

# **Using GIS to Contrast Perceived Versus Preferred Priorities for Brownfield Redevelopment in Worcester, MA**

URISA Student Paper Competition Entry

Submitted by

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# **Using GIS to Contrast Perceived Versus Preferred Priorities for Brownfield Redevelopment in Worcester, MA**

## **ABSTRACT**

This paper compares the perceived priorities of decision-makers with the stated desires of stakeholders concerning brownfield redevelopment in the City of Worcester, MA. Redeveloping brownfields left over from Worcester's industrial past is held as a critical strategy for the future of this city in central Massachusetts. However, the goals of this strategy vary across stakeholder groups. Key informants were surveyed regarding their perceptions of brownfield redevelopment. An inventory of Worcester brownfields was created from Massachusetts Department of Environmental Protection records. A multicriteria evaluation was carried out through Geographic Information Systems. This study found that while economic development and job creation are the apparent focus for one set of influential decision-makers, protection of natural resources and public health are important to another group of stakeholders. The outcomes for each end-use objective were examined to determine whether the goals for each could be met while focusing on only one redevelopment strategy. Results reveal the land parcels that satisfy the objectives for only one group, both groups, or neither group. Previously redeveloped sites were evaluated based on the same criteria to determine the extent to which existing and preferred priorities had been satisfied with these revitalization efforts. The results show that focusing on perceived priorities will not accomplish preferred objectives for brownfield redevelopment in Worcester.

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# 1 INTRODUCTION

## 1.1 Research Rationale

In recent years, brownfield redevelopment has come to be viewed as a strategy for sustainable land use and urban revitalization (BenDor and Metcalf 2005). The costs associated with not mitigating and redeveloping brownfields, apart from long term health risks, include loss of tax revenues and a decrease in density of economic activity in urbanized areas (Meyer 2003). Urban sprawl into outlying green spaces, a hollow urban core, and redundant infrastructure are byproducts of ignoring brownfields. Redeveloping brownfields left over from Worcester's industrial past is held as a critical strategy for the future of this city in central Massachusetts. With a finite supply of land within city boundaries, reclaiming brownfields is an important strategy for economic growth. Expansion of the tax base is necessary for the city to have the resources to meet the challenges inherent in an urban environment. Reclaiming brownfield sites will have a major impact on future economic growth and reclamation of neighborhoods (Kotsopoulos 2001). Worcester has had success in the past at redeveloping contaminated sites, such as the downtown hospital complex, often relying on public/private partnerships to advance projects. Brownfield redevelopment has been a priority issue within city government. The mayor has commissioned a Brownfields Roundtable to bring together local environmental, financial and development professionals to continue the success (Nemeth 2005). The Roundtable has lobbied successfully on behalf of brownfields legislation. However, the goals of the brownfield redevelopment strategy vary across stakeholder

groups in the city. McCarthy (2002) noted that residents in neighborhoods with brownfields preferred recreational and community facilities and affordable housing as end-uses for the properties. There is a divide between community members and the government, whose primary goals for brownfield redevelopment include increased jobs and tax base. This research examines the difference between stakeholder priorities and addresses the question of whether perceived priorities serve preferred objectives for brownfield redevelopment in the City of Worcester.

## **1.2 Literature Review**

Issues for consideration in brownfield redevelopment are documented in the literature. Categories of costs associated with brownfields, both related to cleaning and leaving alone, are explored in Meyer (2003). Alberini et al. (2005), used pair wise comparisons of hypothetical brownfields with different policy mixes to explore the differences between those developers with experience in brownfields and those with none as to which policies are attractive as incentives to promote redevelopment. The importance of an accurate inventory to help track the impact of redevelopment projects in the community was the impetus behind Coffin (2003) discussing the development of a database of brownfield properties. Moo-Young and Alattar (2003) included a site selection survey used in Pennsylvania to rank brownfields for potential redevelopment. The criteria used relate to transportation access, infrastructure, zoning, size of parcel, and previous reuse efforts. The conclusion reached by Leigh (2002), that brownfield redevelopment rates in poverty neighborhoods are lower than for non-poverty, suggested

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the need to increase redevelopment in poverty neighborhoods to reduce a trend toward widening inequalities.

Researchers have utilized Geographic Information Systems (GIS) for brownfield decision making. Boott (2001) emphasized data collection and a participatory process in establishing a GIS for brownfields, concluding that the development process should be iterative. A Brownfield Site Ranking Model, utilizing Smart Places® ArcView® extension, was created by Thomas (2002) for selecting sites for potential redevelopment. That research discussed the importance of knowing user needs in relation to the brownfields, obtaining site specific data to differentiate between brownfields and having specific indicators and measurable criteria for ranking the sites. Rocco et al. (2002) provide a methodology for decision making regarding brownfield property reuse, including the kinds of data needed to make useful decisions. Risk profiles and factor weights are considered in the process through the use of GIS. Internet-based GIS applications were part of the strategy in redeveloping brownfields in Emeryville, CA (Dayrit et al. 2002). Choosing target parcels for redevelopment in an inner city, based on particular objectives and criteria, was the focus of Simons and Salling (1995). The paper presented a methodology for using GIS as a decision-support tool in the planning process. Milionis et al. (2000) applied GIS to the issue of brownfields redevelopment as they performed a risk assessment for human health and analyzed site suitability for a particular reuse using weighted scores.

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The literature suggests that more than economic benefits are available with brownfield redevelopment. Broadening the revitalization focus to include a greater mix of land uses can help bring a higher quality of life to urban areas with brownfields. Creating green spaces out of brownfields can complement other types of redevelopment, such as the more typical commercial or industrial, on nearby properties (DeSousa 2006). Lack of integration between public health and the physical environment has been suggested as one reason behind the obesity epidemic in the United States. Redeveloping a brownfield in a neighborhood can improve the neighborhood and people's health whether jobs or green spaces are created (Black 2000). Redeveloping brownfields into new housing is one strategy for reducing crime and incivilities in neighborhoods (Brown et al. 2004). Environmental justice and health disparities can be addressed through brownfield redevelopment depending on which sites are prioritized for redevelopment. As such, brownfield redevelopment is critical to urban revitalization. Public health benefits and successful neighborhood redevelopment can be achieved when public health is part of the decision making process for brownfield redevelopment (Litt et al. 2002). Brownfields redevelopment is an effective smart growth policy. Both the environment of the urban core and outer greenfields can benefit from redeveloping brownfields (Greenberg et al. 2001).

Constructing urban green space is one alternative for brownfields. A major barrier to choosing green space as an end-use is the view that economic growth is not an expected outcome of the project. Creating green space out of brownfields can enhance the

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economic and social appeal of a blighted area. While justifying a non-commercial end-use is more difficult, turning brownfields into green space is more easily accepted in the affected community (DeSousa 2003). Research findings indicate that concerns over exposure to contamination are not raised by citizens when a brownfield is turned into a green space (DeSousa 2006). Greening opportunities can be more easily identified when inventories of brownfields and green space are established. Both public and private sector funding is necessary for this kind of revitalization.

A diverse redevelopment strategy must be pursued to allow for a mix of end-uses. Most redevelopment projects focus on a single brownfield property; considering a wider area in the redevelopment strategy takes into consideration the benefits of off-site development and investment. Meyer (1998) holds that off-site benefits may add support to make projects more feasible. In addition, an area-wide perspective helps to connect brownfield policy to broader economic development efforts. McCarthy (2002) states that government initiatives should focus on redeveloping the least viable sites instead of spending money on sites more likely to be taken up by private developers. The most common brownfield sites in the U.S., according to Johnson (2002), are the small, abandoned lots that bring blight to the neighborhood. There is little incentive for cleaning up these sites, but big effects to the impoverished neighborhoods if done. Promoting the redevelopment of smaller brownfield sites which are scattered around the urban landscape should be the focus of local governments (Meyer and Lyons 2000). Improving infrastructure and services in affected neighborhoods may assist in drawing

developers who would combine the smaller brownfield sites with surrounding properties for redevelopment. Thus, entire neighborhoods might be revitalized.

Community involvement in brownfield projects is important to the success of the project. Brownfield redevelopment is a complex process that can extend over a long period of time. Early community involvement can help to secure critical benefits to their neighborhoods (Bartsch and Dorfman 2000). Economic return has often been the measure of success in brownfield revitalization. The National Brownfields Environmental/Community Caucus (1999) recommends broadening the definition of success to include improvement in public health, creation of ownership opportunities for the community and enhancement of the quality of life in neighborhoods containing brownfields. Meaningful brownfield redevelopment includes incremental change in communities and requires the efforts of public agencies, community groups, developers and funders.

### **1.3 Research Location**

The study area under consideration is the City of Worcester, MA, USA. Located in central Massachusetts, the population of Worcester is approximately 180,000 making it the second largest city in New England. It covers about 98 square kilometers. Worcester contains several institutions of higher learning and a burgeoning biotechnology industry. The history of the city includes many innovations in manufacturing. It is the legacy of this industrial past that is evident in the many brownfields in Worcester. City

government considers brownfield redevelopment a key issue. A Mayor's Brownfields Roundtable exists to promote redevelopment and influence legislation. This paper examines the current priorities for brownfield redevelopment and whether the variety of views of all stakeholders is represented in those priorities.

## **2 METHODS**

### **2.1 Data**

Several sources supplied the data for this study. The City of Worcester GIS Section of the Technical Services Division provided the majority of the data related to city infrastructure. The Office of Geographic and Environmental Information (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs provided data related to environmental justice, aquifer location and colleges and universities ([www.mass.gov/mgis/massgis.htm](http://www.mass.gov/mgis/massgis.htm)). Brownfield information was obtained through the Massachusetts Department of Environmental Protection (MassDEP) website ([www.mass.gov/dep/cleanup/sites/sitelook.htm](http://www.mass.gov/dep/cleanup/sites/sitelook.htm)). Additional data associated with crime and current development was derived from facts on the City of Worcester official website ([www.ci.worcester.ma.us](http://www.ci.worcester.ma.us)). The Census Bureau was the source for some demographic statistics ([http://factfinder.census.gov/home/saff/main.html?\\_lang=en](http://factfinder.census.gov/home/saff/main.html?_lang=en)).

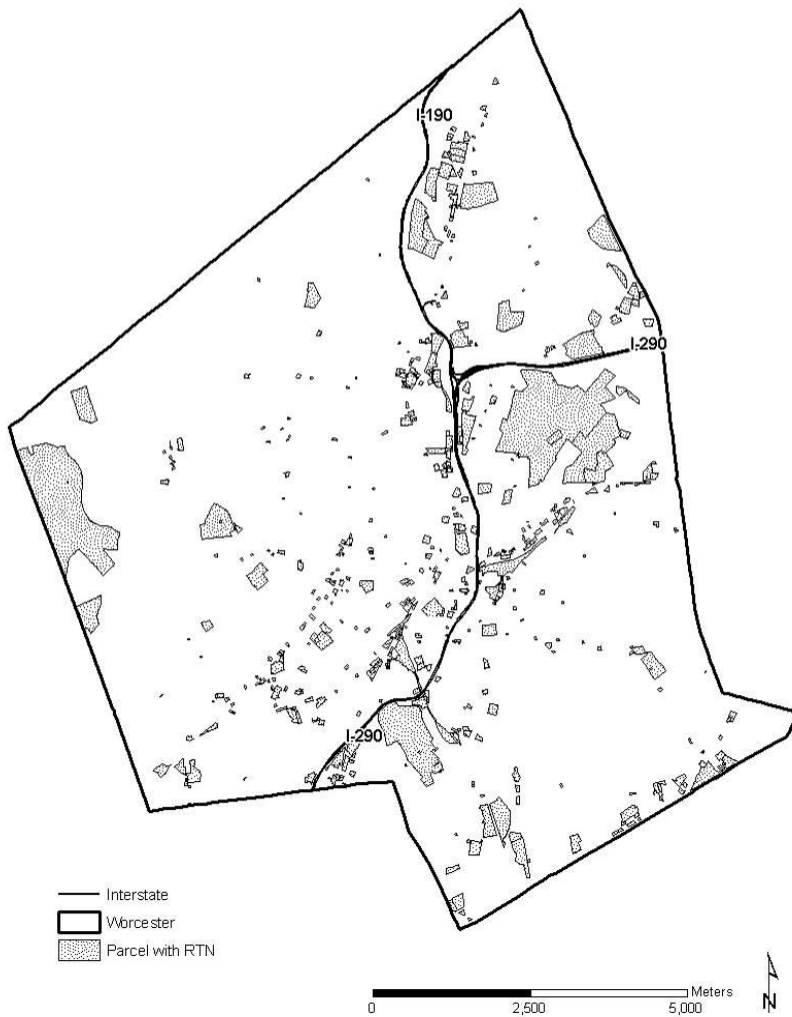
## Using GIS to contrast perceived versus preferred priorities

Data were initially processed in the ArcGIS® software. All layers were projected in NAD 1983 State Plane Massachusetts Mainland with a distance unit of meters. A list of layers can be viewed in Table 1.

<b>Factor in Survey</b>	<b>GIS Layer(s)</b>
Interest by an investor	Parcel size, Location of colleges & universities
Economic development	Vacant commercial/industrial & residential parcels, Abandoned buildings, Tax title properties
Proximity to major roads or highways	Interstate exits, Railroads
Severity of contamination	MassDEP status codes
Current development in surrounding area	Cultural & Development hotspots
Community support	Community Development Corporations
Public health	Aquifer location
Zoning	Residential, Commercial/Industrial zoning
Protection of natural resources	Water features, Parks, Community gardens
Adjacency to vulnerable populations	Environmental Justice Zones, Schools, Children & Elderly
Crime prevention	Percent of total incidents per Police Statistical Area

**Table 1. GIS layers that represent factors in survey.**

For this study, brownfields are defined as properties with a Release Tracking Number (RTN) as assigned by MassDEP. The 485 brownfields being considered in this study are pictured in Figure 1.



**Figure 1. Brownfield parcels (n=485) in Worcester, MA that were prioritized in this study.**

## **2.2 Procedure**

**2.2.1 Survey** The first stage of the research was to administer a survey. The anonymous survey (Figure 2) was given to the volunteer participants of the Mayor's Brownfield Roundtable at a regular monthly meeting.

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This survey is to gather input from professionals involved in brownfield redevelopment to include in my **Clark U. graduate IDCE research**. In the redevelopment of brownfields, many factors or criteria can be considered to influence the attractiveness of the project. For the following two questions, I'm looking for your opinion on what drives brownfield redevelopment in the City of Worcester. (**You may leave any question unanswered.**)

**Please use a scale of 1-10 (1=least, 10=most) to rate each factor.**

What influence has the factor had on promoting brownfield redevelopment in Worcester?	Factor	In your opinion, what influence <b>should</b> the factor have in promoting brownfield redevelopment?
_____	Protection of natural resources	_____
_____	Severity of contamination	_____
_____	Community support	_____
_____	Adjacency to vulnerable populations	_____
_____	Current development in the surrounding area	_____
_____	Proximity to major roads or highways	_____
_____	Zoning	_____
_____	Interest by an investor	_____
_____	Crime prevention	_____
_____	Economic development	_____
_____	Public health	_____

Is there a different factor that you would add to this list? \_\_\_\_\_  
 How would you rate this? \_\_\_\_\_

*This survey is voluntary. Your responses will remain anonymous.*

*\*Please do not include any identifying information on the survey.\**

**Participant responses cannot be traced back to participants.**

**Please return the survey at the end of the meeting to the folder on the table.**

Thank you for your time and input!

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**Figure 2. Survey instrument administered to Mayor's Brownfield Roundtable.**

Government officials, legal professionals, environmental and regulatory experts concerned with the brownfield issue in the City of Worcester are part of the Roundtable. Approximately 50% of those in attendance completed the survey, which resulted in 8 responses. The survey gauged perceptions regarding brownfield redevelopment priorities

in Worcester. Respondents were asked to rate 11 factors in two different ways. First, factors were rated, on a scale of 1 – 10, according to their perceived current influence on redevelopment in Worcester. Secondly, the same set of factors were rated according to what influence the respondents' preferred. Additional stakeholders were interviewed to understand their priorities for brownfield redevelopment in Worcester. Academic researchers, an environmental activist and government official not involved in the Mayor's Brownfield Roundtable shared their views on redevelopment priorities.

**2.2.2 GIS Layers** Next, survey factors were translated into GIS layers. The literature and expert opinion suggested factors to include in the study. Layers were chosen to represent the range of criteria from economic factors to quality of life issues. All GIS layers were created with publicly accessible data. Initial data processing occurred in ArcGIS® software. Prepared vector layers were imported into Idrisi® Andes. Vector files were rasterized. A resolution of 20m<sup>2</sup> was chosen based on sizes of known brownfields; a majority of brownfields would be larger than one pixel with this resolution. Additional processing of the raster layers, included reclassing values or calculating distance from features, prepared the data for multi-criteria evaluation.

**2.2.3 Multi-Criteria Evaluation** Multi-criteria evaluations were executed in Idrisi®. First, raster layers were standardized on a 0-255 scale with 255 indicating highest suitability. Standardization methods included using fuzzy set membership functions (Jiang, 2000). Control points for these functions were derived from various sources. A spatial join with previously redeveloped brownfields was used to determine

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distances to features such as highway exits to use for control points. Relevant literature suggested important cutoffs for parcel size and contamination severity, for example. Massachusetts water supply regulations informed the choice of control points for the public health criterion.

Factors were weighted using a pairwise comparison process (Eastman 2006). A factor was scored based on its relative importance to each other factor. Survey ratings guided the decisions made in the pairwise comparison process. Weights were calculated for the two objectives: perceived redevelopment practices and preferred redevelopment practices. Weights derived using perceived influence ratings are listed in Table 2. The weights derived using the preferred influence ratings are documented in Table 3.

<b>Survey Factor</b>	<b>Survey Ranking</b>	<b>Weight</b>
Interest by investor	1	0.1810
Economic development, perceived practice	2	0.1608
Proximity to transportation	3	0.1365
Severity	4	0.1229
Current surrounding development	5	0.0961
Community support	6	0.0890
Public health	7	0.0768
Commercial/Industrial Zoning	8	0.0603
Protection of natural resources	9	0.0409
Adjacency to vulnerable populations	10	0.0232
Crime	11	0.0126

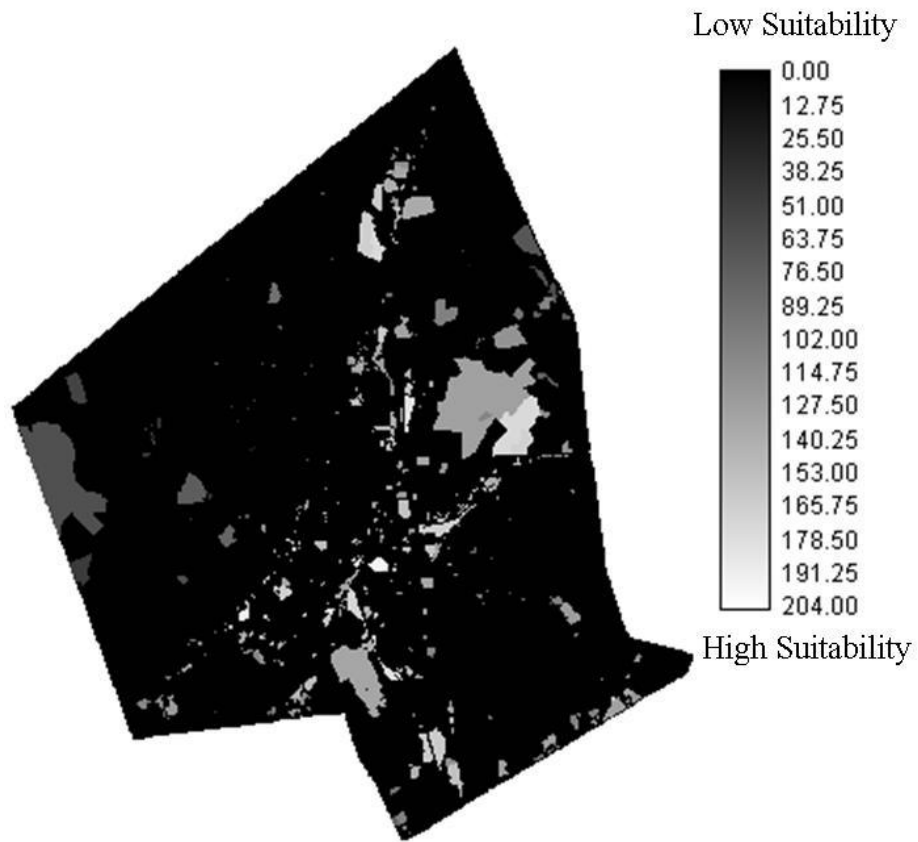
**Table 2. Weights assigned to each factor based on perceived influence survey results.**

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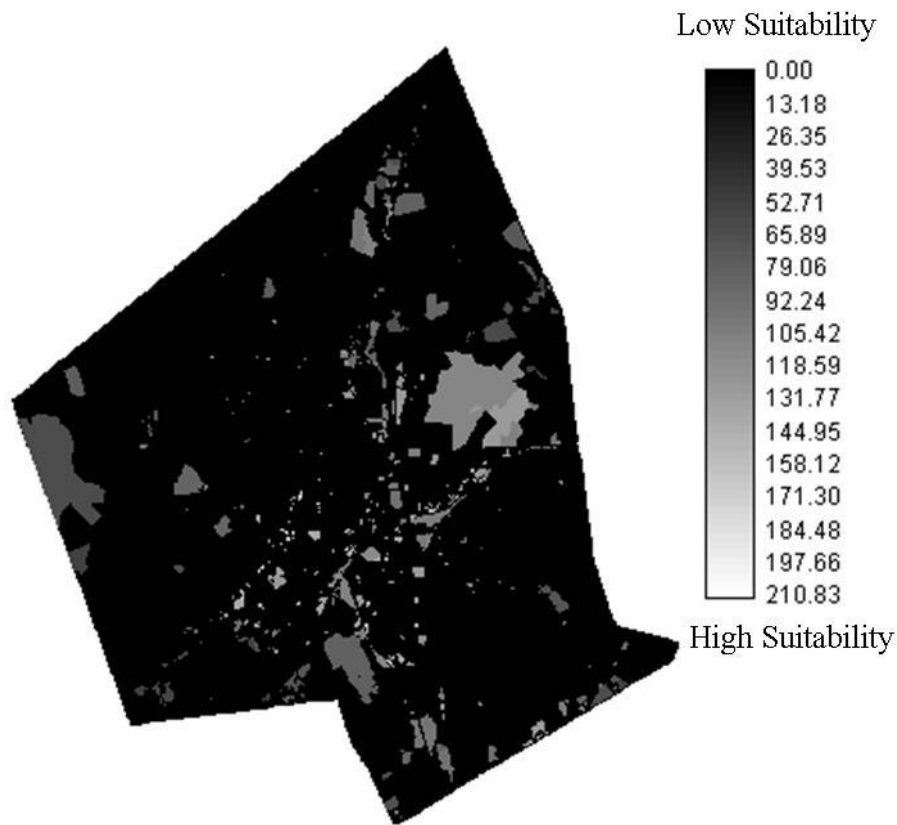
<b>Survey Factor</b>	<b>Survey Ranking</b>	<b>Weight</b>
Economic development, Preferred Practice	1	0.1482
Interest by investor	2	0.1399
Current surrounding development	3	0.1192
Adjacency to vulnerable populations	4	0.1062
Community support	5	0.0974
Proximity to transportation	6	0.0974
Severity	7	0.0869
Protection of natural resources	8	0.0678
Public health	9	0.0678
Residential Zoning	10	0.0397
Crime	11	0.0296

**Table 3. Weights assigned to each factor based on preferred influence survey results.**

These weights represent the importance assigned to each factor based on survey ratings. Standardized factors were aggregated with the derived weights through a weighted linear combination for each objective. The average of all pixel suitability scores within each brownfield was extracted and assigned as the suitability score for the entire brownfield. Suitability scores for brownfield redevelopment were calculated twice, first according to the perceived practice objective (Figure 3) and second based on the preferred practice objective (Figure 4).



**Figure 3. Multi-Criteria Evaluation results for perceived practice objective. Black color indicates areas that are not brownfields. Larger values indicate higher suitability for redevelopment.**



**Figure 4. Multi-Criteria Evaluation results for preferred practice objective. Black color indicates areas that are not brownfields. Larger values indicate higher suitability for redevelopment.**

Twelve previously redeveloped brownfield parcels were also evaluated. Each was assigned a suitability score based on the multi-criteria evaluations for perceived and preferred objectives to use in analysis.

**2.2.4 Display and Analysis** Display of results was accomplished in ArcGIS®. Two maps of suitability scores for each brownfield were created. One map contained the scores for the perceived practice objective and the other for the preferred practice

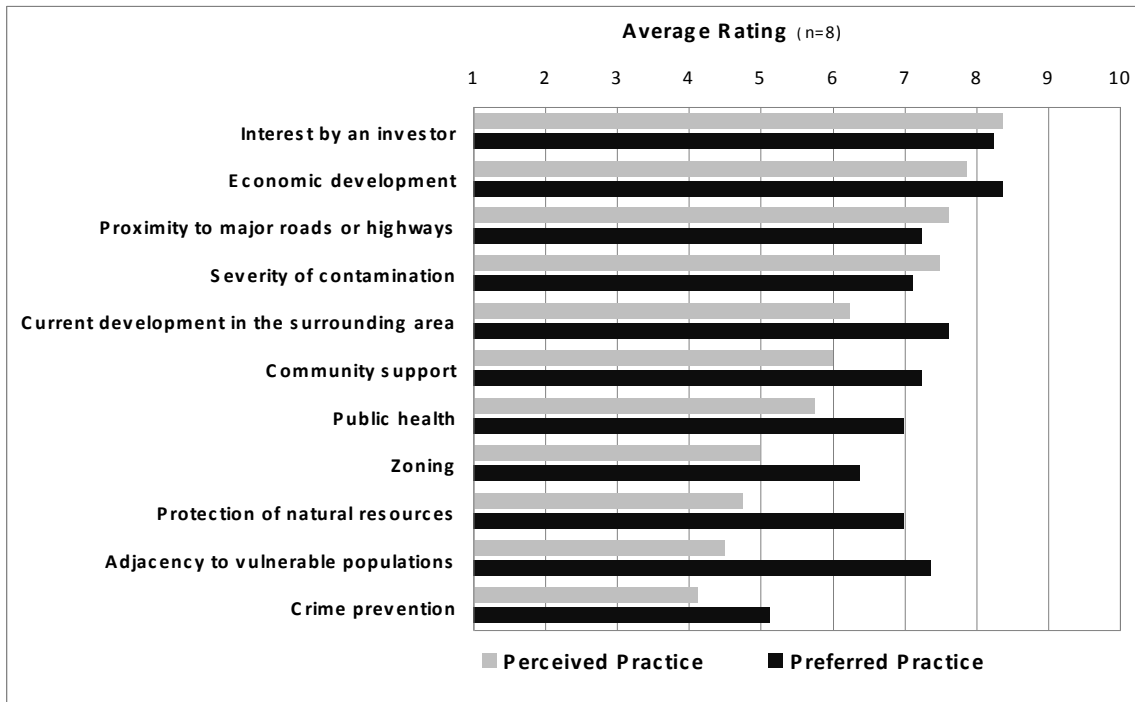
objective. Brownfields were ranked based on suitability scores with 485 indicating highest suitability for redevelopment and 1 indicating lowest suitability score.

Various analyses on the results were completed. Ranks from the perceived practice were plotted against ranks from preferred practice to test for associations between the ranks. The suitability scores for previously redeveloped brownfields were compared to scores of existing brownfields to understand how the different objectives were met by the revitalized properties. A regression analysis was performed to determine which factors had the most influence on the difference in ranks between objectives. The difference between ranks for each brownfield (preferred ranking minus perceived ranking) was the dependent variable. The predictor, or independent, variables in the regression were the standardized factor maps.

### **3 Results**

The survey results show that perceived current practice and preferred practice for brownfield redevelopment are different. A bar chart summarizes the survey results, illustrating the average rating each factor received for perceived and preferred influence on redevelopment (Figure 5).

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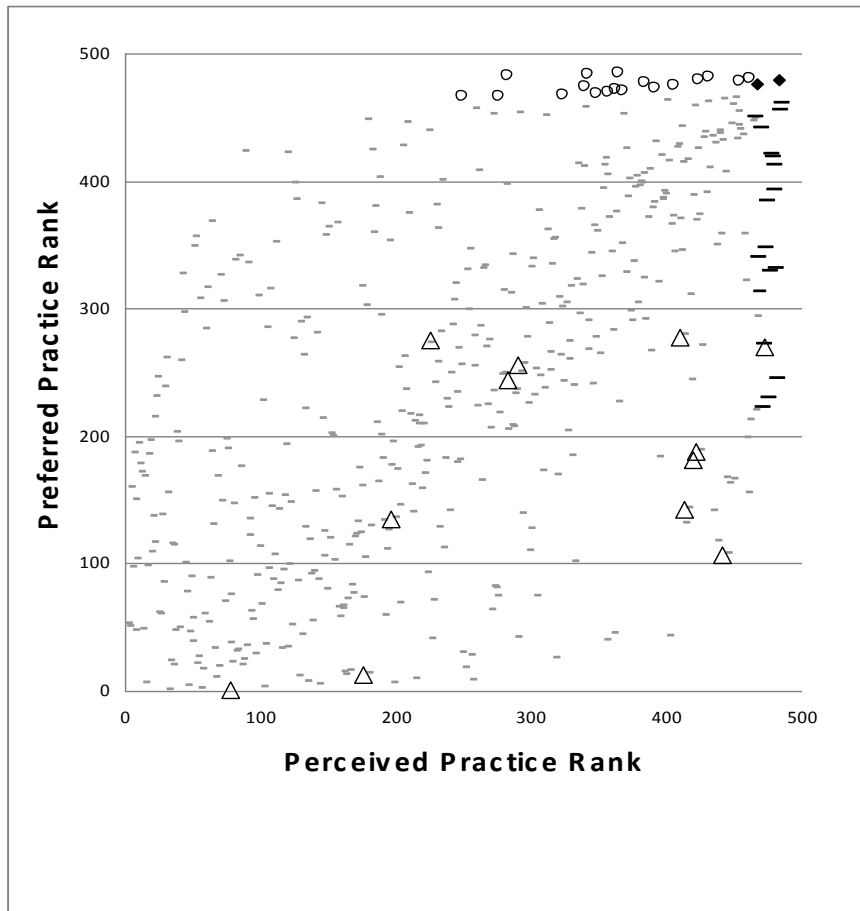


**Figure 5. Comparison of average ratings for perceived practice versus preferred practice for brownfield redevelopment as obtained through survey.**

Factors related to economic development received the highest ratings according to their perceived influence on brownfield redevelopment. Factors related to quality of life, such as public health and protection of natural resources, received a lower average rating based on perceived current brownfield redevelopment practice. Quality of life factors received a higher average value when respondents rated based on preferred practice for redevelopment. Economic factors were still among the top rated influencers for this objective (Table 3). However, the difference in ratings between all factors was less for preferred than perceived practice.

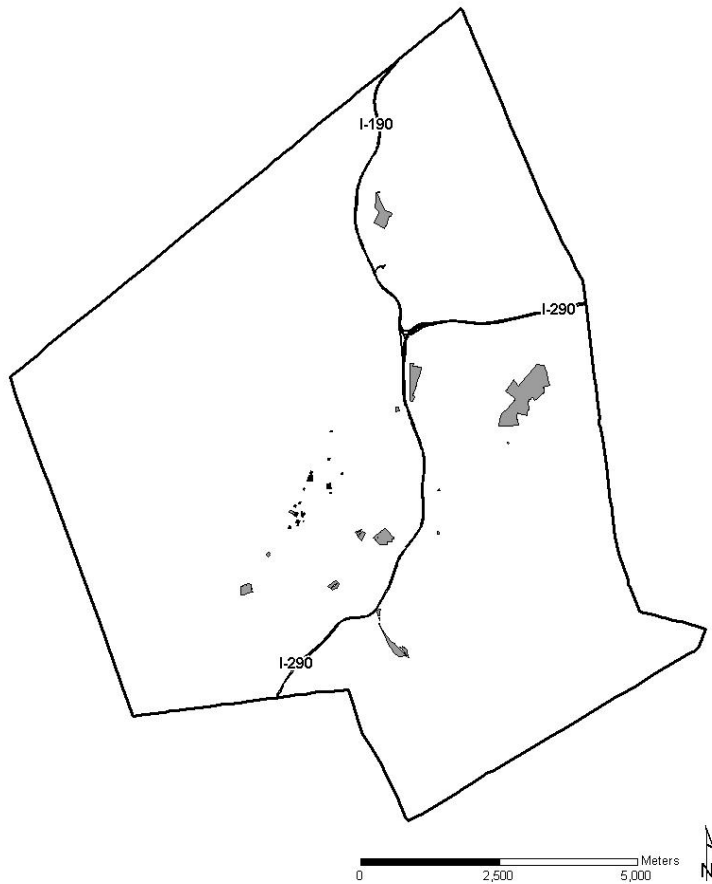
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Conversations with other stakeholders revealed a similar dichotomy. While economic development and job creation are the apparent exclusive focus for one set of influential decision-makers, protection of natural resources and public health are of primary importance to another group of stakeholders. A plot of ranks revealed a lack of tight correspondence of the ranks of brownfields based on perceived practice and the ranks of brownfields based on preferred practice (Figure 6). The top twenty ranked brownfields for each objective showed two brownfields overlapped the objectives (Figure 6).








**Figure 6. Scatterplot of perceived versus preferred ranks with top twenty ranked parcels and previously redeveloped brownfields highlighted. Each dot represents one brownfield parcel.**

Maps of the top twenty brownfields were created (Figures 7 and 8).



**Top Twenty Brownfield Parcels**

-  Perceived Practice Only
-  Preferred Practice Only
-  Perceived and Preferred
-  Interstate
-  Worcester







**Figure 7. Twenty brownfield parcels with highest suitability scores for redevelopment for each objective, Worcester extent.**

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The top twenty brownfields according to perceived practice were generally larger parcels along interstate corridors (Figure 8). The top twenty brownfields according to preferred practice were clustered together farther from the interstate corridors (Figure 9).



### Top Twenty Brownfield Parcels

-  Perceived Practice Only
-  Preferred Practice Only
-  Perceived and Preferred
-  Interstate
-  Major Road
-  Worcester

**Figure 8. Top twenty ranked brownfield parcels, zoom in on figure 7.**



**Top Twenty Brownfield Parcels**

- Perceived Practice Only
- Preferred Practice Only
- Perceived and Preferred
- Major Road

**Figure 9. Close up of top twenty ranked brownfield parcels based on preferred practice objective.**

A statistical analysis illuminated the top factors influencing the difference in rankings between objectives. The difference in ranks (preferred minus perceived) was regressed against all factors. The first four factors added into the equation in a forward stepwise regression ( $\alpha = 0.05$ ) were 1) transportation factor for preferred practice ( $\beta = 0.671$ ), 2) vulnerable populations ( $\beta = 0.326$ ), 3) residential zoning ( $\beta = 0.300$ ), 4) economic

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development factor for perceived practice ( $\beta = -0.234$ ). A positive  $\beta$  coefficient means that an increase in the factor score causes an increase in the difference between ranks. A negative  $\beta$  coefficient means that an increase in the factor score causes a decrease in the value of preferred minus perceived rank.

Suitability scores for previously redeveloped brownfields were derived using the same multi-criteria evaluations. The twelve previously redeveloped brownfield parcels were overlaid with the top ranked brownfields prioritized in this study (Figure 10).



**Figure 10. Overlay of previously redeveloped brownfield parcels with twenty current brownfield parcels with highest suitability scores for redevelopment based on perceived and preferred objectives.**

Ranks received by the previously redeveloped brownfields based on perceived practice were plotted against ranks based on preferred practice (Figure 6). The redeveloped

brownfield with the highest suitability score based on the perceived objective ranked in the top twenty (472/485). None of the previously redeveloped brownfield sites received a suitability score based on preferred practice that was high enough to rank in the top twenty; the previously redeveloped brownfield with the highest suitability score based on the preferred objective ranked 280/485.

## **4 DISCUSSION**

### **4.1 Interpretation**

Brownfields redevelopment has varying goals dependent on the stakeholder. The perceived practice in the City of Worcester leans more to economic development and job creation. Stakeholders in the City desire for quality of life issues to be addressed through brownfield redevelopment. Yet, the current focus will not achieve both economic development and quality of life objectives. The results show that highly ranked sites based on preferred objectives are not associated with highly ranked sites based on perceived objectives.

### **4.2 Further research**

Multi-criteria evaluation in GIS can be used for focusing stakeholders on the issue. With the results of this research, the next step would be to get stakeholders together for discussion. Many questions should be raised. What should be the definition for brownfields? Which factors should be represented with different data? Are there factors

that are missing? Are the factors standardized and weighted appropriately? What kind of trade-off exists between different factors? Answers to these questions will guide the next steps for this research.

## **5 CONCLUSIONS**

This research has shown that exclusive focus on the perceived priorities would not meet the broader list of preferred objectives for brownfield redevelopment in the City of Worcester. Brownfield redevelopment is a critical issue in post-industrial Worcester. However, the goals of the brownfield redevelopment strategy vary across stakeholder groups in the city. If the government will represent all of its constituents, it must consider a broader set of criteria for prioritizing properties. Perhaps new partnerships between the Mayor's Brownfields Roundtable and other key players in the City can help to achieve brownfield redevelopment results that would be considered successful across disparate stakeholders.

## **ABOUT THE AUTHOR**

The author received her MA in Geographic Information Sciences for Development and Environment from Clark University in May 2008. She earned a BS in Atmospheric Science from Purdue University and MA in Teaching from Fairfield University.

Currently, the author is working as a GIS technician for the City of Worcester, MA. She is also chair of the GIS subcommittee of the City of Worcester Mayor's Brownfield Roundtable.

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