**Using Spatial Analyst to Determine Effects of Demolition on Blood Lead Levels in St. Louis City Children**

*A Preliminary Look*

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ABBREVIATIONS WITH DEFINITIONS:
CDC – Centers for Disease Control and Prevention
DHSS – Missouri Department of Health and Senior Services
EBL – Elevated Blood Lead Level(s)
EPHT – Environmental Public Health Tracking Grant
ESRI – Environmental Systems Research Institute
GIS – Geographic Information System(s)
HUD – Housing and Urban Development
NHANES – National Health and Nutrition Examination Survey
STELLAR – Systematic Tracking of Elevated Lead Levels and Remediation
$\mu$g/dl – micrograms per deciliter

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**Abstract**

Childhood lead poisoning is a major environmental public health problem in Missouri that causes adverse effects in the cognitive development, behavior, and growth of children. The Missouri Department of Health and Senior Services (DHSS) began collecting information on blood lead testing in 1993. The increased quantity and quality of blood lead testing data since that date has enabled DHSS staff to determine high-risk areas in Missouri; and to begin conducting more sophisticated blood lead studies.

One high-risk area, St. Louis City, contains 6% of the state's child population less than 72 months of age, but reported 49% of Missouri's elevated cases in 2002. One possible contributing factor is ambient lead dust dispersed from building demolitions. From 2001 to 2002, St. Louis City issued permits for the demolition of more than 2,000 buildings.

This preliminary study utilized elevated blood lead testing data for children under 72 months of age and the total number of demolitions completed within the city from 2001 to 2002 to identify areas in St. Louis City for further investigation on whether demolitions have an impact on elevating blood lead levels. The home addresses of elevated children and addresses of demolitions were geocoded and then processed through Environmental Systems Research Institute's Geographic Information Systems software, Spatial Analyst, to create spatial density layers. Spatial Analyst's map calculator was then used to combine the layers to determine spatial associations between those demolitions and elevated cases that fell three or more standard deviations above the mean. Finally, Chi-Square analysis was conducted to check for dependence/independence between area of residence and frequency of elevated blood levels in

children. The results were then presented to Tulane University Center For Applied Environmental Public Health for further investigation.

**Introduction**

Lead poisoning continues to be one of the greatest preventable public health hazards facing American children. Since 1970, the Centers for Disease Control and Prevention (CDC) has been tracking lead poisoning in children through The National Health and Nutrition Examination Survey (NHANES). In 1999-2000, NHANES showed that children under the age of six with elevated blood lead levels 10 micrograms per deciliter (μg/dl) or greater comprised about 434,000 (2.2%) of the total child population. Due to low prevalence of elevated blood lead levels and limits to these estimates, the CDC cautions that even this total is suspect. Based on these numbers, the CDC has as one of its *Healthy People 2010* goals the elimination in children of elevated blood lead levels of 10 μg/dl or greater (Centers for Disease Control and Prevention 2003).

Among the tools being used to target efforts to reduce childhood blood lead poisoning is Geographic Information Systems (GIS). Through the use of GIS software, public health professionals can better analyze and visualize data. This has greatly improved their ability to select targeted areas for blood lead screening in cities and counties throughout the United States.

Environmental public health journals contain numerous articles about projects that utilize GIS in an effort to concentrate scarce resources needed to reduce childhood blood lead poisoning.

Among them is a study by Michael G. Barndt of the Nonprofit Center of Milwaukee. In 1999, Barndt used Spatial Analyst, an extension of ArcView GIS software, to compare 24,000 annual lead screening results in Milwaukee with demographics and property records for 250,000 city parcels. Barndt utilized this relatively new software in his study because it allowed for the examination of clustering attributes, while avoiding the use of arbitrary units like Zip Codes. He also pointed out that additional benefits to using Spatial Analyst software included maximum granularity (detail), emphasis on explicit spatial patterns, and higher levels of confidentiality (Barndt, 1999).

Developed by Environmental Systems Research Institute (ESRI), Spatial Analyst contains several analytical and modeling tools. Some of the features provided by these tools are the ability to create continuous surfaces from scatter points or contours, perform cell-based map analysis, conduct neighborhood and zonal analysis, perform distance and cost analysis, undertake several advanced map algebra functions, and generate spatial density maps from point features (ESRI 2004).

Since its introduction in 1998, a variety of professions have embraced the use of Spatial Analyst. Law enforcement has utilized the software to determine high crime areas and reallocate officers. Foresters have used the software to determine areas of high fire potential. Corporations have used it to determine the best place to locate stores to obtain the maximum earning potential, and environmental specialists have used it to model air quality or to determine the impact of chemical spills in waterways. Its use in public health has been limited, primarily focusing on the creation of exposure maps through kriging.

Missouri Department of Health and Senior Services (DHSS) staff first used Spatial Analyst software in late 2002 to analyze the spatial distribution of elevated blood lead levels in children less than 72 months in age (2001 data) in St. Louis City. Final results identified several areas throughout the city where elevated blood lead levels concentrated (Smith 2002).

In 2002, The Missouri Department of Health and Senior Services was awarded Part B funding through the CDC's Environmental Public Health Tracking Grant (EPHT). As part of its funding request, Missouri began collaborating in 2003 with the Tulane University Center for Applied Environmental Public Health and the City of St. Louis on a retrospective epidemiological study to determine the impact of building demolitions in St. Louis City on elevated blood lead levels in children less than 72 months of age. Study participants proposed examining the relationship between demolition of housing units constructed prior to 1978 and blood lead levels in children living in the vicinity of demolition sites. Controlling ambient lead dust released during a demolition is important because it potentially can enter the residential environment on the soles of shoes, on the clothes of children, or through open windows and doors, thus increasing the likelihood of ingestion by children. If the study identified a correlation, plans of action would be developed to mitigate the effects.

To identify areas in St. Louis City for investigation, DHSS staff utilized Spatial Analyst software. This preliminary project built on the initial work completed in 2002 by identifying those areas where there was a spatial association between concentrations of children less than 72 months in age with elevated blood lead levels and higher concentrations of building

demolitions in the city. Chi-Square analysis was conducted to check for dependence / independence between area of residence and frequency of elevated blood lead levels in children. Identified areas of association were provided to Tulane University for further study.

**The St. Louis Demolition Study**

DHSS began collecting statewide information on blood lead testing in 1993. The increased quantity and quality of blood lead testing data collected since that date has enabled DHSS staff to determine high-risk areas like St. Louis City.  St. Louis City contains 6% of the state's child population less than 72 months of age (Figure 1), but reported 49% of all Missouri elevated cases in 2002. One possible contributing factor is ambient lead dust dispersed from building demolitions. From 2001 to 2002, St. Louis City issued permits for the demolition of more than 2,000 buildings (St. Louis City 2003).

In 2002, St. Louis City lead detoxification crews began reporting to St. Louis City public health officials that children near demolition sites were showing higher than normal rates of elevated blood lead levels. Crewmembers stated that children, who had undergone Chelation Therapy to reduce blood lead levels, would return home, only to be back in the hospital within two weeks. Since most of their residences had undergone some form of abatement during the child's absence, they strongly suspected that airborne lead from demolitions was the culprit.

In his 1999 study, J.J. Diorio discovered that demolition activities could increase health risks as a result of the materials dispersed into the environment (Diorio 1999). A more in-depth study conducted from 1999-2000 in Baltimore, Maryland, by the Kennedy Krieger Research Institute,

John Hopkins University, and the U.S. Department of Housing and Urban Development (HUD) discovered that within 10 meters of a demolition site ambient dust lead levels did rise. Collecting lead dust fall-out at three different demolition sites in Baltimore, the team discovered that the geometric mean (GM) lead dust fall-out rate increased 40-fold to 410 µg Pb/$m^2$/hr (2,700 µg Pb/$m^2$ per typical work day) during demolition and 6-fold to 61 µg Pb/$m^2$/hr (440 µg Pb/$m^2$ per typical work day) during debris removal. Lead concentrations in dust fall-out also increased during demolition (GM, 2,600 mg/kg) and debris removal (GM, 1,500 mg/kg) compared with baseline (GM, 950 mg/kg) (Farfel et al. 2003).

**Materials and Methods**

The City of St. Louis has been collecting blood lead test information on children for nearly 40 years. Since 1993, these data have been reported to DHSS and stored in its Systematic Tracking of Elevated Lead Levels and Remediation (STELLAR) database. This database contains the child's name, dates of tests, test results, and any action taken to reduce elevated blood lead levels. While the system tracks multiple test results for each child, to limit duplication, only the highest reported venous results for both 2001 and 2002 were utilized for this preliminary study.

To begin the study, test results for 2001 and 2002 were queried from STELLAR and interactively geocoded.  All addresses in this study were geocoded using CENTRUS geocoding software produced by Group One Software. In 2001, 10,414 individual children were screened. This number increased to 10,792 in 2002. From this screening data a subset of those children with test results of 10 µg/dl or greater was created. In 2001, 2,017 children had elevated blood lead levels. In 2002, the number declined to 1,667.

This study utilized demolition data obtained from the St. Louis City Building Division's

Demolitions Permit database. The date of completion for each project was queried to find all

demolitions that occurred between January 1, 2001, and December 31, 2002. The addresses for

these completed projects were then interactively geocoded. In 2001, 990 demolitions were

completed and 907 (91.6%) of these successfully geocoded. In 2002, St. Louis City recorded

1,033 demolitions and 954 (92.4%) of these geocoded successfully.

**Use of Spatial Analyst Software**

A feature of ESRI's Spatial Analyst software is the ability to utilize a series of predefined

algorithms to create spatial density layers from point features. Through the creation of these

layers, "hot spots" or areas of high concentration can be identified.

The geocoded data for elevated blood lead cases and demolitions were processed in Spatial

Analyst to identify those areas of highest concentration. The St. Louis City border served as the

extent for the process. Cells (the basic spatial unit for a raster image) were processed at the

accepted standard of 50 meters. The results, shown in Figures 2- 5, identified several areas

throughout the city where elevated blood lead cases and demolition activity were concentrated.

While spatial density maps do show those areas where elevated blood lead cases and

demolitions are greatest in the city, they still do not answer the question of where spatial

associations between these two exist. Another feature of the Spatial Analyst software is the

ability to perform "map algebra". Through the map calculator function, two or more layers can be compared.

To prepare the layers for comparison, the elevated blood lead cases and demolition layers were reclassified from one to nine using Spatial Analyst's reclassify function, with one (1) being the least dense and nine (9) being the most dense. To guarantee that only the most significant associations were identified, the statistical distribution of each layer was evaluated. Comparisons for each layer were conducted at three standard deviations above the mean to reduce chance of random error. In 2001, this equated to an elevated blood lead target score of 4.775 and a demolition target score of 4.796. Three standard deviations above the mean for the number of elevated blood lead cases in 2002 yielded a target score of 5.474 and for the demolitions a target score of 5.572. For each year these totals were rounded to the nearest whole number to match the one to nine reclassifications.

Using the map calculator, the reclassifications greater than or equal to each rounded whole number for elevated blood lead cases and demolitions were combined. In 2001, elevated blood lead cases and demolitions were compared at five (5) or greater. In 2002, elevated blood lead cases were compared at five (5) or greater, while demolitions were compared at six (6) or greater. The final results, shown in Figures 6 and 7, identify several areas throughout the city that warranted a closer look by Tulane University.

**Chi-Square Test**

It is useful to statistically confirm a relationship that appears to be evident when viewed on a map. In this case, the numbers of children with and without elevated blood lead levels were examined as to whether they fell into or outside of demolition areas using the Chi-Square test for significant differences. Children were defined as any persons 72 months of age and under living in the City of St. Louis. Elevated Blood Lead Levels were defined as individuals having a blood lead level test result equal to or greater than 10 micrograms of lead per deciliter of blood. Demolition areas were defined as any area of The City of St. Louis falling within ¼ mile of any demolition (per the proposed Tulane University study protocol).

A Chi-Square test for significant differences was conducted once each for calendar years 2001 and 2002 comparing numbers of elevated and non-elevated blood lead test results by number of lead tests inside and outside of demolition areas. The null hypothesis was that blood lead level in children is independent of demolitions in St. Louis City. For Alpha=.05, df=1, the critical value to reject the null hypothesis was 3.84. The total calendar year for 2001 yielded a Chi-Square of 24.732 (N=10,414), and the total calendar year for 2002 yielded a Chi-Square of 61.288 (N=10,792). At Alpha=.05, there was sufficient evidence to reject the hypothesis that elevated and non-elevated blood lead test results are independent of areas of demolitions and areas of non-demolitions for the years 2001 and 2002.

A second set of Chi-Square tests were run in which numbers of elevated and non-elevated blood lead test results were examined by the number of blood lead tests in and out of

demolition areas for only those areas where 50% or more of housing was built prior to 1950 (Figure 8). This helped control for the possibility that the majority of demolitions occur in areas of older housing and that older housing itself might account for the apparent dependence between blood lead levels and demolitions shown above. The total calendar year 2001 numbers of elevated blood lead level test results by demolition and non-demolition areas in only areas with greater than 50% or more of housing built before 1950 yielded a Chi-Square of 126.907 (N=8,408). The total calendar year 2002 numbers of elevated blood lead level test results by demolition and non-demolition areas in only areas with greater than 50% or more of housing built before 1950 yielded a Chi-Square of 26.368 (N=8,500). At Alpha=.05, there was sufficient evidence to reject the hypothesis that elevated and non-elevated blood lead test results are independent of areas of demolitions and areas of non-demolitions in those areas where 50% or more of housing is older than 1950 for the years 2001 and 2002.

Finally, Chi-Square tests were run in which numbers of elevated and non-elevated blood lead test results were examined by the number of blood lead tests inside and outside of demolition areas for only those areas where 75% or more of housing was built prior to 1950. This helped to further control for variations between amount of newer and older houses even when controlled at the 50% mark. The total calendar year 2001 numbers of elevated blood lead level test results by demolition and non-demolition areas in only areas with greater than 75% or more of housing built before 1950 yielded a Chi-Square of 13.386 (N=3,437). The total calendar year 2002 numbers of elevated blood lead level test results by demolition and non-demolition areas in only areas with greater than 75% or more of housing built before 1950 yielded a Chi-Square of 18.331 (N=3,751). At Alpha=.05, there was sufficient evidence to reject the

hypothesis that elevated and non-elevated blood lead test results are independent of areas of demolitions and areas of non-demolitions in those areas where 75% or more of housing is older than 1950 for the years 2001 and 2002.

**Final Conclusion**

The purpose of this preliminary study was to identify areas for further investigation. Two findings stand out from the initial results. First, Spatial Analyst is a useful tool for comparing elevated blood lead levels and demolitions. It allows the researcher to visually see where "hotspots" exist. The map calculator function also allows for the combining of layers to better focus research efforts on those areas found to have a strong spatial association.

Second, the Chi-Square tests suggest that there was a dependency between blood lead level and proximity to demolitions. While a directional relationship was not indicated by this study, it does support the need for further analysis to determine if residence in demolition areas contributes to elevated blood lead levels. Based on these preliminary findings, more intense analysis incorporating lead dispersion models and climatic data is planned for one or two of the areas identified by Spatial Analyst as having strong spatial association.

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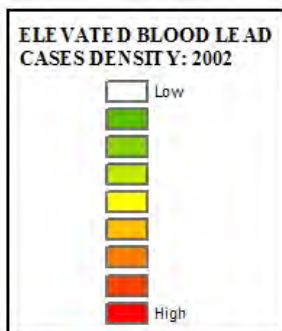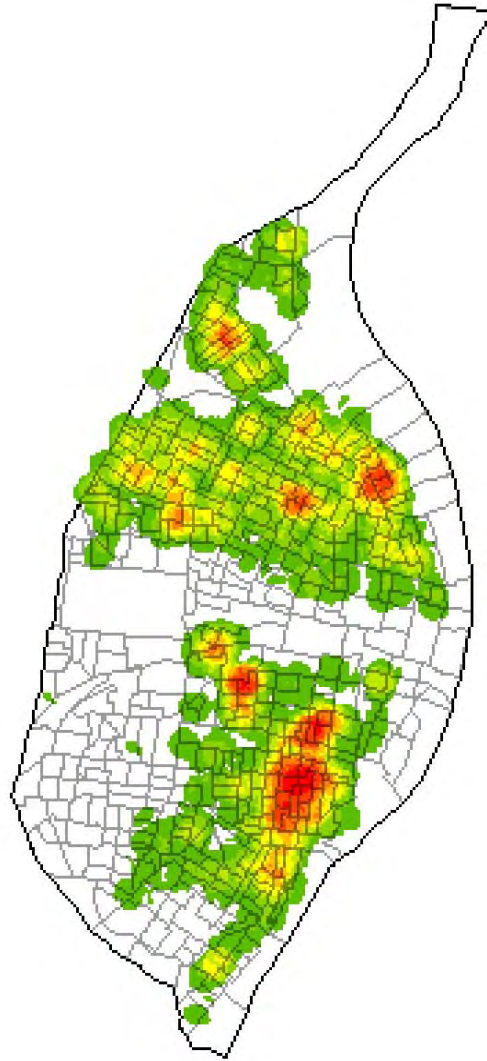
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**Total by Block Group**

- 0
- 1 - 50
- 51 - 100
- 101 - 200
- 201 - 300
- 301 - 400
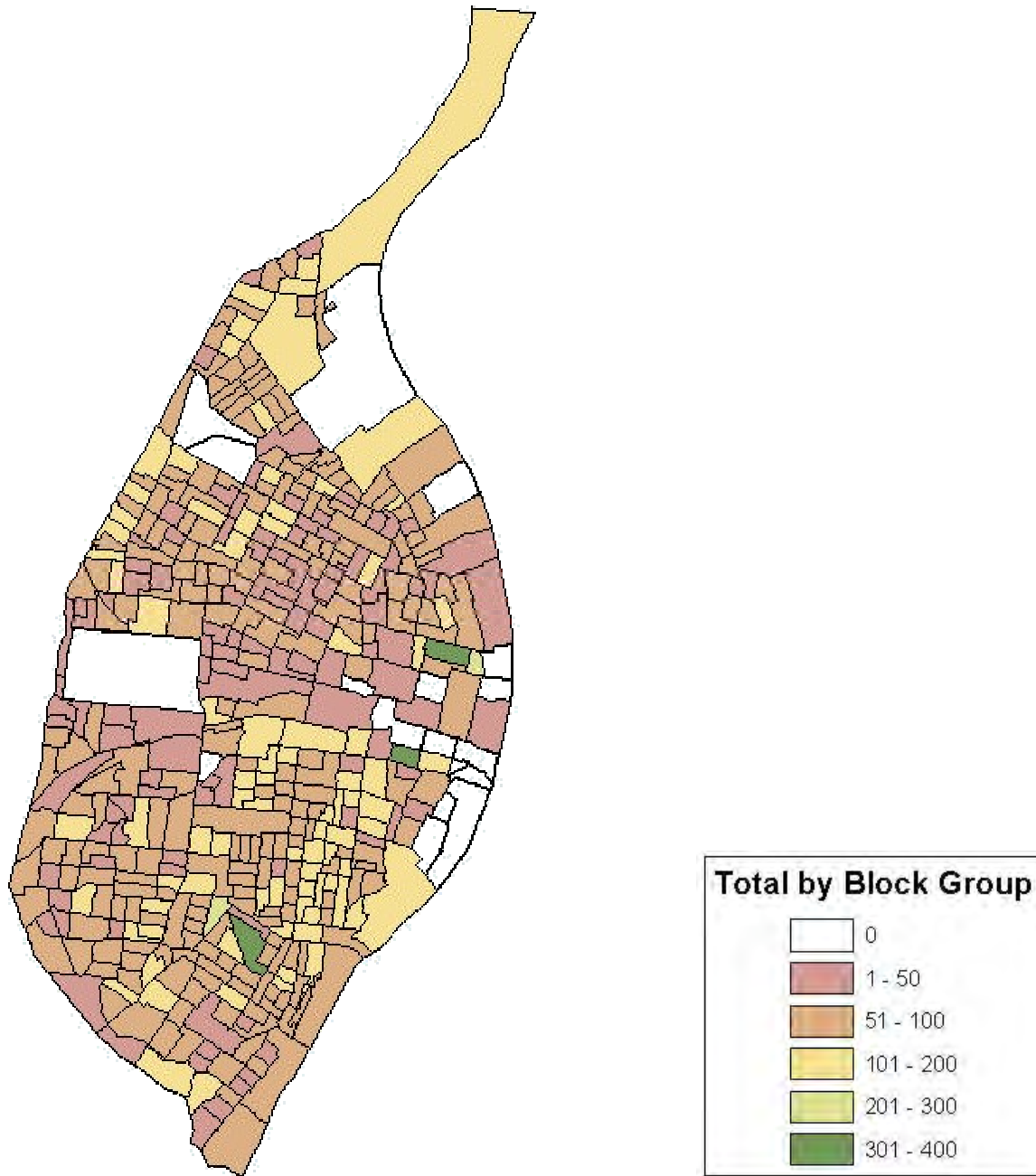
**Figure 1: Total Children Under 72 Months of age
In St. Louis City: Census 2000**

ELEVATED BLOOD LEAD
CASES DENSITY: 2001

Low

High

**Figure 2: Density of Elevated Blood Lead Cases for 2001**

**ELEVATED BLOOD LEAD CASES DENSITY: 2002**
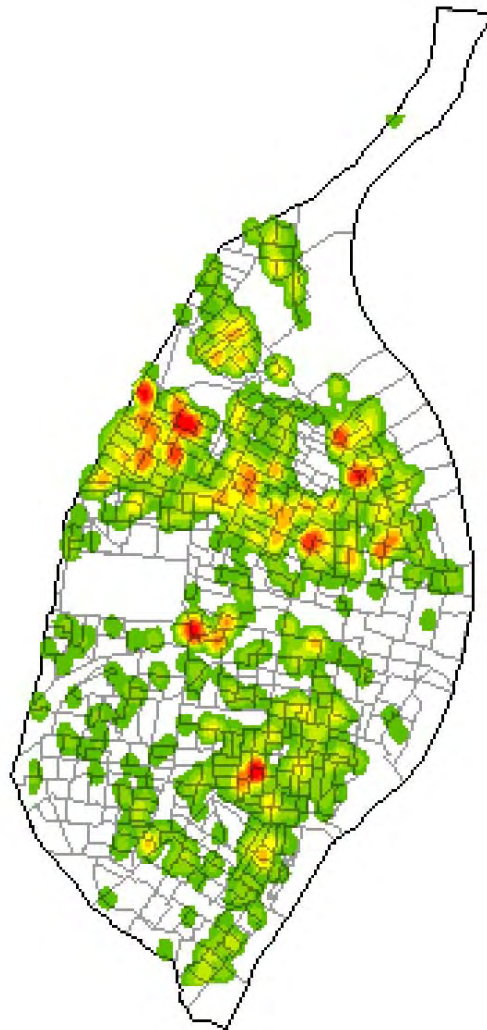
Low
High

**Figure 3: Density of Elevated Blood Lead Cases for 2002**

DEMOLITION DENSITY: 2001

Low

High
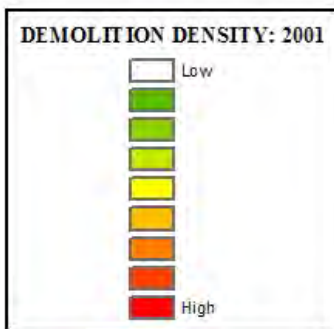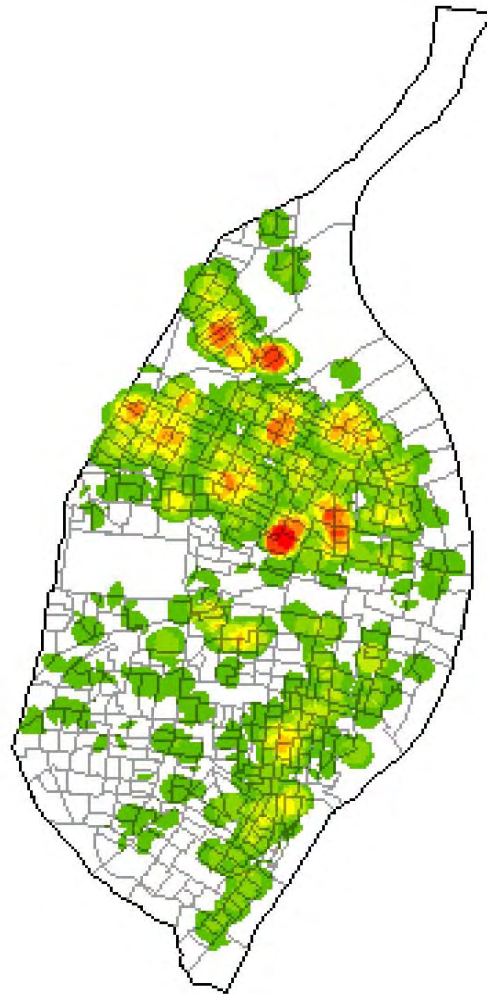
Figure 4: Density of Demolitions 2001

DEMOLITION DENSITY: 2002

Low

High
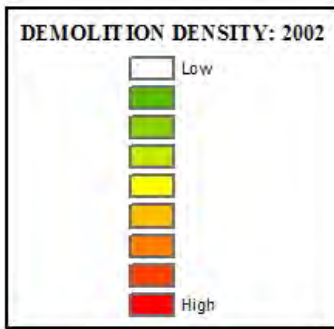
**Figure 5: Density of Demolitions 2002**

SPATIAL ASSOCIATION: 2001
☐ NO SPATIAL ASSOCIATION
■ SPATIAL ASSOCIATION
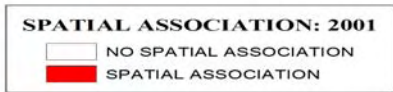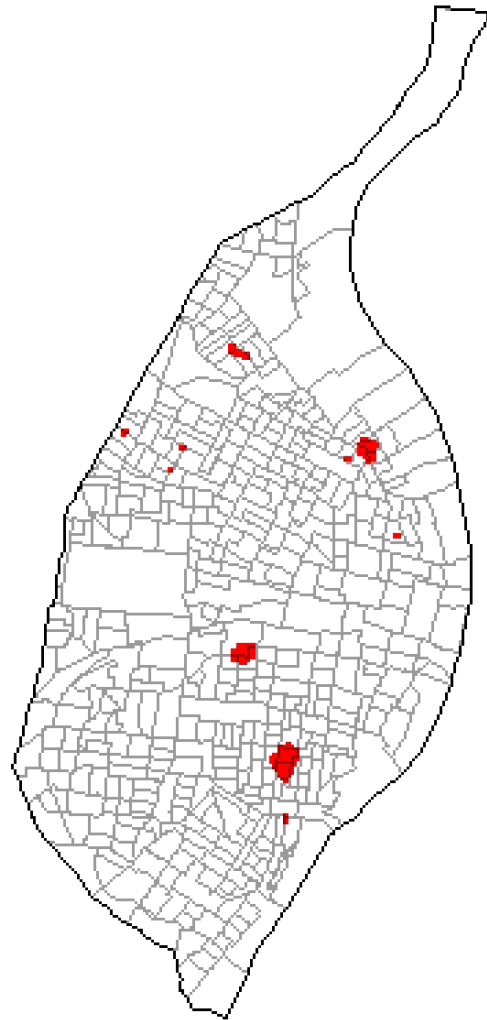
**Figure 6: Spatial Association between EBLs and Demolitions 2001**

SPATIAL ASSOCIATION: 2002
NO SPATIAL ASSOCIATION
SPATIAL ASSOCIATION
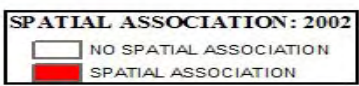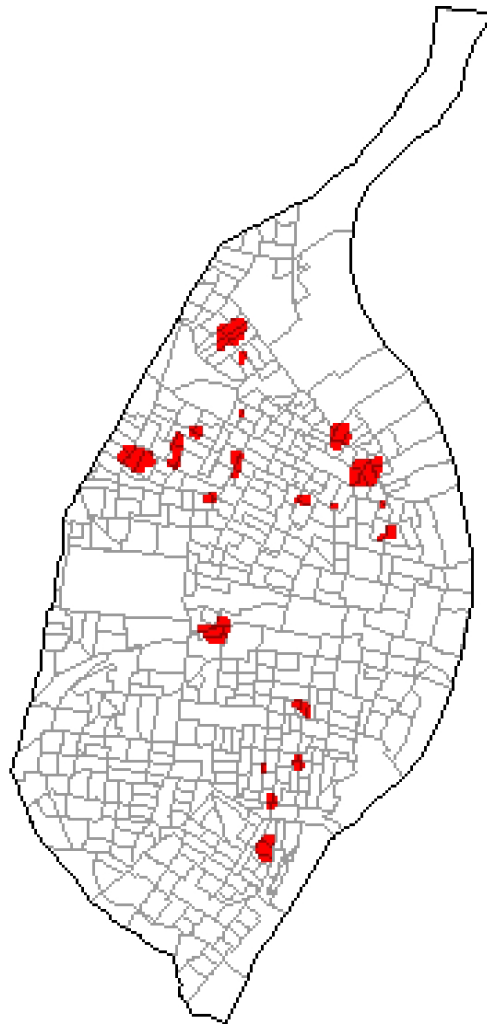
**Figure 7: Spatial Association between EBLs and Demolitions 2002**
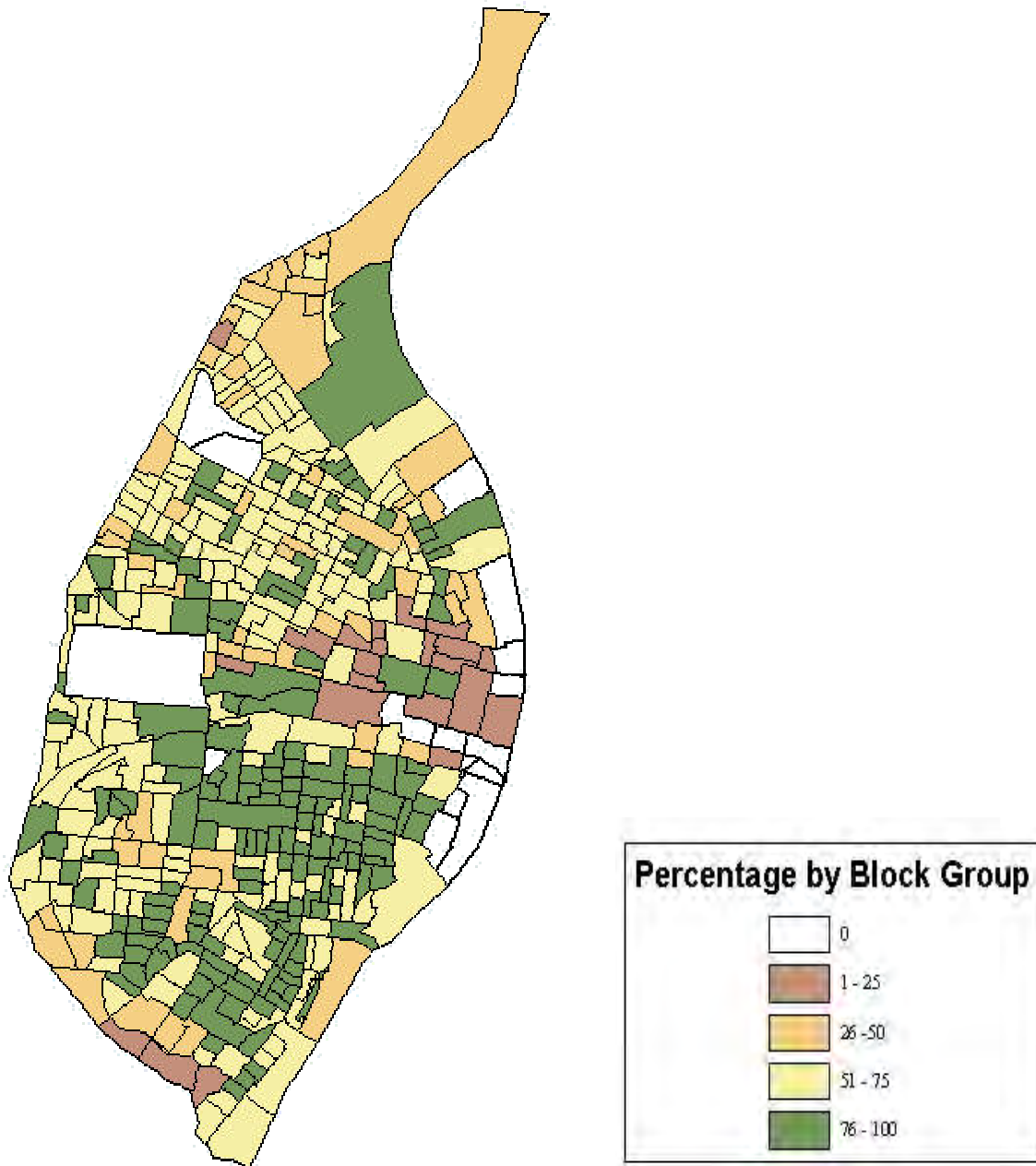
**Figure 8: Percentage of Housing 50 Years or
Older In St. Louis City: Census 2000**