Urban Tree Canopy Assessment & Planting Plan

Atlanta, Georgia

Made possible by the generous support of

Bank of America

U.S. Forest Service, Department of Agriculture

AMERICAN FORESTS

Contents

Tables

Figures

Appendices

Acknowledgments

Funding for this project has been made possible by American Forests, the Bank of America Charitable Foundation and the United States Forest Service.

American Forests would like to thank Trees Atlanta and, in particular, Susan Cunningham, Greg Levine, Alex Bessely, Kate Connor and Lauren Sandoval for their collaborative vision and assistance in the goals and outcomes, providing feedback and contributing general oversight for this important project.

American Forests also thanks The Davey Tree Expert Company for the consultation and analysis theycontributed to this project.

Introduction

American Forests launched Community ReLeaf in spring 2013 as a replicable three-stage program which combines assessments, strategic restoration and capacity-building for outreach and education in targeted cities across the country. Reaching geographically and culturally diverse communities, American Forests aims to bring national attention to the value of our urban forests and plans to be working in 20 major cities by 2020.

In its inaugural year, Community ReLeaf worked in Atlanta, Ga.; Asbury Park, N.J.; Detroit, Mich.; Nashville, Tenn.; and Pasadena, Calif. This assessment is one of the five completed reports.

Using the best available scientific measures and methods, the results of the assessments provide insight for urban forestry practitioners, city officials and the general public into the overall condition of each city's urban forest and the environmental and socioeconomic benefits it provides at both the local and national levels — thereby informing strategic preservation and restoration activities.

About American Forests

American Forests restores and protects urban and rural forests. Founded in 1875, it is the oldest national nonprofit conservation organization and has served as a catalyst for many milestones in the conservation movement including the founding of the U.S. Forest Service and the national forest and national park systems. American Forests has conducted thousands of forest ecosystem restoration projects and public education efforts; since 1990 it has planted more than 45 million trees in all 50 states and in 44 countries, resulting in cleaner air and drinking water, restored habitat for wildlife and fish and the removal of millions of tons of carbon dioxide from the atmosphere. Learn more at www.americanforests.org.

About Bank of America's Corporate Social Responsibility

The Bank of America Charitable Foundation's commitment to corporate social responsibility (CSR) is a strategic part of doing business globally. The bank's CSR efforts guide how it operates in a socially, economically, financially and environmentally responsible way around the world, to deliver for shareholders, customers, clients and employees. Its goal is to help create economically vibrant regions and communities through lending, investing and giving. By partnering with stakeholders, the Bank of America Charitable Foundation creates value that empowers individuals and communities to thrive and contributes to the long-term success of its business. The Bank of America Charitable Foundation has several core areas of focus for its CSR, including responsible business practices; environmental sustainability; strengthening local communities with a focus on housing, hunger and jobs; investing in global leadership development; and engaging through arts and culture. As part of these efforts, employee volunteers across the company contribute their time, passion and expertise to address issues in communities where they live and work. Learn more at www.bankofamerica.com/about and follow Bank of America Charitable Foundation on Twitter at @BofA_Community.

About the U.S. Forest Service

The mission of the Forest Service is to sustain the health, diversity and productivity of the nation's forests and grasslands to meet the needs of present and future generations. The agency manages 193 million acres of public land, provides assistance to state and private landowners and maintains the largest forestry research organization in the world. Public lands managed by the Forest Service contribute more than $13 billion to the economy each year through visitor spending alone. Those same lands provide 20 percent of the nation's clean water supply — a value estimated at $7.2 billion per year. The agency also has either a direct or indirect role in stewardship of about 80 percent of the 850 million forested acres within the U.S., of which 100 million acres are urban forests located in or near areas where most Americans live.

Executive Summary

This report was developed by American Forests with a focus on assessing environmental and public health benefits from the urban tree canopy (UTC) in the Atlanta metropolitan area. The primary project goals of this assessment and report were to establish baseline data on the extent and function of the urban forest as it relates to public health and to develop tools and resources for promoting awareness of the benefits of trees.

Atlanta's urban provides many benefits. Environmental benefits include cooler air temperatures, conserved energy from reduced utility use, air pollution mitigation, improved water quality, reduced flooding and creation and preservation of wildlife habitat. Socioeconomic benefits include improved public health, increased recreational and educational opportunities, stronger community cohesion, lower crime rates, higher property values and enhanced quality of life.

For the study, American Forests selected 51 school zones encompassing three Atlanta-area school districts — Atlanta Public Schools, Dekalb County Schools, and City Schools of Decatur. School zones were used as a foundation of this study in order to determine the impact tree canopy has on the broader environment and population from which schools draw their students.

The 51 school zones included in this study comprise approximately 101,600 acres, or 158.75 square miles. Zone identification numbers were assigned by The Davey Research Group (DRG) and are used in this report. American Forests completed UTC assessments, estimated environmental benefits using i-Tree Vue and i-Tree Design software, compiled demographic and public health data and estimated public health benefits using the United States Environmental Protection Agency (EPA) Environmental Benefits Mapping and Analysis Program (BenMAP). On average, 47% of the land within all 51 school zones is covered with tree canopy and 25% is covered by impervious surfaces. Most school zones (44 of 51) have more tree canopy cover than impervious surfaces, while zones near Atlanta's urban core have less tree canopy cover and more impervious surfaces. Canopy cover across the entire city removes an estimated 3.6 million pounds of air pollutants — a benefit valued at $41,877,244. The health benefits related to trees removing air pollutants total approximately $12,597,919.

The benefits of the urban forest will increase as existing trees mature and new trees are planted. However, with an average of 47% tree canopy cover already living in the study area, it is critical to promote the benefits of the urban forest to the community at large and fund tree management throughout each tree's life cycle. This effort should include not only planting new trees, but also maintaining the health and safety of existing trees, removing dying or critically diseased trees in a timely manner, and reusing urban wood waste.

Table 1. Summary of 2010 UTC Assessment Results for Atlanta-Area School Zones

School Zone ID# (School Area Name)	Urban Tree Canopy Assessment (%)	
	Tree Canopy Cover (Percent of Area)	Impervious Surfaces (Percent of Area)
Percent of Tree Canopy Cover, Top Ten		
Zone 2 (Beecher Hills)	72.36	6.89
Zone 31 (Jackson)	67.60	9.84
Zone 11 (Cleveland Avenue)	66.29	11.62
Zone 34 (Kimberly)	65.34	14.43
Zone 7 (Brandon)	62.66	14.37
Zone 29 (Humphries)	61.45	12.88
Zone 22 (Fickett)	60.69	13.19
Zone 33 (Kelley Lake)	60.60	20.50
Zone 16 (Deerwood)	59.26	15.33
Zone 49 (Venetian Hills)	59.04	13.90
Percent of Tree Canopy Cover, Bottom Ten		
Zone 42 (Slater)	36.22	28.08
Zone 32 (Jones)	35.73	33.28
Zone 51 (Whitefoord)*	35.57	42.31
Zone 5 (Bolton Academy)*	33.98	38.40
Zone 14 (D.H. Stanton)	32.07	28.74
Zone 25 (Gideons)*	28.43	40.27
Zone 45 (Thomasville)*	23.95	33.92
Zone 28 (Hill-Hope)*	18.39	53.70
Zone 19 (Dunbar)*	17.69	52.95
Zone 10 (Centennial Place)*	16.43	60.27

* These seven school zones contain more impervious surfaces than tree canopy cover.

School Zone UTC Assessment

On average, 47% of the land within all 51 school zones is covered with tree canopy and 25% is covered by impervious surfaces, which do not allow rainfall to infiltrate and typically include roads, buildings, parking lots and sidewalks. Table 1 lists the 10 school zones with the largest percent tree canopy cover and the 10 with the smallest. Most (44 of 51) zones have more tree canopy coverage than impervious surface area. Figure 1 compares distribution of tree canopy cover across all school zones; Figure 2 compares distribution of impervious surfaces. School zones near Atlanta's urban core have less tree canopy cover and more impervious surfaces than outlying areas.

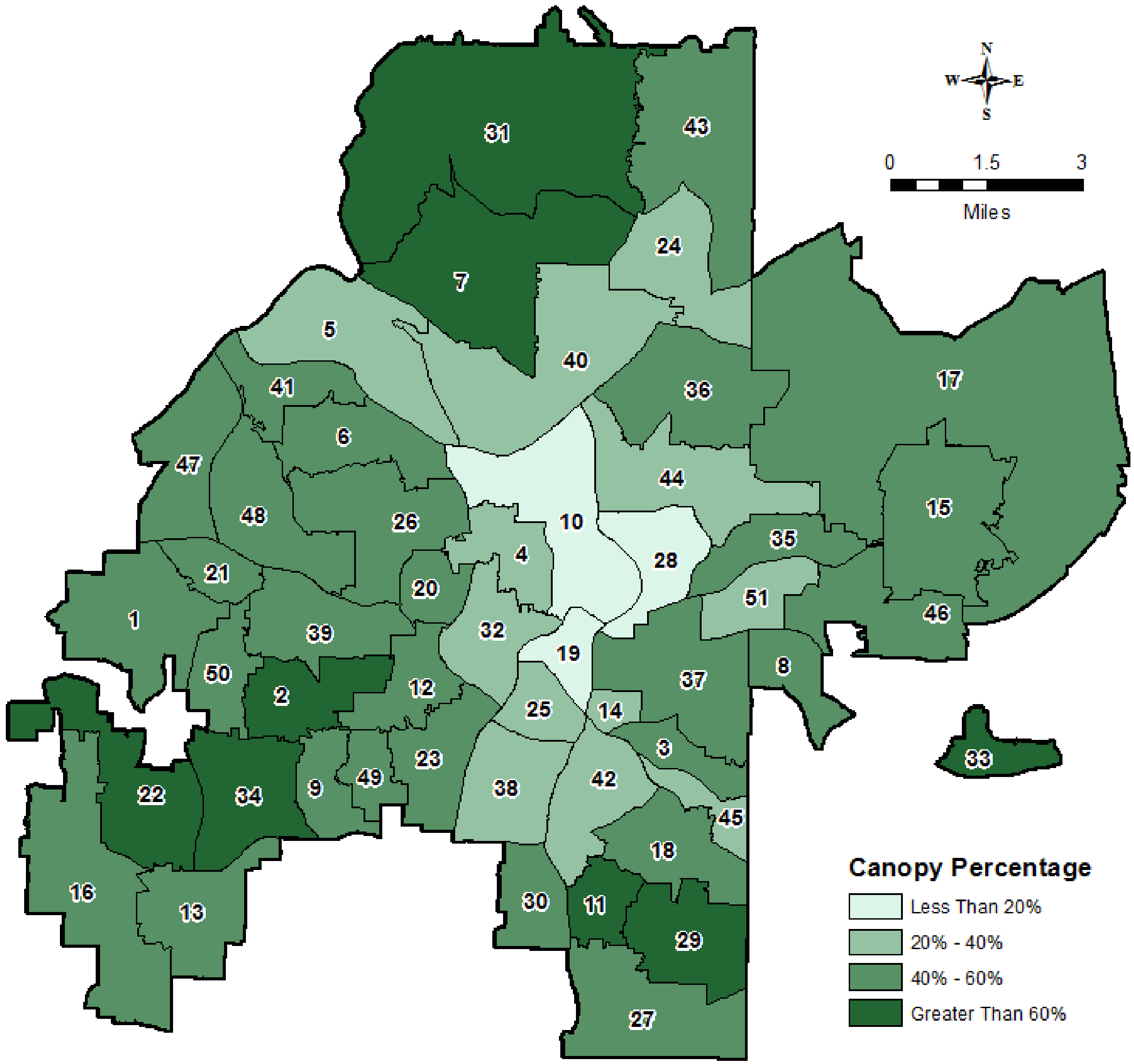


Figure 1. Comparison of tree canopy cover in 2010 for 51 Atlanta-area school zones.

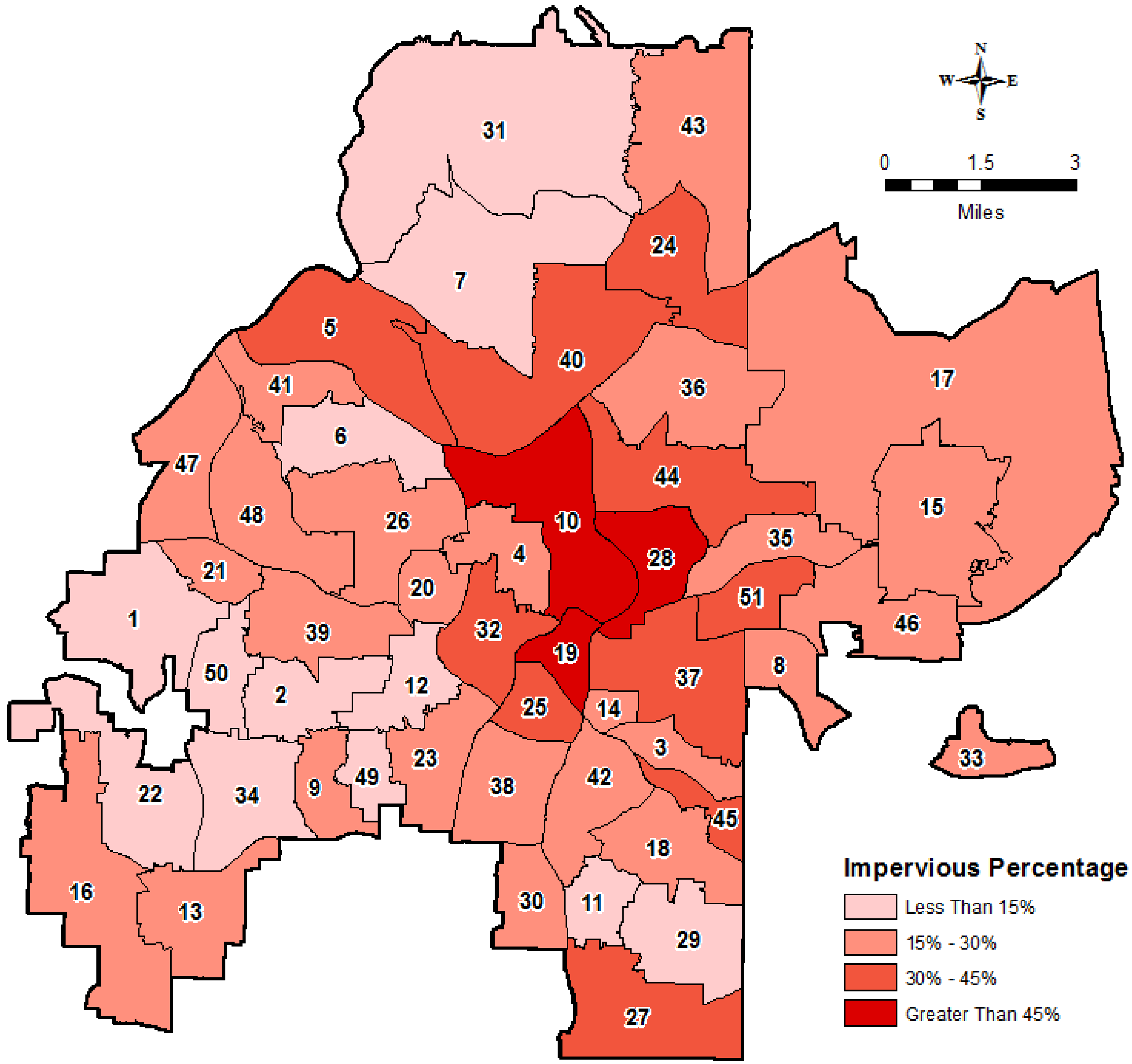


Figure 2. Comparison of impervious surfaces in 2010 for 51 Atlanta-area school zones.

I-Tree Vue Analysis

I-Tree Vue interprets National Land Cover Database (NLCD) satellite-based imagery; produces statistical estimates of tree canopy, impervious surfaces and other land cover types; and calculates benefits such air pollutant removal and carbon storage and sequestration. The following is an explanation of each analysis:

Air Quality: The software supports analysis of pollution removal from different land cover classes including tree canopy. Air pollutants included in estimates are carbon monoxide (CO), ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and particulate matter (PM_{10}). Reports quantify the monetary and unit values of pollution reduction directly associated with current tree canopy.

Carbon: The software model also provides the solution to evaluating the carbon sequestration and storage services provided by the project area's land cover classes. Results demonstrate the amount of tree canopy directly correlated to current carbon dioxide (CO_2) levels.

The urban forest plays an important role in supporting and improving the quality of life in urban areas. When properly maintained, trees provide abundant environmental and socioeconomic benefits far in excess of the time and money invested in their planting and maintenance.

School Zone Environmental Benefits

Trees conserve energy, mitigate stormwater runoff, reduce CO_2 levels and remove air pollutants. Tree canopy cover within the study area annually removes 3,601,607 pounds of air pollutants and 2,051,926 tons of carbon valued at $41,877,244 for an average of $1,085,353 per school zone.

Table 2. 2010 Ecosystem Benefit Results for Atlanta-Area School Zones

School Zone ID# (School Area Name)	Tree Canopy Cover (Percent)	Tree Canopy Cover (Acreage)	Air Quality (US Dollars)	Carbon (US Dollars)
Percent of Tree Canopy Cover, Top Ten				
Zone 2 (Beecher Hills)	72.36	1,438	63,458	865,064
Zone 31 (Jackson)	67.60	5,058	315,470	4,300,496
Zone 11 (Cleveland	66.29	503	31,964	435,736
Zone 34 (Kimberly)	65.34	1,249	79,441	1,082,939
Zone 7 (Brandon)	62.66	2,535	156,709	245,020
Zone 29 (Humphries)	61.45	1,055	67,269	917,018
Zone 22 (Fickett)	60.69	1,410	89,536	1,220,561
Zone 33 (Kelley Lake)	60.60	389	24,589	335,191
Zone 16 (Deerwood)	59.26	2,011	141,650	1,930,981
Zone 49 (Venetian Hills)	59.04	370	23,509	320,476
Percent of Tree Canopy Cover, Bottom Ten				
Zone 42 (Slater)	36.22	561	152,189	488,493
Zone 32 (Jones)	35.73	483	128,042	410,988
Zone 51 (Whitefoord)	35.57	333	90,222	289,594
Zone 5 (Bolton Academy)	33.98	921	241,225	780,953
Zone 14 (D.H. Stanton)	32.07	96	25,733	82,597
Zone 25 (Gideons)	28.43	215	57,377	184,168
Zone 45 (Thomasville)	23.95	135	35,947	115,384
Zone 28 (Hill-Hope)	18.39	235	63,040	202,345
Zone 19 (Dunbar)	17.69	116	31,050	99,665
Zone 10 (Centennial Place)	16.43	466	125,136	401,660

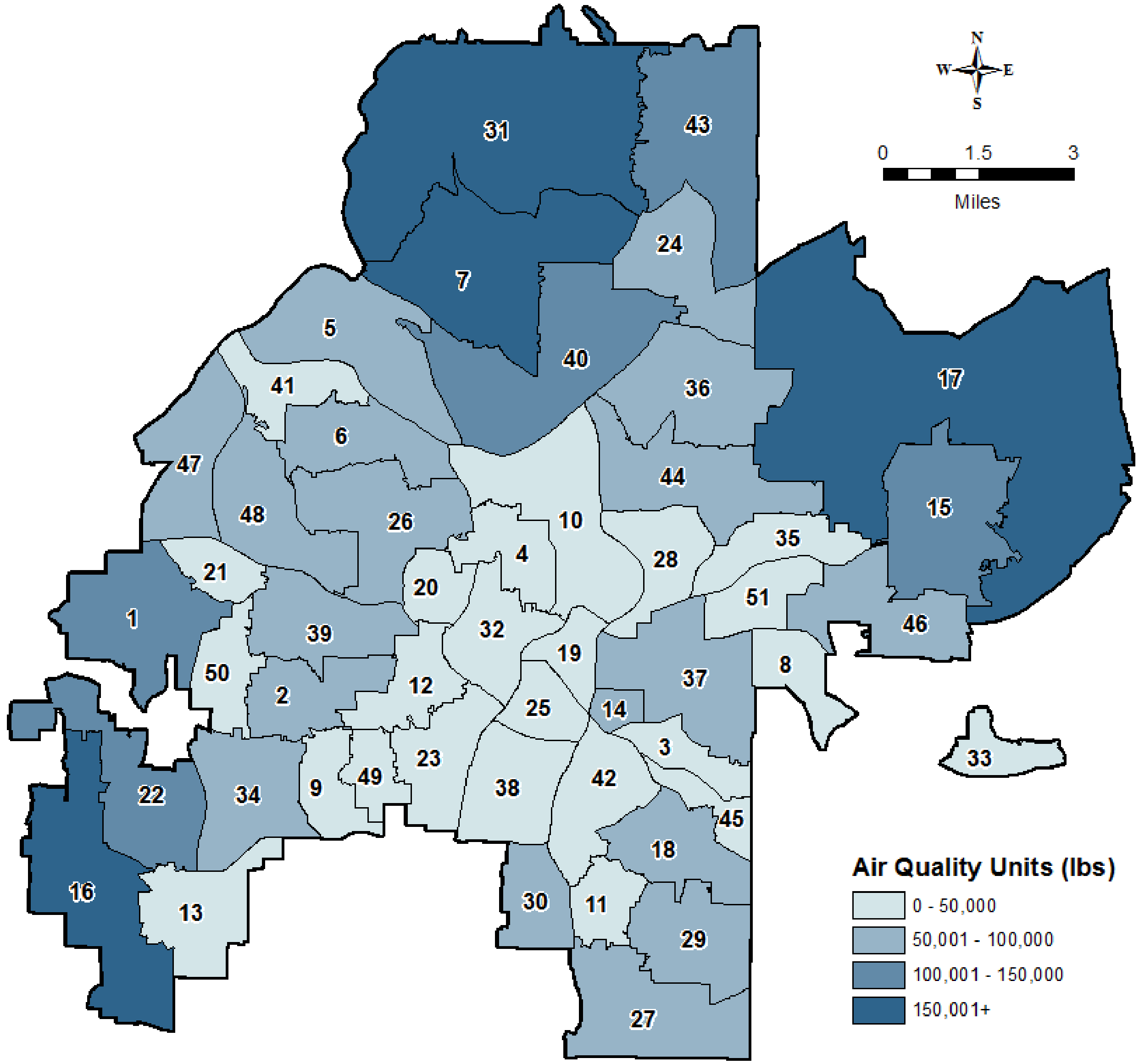


Figure 3. Comparison of air quality improvement benefit in 2010 for 51 Atlanta-area school zones.

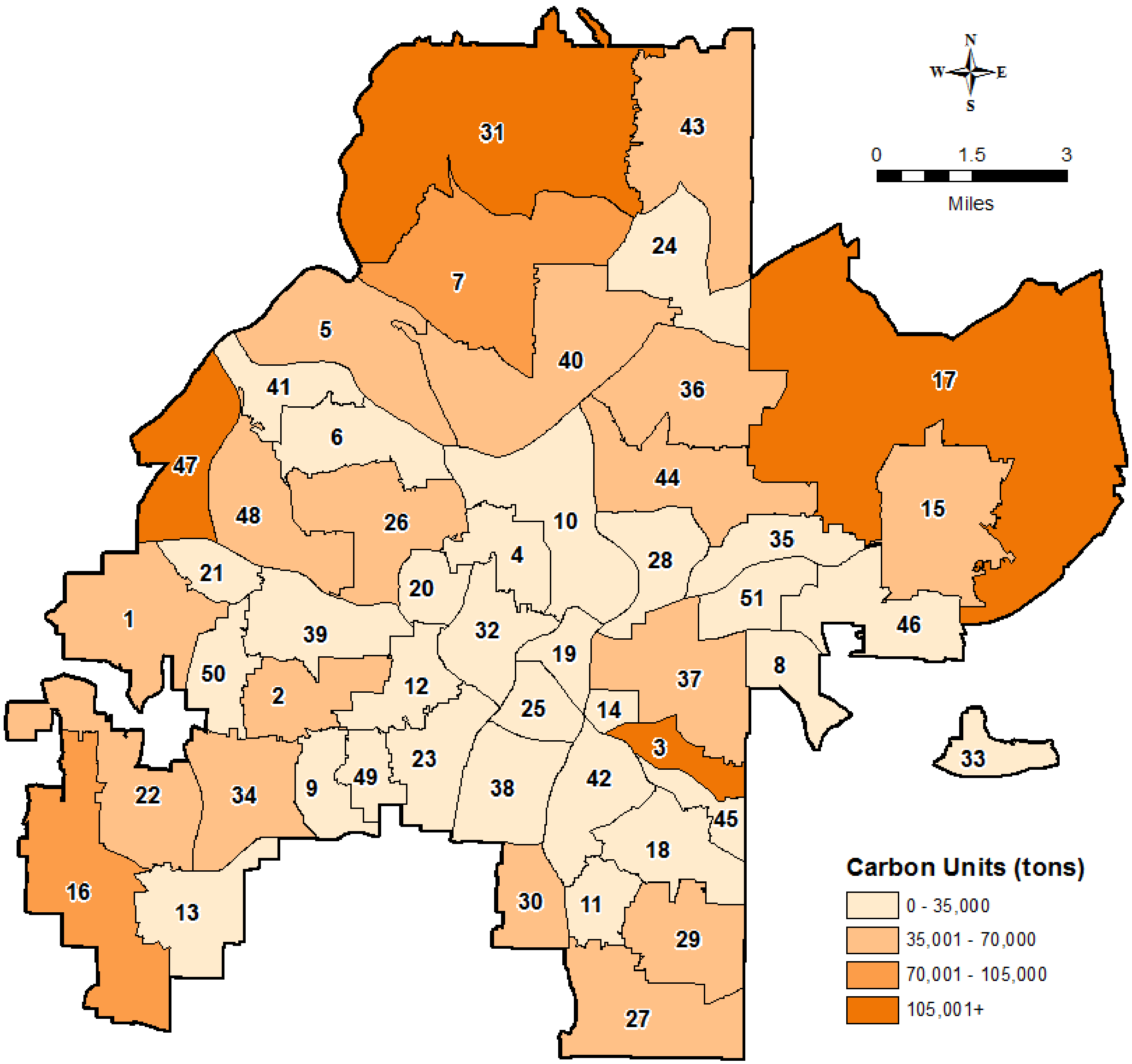


Figure 4. Comparison of carbon-reduction benefits in 2010 for 51 Atlanta-area school zones.

School Zone Demographics

The amount of tree canopy within a school zone has socioeconomic as well as environmental impacts. Census block group data from 2010 is used to assess population, median household income, ethnicity and age. Table 4 lists the census block group data for the 10 school zones with the largest percent tree canopy cover and the 10 school districts with the smallest.

Table 4. 2010 Demographic Results for Atlanta-Area School Zones

School Zone ID# (School Area Name)	Tree Canopy Cover (Percent)	Tree Canopy Cover (Acreage)	Estimated Population	Median Income (US Dollars)	Majority Ethnicity	Majority Age
Percent of Tree Canopy Cover, Top Ten						
Zone 2 (Beecher Hills)	72.36	1,438	3,920	42,186	African-American	45-64
Zone 31 (Jackson)	67.60	5,058	16,155	164,182	Caucasian	45-64
Zone 11 (Cleveland Avenue)	66.29	503	4,395	31,499	African-American	0-17
Zone 34 (Kimberly)	65.34	1,249	4,551	45,762	African-American	0-17
Zone 7 (Brandon)	62.66	2,535	16,912	105,783	Caucasian	25-44
Zone 29 (Humphries)	61.45	1,055	3,936	26,632	African-American	0-17
Zone 22 (Fickett)	60.69	1,410	9,123	54,833	African-American	25-44
Zone 33 (Kelley Lake)	60.60	389	5,219	24,740	African-American	45-64
Zone 16 (Deerwood)	59.26	2,011	9,160	49,213	African-American	25-44
Zone 49 (Venetian Hills)	59.04	370	5,787	30,776	African-American	45-64
Percent of Tree Canopy Cover, Bottom Ten						
Zone 42 (Slater)	36.22	561	6,126	24,520	African-American	25-44
Zone 32 (Jones)	35.73	483	12,907	20,523	African-American	18-24
Zone 51 (Whitefoord)	35.57	333	4,730	41,789	African-American	25-44
Zone 5 (Bolton Academy)	33.98	921	6,950	59,052	Caucasian	25-44
Zone 14 (D.H. Stanton)	32.07	96	1,476	27,222	African-American	25-44
Zone 25(Gideons)	28.43	215	4,880	18,305	African-American	0-17
Zone 45 (Thomasville)	23.95	135	5,408	9,955	African-American	25-44
Zone 28 (Hill-Hope)	18.39	235	15,659	28,909	African-American	25-44
Zone 19 (Dunbar)	17.69	116	4,114	18,123	African-American	25-44
Zone 10 (Centennial Place)	16.43	466	27,755	37,123	Caucasian	18-24

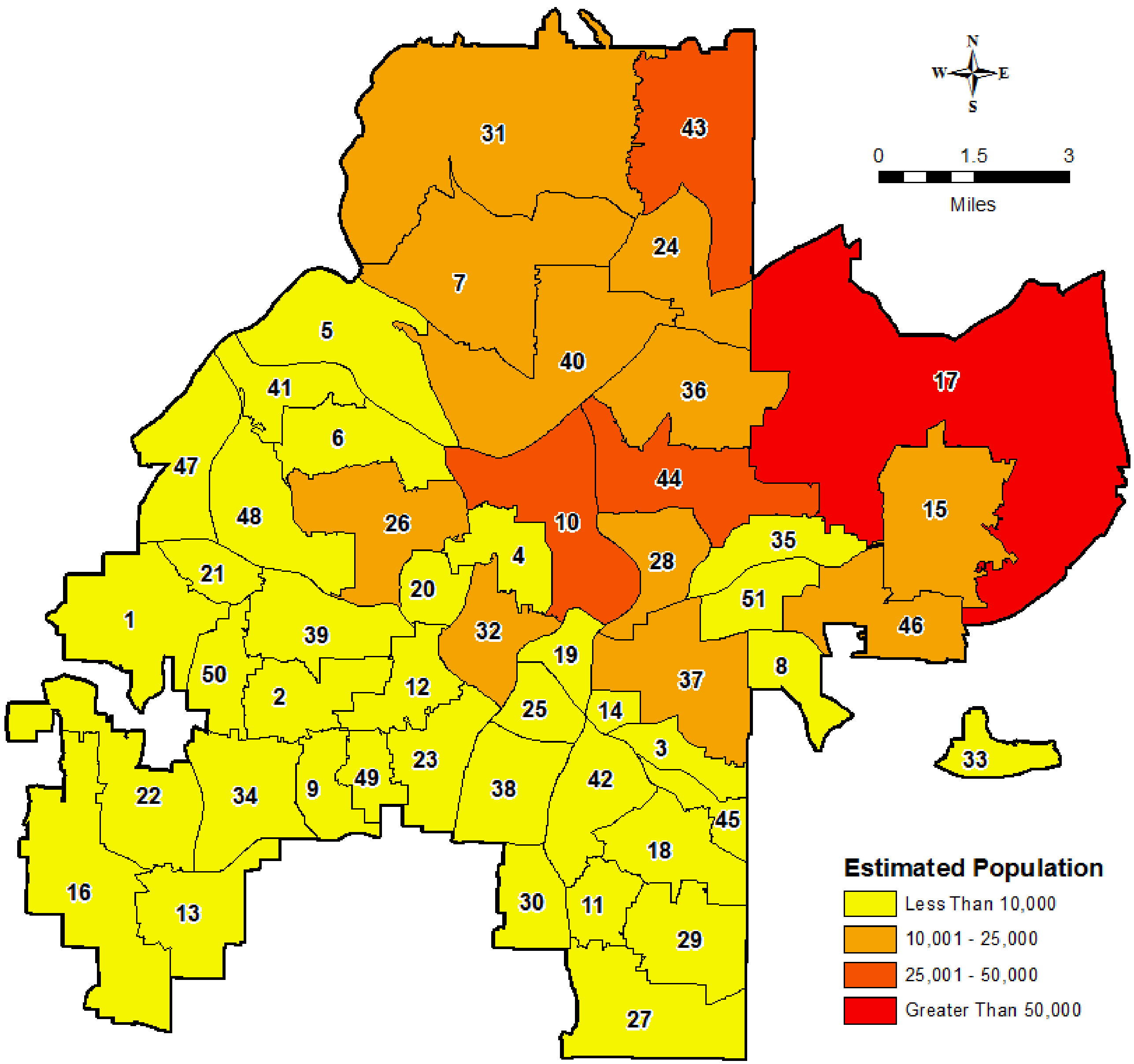


Figure 6. Comparison of estimated population in 2010 for 51 Atlanta-area school zones.

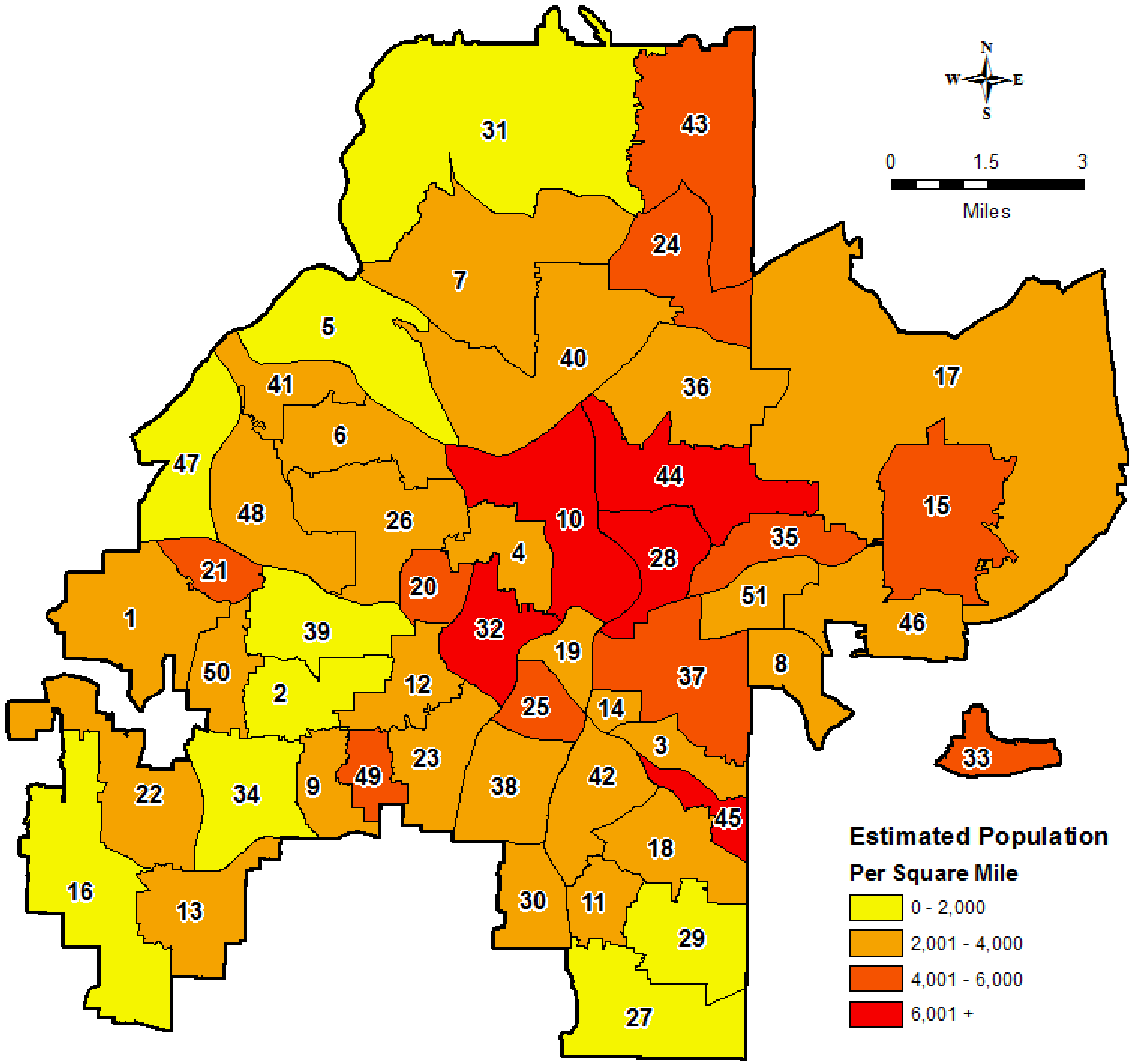


Figure 7. Comparison of estimated population per square mile in 2010 for 51 Atlanta-area school zones.

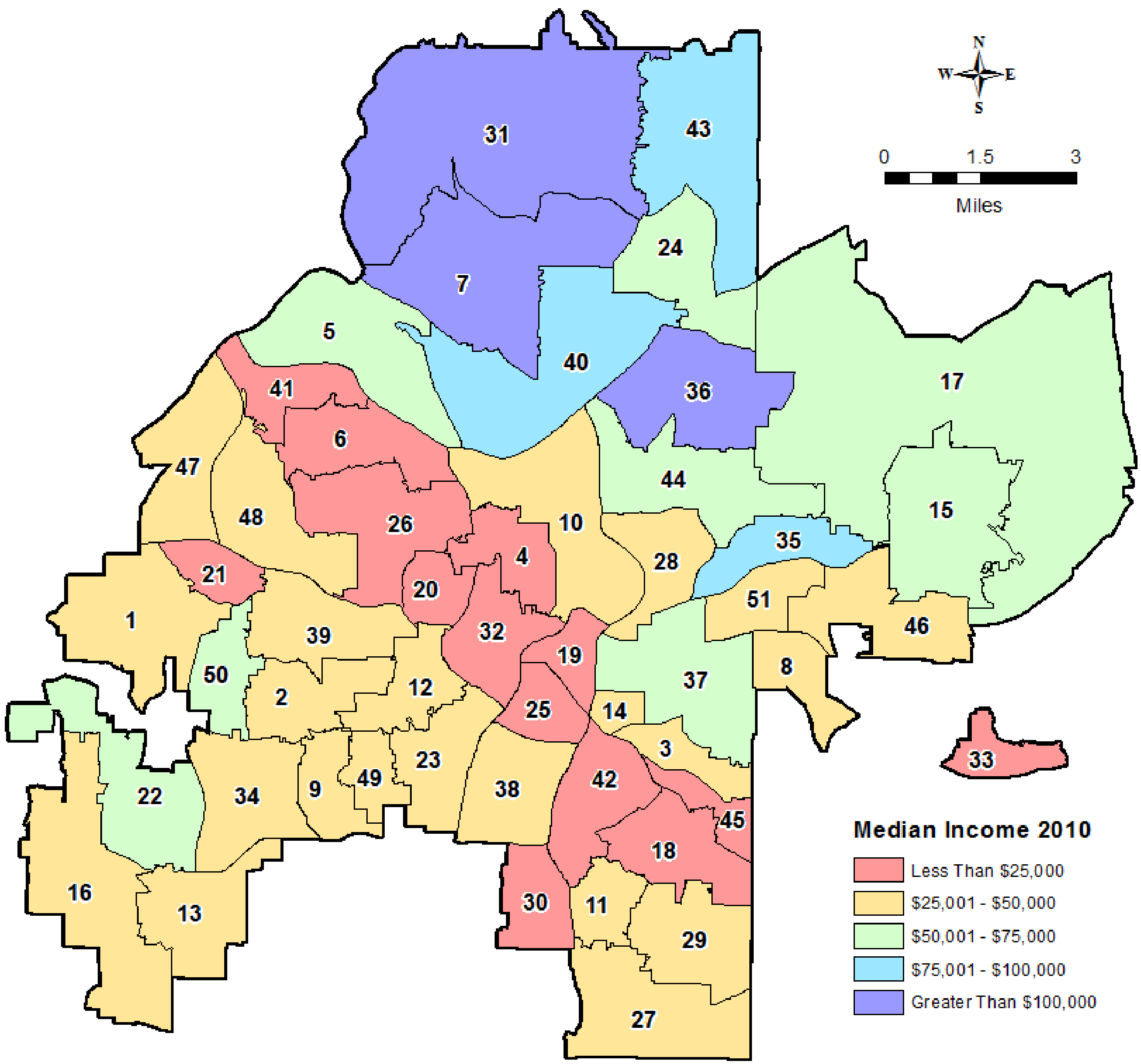


Figure 8. Comparison of median income in 2010 for 51 Atlanta-area school zones.

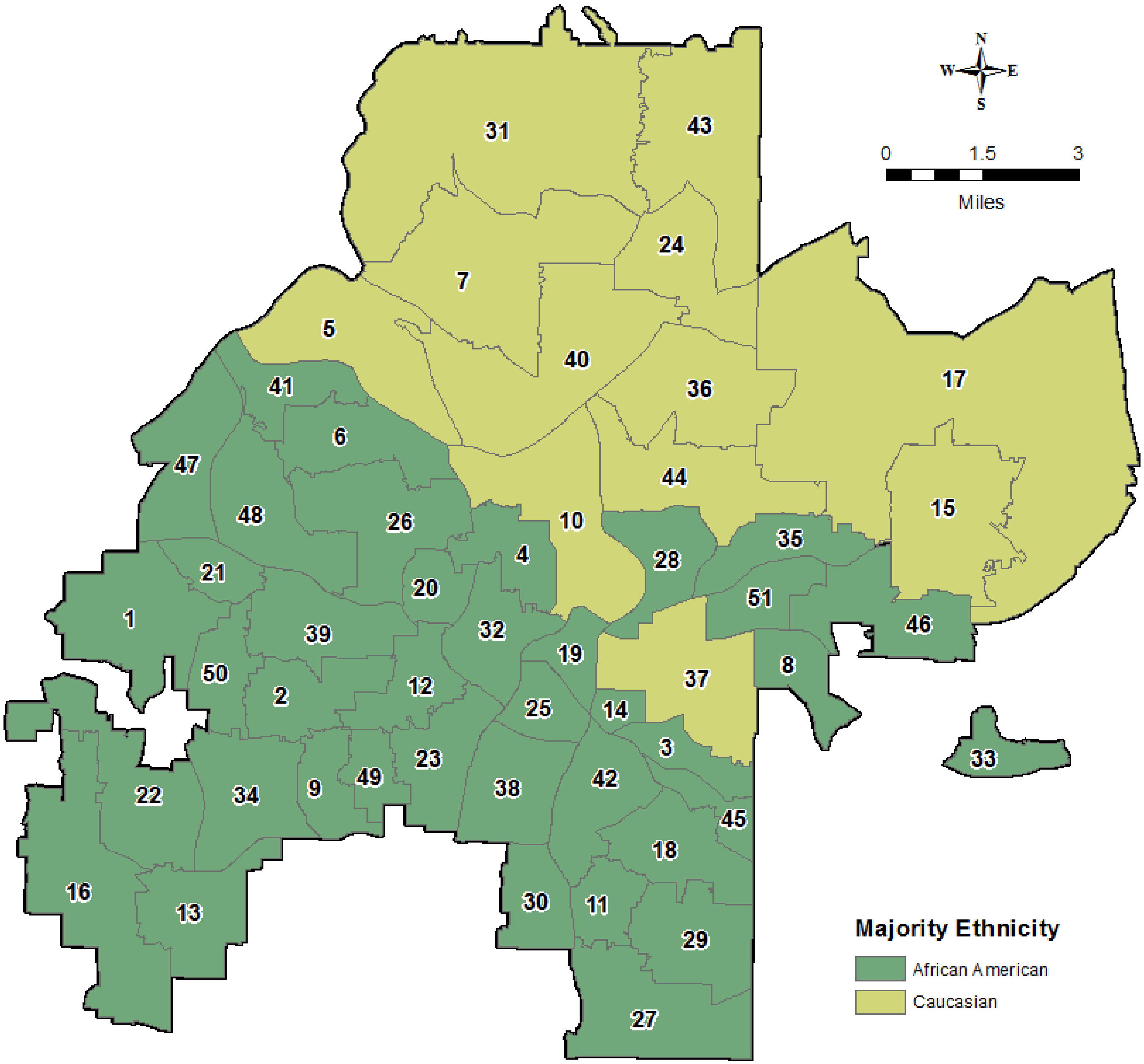


Figure 9. Comparison of ethnic majority in 2010 for 51 Atlanta-area school zones.

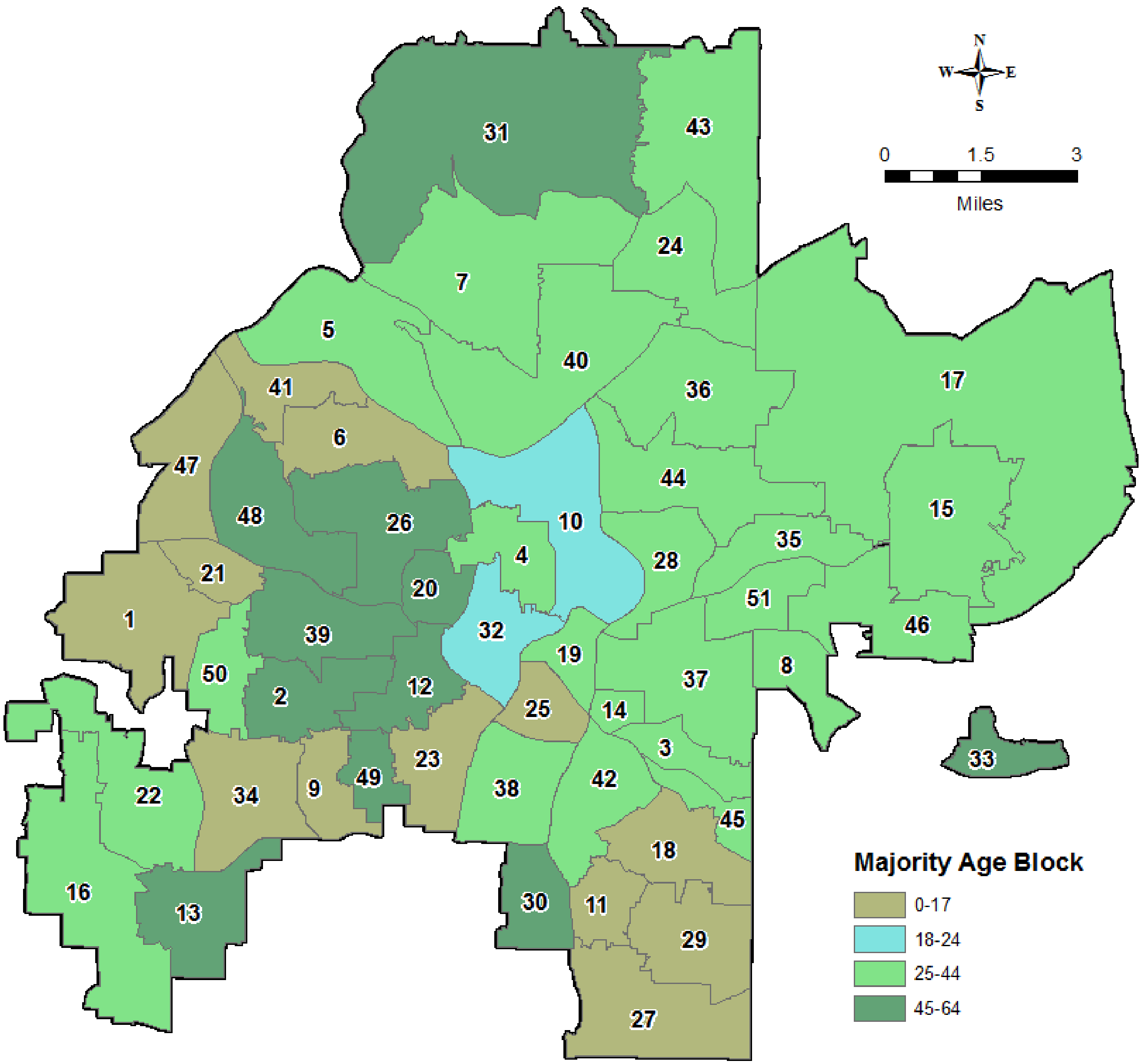


Figure 10. Comparison of age majority in 2010 for 51 Atlanta-area school zones.

School Zone Public Health

Tree canopy is tied to public health. Table 5 lists the public health data for the 10 school zones with the largest percent of tree canopy cover and the 10 zones with the smallest. The number of respiratory illnesses are actual hospital admissions related to respiratory illnesses reported in 2010 and gathered from the Georgia Department of Public Health. Not all respiratory illnesses reported may be directly related to air-quality issues.

Table 5. Public Health Results for Atlanta-Area School Zones

School Zone ID# (School Area Name)	Tree Canopy Cover (Percent)	Tree Canopy Cover (Acreage)	Number of Respiratory Illnesses* (Average)	Most Frequent Respiratory Illness**
Percent of Tree Canopy Cover, Top Ten				
Zone 2 (Beecher Hills)	72.36	1,438	72.5	Other
Zone 31 (Jackson)	67.60	5,058	106.5	Other
Zone 11 (Cleveland Avenue)	66.29	503	39.5	Pneumonia
Zone 34 (Kimberly)	65.34	1,249	41.0	Pneumonia/Bronchitis/Other
Zone 7 (Brandon)	62.66	2,535	93.5	Pneumonia
Zone 29 (Humphries)	61.45	1,055	83.5	Other
Zone 22 (Fickett)	60.69	1,410	42.5	Other
Zone 33 (Kelley Lake)	60.60	389	85.0	Pneumonia
Zone 16 (Deerwood)	59.26	2,011	106.0	Other
Zone 49 (Venetian Hills)	59.04	370	0.0	-
Percent of Tree Canopy Cover, Bottom Ten				
Zone 42 (Slater)	36.22	561	58.5	Asthma
Zone 32 (Jones)	35.73	483	100.0	Other
Zone 51 (Whitefoord)	35.57	333	68.0	Pneumonia
Zone 5 (Bolton Academy)	33.98	921	45.0	Bronchitis/Asthma/Other
Zone 14 (D.H. Stanton)	32.07	96	26.0	Pneumonia/Other
Zone 25 (Gideons)	28.43	215	72.0	Pneumonia
Zone 45 (Thomasville)	23.95	135	22.5	Pneumonia/Other
Zone 28 (Hill-Hope)	18.39	235	125.5	Pneumonia/Bronchitis
Zone 19 (Dunbar)	17.69	116	62.0	Other
Zone 10 (Centennial Place)	16.43	466	167.0	Pneumonia

* Where zero illnesses are reported, this is attributable to the school zone's data having been lumped into other districts due to census block and school zone boundary overlap.
**For "Other" the data does not specify the exact respiratory condition.

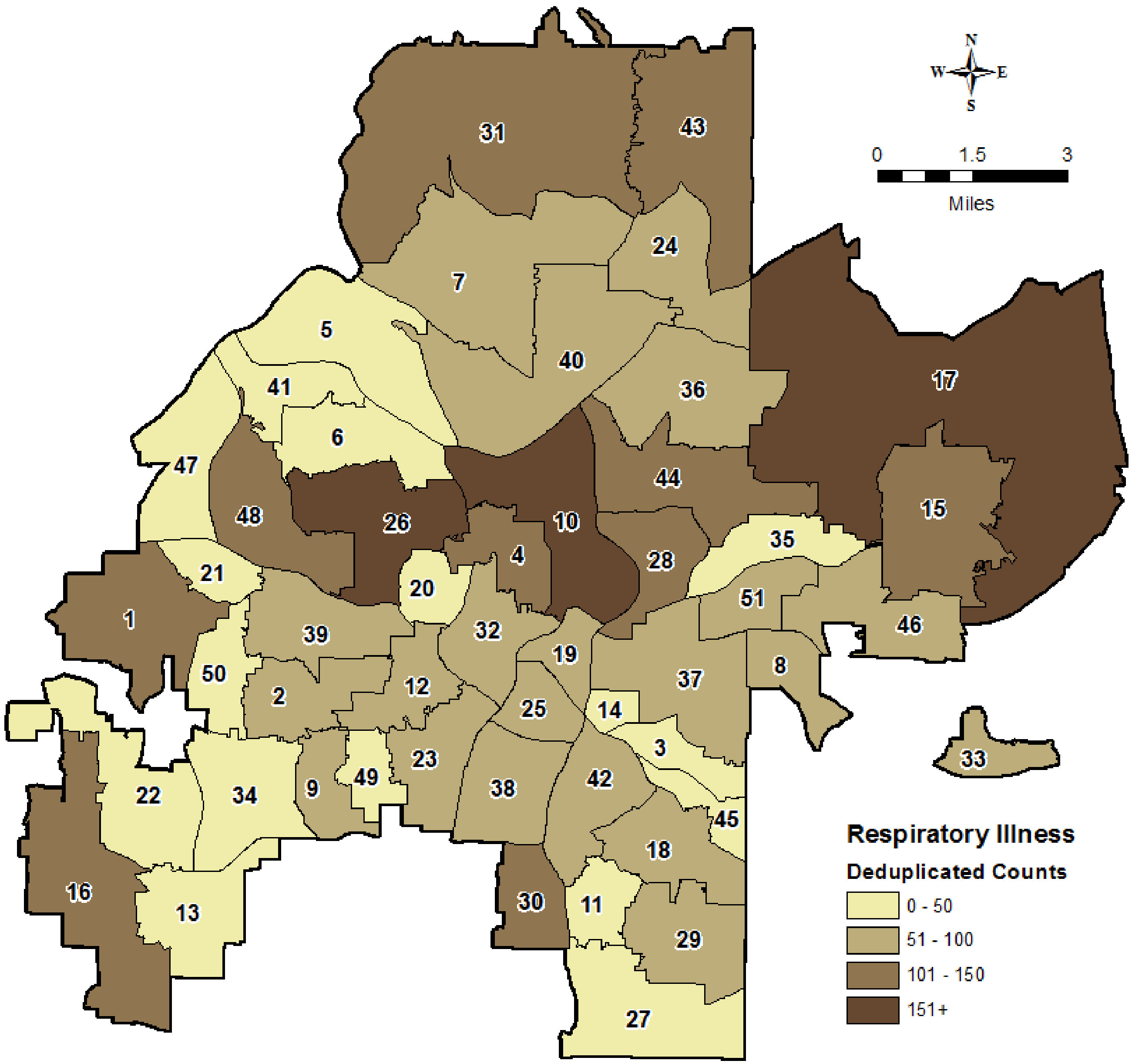


Figure 11. Comparison of respiratory illness in 2010 for 51 Atlanta-area school zones.

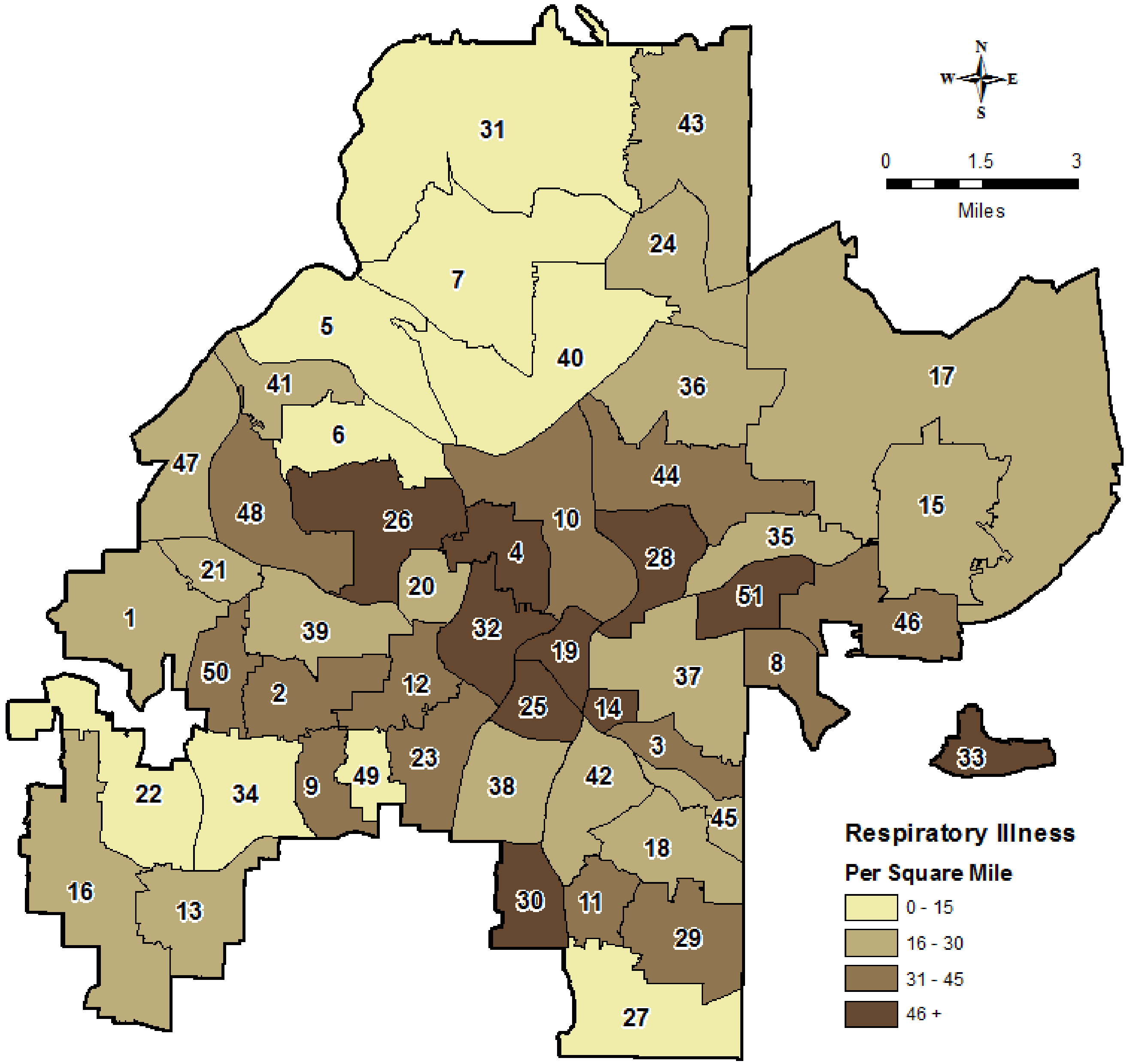


Figure 12. Comparison of respiratory illness per square mile in 2010 for 51 Atlanta-area school zones.

BenMAP calculates and compares benefits present throughout the study area using 2010 tree canopy coverage data. See Tables 6 and 7.

Table 6. Summary of Public Health Benefit Results for 51 Atlanta-Area School Zones

Incident	Number of Annual Incidents Not Occurring (Average)	Value of Savings (US Dollars)
Hospital Admissions	4.8	143,401
Emergency Room Visits	2.2	924
Asthma Exacerbation	1,316.6	109,005
Acute Respiratory Symptoms	1,561.7	135,507
Mortality	1.5	12,009,729
School Loss Days	396.7	38,953
Acute Bronchitis	0.8	74
Acute Myocardial Infarction	0.3	25,736
Chronic Bronchitis	0.4	106,736
Hospital Admissions, Cardiovascular	0.2	7,344
Hospital Admissions, Respiratory	0.1	4,110
Lower Respiratory Symptoms	9.8	510
Upper Respiratory Symptoms	8.6	385
Work Loss Days	82.1	15,505
Total	3,385.8	12,597,919

Table 7. Public Health Benefit Results for Atlanta-Area School Zones

School Zone ID# (School Area Name)	Tree Canopy Cover (Percent)	Tree Canopy Cover (Acreage)	Estimated Number of Incidences (Average)	Value of Savings (US Dollars)
Percent of Tree Canopy Cover, Top Ten				
Zone 2 (Beecher Hills)	72.36	1,438	39.0	147,059
Zone 31 (Jackson)	67.60	5,058	177.2	694,760
Zone 11 (Cleveland Avenue)	66.29	503	48.6	204,224
Zone 34 (Kimberly)	65.34	1,249	40.9	154,185
Zone 7 (Brandon)	62.66	2,535	136.4	453,761
Zone 29 (Humphries)	61.45	1,055	40.4	169,523
Zone 22 (Fickett)	60.69	1,410	76.1	287,076
Zone 33 (Kelley Lake)	60.60	389	45.3	152,704
Zone 16 (Deerwood)	59.26	2,011	74.6	281,455
Zone 49 (Venetian Hills)	59.04	370	57.6	245,269
Percent of Tree Canopy Cover, Bottom Ten				
Zone 42 (Slater)	36.22	561	37.0	155,533
Zone 32 (Jones)	35.73	483	77.7	331,030
Zone 51 (Whitefoord)	35.57	333	23.7	83,992
Zone 5 (Bolton Academy)	33.98	921	32.4	122,412
Zone 14 (D.H. Stanton)	32.07	96	8.0	33,957
Zone 25 (Gideons)	28.43	215	23.4	99,589
Zone 45 (Thomasville)	23.95	135	21.0	84,143
Zone 28 (Hill-Hope)	18.39	235	47.1	192,249
Zone 19 (Dunbar)	17.69	116	12.3	52,234
Zone 10 (Centennial Place)	16.43	466	62.7	236,377

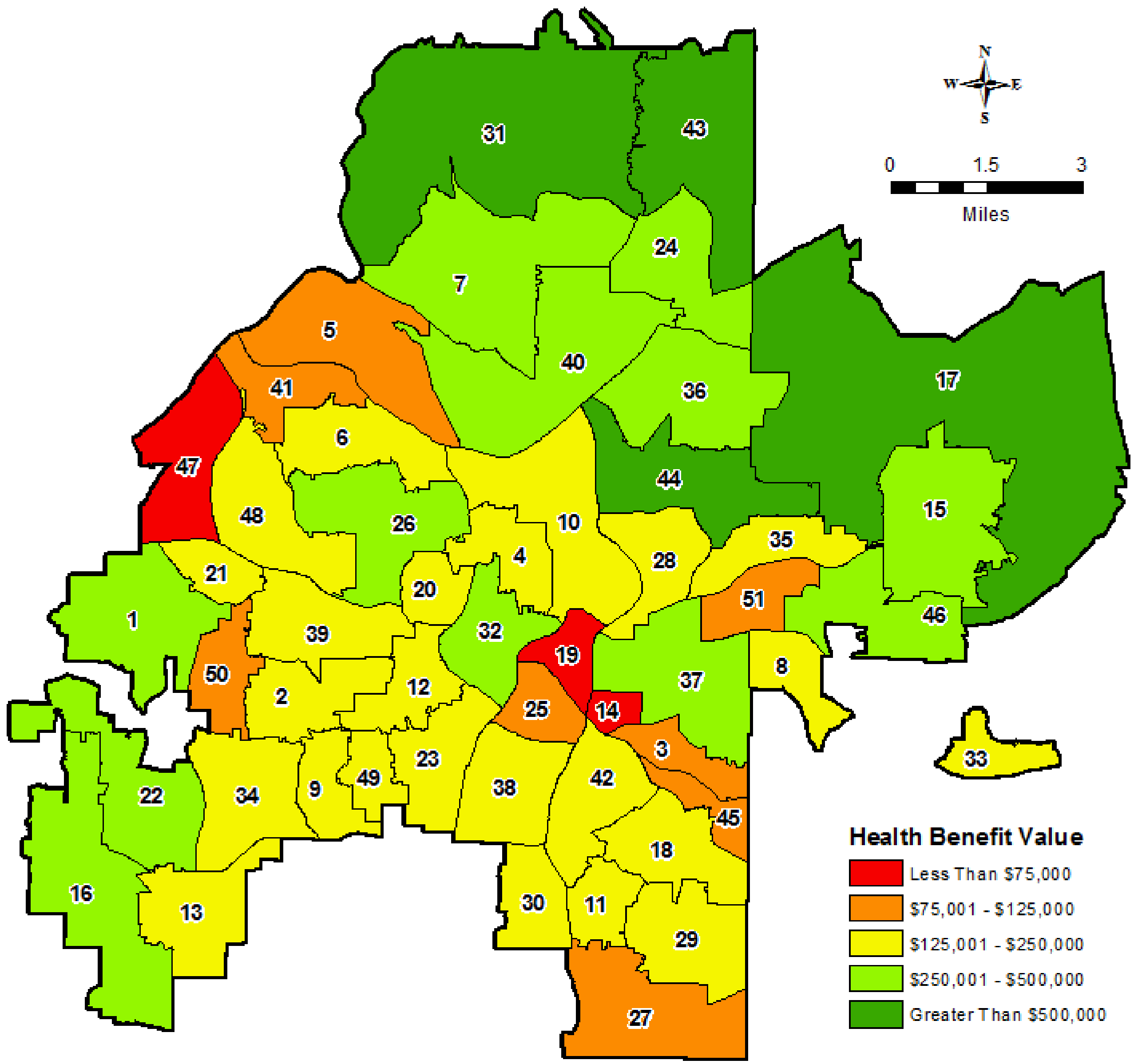


Figure 13. Comparisons of health benefit savings in 2010 for 51 Atlanta-area school zones.

Conclusions

Environmental Benefits

Trees reduce temperatures and remove air pollutants and volatile organic compounds. Lower temperatures alter pollution concentrations and reduce ozone formation. Intercepted air pollutants are absorbed into tree leaves as gases or retained on leaf surfaces as particles. Trees also reduce energy consumption by shading surfaces and slowing wind speeds, thereby lowering power plant emissions.

Socioeconomic Benefits

- Population appears to have no overall significant influence on tree canopy cover percentages. However, the zone with the lowest tree canopy cover percentage has the highest population and the zone with the highest tree canopy cover percentage has one of the lowest.
- Total average combined income for the 10 zones with the most tree canopy cover ($57,580) is almost twice the total average combined income ($28,546) of the 10 zones with the lowest.
- Ethnicity does not appear to be correlated to tree canopy cover.
- There is more tree canopy cover where the majority age is higher

Health Benefits

- The total average number of respiratory illnesses in the 10 zones with the highest tree canopy cover percentage is 670; while the average number of illness in the zones with the lowest canopy is 746. The latter also report more cases of asthma.
- The annual monetary benefit of trees on human health in highly-canopied zones ($2,790,016) is double that for low-canopy zones ($1,391,516).
- Among zones similar in majority race and age, the two factors most influencing the annual value of public health benefits from trees are income and overall tree canopy cover percentage.

Table 8. Example of the Link Among Low Income, Low Tree Canopy Cover and Public Health Benefits

Demographic Characteristics (race and majority age)	School Zone ID# (School Area Name)	Income (US Dollars)	Tree Canopy Cover (Percent)	Public Health Benefits (US Dollars)
Caucasian 25-44	Zone 7 (Brandon)	105,780	62.66	453,850
	Zone 5 (Bolton Academy)	59,052	33.98	122,432
African-American 0-17	Zone 29 (Humphries)	26,632	61.45	169,545
	Zone 25 (Gideons)	18,305	28.43	99,602
African-American 25-44	Zone 22 (Fickett)	54,833	60.69	297,122
	Zone 19 (Dunbar)	18,123	17.69	52,240

Recommendations

- Utilize this UTC analysis to educate the public about the benefits of trees, particularly those associated with public health.
- Use Arbor Day or Earth Day celebrations to raise awareness of Atlanta's urban forest and the benefits it provides.
- Partner with state and local public health agencies to initiate tree plantings and education projects in Atlanta communities.
- Implement a "Tree Stewards" program in each community to plant and maintain trees with neighborhood volunteers.
- Encourage decision makers to support tree care.
- Select proper species and locations.
- Use low volatile organic compound-emitting trees.
- Use ornamental trees for landscape diversity, seasonal interest and educational opportunities.

References

Casey Trees. 2008. "Growing a Healthier DC: Green "Green Jobs". *A Casey Trees Issue Brief*. Washington, DC: Casey Trees.

Coder, K.D. 1996. "Identified Benefits of Community Trees and Forests." University of Georgia Cooperative Extension Service, Forest Resources Publication FOR96-39.

Coley, R.L., F.E. Kuo, and W.C. Sullivan. 1997. "Where Does Community Grow? The Social Context Created by Nature in Urban Public Housing." *Environ. Behav*. 29, 4:468-492.

Faber Taylor, A., A. Wiley, F.E. Kuo, and W.C. Sullivan. 1998. "Growing up in the inner city: Green spaces as places to grow." *Environ. Behav*. 301:3–27.

Friedman M.S., K.E. Powell, L. Hutwagner, L.M. Graham, and W.G Teaque. 2001. "Impact of changes in transportation and commuting behaviors during the 1996 Summer Olympic games in Atlanta on air quality and childhood asthma." *JAMA* 285(&):897-905.

Heisler, G.M. 1986. "Energy Savings with Trees". *J. Arbor* 12(5):113–125.

Kuo, F.E.. 2003. "The role of Arboriculture in a Healthy Social Ecology." *J. Arbor* 29(3), pp148 - 155.

Kuo, F.E., W.C. Sullivan, RL Coley, and L Brunson. 1998. "Fertile Ground for Community: Inner-City Neighborhood Common Spaces." *Am. J. Community Psychology* 26, 6: 823-851.

Kuo, F.E. and Faber Taylor, A. 2004. "A potential natural treatment for Attention-Deficit/Hyperactivity Disorder: Evidence from a national study." *Am. J. Public Health*. 94(9), 1580–1586.

Lovasi, G.S., J.W. Quinn, K.M. Neckerman, M.S. Perzanowski, and A. Rundle. 2008. "Children living in areas with more street trees have lower prevalence of asthma." *J. Epidemiol Community Health* 62:647–9.

McPherson, E.G., J.R. Simpson, P.J. Peper; S.L. Gardner, K.E. Vargas, S.E Maco, Q. Xiao. 2006. *Piedmont Community Tree Guide: Benefits, Costs, and Strategic Planting*. General Technical Report PSW-GTR-200. Washington, DC: USDA Forest Service.

National Urban Forestry Unit. 2005. *Trees Matter!* Wolverhampton, West Midlands, England.

North Carolina State University. 2012. "Americans are Planting Trees of Strength". http://www.treesofstrength.org/benefits.htm. Accessed May 12, 2012.

Nowak, D.J. 1992. *Urban Forest Structure and the Functions of Hydrocarbon Emissions and Carbon Storage*. In Proceedings of the Fifth National Urban Forest Conference, Los Angeles, California. Washington, DC: American Forests.

Nowak, D.J, D.E. Crane, and J.C. Stevens. 2006. "Air pollution removal by urban trees and shrubs in the United States." *Urban Forestry & Urban Greening* 4:115–123.

Nowak, D.J., S. Hirabayashi, A. Bodine, and R. Hoehn. 2013. "Modeled $PM_{2.5}$ removal by trees in ten U.S. cities and associated health effects." *Envir Pollution* 178: 395-402.

Pope, C.A., R.T. Burnett, G.D. Thurston, M.J. Thun, E.E. Calle, D. Krewski, J.J. Godleski. 2004. "Cardiovascular Mortality and Long-Term Exposure to Particulate Air Pollution." *Circulation* 109:71-77. doi: 0.1161/01. http://circ.ahajournals.org/content/109/1/71.full.pdf.

Sampson, R., J. Morenoff, and T. Gannon-Rowley. 2002. Assessing "neighborhood effects": Social processes and new directions in research. *Annual Review of Sociology* 28:443-478.

Ulrich, R. 1984. "View through Window May Influence Recovery from Surgery." *Science* 224(4647): 420–421.

Ulrich, R. 1986. "Human Responses to Vegetation and Landscapes." *Landscape and Urban Planning* 13:29–44.

Ulrich R.S., R.F. Simmons, B.D. Losito, E. Fiority, M.A. Miles and M. Zeison. 1991. "Stress Recovery During Exposure to Natural and Urban Environments." *J. Envir Psych* 11(3): 201-230.

University of Washington. 2013. "Wellness and Physiology-A Literature Review. In: Green Cities: Good Health." College of the Environment, University of Washington. Last modified June 25, 2013. www.greenhealth.washington.edu.

U.S. Forest Service. 2003. "Benefits of Urban Trees. Urban and Community Forestry: Improving Our Quality of Life". *Forestry Report* R8-FR 71.

U.S. Environmental Protection Agency. 2012. "Environmental Benefits Mapping and Analysis Program (BenMAP)." http://www.epa.gov/air/benmap/. Accessed December 2013. Wolf, K.L. 1998a. "Trees in Business Districts: Positive Effects on Consumer Behavior!" *University of Washington, College of Forest Resources Factsheet*. 30(November).

Wolf, K.L. 1998a. "Urban Nature Benefits: Psycho-Social Dimensions of People and Plants." *University of Washington, College of Forest Resources Fact Sheet*. 1(November).

———. 1998b. "Trees in Business Districts: Comparing Values of Consumers and Business. *University of Washington College of Forest Resources Fact Sheet*. 4(November).

———. 1999. "Grow for the Gold." *TreeLink Washington DNR Community Forestry Program*. 14(spring).

———. 2000. “Community Image: Roadside Settings and Public Perceptions.” *University of Washington, College of Forest Resources Factsheet.* 32(August).

———. 2003. “Public Response to the Urban Forest in Inner-City Business Districts”. *J. Arbor* 29(3):117–126.

———. 2007. “City Trees and Property Values”. *Arborist News* (August):34-36.

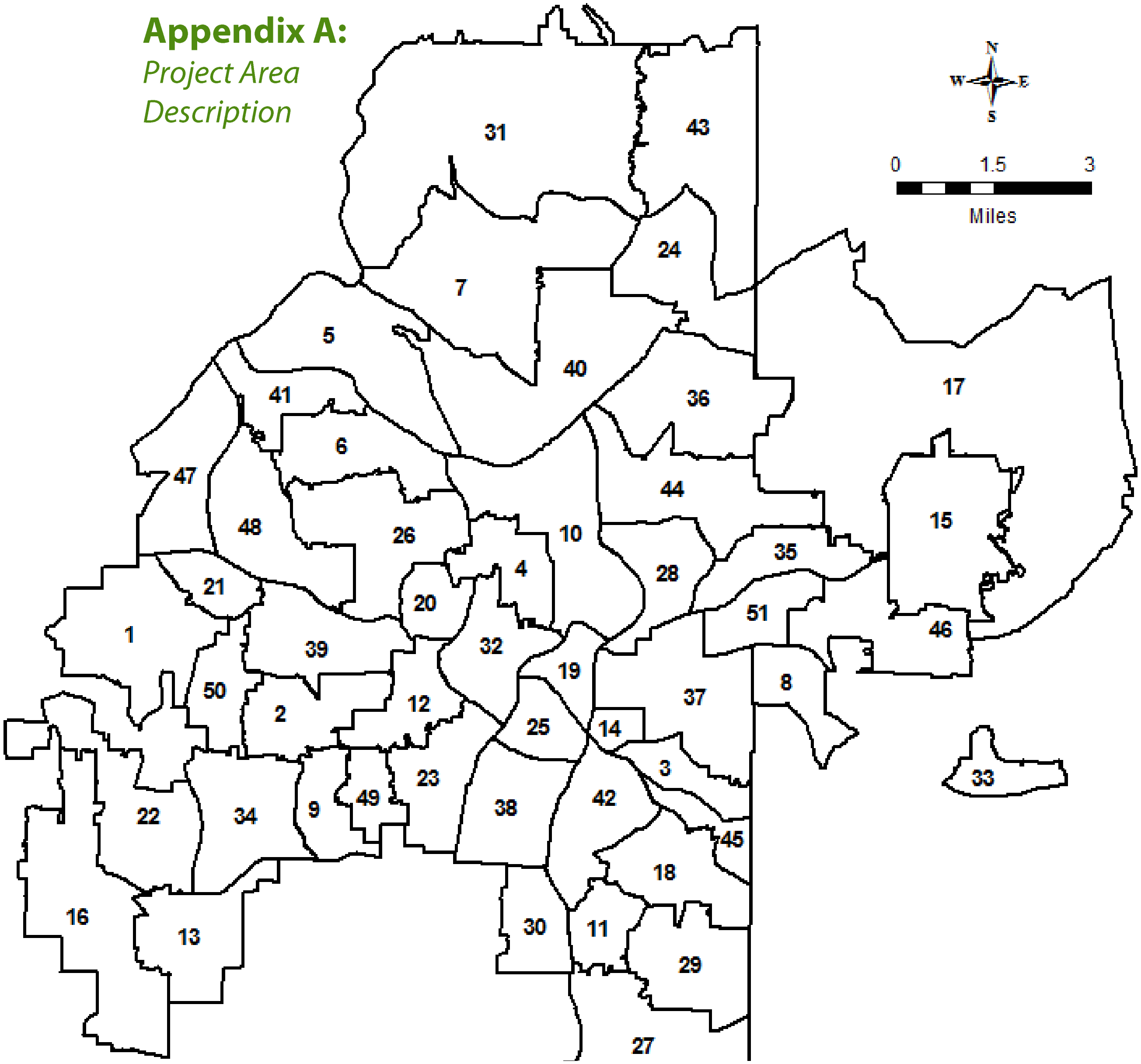
———. 2010. “Crime & Public Safety - A Literature Review. In: Green Cities: Good Health.” College of the Environment, University of Washington. Last modified May 27, 2013. www.greenhealth.washington.edu.

Wolf, K.L., and K. Flora. 2010. “Mental Health and Function - A Literature Review. In: Green Cities: Good Health.” College of the Environment, University of Washington. Last modified October 31, 2013. www.greenhealth.washington.edu.

Wolf, K.L., and M.A. Rozance. 2013. “Social Strengths - A Literature Review. In: Green Cities: Good Health.” College of the Environment, University of Washington. Last modified May 30, 2013. www.greenhealth.washington.edu.

Appendix A:

Project Area Description



ID Number	District Name
1	Adamsville-Miles
2	Beecher Hills
3	Benteen
4	Bethune
5	Bolton Academy
6	Boyd
7	Brandon
8	Burgess-Peterson
9	Cascade
10	Centennial Place
11	Cleveland Avenue
12	Connally
13	Continental Colony
14	D.H. Stanton
15	Decatur School District
16	Deerwood
17	DeKalb County
18	Dobbs
19	Dunbar
20	F.L. Stanton
21	Fain
22	Fickett
23	Finch
24	Garden Hills
25	Gideons
26	Grove Park-Woodson
27	Heritage Academy
28	Hill-Hope
29	Humphries
30	Hutchinson
31	Jackson
32	Jones
33	Kelley Lake
34	Kimberly
35	Lin
36	Morningside
37	Parkside
38	Perkerson
39	Peyton Forest
40	Rivers
41	Scott
42	Slater
43	Smith
44	Springdale Park
45	Thomasville
46	Toomer
47	Towns
48	Usher
49	Venetian Hills
50	West Manor

*District identification numbers were assigned by Davey Resource Group and are used for ease of reference in this report.

Appendix B: *Project Methodologies*

Urban Tree Canopy (UTC) Assessment

➢ Classification

American Forests utilized an object-based image analysis and semi-automated feature extraction method to process and analyze current high-resolution color infrared (CIR) aerial imagery and remotely-sensed data to identify tree canopy cover and land cover classifications. The use of imagery analysis is cost-effective and provides a highly accurate approach to assessing your community's existing tree canopy coverage. This supports responsible tree management, facilitates community forestry goal-setting, and improves urban resource planning for healthier and more sustainable urban environments.

Advanced image analysis methods were used to classify, or separate, the land cover layers from the overall imagery. The semi-automated extraction process was completed using Feature Analyst, an extension of ArcGIS® software. Feature Analyst uses an object-oriented approach to cluster together objects with similar spectral (for example, color) and spatial or contextual (for example, texture, size, shape, pattern and spatial association) characteristics. The land cover results of the extraction process were post-processed and clipped to each project boundary prior to the manual editing process in order to create smaller, manageable and more efficient file sizes. Secondary source data, high-resolution aerial imagery provided by each urban tree canopy (UTC) city and custom ArcGIS® tools were used in the final manual editing, quality checking and quality assurance processes (QA/QC). The manual QA/QC process was implemented to identify, define and correct any misclassifications or omission errors in the final land cover layer.

➢ Classification Workflow

1) Prepare imagery for feature extraction (resampling, rectification, etc.), if needed.
2) Gather training set data for all desired land cover classes (canopy and impervious).
3) Extract the canopy layer only; this decreases the amount of shadow removal from large tree canopy shadows. Fill small holes and smooth to remove rigid edges.
4) Edit and finalize canopy layer at 1:4,000 scale. Editing for this project was done at a coarse scale.
5) Edit the impervious layer at 1:4,000 scale to reflect actual impervious features, such as roads, buildings, parking lots, etc., to update features. Editing for this project was done at a coarse scale.
6) Use geo-processing tools to clean, repair and clip all edited land cover layers to remove any self-intersections or topology errors.
7) Thoroughly inspect final land cover dataset for any classification errors and correct as needed.
8) Perform accuracy assessment. Repeat Step 7, if needed.

I-Tree Vue

American Forsts used i-Tree Vue (Version 4.0: USDA Forest Service 2012) to calculate the environmental benefits tree canopy cover provides. Studies have shown that National Land Cover Data (NLCD) underestimates both tree canopy and impervious cover to varying degrees. Within i-Tree Vue, a user-defined adjustment factor applies uniformly across the entire area of interest and allows the user to reset the overall tree canopy and impervious cover percentages. By adjusting the tree canopy values to the existing values derived from the 2010 land cover extractions, ecosystem services such as carbon storage, carbon sequestration and pollution removal values can be estimated more accurately. By default, i-Tree Vue uses state average data for the analysis; however, additional adjustments can be made if local information is available. Further analyses utilize the adjusted imperious cover values to calculate estimated available greenspace and model tree canopy percent change. The following is an explanation of each analysis.

Air Quality: I-Tree Vue uses NLCD satellite-based imagery to assess a project area's land cover and quantifies the monetary and unit values of pollution reduction.

Carbon: I-Tree Vue models the urban forests' carbon benefits, demonstrating the amount of UTC directly correlated to current and future increases in carbon reduction.

I-Tree Design

American Forests used i-Tree Design (Version 6.0) to calculate the environmental benefits landscape trees and future trees provide. I-Tree Design uses average species growth equations and geographic information from city, county, state, and climate region. The U.S. Forest Service notes that this tool is to be used as a starting point in understanding parcel-level tree benefit values. Values are not precise enough for high-level scientific studies.

Utilizing aerial imagery from Google® Maps™, the user draws air-conditioned and heated stuctures occuring on the property and maps existing trees or future trees. I-Tree Design uses the specified species selection, size, condition and location (distance from and orientation direction around drawn buildings) to estimate effects of air quality, CO_2, energy use and stormwater. Primarily, these environmental benefits are quantified by a measurable unit and valued monetarily for the current year. Benefits can be forecasted as annual benefits for a specified number of years (up to 40), project total benefits across that specified future timeframe, or past total benefits, based on estimated tree age.

Air Quality: I-Tree Design quantifies monetary and unit values of air pollution reduction using methods and models derived from i-Tree Streets to calculate air pollutant deposition and using a number of sources (see http://www.itreetools.org/design.php) to calculate pollutant removal.

Carbon: I-Tree Design quantifies carbon sequestration monetary and unit values from species-based biomass equations.

Energy: I-Tree Design quantifies energy conservation monetary and unit values using trees' effects on buildings from shade, evapotranspiration, and wind speed reduction.

Stormwater: I-Tree Design quantifies stormwater management monetary and unit values derived from methods and models i-Tree Streets.

Demographic and Public Health

➢ Census Block Group Data

Block group data were downloaded from census tables for Fulton and DeKalb counties and joined to geographic information system (GIS) census block groups. Data taken at the block group level were aggregated for each school zone and averaged. Since the boundary layers for the school zones and census block groups do not completely match, the values for population, median household income, ethnicity and age were estimated. An explanation of the data aggregation technique can be found in the next section.

➢ Data Aggregation

In order to complete this demographic analysis, block group data needed to be aggregated for each school zone. However, census block group boundaries do not directly correlate with zone boundaries. To address this boundary conflict, census block groups were assigned to the school zone with the greatest area within that block group. While a vast majority of the block groups could be aggregated with little issue and closely matched school zone boundaries, some of them needed to be assigned.

➢ Public Health Data

Health statistics for common respiratory illnesses such as influenza, pneumonia, bronchitis, emphysema and asthma were provided by the Georgia Department of Public Health. The deduplicated counts for each respiratory illness listed above were analyzed. A deduplicated count only records one occurrence per each illness for an individual, which eliminates cases of chronic illness.

Data were provided at the census tract level. Deduplicated counts were aggregated and estimated using the same methodology as the census block group data.

Environmental Benefits Mapping and Analysis Program (BenMAP)

BenMAP is a software application developed by the EPA that uses community-level ambient pollution exposure data to estimate the health impacts and economic benefits that occur when populations experience changes in air quality. Benefit values derived from the BenMAP model focus only on adverse human health effects of air pollution and related patient treatment costs. The U.S. Forest Service incorporated an adaptation of the BenMAP model within their own i-Tree Eco model, allowing for estimation of reductions in air pollution and the resulting positive public health impact attributable to tree canopy.