THE EFFECT OF OPEN SPACE ON RESIDENTIAL PROPERTY VALUES IN WAKE COUNTY, NC

by

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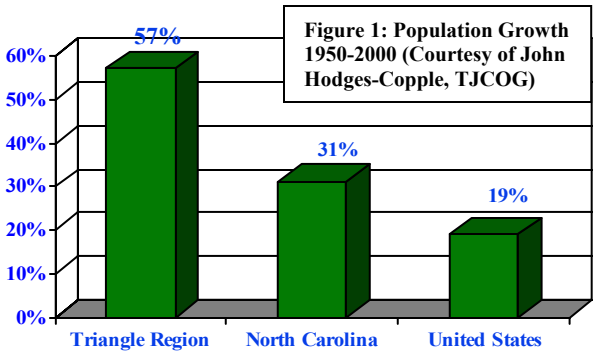


Figure 1: Population Growth 1950-2000 (Courtesy of John Hodges-Copple, TJCOG)

Like many places across the country, Wake County, North Carolina is rapidly losing open space to urbanization. This was the fastest-growing county in North Carolina and the 17th fastest-growing in the nation during the 1990s (WC, 2000). This county is located in the Raleigh-Durham Metropolitan Area, which is often referred to as the Research Triangle. **Figure 1** shows that the population growth in the Triangle over the past 15 years has continued to outpace the rest of the state and the rest of the country. The U.S. Census projects that North Carolina will become the 7th most populous state by 2030, with over 12.2 million residents.

Past population growth has translated into steep land conversion rates throughout the Triangle. Between 1950 and 2000, the number of urbanized acres in the Triangle region increased 1,670%, while the population grew by 480% (TJCOG, 2006). This indicates a land-consumptive, low-density pattern of growth. As of 2003, over 41% of Wake County had been developed, while only 9% of the total land mass had been protected as open space (WC, 2003). According to the Wake County Department of Parks, Recreation & Open Space, "Given the current rate of growth and development, if the County does not begin to emphasize land conservation policies and programs, an estimated 78 percent of the county land area will be developed by the year 2020" (WC, 2003). This estimate was based on fact that in 2003, Wake County was developing land at the rate of 27 acres per day (WC, 2003).

Open space provides numerous benefits to Wake County which will be lost or compromised if current development patterns continue unaltered. These benefits include water purification and protection of drinking water supplies, provision of wildlife habitat, and human

health and recreation benefits. But the significance of Wake County's open space problem is more than the loss of these benefits; it is also the financial, environmental, and aesthetic costs associated with the sprawling development rapidly replacing these open spaces.

Wake County's shrinking stock of open space can be attributed to a number of inter-related factors, including the combination of rapid population growth and low-density development pattern described above. Also at issue is the fact that many of the benefits provided by open spaces, such as wildlife habitat, scenic vistas, and water purification, are public goods which do not provide a return to the landowner. These types of public good benefits are by definition non-excludable (impossible or very costly to exclude anyone from use) and non-consumptive (one person's enjoyment of the good does not diminish its availability for others) (Fausold and Liliholm, 1999). Not all open space attributes are public goods. For example, private landowners can control access to (and charge for) enjoyment of private trails on their property. However, these landowners cannot effectively stop people from enjoying the view over their property as they pass by, for example, or sequester all water purified by the site for private gain. Without the ability to profit from the public good aspects of open space, landowners will value it at less than its "true" economic value. As a result, the private sector will supply an amount of open space that is less than the socially-optimal amount.

The underproduction of open space by the private sector is the main reason for public open space programs. Presumably, government would like to retain open space land when the total benefits of doing so exceed the costs. Estimates of preferences and dollar values associated with public good benefits are thus essential to making important policy and planning decisions about zoning, restrictions on land use, and government provision of public parks (McConnell and Walls, 2005). Estimates of the relationship between private property values and proximity to private open space could also help to increase the quantity of open space provided by developers. Developers might choose to incorporate a large community open space (as in a conservation

subdivision) if they determine that their customers would pay significantly more for a home with access to that open space, even considering tradeoffs in lot size.

The two major approaches for estimating the value of open space from the economics literature are revealed preference methods and stated preference methods. In the first category are hedonic property value studies (such as this Masters Project). Hedonic price studies infer open space value by estimating the sales price of residential property as a function of numerous attributes, including measures of proximity to open space. Stated preference methods include contingent valuation. These studies use carefully-designed surveys to elicit respondents' willingness to pay for various open space amenities. Both the revealed and stated preference studies generally show that there is value to preserving most types of open space, but the values tend to vary widely with the size of the area, the proximity of the open space to residences, the type of open space, and the method of analysis (McConnell and Walls, 2005).

This Masters Project employs hedonic price analysis, a revealed preference method, to estimate a component of the economic value of open space in Wake County, NC. Specifically, I seek to quantify the portion of economic value that is reflected in increased sale prices of single-family residential properties. If significant, these results can be used to calculate the incremental property tax revenue associated with open spaces, demonstrating that open spaces actually do provide a modest return to local government in the form of increased property taxes. As mentioned above, this research could also be used to encourage additional private provision of open space, by showing a positive relationship between proximity to private open spaces and house sale price.

1.2 Research Timeline

The concept for this research took shape in January, 2005, in consultation with Dr. Yan Song of the Department of City & Regional Planning at UNC and David Carter of the Wake

County Department of Parks, Recreation, and Open Space. I approached Mr. Carter about a summer job, proposing that we work together to find a research topic that would be of interest to him and could form the basis for my Masters Project. With the help of my research advisor, Dr. Yan Song, I prepared an internship proposal describing this hedonic study and presenting a rough timeline. This proposal met with David Carter's approval.

In late February, 2005, I applied for the Moore Fellowship, a research grant from NC Beautiful. This non-profit promotes environmental education and stewardship across the state through a variety of programs, including research support to graduate students. After a competitive application process, I was named UNC-Chapel Hill's Moore Fellow for 2005-2006. This grant has helped to facilitate my research in a variety of ways, most notably the provision of a computer capable of supporting ArcInfo and other memory-intensive software applications.

My research began in earnest in May, 2005 when I began working full-time at Wake County. My first task was an in-depth literature review of previous studies on the relationship between open space and residential property values. This literature review helped to identify and refine the list of variables to be included in this analysis. Over the summer, I collected the necessary data and used Microsoft Access and Geographic Information Systems (GIS) software to prepare a geodatabase that includes values for all variables for each of the single-family homes in my data set. Toward the end of the summer I began conducting Ordinary Least Squares (OLS) regressions on this dataset using a statistical software package (SPSS).

During the fall of 2005, in collaboration with Dr. Song, I used the instrumental variables technique to remove endogeneity bias in the variable for the distance from each house to the nearest public open space. Also during this period, I added a new variable to account for the diluting effect of large backyards on the need for nearby public open space. My work with Dr. Song in the fall of 2005 confirmed and clarified trends suggested by my initial OLS regressions.

In January, 2006, I earned a 2006 UNC-CH Graduate School's Graduate Education Advancement Board (GEAB) Recognition Award for this research. The Recognition Award,

sponsored by The Graduate School's external advancement board of private citizens, recognizes outstanding graduate student research determined to be of particular benefit to North Carolina.

1.3 Summary of Findings

My Masters Project demonstrates that homes in Wake County have higher property values if they are located closer to open spaces. For example, I estimate that an average home in Raleigh would be worth $4,221 more if it were within 1500 feet of a public open space than it would if it were located farther than 1500 feet from a public open space. This difference in property value would generate an additional $42 annually in county and city property taxes per house. My results also indicate that larger open spaces have a greater impact on property value, and that public open spaces are a greater amenity in dense areas where homes have small yards. These results will help conservationists in Wake County and across the state to make convincing economic arguments for open space preservation. My research will also help convince developers of the potential profitability of incorporating significant open spaces into their residential developments.

1.4 Report Structure

Chapter 2 of this Masters Project presents an in-depth literature review of hedonic studies on open space. Chapter 3 details my methods, explaining the theoretical model underpinning this work and introducing the study area, data sources, and variables used. Chapter 4 presents the results of my initial Ordinary Least Squares regressions and introduces the identification problem (endogeneity), which I discuss in more detail in Chapter 5. Chapter 6 treats the public finance implications of this research, considering in detail the open space financing mechanisms available to local governments in North Carolina. Chapter 7 concludes this Masters Project with a summary of findings, policy recommendations, and caveats associated with the hedonic method in general and this research in particular.

CHAPTER 2: LITERATURE REVIEW

The hedonic price method has been used extensively by researchers to estimate the value of open spaces. This section summarizes the results of 27 studies chosen from over 40 hedonic price analyses reviewed. These papers represent a wide range of geographies and densities, and the authors attempt to measure amenities from a range of open space types using a variety of different variable specifications. For the purposes of this literature review, studies are grouped into categories according to the author's choice of open space variable(s). These categories are: binary variables, continuous distance variables, and landscape pattern variables.

This literature review does not incorporate hedonic studies focusing exclusively on water features such as lakes (e.g. Boyle and Taylor, 2001), wetlands (Mahan et al, 2000), and streams (Mooney and Eisgruber, 2001 and Streiner and Loomis, 1995). Similarly, I excluded hedonic studies of other specific environmental attributes such as water quality (Leggett and Bockstael, 2000) and proximity to hazardous waste landfills (Michaels and Smith, 1990).

2.1 Binary Variables

Seven of the studies reviewed use binary variables exclusively to examine the amenity effects of open spaces. Some of these studies measure only direct adjacency, while others use binary variables to test the effect of certain distance ranges or "zones." Results vary among these studies, but appear to depend largely on the type of open space under consideration.

One of the earliest hedonic studies was completed by Weicher and Zerbst (1973), who examine seven parks in Columbus, OH using binary adjacency variables. These authors find that adjacency to neighborhood parks can have either a positive or negative effect on home value depending on whether the home faces or backs onto the park. For properties facing open spaces, Weicher and Zerbst observe positive externalities of 7-23% of property values (p. 105). The

authors note that these benefits represent a substantial fraction of the opportunity cost of the park. A negative externality exists, however, where houses back onto a park or are located across from heavily-used facilities. This finding is echoed by Shultz and King (2001) (summarized in "continuous distance" section) and Espey and Owusu-Edusei (2001).

Espey and Owusu-Edusei (2001) study the effect of proximity to parks in Greenville, SC. The authors divide the city's parks into four groups according to size, attractiveness, and park amenities. They use dummy variables to indicate whether a house is within a certain distance range of each park type (e.g. 1 = within 300 feet of a Type 1 park, 0 = farther than 300 feet from a Type 1 park). In general, the authors find that parks have a positive impact on property values in Greenville, though they find disamenity effects associated with close proximity to "small basic neighborhood parks" and "medium basic" parks (p. 490-491).

Earnhart (2001) uses a series of dummy variables to determine the effect of adjacency to various water and land open space features in Fairfax, CT. The author's results show positive effects from water adjacency, but no significant effect from the land features relative to a baseline of "backyard". These findings suggest the importance of controlling for a home's own private open space (backyard) in hedonic studies on the potential amenity value of other nearby open spaces. As discussed in subsequent chapters, Dr. Song and I corroborate Earnhart's (2001) conclusion, finding that the size of a home's backyard is significantly related to the amenity value associated with public open space proximity.

Anderson (2000) explores the relationship between adjacency to open space and the sale prices of homes in Hennepin County, MN (Minneapolis and suburbs). In this study, "open space" includes parks, undeveloped areas, and golf courses. Anderson concludes that adjacency to open space increases home sale price by approximately $40,000, or 20% of the mean-valued home. Golf courses are generally found to be a statistically significant amenity in hedonic price studies, which may contribute to Anderson's very strong results. Quang Do and Grudinski (1995) confirm

the amenity value of golf courses, finding that homebuyers in a suburb of San Diego pay a premium of approximately 7.6% for properties directly abutting a golf course (p. 268).

Bolitzer and Netusil (2000) use three different models to examine the relationship between open space and housing sale prices in Portland, OR. The first model uses a dummy variable to examine the effect of any type of open space within 1500 feet of a home. The second distinguishes between four open-space types: public, private, cemetery, and golf course. The third model focuses on distance effects using six dummy variables representing distance ranges ("zones") from the nearest open space of any type. The authors find that size and distance from public parks and golf courses has a significant effect on housing price. Their third model shows that the estimated amenity impact decreases with distance; within 100 feet of an open space, house sale price was expected to increase by $3,523 (1990 dollars), whereas houses in the 1301-1500 ft distance zone were expected to see a price impact of $1,004 (p. 192).

Also in 2000, Netusil published a hedonic price study on Portland, OR which focuses on the effects of proximity to publicly-owned open spaces and private open spaces greater than ten acres. The author restricts the neighborhood under consideration to within 1500 feet of each home. Netusil also includes dummy interaction variables representing the house's neighborhood within Portland. The author concludes that the open space amenity effect varies with the value of homes in the neighborhood, and that open space proximity only increases sale price in high median value neighborhoods. Assuming a property tax rate of 1.5 percent, Netusil concludes that "a home located within 1500 feet of open space in a high value neighborhood will generate approximately $150 in additional property tax revenues per year" (Netusil, 2000; p. 2).

Netusil and Lutzenhiser (2001) completed another hedonic study on open spaces in Portland, OR which includes the following open space types: urban park, natural area park, specialty park/facility (types defined by use and percentage native vegetation), golf and cemetery. They find significantly positive effects on sale price from being within 1500 feet of all open space types, except the cemetery variable, which is not significant. Netusil and Lutzenhiser calculate

estimated dollar effects by distance range and open space type. These effects range from $1,926-$342 for urban parks, $11,210-$9,980 for natural area parks, $13,916-$4,336 for golf courses, and $10,283-$3,839 for specialty parks/facilities (p. 297).

2.2 Continuous Distance Variables

This section covers eight hedonic studies that use continuously varying straight-line distance measures to evaluate the effect of open space proximity on housing value. Though it is difficult to summarize results across these studies, the following themes emerge:

1) Results for continuous distance variables, like binary variables, often vary according to the type of open space considered;
2) Different housing submarkets (and associated amenity effects) may exist in close proximity; and
3) Different studies within the same geographic area may produce contrasting results.

Schultz and King (2001) and Anderson and West (2003) demonstrate the first theme listed above. They use 1990 U.S. Census data to construct a hedonic model for the Tuscon, Arizona area. The authors measure the straight-line distance to the nearest open space of the following types: large resource area, undeveloped park, medium/regional park, small neighborhood park, public golf course, private golf course, Class I/II wildlife habitat. They find that proximity to large protected areas, golf courses, and Class II wildlife habitats raises values, but proximity to undeveloped/neighborhood parks and Class I habitats lowers values.

Similarly, Anderson and West (2003) find that open space amenity effects differ by open space type in the vicinity of Minneapolis and St. Paul, MN. They consider the following types of open space: parks (generally more developed), special parks (national, state, and regional parks, arboretums, nature centers, natural areas, and wildlife refuges), golf courses, and cemeteries. Anderson and West add a layer of complexity, constructing separate models for city and suburban homes in their study area. For city homes, they find that distances from regular parks, special

parks, lakes and rivers has a negative impact on sale price (i.e. these features function as amenities). In the suburbs, proximity to golf courses, lakes and rivers is an amenity. Their size/distance interactive term is negative and significant in cities, suggesting that effect of proximity is stronger for larger parks. The difference in Anderson and West's (2003) results for city and suburban areas suggest that these constitute different housing submarkets.

Studies by Correll et al (1978) and Cheshire and Sheppard (1995) provide further evidence that open space amenity effects can differ within the same geographic area. Correll et al (1978) analyze the effects of a greenbelt in Boulder, CO on housing prices in three nearby neighborhoods. The authors find a "quasi-public good benefit…associated with the increased property values adjacent to greenbelts" which "could provide additional tax revenue to support such purposes" (p. 208). Specifically, Correll et al report a statistically significant decrease of $4.20 in the price of residential property for every foot farther away from the greenbelt (Correll at al, p. 211). Their results are not consistent, however, when each neighborhood is examined separately. The authors theorize that this is due to the timing and planning of greenbelt purchases in relationship to residential construction. Ridell (2001) supports the idea of a lag in amenity value, suggesting that "Failure to take account of systemic market changes may be one possible explanation for the mixed findings of [Correll et al 1978]… Price effects may not have had time to fully realize their impact…resulting in inconclusive results" (p. 511).

Similarly, Cheshire and Sheppard (1995) report different results for the two British towns in their study. They find that nearness to public ("open access") land is positively correlated with house price in both towns, though private open spaces ("closed land," such as intensively farmland and woodland) is highly valued only in one town and had a negligibly positive effect in the other. The authors hypothesize that the difference in observed effects for private open spaces has to do with the differing amounts and types of open space present in each community (p. 258).

Researchers conducting hedonic studies in the same region may reach different conclusions about the amenity value of open space in their study area. For example, Li and

Brown (1980) find no statistically significant relationship between proximity to conservation/recreation areas and house price in their sample of 781 homes from 15 suburbs of Boston, MA. In contrast, a recent (unpublished) hedonic study of 210 homes in Lynnfield, MA, located 15 miles north of Boston, finds a significant negative correlation with distance from permanently protected conservation and historic areas (Donnelly, 2005).

A similar contrast is found between Smith et al (2002) and other studies on open space in Wake County, NC. Smith et al employ both continuously varying and binary variables to investigate the differential impact of "fixed" vs. "adjustable" open space in an area of north Raleigh, NC. They incorporate adjacency dummy variables and straight-line distance measures for each of the following open space types: golf courses, public lands, vacant lots, agricultural land, and forestland. The authors find that golf courses and vacant land function as amenities in this submarket. However, they find that public open space functions as a disamenity in their study area, which consists of a three-mile wide strip along 29 miles of the new I-540 loop. Their public open space category includes open-access parks, greenways, and private eased land.

McConnell and Walls (2005) suggest that perhaps Smith et al (2002) should have split the public category into several sub-categories, noting the mixed results of studies on various types of public parks (as described above). However, Smith et al's (2002) findings contrast other hedonic work on open space in Wake County in which the open space variables were similarly defined or even more aggregated. Palmquist and Fulcher (2003), Walsh (2003), and this Masters Project all report a positive externality associated with parks in Wake County. Each of these studies considers the entire county, as opposed to an area of North Raleigh. Palmquist and Fulcher (2003) include two park proximity variables in their hedonic study of lake access: distance to the nearest park (<70 acres) and distance to nearest large park (>70 acres). They find that greater distance to parks reduces the sale price of homes in Wake County.

Results from a non-hedonic price study by Walsh (2003) also confirm the positive findings of Palmquist and Fulcher (2003) and this Masters Project. Walsh (2003) uses a structural

equilibrium model of an urban land market, calibrated to data from Wake County. Based on this model, the author calculates that the average household, currently living one-half mile from open space, would be willing to pay a one-time amount of $4,104 (in 1992 dollars) to reduce its distance from open space by one-quarter mile.

2.3 Landscape Pattern Variables

This section summarizes the results of ten hedonic studies that use landscape pattern variables to examine the impact of open space on property value. These variables measure the percentage of a particular land use surrounding each house. Each study defines the relevant neighborhood differently, though several measure percentages based on a ¼-mile neighborhood radius. Several studies summarized toward the end of this section also employ the instrumental variables technique to correct for endogeneity.

Bockstael (1996) considers the effect on home sale price of several neighborhood percentage variables including the percentages of surrounding forest, agricultural cropland, agricultural pasture land, and preserved open space. The author defines "neighborhood" to include the 250 acres surrounding each house. Bockstael finds that a large proportion of surrounding open space is a significant amenity in this seven county region of Maryland.

Geoghegan, Wainger and Bockstael (1997) examine the relationship between sale price of homes in the Patuxent Watershed of Maryland and the percentage of open space in forestry and agricultural use in the vicinity of each home. The authors use two neighborhood sizes: within 0.1 km and within 1 km. Geoghegan et al (1997) find that the percentage of forest and farmland within a 0.1 km radius has a significantly positive effect on home sale price, whereas the percentage of forest and farmland within 1 km is a significant disamenity.

Acharya and Bennett (2001) study the effect of numerous landscape variables on the effect of sale prices in New Haven County, CT. Their open space variables consist of the percentage of the nearby landscape in open space within ¼ mile ("visual zone") and 1 mile

("neighborhood") radii. The authors find the percentage of open space to be a significantly positive neighborhood feature. The magnitude of the open space coefficient is similar for both the 1/4 and 1 mile radii (p. 233).

A 2002 article by Geoghegan uses similar landscape (percentage-based) variables, choosing a 1600 meter neighborhood radius to examine the difference in amenity effect between "permanent" and "developable" open spaces in Howard County, MD. The author defines developable land to include agricultural cropland, pasture, and forest land. Permanent land includes parks and publicly-eased land, including eased farms. Geoghegan estimates positive regression coefficients for both permanent and developable open space. The permanent coefficient is over three times the developable coefficient, but the developable result is not statistically significant.

Burton and Hicks (2003) examine the effect of park presence and various park attributes on house sale price in Charleston and Huntington, WV, using census tracts as the neighborhood. They find that the addition of a park to any given census track adds $2,535 dollars to the median value of homes within that track. Burton and Hicks also find that the addition of a jogging or fitness trail contributes $11,059 to the median home value (p. 7). Based on their findings, the authors suggest using tax-increment financing for recreational projects.

Netusil (DRAFT 2005) continues exploring the impacts of open space proximity on the housing market in Portland, OR during the years 1999-2001, using variables based on the percentage of each open space type within ¼ mile. The author employs the following ten categories of open space: private natural area, public natural area, private specialty park, public specialty park, trail, urban park, private golf course, public golf course, private cemetery, and public cemetery. Netusil defines "natural areas" as parks where 50% or more of the land is in native or natural vegetation (Netusil, 2005; p. 11). Netusil finds that proximity to public golf courses, public specialty parks, private specialty parks, and private natural areas is significantly

correlated with increased property values, whereas proximity to private cemeteries significantly decreases property values.

Ready and Abdalla (2003) conduct a hedonic price analysis for 8,090 single family houses sold between 1998 and 2002 in Berks County, PA. The authors measure land use within 400 meters and within 1600 meters of each house using GIS. They consider the following open space land uses: eased open space; government-owned; agricultural security areas; and grass, pasture, and cropland. The authors use the instrumental variables technique to reduce possible bias due to endogeneity between land use and house prices. They chose the following instruments: average slope; average elevation; average septic suitability index; average building suitability index; average agricultural productivity index; and proportion of open space surrounding the house in an agricultural security area. Ready and Abdalla calculate each of these variables for the area within 400 meters of the house and for the area between 400 meters and 1600 meters from the house.

Ready and Abdalla (2003) find that open space is the most desirable land use within 400 meters of a home. Privately-owned open space with easements has a larger amenity value than land without easements. Between 400-1600 meters, commercial land is the most attractive, followed by large-lot residential, and then open space. Within this distance range, grass, crops and pasture are preferred to forested open space, and eased open space is preferred to uneased open space. Outside of 400 meters, government open space is a greater amenity than privately-owned, uneased open space.

Irwin and Bockstael (2001) study the effect of several neighborhood percentage variables on the sale of nearly 56,000 homes in four Maryland counties from January 1995 to December 1999. They define three open space variables: 1) privately-owned, developable (crop, pasture, and forest land); 2) privately-owned, protected by easement/conservation area; and 3) publicly-owned. The authors focus particularly on problems of endogeneity and spatial correlation. They use the instrumental variables (IV) technique to correct for biased coefficients associated with

their private open space variables. Irwin and Bockstael employ the following instrumental variables: parcel slope, soil drainage ability, and soil quality. They find that publicly-owned open space has a significantly positive impact on housing price, as does the privately-owned protected variable, when treated as exogenous. The privately-owned developable variable has a negative effect in the OLS model, but a significantly positive effect in the IV model.

Irwin (2002) conducted a hedonic price study on the same four-county region studied by Irwin and Bockstael (2001). Irwin specifies all open space variables as the percentage of the surrounding neighborhood, defined by a 400m radius around the center point of each residential parcel in the study. The author incorporates percentage variables for the following private land uses: cropland, pastureland, forestland, and easement land. She also uses percentage variables for publicly-owned military and non-military land. Irwin chooses four instrumental variables: a slope dummy (1 = slope greater than 15 percent, 0 = lesser slope), a drainage dummy (1 = poor drainage, 0 = otherwise); a soil quality dummy (1 = current farm with prime agricultural soils, 0 = otherwise); and straight-line distance to Washington D.C. and Baltimore.

Irwin (2002) finds positive and significant amenity effects associated with proximity to privately-owned conservation lands, public non-military open space, and developable forests. The author's IV results were similar to her OLS results. Using first stage estimates from the hedonic pricing model, the author predicts the change in the mean property's price, given a change in the neighboring landscape from one acre of pastureland to other land uses (p. 474). Irwin finds that the within a parcel's neighborhood, conversion of one acre of developable pastureland to privately owned conservation land would increase the mean residential property value by $3,307, or 1.87% (p. 474-475). Conversion of one acre to publicly owned non-military land use increases the mean residential value by $994, or 0.57% of the predicted value. Alternatively, converting one acre to low density residential land use would decrease the mean property value by $1,530, or 0.89% (p. 475). In general, Irwin finds that the spillover amenity effects from preserved open spaces are significantly greater than those associated with

developable farmland and forest land, and that private protected lands are a greater amenity than public protected lands (p. 476-477).

Geoghegan, Lynch, and Bucholtz (2003) continue to investigate the amenity difference between permanently protected and developable open space. This hedonic price study covers three counties in Maryland, evaluating the effect of the percentage of a home's neighborhood (within 100 meters and 1500 meters) dedicated to permanently-preserved vs. developable open space. In this study, preserved open space includes lands under agricultural easements, private and public open spaces, golf courses, and cemeteries. Developable open space consists of agricultural and forest land without formal protection. Geoghegan et al (2003) employ the Instrumental variables technique, following Irwin and Bockstael (2001). Their chosen instruments are: soil attributes, slope, distance to nearest transportation node, and current/future sewer connection (p. 38). The authors find a positive and significant effect on house prices associated with proximity to permanently protected open space in Howard and Calvert counties. Agricultural and forest land coefficients are negative or insignificant in all counties. The wide variation in their findings by county suggests, again, that the value of open space results is highly location dependent (McConnell and Walls, 2005; p. 27). This echoes findings by Correll et al (1978), Cheshire and Sheppard (1995), and Anderson and West (2003) (summarized above under continuous distance studies).

Geoghegan et al (2003) predict that a 1% increase in agricultural easements would generate an additional $579,233 of property taxes in Howard County and $251,674 in Calvert County (p. 43). Using recent land prices, they calculate that these funds would allow the purchase of 110 and 88 new easement acres, respectively (p. 43). Therefore, the property taxes generated by a 1% increase in agricultural easements would pay for a significant portion of the up-front costs associated with the purchase of those easements (p. 43).

2.4 Summary and Conclusions

McConnell and Walls (2005) undertook a massive literature review, synthesizing results of both hedonic and contingent valuation studies on the value of open space. They note in their conclusions the difficulty of generalizing results amongst these studies:

> Each study deals with a particular open space area or set of areas that are unique to a particular region and time period. And each study is measuring a set of services provided by the open space to a particular group of households. Estimated values vary widely across the studies and sometimes even within the studies. For example, hedonic models estimated on data from adjacent counties can turn up vastly different results. Thus, one conclusion that we draw from the extant literature is that open space values are case study–specific. Policymakers looking for a specific dollar value to attach to a particular open space project may find it difficult to use the existing research for that purpose. What can be gleaned from the literature is some general results about the direction of particular effects, how values vary by location and other variables, and the differences between the methodologies used to estimate values.

In spite of these caveats, McConnell and Walls (2005) include a table which summarizes what they feel to be the best estimates of marginal implicit prices associated with open space. They report that as a percentage of mean house prices, the marginal implicit price of being located 200 meters closer to an open space range from negative to 2.8 percent of the average house price. In general, the percentages obtained from the models that use dummy variables rather than continuous distance or percentage of surrounding land variables tend to be higher. One dummy variably study found that being near an open space raises average house prices by as much as 16.8 percent (McConnell and Walls, 2005; p. 28).

Table 1 on the following page summarizes results reported in McConnell and Walls for some of the studies considered as part of this literature review. Results are organized by variable categories (binary, continuous, and landscape pattern).

Table 1: Summary of Hedonic Studies (from McConnell and Walls, 2005)

Citation	Variable Type	Open Space Variable	Marginal value in $	Marginal value as % of house price
Binary Variables				
Lutzenhiser and Netusil, 2001	Living within 1500 feet of:	Natural area	$10,648	16.10%
		Specialty park	$5,657	8.50%
		Urban park	$1,214	1.80%
Continuous Distance Variables				
Anderson and West, 2003	Living 200 m (~1 city block) closer to:	Developed park	$458 (city); $0 (suburbs)	0.44% (city)
		Special park	$600 (city); $0 (suburbs)	0.58% (city)
Shultz and King, 2001	Living 200 m (~1 city block) closer to:	Large natural resource area	$81	N/A
		Class II wildlife habitat	$429	
		Undeveloped park	-$206	
		Regional/district park	-$98	
		Neighborhood park	-$568	
		Class I wildlife habitat	-$130	
Smith et al, 2002	Living 200 m (~1 city block) closer to:	Public open space	-$553	-0.33%
Landscape Pattern Variables				
Acharya and Bennett, 2001	1% increase in open space surrounding house:	(In 1600 m buffer)	$75	0.06%
Geoghegan, Lynch, and Bucholtz, 2003	1% increase in surrounding open space with these characteristics:	Protected farm/forest/public open space in 1600 m buffer	$0 to $1,306	0% to 0.71%
		Protected farm/forest/public open space in 100 m buffer	$0 to $1,106	0% to 0.05%
		Developable farm/forest/public open space in 1600 m buffer	-$599 to -$312	-0.39% to -0.21%
		Developable farm/forest/public in 1000 m buffer	-$768 to $0	-0.05% to 0%
Irwin 2002	Conversion of 1 acre of developable pastureland into:	Conservation land	$3,307	1.87%
		Public (nonmilitary) land	$994	0.57%
		Forestland	-$1,424	-0.82%
		Low-density residential	-$1,530	-0.89%

CHAPTER 3: METHODS—HEDONIC MODEL

This Masters Project employs hedonic price analysis to estimate a component of the economic value of open space in Wake County, NC. Hedonic price analysis infers the value of a non-market resource (open space) from the prices of goods actually traded in the marketplace (the surrounding residential properties) (Crompton, 2000). This method relies on the fact that amenities, such as open space proximity, are capitalized into the sale price of residential homes. Hedonic modeling seeks to explain home sale price in terms of various property attributes, estimating the value of individual housing amenities (or disamenities) based on market interactions. Numerous variables affect the sale price of a home, including structural features (e.g. number of bathrooms), neighborhood characteristics (e.g. median household income of neighborhood residents), and accessibility (e.g. proximity to the nearest downtown area). As a result, this model requires the researcher to control for the influence on sale price of numerous other variables, including physical housing attributes, location/general accessibility, public services, and neighborhood socio-economic characteristics. Specifically, I use a semi-log model with the following specification:

$$ln\ P_i = f(S_i, N_i, M_i, C_i, E_i)$$

where $ln\ P_i$ is the price is the natural log of the sale price of a given house, S_i is a vector of structural characteristics, N_i is a vector of neighborhood characteristics, M_i is a vector of public sector characteristics (e.g. whether house is located within a municipality or not), C_i is a vector of accessibility characteristics (e.g. proximity to a downtown area), and E_i is a vector of environmental characteristics (e.g. proximity to various open space types).

3.1 Variables

This section describes the set of variables used in the research. The dependent variable in all model specifications is the natural log of house sale price. All other variables are independent variables included to help explain the variation in sale price.

3.1.1 Control Variables

I included numerous control variables in this study to account for the effects of a variety of property characteristics on house sale price. **Table 2** lists these control variables, separating them into the following categories: structural, public sector, neighborhood, and regional accessibility characteristics.

Table 2: Control Variables by Category

Variable Name	Description	Unit
Structural Characteristics		
BATHS	Number of bathrooms	# of bathrooms
HEATEDAREA	Heated area	Square feet
LOT_SIZE	Lot size	Acre
FOOTPRINT	House footprint	Square feet
AGE	Age	Year
AIR_YN	Air conditioning or not	Binary
STORIES	Number of stories	# of stories
Public Sector Characteristics		
INCITY	Within a municipality or not	Binary
RD_YN	Within 500 ft of major road or not	Binary
Neighborhood Characteristics		
HOUSEHOLDS	Median household income in census block group (2000)	Dollar
PCT_NONWH	Percentage of non-white residents in census block group (2000)	Percentage
DENSITY	Density: number of people in census block group (2000) divided by block group area	# of people/acre
Regional Accessibility Characteristics		
DIST_CENTER	Distance to nearest major regional activity center	Yard

3.1.2 Open Space Variables

The variables of particular interest to this study are the proximity and size of the nearest open space. Open spaces have been divided into the following categories:

- Golf courses;
- Public open spaces; and
- Other open spaces.

The "other" category is a compiled layer which includes private open spaces, vacant parcels, and agricultural, forest, and horticultural lands which qualify for preferential taxation. Originally, each of these "other" land uses were considered separately, such that there were seven types of open space included in the study. Results from regressions on these preliminary specifications were inconsistent. The combined "other" open space layer has, in contrast, returned consistent results. It is comparable to the privately-owned open space variables used by Netusil et al (2000); Cheshire and Sheppard (1995); Irwin (2002); Irwin and Bockstael (2001); and Anderson (2000, unpublished).

One model specification uses continuous distance variables for each of the three open space categories. These variables measure the distance between each house and the nearest open space of that type, with no upper limit on distance. In the other model specification, I replace the continuous variable for public open space (DIST_PUB) with a binary variable (BUFFER_PUB). This binary variable has a value of "1" for homes within 1500 feet of a public open space and "0" for homes farther than 1500 feet. The 1500 foot cutoff is arbitrary, but there is precedence for use of this value in the literature (Netusil, multiple papers, and Espey and Owusu-Edusei, 2001). All regressions incorporate three size variables, representing the acreage of the nearest open space of each type.

At the recommendation of Dr. Yan Song, I added an additional variable to the regression to account for the relationship between the size of a home's backyard and the relative amenity

value of the nearby public open space. This is an interaction variable which multiples the distance from each house to the nearest public open space (DIST_PUB) by a proxy for backyard size (calculated as the property's lot size minus the house footprint in acres).

Table 3 summarizes the open space variables used in this analysis.

Table 3: Open Space Variables

Variable Name	Description	Unit
Proximity to Open Space		
DIST_GOLF	Distance to nearest golf course	Yard
DIST_PUB and BUFFER_PUB	Distance to nearest public open space	Yard
DIST_OTHER	Distance to nearest "other" open space	Yard
Size of Nearest Open Space		
SIZE_GOLF	Size of nearest golf course	Acre
SIZE_PUB	Size of nearest public open space	Acre
SIZE_OTHER	Size of nearest "other" open space	Acre
Interaction Variable		
INTERACTION	(Distance to nearest public open space) x (Lot size – (house footprint/43560))	Yard*Acre

3.2 Data

The following sub-sections describe the study area and data sources used in this research, as well as the methods that I used to screen the dataset and calculate the relevant open space measures. The data section concludes with descriptive statistics for all variables.

3.2.1 Study Area

Wake County, with its twelve municipalities, is one of 100 counties in North Carolina. This county covers a total of 549,000 acres, or 860 square miles (Wake County website). **Figures 1 and 2**, below, show Wake County's location within the state, and the layout of the municipalities and major roads within the county. In 2000, Wake County's total population was 627,846. U.S. Census 2000 reports a median household income of $54,988 and a median house price of $162,900.

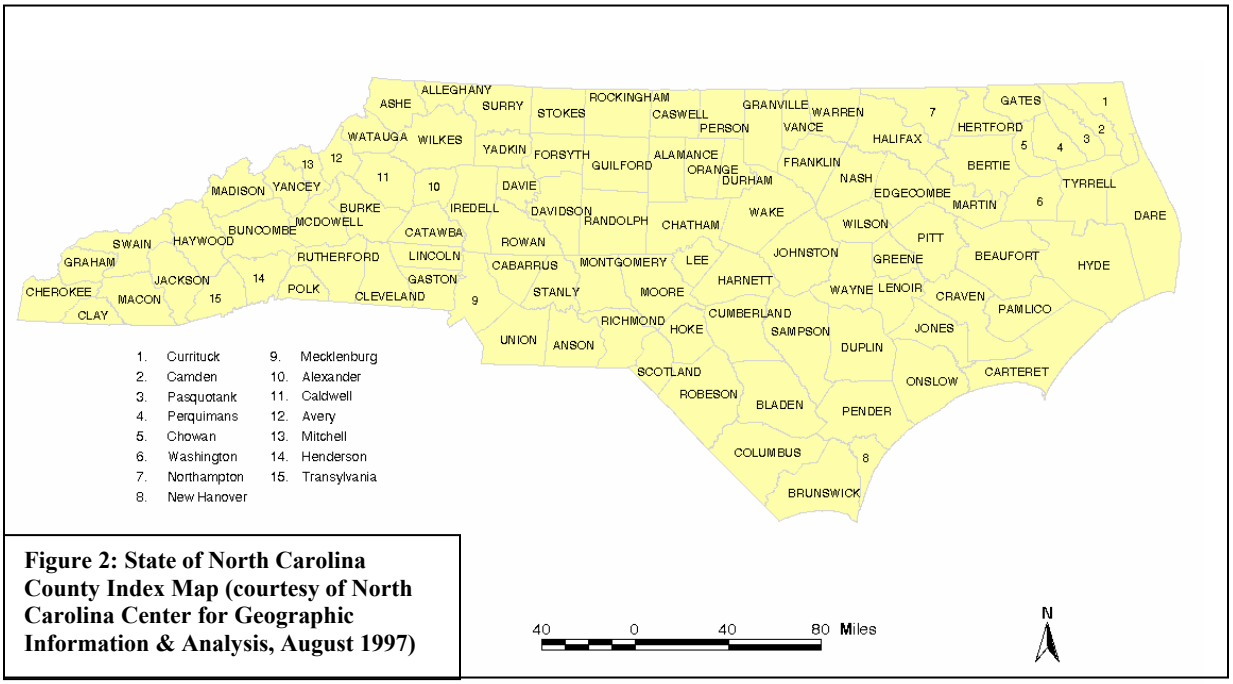


Figure 2: State of North Carolina County Index Map (courtesy of North Carolina Center for Geographic Information & Analysis, August 1997)

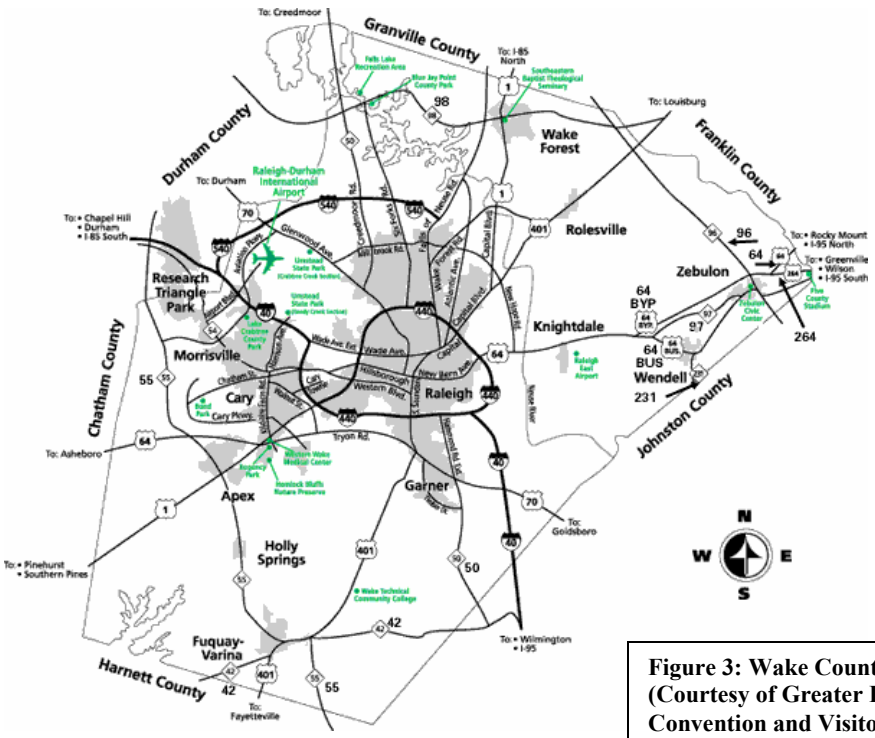


Figure 3: Wake County Map (Courtesy of Greater Raleigh Convention and Visitors Bureau)

3.2.2 Data Sources

I obtained data for this research from the 2000 U.S. Census and Wake County government sources. I downloaded data from the Census 2000 and the Wake County GIS (WCGIS) websites, copied additional layers from shared Wake County servers, and queried the County's tax assessment database with the help of the Wake County GIS department. **Table 4**, below, summarizes my data sources.

Table 4: Summary of Datasets and Sources

Dataset	Source
Houses sold in Wake County in 2004 (with geographic reference)	WCGIS "parcels" layer
Sale price and structural characteristics of houses in dataset	Wake County Tax Assessor's Database (joined to "parcels" layer with assistance from WCGIS)
Public sector characteristics associated with each house	WCGIS "corp" layer
Neighborhood characteristics associated with each house	Census 2000 data and WCGIS "blkgrp" layer
Location of major activity centers	Constructed layer with input from Wake County Planning Department
Location of golf courses	Selection from WCGIS "parcels" layer
Location of public open spaces	WCGIS layer "new_os_pub"
Location of "other" open space	Merge of selected agricultural, forest, horticultural, and vacant land from "parcels" layer, plus private open spaces selected from WCGIS "priv_os" layer

3.2.3 Dataset Screening

The Wake County GIS and tax assessment data contains attributes for all land parcels in Wake County and sales data back to the 1920s. Hedonic price analyses typically filter available information to arrive at a dataset containing attribute and sales information for residential parcels in a certain narrow range of years. In this case, I chose to only consider single-family residential properties transacted in 2004.

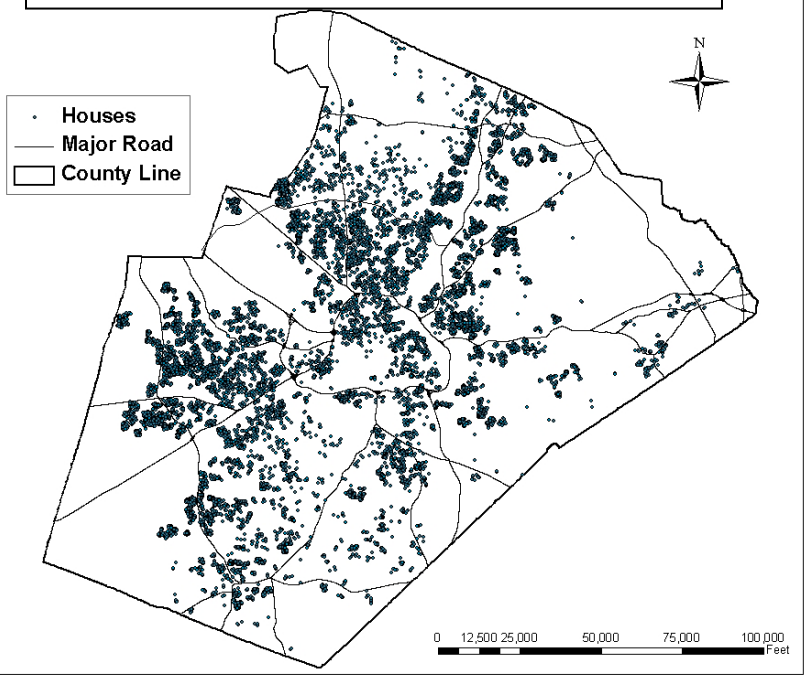
My data base includes only those house sales that met the following criteria:

- 2004 sale date
- Single-family residential classification
- Residential activities
- Land classification: residential, less than 10 acres
- Houses with living space greater than 600 sq feet
- Parcel size greater than 0.1 acre, smaller than 5 acres
- House built within last 60 years (year_built <1944)

- Only "arms-length" transactions: sale price must be more than 60% or less than 160% of total assessed value
- Assessed value of the land must be greater than US $1.00 per square foot
- Assessed value of improvements must be greater than US $25.00 per square foot
- Individual ownership
- Detatched units
- Built before 2005

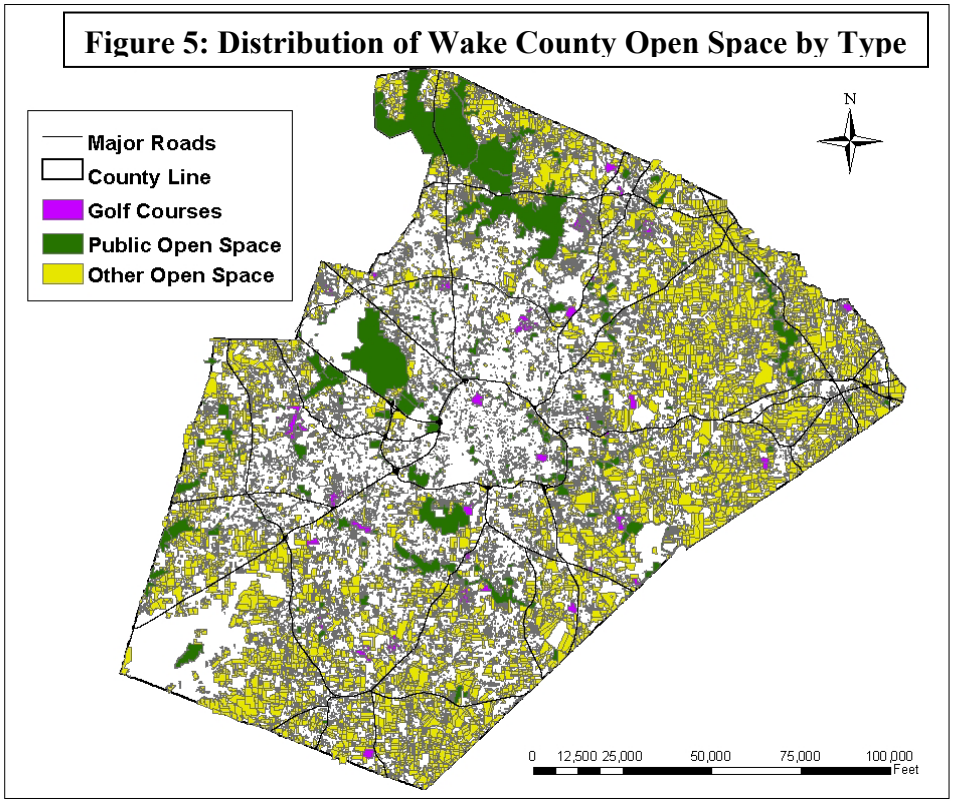
Application of these screens resulted in a sample of 14,564 house sales. Next, I deleted aberrant data, such as one house with '1997' rooms, another with a sale price of $2.9M (significantly higher than other sale prices), and four homes that fell outside of U.S. Census boundary lines for Wake County. Deleting aberrant data reduced the dataset to the final number of 14,564 house sales. **Figure 3**, below, shows the spatial distribution of these homes.

Figure 4: Final Set of Houses Used in Study



3.2.4 Calculation of Open Space Measures

After I prepared the database of house characteristics, I calculated the distance from each house to the nearest open space of each type using ArcInfo. The output files contained all of the original house attributes plus new columns for DIST_PUB, DIST_GOLF, and DIST_OTHER. Using parcel identification numbers, I joined these output files to the master table to incorporate the size of the nearest open space of each type. **Figure 4** shows the spatial distribution of the three types of open space used in this study: golf courses, public open space, and other open space.



3.2.5 Descriptive Statistics

The following table presents descriptive statistics for all variables used in this analysis.

Table 5: Descriptive Statistics

Variable Name	Unit	Mean	Standard Deviation	Minimum	Maximum
LnSALPRIC	Ln (dollar)	12.26	0.48	10.20	14.48
BATHS	# of bathrooms	2.52	0.53	1.00	3.50
HEATEDAREA	Square feet	2245.30	856.13	624.00	8658.00
LOT_SIZE	Acre	0.33	0.23	0.10	2.84
FOOTPRINT	Square feet	1955.78	652.43	576.00	7016.00
AGE	Year	10.80	12.90	1.00	60.00
AIR_YN	Binary	0.99	0.11	0.00	1.00
STORIES	# of stories	1.63	0.44	1.00	3.00
INCITY	Binary	0.86	0.35	0.00	1.00
RD_YN	Binary	0.02	0.14	0.00	1.00
HOUSEHOLDS	Dollar	66332.99	19991.64	9338.00	146756.00
PCT_NONWH	Percentage	0.24	0.17	0.01	1.00
DENSITY	# of people/acre	2.00	1.85	0.01	17.73
DIST_ACT	Feet	11154.37	6106.99	432.80	44448.45
DIST_GOLF	Yard	3555.29	1938.42	50.61	11566.46
DIST_PUB	Yard	1179.48	924.26	10.98	6769.39
DIST_OTHER	Yard	155.89	110.65	4.14	905.89
SIZE_GOLF	Acre	194.29	144.73	15.01	530.57
SIZE_PUB	Acre	154.04	1292.21	0.02	18441.76
SIZE_OTHER	Acre	3.91	14.66	0.00	186.71
DIST_UC	Yard	9572.67	2436.89	628.35	17453.11
INTERACTION	Acre*Yard	408.18	740.39	0.87	11557.66

CHAPTER 4: RESULTS

4.1 Ordinary Least Squares

Table 6 on the following page presents my Ordinary Least Squares (OLS) regression results for two model specifications. One model uses the continuous distance variable for public open space (DIST_PUB), and the other uses the binary variable (BUFFER_PUB), as described above. Positive coefficients indicate a direct relationship between the associated variable and sale price; negative coefficients indicate an inverse relationship. Both model specifications explain over 85% of the variation in sale price (R^2 value of 86%). All control variables in both models have their expected sign and are significant.

As indicated by Table 6, the first model specification returns insignificant results for DIST_PUB (the continuous variable). In the second specification, when I use BUFFER_PUB instead of DIST_PUB, BUFFER_PUB is positive and significant at the 1% level. This result indicates that public open spaces are an amenity for houses located within a 1500 foot radius. At 0.02, the BUFFER_PUB coefficient is in the range of control variables such as the number of stories (0.087) and location within a municipality (0.06).

The other two open space distance variables, DIST_GOLF and DIST_OTHER, are negative and significant in both specifications, indicating that proximity to these types of open spaces raises home prices. The significance of DIST_OTHER increases from the 10% to the 1% level in the second model specification. SIZE_GOLF and SIZE_PUB are positively and significantly correlated with house sale price in both specifications. Variables representing the size of the nearest "other" open space (SIZE_OTHER) and the distance to the nearest activity center (DIST_UC) are not significant in either OLS specification.

Table 6: Ordinary Least Squares Regression Results

	Continuous Variable Specification		Binary Variable Specification	
Variable Name	**Estimate**	**Significance**	**Estimate**	**Significance**
(Constant)	10.6954450	***	10.683736	***
Baths	0.1232150	***	0.1233745	***
heatedarea	0.0002450	***	0.0002451	***
lot_size	0.1190740	***	0.1185447	***
footprint	0.0002200	***	0.00022	***
age	-0.0016810	***	-0.001789	***
air_yn	0.1106630	***	0.1110001	***
stories	0.0868620	***	0.0869112	***
pct_nonwh	-0.4057150	***	-0.405789	***
density	-0.0122650	**	-0.0082427	**
in_city	0.0513710	***	0.0611328	***
rd_yn	-0.0451070	***	-0.0453002	***
dist_UC	-0.0000674		-0.0001399	
households	0.0000010	***	0.000001	***
dist_golf	-0.0000050	***	-0.0000053	***
dist_pub (continuous)/ buffer_pub (binary)	-0.0000060		0.0211479	***
dist_other	-0.0000540	*	-0.0000894	***
size_golf	0.0001080	***	0.0001485	***
size_pub	0.0000070	***	0.0000137	***
size_other	-0.0001610		0.0001536	
Interaction	0.0000137	*	0.0000101	*
R-Square	**0.86**		**0.86**	

*** Significance at 1% level
** Significance at 5% level
* Significance at 10% level

4.2 Identification Problem

In estimating hedonic models, a number of econometric issues arise. These issues include questions of functional form, the extent of the housing market, and identification problems (endogeneity). During the fall of 2005, Dr. Yan Song and I worked to eliminate biased coefficients due to endogeneity, a problem that is particularly relevant in the use of hedonic models to quantify the effects of land use spillovers. I present results from this analysis in the following chapter.

CHAPTER 5: INSTRUMENTAL VARIABLES

5.1 Potential Endogeneity Issue

Hedonic models assume that each independent variable is exogenous, meaning that it influences the dependent variable (sale price), but is not influenced in turn by the dependent variable. We are particularly concerned with the effects of endogeneity on the distance to public open space variable. The distance from a home to the nearest public open space is, to some degree, endogenous to that house's sale price. In other words, proximity to open space influences house price, but house prices in turn influence how much open space is protected in the vicinity. In areas with higher property values, increased development pressure reduces the amount of open land available for purchase. Conversely, less expensive areas will tend to have more available open space.

As Ready and Abdalla (2003) explain, "The danger is in concluding that [the presence/proximity of] open space is depressing house prices, when in fact it is the low house prices that are allowing open space to survive" (p. 4). This explanation works best for vacant land, and may be too simplistic to apply to public open space. For example, a wealthy municipality with high property values may have less available open space, but their financial and political environment may allow the purchase of more acres of public open space than a less wealthy town. However, as explained below, we determined that endogeneity associated with the distance to public open space variable is enough of a concern in this case to warrant investigation.

5.2 Instrumental Variables Approach

We performed a Hausman endogeneity test on DIST_PUB to determine whether the differences between our IV and OLS estimates are large enough to suggest that the OLS estimates are biased. We found the Hausman statistic to be 42.23 (chi-square), significant at the 0.000 level. This small p-value indicates that there is a significant difference between the IV and OLS

coefficients, such that the coefficient produced by OLS is not consistent for this variable. We therefore adopt an instrumental variables (IV) approach to correct for endogeneity in the distance to the nearest public open space variable (DIST_PUB).

In this technique, the researcher identifies new variables (instruments) that are expected to be correlated with the endogenous variable under consideration, but not correlated with house sale price. These variables act as proxies for the opportunity cost of development (Irwin & Bockstael, p. 703). The IV technique involves two steps. First, using OLS, the instruments are regressed as independent variables against the variable of interest (here, distance to public open space). If the chosen IVs are significant, then they are useful instruments. Second, the researcher estimates the hedonic price function using OLS, replacing the endogeneous variable (distance to public open space) with its predicted values from the first-stage regression with the instruments. The resulting set of coefficients has now been adjusted for the endogeneity of the chosen variable.

We originally chose two IVs as proxies for the opportunity cost of development: slope and soil quality. We expected these to be correlated with the spatial pattern of land uses (e.g. whether or not the land becomes a public park), but not with the residential housing market. Following standard IV methodology, we regressed these variables as independent variables, using the distance from each house to public open space as the dependent variable. The resulting coefficients for each IV then function as variables themselves, substituting for the original DIST_PUB variable in a multivariate regression on the log of home sale price. Regressions using this procedure with slope and soil quality instruments returned inconsistent results[1], indicating that these variables do not function well as instruments in this case. We then chose two new IVs: 1) the percentage of golf and public open space in the same census tract as each public open space, and 2) the distance from each public open space to the nearest major road.

[1] For example, the coefficient for the number of stories in a particular house indicated that more stories was a disamenity, which is inconsistent with the real estate market.

5.3 Instrumental Variables Results

These two new IVs were found to be significant in the first regression. **Table 7** presents final results from the IV model, using the corrected (continuous) public open space variable. All results are significant at the 1% level, with the exception of the density variable (significant at 5%) and DIST_UC (not significant). As with the OLS models, this specification has an R^2 value of 0.86, and the coefficients for all control variables are consistent with expectations. **Table 8** on the following page interprets these results in terms of their relationship to house sale price.

Table 7: Instrumental Variables Regression Results

Variable Name	Estimate	Significance
(Constant)	10.6814583	***
baths	0.1232246	***
heatedarea	0.00024	***
lot_size	0.0838611	***
footprint	0.0002257	***
age	-0.001615	***
air_yn	0.1119599	***
stories	0.0866858	***
pct_nonwh	-0.408771	***
density	-0.0118421	**
in_city	0.0512534	***
rd_yn	-0.0458899	***
dist_UC	-0.0000957	
households	0.000001	***
dist_golf	-0.0000061	***
dist_pub (continuous)	-0.0000152	***
dist_other	-0.0000562	***
size_golf	0.0001163	***
size_pub	0.0000066	***
size_other	0.0000063	***
Interaction	0.000023	***
R-Square	**0.86**	

*** Significance at 1% level
** Significance at 5% level
* Significance at 10% level

Table 8: Interpretation of Instrumental Variables Regression Results

	Coefficient Sign	Interpretation
Dependent Variable		
Natural log of house sale price		
Independent Variables		
Structural Characteristics		
Number of bathrooms	+	More bathrooms raises sale price
Heated area	+	Larger heated area raises sale price
Lot size	+	Larger lot size raises sale price
House footprint	+	Larger house footprint raises sale price
Age	-	Older homes sell for less
Air conditioning or not	+	Presence of A/C raises sale price
Number of stories	+	More stories raises sale price
Public Sector Characteristics		
Within a municipality or not	+	Houses w/in municipal boundaries sell for more
Within 500 ft of major road or not	-	Houses w/in 500 ft of a major road sell for less
Regional Accessibility		
Distance to major regional activity centers	N/A	Coefficient not significant
Neighborhood Characteristics		
Median household income in census block group (2000)	+	Houses in higher median income neighborhoods sell for more
Percentage of non-white residents in census block group (2000)	-	Houses in neighborhoods with a higher percentage of non-white residents sell for less
Density: # people in census block group (2000) divided by block group area	-	Houses in dense neighborhoods sell for less
Proximity to Open Space		
Distance to nearest golf course	-	Homes near golf courses sell for more
Distance to nearest public open space	-	Homes near public open spaces sell for more
Distance to nearest "other" open space	-	Homes near “other” open spaces sell for more
Size of Nearest Open Space		
Size of nearest golf course	+	Larger golf courses have a larger amenity effect
Size of nearest public open space	+	Larger public open spaces have a larger amenity effect
Size of nearest "other" open space	+	Larger “other” open spaces have a larger amenity effect
Interaction Variable		
(Distance to nearest public open space) x (Lot size – Footprint/43560)	+	Being close to a public open space is a greater amenity for houses with small yards

CHAPTER 6: PUBLIC FINANCE IMPLICATIONS

6.1 Tax Value Calculations

In order to make these results more meaningful, I used them to calculate the difference in the property value of an average Wake County home associated with proximity to open space. This difference in property value can then be translated into a value for the open-space related annual property tax revenue. I use the coefficients from the second OLS specification (with BUFFER_PUB, the binary open space variable) to model the sale price of two different hypothetical houses in Wake County. I assume that one of these houses is located within 1500 feet of a public open space, and the other is located farther than 1500 feet from a public open space. Otherwise, these two houses are identical, having the median value for all of the continuous variables. Both homes are assumed to have air conditioning and be in Wake County, but not within the boundaries of a municipality (value of "0" for IN_CITY).

Using this method, I calculate the value of the hypothetical house near a public open space to be $189,767. The house farther away from a public open space is worth $185,796. The difference in value is $3,971.05, which represents a 2.09% change in value associated with open space proximity. This increase in property value would generate $24 per house per year in Wake County taxes. These results are presented in the two-page research summary that I prepared for David Carter of Wake County (**Appendix A**). If these houses are assumed to be located in Raleigh (value of "1" for in_city), the open-space related change in sale price is $4,221.38, and an additional $42.17 of property taxes per year per house flows back to Raleigh and Wake County.

These calculations assess the difference in sale price associated with proximity to the median-sized open space of approximately 154 acres. When I substitute a 1-acre public open space, the impact on sale price is only $8 less than the values reported above for the 154 acre public open space. The relative insensitivity of sale price to park size could be due to the use of a continuous variable for size (as compared to a binary variable for proximity).

Results from this hedonic price analysis are surprisingly congruent with Walsh's (2003) estimates of willingness-to-pay for open space proximity from his structural equilibrium model. As summarized in chapter 2, Walsh (2003) calculates that the average Wake County household, currently living one-half mile from open space, would be willing to pay a one-time amount of $4,104 (in 1992 dollars) to reduce its distance from open space by one-quarter mile. However, we must compare these two sets of results with caution. My hedonic price analysis consists only of a first-stage analysis. As a result, I am limited to conclusions about the relationship between sale price and open space proximity. While this relationship suggests something about willingness-to-pay for open space proximity, I do not directly estimate welfare changes associated in the way that Walsh (2003) does.

6.2 Local Government Financing of Open Space Protection

The remainder of this chapter presents the rationale for local government financing of public open space, followed by a discussion of which financing mechanisms are most feasible for North Carolina's local governments to use in protecting open space.

6.2.1 Rationale for Local Government Financing of Open Space

Open space is one type of public sector infrastructure (capital). Several features of public sector capital explain why the private market fails to produce optimum quantities of these goods (Ulbrich and Maguire, 2005). First, this type of infrastructure typically provides public good benefits. As discussed in Chapter 1, public goods are non-rival and non-excludable, such that the market fails to create the incentives for adequate production by private entities. Second, public sector capital often generates positive externalities which do not accrue to the property owner and therefore do not send the appropriate market signals. In the case of open space, these externalities can be represented by increasing property values for nearby residents, as demonstrated in Wake County. Finally, the cost structure of public infrastructure, heavily weighted toward the initial

capital investment, has consequences for its provision by the private sector. This cost structure renders unlikely the possibility that the market would support more than one supplier in a given area, making that sole supplier a monopolist. Monopolies usually produce less service at a higher price than optimal, and are relatively unresponsive to consumer demand. As a result of all of these characteristics, many localities rely on the public sector to provide appropriate quantities of infrastructure such as open space.

Any level of government can protect open space, as evidenced by the park systems of federal, state, county, and municipal governments. However, the responsibility for open space protection is increasingly falling to local (county and municipal) governments. This parallels the general trend of devolution of governmental responsibility and accompanying fiscal responsibility (Fausold and Liliholm, 1996). At the same time as higher-level government preservation programs are weakening, bottom-up conservation efforts are strengthening. Local land conservation trusts are playing an increasingly important role in land preservation as their advocacy and institutional capacity continues to expand.

6.2.2 Choice of Local Government Financing Mechanism

There are two primary ways to finance public capital projects such as open space acquisition: 1) pay-as-you-go and 2) pay-as-you-use. Pay-as-you-go strategies accrue a reserve of tax revenue over time for eventual use in financing capital projects. Pay-as-you-use involves borrowing funds up-front, usually via bonds, which are repaid with interest from taxes in future years. In deciding which financing strategy is most appropriate for open space protection, each local government must ask two key questions. First, when is the money needed? And second, what exactly are our open space capital needs (i.e., do we need funds for land acquisition, maintenance, operations, etc.)?

6.2.2.1 Pay As You Go

Some local governments choose to finance open space acquisition and maintenance using pay-as-you-go strategies which impose specific taxes for defined periods of time. The revenues from these taxes are set aside for conservation. Tax strategies most often used for open space protection include sales taxes, real estate transfer taxes, and property (ad valorem) taxes (EPA, 1999). Each of these strategies is considered in detail below, along with two additional varieties of the property tax: special assessments and service district taxation.

Sales Taxes

Local-option sales taxes are add-ons to state general sales and use taxes. Typically, local taxes are limited to a specified time period, or a dollar collection total, and a specific use. The dedicated revenue stream may be used to back local general obligation or revenue bonds, or to pay for a specific program directly, such as parks and conservation (EPA, 1999).

Sales taxes have been a successful means of generating funds for open space protection in Florida, Georgia, South Carolina, and Tennessee (see **Table 9** in the conclusions to this chapter). In North Carolina, counties are authorized to adopt general sales taxes in addition to state and county general sales taxes, but additional special-purpose sales taxes must be authorized by the legislature. In 1997, the state authorized Mecklenburg County to adopt an additional sales tax to fund public transit. The following year, the county's voters approved an additional ½% sales tax to fund the Charlotte Area Transit System (Goldman et al, 2001). Gaston County and Dare County have also been granted the authority to impose additional special-purpose sales taxes for economic development and beach re-nourishment, respectively. However, neither was successfully implemented. Gaston's was voted down, and Dare's was instated by county officials but overturned by a citizen vote (Lawrence, 2006). All three of these instances of legislative approval for additional sales taxes were somewhat anomalous, and none were for conservation-related purposes (Lawrence, 2006).

Real Estate Transfer Tax

Real estate transfer taxes are charged to the buyer and/or seller of real property at the time of sale. These taxes are based on a percentage of sale value of the property, a flat deed registration tax, or a combination of these methods (EPA, 1999). Sometimes sellers bear the cost of this tax; in other cases it is imposed on buyers who, it is argued, are making an investment in the future of a community (TPL, 2006). Real estate transfer taxes could be dedicated to any land-oriented environmental program, and the tax could be extended to new construction (EPA, 1999).

Real estate transfer taxes based on property values can generate a large amount of revenue at relatively low rates. Most governments already have system in place for recording sales, which eases collection of transfer taxes. Tax rates can be graduated to increase equitability and a close cost/benefit relationship. Dedication of revenues to popular land protection programs enhances the acceptability of the tax. However, revenues depend on the level of real estate market activity, which is subject to wide and frequent fluctuations (EPA, 1999).

In North Carolina, a statewide real estate transfer tax is assessed at the rate of $1.00 per $500 of the value of each deed, instrument, or writing by which any real property is conveyed to another person (WSBI, 2006). In addition, seven counties (Dare, Camden, Chowan, Currituck, Pasquotank, Perquimans, and Washington) are authorized to levy a local real estate transfer tax of $1 per $100 of value (NCDOR, 2005). Additional local governments must get special legislative approval to apply an additional real estate transfer tax (TPL, 2006). This approval seems unlikely (Lawrence, 2006). Even if the tax were authorized, its use would be heavily opposed by local real estate interests.

Property Taxes

Real property taxes are charged to property owners as a percentage of the current assessed value of property. There are two main ways localities use property taxes to fund environmental projects. The first is to earmark a specific portion of current annual revenues for a

particular spending need, such as open space. The second is to direct a temporary or permanent property tax increase to a specific purpose, a method which has been increasingly employed. New Jersey represents the most publicized use. By 1997, two NJ counties and 21 municipalities had passed a one or two penny per $100 in value "land preservation tax" to finance open space and farmland trust funds (EPA, 1999).

Earmarking current revenues for open space spending is an attractive strategy. In Wake County, the percentage of set-aside could be based on my findings regarding the amount of annual tax revenue generated by open space's amenity effects. Earmarking would not require an increase in taxes. However, this would be difficult to accomplish in an environment of increasingly tight local government finances. It may not be possible to get consistent internal consensus to allocate scarce resources for conservation, deemed by many to be an "extra." Spending decisions are often made on a discretionary, annual basis, and there would be no guarantee that the funds would be successfully culled out and used for their intended purpose (Luger, 2006).

Alternatively, Wake County could choose to increase property taxes to fund open space. North Carolina local governments can increase property taxes without a referendum up to the state-imposed cap of $1.50 per $100 in value (Lawrence, 2006). Tax rates vary by county and municipality. The 2004-05 weighted average county-wide tax rate for all 100 North Carolina counties was $0.646 per $100 of appraised valuation, with a range of $0.35 to $1.091 (NCDOR, 2005). Currently, combined county/city property tax rates in Wake County vary from $0.999 per $100 in Raleigh to $1.164 per $100 in Garner. These rates are above state averages, but still have a buffer of unused property tax capacity below the $1.50 cap.

There is precedence in Wake County for special-purpose taxes. For example, this county currently has a 1% tax on prepared foods, the proceeds of which go into the Wake County Occupancy and Prepared Food/Beverage Tax fund. This fund is used for museums and other cultural purposes (Lawrence, 2006). However, North Carolina's local governments do not

currently have the authority to sequester a portion of property tax revenue into a separate fund in order to shield it from other uses. If an additional property tax were imposed without an accompanying special fund, this method presents the same accountability problem as earmarking without raising taxes. Political pressure might force them to follow through with conservation spending (with enough citizen support), but committing to this every year in the face of other budget crises would be difficult.

Imposing a specific property tax increase for open space may limit the county/town's ability to raise property taxes for other purposes. And raising property taxes is always unpopular, regardless of purpose. To date, only one North Carolina jurisdiction (Randolph County) has proposed the use of additional property taxes to fund open space acquisition (TPL database). Randolph County put it to a referendum vote in 2004, and the measure did not pass.[2]

Property Taxes: Special Assessment

An alternative way to design a property tax increase for conservation is as a special assessment, a recurrent charge levied by local jurisdictions on a sub-group of population. In order to be equitable, this sub-group must receive property value benefits from an improvement that are not enjoyed by others in the area. The relevant property owners must be located in limited, identifiable areas (EPA, 1999). The system for collecting assessments is usually tied to the collection of ad valorem property taxes. This idea is closely related to Tax Increment Financing, but instead of issuing a bond, funds are generated from charges to individuals in the special assessment district (EPA, 1999). A special assessment district is not a political entity; it is simply a designated area in which a local government levies open space charges.

At this time, there is no enabling legislation which would allow North Carolina local governments to impose differential property tax rates within a jurisdiction, rendering them unable

[2] This referendum would have been advisory only, since North Carolina local governments already have the authority to increase property taxes without voter approval.

to levy special assessments (Luger, 2006 and Lawrence, 2006). However, counties do have the authority to create service districts within their jurisdiction (summarized below).

Service Districts

North Carolina counties can create service districts in which additional property taxes are levied in order to provide funds for provision of specific services. Within the district, the new tax must be levied at a uniform rate. Service districts in North Carolina most commonly fund new fire departments and school levies, with rates of $0.20 or less per $100 in value (NCDOR, 2005). There are currently few special district taxes apart from school levies and rural fire district levies, but "recreation" funding is one of the purposes allowed by North Carolina law (NCDOR, 2005 and Lawrence, 2006).

No vote is necessary to set up a service district. However, if the desired area is located within a municipality, that city/town must consent to use of this mechanism (Lawrence, 2006). The primary challenge to the use of service districts for open space protection and provision of recreational services is determining where the district's boundary should be. My findings demonstrate there is a significant relationship between open space proximity and property value in Wake County. The strength of this relationship diminishes with distance, but locating the appropriate boundary is not clear-cut[3]. The service district size could conceivably vary with the acreage of nearby open space.

6.2.2.2 Pay As You Use

Pay-as-you-use (bonding) is generally considered to be the most appropriate strategy for funding land acquisition by the public sector for protection as open space, primarily for timing reasons. As an area develops, the price of undeveloped land increases, such that $1 of public conservation funds now might only have $0.75 of purchasing power in five years, for example.

[3] My 1500 foot cutoff for evaluating price effects is basically arbitrary, though supported in the literature.

Early purchase also helps avoid land bidding wars with individuals (such as developers) who have greater purchasing power than the local government.

Bond type is defined by the way in which the debt will be retired. Below, I analyze the feasibility of using several different bonding strategies for open space protection, beginning with general obligation and revenue bonds.

General Obligation and Revenue Bonds

General obligation (GO) bonds are the most common type. GO bonds are backed with the "full faith and credit" of the local government. This means that the jurisdiction will use its taxing power to repay the bond, and if all else fails, that bondholders can seize local government assets as repayment. Localities typically secure GO bonds with property taxes, and voter approval is frequently required for issuance (EPA, 1999).

The other major category of bonds is revenue bonds. Revenue bonds are only appropriate to fund open spaces where entrance fees can be reliably collected. In most jurisdictions, it is not feasible to charge entrance fees on all public open spaces. Historically, GO bonds are used for public infrastructure (such as open space) that does not generate a revenue stream, and revenue bonds used otherwise (Ulbrich and Maguire, 2005).

Newer bond instruments include project development financing (North Carolina's tax-increment financing mechanism) and hybrid tax/bond strategies such as special tax bonds and service district bonds. I describe each of these in detail below.

Project Development Financing

Tax increment bonds, which differ slightly from special assessment bonds, are local bonds issued for designated districts where the benefit from the project being financed is manifested through higher property values. North Carolina has recently passed enabling legislation for their version of tax-increment financing, which is called project development financing (PDF). PDF generates revenue for bond repayment from the incremental change in

property values caused by the financed improvement. The enabling legislation for PDF does not list parks, recreation, open space, conservation etc. as allowed uses for this mechanism (Lawrence, 2006). With enough lobbying, the legislature might be persuaded to allow PDF for open space provision.

However, PDF presents particular concern for financing open space. First, as stated in the literature review (chapter 2), research shows that the degree to which open spaces affect property values varies with park type, amenities provided, and geographic area. As a result, a place-specific study would be required in each case to estimate the size of the future tax increment produced by a new park facility. Second, the real estate market may be slow to incorporate the amenity value of a newly-protected open space into property values, such that the increment needed to pay the debt service does not materialize for a period of time (McConnell and Walls, 2005; p. 16). Third, open space programs usually fund the acquisition of numerous parcels distributed throughout a jurisdiction, such that it would be difficult to delineate the relevant financing district. For all these reasons, it seems likely that the use of PDF will be restricted to more traditional economic development projects such as stadiums and entertainment facilities.

Special Tax Bonds

Special tax bonds are usually issued by local governments to finance a particular type of facility, and are backed by the pledge of proceeds from excise taxes, special assessment taxes or property (ad valorem) taxes. Localities recently have used special tax bonds to finance parks and open space using local sales tax and property tax surcharges (EPA, 1999). One such bond was approved by voters in Osceola County, FL, in 2004: a $60,000,000 bond for open space, wildlife, watershed protection, and recreation was accompanied by a 20-year, 1/4 mill increase in property taxes (TPL database). The accompanying tax surcharges may be approved for a limited time period or to collect a specified amount of money (EPA, 1999).

At this time, North Carolina local governments do not have the ability to use special tax bonds (Lawrence, 2006). However, counties do have the authority to borrow against recreation service districts, as discussed below.

Service District Bonds

North Carolina counties have the authority to create service districts to fund provision of recreation services. Counties are further authorized to issue bonds secured by the revenues from that service district. Issuing service district-secured bonds requires two concurrent referenda, one at the county level and one within the service district. If the district's revenues are not sufficient to pay off the bond, the county can use general funds for the remainder (Lawrence, 2006).

6.2.3 Conclusion: Pay-as-you-go vs. Pay-as-you-use

If the local government's primary capital need is for land acquisition, pay-as-you-go as the sole open space funding strategy will likely be insufficient, due to the time lag in generating a significant reserve. This time lag between taxes paid and acquisition may also create a timing mismatch between those who pay for the open space and those who benefit from it. However, these problems are largely eliminated if the funding need is for park maintenance instead of initial land purchase. In this case, generation of an annual sum from an increase in tax revenue would match the time profile of annual maintenance costs. Pay-as-you-go is also appropriate for local governments who have not yet had time to assess acquisition priorities and would prefer to accrue funds for future purchases.

Interim land use restrictions and economic incentives can be used in combination with pay-as-you-go to try to protect key lands during the accrual period. Options include current use tax assessment, two-rate (land value taxation), downzoning to very low densities, applying watershed protection and/or agricultural zoning designations, and transferring/purchasing development rights. However, many such restrictions, especially those that can be done without significant public expenditures, are politically infeasible or require legislative approval. Further,

some are of questionable effectiveness. For example, without adequate penalties and contractual enforcement, current use taxation may have the unintended effect of subsidizing developers to purchase land speculatively and hold it (Bird and Slack, 2002).

Within the southeast region of the U.S., the relative popularity of pay-as-you-go vs. pay-as-you-use financing for open space protection by local entities varies by state. The following table summarizes all open space/conservation referenda in the southeast states in 2004 (data from TPL/LTA, 2004). Throughout the region, approximately the same number of tax referenda were floated as compared to bond referenda (18 vs. 20), but the bond referenda had a much higher success rate (90.5% vs. 66.7%). In 2004, six out of seven open space referenda in North Carolina were for bonds.

Table 9: Summary of Conservation Finance Referenda, Southeast States, 2004

	Tax Referenda			Bond Referenda			Hybrid Tax/Bond Referenda		
State	**Floated**	**Types**	**Pass**	**Floated**	**Types**	**Pass**	**Floated**	**Types**	**Pass**
Florida	6	Sales (4); property (2)	4	12	GO (11), Property (1)	11	1	Bond plus property tax increase	1
Georgia	6	Sales (6)	5	2	GO (2)	2	N/A	N/A	N/A
Louisiana	2	Property (2)	1	N/A	N/A	N/A	N/A	N/A	N/A
North Carolina	1	Property (1)	0	6	GO (6)	6	N/A	N/A	N/A
South Carolina	2	Sales (2)	1	N/A	N/A	N/A	N/A	N/A	N/A
Tennessee	1	Sales (1)	1	1	GO (1)	0	N/A	N/A	N/A
TOTAL	**18**		**12**	**21**		**19**	**1**		**1**

The Trust for Public Land tracks conservation referenda on a national basis. Their LandVote database lists 35 conservation-related referenda in North Carolina from 1994-2005. **Appendix B** provides details on these referenda, stating where each was proposed, its purpose, the amount of funding involved, whether or not it passed, and by what margin. Of North Carolina's 35 conservation-related referenda in the past decade, 34 were for bond issues and one was for a 20-year, $0.02 per $100 property tax. 29 of the 35 measures passed (the property tax

measure was not among them). Interpreting these results is somewhat complicated by the fact that many of the bonds were proposed for a variety of purposes in addition to open space protection. However, it is clear that North Carolina voters, on the whole, strongly support open space protection. Due to a combination of legislative, political, and financial factors, North Carolina to date has used GO bonds almost exclusively to fund public open space acquisition by local governments.

Wake County is currently funding their land acquisition program entirely through GO bonds. Voters in this county have passed two open space GO bonds within the last five years: a $15,000,000 bond in 2000, and a $26,000,000 bond in 2004. Wake County's open space program has preserved 3,200 acres of open space since 2000. In recognition of this fact, Wake County was recently honored as one of six winners of the second annual County Leadership in Conservation Awards (WC, 2006). General obligation bonds issued by Wake County are primarily secured by property taxes, as they are in other local governments across the country. This Masters Project demonstrates that there is a significant link between public open space and property value in this county. Therefore, in this case there is a reasonable cost/benefit correlation between revenue procurement (via GO bonds secured primarily by property taxes) and spending for open space (which boosts property values).

Table 10 summarizes my analysis of strategies for local government financing of open space in North Carolina. As indicated, I consider property tax increases, service district taxation, and service district bonds to be the most feasible strategies for local governments to use in addition to GO bonds to protect open space. I discuss the relative efficiency and equity characteristics of these strategies below. Property tax increases would be especially useful if the General Assembly could be persuaded to grant Wake County the authority to set up a fund to receive the incoming money and reserve it for conservation purposes. Earmarking current revenues for open space spending is another attractive strategy, and would not require an increase

in taxes or indebtedness. However, consistently sequestering a portion of current revenues for conservation would be challenging in the face of increasingly tight local government finances.

Table 10: Assessment of Financing Strategies for Open Space Protection by Local Governments in North Carolina

Strategy	Feasibility for Use by NC Local Governments
Pay-as-you-go	
Local sales tax	Low. Sales taxes are relatively popular in general, but the legislature is not likely to grant this privilege to additional counties.
Local real estate transfer tax	Low. North Carolina cities must get special legislative approval to levy additional real estate transfer taxes. Even with authority, significant local opposition expected.
Earmarking property tax	Low/Medium. Would not require increase in taxes, but difficult to actually sequester conservation funds in tight budgetary conditions.
Property tax increase	Medium. Local governments have the authority to impose additional property taxes. Best if funds are sequestered into a separate fund. Local government would not be legally bound to use additional tax revenue for stated purpose, and property tax increases are notoriously unpopular.
Property tax: special assessment	Low. No enabling legislation.
Service district	Medium. County can establish district without a vote. May be difficult to determine appropriate boundaries. Needs consent of municipality if within municipal borders.
Pay-as-you-use	
General obligation bond	High. Has been used extensively in NC for the protection of open spaces. Reasonable benefit correlation, as GO bonds are primarily secured by property taxes.
Revenue bond	Low. Unless entrance fees can be charged, open spaces do not generate revenues.
Project development financing (PDF)	Low. Not authorized for parks/recreation/etc. Even if authorized, issues with time lag of amenity value and cumbersome assessments.
Hybrid	
Special tax bond	Low. No enabling legislation.
Service district bond	Medium. May be difficult to determine appropriate service district boundaries. Requires two concurrent referenda, one at the county level and one within the service district.

Property taxes are economically inefficient when they create incentives for citizens to move to other jurisdictions to escape the tax. Thus, the inefficiency increases in proportion to the differential in rates between neighboring jurisdictions. The benefit principle applies where property-based taxes are used to fund public open space provision: residents who benefit more

from open space proximity have higher property values and therefore pay more in taxes. Use of additional property taxes is administratively efficient, since collection systems are already in place. This type of tax is at least somewhat vertically inequitable, since lower-income people generally spend a larger percentage of their income on housing. Property taxes are generally horizontally equitable, meaning that people with similar properties would pay similar amounts in tax (and people with more expensive properties pay more).

Similarly, use of a service district would be economically inefficient if it caused residents to avoid living in an area that they would have otherwise chosen. The benefit principle applies even more tightly here than with property taxes, since only those residents who directly benefit are charged for open space provision. The issue of exactly where to draw the district boundary remains, however. This mechanism would create a new administrative burden on the local government, diminishing its overall efficiency. Within a service district, the property tax rate would be uniform, such that the tax would be roughly horizontally equitable. However, at a larger scale, there would be horizontal inequity between district residents and residents in the rest of the town with properties of similar value, due to the differential total property tax burden.

Several other property-based strategies are theoretically appealing for use by local governments in financing open space, including special assessment taxes, special tax bonds, and real estate transfer taxes. However, these strategies would need to overcome the hurdles of enabling legislation and/or special legislative approval, in addition to probable unpopularity.

CHAPTER 7: CONCLUSIONS AND POLICY RECOMMENDATIONS

In total, this research employs three variations of a semilog hedonic model to explore the relationship between open spaces of various types and the sale price of single-family homes in Wake County, NC. These three models are:

1) Ordinary Least Squares linear regression with a continuous variable for distance to the nearest public open space (DIST_PUB);

2) Ordinary Least Squares linear regression with a binary variable for distance to the nearest public open space (BUFFER_PUB); and

3) Instrumental Variables estimation with a continuous variable for distance to the nearest public open space (DIST_PUB), corrected for endogeneity.

Table 11 on the following page presents final regression results from all three models. Coefficient results are similar throughout, with the exception of the variables for the distance to public open space (DIST_PUB) and the size of "other" open spaces (SIZE_OTHER). In the OLS model, DIST_PUB is negative but insignificant. Addition of the IV technique serves to increase this coefficient slightly and raise its significance to the 5% level. This is further proof that there is endogeneity present in the original OLS model. Correcting for this bias reveals the significant relationship between proximity to public open space and house sale price. As expected, the binary variable BUFFER_PUB returns a coefficient of much greater magnitude than the continuous variable counterpart (DIST_PUB). This variable was used to calculate the difference in the property value of an average Wake County home associated with proximity to open space. Interestingly, these results are similar to Walsh's (2003) conclusions regarding Wake County residents' willingness to pay to live closer to open spaces.

In summary, my results suggest the following conclusions:

- proximity to all types of open space increases residential property values Wake County;
- larger open spaces of all types have a larger amenity effect than small open spaces; and
- public open spaces are a greater amenity in dense areas where homes have small yards.

Table 11: Regression Results, All Specifications

	Ordinary Least Squares				Instrumental Variables	
Variable Name	Continuous		Binary		Continuous	
	Estimate	Sig.	Estimate	Sig.	Estimate	Sig.
(Constant)	10.6954450	***	10.683736	***	10.6814583	***
baths	0.1232150	***	0.1233745	***	0.1232246	***
heatedarea	0.0002450	***	0.0002451	***	0.00024	***
lot_size	0.1190740	***	0.1185447	***	0.0838611	***
footprint	0.0002200	***	0.00022	***	0.0002257	***
age	-0.0016810	***	-0.001789	***	-0.001615	***
air_yn	0.1106630	***	0.1110001	***	0.1119599	***
stories	0.0868620	***	0.0869112	***	0.0866858	***
pct_nonwh	-0.4057150	***	-0.405789	***	-0.408771	***
density	-0.0122650	**	-0.0082427	**	-0.0118421	**
in_city	0.0513710	***	0.0611328	***	0.0512534	***
rd_yn	-0.0451070	***	-0.0453002	***	-0.0458899	***
dist_UC	-0.0000674		-0.0001399		-0.0000957	
households	0.0000010	***	0.000001	***	0.000001	***
dist_golf	-0.0000050	***	-0.0000053	***	-0.0000061	***
dist_pub OR buffer_pub	-0.0000060		0.0211479	***	-0.0000152	***
dist_other	-0.0000540	*	-0.0000894	***	-0.0000562	***
size_golf	0.0001080	***	0.0001485	***	0.0001163	***
size_pub	0.0000070	***	0.0000137	***	0.0000066	***
size_other	-0.0001610		0.0001536		0.0000063	***
Interaction	0.0000137	*	0.0000101	*	0.000023	***
R-Square	**0.86**		**0.86**		**0.86**	

*** Significance at 1% level
** Significance at 5% level
* Significance at 10% level

My findings also show developers that there is economic value in providing private open space as part of development and redevelopment projects in Wake County. This argument is particularly applicable to conservation subdivisions. Using clustering, conservation design can yield the same number of units as conventional subdivisions while also providing large areas of

open space, which serves to significantly increase the property values of homes within the development.

This research demonstrates that public open spaces in Wake County are helping to pay for themselves by boosting property values, generating marginal property tax revenue that flows back to local governments. These results provide economic justification for Wake County's existing open space program, which to this point has relied on general obligation bonds to provide up-front capital for land acquisition.

Going forward, Wake County may want to consider a combination of pay-as-you-use and pay-as-you-go to finance open space programs. Pursuant to voter approval, continued use of GO bonds could be supplemented by service district bonds. These bond revenues would be most useful for up-front capital costs associated with land acquisition. The most feasible pay-as-you-go strategies are service district taxation and additional property taxes. These annual revenues would be best used for ongoing maintenance costs, and could also be saved for potential future acquisitions. Property tax increases would be especially effective in financing open space if local governments could obtain the authority to set up conservation funds for the incoming revenue.

In closing, a few caveats about this research. As mentioned in chapter 6, this hedonic price analysis consists only of a first-stage analysis. As a result, I can draw conclusions about the relationship between sale price and open space proximity, but cannot directly evaluate the associated welfare changes (as Walsh does in his 2003 paper). In addition, I have modeled Wake County as a single market. There may be multiple sub-markets within Wake County, each of which warrants its own hedonic model. Consideration of sub-markets was not within the scope of this study. Further, my dataset consists only of detached single-family homes transacted during a particular year, ignoring rental properties, multi-family units, and houses that did not change hands during this time.

Finally, this research provides only a partial estimate of the economic value of open space. Other economic benefits, including those associated with water-quality purification and the

existence of pristine habitat (non-use values), are not captured here. Future studies could attempt to quantify other components of the economic value of open space in this area using other research methods. A combination of use (e.g. hedonic) and non-use (e.g. contingent valuation) methods may be ideal to capture a wider range of services provided by open spaces (McConnell and Walls, 2005; p. 5).

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APPENDIX A: RESEARCH SUMMARY PREPARED FOR WAKE COUNTY DEPARTMENT OF PARKS, RECREATION AND OPEN SPACE

The Economic Benefits of Open Space in Wake County, North Carolina

Wake County is facing the rapid loss of open space. As of 2003, only 9% of Wake County was protected open space, and remaining open spaces were being developed at the rate of 27 acres per day. Open space provides numerous benefits to Wake County which will be lost or compromised if current development patterns continue unaltered. These benefits include water purification and protection of drinking water supplies, provision of wildlife habitat, and human health and recreation benefits.

Open space also provides a variety of economic benefits. By purifying and protecting water supplies, it avoids costly water treatment facilities. By preserving natural amenities, it keeps tourists coming to the area. And by enhancing the property value of surrounding homes, open space generates additional property tax revenues that flow back to the local government.

Numerous studies across the country have demonstrated that proximity to open space has a significant and positive impact on residential property values. In 2005, the Wake County Department of Parks, Recreation, and Open Space commissioned a study to determine whether or not Wake County's open spaces are increasing property values. This study was conducted by Katherine Henderson, a Masters student at UNC's Department of City & Regional Planning in Chapel Hill.

In order to examine the effect of open space proximity on sale price, this study chose a dataset of over 14,000 single-family homes sold in Wake County in 2004 (see **Figure 1**).

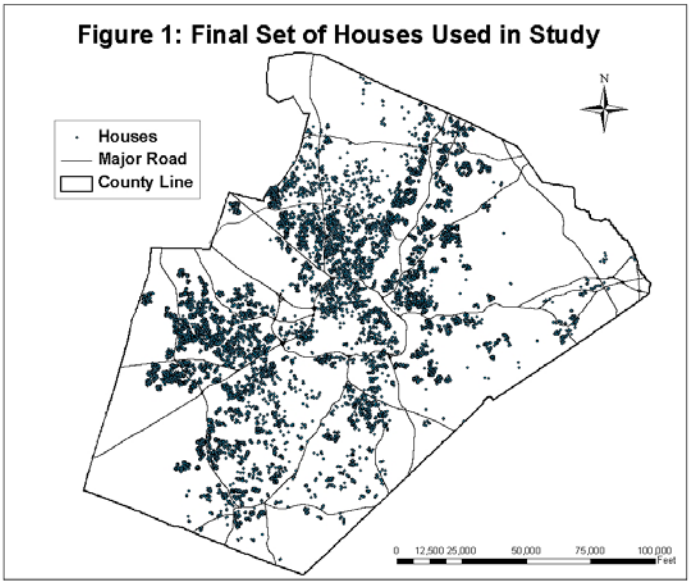


Figure 1: Final Set of Houses Used in Study

Ms. Henderson gathered information from the Wake County Tax Assessor's office about the structural characteristics of each of the 14,000+ houses in the study. She focused on house attributes known to influence sale price, including square feet of living space, number of bathrooms, and lot size. Neighborhood characteristics were then assigned to each house using Census 2000 data. Finally, Ms. Henderson measured the distance from each house to the nearest open space. Open spaces were divided into three categories:

1) public open spaces;
2) golf courses; and
3) other open spaces, including farm, forest, and vacant land.

The distribution of open spaces of each type throughout the county is shown below in **Figure 2**.

In total, this study examined the effect of twenty house characteristics on sale price. This included thirteen structural/ neighborhood characteristics, proximity to each of the three open space types, the size of the nearest open space of each type, and a variable representing the size of a home's private backyard.

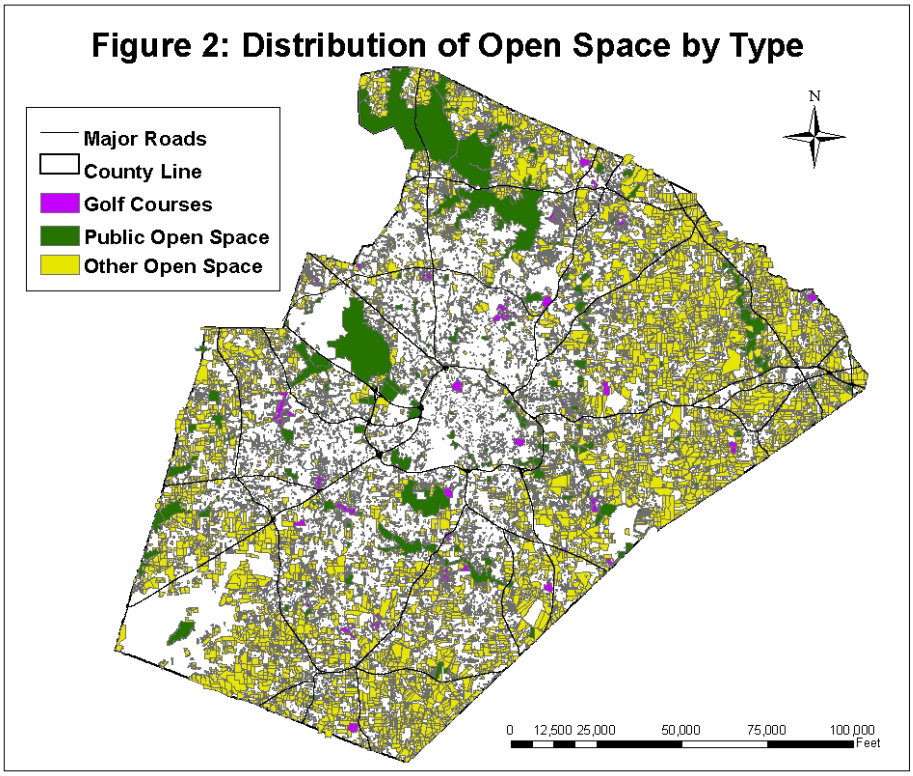
With the help of statistical software, Ms. Henderson evaluated the contribution of each characteristic to the total sale price of the home. As expected, she found that houses with more square footage, stories, and bathrooms sell for more. Air conditioning and larger lot sizes raise sale price, as does a house's location within a municipality. In general, results for the structural/neighborhood characteristics followed expectations, echoing similar studies conducted throughout the country.

With regard to open space, Ms. Henderson found that homes in Wake County sell for significantly more money if they are located closer to any type of open space. In general, larger open spaces were found to have a greater impact on sale price.

Using her results, Ms. Henderson calculated that an average home[1] in Wake County would be worth approximately $3,971 more if it were within 1500 feet of a public open space than it would if it were located farther than 1500 feet from a public open space. This difference represents a 2.09% change in property value, and would generate an additional $24 annually in county property taxes per house.

This research confirmed that investing in Wake County's open spaces is a good economic decision. Open spaces provide local governments with a modest return on investment in the form of increased property tax revenue. This is only one of the many economic benefits associated with open spaces. When added to the myriad environmental and public health benefits, the case for aggressive conservation of Wake County's remaining open spaces is overwhelming.

Figure 2: Distribution of Open Space by Type



[1] An "average home" for the purposes of these calculations is a hypothetical house with the median characteristics for all variables.

Appendix B: Conservation Finance Referenda in NC, 1994-2005 (data from Trust for Public Land LandVote database)

Jurisdiction Name	Jurisdiction Type	Date	Description	Finance Mechanism	Purpose	Conservation Funds at Stake	Conservation Funds Approved	Pass?	% Yes	% No
Asheville	Municipal	5/12/1999	Question, Bond for open space, natural areas, greenways, easements, playgrounds, parks, recreation	Bond	Parks, greenways, open space, recreation	$18,000,000		no	47%	53%
Orange County	County	11/6/2001	Bond to purchase land and easements for watershed protection	Bond	Watershed protection	$20,000,000	$20,000,000	yes	67%	33%
Mecklenburg County	County	11/2/1999	Land Purchase Bonds, Bond for open space, schools, other county purposes	Bond	Open space	$106,000,000	$106,000,000	yes	61%	39%
Mecklenburg County	County	11/2/1999	Parks and Recreation Facilities Bond, Bond for parks, recreation	Bond	Parks, recreation	$16,000,000	$16,000,000	yes	69%	31%
Carrboro	Municipal	11/4/2003	Bond for Sidewalks and Greenways, Bond for sidewalks, greenways, parks	Bond	Greenways, parks	$2,500,000	$230,000	yes	73%	27%
Cary	Municipal	4/8/2003	Bond for improving, expanding, and acquiring parks, greenways, recreation centers	Bond	Parks, greenways, recreation	$15,000,000	$15,000,000	yes	56%	44%
Chapel Hill	Municipal	11/4/2003	Bond for land acquisition, open space	Bond	Open space	$2,000,000	$2,000,000	yes	76%	24%
Huntersville	Municipal	11/4/2003	Bond for parks, recreation, streets	Bond	parks, recreation	$3,000,000	$3,000,000	yes	69%	31%
Mount Holly	Municipal	6/3/2003	Bond for improving and acquiring parks, open space, greenways, trails	Bond	Parks, open space, greenways, trails	$1,150,000	$1,150,000	yes	62%	38%
Raleigh	Municipal	10/7/2003	Parks and Recreation Bonds, Bond for parks, greenways	Bond	Parks, greenways, trails	$47,250,000	$47,250,000	yes	69%	31%
New Hanover County	County	5/2/2000	$34 million bond issue for open space acquisition and recreation	Bond	open space, recreation	$34,000,000		no	41%	59%

Greensboro	Municipal	11/7/2000	Bond issue for parks and recreational facilities	Bond	Parks, recreation	$34,200,000	$34,200,000	yes	69%	31%
Wake County	County	11/7/2000	Bond issue for acquisition of open space	Bond	Open space	$15,000,000	$15,000,000	yes	77%	23%
Garner	Municipal	11/7/2000	Bond issue to acquire and improve land for public parks	Bond	Parks, recreation	$3,500,000	$3,500,000	yes	68%	32%
Guilford County	County	5/2/2000	Bond issue for parks acquisition and development, and recreation	Bond	Parks, recreation	$10,000,000	$10,000,000	yes	62%	38%
Apex	Municipal	11/5/1996	Bond for Parks, Recreation, Land Acquisition, Community Center	Bond	Recreation, parks, open space	$6,000,000	$6,000,000	yes	83%	17%
Durham	Municipal	11/5/1996	Bond Question 3, Bond for Parks, Recreation	Bond	Parks, recreation	$5,350,000	$5,350,000	yes	67%	33%
Chapel Hill	Municipal	11/5/1996	Bond for Parks, Recreation, Open Space	Bond	Open space, parks, recreation	$3,000,000	$3,000,000	yes	66%	34%
Orange County	County	11/4/1997	Bonds for Parks, Recreation	Bond	Recreation, parks	$3,000,000	$3,000,000	yes	54%	46%
Wake County	County	11/2/2004	Bond for open space, recreation, and for the protection of water quality and wildlife habitats	Bond	Open space, recreation, watershed protection, wildlife habitat	$26,000,000	$26,000,000	yes	75%	25%
Matthews	Municipal	11/2/2004	Bond for parks and greenways	Bond	Parks, greenways	$5,000,000	$5,000,000	yes	67%	33%
Guilford County	County	11/2/2004	Bond for parks, greenways, watershed protection, and open space	Bond	Open space, recreation, watershed protection, parks, and greenways	$20,000,000	$20,000,000	yes	55%	45%
Wake Forest	Municipal	11/3/1998	Bond issue for parks, recreation and land acquisition	Bond	Parks, recreation, open space	$3,200,000	$3,200,000	yes	68%	32%
Mecklenburg County	County	11/2/2004	Bond to improve parks and provide recreational facilities	Bond	Parks, recreation	$44,000,000	$44,000,000	yes	63%	37%

Randolph County	County	11/2/2004	20-year, 2 cent per $100 property tax to fund a variety of long term recreation needs, including land acquisition and district park development	Property tax	Parks, recreation, greenways, trails	$30,000,000		no	32%	68%
Apex	Municipal	11/2/2004	Bond to acquire and improve parks and recreational facilities	Bond	Open space, parks, recreation	$13,000,000	$13,000,000	yes	86%	14%
Morrisville	Municipal	11/2/2004	Bond to acquire and construct new parks and recreational facilities and expand existing parks	Bond	Open space, parks, recreation	$4,000,000	$4,000,000	yes	78%	22%
Orange County	County	11/8/1994	Bond for farmland preservation	Bond	Farmland	$5,000,000		no	46%	55%
Wilmington	Municipal	11/5/1996	Bond for parks, Recreation	Bond	Recreation, parks			yes	59%	41%
Cary	Municipal	5/3/2005	Bond to preserve natural resources including open space, wildlife, and watershed protection	Bond	Open space, wildlife habitat, watershed protection	$10,000,000	$10,000,000	yes	75%	25%
Mecklenburg County	County	11/7/1995	Bond issue for acquisition, improvement and maintenance of park and recreational facilities	Bond	Recreation, parks, greenways	$20,650,000	$20,650,000	yes	66%	34%
Mint Hill	Municipal	11/8/1994	Bond for parks	Bond	Parks	$400,000	$400,000	yes	56%	44%
Cary	Municipal	4/8/1994	Bonds for parks and recreation	Bond	Open space, parks, recreation, greenways	$1,885,000	$1,885,000	yes	54%	46%
Mecklenburg County	County	11/8/2005	Bond for the purchase of land to protect the Mountain Island Lake watershed and for a community college and public school purposes	Bond	Watershed protection, parks	$20,000,000		no	47%	53%
Union County	County	11/8/1994	Bond for the acquisition of land, installation of furnishings and equipment	Bond	Parks, open space			no	42%	58%

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