Revitalizing Indianapolis' Near West Side Community Using Brownfield Prioritization Systems

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Background

The purpose of this study is to determine how remediation of 141 Brownfield sites in Indianapolis, Indiana should be prioritized. The Brownfields are characterized by their impact on human and ecological exposures and are compared to indicators for social determinants, pollution, and environmental vulnerability in order to find relationships between those factors and presence and severity of Brownfield sites.

- Brownfield sites are defined by the EPA as "property where the expansion, redevelopment, or reuse of which is complicated by the presence of hazardous substances, pollutants, or contaminants"[1]
  - Brownfield sites are often unused parcels of land that can impact neighborhoods socially and economically.
  - Redevelopment of Brownfields can lead to new sources of revenue, increases in local tax bases, job growth, improved infrastructure, and has positive impacts on human health and the environment[1].
  - Exposure to air pollutants may have additive or synergistic effects with Brownfield site contaminants.
- The Indiana Finance Authority keeps a Site List of sites in the Brownfields Program in Indiana. [2] According to the Site List, there are 354 individual Brownfield Site in Marion County, Indiana (Indianapolis).
- 141 such sites were maintained in a Brownfield site database, where they were scored according to the Colorado Department of Public Health and Environment's (CDPHE) Brownfield Site Prioritization Criteria[3].
  - This scoring System is based on human and ecological toxicity, site characteristics, human exposure, and ecological exposure.
  - Brownfields were also scored based on the social, pollution, and environmental vulnerability characteristics of their respective census tracts.
  - Social, pollution, and environmental vulnerability are scored using the Multi-Layer Data Community Action Tool (MDCAT).
- The MDCAT was created by a joint collaboration between the Indiana University School of Public Health and local Indianapolis stakeholders
- The MDCAT is a census tract level mapping tool that uses pollution and social indicators to determine the areas with the greatest vulnerability, based on the intersection of those indicators
  - The MDCAT is based on the CalEnviroScreen 2.0 tool, a tool used to identify the areas within California that are most disproportionately burdened by pollutants[4]. The top 10% of these areas are granted funds for the revitalization of the areas.

Methodology

The MDCAT index score[5] is based on the following indicators:

Pollution Characteristics
- SO_2 Concentrations
- PM 2.5 Concentrations
- Diesel PM Emissions
- Toxic Releases
- Traffic Density
- ½ Cleanup sites
- ½ Groundwater Threats
- ½ Hazardous Waste
- ½ Impaired Water Bodies

X

Population Characteristics
- Children and Elderly
- Low Birth-weight Infants
- Educational Attainment
- Linguistic Isolation
- Poverty
- Unemployment

= MDCAT SCORE

- The Brownfield Prioritization Scoring Criteria developed by the CDPHE are based on the Technical Evaluation Panel model used in prioritizing sites under Colorado house bill.
- The CPDHE system was chosen based on its use of site characteristics, but also economic impact data. Scoring based on economic impact will take place in phase II of the scoring and is not represented in this study.
- Scores scale for each of the criterion from 1 to 5, where 5 is the most severe score that can be given.[5]
- The Brownfield score can range between 30 and 100 points, with 100 representing the site most in need of remediation[5].

Value Ranking Factor	1	2	3	4	5
Human Toxicity	Concentrations below Detection Limits	Concentrations above Detection Limits, below IDEM Residential Regulatory Limits	Concentration above IDEM Residential Regulatory Limits	Concentrations above IDEM Industrial Regulatory Limits	Many contaminants above IDEM Industrial Limits, Concentrations serious concern
Ecological Toxicity	Toxicity score <100 and Bioaccumulation <500	Toxicity score <100 and Bioaccumulation score <500	Toxicity score 1,000 and Bioaccum. <500	Toxicity score >1,000 and Bioaccum. >500	Toxicity Score 10,000 and Bioaccumulation <=5,000
Site Characteristics	Low likelihood of release. Contaminants contained,	Access restricted, Site maintenance unknown	Structures may be present, but unmaintained	No evidence of Containment structures o	Access Unrestricted; No containment
Human Exposure	Low potential for exposure to a small number of people	Low potential for exposure to a small population of people	High potential for exposure to >1,000 people;	Exposures Exist	Exposures exist above unsafe concentrations
Ecological Exposure	No exposure to endangered or threatened species	Potential exposure to managed habitat	Potential exposure to critical habitats	Exposure in managed area or wetlands	Exposure to critical habitat of threatened or endangered species

Statistical Analysis

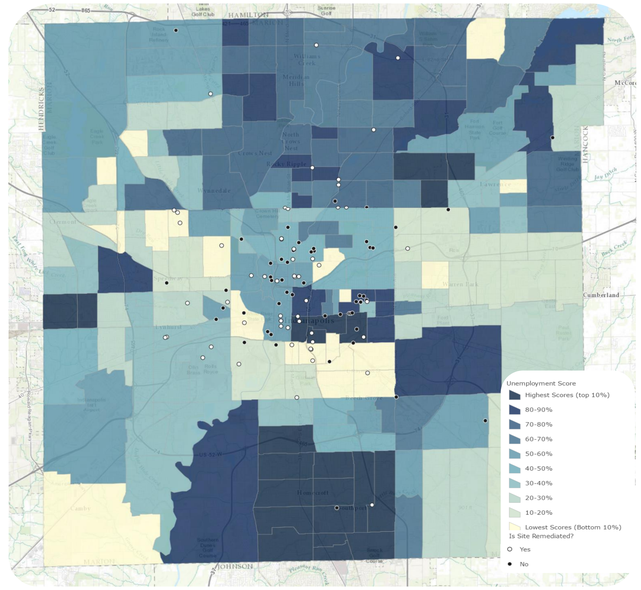
Statistical analysis was done to characterize: census tracts with and without Brownfield sites, remediated and non-remediated sites, and correlation between indicator scores and the presence of a Brownfield site.

- Of the 141 total sites, 30 sites were excluded, leaving 111 sites that were scored for prioritization.
  - Reasons for exclusion from scoring include: duplicate entry, too little information to score, site being outside of Marion County, and non-brownfield sites.
- Statistical Analysis was done in IBM's SPSS Statistics program.
- A Pearson's correlation coefficient was computed to assess the relationship between the Brownfield prioritization score and MDCAT Indicator scores. These results are summarized in Table 1.
- Single sample t tests were conducted to determine if there were significant differences in mean MDCAT indicator values within the brownfield site census tracts and mean values for the county. These results are summarized in table 2.
- A set of independent t-tests were conducted to determine if there were significant differences between mean characteristics of remediated and unremediated sites, the results of which are shown in table 3.

Mapping Analysis

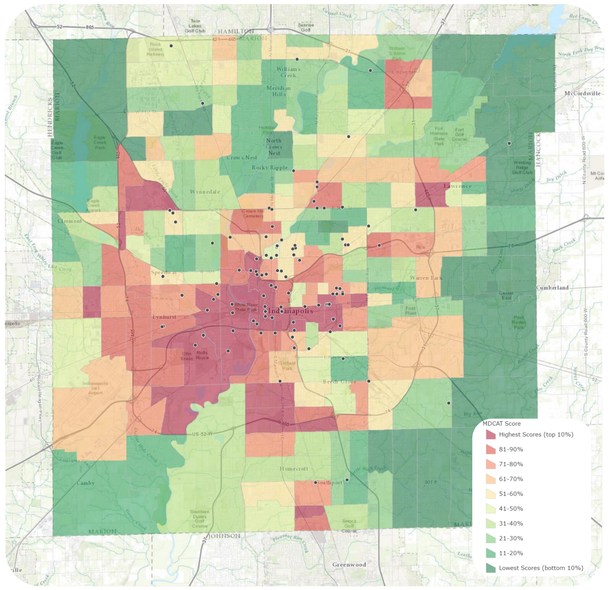
- The 111 sites were also geocoded and uploaded to ESRI's ArcGIS 10.5 software where they were mapped to show relevant information.
- Map 1 depicts the location of Brownfield sites in addition to showing areas of vulnerability, represented by the MDCAT Index.
- Map 2 shows the relative severity of Brownfield sites
- Map 3 shows where remediated and unremediated sites are in addition to showing areas with high levels of unemployment.

Unemployment Score for Census Tracts in Marion County, Indiana Compared to Remediated and Unremediated Brownfields



Map 3: Brownfield sites shown in black, have not been remediated. Brownfield sites shown in white have been remediated. Census tracts are scored using the unemployment indicator. The Census tracts that are the darkest blue have the highest rates of unemployment relative to Marion County.

Total MDCAT Score for Census Tracts in Marion County, Indiana With Brownfield Sites



Map 1: Locations of The 111 Brownfield Sites in Marion County, Indiana. Census tracts that are most Red have a higher MDCAT Index and are more environmentally vulnerable

Results

Main Analyses

- The scores ranged from 30 to 75 (75 being the site most in need of prioritization). The median score was 55 and the mean for the set was 54.29. Map 2 displays the relative severity of the score for each site.
- Of the 111 sites, 58 were remediated 53 were unremediated.
- Unremediated sites were found in census tracts with a significantly higher unemployment rate than remediated sites.
- Remediated sites were located in census tracts with significantly higher levels of traffic density and diesel PM.
- A significant negative relationship was reported between Brownfield prioritization score and traffic density.
- A significant positive association was reported between Brownfield prioritization score and both poverty and (lack of) education.
- Census tracts where Brownfield sites are located have higher amount of vulnerability (MDCAT Index), Low birth weight infants, (lack of) education, poverty, linguistic isolation, toxic releases, Diesel PM, and PM 2.5.
- Census tracts where Brownfield sites are located have a smaller proportion of the population under age 10 or over age 65.

Frequency of Brownfield Scoring

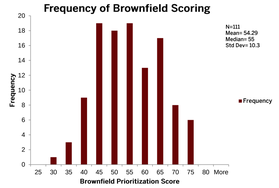


Figure 1: Distribution of Brownfield Prioritization Scores

Table 1

Correlations Among MDCAT Indicators and Brownfield Prioritization Scores

Variables	*M* (*SD*)	Brownfield Score	Variables	*M* (*SD*)	Brownfield Score
SO_2	50.8 (27.1)	.080	Imp. Water	40.5 (33.4)	-.034
PM 2.5	57.6 (27.5)	-.024	Age	35.8 (29.6)	-.061
Diesel PM	65.4 (28.2)	-.036	LBW	55.9 (30.3)	-.016
Tox. Release	66.6 (27.4)	-.021	Educ.	61.1 (30.1)	.200*
Traff Dens.	46.6 (23.1)	-.279**	Ling. Isol.	57.3 (28.1)	.030
Cleanup Sites	56.7 (37.1)	-.170	Poverty	65.3 (24.3)	.249**
Gwater Threats	55.6 (35.1)	-.032	Unemploy.	50.9 (27.5)	.086
Haz. Waste	5.36 (19.7)	-.006	MDCAT	42.2 (13.6)	.047

Notes. * $p < .05$.

** $p < .01$.

Table 2
Results of One-sample t-test and Descriptive Statistics for MDCAT Indicators

Outcome	*M*	*SD*	n	Comparison Value	95% CI for Mean Difference	t	df
MDCAT Index	42.18	1.28	111	31.79	7.84, 12.94	8.073***	110
LBW Infants	55.91	2.87	111	48.44	1.78, 13.17	2.601*	110
Unemployment	50.81	2.60	111	50.22	-4.58, 5.75	.224	110
Poverty	60.27	2.31	111	50.22	10.47, 19.61	6.524***	110
Ling. Isol.	57.26	2.67	111	50.22	1.74, 12.3	2.634*	110
Education	61.10	2.85	111	50.22	5.22, 16.53	3.813***	110
Age	35.84	2.80	111	50.22	-19.93, -8.82	-5.125***	110
Traffic Density	46.65	2.19	111	50.22	-7.92, 0.76	-1.633	110
Tox. Releases	66.60	2.60	111	50.22	11.231, 21.53	6.306***	110
Diesel PM	65.42	2.68	111	50.22	9.89, 20.51	5.667***	110
SO_2	50.82	2.57	111	50.22	-4.49, 5.69	.234	110
PM 2.5	57.6	2.61	111	50.22	2.21, 12.55	2.827**	110

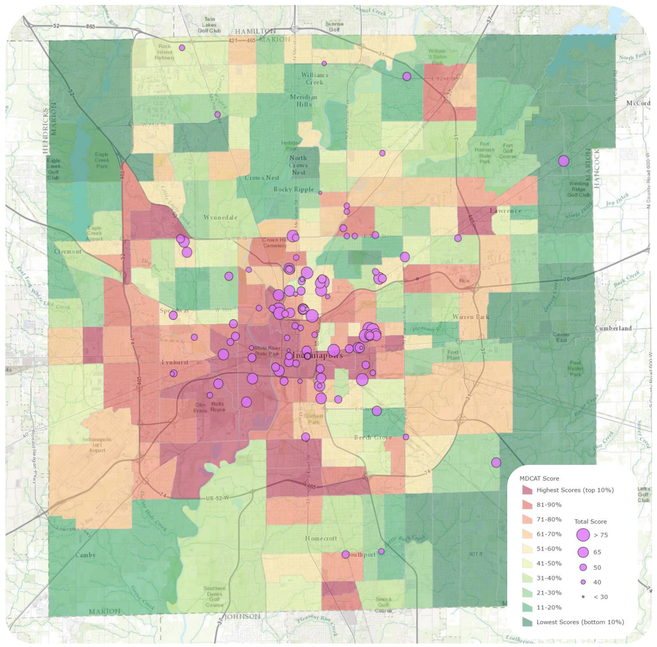
* $p < .05$.
** $p < .01$.
*** $p < .001$

Table 3
Results of t-test and Descriptive Statistics MDCAT Indicator Scores by Site Remediation

	Site Remediated						95% CI for Mean Difference		
	Yes			No					
	M	*SD*	n	*M*	*SD*	n		t	df
MDCAT Index	42.04	14.23	58	42.33	12.91	53	-5.41, 4.84	-.112	109
Unemployment	45.93	28.34	58	56.14	25.71	53	-20.41, .008	-1.989*	109
Poverty	62.37	23.20	58	68.45	25.29	53	-15.20, 3.04	-1.321	109
Linguistic Isolation	54.63	28.99	58	60.12	27.13	53	-16.08, 5.10	-1.028	109
Education	56.90	28.42	58	65.70	31.40	53	-20.05, 2.44	-1.552	109
Low Birth Weight Infants	56.67	31.61	58	55.09	29.04	53	-9.88, 13.03	0.272	109
Age	35.14	31.19	58	36.61	27.91	53	-12.65, 9.71	-0.261	109
SO_2	46.14	27.77	58	55.95	25.54	53	-19.87, 2.65	-1.93	109
PM 2.5	63.21	25.41	58	51.47	28.59	53	1.58, 21.96	2.291*	109
Diesel PM	65.83	30.68	58	64.98	25.63	53	-9.8, 11.53	0.156	109
Toxic Releases	69.04	27.70	58	63.94	27.02	53	-5.10,15.41	.983	109
Traffic Density	53.63	19.47	58	39.01	24.44	53	6.33, 22.99	3.409*	109
Cleanup Sites	59.85	35.74	58	53.22	38.49	53	-7.34, 20.60	0.941	109
Groundwater Threats	56.14	34.44	58	54.98	36.01	53	-12.13, 14.41	.172	109
Hazardous Waste	6.50	22.27	58	4.12	16.75	53	-4.99, 9.77	.634	109

* $p < .05$.

Total MDCAT Score for Census Tracts With Brownfield Prioritization Scoring



Map 2: Location and Prioritization score of The 111 Brownfield Sites in Marion County, Indiana. Census tracts that are most Red have a higher MDCAT Index and are more environmentally vulnerable. The largest "bubbles" are the sites in the most need of remediation.

Discussion and Conclusion

The results describe Indianapolis as a city where environmental injustice is very much a concern.

- Where a Brownfield site is located and the severity of the Brownfield site is impacted by social indicators.
  - The single sample T-tests describes how Brownfield sites are more likely to be present in census tracts where the populations is more poverty-stricken, less educated, at risk for LBW infants, and less able to communicate.
  - Results of the Pearson correlation coefficient test also demonstrated that there is a relationship between the Brownfield prioritization score and both education and poverty.

Additionally, the results describe how the accumulation of pollution factors can result in environmental vulnerability.

- The results demonstrate that census tracts with brownfield sites are more likely to have higher rates of PM 2.5, Diesel PM, and toxic releases from facilities.

The intention of conduction the independent t-tests was to determine if brownfields in areas with less vulnerability were being prioritized for remediation.

- Results demonstrated that this was not the case; there was no significant difference in MDCAT index scores for remediated and unremediated sites.
- Brownfield sites were less likely to be remediated if in a census tract with high unemployment rates.
- Brownfields were more likely to be remediated if they were present in areas with more traffic density.

Limitations

- A main limitation for this study is that the presence of a brownfield in a census tract has a role in the scoring of the MDCAT index score, as well as the cleanup site and groundwater threat indicators.
- Additionally, the definition of remediation is ambiguous. Whether a site was considered remediated is based on interpretation of the author, considering the current site use and site characteristics.

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