Transit-Oriented Brownfield Redevelopment

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Abstract

Brownfield properties are properties wherein future use is inhibited either by the presence or perceived presence of harmful pollutants. As a consequence, these properties are difficult to develop and prospective developers require sufficient positive incentives in order to be attracted to these projects. To investigate the extent to which public transit can act as an amenity for these properties, this study examines the relationship between commuter rail transit stations and brownfield property redevelopment rates in Mecklenburg County, NC using both a linear probability model and a propensity score matching approach. The analysis results indicate that there is indeed a relationship between light rail and brownfield redevelopment, but the direction of the relationship depends on the analysis technique used.

Introduction

In order to fulfill the desires for economic growth, municipal and state governments must be simultaneously creative in their incentive programs to developers and entrepreneurs but also meticulous in their assurance that all community members may benefit, so that the growth might be sustained. Changes in the rate of brownfield redevelopment may thus serve as a measurement of the pervasiveness of such economic stimulus, as these sorts of properties are less likely to benefit from any positive financial interests. This is true by definition, as any property, the expansion, redevelopment, or reuse of which might be complicated by the presence of a hazardous material, is considered a brownfield. The EPA estimates that there are more than 450,000 such sites within the United States. Research has shown that in addition to the environmental benefits, the remediation and ultimate reuse of these brownfield sites yields significant economic benefits to the surrounding areas, stimulating a positive feedback cycle that can multiply the effectiveness of scarce city funds in promoting development in target areas (De Sousa et al. 2009).

The purpose of this article is to investigate to what extent the construction and operation of commuter light rail stations can stimulate brownfield redevelopment within Mecklenburg County, North Carolina. Specifically, the article seeks to address the following research questions: First, does the construction and operation of commuter light rail increase the likelihood at which brownfield properties will be redeveloped? Second, is this relationship between commuter light rail and brownfield redevelopment linear with respect to distance?

To answer these questions, this study constructs a dataset from materials made available by the North Carolina Department of Environmental Quality (NCDEQ). Variables characterizing a property's assessed value, level of pollution, valuation changes over time, and distance to rail are collected. This dataset is then analyzed using two econometric techniques – a linear probability model and a propensity score matching technique – in order to assess the sensitivity of the results to model specification.

The novel consideration presented by this paper that has not been previously addressed in the brownfield redevelopment literature is that regarding non-linear effects of distance to rail on redevelopment. The procedure follows that outlined in (Irwin N et al 2017), and involves the calculation of non-overlapping rings around each transit station. The theoretical justification for this approach is that the externalities associated with a transit station, such as increased mobility and inter-connectedness to other areas of the city, vary at certain recognizable distance thresholds. Perhaps most importantly, a distance of 0.75km represents about a 10 minute walk on average, and so it is likely that distances beyond this point are less attractive for pedestrian travel, and may be where the observed treatment effect of proximity to light rail begins to alter.

The results are mixed, as the linear probability model results suggest that brownfields nearer transit stations are in fact less likely to redevelop, with a 33.4% lower probability of redevelopment than those properties farthest away. The linear probability model results also strongly suggest that the effect of proximity to rail is nonlinear. On the other hand, the results from the propensity score matching technique suggest that brownfields closest to transit stations are 8.7% more likely to redevelop than those farthest away. The primary contribution of this research is the generation of further evidence to a perplexing section of the literature commonly confounded by insufficient sample sizes and questions of external validity.

Background: North Carolina's Brownfield Redevelopment Process

For a prospective developer of a brownfield site, the pre-development phase is the riskiest step of redevelopment. This is because they must invest a certain amount of capital into investigating the level of contamination within the property and estimating potential costs of remediating those contaminants. Once the level of contamination is identified, prospective developers also face uncertainty in financing efforts, as lenders may be wary of who will be held liable for the contaminants' presence in the first place. If a lender has reason to believe that the redevelopment process will be brought into jeopardy from this, they may be less likely to provide financing. It is for this reason that the NCDEQ decided to build their brownfield redevelopment program around a brownfield agreement between the department and any prospective developer.

A brownfield agreement is essentially a covenant not-to-sue offered to a prospective developer by the NCDEQ. This allows the prospective developer to restrict their liability for remediation to only those specific actions outlined in the agreement, as opposed to a more open-ended liability for environmental cleanup. By having a clearly defined limit of liability, prospective developers greatly reduce the level of uncertainty inherent to a brownfield property remediation, and so reduce the level of risk to which a lender would have to expose themselves to.

However, in order to qualify for a brownfield agreement, the prospective developer must submit an application (with the associated fee) that articulates the measures that will be taken to preserve public health, the intentions for reuse, and the level of public benefit generated by the completion of the redevelopment process. Specifically, The Brownfields Property Reuse Act of 1997. (1997-357, s. 2.) requires that the level of public benefit generated by the project be commensurate with the value of the liability protection provided. Examples of acceptable public benefit include such factors as economic revitalization of an area, job creation, increased office space, as well as environmental benefit. An unacceptable level of public benefit would be if a prospective developer sought to redevelop a brownfield property into a parking area/garage for private purposes.

Lastly, as the NCDEQ seeks to promote the redevelopment of as many properties as possible, for public health and economic growth purposes, an additional incentive is present in the form of a 5-year property tax exclusion. For properties wherein the developer has entered into a brownfields agreement, completed the agreed-upon improvements, and submitted an application for the tax exclusion, the North Carolina Department of Revenue agrees to exclude 90%, 75%, 50%, 30%, and finally 10% of the tax liability on the appraised value of a property in the first, second, third, fourth, and fifth year, respectively, after project completion. In this way, the local government can provide a financial incentive to prospective developers without requiring any additional grant funding that would most likely have to be sourced from the federal government.

Background: The Development of Mecklenburg County's LYNX Blue Line

The LYNX Blue Line is North Carolina's sole light rail system and services the Charlotte area, which is at the center of Mecklenburg County. The Blue Line completed construction in 2007 along with an expansion in 2018 that extended service to the University City and University of North Carolina – Charlotte areas. The Blue Line is 19.3 miles long and is estimated to boast a daily ridership of about 30,000 passengers (American Public Transportation Association 2020).

The City of Charlotte has emphasized, in reports such as the 2030 Transit System Plan and Centers, Corridors, and Wedges Growth Framework, their commitment and belief in transit-oriented development strategies. As depicted in Figure 2, the Charlotte-Mecklenburg Planning Department has designated certain sections of the county as Growth Corridors, Wedges, and Mixed-Use Activity Centers. Growth Corridors are intended to be the primary areas of growth for the City moving forward, primarily including office space, single-family residential neighborhoods, and mixed-use areas all centered around transit stations. Growth is intended to be focused in the development of vacant land and reuse of underutilized properties, such as brownfields. Wedges are intended to be low-density residential areas utilizing automobile transit. Mixed Use Activity Centers are intended to represent a higher emphasis on a mix of commercial and civic uses, and in some cases high-density housing. Commercial property land uses such as industrial, warehousing, and distributions would be relegated to the industrial center areas.

In summary, one of the intended functions for the LYNX Blue Line, and all later transit plans, is to assist in the sustainable development of the Charlotte area along the specified guidelines. It is important to keep this in mind when studying the Blue Line as a treatment variable, as it means the placement of the rail is not necessarily exogenous. Further discussion on this point is present in section 4.

Related Literature

The literature regarding brownfield redevelopment and the factors that motivate it has been growing in recent years. Most of this discussion has centered specifically around what factors can predict brownfield redevelopment (Bacot & O'Dell 2006, Beames et al. 2018, Lee & Mohai 2013). Some of this research has also touched on the spatial patterns of brownfield redevelopment and how public infrastructure can impact it (Frantal et al. 2015, Kim & Lee 2018, Lange & McNeil 2004). However, the literature specifically investigating the nature of this spatial relationship between public transportation and infill development, a term covering more underused sites than just brownfields, is sparse. One of the more closely related papers is Guthrie & Fan (2013), wherein the authors investigate the relationship between streetcar stops and the rate of building permit requests in New Orleans immediately after Hurricane Katrina. They find that distance to stops strongly predict building permits, and more specifically that residential building permits are displaced in the areas near transit stops, but commercial permits increase. The nature of property development in that instance, redevelopment of underused, damaged or otherwise difficult to develop properties is reminiscent of brownfield redevelopment, but the sample and population are still quite different.

Bacot and O'Dell (2006) also use Charlotte, North Carolina as a case study as they attempt to identify that most important factors for incentivizing brownfield redevelopment. They focus on parcel-level characteristics and government involvement. They found that the foremost concern of investors was costs, as opposed to parcel size or even anticipated profits. I chose to structure my analysis based off of this and, as later explained, account for heterogeneity based on contaminants into my experimental design. However, Bacot and O'Dell do not account for the presence of public infrastructure near each brownfield parcel, and so this gap in the redevelopment literature remains unaddressed.

Another study that also examined the LYNX Blue Line is Billings (2011), which examined the effects of the Blue Line on real estate in areas surrounding the transit stations. Billings used a hedonic price model and discrete treatment radii (area surrounding stations) in order to analyze this effect and found a statistically significant increase in the value of residential properties near stations, and no statistically significant effect on commercial properties. However, Billings attributes this latter finding to an insufficient amount of time between analysis and treatment. So in addition to my paper distinguishing itself through a different type of analysis model, it should also benefit from an additional 8 years of data to be included in the analysis.

Data

The data set for this study was constructed from documents made available by the NCDEQ, through the Laserfiche WebLink document center. Various documents including property PLATs, brownfield property applications, and formal brownfield agreements were accessed in order to acquire or determine tax parcel identification numbers. These unique identification numbers were then used to obtain detailed property data from Mecklenburg County's Polaris 3G web tool, including factors such as transaction dates, transaction values, and detect any improvements or renovations made to the properties throughout the time frame of interest, 2003 to 2020.

From this value, transactions, and improvements data dates of redevelopment completion can be calculated. While the NCDEQ does not have any documentation signifying or announcing the completion of development on a project, this can be coded for utilizing the data. A completed redvelopment is detected based off of two criteria. The first, the listed "Reason for Value Change" within the property report must be one of the following 6 entries.

- Remodeled Improvements and/or New Addition
- Improvement/Addition/Remodeling Completed for Tax Year
- Building Partially Complete
- Change in Zoning and/or Land Use
- New Improvement
- Building Demolished

The second criteria for a brownfield property to be considered redeveloped within this data set is that a brownfield agreement must have been completed prior to the date for one of the previously stated six "Reason for Value Change" listed in the property report. A brownfield property is considered redeveloped if a brownfield agreement has been completed prior to the year in which one of the above 6 reasons for valuation changes occurred.

In addition to specific data about the value, transaction dates, and improvements made to each brownfield property, Polaris 3G also provides the unique geolocation of each parcel. This is given in both coordinates (latitude and longitude) as well as the census tract wherein each property is located. Distances from each parcel to the nearest Blue Line transit station are calculated from this data. In order to do this, the location of each brownfield was georeferenced and plotted using ArcGIS. Additionally, a shapefile of the LYNX Blue Line Stations was obtained through the Charlotte, NC Open Data Portal. Proximity to rail is then calculated for each brownfield as the euclidean distance from the property's coordinates to the nearest LYNX Blue Line Station.

The final variable of interest in this study is the number of land use restrictions applied to each brownfield property. This data was also collected through the Laserfiche Weblink document center hosted by the NCDEQ, and was collected in order to account for the type and severity of pollution present on each property. This is incorporated as a simple count for each property as detailed in the Land Use Restrictions Update, which each brownfield property owner must submit annually to ensure that all restrictions are being adhered to.

Summary statistics for relevant variables are given in table 1. Most relevant to the analysis is that the mean distance to rail is 2.69km, with relatively large (4.15km) standard deviations. This suggests that brownfields are not uniformly located close to transit stations, and in fact most are outside of the designed treatment radius of 0.75km. For a further examination of the spatial distribution of brownfields and transit stations, Figure 1 displays this relationship.

Empirical Methodology

The primary research questions considered in this study are:

- Does the construction and operation of commuter light rail increase the likelihood at which brownfield properties will be redeveloped?

- Is this relationship between commuter light rail and brownfield redevelopment linear with respect to distance?

To address the first question, a linear probability model is utilized for simplicity of interpretation. In this model, let the unit of observation be an individual brownfield, indexed by i, and let P be a dummy variable that equals 1 if a property is redeveloped in a given year, t. Furthermore, this dummy variable continues to equal 1 for every subsequent year in the study after redevelopment. An individual brownfield's distance to the rail is calculated as described in the Data section, it is the planar (euclidean) distance from each property to the nearest transit station and measured in kilometers. The individual brownfield's Value measured in dollars is the average of all tax parcels that make up each brownfield property, and is calculated every year for which data is available. And so, the primary equation of interest is therefore:

$$P_{it} = \beta_0 + \beta_1 Dist_i + \beta_2 LUR_i + \beta_3 Value_{it} + \beta_4 Loc_i + \beta_5 Year_t + \epsilon_i$$

where *Loc* stands for a variety of spatial fixed effects, as both census tract-level and a more general "Quadrant" fixed effects are used. Census tract information is collected along with property value information from the Mecklenburg County Assessor's office. The "Quadrant" fixed effect is calculated as a result of subdividing the Charlotte-Mecklenburg area into 4 non-overlapping Quadrants, with the origin being the transit-station located most closely to the center of downtown Charlotte, the Charlotte Transportation Center (CTC). Thus, a brownfield property with longitude and latitudes greater than that of the CTC is considered to be in Quadrant 1. A property with smaller longitude and larger latitude is considered to be in Quadrant 2. A property with smaller longitude and smaller latitude is in Quadrant 3, and one with larger longitude but smaller latitude is in Quadrant 4. Lastly, a year-level fixed effect is included in the regression analysis to control for time trends, and ϵ is a random error.

The population of interest in this study is all brownfields located within the boundaries of Mecklenburg County, NC. As of the time of data collection, this value was calculated to be 253 properties. All of these properties are included in the analysis. While the brownfield program began operations in North Carolina in 1997, there are no properties within this data set that had remediations before the year 2003, and so the time-frame of interest is 2003 to 2019.

If distance to light rail confers positive benefits to a redeveloped brownfield, one would expect to see positive coefficients within the linear probability model on the rings for those distances within walking distance, or less than 1km. That is to say, brownfields within a 1km walk from transit stations should be more desireable to property developers, as they would benefit most from the increased foot-traffic of potential consumers or be most appealing to those working professionals desiring accessible transit near their housing locations. Therefore, the likelihood of a property positioned in such a location redeveloping would increase. This effect of distance to light rail would be expected to decrease as distances increase, as the construction of the light rail would be less significant of a change in the transit access to these properties. That is to say, other modes such as automobile transit, would have been possible as well and so the marginal improvement in accessibility provided by a transit station is lessened.

Regarding the propensity score matching approach, this is intended to address any potential endogeneity issues associated with the distance to rail variable. As mentioned previously, the Charlotte-Mecklenburg Planning Department has mentioned their approval of the utilization of transit-oriented development strategies as a primary means of controlling future development. Therefore, it is a possibility that assignment of this treatment - distance to light rail- through the form of station construction is not entirely random. A propensity score matching technique would be one way to address this endogeneity issue as it calculates propensity scores which are measures of the likelihood of an individual brownfield to receive treatment based on observed variables. In this study, Quadrant, property value, and the number of land use restrictions imposed on a property are used to calculate propensity scores. These variables are chosen because they are exogenously determined, as in the case of quadrant, correlated with parcel-specific characteristics, such as property condition, neighborhood, and parcel size in the case of property value, and indicative of the type and severity of pollution on the parcel in the case of the number of land use restrictions. By comparing properties with similar characteristics and thus similar likelihoods of receiving treatment, one may be able to better determine any differences in the rates of redevelopment between the treated parcels, those within 0.75km of a light rail station, and the untreated parcels, those outside the 0.75km radius.

Results

Two forms of the linear probability model are estimated in this analysis, and regression results are given in table 2. The first model includes a continuous variable that records distance to light rail stations calculated as previously discussed. In this model, the results suggest that, as the distance to light rail increases, the probability of a brownfield property being redeveloped also increases by 5.3% for every kilometer added. This result is statistically significant at the 5% level. Additionally, the marginal effect of one more land use restriction is estimated to constitute a 2.9% decrease in the likelihood of a brownfield property being redeveloped, and this is also significant at the 5% level. Lastly, in this first model the effect of a change in a brownfield's property value is a precisely estimated 0 effect. This means that, for any property, its value before remediation is not at all informative of its likelihood to redevelop.

The second linear probability model accounts for heterogeneity in the effect of distance to light rail on redevelopment probability. In this model, a brownfield located between 0 and 0.25km from the nearest transit station has a 33.4% lower probability of being redeveloped. A brownfield located between 0.25km and 0.5km has a 31.2% lower probability of being developed. Lastly, a brownfield located between 0.5km and 1km from the nearest transit station has a 29% lower probability of being redeveloped compared to the counterfactual, that being any brownfield located over 15 kilometers away from the transit station. These results are all statistically significant at the 5% level. The only other distance ring that is also statistically significant is that of brownfields located between 10km and 15km from a transit station, wherein the data suggests that these properties are 51% more likely to redevelop than those farther away, and this is significant at the 1% level. The parcel specific variables, land use restrictions and property value, have similar coefficients to the previous model.

In both linear probability models, these results disprove the previously stated hypotheses. It does not appear to be the case that properties located nearer the light rail are more likely to redevelop than those farther away - in fact the opposite is true. This evidence contradicts those conclusions reached in most of the comparable literature, including Frantal et al (2015) and De Sousa et al (2009), who both found that proximity to rail increased the likelihood of redevelopment for at least one type of brownfield property. However, these results do support the hypothesis that the effect of distance between the brownfield properties and light rail stations is nonlinear, as the direction of the measured effect seems to change at some point beyond the 2km radius.

Results of the propensity score matching approach are given in tables 3 through 6. Regarding results from the propensity score matching approach, differences in remediation rates are present and also statistically significant at the 5% level. In order to calculate the treatment effect for the treated population, or the change in redevelopment rates for those brownfields located within 1 km of the nearest transit station, we can calculate the equation:

$$TT = E(Y_1 - Y_0) \tag{1}$$

where Y_1 is the redevelopment rate for the brownfields near transit stations, Y_0 is the redevelopment rate for brownfields far from transit stations. Doing so shows that there is a 8.7 percentage difference in redevelopment rates between brownfield near transit stations and brownfields far from transit stations. This evidence seemingly contradicts that found from via the linear probability model, as the propensity score matching results suggest that proximity to transit stations actually increases the likelihood of redevelopment.

Conclusion

In conclusion, this analysis provides mixed evidence. When utilizing a linear probability model, proximity to light rail stations is actually a suppressing factor as it relates to brownfield property redevelopment. While this relationship is most negative at smaller distances between stations and brownfields, it gradually becomes positive as distances increase, suggesting that brownfields located between 10km and 15km from transit stations are most likely to redevelop. However, when utilizing a propensity score matching technique, the evidence points in the opposite direction, suggesting that proximity to rail is expected to increase the probability that a brownfield property would redevelop.

This evidence is contradictory to that of the brownfield redevelopment literature at large, but may be nonetheless informative. If present, the nature of the relationship between transit stations and brownfield property redevelopment rates is certainly nonlinear, and the magnitude of the effect in this population is large. However, the question of external validity is not answered in this study. There is no reason to believe that the dynamics detected here are representative of those present in other locations, as continued research and data collection in this topic is necessary to make such a claim.

Threats to the validity of the results discussed here are primarily centered around omitted variables bias and errors in variable bias. Regarding the former, more specific parcel-specific variables such as acreage, land use prior to redevelopment, and transit access prior to redevelopment were not collected but may have been informative. Depending on the nature of the relationship between these variables and a brownfield's probability to redevelop, the coefficients detected in this study may have been biased in either direction. Regarding the latter, errors in variable bias may be present as a result of measurement error within a given brownfield's property value. The true value of a property is difficult to determine outside of a market transaction, as the assessed value may not be representative of the market value. Furthermore, the precisely estimated zero coefficient found in both model estimations is unlikely to be a realistic representation of the dynamic, but without a larger sample size or alternative measures of property value it is difficult to determine.

Regarding future research, more investigations into the nature of the relationship between brownfield remediation rates and transit stations should be conducted. The spatial dynamic discussed in this paper is likely not representative of all locations and may be better identified through another functional form specification. A particularly promising study would be one that aggregates data from multiple different states across a country, as a data set even larger than that created as a result of this study has likely not yet been utilized to answer these research questions.

Tables & Figures

Table 1: Summary Statistics for Relevant Variables

Statistic	N	Mean	St. Dev.	Min	Max
Property Value ($)	1,438	5,013,330.00	11,210,046.00	0.00	142,327,400.00
Distance to Rail (km)	1,448	2.69	4.15	0.03	23.49
Land Use Restrictions Count	1,101	11.94	3.02	4.00	18.00

Table 2: Linear Probability Model Estimates of Proximity to Rail on Brownfield Redevelopment Rate

	Redevelopment Probability	
	(1)	(2)
Distance to Rail (km)	0.053***	
	(0.012)	
Distance (0-0.25km]		−0.334***
		(0.127)
Distance (0.25km-0.5km]		−0.312**
		(0.123)
Distance (0.5km-1km]		−0.290**
		(0.124)
Distance (1km-2km]		−0.188
		(0.124)
Distance (2km-4km]		−0.176
		(0.135)
Distance (4km-8km]		0.051
		(0.142)
Distance (8km-10km]		−0.157
		(0.203)
Distance (10km-15km]		0.512***
		(0.185)
Land Use Restrictions	−0.029***	−0.026***
	(0.005)	(0.005)
Property Value ($)	0.001***	0.001***
	(0.000)	(0.000)
Constant	1.266***	1.543***
	(0.096)	(0.150)
Observations	1,093	1,093
R^2	0.361	0.369
Adjusted R^2	0.322	0.327
Notes:	Each entry is an LPM coefficient with HS Robust Standard Errors in Parentheses *** p<0.01, ** p<0.05, * p<0.1	

Table 3: Comparison of unmatched observations

	Untreated	Treated	p-value
n	645	448	
Quadrant (mean (SD))	2.55 (1.03)	2.38 (0.92)	0.006
Property Value (mean (SD))	43.61 (86.37)	79.80 (164.07)	<0.001
Land Use Restrictions (mean (SD))	11.70 (3.12)	12.28 (2.85)	0.002
Remediated = 1 (%)	285 (44.2)	237 (52.9)	0.006

Table 4: Sample Sizes

	Control	Treated
All	645	448
Matched	448	448
Unmatched	197	0
Discarded	0	0

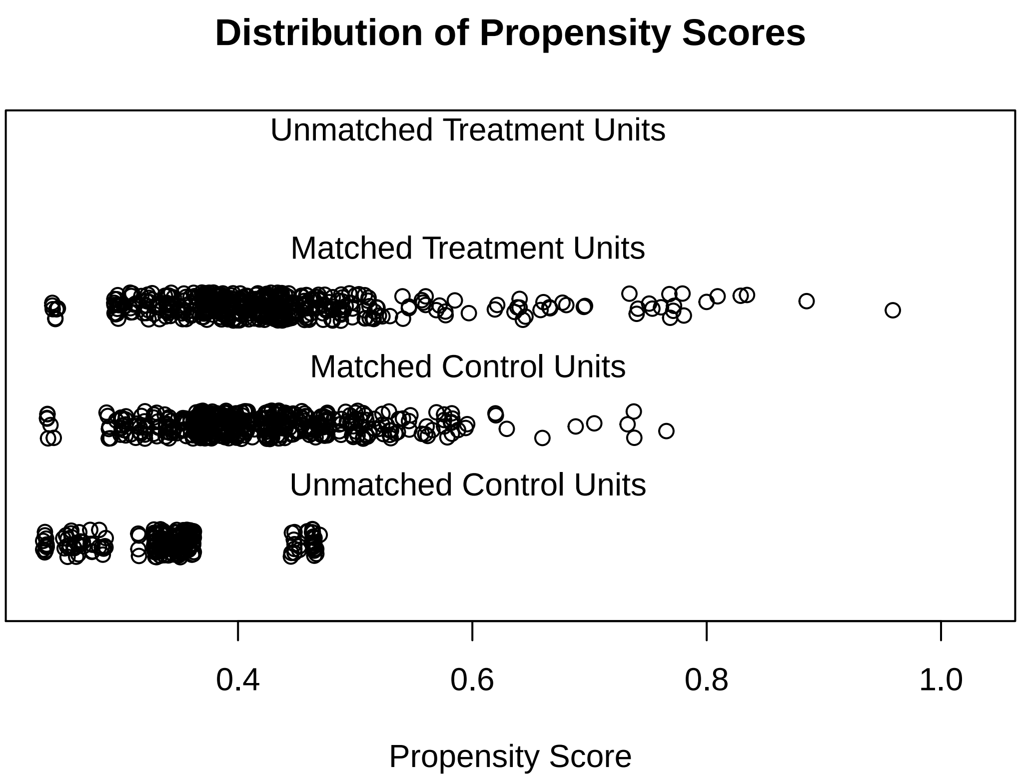


Table 5: Summary of balance for matched data

	Means Treated	Means Control	Mean Diff
distance	0.43	0.42	0.01
Quadrant	2.38	2.38	0.01
‘Property Value‘	79.80	52.54	27.26
‘Land Use Restrictions‘	12.28	12.29	-0.01

Table 6: Comparison of matched samples

	Untreated	Treated	p-value
n	645	448	
Quadrant (mean (SD))	2.55 (1.03)	2.38 (0.92)	0.006
Property Value (mean (SD))	43.61 (86.37)	79.80 (164.07)	<0.001
Land Use Restrictions (mean (SD))	11.70 (3.12)	12.28 (2.85)	0.002
Remediated = 1 (%)	285 (44.2)	237 (52.9)	0.006

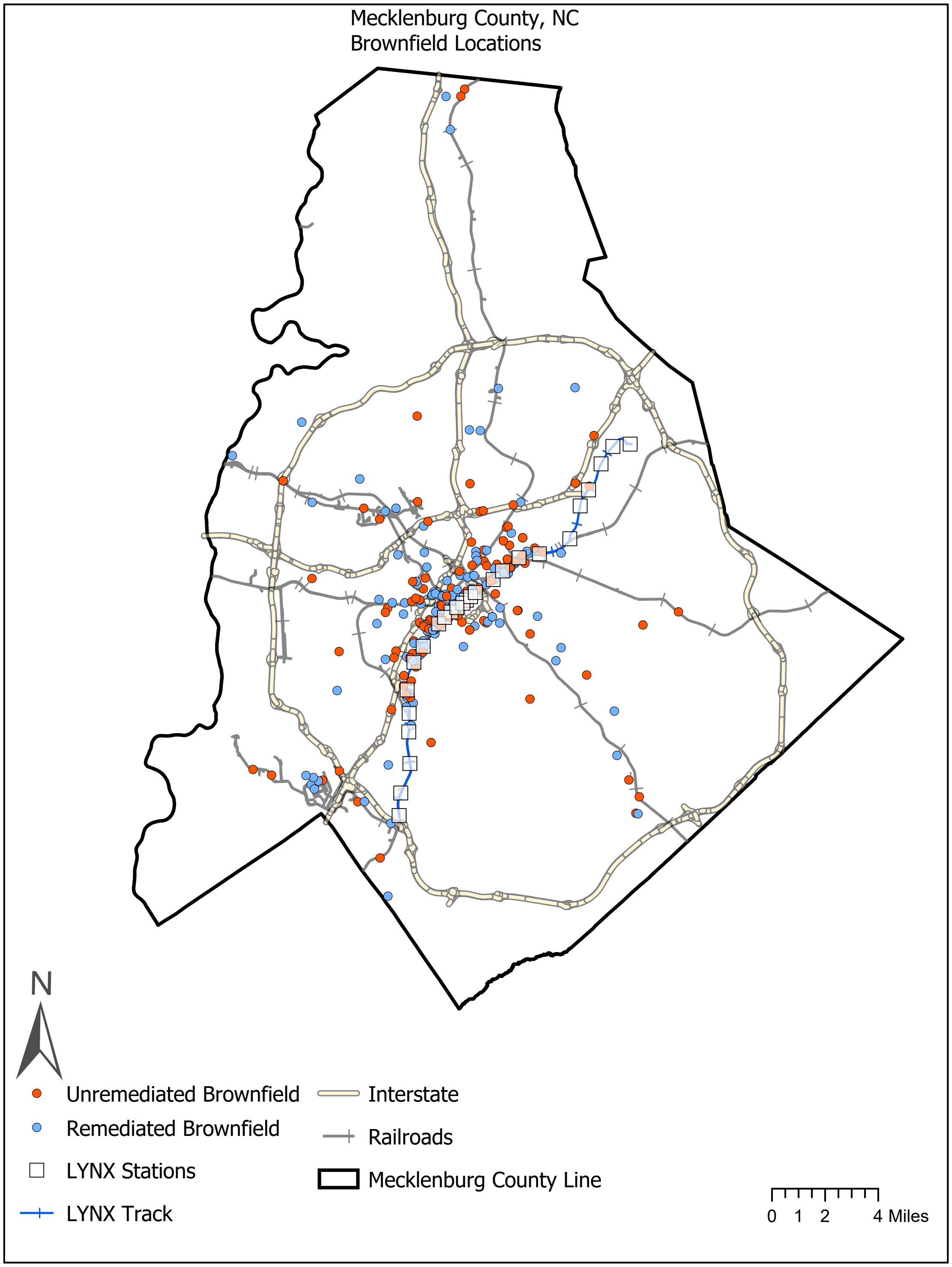
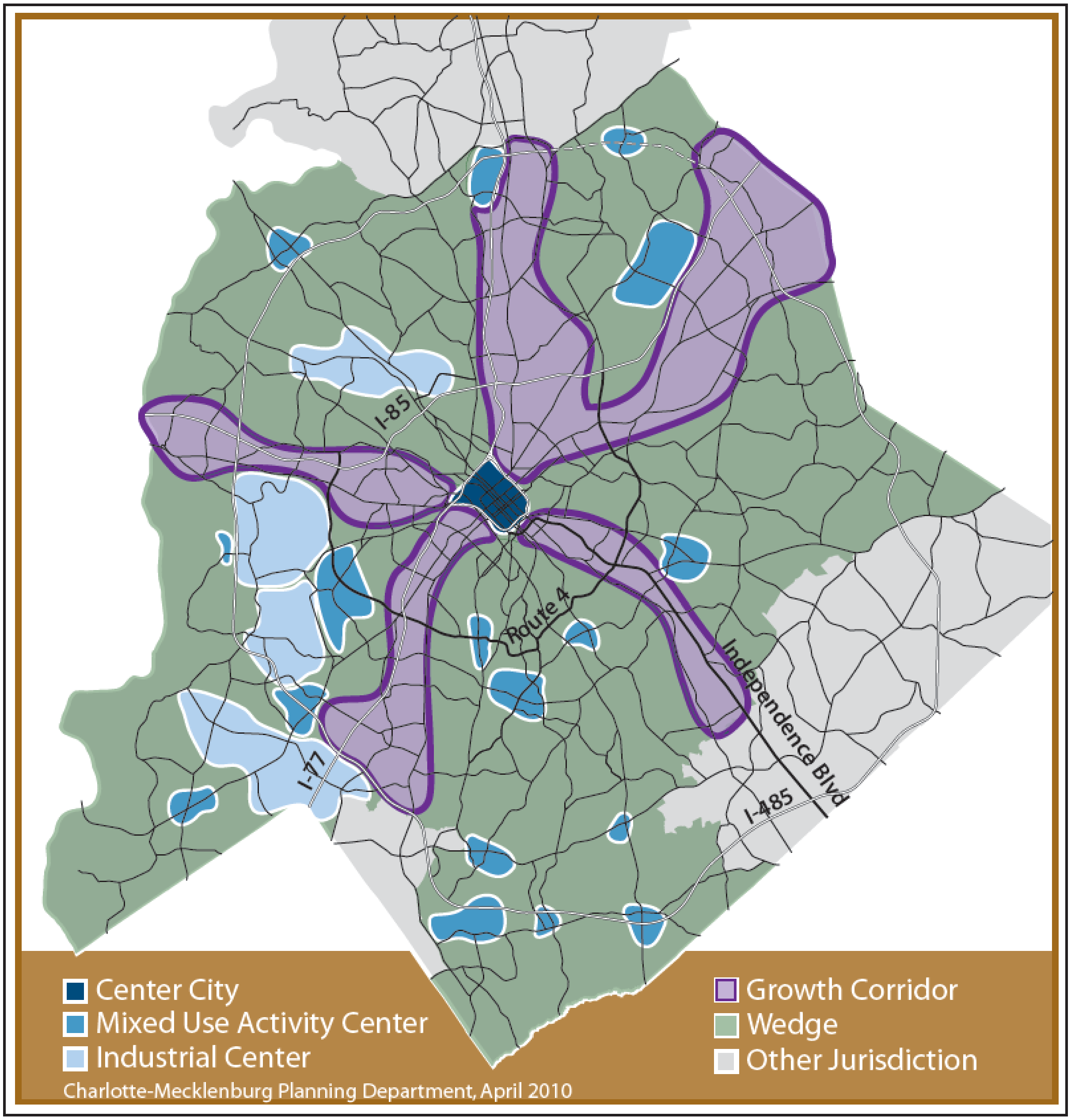


Figure 1: Spatial Distribution of Brownfield Properties and Transit Lines

Activity Centers, Growth Corridors and Wedges



This map is intended to be a "snapshot" in time and will likely evolve as new area plans are adopted. Through each area planning process, the boundaries of the pertinent Activity Centers, Growth Corridors and Wedges will be reviewed and adjusted, if necessary, and any newly identified Activity Centers or Growth Corridors will be added. Please contact the Planning Department or visit *www.charlotteplanning.org* for the most current version of this map.

Figure 2: Charlotte-Mecklenburg County Transit Oriented Development Plans

References

[1] Hunter Bacot and Cindy O'Dell. (2006). Establishing Indicators to Evaluate Brownfield Redevelopment. In *Economic Development Quarterly*. **20**. 142-161

[2] Alistair Beames, Steven Broekx, Uwe Schneidewind, Dries Landuyt, Maarten van der Meulen, Reinout Heijungs, and Piet Seuntjens. (2018) Amenity Proximity Analysis for Sustainable Brownfield Redevelopment Planning. In *Landscape and Urban Planning*. **171**. 68-79.

[3] Stephen B. Billings. (2011). Estimating the Value of a New Transit Option. In *Regional Science and Urban Economics*. **41**. 525-536

[4] Marco Caliendo and Sabine Kopeinig. (2008). Some Practical Guidance for the Implementation of Propensity Score Matching. In *Journal of Economic Surveys*. **22**. 31-72

[5] John I. Carruthers and Gudmundur F. Ulfarsson. (2003). Urban Sprawl and the Cost of Public Services. In *Environment and Planning B: Planning and Design*. **30**. 503-522.

[6] Christopher A. De Sousa, Changshan Wu, and Lynne M. Westphal. (2009). Assessing the Effect of Publicly Assisted Brownfield Redevelopment on Surrounding Property Values. In *Economic Development Quarterly*. **23**. 95-110.

[7] Reid Ewing, Shima Hamidi, James B. Grace, Yehua Dennis Wei. (2016). Does Urban Sprawl Hold Down Upward Mobility?. In *Landscape and Urban Planning*. **148**. 80-88

[8] Bohumil Frantal, Bryn Greer-Wootten, Petr Klusacek, Tomas Krejci, Josef Kunc, and Stanislav Martinat. Exploring Spatial Patterns of Urban Brownfields Regeneration: The Case of Brno, Czech Republic In *Cities*. **44**. 9-18.

[9] Andrew Guthrie and Yingling Fan. (2013). Streetcars and Recovery: An Analysis of Post-Katrina Building Permits around New Orleans Streetcar Lines. In *Journal of Planning Education and Research*. **33**. 381-394.

[10] Shima Hamidi, Reid Ewing, Ilana Preuss, Alex Dodds. (2015). Measuring Sprawl and Its Impacts: An Update. In *Journal of Planning Education and Research*. **35**. 35-50.

[11] Matthew E. Kahn. (2007). Gentrification Trends in New Transit-Oriented Communities: Evidence from 14 Cities that Expanded and Built Rail Transit Systems. In *Real Estate Economics*. **35**. 155-182.

[12] Hwayoung Kim and Semyeoung Lee. (2018). An Empirical Analysis of the Effect of Transit-Oriented Development Policy on the Land Use Composition Change Around Light-Rail Transit. In *Journal of the Korean Urban Management Association*. **31**. 165-179.

[13] Deborah A. Lange and Sue McNeil. (2004). Brownfield Development: Tools for Stewardship. In *Journal of Urban Planning and Development*. **130**. 109-116.

[14] Sangyun Lee and Paul Mohai. (2013). The Socioeconomic Dimensions of Brownfield Cleanup in the Detroit Region. In *Population and Environment*. **24**. 420-429.

[15] Nicholas B. Irwin, H. Allen Klaiber, Elena G. Irwin. (2017). Do Stormwater Basins Generate co-Benefits? Evidence from Baltimore County, Maryland. In *Ecological Economics*. **141**. 202-212.