System for reporting. The database provides start and completion dates, reported reuse, and location for 683 brownfields (N = 683) situated in 269 counties. Counties with one brownfield site with completed reuse information were included (N = 181).

4.2. Variables

4.2.1. Community Stress

Reuse Choice (Dependent Variable)

Grantees categorize brownfield reuse as greenspace, residential, commercial or industrial, or multiple reuses. For this analysis, reuse was categorized as greenspace only and other reuses, and then as green only, green and other in combination, and other non-green reuses.

4.2.2. Residential Location

Flood Plain Designation (Independent Variable)

County designation of flood risk was determined in one of two ways. First, the National Flood Hazard Layer (NFHL) county and municipal coverage was accessed from the Federal Emergency Management Agency (FEMA) website (www.fema.gov, 20 February 2017). The NFHL file listed 2363 flood map locations; 2359 located in the 50 states (2220 in counties, 77 in cities, and 57 in towns and villages) and two tribal land areas. Four located in US territories were not included in this analysis. FEMA NFHL Keyhole Markup Language flood files imported into Google Earth were used to determine mapped brownfield property locations in areas with a minimum 0.2% probability of experiencing a so-called 500-year flood (which have a 1-in-500 chance of occurring in any given year) and distance to flood-source waters. Where the brownfield property record listed more than one property identification or listed multiple parcel addresses, each was examined and mapped to discern flood status. Median distances of brownfields in 500-year flood areas to flood-source waters were measured to be 605 feet. Second, for counties where FEMA flood data was not available, brownfield location distance to flood-source waters areas within 605 feet of a flood source were categorized as having flood risk less than every 500 years, while those further than 605 feet were categorized as having no flood risk. In counties with multiple brownfields, if at least one brownfield was coded as flood risk, the entire county was categorized as flood plain.

Region

Ten EPA regions were collapsed into three aggregate regions: New England, the Mid-Atlantic, and the Southeast (EPA Regions 1–4, 6); the Mid-West (EPA Regions 5, 7); and the Mountain West and Pacific Northwest (EPA Regions 8–10).

Race and Ethnicity

County population percent by race and ethnicity (% single race or ethnicity reported) were obtained from the 2005–2009 American Community Survey (ACS).

4.2.3. Community Environmental Stressors

Superfund and Brownfield Sites

Superfund sites (1317) and brownfield locations (683) were extracted from the EPA's Cleanups in My Community database (February 2017). Counts of Superfund sites and brownfields per county were extracted. A presence of a brownfield or superfund site was created as a yes/no variable indicating any and no sites within the county.

4.2.4. Neighborhood Resources

Age, Income, Poverty Level, Head of Household, Occupied Housing, Education, and Employment

County data were acquired from the American Community Survey's (ACS) 2005–2009 five-year estimates. County characteristics used in this analysis included age (% <5 years, $5 \leq 25$, $25 \leq 45$, $45 \leq 65$, $65 \leq 85$, and 85 and over), median household income ($), income by poverty ratio (percent <100%, $100 \leq 125\%$, $125 \leq 200\%$, or over 200% of poverty), single female head of household (%), occupied housing (%), educational attainment (% less than 9th grade, % some high school, and % some college), and employment (% of persons 16 and older).

4.2.5. Structural Factors

Population Density

County population density was calculated from the 2005–2009 ACS as population/land area.

Data Analysis

Exploratory data analysis examined all continuous variables to ensure that assumptions of normality were met; where they were not met, data were log transformed to more closely meet normality assumptions; all results are anti-logged for the reader's convenience. Correlations between continuous variables examined collinearity. ANOVA and Chi-square tests were used to compare project outcomes by regional differences, neighborhood resources, and structural factors. Chi-square single and multiple categorical comparisons used p-values of less than 0.05 to judge statistical significance.

Logistic and multinomial logistic regression was used to analyze bivariate and multivariate categorical data related to reuse choice, flooding risk, and associations with race and ethnicity, neighborhood resources, community stressors, and structural factors of counties. The full model examined regional interactions with race and ethnicity, using the Mid-West as the reference for regional comparisons, and included interaction variables for region and all race and ethnicities examined in this analysis. Variables that did not meet the $p < 0.05$ test for significance were removed through backward stepwise elimination. Where removal of a variable resulted in a 10% or more change in the full model relative risk ratio, the variable was retained as potential confounders.

Interactions of race/ethnicity and location were evaluated and found not statistically significant.

Stata 14 was used to conduct statistical analyses. Google Earth was used for mapping brownfield site locations to identify proximity to flood plains and measuring flood-zone distances.

5. Conclusions

Planning and development agencies and environmental regulators engaged in brownfield cleanup for redevelopment must tackle local structural impediments to creating resilient and healthy neighborhoods. The Gee and Payne-Sturges model provides a useful framework to consider community and environmental factors, some of which may be modifiable as part of environmental regulatory activities, investment and planning for revitalization that also includes natural hazard risks facing communities and counties [64,76–80].

The brownfield revitalization process requires public notification, and community engagement can prompt discussion of environmental stressors and healthy reuse options in areas subject to flooding or other natural hazards where structural- and non-structural-management approaches need updating. Like knowledge formation that links residents and experts in mapping environmental hazards, exposure- or flood-risk planning and site revitalization can build neighborhood resources for brownfield-site investigation, environmental study, reuse design, and communication and decision-making about reuse choice benefits for preparedness and flood prevention planning [82,83,103,104]. Exploration of participatory processes and community engagement is needed to reduce community stressors, strengthen and reinforce neighborhood resources, and contribute to healthier communities. The Gee and Payne-Sturges model contributes to understanding processes relevant to revitalization and resiliency planning as both community and individual actions are needed to reduce risk and drive community resilience capacity building activities.

Resilience and preparedness planning considers and invests in local populations, training needs, and employment to counter population vulnerabilities and locational risk. Prevention and preparedness response for residents of all educational and cultural backgrounds and abilities remain pressing needs for all government levels [17,52,54,104–107]. This work lays a foundation for future work factoring community building into revitalization efforts that expand and improve resilience.

Author Contributions: Conceptualization, A.M.M.C. and N.F.K.; Methodology, A.M.M.C. and N.F.K.; Formal Analysis, A.M.M.C. and N.F.K.; Investigation, A.M.M.C. and N.F.K.; Data Curation, A.M.M.C.; Writing-Original Draft Preparation, A.M.M.C.; Writing-Review & Editing, N.F.K.; Visualization, A.M.M.C. and N.F.K.; Supervision, N.F.K.

Funding: This research received no external funding.

Acknowledgments: I would like to thank Norma Kanarek, Janice Bowie, Mary Fox, and Michael Trush of the Johns Hopkins University, Bloomberg School of Public Health and Sandra Whitehead of the National Environmental Health Association for serving on my committee and for their sage advice and time, assistance and insights in my research. I am indebted to my colleagues and friends in the U.S. and around the world for our shared work with communities and their residents to reduce risks, protect public health and restore degraded lands in our professional careers and academic lives. You inspire me to keep feeding my curious appetite for public health, environmental improvement, and new approaches to create wealth and health.

Conflicts of Interest: The author, A.M.M.C., declares a personal circumstance as an employee of the U.S. EPA, Office of Brownfields and Land Revitalization that may be perceived as a conflict or influencing the representation of this information or interpretation of reported research results. Apart from the authors, no organization had a role in the design of the study; in the collection, analyses or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

References

1. Alker, S.; Joy, V.; Roberts, P.; Smith, N. The Definition of Brownfield. *J. Environ. Plan. Manag.* **2000**, *43*, 49–69. [CrossRef]
2. Alberini, A.; Longo, A.; Tonin, S.; Trombetta, F.; Turvani, M. The role of liability, regulation and economic incentives in brownfield remediation and redevelopment: Evidence from surveys of developers. *Reg. Sci. Urban Econ.* **2005**, *35*, 327–351. [CrossRef]
3. Adams, D.; De Sousa, C.; Tiesdell, S. Brownfield Development: A Comparison of North American and British Approaches. *Urban Stud.* **2010**, *47*, 75–104. [CrossRef]

4. Bartke, S.; Schwarze, R. No perfect tools: Trade-offs of sustainability principles and user requirements in designing support tools for land-use decisions between greenfields and brownfields. *J. Environ. Manag.* **2015**, *153*, 11–24. [CrossRef] [PubMed]
5. Silverstein, J.D. "Mechanics" of the Deal: Assembling the Brownfields Team. *Environ. Pract.* **2003**, *5*, 53–57. [CrossRef]
6. Goodstein, M.D.; Trinward, K.J.; Lynch, A. Research Article: Pushing the Envelope on Brownfield Remediation: Strategies and Case Studies That Maximize Limited Resources through Alternative Funding Sources. *Environ. Pract.* **2011**, *13*, 130–142. [CrossRef]
7. Greenberg, M.R. Improving neighborhood quality: A hierarchy of needs. *Hous. Policy Debate* **1999**, *10*, 601–624. [CrossRef]
8. De Sousa, C.A. The greening of brownfields in American cities. *J. Environ. Plan. Manag.* **2004**, *47*, 579–600. [CrossRef]
9. Dennis, M.; James, P. Site-specific factors in the production of local urban ecosystem services: A case study of community-managed greenspace. *Ecosyst. Serv.* **2016**, *17*, 208–216. [CrossRef]
10. Siikamäki, J.; Wernstedt, K. Turning brownfields into greenspaces: Examining incentives and barriers to revitalization. *J. Health Polit. Policy Law* **2008**, *33*, 559–593. [CrossRef] [PubMed]
11. Brody, S.D.; Highfield, W.E. Open Space and Flood Mitigation: A National Study. *Land Use Policy* **2013**, *32*, 89–95. [CrossRef]
12. Hartig, J.H.; Krueger, A.; Rice, K.; Niswander, S.F.; Jenkins, B.; Norwood, G. Transformation of an industrial brownfield into an ecological buffer for Michigan's only Ramsar Wetland of International Importance. *Sustainability* **2012**, *4*, 1043–1058. [CrossRef]
13. Jonkman, S.N.; Maaskant, B.; Boyd, E.; Levitan, M.L. Loss of life caused by the flooding of New Orleans after Hurricane Katrina: Analysis of the relationship between flood characteristics and mortality. *Risk Anal.* **2009**, *29*, 676–698. [CrossRef] [PubMed]
14. Lane, S.N.; Odoni, N.; Landström, C.; Whatmore, S.J.; Ward, N.; Bradley, S. Doing flood risk science differently: An experiment in radical scientific method. *Trans. Inst. Br. Geogr.* **2011**, *36*, 15–36. [CrossRef]
15. Levi, D.; Kocher, S. The use of coastal brownfields as nature preserves. *Environ. Behav.* **2006**, *38*, 802–819. [CrossRef]
16. U.S. General Accountability Office (GAO). Superfund: Barriers to Brownfield Redevelopment. RCED-96-125; 1996. Available online: https://www.gao.gov/index/html (accessed on 10 November 2017).
17. U.S. General Accountability Office (GAO). Community Development: Reuse of Urban Industrial Sites GAO/RCED-95-172. 1995. Available online: https://www.gao.gov/index/html (accessed on 10 November 2017).
18. Howland, M. Employment Effects of Brownfield Redevelopment: What Do We Know from the Literature? *J. Plan. Lit.* **2007**, *22*, 91–107. [CrossRef]
19. BenDor, T.K.; Metcalf, S.S.; Paich, M. The dynamics of brownfield redevelopment. *Sustainability* **2011**, *3*, 914–936. [CrossRef]
20. U.S. Environmental Protection Agency. Office of Brownfield and Land Revitalization Webpage. Available online: https://www.epa.gov/brownfields/overview-brownfields-program (accessed on 1 December 2017).
21. Rall, E.L.; Haase, D. Creative intervention in a dynamic city: A sustainability assessment of an interim use strategy for brownfields in Leipzig, Germany. *Landsc. Urban Plan.* **2011**, *100*, 189–201. [CrossRef]
22. De Sousa, C. Policy performance and brownfield redevelopment in Milwaukee, Wisconsin. *Prof. Geogr.* **2005**, *57*, 312–327. [CrossRef]
23. Schilling, J.; Logan, J. Greening the Rust Belt: A Green Infrastructure Model for Right Sizing America's Shrinking Cities. *J. Am. Plan. Assoc.* **2008**, *74*, 451–466. [CrossRef]
24. U.S. Environmental Protection Agency. Office of Brownfield and Land Revitalization, Laws & Regulation Webpage. The Small Business Liability Relief and Brownfield Revitalization Act of 2001, Signed into Law. Public Law 107-118, 15 Stat. 2356; 2002. Available online: https://www.epa.gov/brownfields/brownfields-laws-and-regulations (accessed on 1 December 2017).
25. Mendez, M.O.; Maier, R.M. Phytostabilization of Mine Tailings in Arid and Semiarid Environments—An Emerging Remediation Technology. *Environ. Health Perspect.* **2007**, *116*, 278–283. [CrossRef] [PubMed]
26. Greenberg, M.R. Reversing urban decay: Brownfield redevelopment and environmental health. *Environ. Health Perspect.* **2003**, *111*, A74. [CrossRef] [PubMed]

27. Chen, M.; Daroub, S.H.; Ma, L.Q.; Harris, W.G.; Cao, X. Characterization of lead in soils of a rifle/pistol shooting range in central Florida, USA. *Soil Sediment Contam.* **2002**, *11*, 1–7. [CrossRef]
28. Rimer, A.L. Environmental Liability and the Brownfields Phenomenon: An Analysis of Federal Options for Redevelopment. *Tulane Environ. Law J.* **1996**, *10*, 63–121.
29. Bartsch, C.; Collaton, E.; Pepper, E. *Coming Clean for Economic Development*; Northeast-Midwest Institute: Washington, DC, USA, 1996.
30. Meyer, P.B. Brownfields and red ink: The costs of contaminated (and idle) land. *Environ. Pract.* **2003**, *5*, 40–47. [CrossRef]
31. Howland, M. The Impact of Contamination on the Canton/Southeast Baltimore Land Market. *J. Am. Plan. Assoc.* **2000**, *66*, h411–h420. [CrossRef]
32. Longo, A.; Alberini, A. What are the effects of contamination risks on commercial and industrial properties? Evidence from Baltimore, Maryland. *J. Environ. Plan. Manag.* **2006**, *49*, 713–737. [CrossRef]
33. Simons, R.; Levin, W.; Sementelli, A. The Effect of Underground Storage Tanks on Residential Property Values in Cuyahoga County, Ohio. *J. Real Estate Res.* **1997**, *14*, 29–42. [CrossRef]
34. Heberle, L.; Wernstedt, K. Understanding brownfields regeneration in the US. *Local Environ.* **2006**, *11*, 479–497. [CrossRef]
35. Lange, D.; McNeil, S. Clean it and they will come? Defining successful brownfield development. *J. Urban Plan. Dev.* **2004**, *130*, 101–108. [CrossRef]
36. Khan, F.I.; Husain, T.; Hejazi, R. An overview and analysis of site remediation technologies. *J. Environ. Manag.* **2004**, *71*, 95–122. [CrossRef] [PubMed]
37. Mulligan, C.N.; Yong, R.N.; Gibbs, B.F. Remediation technologies for metal-contaminated soils and groundwater: An evaluation. *Eng. Geol.* **2001**, *60*, 193–207. [CrossRef]
38. Swartjes, F.A. Risk-based assessment of soil and groundwater quality in the Netherlands: Standards and remediation urgency. *Risk Anal.* **1999**, *19*, 1235–1249. [CrossRef] [PubMed]
39. Lange, D.A.; McNeil, S. Brownfield Development: Tools for Stewardship. *J. Urban Plan. Dev.* **2004**, *130*, 109–116. [CrossRef]
40. Haninger, K.; Ma, L.; Timmins, C. The Value of Brownfield Remediation. *J. Assoc. Environ. Resour. Econ.* **2017**, *4*, 197–241. [CrossRef]
41. De Sousa, C.A.; Wu, C.; Westphal, L.M. Assessing the Effect of Publicly Assisted Brownfield Redevelopment on Surrounding Property Values. *Econ. Dev. Q.* **2009**, *23*, 95–110. [CrossRef]
42. Garvin, E.C.; Cannuscio, C.C.; Branas, C.C. Greening vacant lots to reduce violent crime: A randomised controlled trial. *Inj. Prev.* **2013**, *19*, 198–203. [CrossRef] [PubMed]
43. Garvin, E.; Branas, C.; Keddem, S.; Sellman, J.; Cannuscio, C. More Than Just an Eyesore: Local Insights And Solutions on Vacant Land And Urban Health. *J. Urban Health* **2013**, *90*, 412–426. [CrossRef] [PubMed]
44. Burby, R.J.; Deyle, R.E.; Godschalk, D.R.; Olshansky, R.B. Creating hazard resilient communities through land-use planning. *Nat. Hazards Rev.* **2000**, *1*, 99–106. [CrossRef]
45. Burby, R.J.; Nelson, A.M.M.C.; Parker, D.; Handmer, J. Urban Containment Policy and Exposure to Natural Hazards: Is There a Connection? *J. Environ. Plan. Manag.* **2001**, *44*, 475–490. [CrossRef]
46. McCarthy, L. The brownfield dual land-use policy challenge: Reducing barriers to private redevelopment while connecting reuse to broader community goals. *Land Use Policy* **2002**, *19*, 287–296. [CrossRef]
47. Senier, L.; Hudson, B.; Fort, S.; Hoover, E.; Tillson, R.; Brown, P. Brown Superfund Basic Research Program: A Multistakeholder Partnership Addresses Real-World Problems in Contaminated Communities. *Environ. Sci. Technol.* **2008**, *42*, 4655–4662. [CrossRef] [PubMed]
48. Greenberg, M. Should housing be built on former brownfield sites? *Am. J. Public Health* **2002**, *92*, 703–705. [CrossRef] [PubMed]
49. Rogge, M.E.; Davis, K.; Maddox, D.; Jackson, M. Leveraging Environmental, Social, and Economic Justice at Chattanooga Creek: A Case Study. *J. Community Pract.* **2005**, *13*, 33–53. [CrossRef]
50. Wolch, J.R.; Byrne, J.; Newell, J.P. Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'. *Landsc. Urban Plan.* **2014**, *125*, 234–244. [CrossRef]
51. Bardos, R.P.; Jones, S.; Stephenson, I.; Menger, P.; Beumer, V.; Neonato, F.; Maring, L.; Ferber, U.; Track, T.; Wendler, K. Optimising value from the soft re-use of brownfield sites. *Sci. Total Environ.* **2016**, *563–564*, 769–782. [CrossRef] [PubMed]

52. Bulkeley, H. Cities and the governing of climate change. *Annu. Rev. Environ. Resour.* **2010**, *35*, 229–253. [CrossRef]
53. Lee, C. Environmental justice: Building a unified vision of health and the environment. *Environ. Health Perspect.* **2002**, *110*, 141–144. [CrossRef] [PubMed]
54. Pastor, M.; Morello-Frosch, R. Integrating Public Health And Community Development To Tackle Neighborhood Distress And Promote Well-Being. *Health Aff.* **2014**, *33*, 1890–1896. [CrossRef] [PubMed]
55. Goodman, R.M.; Speers, M.A.; Mcleroy, K.; Fawcett, S.; Kegler, M.; Parker, E.; Smith, S.R.; Sterling, T.D.; Wallerstein, N. Identifying and Defining the Dimensions of Community Capacity to Provide a Basis for Measurement. *Health Educ. Behav.* **1998**, *25*, 258–278. [CrossRef] [PubMed]
56. Luederitz, C.; Brink, E.; Gralla, F.; Hermelingmeier, V.; Meyer, M.; Niven, L.; Panzer, L.; Partelow, S.; Rau, A.-L.; Sasaki, R.; et al. A review of urban ecosystem services: Six key challenges for future research. *Ecosyst. Serv.* **2015**, *14*, 98–112. [CrossRef]
57. Labat, D.; Goddéris, Y.; Probst, J.L.; Guyot, J.L. Evidence for global runoff increase related to climate warming. *Adv. Water Resour.* **2004**, *27*, 631–642. [CrossRef]
58. Greenberg, M.; Lee, C.; Powers, C. Public health and brownfields: Reviving the past to protect the future. *Am. J. Public Health* **1998**, *88*, 1759–1760. [CrossRef] [PubMed]
59. Bullard, R.D.; Johnson, G.S. Environmentalism and Public Policy: Environmental Justice: Grassroots Activism and Its Impact on Public Policy Decision Making. *J. Soc. Issues* **2000**, *56*, 555–578. [CrossRef]
60. Leigh, N.G. *Promoting More Equitable Brownfield Redevelopment: Promising Approaches for Land Banks and Other Community land Development Entities*; Lincoln Institute of Land Policy: Cambridge, MA, USA, 2000.
61. Greenberg, M.; Lowrie, K.; Mayer, H.; Miller, K.T.; Solitare, L. Brownfield redevelopment as a smart growth option in the United States. *Environmentalist* **2001**, *21*, 129–143. [CrossRef]
62. Nagengast, A.; Hendrickson, C.; Lange, D. Commuting from U.S. Brownfield and Greenfield Residential Development Neighborhoods. *J. Urban Plan. Dev.* **2011**, *137*, 298–304. [CrossRef]
63. Northridge, M.E. Sorting Out the Connections between the Built Environment and Health: A Conceptual Framework for Navigating Pathways and Planning Healthy Cities. *J. Urban Health Bull. N. Y. Acad. Med.* **2003**, *80*, 556–568. [CrossRef] [PubMed]
64. Pediaditi, K.; Doick, K.J.; Moffat, A.J. Monitoring and evaluation practice for brownfield, regeneration to greenspace initiatives. *Landsc. Urban Plan.* **2010**, *97*, 22–36. [CrossRef]
65. Gee, G.C.; Payne-Sturges, D.C. Environmental Health Disparities: A Framework Integrating Psychosocial and Environmental Concepts. *Environ. Health Perspect.* **2004**, *112*, 1645–1653. [CrossRef] [PubMed]
66. Morello-Frosch, R.; Pastor, M.; Sadd, J. Environmental Justice and Southern California's "Riskscape": The Distribution of Air Toxics Exposures and Health Risks among Diverse Communities. *Urban Aff. Rev.* **2001**, *36*, 551–578. [CrossRef]
67. Comfort, L.K. Cities at Risk: Hurricane Katrina and the Drowning of New Orleans. *Urban Aff. Rev.* **2006**, *41*, 501–516. [CrossRef]
68. Liévanos, R.S. Retooling CalEnviroScreen: Cumulative Pollution Burden and Race-Based Environmental Health Vulnerabilities in California. *Int. J. Environ. Res. Public Health* **2018**, *15*, 762. [CrossRef] [PubMed]
69. O'Neil, S.G. Superfund: Evaluating the Impact of Executive Order 12898. *Environ. Health Perspect.* **2007**, *115*, 1087–1093. [CrossRef] [PubMed]
70. Pastor, M.; Sadd, J.; Hipp, J. Which Came First? Toxic Facilities, Minority Move-In, and Environmental Justice. *J. Urban Aff.* **2001**, *23*, 1–21. [CrossRef]
71. Lopez, R. Segregation and black/white differences in exposure to air toxics in 1990. *Environ. Health Perspect.* **2002**, *110* (Suppl. 2), 289–295. [CrossRef] [PubMed]
72. Litt, J.S.; Burke, T.A. Uncovering the historic environmental hazards of urban brownfields. *J. Urban Health* **2002**, *79*, 464–481. [CrossRef] [PubMed]
73. Mohai, P.; Lantz, P.M.; Morenoff, J.; House, J.S.; Mero, R.P. Racial and Socioeconomic Disparities in Residential Proximity to Polluting Industrial Facilities: Evidence from the Americans' Changing Lives Study. *Am. J. Public Health* **2009**, *99*, S649. [CrossRef] [PubMed]
74. Abel, T.D. Skewed Riskscapes and Environmental Injustice: A Case Study of Metropolitan St. Louis. *Environ. Manag.* **2008**, *42*, 232–248. [CrossRef] [PubMed]
75. Yasenchak, L. Research Article: What We Know About the Ubiquitous Brownfield: A Case Study of Two New Jersey Cities and Their Gas Stations. *Environ. Pract.* **2009**, *11*, 144–152. [CrossRef]

76. Vickery, J.; Hunter, L.M. Native Americans: Where in Environmental Justice Research? *Soc. Nat. Resour.* **2016**, *29*, 36–52. [CrossRef] [PubMed]
77. Payne-Sturges, D.; Gee, G.C. National environmental health measures for minority and low-income populations: Tracking social disparities in environmental health. *Environ. Res.* **2006**, *102*, 154–171. [CrossRef] [PubMed]
78. Cutter, S.L.; Boruff, B.J.; Shirley, W.L. Social Vulnerability to Environmental Hazards. *Soc. Sci. Q.* **2003**, *84*, 242–261. [CrossRef]
79. McGuire, A.P.; Gauthier, J.M.; Anderson, L.M.; Hollingsworth, D.W.; Tracy, M.; Galea, S.; Coffey, S.F. Social Support Moderates Effects of Natural Disaster Exposure on Depression and Posttraumatic Stress Disorder Symptoms: Effects for Displaced and Nondisplaced Residents. *J. Trauma. Stress* **2018**, *31*, 223–233. [CrossRef] [PubMed]
80. Geronimus, A.T. To mitigate, resist, or undo: Addressing structural influences on the health of urban populations. *Am. J. Public Health* **2000**, *90*, 867–872. [CrossRef] [PubMed]
81. Morello-Frosch, R.; Lopez, R. The riskscape and the color line: Examining the role of segregation in environmental health disparities. *Environ. Res.* **2006**, *102*, 181–196. [CrossRef] [PubMed]
82. McCarthy, L. Off the Mark? Efficiency in Targeting the Most Marketable Sites Rather Than Equity in Public Assistance for Brownfield Redevelopment. *Econ. Dev. Q.* **2009**, *23*, 211–228. [CrossRef]
83. Pizzol, L.; Zabeo, A.; Klusáček, P.; Giubilato, E.; Critto, A.; Frantál, B.; Martinát, S.; Kunc, J.; Osman, R.; Bartke, S. Timbre Brownfield Prioritization Tool to support effective brownfield regeneration. *J. Environ. Manag.* **2016**, *166*, 178–192. [CrossRef] [PubMed]
84. Chrysochoou, M.; Brown, K.; Dahal, G.; Granda-Carvajal, C.; Segerson, K.; Garrick, N.; Bagtzoglou, A. A GIS and indexing scheme to screen brownfields for area-wide redevelopment planning. *Landsc. Urban Plan.* **2012**, *105*, 187–198. [CrossRef]
85. Noonan, F.; Vidich, C.A. Decision analysis for utilizing hazardous waste site assessments in real estate acquisition. *Risk Anal.* **1992**, *12*, 245–251. [CrossRef]
86. Kubal, C.; Haase, D.; Meyer, V.; Scheuer, S. Integrated urban flood risk assessment—Adapting a multicriteria approach to a city. *Nat. Hazards Earth Syst. Sci.* **2009**, *9*, 1881–1895. [CrossRef]
87. Pinter, N. One step forward, two steps back on US floodplains. *Science* **2005**, *308*, 207–208. [CrossRef] [PubMed]
88. Michel-Kerjan, E.; Kunreuther, H. Redesigning flood insurance. *Science* **2011**, *333*, 408–409. [CrossRef] [PubMed]
89. De Sousa, C.A.; Spiess, T.B. The management of brownfields in Ontario: A comprehensive review of remediation and reuse characteristics, trends, and outcomes, 2004–2015. *Environ. Pract.* **2018**, *20*, 4–15. [CrossRef]
90. Dorsey, J.W. Brownfields and Greenfields: The Intersection of Sustainable Development and Environmental Stewardship. *Environ. Pract.* **2003**, *5*, 69–76. [CrossRef]
91. Godschalk, D.R. Urban Hazard Mitigation: Creating Resilient Cities. *Nat. Hazards Rev.* **2003**, *4*, 136–143. [CrossRef]
92. Lee, A.M.M.C.K.; Maheswaran, R. The health benefits of urban green spaces: A review of the evidence. *J. Public Health* **2001**, *33*, 212–222. [CrossRef] [PubMed]
93. Smit, J.; Nasr, J. Urban agriculture for sustainable cities: Using wastes and idle land and water bodies as resources. *Environ. Urban.* **1992**, *4*, 141–152. [CrossRef]
94. Beyer, K.; Kaltenbach, A.; Szabo, A.; Bogar, S.; Nieto, F.; Malecki, K. Exposure to Neighborhood Green Space and Mental Health: Evidence from the Survey of the Health of Wisconsin. *Int. J. Environ. Res. Public Health* **2014**, *11*, 3453–3472. [CrossRef] [PubMed]
95. van den Berg, A.E.; Maas, J.; Verheij, R.A.; Groenewegen, P.P. Green space as a buffer between stressful life events and health. *Soc. Sci. Med.* **2010**, *70*, 1203–1210. [CrossRef] [PubMed]
96. Coppel, G.; Wüstemann, H. The impact of urban green space on health in Berlin, Germany: Empirical findings and implications for urban planning. *Landsc. Urban Plan.* **2017**, *167*, 410–418. [CrossRef]
97. Fan, Y.; Das, K.V.; Chen, Q. Neighborhood green, social support, physical activity, and stress: Assessing the cumulative impact. *Health Place* **2011**, *17*, 1202–1211. [CrossRef] [PubMed]
98. Homsy, G.C.; Warner, M.E. Cities and Sustainability: Polycentric Action and Multilevel Governance. *Urban Aff. Rev.* **2015**, *51*, 46–73. [CrossRef]

99. De Sousa, C.A. Unearthing the benefits of brownfield to green space projects: An examination of project use and quality of life impacts. *Local Environ.* **2006**, *11*, 577–600. [CrossRef]
100. Wang, X. Exploring trends, sources, and causes of environmental funding: A study of Florida counties. *J. Environ. Manag.* **2011**, *92*, 2930–2938. [CrossRef] [PubMed]
101. Burby, R.J. Flood insurance and floodplain management: The US experience. *Glob. Environ. Chang. Part B Environ. Hazards* **2001**, *3*, 111–122. [CrossRef]
102. Stiles, W.A., Jr. Sea level rise-from my front porch. *Bull. At. Sci.* **2018**, *74*, 81–90. [CrossRef]
103. Ludy, J.; Kondolf, G.M. Flood risk perception in lands "protected" by 100-year levees. *Nat. Hazards* **2012**, *61*, 829–842. [CrossRef]
104. Rufat, S.; Tate, E.; Burton, C.G.; Maroof, A.S. Social vulnerability to floods: Review of case studies and implications for measurement. *Int. J. Disaster Risk Reduct.* **2015**, *14*, 470–486. [CrossRef]
105. Ash, K.D.; Cutter, S.L.; Emrich, C.T. Acceptable losses? The relative impacts of natural hazards in the United States, 1980–2009. *Int. J. Disaster Risk Reduct.* **2013**, *5*, 61–72. [CrossRef]
106. Wachinger, G.; Renn, O.; Begg, C.; Kuhlicke, C. The risk perception paradox—Implication for governance and communication of natural hazards. *Risk Anal.* **2013**, *33*, 1049–1065. [CrossRef] [PubMed]
107. Corburn, J. Bringing local knowledge into environmental decision making: Improving urban planning for communities at risk. *J. Plan. Educ. Res.* **2003**, *22*, 420–433. [CrossRef]