Determinants of the Number of Brownfields: An Analysis of U.S. Cities

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Abstract: This paper analyzes the relationship between the seemingly ever-increasing suburban sprawl, and the number of brownfields in well-known cities around the nation in 1997. The reasons and implications of suburban sprawl in relation to brownfields are also discussed. Study shows that metropolitan statistical area population density, median house price, and the percent of the labor force in manufacturing in 1970 have more significant effects on the number of brownfields; MSA per capita income and unemployment have negligible effects. Percent change in urban land from 1982-1997 also has an insignificant effect.

I. Introduction:

Because of the decline in manufacturing employment, a large number of aged factories sit idle in American cities. While some of these properties are contaminated with wastes, others are only perceived as tainted. These sites, commonly known as brownfields, have potential contamination and costs associated with redevelopment that often prevent developers, lenders, and investors from redeveloping the site. Because of this, home development tends to sprawl toward city boundaries—toward virgin land also known as greenfields. Developing greenfields means ignoring the already-abandoned facilities in urban centers. Not only do these areas serve as a blemish on the community, but they create safety risks, health risks, and economic risks for local residents (Environmental Protection Agency, 2004).

In 1998, 16,500 brownfield sites were reported in 126 major cities around the U.S., accumulating 47,000 acres of unused promise and potential (U.S. Conference of Mayors, 1998). The American Farmland Trust claims that over 13,823,000 acres of land were lost largely to greenfield development between the years 1982-1992 alone. Those 13.8 million acres are roughly the same size as Connecticut, Rhode Island, New Jersey, Delaware, and a quarter of Maryland combined (Cochran, 1998). Worse yet, nearly a quarter of this land was considered "prime" or unique farmland.

Brownfields have been accused of driving up unemployment and fostering penury. Brownfields take up valuable space within a city's boundaries, and at the same time devaluate the land, making other open land more attractive. In a survey conducted in 2001 in New Jersey, the majority of respondents that said that they would be content living on a redeveloped

brownfield site were those respondents who were relatively poor, young renters (Greenberg, 2001).

In terms of the affects on local and regional economies, the wasted spaces inside city areas are possible sources of tax revenue. While they remain abandoned properties, that locality is forfeiting potential jobs and downtown revitalization. Over 100 cities estimated that they would receive additional annual tax revenues in the range of $205 - $500 million if they could return their brownfields to economic use, as well as augment the job market with 236,000 new lines of work (Cochran, 1998).

Brownfields and urban sprawl have an impact on the local economy, the regional economy, and the availability of land and resources. Living in the Northeast, it is easy to identify with this ever-increasing construction of suburban homes. These migrating individuals work in the major cities they move away from, yet it is completely acceptable. This paper aims to measure the causes of the variation in the number of brownfields across U.S. cities. We find that higher population densities and lower house prices increase brownfield acreage. We also find some evidence that lower per-capita income and a higher share of the labor force in manufacturing circa 1970 are associated with an increase in brownfield acreage. However, there is no evidence of a sprawl effect on the number of brownfields.

II. Background:

In the years immediately following World War II, the United States was regarded as the manufacturing powerhouse in the world. In recent decades, however, the growth of payrolls in the service industry has tarnished that image. The manufacturing decline left us with souvenirs

in the form of brownfields—abandoned factories, buildings, and contaminated sites, scattered around metropolitan centers.

Robert O. Lenna, Chairman on the Environment Financial Advisory Board for the Environmental Protection Agency, defines brownfields in his advisory letter to Judge Carol M. Browner of the EPA: "The term brownfield should include any site, whether urban or rural, industrial or non-industrial, and whether abandoned, idled, under-used, or previously undeveloped, at which the timely use, expansion of the current usage, or redevelopment of the site is prevented by real or suspected environmental contamination – regardless of the actual severity of any contamination." These abandoned areas can be seen in almost every densely populated and once-manufacturing-based older city. In New Jersey, brownfields are common in areas such as Jersey City and Newark in Essex County, and Trenton and Red Bank in central New Jersey. In 1998, Andrew Cuomo, Secretary of Housing and Urban Development (HUD) estimated that there were 450,000 vacant or underused industrial sites in the nation.

Brownfields have been accused of being "blights on the neighborhoods, discouraging economic development and undermining local [government] tax bases," says Ken Brown, executive director for the NALGEP (Preston, 2003). They are common sites in neighborhoods filled with the less fortunate, and may play a role in causing neighborhood decline (Sirmans and Macpherson, 2003). The costs associated with redeveloping them are sometimes astounding due to contamination and regulated clean-up.

In early-to-mid 1990s, the government began focusing on the wasted land inside cities, and became determined to turn brownfields into city greenfields. In 1993, the Environmental Protection Agency (EPA) was a catalyst in starting a small brownfields pilot program for local

and regional governments to dean up brownfields sites and turn them into probable jobs, houses, and recreational facilities (Greenberg, 2001). During the Clinton administration, President Bill Clinton proposed the 1994 Superfund Reform Act (SRA), a Clinton-sponsored bill aimed at aiding the EPA's efforts in eliminating brownfields. Unfortunately, Congress did not pass the bill. Despite the rejection, the Superfund Reform was becoming more popular, and the EPA continued with their plans. EPA's program sought to transform the meaning of brownfields: "to change the language of brownfields from talk of obstacles to talk of opportunity" (Kibel, 1998).

An April 1996 report issued by EPA reflects this shift: "Implementation of the Brownfields Action Agenda will help reverse the spiral of unaddressed contamination, declining property values and increased unemployment often found in inner city industrial areas." As such, the EPA Agenda suggested that the brownfields issue was not just about limiting the liability of banks and real estate developers; it was also about providing inner-city residents with a strategy to improve the economy and environmental health of their communities (Kibel, 1998). In 2001, the EPA developed the Small Business Liability Relief and Brownfield Revitalization Act, allowing the EPA "to award $250 million a year in grants to local governments for assessing and cleaning up contaminated sites. A few months later, the EPA announced it had awarded $73.1 million to 176 applicants" (Preston, 2003). With the emergence of investors, progress is underway.

At the same time, concerns about rapid development of virgin and agricultural land received greater attention. According to William Fulton (2003), sprawling is an elusive term that is tricky to define. They explain it simply in terms of land resources consumed to accommodate new population (Fulton). In simpler terms, sprawl occurs when a certain city area,

for example New York, is adding urbanized land at a much faster rate than they are adding population. This means that individuals are moving away from the cities, and into the suburbs for reasons other than population growth, increasing the amount of urbanized land surrounding a particular city. Suburban sprawl may also decrease the amount of agrarian land. Generally, economists are opposed to sprawl due to the lack of attention on preserving greenlands and land resources.

Also known as an "exploding metropolis," suburbanization has had grave affects on areas both environmentally and economically. The conversion of surrounding farmland to subdivisions and industrial uses has destroyed beautiful landscapes and has displaced rural communities (Kibel, 1998). The lack of adequate public transportation, the reliance on automobiles, and the increasing distance of commutes has also led to severe air pollution in many metropolitan areas (Downs, 1992). Economically, the impacts of suburbanization receive mixed reviews. For the automobile and construction industries, and for the local treasuries of many suburban municipal governments, increasing suburbanization has lead to increasing profits; in the city centers, however, it has been a disaster. As businesses and residents continue to leave for the suburbs, cities have seen a decline in tax revenues and municipal services, and a rise in unemployment and crime (Calland, 1995).

Bruce Katz (2002) considers smart growth and its relation to sprawl. He defines smart growth: "It contends that the shape and quality of metropolitan growth in America are no longer desirable or sustainable. It argues that metropolitan areas could grow in radically different ways if major government policies on land use, infrastructure and taxation were overhauled" (Katz).

Despite all of these arguments against suburban sprawl, there are those that favor it. Easterbrook (1999) points to the benefits associated with suburbanization in America:

> Despite its negative image, sprawl is efficient and reflects consumer preference. In a nation where so much developable land remains, sprawl is hardly the environmental threat it is made out to be. The real threat is that the nation might adopt policies that halt development and frustrate the millions of people who seek their share of the suburban dream. (Easterbrook)

Away from being a sort of social status and "attainable dream," it is also discussed that suburbanization is just another way of viewing how Americans have always been—from the days of moving into the undeveloped western lands during the manifest destiny, and now in leaving the inner cities to tackle new opportunities. However one views it, it is evident that people are both for and against suburban sprawl, as pros and cons exist on both sides.

While no federal laws exist to combat suburban sprawl, local governments and communities have developed strategies to control suburban growth. Three of the most widely used strategies for controlling sprawl are slow-growth initiatives, residential lot requirements, and private land trusts (Downs). Slow-growth initiatives place an absolute percentage limit, or even an absolute moratorium, on the amount of new residential units that can be built in a given time period (Kibel). Residential lot requirements establish rules regarding the size or type of new residential construction, such as only single-family homes with a minimum amount of acreage. Private land trusts allow local citizens to purchase open space or farmland as a group,

and thereby putting a stop to such properties from being converted to commercial or residential use (Kibel). Such investments retain greenfields and agrarian land.

Fulton further discusses some possibilities to combat sprawling through regional cooperation. Titled "fair-share housing programs," they could ensure that more local governments accommodate high density and affordable housing. Tax-base sharing could be designed in conjunction with fair-share housing to reduce the incentives for local municipalities to compete over new and industrial development (Fulton). These policies fighting suburbanization have been enacted in several areas, but they are by no means universal. Here in lies a difference between suburban sprawl and brownfields: brownfields are desired to be eliminated by all, while suburban sprawl is not necessarily a bad entity.

Because brownfields are often abandoned industrial sites, we include in each of the observed cities the relative employment in manufacturing for 1970. It is presumed that the number of brownfields has increased since then, leaving behind deserted factories that resemble ghost-towns. Some believe this is quite possible. According to Paul Stanton Kibel (1998), the augmentation of untouchable brownfields has encouraged suburban sprawl and the destruction of open space. With this, a relationship may exist between the two, but maybe not necessarily what Dr. Kibel states. Greenberg (2001) discusses that the positive impacts of brownfield redevelopment can extend beyond the locality where the brownfields are located by providing an alternative to sprawl and thereby preserving greenfields around the city boundaries. In his study conducted in nine urban New Jersey cities, brownfield redevelopment has lead to an overall increase in the region's jobs (whether construction or permanent), an expansion of people housed, and substantial increases in annual taxable revenues. In those same regions, Greenberg

found that from 1980 to 1996, the respective cities actually lost population, decreasing from 385,000 in 1980 to 370,000 in 1996 (Greenberg). So in Kibel's article, Brownfields are a reason for the sprawl, while Greenberg shows that redevelopment has reversed the effects of sprawl.

The next section will discuss what I tested: what impacts the estimated amount of brownfields. It is known that undeveloped land and brownfields are substitutes. Regulations that make it more difficult to develop land at the urban boundaries, such as those discussed above, should increase brownfield redevelopment in the metropolitan statistical area.

III. Data and Methods:

An empirical analysis of brownfield acreage was conducted using cross-sectional data from the year 1997. The dependent variable is collected at the city level while the independent variables are at the SMSA level. Brownfield acreage estimates for each city were obtained from the National Report on Brownfield Redevelopment from the United States Conference of Mayors' January 1998 report, offering the estimated number of brownfields in 1997 (U.S. Conf. of Mayors, 1998). The data collected in this report was for 126 cities, both large and small (population > 250,000 and population < 200,000, respectively). This study includes only 52 observations because city-specific data for the smaller cities, such as Bloomfield, NJ or Malden, MA, was often part of a larger SMSA. This created problems in matching the city data with the SMSA data. Such smaller cities and observations would distort the data based on the assumption that the number of brownfields for Tacoma, WA, for example, cannot share data with its SMSA area: Seattle/Tacoma, because I do not have the estimated number of brownfields in Seattle, WA. For this reason, and to my dissatisfaction, localities familiar to me in Northern and Central New Jersey—areas with a myriad of brownfields per square mile, like Trenton, Paterson, or

Newark, could not be included in the study. Similar observations occurred all over the United States, not just in the Northeast, such as San Bernardino, CA. The problem did not persist only in small cities, but larger observations as well, such as Akron, OH and Buffalo, NY, which incorporated many smaller cities in their respective SMSA's. Thus, any SMSA that included cities for which brownfield data was not collected was eliminated from the study.

The dependent variable is relative brownfield acreage for each city. In order to take into account the relative sizes of the cities, the dependent variable was calculated in the regression as: Acres=Brownfield Acreage/Total City Acreage, by political city boundaries. If a city like Buffalo, NY has 3,000 brownfield acres and Charleston, SC has 1,000 acres, this does not mean Buffalo is in worse shape than Charleston. We must account for city size. From here, I regressed brownfield acreage per total land acreage based on SMSA unemployment, population density, income per capita, the percent of total labor force in manufacturing (1970), median house price, and percent change in urbanized land (1982-1997).

Unemployment and political city boundaries were collected from the Bureau of Labor Statistics' January 1998 report. With higher unemployment, I expected higher brownfields because with bankruptcies or foreclosures on properties that were once corporations or factories, unemployment would increase, and consequently, so would the number of brownfields. Population density was attained from the Census 1998 Press Release on Metropolitan area per square mile, and also from the State and Metropolitan Data Book (Daley, 1997-1998). This variable was considered because population density is higher for older cities, and older cities are more likely to have brownfields. Income per capita was obtained from the Bureau of Economic Analysis (1997), and would test for any correlation between the economic well-being of the city and the number of brownfields. Higher income areas may be more able to redevelop their

brownfields. The percent of the labor force in manufacturing for the year 1970 was obtained directly from the Statistical Abstract of the 1971 Census. Because brownfields are typically old manufacturing sites, a city which had a very high manufacturing labor force in the past would be inclined to having more brownfields today. Some 1997 median house prices were obtained in the 1998 statistical abstract, leaving many observations without a value. Due to a nominal difference in known values, the remainder of median house prices was obtained from the 2000 Census. Lastly, the change in urbanized land from the years 1982-1997 was acquired from the National Resource Inventory (NRI, 1997). Overall, developed land has been on a constant rise in the U.S. as a whole, which can be seen in Graph I in the Appendix. This variable was used in an attempt to capture the affects of increasing urbanized land and therefore urban sprawl at the SMSA level, checking for a correlation between sprawl and brownfields. We expect more sprawl will reduce pressure to redevelop brownfields because it is always cheaper to develop virgin land at the periphery rather than clean up sites at the city center.

IV. Results and Analysis:

Table 1 reports means and standard deviations for the dependent and independent variables. The mean percentage acreage for brownfields in the data set is 3.49×10^{-5}, but the variation in brownfield acreage across cities is enormous. The standard deviation is 6.26×10^{-5} and the minimum value is 0.094×10^{-5} (Tuscaloosa, AL), while the maximum value is 40.85×10^{-5} (New York). Similarly, density shows an enormous variance. The standard deviation is 1,035 and density varies from a low of 23.6 to more than 7,500 people per square mile. After checking and correcting for heteroskedasticity, I found the estimated amount of brownfield acres per total land acreage to be estimated with the following equation:

$$\hat{Acres} = \alpha - \beta_1 Unempl + \beta_2 PopDens - \beta_3 IncPerCap + \beta_4 Manuf1970 - \beta_5 HousePr + \varepsilon_1$$

where $\hat{Acres}$ is the estimated percentage of total SMSA acreage that will be brownfields. The parameters estimates for β_1, β_2, β_3, β_4, and β_5 are the coefficients in each term. From **Table 2** we see that all other parameters being equal to zero, the expected brownfield acres in any given city are 5.86691×10^{-5} percentage points (since we multiplied the brownfield acres/total land acreage by 10,000), or .0000586691 percentage points of total land acreage. Due to possible correlation between some of the variables, regressions were run with different specifications, each with a removal of a different independent variable in question (refer to **Table 3** for correlation coefficients).

Unemployment has no relation to the expected brownfield acres. Income per capita is highly correlated with house prices. In equations where both variables are included, income per capita is not significant in the model. Removing house prices from the equation produces a significant effect for per-capita income. The effect of population density on the number of brownfields is more reliable. Across all specifications, the effect of density on brownfields is essentially the same, and it is directly related with the expected ratio of brownfields. As population density in a city rises by one hundred people per square mile, brownfields are expected to rise 0.59×10^{-5} percentage points.

Originally, I thought that a higher population density would mean less brownfields because of there being a higher demand for space in the city. For example, New York is highly dense with fairly expensive homes or apartments, which would indicate to me that less brownfields should exist since land seems to be in such high demand. But this regression shows the opposite, leaving only one other explanation. This *PopDens* variable could be picking up the

relative age of the city. Older cities will have a tight infrastructure, with buildings on-top-of buildings, etc, while newer cities will not be inclined to have the same design since the automobile eliminates that requirement. Cities with very high population densities, I will use New York again, are very old cities. It is inherent for an old city to have a high density since the infrastructure was created *before* the advent of the automobile. Newer cities after the automobile do not need to be congested, and will be more commodious to the inhabitants. If a city is older, then, chances are it had a larger-than-normal manufacturing center, a center which could now be obsolete and idle, explaining both the high density and higher brownfield percentage.

The sign in front of *HousePr* is consistent with expectations. If house prices are higher, brownfields are more likely to be redeveloped. Thus, higher house prices are associated with a lower number of brownfields. The effect is significant and robust across a series of specifications. A one thousand dollar increase in house prices decreases the percentage of land in brownfields by about 0.047×10^{-5} percentage points. While the estimates for percentage employment in manufacturing for 1970 have the correct sign, it is significant in only some specifications, as in the removal of house prices. A one percentage point increase in manufacturing employment in 1970 increases brownfield acreage by about 0.07×10^{-5} percentage points.

In an attempt to capture any affects of suburban sprawl, I ran a regression that added the independent variable, *ChgUrbLand*, or percent change in urbanized land from the years 1982 to 1997. Since suburban sprawl and brownfield redevelopment are substitutes, as people moved out of the city to its boundaries, they would shun the possibility of redevelopment and the number of brownfields fails to fall, or will rise. The results in **Table 2** show no significant effect of sprawl on the number of brownfields. Thus we find no evidence that links suburban sprawl

and the number of brownfields. Because of this, for the remaining regressions, I omitted the independent variable *ChgUrbLand*.

V. Conclusion:

Of the 52 cities in this study, brownfields, their consequences, and their potential redevelopment should be of high interest to each. Because of their affects on the local and regional economies, brownfield studies are relevant to any SMSA interested in boosting its tax revenue, adding jobs, or simply making the city more habitable. While cities might turn to any three of the most widely used strategies for controlling sprawl discussed earlier in this paper: slow-growth initiatives, residential lot requirements, and private land trusts (Downs), to reduce the number of brownfields, we find no evidence to link suburban sprawl with the number of brownfields. We tested for the change in urban land over a fifteen-year period, seeing if urban sprawl over those years influenced the number of brownfields in 1997. Although it was insignificant, I believe the variable can be expressed in a different way to better suit the study's parameters in future analyses, for example showing urbanized land over total land for 1997, since it is a cross-sectional analysis.

However, we do find that the median sales price for existing one-family homes are inversely related to the expected percentage of total land acreage in an SMSA that is brownfields; while population density per square mile and the percentage of the 1970 labor force in manufacturing are directly related. The higher the density and former manufacturing force, the higher the number of brownfields.

In the broader picture, from this study, when a municipality questions its brownfields, it should look no further than its history, its inhabitants, and their lifestyles. From there it can

identify its general status and infrastructure, and attain an understanding as to why they exist. Through this knowledge and by identifying the problem, respective boroughs can begin a process of redevelopment.

Table 1: Means and Standard Deviations

Variable	Mean	Standard Deviation	Minimum	Maximum
Acres of Brownfields	3.49	6.26	0.094	40.85
Unemployment, SMSA	4.80	2.50	2.40	17.30
Population Density, SMSA	4.8247	10.3502	.2360	75.0420
Income Per Capita, SMSA	23.933	3.588	15.959	33.721
%Labor Force Manufacturing, 1970	26.74	10.89	7.3	50.4
Median House Price, SMSA	107.040	33.646	64.400	229.000
%Change in Urban Land, 1982-1997	46.42	25.95	13.10	130.40

Dependent Variable: Brownfield Acres, expressed as brownfield acreage/total land acreage X 10,000 for results easier to comprehend and evaluate.
Unempl=unemployment rate at year-end, 1997
PopDens=population density given as hundreds of people/city land area, per square mile
IncPerCap=average personal income per person in thousands of dollars
Manuf1970=% of labor force in manufacturing in 1970
HousePr=median sales price for existing one-family homes, expressed in thousands of dollars
ChgUrbLand=% change in urban land from 1982 to 1997

Table 2: Regression Results for Brownfield Acreage (with standard errors)

Regression	**1**	**2**	**3**	**4**	**5**
Constant	5.867 (4.82)	7.878 (5.01)	4.503* (2.57)	7.194 (4.98)	3.860* (2.15)
Unempl	-0.125 (0.21)	-0.083 (0.22)	-0.091 (0.19)	-0.19 (0.22)	
PopDens	0.589*** (0.0602)	0.578*** (0.0604)	0.581*** (0.0539)	0.568*** (0.0617)	0.575*** (0.0521)
IncPerCap	-0. 072 (0.22)	-0. 064 (0.21)		-0. 34* (0. 19)	
Manuf1970	0.068 (0.045)	0.041 (0.049)	0.065 (0.044)	0.093** (0.045)	0.069 (0.043)
HousePr	-0. 044** (0.02)	-0. 047** (0.02)	-0. 048*** (0.016)		-0.047*** (0.016)
ChgUrbLand		-0.027 (0.021)			
n	52	52	52	52	52
R-Square	.7425	.7517	.7418	.7155	.7406
F-Value	26.52	22.70	33.76	29.56	45.68
Pr > F	<.0001	<.0001	<.0001	<.0001	<.0001

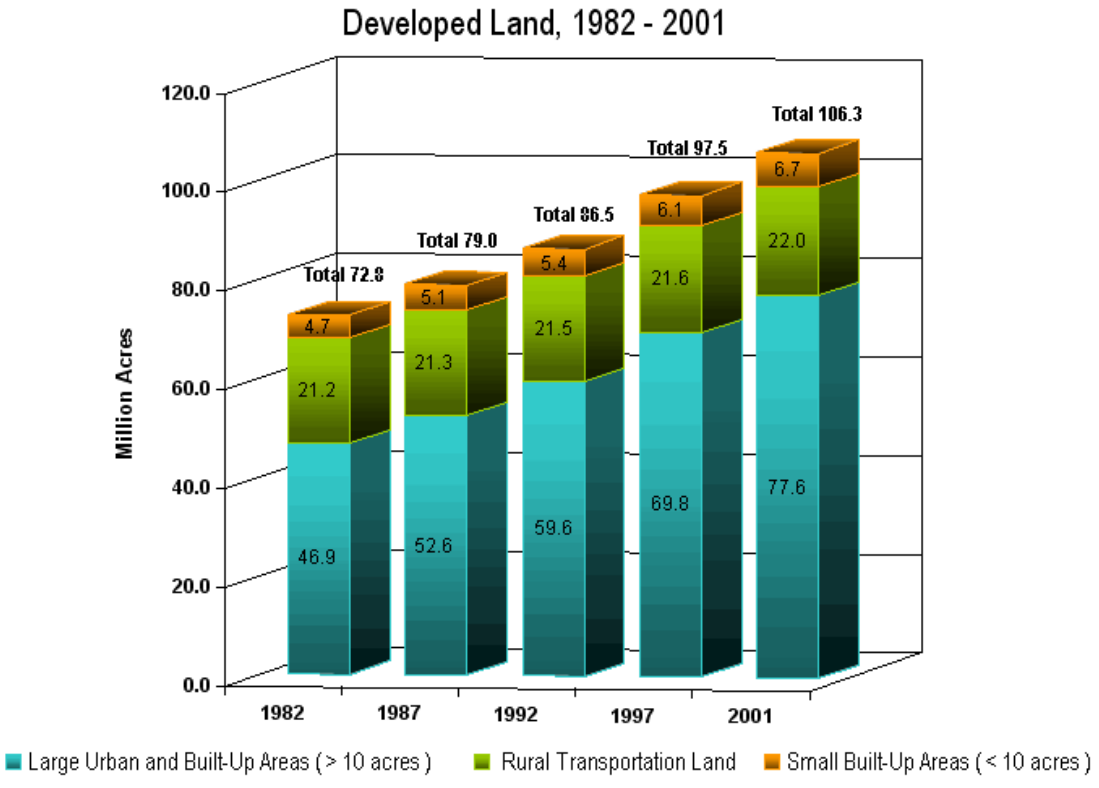
Dependent Variable: Brownfield Acres, expressed as brownfield acreage/total land acreage X 10,000 for results easier to comprehend and evaluate. Each regression checked and corrected for heteroskedasticity.
*t-value shows significance at 0.10 level
**t-value shows significance at 0.05 level
***t-value shows significance at 0.01 level
Unempl=unemployment rate at year-end, 1997
PopDens=population density given as hundreds of people/city land area, per square mile
IncPerCap=average personal income per person in thousands of dollars
Manuf1970=% of labor force in manufacturing in 1970
HousePr=median sales price for existing one-family homes, expressed in thousands of dollars
ChgUrbLand=% change in urban land from 1982 to 1997

Table 3: Pearson Correlation Coefficients for Brownfield Acreage (with probabilities)
Prob > | r | under Ho: Rho=0

	Acres	Unempl	PopDens	IncPerCap	Manuf1970	HousePr
Acres	1.000	0.113 (0.426)	0.82 (<.0001)	0.359 (0.009)	0.144 (0.310)	0.223 (0.108)
Unempl	0.113 (0.426)	1.000	0.16 (0.257)	-0.315 (0.023)	-0.139 (0.329)	-0.043 (0.76)
PopDens	0.82 (<.0001)	0.16 (0.257)	1.000	0.544* (<.0001)	-0.009 (0.945)	0.517* (<.0001)
IncPerCap	0.359 (0.008)	-0.315 (0.023)	0.544* (<.0001)	1.000	0.103 (0.468)	0.667* (<.0001)
Manuf1970	0.144 (0.309)	-0.138 (0.329)	-0.010 (0.945)	0.103 (0.468)	1.000	-0.132 (0.349)
HousePr	0.226 (0.108)	-0.043 (0.760)	0.517* (<.0001)	0.667* (<.0001)	-0.132 (0.349)	1.000

*Shows results with correlation problem
Table shows correlation between *PopDens*, *IncPerCap*, and *HousePr*.

Graph I: Amount of developed land in the U.S.



(Source: National Resource Inventory, USDA)

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