Technical appendices for

The economic value of open space in the Cumberland Region

by

Charles Sims, Ph.D.

Jill Welch, Ph.D.

Rebecca J. Davis, Graduate Research Assistant

Yinan Liu, Graduate Research Assistant

Dong Yan, Graduate Research Assistant

Cassidy Quistorff, Undergraduate Researcher

Matthew N. Murray, Ph.D.

April 19, 2018

Howard H. Baker Jr. Center for Public Policy

1640 Cumberland Avenue

Knoxville, TN 37996

THE UNIVERSITY of TENNESSEE
KNOXVILLE

Technical Appendix A

Open Space Database

The open space database was compiled using geographic information system technology. The variety of sources used to compile the open space database allows us to characterize open space based on type (agricultural, forest, wetlands) and ownership type (state agency, federal agency, private landowner). Open space type was obtained from the National Land Cover Database (NLCD) 2011. The description of land cover types present in the NLCD database is presented in Table A.1.

Table A.1. 2011 National Land Cover Database Classification Descriptions

Developed, Open Space - areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
Developed, Low Intensity - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
Developed, Medium Intensity - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
Developed High Intensity -highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.
Barren Land (Rock/Sand/Clay) - areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
Deciduous Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.

Shrub/Scrub - areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
Grassland/Herbaceous - areas dominated by gramanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
Pasture/Hay - areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
Cultivated Crops - areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.
Woody Wetlands - areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

The shape files for open space ownership type are obtained from the Tennessee Wildlife Resources Agency (TWRA). Those files include conservation easement land (from the National Conservation Easement Database), unprotected open space (from the National Land Cover Database 2011), public land, federal owned open space (DoD, NPS, USACE), state owned open space (state forests, TWRA land, and TDEC land), and local parks layers for Davidson county. For all other counties local parks and greenways were obtained from the Tennessee Recreation and Parks Association.

Technical Appendix B

The Recreational Value of Open Space

Introduction

Open space (forests, agricultural land, public parks, etc.) provide a wide range of benefits to society including recreational opportunities. With decreasing amounts of leisure time in people's busy schedules, proximity to parks and preserved open space can serve as an important recreational outlet and improve people's quality of life. The parks and open space studied in the ten-county study area provide a wide range of opportunities for outdoor recreational pursuits.

To estimate the value of recreational benefits, a benefit transfer approach is used. Though it is preferable to use site-specific data to value recreational benefits at a particular location, this approach is not feasible due to time and budget constraints. Benefit transfer represents an attractive alternative approach and is employed in this study. Essentially, benefit transfer estimates recreation benefits at a particular open space site by using existing economic information derived from other similar open space areas. While benefit transfer is a second-best estimation strategy, it is better than the alternative of not accounting for recreational benefits which implies that recreational benefit is zero (Rosenberger and Loomis 2001).

The industry standard approach for estimating recreational benefits is the unit-day-value approach. Loomis (2005) summarized and compiled a number of empirical studies of the value per day of different recreational uses. The value per day generated by recreational activities can be estimated using either revealed preference approaches or stated preference approaches. Revealed preference approaches infer the value of recreational activities from observed purchases of other related market goods. For example, the value that people hold for state and national parks may be reflected in the expenditures incurred to travel to a park. The travel cost method (TCM) is the most frequently used revealed preference approach. It basically uses total costs of a recreational activity (travel, lodging, entrance fees, equipment rentals, travel time) as a proxy for the price of the recreational activity in estimating the demand function. The time and travel cost expenses incurred represent the "price" of access to the site. Thus, people's WTP can be estimated based on different number of trips people take when they are faced with different "prices". This is equivalent to estimating WTP for a marketed good based on different demands at different prices.

The contingent valuation method (CVM) is the most frequently used stated preference technique. CVM asks people how much they are willing to pay for specific recreational activities, or in some cases, how much they are willing to accept in order to give up certain recreational activities. Though revealed preference approaches typically result in slightly higher estimates than stated preference methods (Rosenberger and Loomis 2001), most studies that have compared the two techniques find that they are not statistically different.

Table B.1 lists average consumer surplus per-person per-day for different activities. Consumer surplus is the value of recreation in addition to what is paid to enjoy recreational activities such as park access fees. It is also referred to as the net WTP in excess of the cost of the activity. Loomis (2005) also reported different values for different areas, and table B.1 only includes those reported for the Southeast area in 2004 dollars. Mean, min and max in table B.1 were calculated with data from different studies compiled by (Loomis 2005). These values are treated as a constant per-unit measure with no consideration for congestion. In other words, the first recreation trip generates the same value as the last recreational trip.

Table B.1. Willingness to Pay Values

Activity	Mean	Min	Max
Camping	25.79	3.3	65.02
Fishing	79.2	3.6	556.82
Canoeing	127.46	18.05	394.82
Hiking	60.38	1.87	262.04
Boating	58.92	6.91	134.34
Biking	49.62	20.86	67.52
Picnicking	36.62	28.56	44.69
Swimming	60.92	13.64	134.34

Source: Loomis (2005)

Methodology

The main recreational activities in the parks and most recent visitor data for the nine state parks within the ten-county region were obtained from their websites (see table B.2). Visitor information was not available for Cedars of Lebanon State Park and Port Royal State Historic Park. An ordinary least-squares (OLS) regression was used to predict number of visitors for these two state parks based on park size, distance to the closest metropolitan area (Nashville), and visitor information from other state parks (see table B.2). Since only total visitor data is available for each park, we cannot calculate the economic value for the different activities performed at a park. Instead, we collect values for activities from table B.1 and, based on the different activities in each park, we calculate a mean WTP of recreational activities for each state park that reflects the recreational opportunities at each park. These average activity values are then multiplied by total number of visitors to obtain the economic values of these parks. Since the values reported in (Loomis 2005) were in 2004 dollars, table B.2 also inflated these number by the CPI (obtained from the U.S. Bureau of Labor Statistics).

In addition, there are also two national parks and three lakes in the ten-county study area. Table B.3 and B.4 show their visitation information, the general recreational per-person per-day value/ average per-activity recreational value, and the total economic value per year due to recreation on each park or lake. In total, the economic values of national and state parks and lakes in this area amount to $1,219.60 million.

Table B.2. Visitor Number, Activities, and Economic Value for State Parks

Park	Distance to Nashville	Size (acres)	Number of Visitors per year	activities	Avg per activity value	Economic Value $M per year
Dunbar Cave State Park	48	110	586,382	picnic fishing hiking	58.74	$44.38
Port Royal State Historic Park	46	26	573,632	picnic canoe fishing hiking	75.92	$56.11
Montgomery Bell State Park	45	4,102	740,080	camping swimming fishing picnic boating canoe hiking	62.65	$59.74
Harpeth River State Park	34	40	499,222	picnic canoe fishing hiking	75.92	$48.83
Bicentennial Capitol Mall State Park	5	19	312,674	picnic	36.62	$14.75
Radnor Lake State Park	21	1,332	731,555	hiking	60.38	$56.91
Long Hunter State Park	33	2,600	908,771	swimming fishing picnic boat hiking biking	57.61	$67.46
Cedars of Lebanon State Park	42	900	844,762	camping picnic swimming hiking	45.93	$49.99
Bledsoe Creek State Park	53	169	487,292	camping picnic fishing boating canoe hiking	64.73	$40.64

Sources: TDEC, Loomis(2005)

Table B.3. Visitor Number and Economic Value for National Parks

Park	Number of Visitors per year	Recreational Value per person per day	Economic Value $M per year
Stones River National Battlefield	346,213	42.77	$19.08
Natchez Trace Parkway and National Scenic Trail	5,891,315	42.77	$324.65

Sources: NPS, Loomis (2005)

Table B.4. Visitor Number and Economic Value for Corps Lakes

Lake	Number of Visitors per year	Avg per activity value[1]	Economic Value $M per year
J. Percy Priest Lake	3,271,505	$57.61	$242.85
Cheatham Lock and Dam	1,059,374	$57.61	$78.64
Old Hickory Lock and Dam	5,306,094	$57.61	$393.86

Sources: U.S. Army Corps of Engineers, Loomis (2005)

Hunting

A total of 101,562 hunting permits of all classes were sold in 2016 within the ten-county region.[2] While hunting is clearly a valued recreational pursuit on the regions' open space, there is little information on where hunting recreation takes place. Some hunting takes place on private land. Hunting also takes place on wildlife management areas managed by the state and federal government. According to the 2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation report, 87% of hunting occurred on private land in the East South Central region.[3] However, visitation data for these areas is limited. To capture the value of hunting recreation, we use hunting permits sold in the area as a proxy for the amount of hunting that takes place on open space in the ten-county study region. As a result, the county-level values associated with hunting reflect the hunting values where residents live. In contrast, the recreational use values associated with state and federal parks reflect the values where the recreational activity takes place.

The 2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation report revealed that on average, hunters enjoyed 21 hunting days per year. Multiplying permits sold by the average hunting days per year suggests over 2.1 million hunting days originate within the ten-county region. WTP for hunting per person per day, according to (Loomis 2005) is $35.36. Multiplying the number of hunting days by $35.36, we obtain the economic value of hunting on open space for the study area (See Table 6 of the report).

[1] For these lakes, we choose the same recreational value under the same categories of recreational activities as Long Hunter State Park for their proximity.
[2] Data obtained from Tennessee Wildlife Resources Agency via personal communication.
[3] The East South Central region includes Alabama, Kentucky, Mississippi, and Tennessee.

Technical Appendix C

The Health-Related Value of Open Space

Introduction

The medical literature has established the importance of physical activity for reducing morbidity and mortality from chronic diseases (Pratt, et al. 2000). Routine physical activity can prevent or alleviate a variety of health problems. Physically active individuals enjoy a number of positive health outcomes, including lower incidence of cardiovascular diseases, diabetes, depression, certain cancers and obesity. On the other hand, physical **in**activity incurs high human costs in terms of health and quality of life. It shortens lifespans, decreases quality of life, and limits functional independence.

Open space including parks, greenways and trails provide people with opportunities to be physically active. Rosenberger, et al. (2005) concludes that physical inactivity and demands for healthcare are positively correlated. The more inactive one is, the more healthcare one needs. It is also shown that populations with more recreational opportunities are more physically active than those with limited recreational opportunities.

The benefits estimated in this section can be thought of in terms of cost savings resulting from being physically active. These savings ultimately accrue to all of society. For example, direct and indirect medical cost savings are paid through insurance companies that will be added to the premium for individuals and businesses who pay for health insurance. Meanwhile, while worker compensation costs and lost productivity costs are initially covered by businesses, these costs would eventually be passed on to consumers.

Methodology

Centers for Disease Control and Prevention (CDC) recommends that adults participate in at least 150 minutes of moderate-intensity aerobic physical activity per week.[4] According to the CDC State Indicator report, 39% of Tennessee residents meet this guideline and are considered physically active. Applying this percentage to the 1.76 million total population of the ten county area in middle Tennessee, we have an estimate of 444,000 residents that are physically active.[5] Estimation of health-related cost savings is based on these 444,000 physically active individuals (Table C.1).

[4] CDC State Indicator Report, 2014
[5] US Census Bureau

Table C.1. Total Active Population

County	Total Population	Working Age Population Percentage	Working Age Population	Proportion that Exercises	Total Active Population
Cheatham	39,105	0.642	25,105	0.39	9,791
Davidson	626,681	0.678	424,890	0.39	165,707
Dickson	49,666	0.617	30,644	0.39	11,951
Maury	80,956	0.628	50,840	0.39	19,828
Montgomery	172,331	0.64	110,292	0.39	43,014
Robertson	66,283	0.625	41,427	0.39	16,157
Rutherford	262,604	0.656	172,268	0.39	67,185
Sumner	160,645	0.621	99,761	0.39	38,907
Williamson	183,182	0.61	111,741	0.39	43,579
Wilson	113,993	0.627	71,474	0.39	27,875
Total	**1,755,446**		**1,138,442**		**443,994**

Sources: US Census Bureau, CDC State indicator report

The number of physically active individuals was multiplied by the avoided costs associated with physical inactivity. Three types of costs were included: healthcare (both direct and indirect), worker's compensation costs (both direct and indirect) and lost productivity (table C.2). Direct medical costs refer to the costs of actually treating the illnesses or medical conditions caused and/or exacerbated by physical inactivity, which include cardiovascular diseases, diabetes, depression and certain cancers as well as obesity. Indirect medical costs come from the impact on an individual's quality of life resulting from adverse health conditions due to physical inactivity. Individuals can be eligible to collect workers' compensation payments when injuries occur at the workplace. At the same time, an employer incurs administrative costs, or indirect workers' compensation costs when workers claim compensation payments. There are two ways lost productivity costs to business can occur resulting from employee's physical inactivity. The first one is through absenteeism, defined as "not being present or attending to duty or work". The second is through presenteeism, defined as "being at work when you should be at home, either because you are ill or because you are too tired to be effective" (Chenoworth and Bortz 2005). Costs are presented in terms of the annual average costs of being physical inactive per person. In other words, these benefits are the costs avoided by people utilizing open space to exercise at a level that incurs positive health benefits.

Table C.2. Cost Savings ($ per person per year)

Costs	Low	Mean	High	Source
Direct Medical Care Costs	380	587	793	Pratt, et al. (2000)
Indirect Medical Care Costs	1,140	1,761	2,379	Chenoweth and Sugerman (2005)
Direct Workers Compensation Costs	6	10	12	Chenoworth and Bortz (2005)
Indirect Workers Compensation Costs	24	40	48	Chenoweth and Sugerman (2005)
Lost Productivity	Varies by county			Chenoworth and Bortz (2005)

The costs of physical inactivity fall into these categories:

Direct Medical Cost: These refer to the costs of actually treating the illnesses or medical conditions caused and/or exacerbated by physical inactivity. Pratt, et al. (2000) finds direct medical costs range from $216 to $446 with a mean of $ 330 in 2000 dollars. Given the high medical-cost inflation rate in recent years, these costs were multiplied by the medical cost CPI to reflect costs in 2016. Medical costs CPI was obtained from the Bureau of Labor Statistics. Inflated direct medical cost per person per year in this section ranges from $380 to $793 with a mean of $587 in 2016 dollars (Table C.3).

Table C.3. Medical Cost CPI and Direct Medical Costs

Year	Annual Percentage Change	Multiplier	Medical Costs low	Medical Costs expected	Medical Costs high
2000			214	330	446
2001	4.60	1.05	224	345	467
2002	4.70	1.05	234	361	488
2003	4.00	1.04	244	376	508
2004	4.40	1.04	254	392	530
2005	4.20	1.04	265	409	553
2006	4.00	1.04	276	425	575
2007	4.40	1.04	288	444	600
2008	3.70	1.04	299	460	622
2009	3.20	1.03	308	475	642
2010	3.40	1.03	319	491	664
2011	3.00	1.03	328	506	684
2012	3.70	1.04	340	525	709
2013	2.50	1.03	349	538	727
2014	2.40	1.02	357	551	744
2015	2.60	1.03	366	565	764
2016	3.80	1.04	380	587	793

Sources: Pratt et al. (2000), Chenoweth (2005), BLS

Indirect Medical Costs: Indirect medical costs come from the impact on an individual's quality of life resulting from adverse health conditions due to physical inactivity. A dollar value is assigned to pain and suffering from medical conditions and shorter life expectancy associated with physical inactivity. The ratio of indirect medical costs to direct medical costs is 3:1 based on Chenoweth and Sugerman (2005). Indirect medical costs used for analysis ranges from $1,140 to $2,379 per person per year with a mean of $1,761.

Direct Workers' Compensation Costs: Individuals can be eligible to collect workers' compensation payments when injuries occur at the workplace. It has been shown that physically inactive individuals are more likely to incur workers' compensation injuries and have longer recovery periods. Chenoworth and Bortz (2005) estimate a range of worker compensation costs from $6 to $12 per person per year with a mean of $10.

Indirect Workers' Compensation Costs: When workers claim direct compensation, employers incur administrative costs, or indirect worker's compensation costs. Indirect worker's compensation costs have been estimated at about four times larger than direct worker's compensation costs. Consequently, per person per year indirect worker's compensation costs range from $24 to $48 with a mean of $40. This ratio is higher than direct/indirect medical costs ratio because extraneous circumstances will delay and/or impair an individual's return-to-work time frame as well as on-the-job performance (Chenoweth and Sugerman 2005).

Lost Productivity: Lost productivity is the largest contributor to the costs of physical inactivity. There are two ways lost productivity costs can occur resulting from employee's physical inactivity. The first one is through absenteeism, defined as "not being present or attending to duty or work". The second is through presenteeism, defined as "being at work when you should be at home, either because you are ill or because you are too tired to be effective". They are calculated based on the data and methods from (Chenoworth and Bortz 2005). The median salary paid to workers in the county, the number of workers and average hours lost due to absenteeism and presenteeism were used for calculation. Table C.4a and C.4b show how costs were calculated with the follow variables:

VARIABLE 1. Average hours lost per year: These reflect the average hours lost per worker per year due to physical inactivity. The min, max and mean number of lost hours from (Chenoworth and Bortz 2005) are used in this section.

VARIABLE 2. Scheduled work load: This reflects the annual workload of the average worker. It was calculated by multiplying 40 hours per week by 50 weeks.

VARIABLE 3. Lost hours as a percent of scheduled workload: This reflects the percentage of annual workload that is lost due to absenteeism or presenteeism. It was calculated by dividing variable 1 by variable 2.

VARIABLE 4. Median compensation: This reflects the median income of the country. It was obtained from the U.S. Census Bureau.

VARIABLE 5. Lost compensation per employed individual: This was calculated by multiplying variable 3 and variable 4.

VARIABLE 6. Number of workers: This was obtained from the U.S. Census Bureau.

VARIABLE 7. Total lost compensation: This was calculated by multiplying variable 5 by variable 6.

VARIABLE 8. Percent physical inactive: This was calculated by subtracting 39% (of physical active individuals) from 100%.

VARIABLE 9. Total lost productivity cost: This was calculated by multiplying variable 7 by variable 8.

VARIALBE 10. Per capita cost: This was calculated by dividing variable 9 by variable 6.

Table C.4a Step-by-step Calculation for Absenteeism Costs

COUNTY		Scheduled Annual Workload	Avg Hours Lost/Year	Lost Hours as % of Workload	Median Compensation	Lost Compensation per Worker	# of Workers	Total Lost Compensation	% of Workers Physically Inactive	Total Lost Productivity	Per Capita Lost Productivity Cost
Cheatham	Min	2000	3.5	0.00175	51857	90.74975	25301	2296059.425	0.61	1400596	55.36
	Mean	2000	18.08	0.00904	51857	468.78728	25301	11860786.97	0.61	7235080	285.96
	Max	2000	24.88	0.01244	51857	645.10108	25301	16321702.43	0.61	9956238	393.51
Davidson	Min	2000	3.5	0.00175	48368	84.644	435543	36866101.69	0.61	22488322	51.63
	Mean	2000	18.08	0.00904	48368	437.24672	435543	190439748.2	0.61	116168246	266.72
	Max	2000	24.88	0.01244	48368	601.69792	435543	262065317.2	0.61	159859843	367.04
Dickson	Min	2000	3.5	0.00175	44680	78.19	29353	2295111.07	0.61	1400018	47.70
	Mean	2000	18.08	0.00904	44680	403.9072	29353	11855888.04	0.61	7232092	246.38
	Max	2000	24.88	0.01244	44680	555.8192	29353	16314960.98	0.61	9952126	339.05
Maury	Min	2000	3.5	0.00175	47692	83.461	51650	4310760.65	0.61	2629564	50.91
	Mean	2000	18.08	0.00904	47692	431.13568	51650	22268157.87	0.61	13583576	262.99
	Max	2000	24.88	0.01244	47692	593.28848	51650	30643349.99	0.61	18692443	361.91
Montgomery	Min	2000	3.5	0.00175	50344	88.102	99435	8760422.37	0.61	5343858	53.74
	Mean	2000	18.08	0.00904	50344	455.10976	99435	45253838.99	0.61	27604842	277.62
	Max	2000	24.88	0.01244	50344	626.27936	99435	62274088.16	0.61	37987194	382.03
Robertson	Min	2000	3.5	0.00175	53151	93.01425	43614	4056723.5	0.61	2474601	56.74
	Mean	2000	18.08	0.00904	53151	480.48504	43614	20955874.53	0.61	12783083	293.10
	Max	2000	24.88	0.01244	53151	661.19844	43614	28837508.76	0.61	17590880	403.33
Rutherford	Min	2000	3.5	0.00175	56219	98.38325	183035	18007578.16	0.61	10984623	60.01
	Mean	2000	18.08	0.00904	56219	508.21976	183035	93022003.77	0.61	56743422	310.01
	Max	2000	24.88	0.01244	56219	699.36436	183035	128008155.6	0.61	78084975	426.61
Sumner	Min	2000	3.5	0.00175	57382	100.4185	105704	10614637.12	0.61	6474929	61.26
	Mean	2000	18.08	0.00904	57382	518.73328	105704	54832182.63	0.61	33447631	316.43
	Max	2000	24.88	0.01244	57382	713.83208	105704	75454906.18	0.61	46027493	435.44
Williamson	Min	2000	3.5	0.00175	96565	168.98875	125296	21173614.42	0.61	12915905	103.08
	Mean	2000	18.08	0.00904	96565	872.9476	125296	109376842.5	0.61	66719874	532.50
	Max	2000	24.88	0.01244	96565	1201.2686	125296	150514150.5	0.61	91813632	732.77
Wilson	Min	2000	3.5	0.00175	61070	106.8725	74893	8004002.143	0.61	4882441	65.19
	Mean	2000	18.08	0.00904	61070	552.0728	74893	41346388.21	0.61	25221297	336.76
	Max	2000	24.88	0.01244	61070	759.7108	74893	56897020.94	0.61	34707183	463.42

Table C.4b Step-by-step Calculation for Presenteeism Costs

COUNTY		Scheduled Annual Workload	Avg Hours Lost/Year	Lost Hours as % of Workload	Median Compensation	Lost Compensation per Worker	# of Workers	Total Lost Compensation	% of Workers Physically Inactive	Total Lost Productivity	Per Capita Lost Productivity Cost
Cheatham	Min	2000	131.5	0.06575	51857	3409.59775	25301	86266232.67	0.61	52622402	2079.8546
	Mean	2000	140.75	0.070375	51857	3649.436375	25301	92334389.72	0.61	56323978	2226.1562
	Max	2000	150	0.075	51857	3889.275	25301	98402546.78	0.61	60025554	2372.4578
Davidson	Min	2000	131.5	0.06575	48368	3180.196	435543	1385112106	0.61	844918385	1939.9196
	Mean	2000	140.75	0.070375	48368	3403.898	435543	1482543947	0.61	904351807	2076.3778
	Max	2000	150	0.075	48368	3627.6	435543	1579975787	0.61	963785230	2212.8360
Dickson	Min	2000	131.5	0.06575	44680	2937.71	29353	86230601.63	0.61	52600667	1792.0031
	Mean	2000	140.75	0.070375	44680	3144.355	29353	92296252.32	0.61	56300714	1918.0566
	Max	2000	150	0.075	44680	3351	29353	98361903	0.61	60000761	2044.1100
Maury	Min	2000	131.5	0.06575	47692	3135.749	51650	161961435.9	0.61	98796476	1912.8069
	Mean	2000	140.75	0.070375	47692	3356.3245	51650	173354160.4	0.61	105746038	2047.3579
	Max	2000	150	0.075	47692	3576.9	51650	184746885	0.61	112695600	2181.9090
Montgomery	Min	2000	131.5	0.06575	50344	3310.118	99435	329141583.3	0.61	200776366	2019.1720
	Mean	2000	140.75	0.070375	50344	3542.959	99435	352294128.2	0.61	214899418	2161.2050
	Max	2000	150	0.075	50344	3775.8	99435	375446673	0.61	229022471	2303.2380
Robertson	Min	2000	131.5	0.06575	53151	3494.67825	43614	152416897.2	0.61	92974307	2131.7537
	Mean	2000	140.75	0.070375	53151	3740.501625	43614	163138237.9	0.61	99514325	2281.7060
	Max	2000	150	0.075	53151	3986.325	43614	173859578.6	0.61	106054343	2431.6583
Rutherford	Min	2000	131.5	0.06575	56219	3696.39925	183035	676570436.7	0.61	412707966	2254.8035
	Mean	2000	140.75	0.070375	56219	3956.412125	183035	724161893.3	0.61	441738755	2413.4114
	Max	2000	150	0.075	56219	4216.425	183035	771753349.9	0.61	470769543	2572.0193
Sumner	Min	2000	131.5	0.06575	57382	3772.8665	105704	398807080.5	0.61	243272319	2301.4486
	Mean	2000	140.75	0.070375	57382	4038.25825	105704	426860050.1	0.61	260384631	2463.3375
	Max	2000	150	0.075	57382	4303.65	105704	454913019.6	0.61	277496942	2625.2265
Williamson	Min	2000	131.5	0.06575	96565	6349.14875	125296	795522941.8	0.61	485268994	3872.9807
	Mean	2000	140.75	0.070375	96565	6795.761875	125296	851481779.9	0.61	519403886	4145.4147
	Max	2000	150	0.075	96565	7242.375	125296	907440618	0.61	553538777	4417.8488
Wilson	Min	2000	131.5	0.06575	61070	4015.3525	74893	300721794.8	0.61	183440295	2449.3650
	Mean	2000	140.75	0.070375	61070	4297.80125	74893	321875229	0.61	196343890	2621.6588
	Max	2000	150	0.075	61070	4580.25	74893	343028663.3	0.61	209247485	2793.9525

To estimate the total cost savings, we not only need the number of residents who are physical active, we also need to apply the percentage of these residents' exercise that is actually performed on open space to avoid over-estimate. According to 2004 CDC State Indicator Report, having a park within a half mile is linked with higher levels of moderate-to-vigorous physical activity and Tennessee has 17.5% of its population that lives within a half mile of a park (Merriam, et al. 2017). For the state of Pennsylvania, 35% of population lives within a half mile of a park. According to a 2009 Pennsylvania outdoor recreation survey, on average, 41% of its residents' physical activities are performed in a park or on a trail (Graefe, et al. 2009). Given the established association between access to parks and physical activities, we use 20.5%, or half (17.5%/35%) of 41% as a proxy for the percentage of Tennessee residents' physical activities performed on open space. This percentage is utilized to calculate the total cost saving that are actually attributed to open space. Table C.5 shows the avoided costs of each category by multiplying the values of Table C.2 by the total number of physically active population and 20.5% to obtain cost savings attributed to preserved open space.

Table C.5 Health Related Costs Attribuable to Preserved Open Space ($M) per Year

COUNTY	Total Active Population	Direct Medical Care Costs			Indirect Medical Care Costs			Workers Compensation Costs			Indirect Workers Compensation Costs			Lost Productivity		
		Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Cheatham	9791	0.763	1.178	1.592	2.288	3.535	4.775	0.012	0.020	0.024	0.048	0.080	0.096	4.286	5.042	5.552
Davidson	165707	12.909	19.940	26.938	38.726	59.821	80.814	0.204	0.340	0.408	0.815	1.359	1.631	67.653	79.595	87.638
Dickson	11951	0.931	1.438	1.943	2.793	4.314	5.828	0.015	0.024	0.029	0.059	0.098	0.118	4.507	5.303	5.839
Maury	19828	1.545	2.386	3.223	4.634	7.158	9.670	0.024	0.041	0.049	0.098	0.163	0.195	7.982	9.391	10.340
Montgomery	43014	3.351	5.176	6.993	10.052	15.528	20.978	0.053	0.088	0.106	0.212	0.353	0.423	18.279	21.505	23.678
Robertson	16157	1.259	1.944	2.627	3.776	5.833	7.880	0.020	0.033	0.040	0.079	0.132	0.159	7.249	8.528	9.390
Rutherford	67185	5.234	8.085	10.922	15.701	24.254	32.766	0.083	0.138	0.165	0.331	0.551	0.661	31.882	37.510	41.300
Sumner	38907	3.031	4.682	6.325	9.093	14.046	18.975	0.048	0.080	0.096	0.191	0.319	0.383	18.845	22.171	24.412
Williamson	43579	3.395	5.244	7.084	10.184	15.732	21.253	0.054	0.089	0.107	0.214	0.357	0.429	35.521	41.791	46.014
Wilson	27875	2.171	3.354	4.531	6.514	10.063	13.594	0.034	0.057	0.069	0.137	0.229	0.274	14.369	16.906	18.614
TOTAL	443994	34.59	53.43	72.18	103.76	160.3	216.5	0.546	0.91	1.09	2.184	3.64	4.369	210.6	247.7	272.8

Sources: Chenoweth and Bortz, 2005; Graefe et al., 2009; CDC State Indicator Report

Benefits

There are approximately 444,000 physically active individuals within the ten-county region. Physical activity results in annual direct medical cost savings of $53.43 million, with a range of $34.59 million to $72.18 million and annual indirect medical cost savings of $160.3 million, with a range of $103.76 million to $216.5 million; annual direct worker compensation cost savings of $.91 million with a range of $.546 million to $1.09 million and annual indirect worker compensation cost savings of $3.64 million with a range of $2.18 million to $4.36 million; annual lost productivity savings of $247.7 million with a range of $210.6 million to $272.8 million (Table C.5).

Total avoided cost savings attributed to preserved open space amount to $466 million, with a range of $351 million to $566 million (Table C.6).

Table C.6. Min, Mean and Max Cost Savings ($M per year)

COUNTY	Total Active Population	MIN	Mean	MAX
Cheatham	9,791	7.397	9.855	12.039
Davidson	165,707	120.306	161.055	197.429
Dickson	11,951	8.305	11.178	13.757
Maury	19,828	14.282	19.138	23.477
Montgomery	43,014	31.946	42.650	52.178
Robertson	16,157	12.383	16.471	20.095
Rutherford	67,185	53.230	70.537	85.814
Sumner	38,907	31.207	41.298	50.190
Williamson	43,579	49.368	63.214	74.888
Wilson	27,875	23.226	30.609	37.083
TOTAL	443,994	351.651	466.005	566.949

Sources: Chenoweth and Bortz, 2005; Graefe et al., 2009; CDC State Indicator Report

Technical Appendix D

Ecosystem Service Values of Open Space

Introduction

Public and private decision makers must weigh the advantages and disadvantages of human actions that affect ecosystems. For example, when determining whether to develop a parcel of open space, public and private decision makers want and need information on the benefits of the developed parcel and the values that would be lost if the open space parcel were developed. Ecosystem services represent the benefits that human populations derive, directly or indirectly, from ecosystem functions. Ecosystem functions refer to the habitat, biological, or system properties or processes of ecosystems. Ecosystem services and ecosystem functions rarely exhibit a one-to-one relationship. In some cases, a single ecosystem service is the product of two or more ecosystem functions. In other cases, a single ecosystem function contributed to two or more ecosystem services (Costanza, et al. 1997).

Ecosystem services are not fully quantified in terms comparable to other economic services and manufactured capital. Because these values are not captured in markets, they are often given too little weight in policy decisions (Costanza, et al. 1997;Daily 1997;De Groot, et al. 2002).

The type and amount of ecosystem services provided by open space depend on the land cover on that open space. The open space in the ten-county study region is composed of a diverse mixture of land cover such as forests (both deciduous and coniferous), wetlands, pastures, cropland, and developed open space. Each county in our study area is unique in both the types of quantities of land cover. As a result, each county is unique in terms of the ecosystem services provided by the county's open space. The United Nation's Millennium Ecosystem Assessment (MEA) groups ecosystem services into the following categories (Costanza, et al. 2006):

- Provisioning services are the products obtained from ecosystems such as food, energy, water, biomedical, and transportation.
- Regulating services such as regulation of floods, drought, erosion control, climate regulation, and control of pests and pathogens.
- Supporting services such as soil formation, nutrient cycling, pollination, and biological diversity maintenance.
- Cultural services such as recreational, spiritual, religious, educational, and other nonmaterial benefits.

Policymakers and private landowners are often faced with the decision to preserve open space in its current state or convert it to developed uses such as homes, commercial buildings, and industrial facilities. The benefits of development are typically well-defined as many of the values associated with development are reflected in land and real estate markets. In contrast, many of the benefits of preservation (alternatively the opportunity cost of development) are typically omitted from land and real estate markets. Provisioning services are often partially captured in markets and thus are more likely to be considered in development decisions. However, regulating, supporting, and cultural services are poorly understood and rarely included in open space development decisions. The omission of these ecosystem services makes it impossible to know what is gained by preserving open space and what is lost when open space is developed. Estimating the economic values of ecosystem services not captured in land markets reveals real economic values that would otherwise be ignored in development decisions. The result of this omission is an inefficient use of the region's most valuable resource – land.

Methodology

Valuing ecosystem services is challenging due to their dependence on economic, physical, and natural processes. Social, natural, and physical science data must be collected and integrated to determine how dynamic human responses impact ecosystem function and how society values that goods and services that arise from these service. A wide range of scientific data and expertise is needed to directly estimate ecosystem service values.

Instead, this study uses benefit transfer to estimate the ecosystem services provided in the ten-county study region. Benefit transfer is the systematic adoption of existing scientific studies to inform policy decisions in different contexts. Benefit transfer is used as an alternative to the direct estimation approach described above when primary data collection is not possible due to time or budget constraints. Benefit transfer in this section of the report is conceptually identical to the benefit transfer approaches used in the recreation and health sections of this report. Benefit transfer has become a valuable tool in land management planning due to its ability to reliably estimate ecosystem service values for considerably less time and expense than a primary study (Costanza, et al. 2006).

The foundation of any benefit transfer study is the library of existing ecosystem service valuation studies. We utilize the Ecosystem Service Valuation Database (ESVD) compiled by a community of academic researchers (Van der Ploeg and De Groot 2010).[6] The ESVD contains over 1350 ecosystem service value estimates from over 300 case studies. To compile a database of ecosystem service values that would be applicable to the ten-county study region, we only use value estimates from case studies that have similar climate, land cover, and ecosystems to Middle Tennessee. For example, ecosystem services values from a case study in Utah may not be a good proxy for values in Tennessee due to differences in climate and land cover. After

[6] The ESVD is publically available and can be retrieved at https://www.es-partnership.org/services/data-knowledge-sharing/ecosystem-service-valuation-database/

eliminating case studies that differ from Middle Tennessee, we are left with 47 individual value estimates for the types of ecosystems present in north-central Tennessee.

Table D.1 reports the number of studies used as well as the minimum, mean, and maximum willingness to pay values for each ecosystem service. The 47 valuation estimates were grouped into five ecosystem service categories: water supply, water quality, flood mitigation, wildlife habitat, and pollination. Within each ecosystem service category, studies were grouped by the land cover type present in the case study. The studies included in the ESVD utilized a variety of non-market techniques. The list of techniques used for each ecosystem service is included in Table D.1 under "Valuation Method". The techniques are defined as follows:

- Avoided cost (AC): costs that society would incur in the absence of ecosystem services. Examples include the property damage downstream that would be avoided by flood control services provided by riparian buffers and the cost of building infrastructure to supply water that would not be supplied without forests.

- Contingent valuation (CV): Ecosystem values may be estimated by asking survey respondents to assign a value to hypothetical scenarios that involve different combinations of ecosystem services. Examples include survey respondents stated willingness to pay to preserve wildlife habitat created by forests and wetlands.

- Hedonic price method (HP): Ecosystem service values may be reflected in the prices people pay for associated goods.

- Replacement cost (RC): the estimated cost of replacing ecosystem services through anthropogenic approaches. For example, the waste assimilation service provided by wetlands could be replaced with chemical or mechanical alternatives such as wastewater treatment plants.

- Travel cost (TC): Enjoying ecosystem services may require traveling to the open space. In certain instances, this travel cost can reflect the implied value of the ecosystem service.

- Value transfer (VT): some studies in the ESVD use value transfer from other studies

Table D.1. Ecosystem service values used in benefit transfer analysis

Land cover type	# of studies	Min	Mean	Max	Valuation Method
			2004$/acre/year		
Water Supply	23	0	1,093	4,095	AC(2), CV(12), HP(1), RC(1), TC(5), VT(2)
Forests		9	163	385	
Freshwater wetlands		0	1,544	3,839	
Open freshwater		28	409	719	
Riparian buffer		0.15	1,921	4,095	
Waste Assimilation	3	44	309	838	VT(3)
Forest			44		
Freshwater wetland			838		
Pasture			44		
Flood Mitigation	5	6	1,371	5,957	AC(3), VT(2)
Freshwater wetlands		15	3,322	5,957	
Riparian buffers		6	88	201	
Urban greenspace			6		
Habitat	12	1	793	3,383	CV(11), VT(1)
Cropland		419	831	1,242	
Forests		1	923	3,383	
Freshwater wetlands		5	113	222	
Pollination	4	2	74	265	RC(1), DM(1), AC(1), VT(1)
Cropland		2	8	11	
Forests		59	162	265	
Pasture			13		

Source: Costanza et al. (2006), Baker Center calculations

In addition to the ecosystem services in Table D.1, the study also estimates the air pollution removal benefits of forested open space in the ten-county region. Trees have been found to remove significant amounts of regional pollutants such as nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), and particulate matter (PM_{10}). Trees also sequester and store carbon pollution. We use a range of pollution removal rates collected from academic literature to estimate the amount of pollution removed by an acre of forest. These pollution removal rates are presented in Table D.2. Multiplying the pollution removal rates by the area of forest provides an estimate of the amount of each pollutant removed by forested open space. The benefit of the pollution removed by forests were based on the median monetized dollar per ton externality values used in energy decision-making from various studies. Externality values can be considered the estimated costs of pollution to society that are not accounted for in the market price of the goods or services that produced the pollution (Nowak, et al. 2006). These dollars per metric ton of pollutants removed are presented in Table D.2. Due to a lack of previous research, the externality values for ozone were set equal to the value for nitrogen dioxide.

Table D.2. Pollution removal rates and externality values

Pollutant	Estimated pollution removal rates (pounds per acre of tree canopy)			Externality values
	Low	Average	High	$/ton
O_3	8.17	29.07	39.83	6752
PM_{10}	12.66	32.47	50.33	4508
NO_2	7.67	14.16	20.5	6752
SO_2	3.67	9.85	11.33	1653
CO	1.67	1.82	3.08	959
carbon sequestration	2433.95	2555.24	2676.53	43
carbon storage	80123.8	80656.05	81188.3	43

Source: Nowak et al. 2006, Nowak et al. 2007, Sims 2014

From Tables D.1 and D.2, ecosystem service values can vary depending on the amount and type of land cover. In order to estimate the amount of ecosystem services provided by open space, the amount of various land cover types on open space was estimated. Table D.3 shows the amount of each type of open space in each county. Satellite-derived land cover data from 2006 obtained from the Multi-Resolution Land Characteristics (MRLC) Consortium and ArcGIS were used to calculate the acres of the seven different land cover types located on open space. The MRLC is a consortium of nine federal agencies (USGS, EPA, USFS, NOAA, NASA, BLM, NPS, NRCS, and USFWS) that jointly fund the collection of satellite land cover data. While the MRLC contains more than seven land cover classes, the number of classes was condensed for the purposes of our study. The seven different land cover types include: forest, freshwater wetlands, open freshwater, riparian buffer, pasture, urban greenspace, cropland. The amount of riparian buffers were calculated by creating 25 foot buffers around all stream segments in the 10 county region that flow through undeveloped open space. Riparian ecosystem service values were used for all land cover types in the riparian buffer.

Once the area of each ecosystem service type was estimated, ecosystem service flows for the various land cover types were calculated by multiplying areas of each land cover type, in acres, by the minimum, mean, and maximum annualized dollar value per acre for that cover type as reported in the ESVD. Tables D.1 and D.2 included the specific values used. The total ecosystem service value of a given type off open space was determined by adding up the individual ecosystem service values associated with each land cover type found on the open space:

$$V(ESV_i) = \sum_{k=1}^{K} A(LC_i) \times V(ES_{ki})$$

where

$$A(LC_i) = Area\ of\ land\ cover\ i$$
$$V(ES_{ki}) = Annualized\ value\ of\ ecosystem\ service\ k\ for\ each\ land\ cover\ i$$

Table D.3. Land cover type on open space (acre) by county

	Forests	Freshwater wetlands	Open freshwater	Riparian buffer	Pasture	Urban greenspace	Cropland	Total open space
Cheatham	25,112	2,293	2,944	523	22,595	8,672	5,182	67,320
Davidson	76,441	1,013	14,080	1,065	25,700	69,585	3,468	191,353
Dickson	25,761	680	896	1,570	60,297	14,431	3,711	107,346
Maury	117,587	2,100	1,536	2,286	129,693	23,540	14,554	291,296
Montgomery	57,546	4,880	3,008	1,296	58,622	26,405	34,083	185,841
Robertson	70,412	401	128	1,100	105,780	21,273	61,494	260,587
Rutherford	122,925	1,647	3,008	1,566	115,707	37,686	17,878	300,416
Sumner	69,264	390	8,960	1,730	102,579	31,948	19,795	234,666
Williamson	91,450	416	768	1,740	101,845	31,360	7,268	234,846
Wilson	136,075	980	7,680	1,621	139,199	26,315	8,267	320,137
Total	**792572**	**14800**	**43008**	**14497**	**862017**	**291215**	**175699**	**2193807**

Benefits

Water supply

Rainwater provides many beneficial services which we classify as water supply services. However, these services are lost when rainwater flows immediately downstream in the form of runoff. Many land cover types (i.e. forests and wetlands) enhance water supply services by helping ensure that rainwater is stored and released gradually and enhancing groundwater recharge. Using the minimum, mean, and maximum values from (Costanza, et al. 2006) in Table D.1, we find that the water supply services provided by open space range from $15.3 million to 752 million with a likely value of 324.4 (Table D.4 and D.5). The average annual value per acre of water supply services range from $9 to $458 with a likely value of $197. The water supply benefits are driven primarily by the amount of forest and wetland cover types. Those open space parcels with greater amounts of wetland and forest will generate greater amounts of water supply services.

Table D.4. Water supply service benefits by county

		$M per year		
	Acres	Low	Average	High
Cheatham	147,488	1.4	28.9	67.6
Davidson	161,023	1.7	33.0	74.1
Dickson	209,552	1.9	38.1	89.1
Maury	189,877	1.7	38.2	89.3
Montgomery	186,810	1.7	40.2	94.6
Robertson	95,158	0.8	18.0	42.1
Rutherford	149,388	1.4	30.1	70.0
Sumner	164,622	1.6	32.6	74.1
Williamson	185,829	1.7	34.1	79.7
Wilson	153,667	1.5	31.1	71.1
Total	**1,643,415**	**15.3**	**324.4**	**752.0**

Source: Costanza et al. (2006), Baker Center calculations

Table D.5. Water supply service benefits by county

		$M per year				
	Acres	Forests	Freshwater wetlands	Open freshwater	Riparian buffers	**Total**
Cheatham	147,488	23.1	3.5	1.2	1.0	**28.9**
Davidson	161,023	23.6	1.6	5.8	2.0	**33.0**
Dickson	209,552	33.6	1.0	0.4	3.0	**38.1**
Maury	189,877	30.0	3.2	0.6	4.4	**38.2**
Montgomery	186,810	29.0	7.5	1.2	2.5	**40.2**
Robertson	95,158	15.2	0.6	0.1	2.1	**18.0**
Rutherford	149,388	23.3	2.5	1.2	3.0	**30.1**
Sumner	164,622	25.0	0.6	3.7	3.3	**32.6**
Williamson	185,829	29.8	0.6	0.3	3.3	**34.1**
Wilson	153,667	23.4	1.5	3.1	3.1	**31.1**
Total	**1,643,415**	**256.1**	**22.9**	**17.6**	**27.8**	**324.4**

Source: Costanza et al. (2006), Baker Center calculations

Waste assimilation

Water supply is not the only hydrologic service provided by open space in the study area. Open space also provides waste assimilation services. Forest, wetlands, open freshwater, and riparian buffers provide a natural protective buffer between human activity and water supplies. This protective buffer helps filer out pathogens, excess nutrients, metals and sediments. Using the minimum, mean, and maximum values from (Costanza, et al. 2006) in Table D.1, we found that the waste assimilation services provided by open space range from $107 million to $2 billion with a likely value of $120 million (Tables D.6 and D.7). The average annual value per acre of waste assimilation services range from $44 to $838 with a likely value of $49. The waste assimilation benefits are driven primarily by the amount of forest, wetland, and pasture cover types. Those open space parcels with greater amounts of these cover types will generate greater amounts of waste assimilation services.

Table D.6. Waste assimilation service values

		$M per year		
	Acres	Low	Average	High
Cheatham	166,616	7.3	9.2	139.6
Davidson	171,578	7.5	8.4	143.8
Dickson	267,383	11.8	12.3	224.1
Maury	315,748	13.9	15.6	264.6
Montgomery	241,128	10.6	14.5	202.1
Robertson	199,711	8.8	9.1	167.4
Rutherford	260,521	11.5	12.8	218.3
Sumner	256,511	11.3	11.6	215.0
Williamson	285,166	12.5	12.9	239.0
Wilson	283,565	12.5	13.3	237.6
Total	**2,447,927**	**107.7**	**119.5**	**2051.4**

Source: Costanza et al. (2006), Baker Center calculations

Table D.7. Waste assimilation service benefits by county

		$M per year			
	Acres	Forests	Freshwater wetlands	Pasture	**Total**
Cheatham	166,616	6.2	1.9	1.0	**9.2**
Davidson	171,578	6.4	0.8	1.1	**8.4**
Dickson	267,383	9.1	0.6	2.7	**12.3**
Maury	315,748	8.1	1.8	5.7	**15.6**
Montgomery	241,128	7.8	4.1	2.6	**14.5**
Robertson	199,711	4.1	0.3	4.7	**9.1**
Rutherford	260,521	6.3	1.4	5.1	**12.8**
Sumner	256,511	6.8	0.3	4.5	**11.6**
Williamson	285,166	8.0	0.3	4.5	**12.9**
Wilson	283,565	6.3	0.8	6.1	**13.3**
Total	**2,447,927**	**69.1**	**12.4**	**37.9**	**119.5**

Source: Costanza et al. (2006), Baker Center calculations

Flood mitigation

The study area is known for heavy rains and flash floods. Freshwater wetlands, riparian buffers, and urban greenspace help mitigate the effects of flood by trapping and containing storm water. Using the minimum, mean, and maximum values from (Costanza, et al. 2006) in Table D.1, we found that the flood mitigation services provided by open space range from $2.1 million to $1.8 billion with a likely value of $450 million (Tables D.8 and D.9). The average annual value per acre of flood mitigation services range from $6 to $5,697 with a likely value of $1,403. The flood mitigation benefits are driven primarily by the amount of wetland, riparian buffer, and pasture cover types. Those open space parcels with greater amounts of these cover types will generate greater amounts of flood mitigation services.

Table D.8. Flood mitigation service values

		$M per year		
	Acres	Low	Average	High
Cheatham	11,488	0.1	19.5	65.4
Davidson	71,664	0.4	98.8	420.8
Dickson	16,680	0.1	22.2	90.3
Maury	27,926	0.2	39.4	153.2
Montgomery	32,582	0.2	52.5	186.6
Robertson	22,774	0.1	30.6	129.3
Rutherford	40,899	0.3	57.3	234.6
Sumner	34,068	0.2	45.2	193.0
Williamson	33,515	0.2	44.5	189.6
Wilson	28,916	0.2	39.5	162.9
Total	**320,512**	**2.1**	**449.6**	**1825.8**

Source: Costanza et al. (2006), Baker Center calculations

Table D.9. Flood mitigation service benefits by county

		$M per year			
	Acres	Freshwater wetlands	Riparian buffer	Urban greenspace	**Total**
Cheatham	11,488	7.6	0.0	11.9	**19.5**
Davidson	71,664	3.4	0.1	95.4	**98.8**
Dickson	16,680	2.3	0.1	19.8	**22.2**
Maury	27,926	7.0	0.2	32.3	**39.4**
Montgomery	32,582	16.2	0.1	36.2	**52.5**
Robertson	22,774	1.3	0.1	29.2	**30.6**
Rutherford	40,899	5.5	0.1	51.7	**57.3**
Sumner	34,068	1.3	0.2	43.8	**45.2**
Williamson	33,515	1.4	0.2	43.0	**44.5**
Wilson	28,916	3.3	0.1	36.1	**39.5**
Total	**320,512**	**49.2**	**1.3**	**399.2**	**449.6**

Source: Costanza et al. (2006), Baker Center calculations

Wildlife habitat

Certain land cover types support naturally functioning ecosystems that serve as habitat for animal life. Intact forests, wetlands, and agricultural land function as critical population sources for species that humans value for consumptive (e.g., hunting) and nonsumptive (e.g., birdwatching) values. Using the minimum, mean, and maximum values from (Costanza, et al. 2006) in Table D.1, we found that the wildlife habitat services provided by open space range from $75.3 million to $5.5 billion with a likely value of $1.6 billion (Tables D.10 and D.11). The average annual value per acre of wildlife habitat services range from $43 to $3,143 with a likely value of $907. The wildlife habitat benefits are driven primarily by the amount of forests, wetland, and cropland cover types. Those open space parcels with greater amounts of these cover types will generate greater amounts of wildlife habitat services.

Table D.10. Wildlife habitat service values

		$M per year		
	Acres	Low	Average	High
Cheatham	149,202	2.3	135.4	486.4
Davidson	149,346	1.6	136.7	494.6
Dickson	210,797	1.8	193.7	703.0
Maury	200,609	6.3	182.1	640.9
Montgomery	216,589	14.5	192.8	644.3
Robertson	155,424	25.9	137.5	392.9
Rutherford	162,692	7.6	147.2	506.9
Sumner	173,728	8.4	158.2	544.1
Williamson	190,589	3.2	174.9	627.9
Wilson	152,633	3.6	139.3	495.6
Total	**1,761,609**	**75.3**	**1597.8**	**5536.6**

Source: Costanza et al. (2006), Baker Center calculations

Table D.11. Wildlife habitat service benefits by county

		$M per year			
	Acres	Cropland	Forest	Wetlands	**Total**
Cheatham	149,202	4.3	130.8	0.3	**135.4**
Davidson	149,346	2.9	133.7	0.1	**136.7**
Dickson	210,797	3.1	190.5	0.1	**193.7**
Maury	200,609	12.1	169.8	0.2	**182.1**
Montgomery	216,589	28.3	163.9	0.6	**192.8**
Robertson	155,424	51.1	86.3	0.0	**137.5**
Rutherford	162,692	14.9	132.1	0.2	**147.2**
Sumner	173,728	16.4	141.7	0.0	**158.2**
Williamson	190,589	6.0	168.8	0.0	**174.9**
Wilson	152,633	6.9	132.3	0.1	**139.3**
Total	**1,761,609**	**146.0**	**1450.1**	**1.7**	**1597.8**

Source: Costanza et al. (2006), Baker Center calculations

Pollination

Certain land cover types support habitat for plant and insect life that aids in the process of pollination. For example, farmers will use flatbed trucks to move bee hives into agricultural fields during critical periods of the year. Using the minimum, mean, and maximum values from Costanza, et al. (2006) in Table D.1, we found that the pollination services provided by open space range from $94.8 million to $5.5 billion with a likely value of $646.7 million (Tables D.12 and D.13). The average annual value per acre of pollination services range from $36 to $248 with a likely value of $907. The pollination benefits are driven primarily by the amount of forests, pasture, and cropland cover types. Those open space parcels with greater amounts of these cover types will generate greater amounts of wildlife habitat services.

Table D.12. Pollination service values

		$M per year		
	Acres	Low	Average	High
Cheatham	169,504	8.4	24.7	43.6
Davidson	174,032	8.6	25.4	45.2
Dickson	270,414	12.3	37.9	70.7
Maury	328,202	11.1	39.6	83.3
Montgomery	270,330	10.7	33.4	63.0
Robertson	260,803	5.9	23.5	53.5
Rutherford	276,752	8.7	31.9	68.8
Sumner	275,916	9.3	32.7	68.1
Williamson	292,019	11.0	37.3	75.5
Wilson	290,852	8.8	33.6	75.0
Total	**2,608,826**	**94.8**	**320.0**	**646.7**

Source: Costanza et al. (2006), Baker Center calculations

Table D.13. Pollination service benefits by county

		$M per year			
	Acres	Cropland	Forest	Pastures	**Total**
Cheatham	169,504	0.0	23.0	1.7	**24.7**
Davidson	174,032	0.0	23.5	1.9	**25.4**
Dickson	270,414	0.0	33.4	4.5	**37.9**
Maury	328,202	0.1	29.8	9.6	**39.6**
Montgomery	270,330	0.3	28.8	4.4	**33.4**
Robertson	260,803	0.5	15.2	7.9	**23.5**
Rutherford	276,752	0.1	23.2	8.6	**31.9**
Sumner	275,916	0.2	24.9	7.6	**32.7**
Williamson	292,019	0.1	29.6	7.6	**37.3**
Wilson	290,852	0.1	23.2	10.3	**33.6**
Total	**2,608,826**	**1.4**	**254.5**	**64.0**	**320.0**

Source: Costanza et al. (2006), Baker Center calculations

Regional pollution removal

Forested open space has been shown to remove significant amounts of regional pollutants such as nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), and particulate matter (PM_{10}). Using the low, average, and high pollution removal rate from (Nowak, et al. 2006) in Table D.2, we find the pollution removed from the air by forested open space ranges from 25,116 to 89,130 tons with a likely value of 62,264 tons (Tables D.14 – D.16). The pollution removal values are found by multiplying the pollution removal amounts in Tables D.14 through D.16 by the externality value for each pollutant in Table D.2. Using the low, average, and high pollution removal amounts in Table D.14 through D.16, we find that the value of the pollution removal services provided by forested open space ranges from $122.35 million to $467.44 million each year with a likely value of $325.17 million (Tables D.17 – D.19). The average annual value per acre of pollution removal services range from $78 to $298 with a likely value of $207. Those open space parcels with greater amounts of forest will generate greater amounts of pollution removal services.

Table D.14. Estimated pollution removal amounts (tons) based on low removal rate

	Forested acres	O_3	PM_{10}	NO_2	SO_2	CO	**Total**
Cheatham	141,728.0	525.2	813.9	493.1	235.9	107.4	**2,175.5**
Davidson	144,864.0	536.8	831.9	504.0	241.2	109.7	**2,223.6**
Dickson	206,406.4	764.9	1,185.3	718.1	343.6	156.4	**3,168.2**
Maury	183,955.2	681.7	1,056.4	640.0	306.2	139.3	**2,823.6**
Montgomery	177,625.6	658.3	1,020.0	618.0	295.7	134.6	**2,726.5**
Robertson	93,529.6	346.6	537.1	325.4	155.7	70.8	**1,435.6**
Rutherford	143,168.0	530.6	822.1	498.1	238.3	108.4	**2,197.6**
Sumner	153,542.4	569.0	881.7	534.2	255.6	116.3	**2,356.8**
Williamson	182,905.6	677.8	1,050.3	636.3	304.5	138.6	**2,807.5**
Wilson	143,385.6	531.4	823.4	498.8	238.7	108.6	**2,200.9**
Total	**1,571,110.4**	**5,822.3**	**9,022.1**	**5,466.0**	**2,615.4**	**1,190.1**	**24,115.8**

Source: Nowack et al. (2006), Nowack et al. (2007), U.S. Forest Service (2010), Baker Center calculations

TableD.15. Estimated pollution removal amounts (tons) based on average removal rate

	Forested acres	O_3	PM_{10}	NO_2	SO_2	CO	**Total**
Cheatham	141,728.0	1,868.8	2,087.4	910.3	633.2	117.0	**5,616.7**
Davidson	144,864.0	1,910.2	2,133.6	930.4	647.2	119.6	**5,741.0**
Dickson	206,406.4	2,721.7	3,040.0	1,325.7	922.2	170.4	**8,180.0**
Maury	183,955.2	2,425.6	2,709.3	1,181.5	821.9	151.9	**7,290.2**
Montgomery	177,625.6	2,342.2	2,616.1	1,140.9	793.6	146.6	**7,039.4**
Robertson	93,529.6	1,233.3	1,377.5	600.7	417.9	77.2	**3,706.6**
Rutherford	143,168.0	1,887.8	2,108.6	919.5	639.7	118.2	**5,673.8**
Sumner	153,542.4	2,024.6	2,261.4	986.2	686.0	126.8	**6,084.9**
Williamson	182,905.6	2,411.8	2,693.9	1,174.8	817.2	151.0	**7,248.6**
Wilson	143,385.6	1,890.7	2,111.8	920.9	640.6	118.4	**5,682.4**
Total	**1,571,110.4**	**20,716.5**	**23,139.5**	**10,091.0**	**7,019.5**	**1,297.0**	**62,263.6**

Source: Nowack et al. (2006), Nowack et al. (2007), U.S. Forest Service (2010), Baker Center calculations

Table D.16. Estimated pollution removal amounts (tons) based on high removal rate

	Forested acres	O_3	PM_{10}	NO_2	SO_2	CO	**Total**
Cheatham	141,728.0	2,560.5	3,235.5	1,317.9	728.4	198.0	**8,040.3**
Davidson	144,864.0	2,617.2	3,307.1	1,347.0	744.5	202.4	**8,218.2**
Dickson	206,406.4	3,729.1	4,712.1	1,919.3	1,060.8	288.4	**11,709.6**
Maury	183,955.2	3,323.4	4,199.6	1,710.5	945.4	257.0	**10,435.9**
Montgomery	177,625.6	3,209.1	4,055.1	1,651.7	912.9	248.2	**10,076.8**
Robertson	93,529.6	1,689.8	2,135.2	869.7	480.7	130.7	**5,306.0**
Rutherford	143,168.0	2,586.6	3,268.4	1,331.3	735.8	200.0	**8,122.0**
Sumner	153,542.4	2,774.0	3,505.3	1,427.7	789.1	214.5	**8,710.6**
Williamson	182,905.6	3,304.5	4,175.6	1,700.8	940.0	255.5	**10,376.4**
Wilson	143,385.6	2,590.5	3,273.4	1,333.3	736.9	200.3	**8,134.4**
Total	**1,571,110.4**	**28,384.6**	**35,867.3**	**14,609.2**	**8,074.2**	**2,194.9**	**89,130.3**

Source: Nowack et al. (2006), Nowack et al. (2007), U.S. Forest Service (2010), Baker Center calculations

Table D.17. Estimated pollution removal benefits ($M per year) based on low removal rate

	O_3	PM_{10}	NO_2	SO_2	CO	**Total**
Cheatham	3.55	3.67	3.33	0.39	0.10	**11.04**
Davidson	3.62	3.75	3.40	0.40	0.11	**11.28**
Dickson	5.16	5.34	4.85	0.57	0.15	**16.07**
Maury	4.60	4.76	4.32	0.51	0.13	**14.33**
Montgomery	4.44	4.60	4.17	0.49	0.13	**13.83**
Robertson	2.34	2.42	2.20	0.26	0.07	**7.28**
Rutherford	3.58	3.71	3.36	0.39	0.10	**11.15**
Sumner	3.84	3.97	3.61	0.42	0.11	**11.96**
Williamson	4.58	4.73	4.30	0.50	0.13	**14.24**
Wilson	3.59	3.71	3.37	0.39	0.10	**11.17**
Total	**39.31**	**40.67**	**36.91**	**4.32**	**1.14**	**122.35**

Source: Nowack et al. (2006), Nowack et al. (2007), U.S. Forest Service (2010), Baker Center calculations

Table D.18. Estimated pollution removal benefits ($M per year) based on average removal rate

	O_3	PM_{10}	NO_2	SO_2	CO	**Total**
Cheatham	12.62	9.41	6.15	1.05	0.11	**29.33**
Davidson	12.90	9.62	6.28	1.07	0.11	**29.98**
Dickson	18.38	13.70	8.95	1.52	0.16	**42.72**
Maury	16.38	12.21	7.98	1.36	0.15	**38.07**
Montgomery	15.81	11.79	7.70	1.31	0.14	**36.76**
Robertson	8.33	6.21	4.06	0.69	0.07	**19.36**
Rutherford	12.75	9.51	6.21	1.06	0.11	**29.63**
Sumner	13.67	10.19	6.66	1.13	0.12	**31.78**
Williamson	16.28	12.14	7.93	1.35	0.14	**37.86**
Wilson	12.77	9.52	6.22	1.06	0.11	**29.68**
Total	**139.88**	**104.31**	**68.13**	**11.60**	**1.24**	**325.17**

Source: Nowack et al. (2006), Nowack et al. (2007), U.S. Forest Service (2010), Baker Center calculations

Table D.19. Estimated pollution removal benefits ($M per year) based on high removal rate

	O_3	PM_{10}	NO_2	SO_2	CO	**Total**
Cheatham	17.29	14.59	8.90	1.20	0.19	**42.17**
Davidson	17.67	14.91	9.10	1.23	0.19	**43.10**
Dickson	25.18	21.24	12.96	1.75	0.28	**61.41**
Maury	22.44	18.93	11.55	1.56	0.25	**54.73**
Montgomery	21.67	18.28	11.15	1.51	0.24	**52.85**
Robertson	11.41	9.63	5.87	0.79	0.13	**27.83**
Rutherford	17.46	14.73	8.99	1.22	0.19	**42.60**
Sumner	18.73	15.80	9.64	1.30	0.21	**45.68**
Williamson	22.31	18.82	11.48	1.55	0.25	**54.42**
Wilson	17.49	14.76	9.00	1.22	0.19	**42.66**
Total	**191.65**	**161.69**	**98.64**	**13.35**	**2.10**	**467.44**

Source: Nowack et al. (2006), Nowack et al. (2007), U.S. Forest Service (2010), Baker Center calculations

Carbon sequestration and storage

Forested open space helps mitigate climate change by sequestering atmospheric carbon (from carbon dioxide) in new biomass. Carbon sequestration is a measure of how much new carbon dioxide is taken up by the forest each year through new growth. As trees grow, they also store more carbon by holding it in their accumulated tissue. As trees die and decay, they release this stored carbon back to the atmosphere. Carbon storage is an estimate of the total amount of carbon that is currently stored in the above and below ground biomass of the forest. Using the low, average, and high carbon sequestration rates from (Nowak, et al. 2007) and (U.S. Forest Service 2010) in Table D.2, we find the carbon sequestered by forested open space ranges from 1.7 to 1.9 million tons with a likely value of 1.8 million tons (Tables D.20 – D.22). Likewise, the carbon stored by forested open space ranges from 57.0 to 57.9 million tons with a likely value of 57.5 million tons (Tables D.20 – D.22). The carbon sequestration and storage values are found by multiplying the amount of carbon sequestered and stored in Tables D.20 through D.22 by the externality value for carbon (i.e., the social cost of carbon) in Table D.2. Using the low, average, and high sequestration amounts in Table D.20 through D.22, we find that the value of the carbon sequestration services provided by forested open space ranges from $74.59 million to $82.02 million each year with a likely value of $78.30 million (Tables D.23 – D.25). The average annual value per acre of carbon sequestration services range from $47 to $52 with a likely value of $50. Using the low, average, and high storage amounts in Table D.20 through D.22, we find that the value of the carbon storage services provided by forested open space ranges from $2.46 billion to $2.49 billion with a likely value of $2.47 billion (Tables D.23 – D.25). The average value per acre of carbon storage services range from $1,563 to $1,584 with a likely value of $1,573. Those open space parcels with greater amounts of forest will generate greater amounts of carbon sequestration and storage services.

Table D.20. Estimated carbon stored and sequestered based on low removal rate

	Forested acres	Carbon sequestered (tons)	Carbon stored (tons)
Cheatham	141728	156,471	5,150,894
Davidson	144864	159,933	5,264,867
Dickson	206406.4	227,877	7,501,534
Maury	183955.2	203,090	6,685,579
Montgomery	177625.6	196,102	6,455,539
Robertson	93529.6	103,259	3,399,194
Rutherford	143168	158,060	5,203,228
Sumner	153542.4	169,514	5,580,270
Williamson	182905.6	201,931	6,647,432
Wilson	143385.6	158,301	5,211,137
Total	**1571110.4**	**1,734,538**	**57,099,674**

Source: Nowack et al. (2006), Nowack et al. (2007), U.S. Forest Service (2010), Baker Center calculations

Table D.21. Estimated carbon stored and sequestered based on average removal rate

	Forested acres	Carbon sequestered (tons)	Carbon stored (tons)
Cheatham	141728	164,268	5,185,110
Davidson	144864	167,903	5,299,841
Dickson	206406.4	239,233	7,551,366
Maury	183955.2	213,211	6,729,990
Montgomery	177625.6	205,875	6,498,422
Robertson	93529.6	108,404	3,421,775
Rutherford	143168	165,937	5,237,793
Sumner	153542.4	177,961	5,617,339
Williamson	182905.6	211,994	6,691,590
Wilson	143385.6	166,189	5,245,753
Total	**1571110.4**	**1,820,974**	**57,478,978**

Source: Nowack et al. (2006), Nowack et al. (2007), U.S. Forest Service (2010), Baker Center calculations

Table D.22. Estimated carbon stored and sequestered based on high removal rate

	Forested acres	Carbon sequestered (tons)	Carbon stored (tons)
Cheatham	141728	172,065	5,219,327
Davidson	144864	175,873	5,334,814
Dickson	206406.4	250,588	7,601,197
Maury	183955.2	223,331	6,774,401
Montgomery	177625.6	215,647	6,541,305
Robertson	93529.6	113,550	3,444,355
Rutherford	143168	173,813	5,272,357
Sumner	153542.4	186,409	5,654,408
Williamson	182905.6	222,057	6,735,748
Wilson	143385.6	174,078	5,280,370
Total	**1571110.4**	**1,907,411**	**57,858,282**

Source: Nowack et al. (2006), Nowack et al. (2007), U.S. Forest Service (2010), Baker Center calculations

Table D.23. Estimated carbon storage and sequestration benefits ($M per year) based on low removal rate

	carbon sequestration ($M per year)	carbon storage ($M)
Cheatham	6.73	221.49
Davidson	6.88	226.39
Dickson	9.80	322.57
Maury	8.73	287.48
Montgomery	8.43	277.59
Robertson	4.44	146.17
Rutherford	6.80	223.74
Sumner	7.29	239.95
Williamson	8.68	285.84
Wilson	6.81	224.08
Total	**74.59**	**2455.29**

Source: Nowack et al. (2006), Nowack et al. (2007), U.S. Forest Service (2010), Baker Center calculations

Table D.24. Estimated carbon storage and sequestration benefits ($M per year) based on average removal rate

	carbon sequestration ($M per year)	carbon storage ($M)
Cheatham	7.06	222.96
Davidson	7.22	227.89
Dickson	10.29	324.71
Maury	9.17	289.39
Montgomery	8.85	279.43
Robertson	4.66	147.14
Rutherford	7.14	225.23
Sumner	7.65	241.55
Williamson	9.12	287.74
Wilson	7.15	225.57
Total	**78.30**	**2471.60**

Source: Nowack et al. (2006), Nowack et al. (2007), U.S. Forest Service (2010), Baker Center calculations

Table D.25. Estimated carbon storage and sequestration benefits ($M per year) based on high removal rate

	carbon sequestration ($M per year)	carbon storage ($M)
Cheatham	7.40	224.43
Davidson	7.56	229.40
Dickson	10.78	326.85
Maury	9.60	291.30
Montgomery	9.27	281.28
Robertson	4.88	148.11
Rutherford	7.47	226.71
Sumner	8.02	243.14
Williamson	9.55	289.64
Wilson	7.49	227.06
Total	**82.02**	**2487.91**

Source: Nowack et al. (2006), Nowack et al. (2007), U.S. Forest Service (2010), Baker Center calculations

Total Ecosystem Service Benefits

Using the minimum, mean, and maximum values from (Costanza, et al. 2006) in Table D.1, the approximately 3 million acres of open space in the ten-county study region generate between $492 million and $11.4 billion in annual ecosystem service values with a most likely value of $3.2 billion per year (Table D.26).

Table D.26. Total ecosystem service value ($M per year) by county

	Acres	Low	Average	High
Cheatham	183,936	37.3	254.0	852.3
Davidson	259,776	38.1	339.5	1229.2
Dickson	287,991	53.7	357.2	1249.5
Maury	357,664	56.3	362.2	1295.6
Montgomery	305,920	59.9	379.1	1252.7
Robertson	283,705	53.2	242.7	817.9
Rutherford	320,659	47.4	316.0	1148.7
Sumner	318,944	50.1	319.7	1148.0
Williamson	326,302	51.6	350.6	1275.7
Wilson	327,448	44.5	293.6	1092.4
Total	**2,972,346**	**492**	**3,215**	**11,362**

Source: Costanza et al. (2006), Nowack et al. (2006), Nowack et al. (2007), U.S. Forest Service (2010), Baker Center calculations

The goods and services provided by open space do not represent a one-time benefit to society. Instead, ecosystem services can be thought of as a stream of annual natural income. In keeping with this analogy, the ecosystems that provide the services that make up the stream of income can be thought of as the total natural capital of the open space. In financial terms, the valuation methods used in the report and presented in Table D.26 estimate the value of preserved open space by quantifying the value of the annual flow of "natural capital gains" that the asset (open space) provides. The full value of the "natural capital," the stream of future "natural capital gains" must be converted into a present value through discounting. To calculate the full value of the natural capital we assume a constant flow of services indefinitely and a constant discount rate. These assumptions allow us to calculate the present value of the natural capital gains as the annual flow in Table D.26 divided by the discount rate. There is a great deal of debate over the appropriate discount rate to use for valuing ecosystem service flows. A high discount rate implicitly places a smaller weight on future ecosystem services relative to a low discount rate. The present value of the flow of ecosystem service benefits is shown in Table D.27 with four different discount rates. Depending on the values in Tables D.1 and D.2 and the discount rate chosen, the present value of the stream of total ecosystem service benefits (the value of natural capital) ranges from $6.1 billion using the low values and an 8 percent discount rate to $1.1 trillion using the high values and a 1 percent discount rate.

Table D.27. Present value of the annual flow of ecosystem service values ($M)

		Low	Average	High
Flow value		492	3,215	11,362
Discount rate	1%	49,208	321,467	1,136,192
	3%	16,403	107,156	378,731
	5%	9,842	64,293	227,238
	8%	6,151	40,183	142,024

Technical Appendix E

Economic Impact of Open Space

Benefits

Agriculture and Forestry Industries

The RIMS II multipliers for output, earnings, and employment used in conjunction with IMPLAN estimates of direct output for a set of primary, secondary, and input industry codes associated with agriculture and forestry reveal the total economic impact benefits for the counties and the region.[7] IMPLAN industry codes are directly related to the North American Industry Classification (NAICS) codes, which is the standard used by federal statistical agencies in classifying business establishments.

For the agriculture industry, primary NAICS codes include 111 – agricultural crop products, 112 – agricultural livestock products, etc. Secondary NAICS codes for the agriculture industry include 311 – food manufacturing, 312 – beverage and tobacco product manufacturing, etc. Input NAICS codes related to the agriculture industry are 325 – chemical manufacturing (like fertilizer manufacturing) and 327 – nonmetallic mineral product manufacturing (like lime manufacturing).

Primary NAICS codes for the forestry industry are 321 – wood products, 322 paper manufacturing, etc. Secondary NAICS codes associated with the forestry industry include manufacturing like 337 – furniture and related product manufacturing. NAICS codes related to the forestry industry inputs are 113 – forestry and logging.

The industries listed above have different RIMS II multipliers for each county and region and for farms and for forestry, fishing, and related activities.[8] The multipliers for farms and for forestry, fishing, and related activities for each county and 10-county region are averaged to find the total effect of the agriculture and forestry industries on output, earnings, employment, and sales tax revenue. Direct, indirect, multiplier, and total effects of the combined agriculture and forestry industries for each county and 10-county region are found by aggregating primary, secondary, and input industry codes.[9] Total impacts of the agriculture and forestry industries on output are derived directly from IMPLAN estimates of output and RIMS II multipliers.

[7] Each country has its own set of RIMS II multipliers for output, employment, and earnings. In addition, the 10-country region also has a unique set of RIMS II multipliers covering the same metrics for a total of 11 different sets of multipliers.

[8] The forestry, fishing, and related activities industry accounts for commercial fishing. It does not include output activity for sport fishing.

[9] A complete list of the IMPLAN industry codes and their corresponding NAICS codes used in this study can be found in Appendix B of the Agri-Industry Modeling & Analysis Group (AIM-AG) at the University of Tennessee's Institute for Agriculture report "Economic Contributions of Agriculture and Forestry in Tennessee, 2013." Documentation is available at http://aimag.ag.utk.edu/pubimpact.html. Accessed September 2017.

Tourism Industry

The total impacts of county-level tourism are estimated as follows. If we assume that each county's share of total statewide direct traveler spending is the same as each county's share of statewide indirect and multiplier effects, we can estimate the statewide impacts associated with direct traveler spending in a county. The process to determine the indirect and multiplier effects associated with a county's tourism is as follows: (1) determine the percent of statewide total direct traveler spending that is spent in a given county; (2) multiply this percentage by total traveler output (earnings and employment) in the state to determine total output (earnings and employment) in a county that corresponds to tourism. For example, Cheatham County's direct traveler-expenditures of $21.6 million in 2015 were just over 0.1 percent of total statewide direct spending, so just over 0.1 percent of statewide indirect and multiplier impacts are attributed to Cheatham County or about $36.5 million of the total output benefits for the state.

Technical Appendix F

The Property Value Impacts of Open Space

Introduction

A home's value is influenced by structural characteristics (e.g., number of bedrooms, presence of a garage), neighborhood characteristics (e.g., presence of neighborhood amenities, average income levels), and open space characteristics (e.g., proximity to open space, size of open space, type of open space). The impact of open space on property values represents one of the few instances in which open space has a direct impact on market outcomes. As a result of its direct impact on real estate markets, the relationship between open space and property values has the potential to generate significant unintended consequences; especially in rapidly growing areas. Developing open space can help alleviate housing shortages and increase property tax revenues. However, developing open space can also diminish the value of the existing housing stock which would decrease property tax revenues. Quantifying the relationship between open space and property values is critical if the ten-county study region hopes to fully weigh the benefits and costs of open space development.

Methodology

The hedonic pricing model is selected to estimate the value of open space. The hedonic price function formally describes how the price of a house is related to its attributes. One of these attributes if the proximity to open space. To account for different kinds of open space, we consider seven open space types indexed by $i = 1,2, \ldots ,7$. The most basic hedonic price function that could be used to examine the effect of different kinds of open space on the value of house *i* is:

$$Value = \beta_0 + \sum_{i=1}^{7} \beta_{1i} Distance_i + \sum_{i=1}^{7} \beta_{2i} Distance_i * Area_i + \boldsymbol{\beta X} + \varepsilon \qquad (1)$$

where $Value$ is the recorded house value, $Distance_i$ is the distance between a house and open space type i, and $Distance_i * Area_i$ is an interaction term that captures the effect of the size of the open space parcel of type *i*. We include the interaction term to check whether the impact of distance depends on the quality of open space. $\boldsymbol{X}$ is a vector of control covariates including housing structure variables and households' socioeconomic variables. ε is the error term of the model.

Quantifying the relationship between open space type *i* and property values requires the use of statistical analysis to estimate the coefficients β_{1i} and β_{2i}. These coefficients determine how much a home price will change given a change in the proximity and size of open space. The estimation procedure includes three steps.

The first step is to select the nature of the relationship between open space and home values. For example, equation (1) is a linear relationship. A linear relationship presumes that the 1st additional meter away from an open space parcel decreases home values by the same amount as the 100th additional meter. Much of the existing literature indicates that the 100th meter will decrease home values less than the 1st meter – what economists call diminishing returns. This is intuitive, since the further one is away from an amenity, the less impact they may derive from getting even further. To capture these diminishing returns many researchers use a semi-log model (taking the natural log of home values in equation (1)) or a double-log model (taking the natural log of all variables in equation (1) that do not have a value between zero and one). Hedonic pricing models do not give guidance on the appropriate functional form. One of the commonly used approaches for selecting the functional form of the hedonic price function is to compare adjusted R^2 from alternative functional forms. The R^2 statistic indicates how much of the variation in house values can be explained by the various attributes included in the model. Based on our estimation, the semi-log form fit best with the model. Based on this result we rewrite equation (1) as:

$$\ln(Value) = \beta_0 + \sum_{i=1}^{7} \beta_{1i} Distance_i + \sum_{i=1}^{7} \beta_{2i} Distance_i * Area_i + \boldsymbol{\beta X} + \varepsilon \qquad (2)$$

In the semi-log functional form, instead of the absolute rate of change, β measures the percentage change of the left-hand variable which is leaded by the right-hand variable.

The second step is to check for multicollinearity between variables. Multicollinearity arises when two or more of the variables used to predict a home's value in the hedonic price function are closely correlated and may lead to misleading conclusions due to the similarity between variables. Multicollinearity is often common among housing attributes. For example, homes with more bedrooms typically have more bathrooms – it is difficult to isolate the unique values of bedrooms versus bathrooms. Multicollinearity is also common in open space studies. Because the different types of open space usually locate together, an increase in distance to one type of open space can be very closely linked to distance to another type of open space. To test for multicollinearity, we calculate variance inflation factors (VIF) for each of the variables in our model. A VIF greater than 10 is often used as a threshold to indicate when multicollinearity becomes a concern. The largest VIF in our study is 8 which indicates a lack of severe multicollinearity in our model.

The third step is to account for the potential endogeneity of open space variables. Private open space that is not currently protected from development is endogenous in the hedonic pricing equation (Irwin 2002). When open space is privately held and developable, land parcels considered open space are part of the land market and thus affected by the same factors that affect a parcel's residential value. This is not true of privately held open space that is protected from development (e.g., trust lands) and public open space. Identifying the relationship between property value and private open space that could be developed becomes more difficult. For example, a housing shortage in an area will cause home prices to rise on average but will also encourage more open space to be developed. A hedonic analysis using equation (2) would incorrectly conclude that the value of open space had declined in this area.

To correct the endogeneity issue, we first use a statistical test to check whether the distance measure is endogenous and select instrument variables (IV) which are correlated with endogenous variable but exogenous to the home value. We find that distance to all five types of unprotected open space are endogenous, and our selection of IVs are presented in Table F.1

Table F.1. Instrumental variables used in estimation of hedonic price function

Open space variable	Instrumental variable
Agricultural land	Mean elevation of Census Block Group
Forest	Percent of car ownership in Census Block Group
Shrubland	Average travel time to work
Wetland	Percentage of water coverage within Census Block Group
Developed open space	Area of Census Block Group

With the instrumental variables, we estimate the model with the two-stage least squares (2SLS) regression. 2SLS is a common technique to control for the potential endogeneity associated hedonic models. In the first stage, we estimate five endogenous open space variable equations using the IV, and then predict the five endogenous open space variables with the regression result in order to trim out the endogenous part. The first-stage regression equations are:

$$Agriculture = \beta_0^a + \beta_1^a Elevation + \varepsilon^a$$

$$Forest = \beta_0^f + \beta_1^f Car + \varepsilon^f$$

$$Shrub = \beta_0^s + \beta_1^s Time + \varepsilon^s$$

$$Wetland = \beta_0^W + \beta_1^W Water + \varepsilon^w$$

$$Developed = \beta_0^d + \beta_1^d Size + \varepsilon^d$$

Here Elevation stands for the mean elevation within the CBG, Car stands for the percentage of household who has at least one car, Time is the average travel time to work, Water is the percentage of water coverage within CBG, and Size stands for the area size of the CBG. The left-hand variables stand for the distance between house and different types of open space. In the second stage, we use the predicted values to replace the original open space variables and rewrite equation (2) as:

$$\ln(Value) = \beta_0 + \sum_{i=1}^{7} \beta_{1i} \widehat{Distance}_i + \sum_{i=1}^{7} \beta_{2i} \widehat{Distance}_i * Area_i + \boldsymbol{\beta X} + \varepsilon \qquad (3)$$

where the hat stands for the estimated value.

Data

We collected a rich set of data from different government agencies. Our property value and housing attribute data draws from the County Property Assessor's Offices and the Tennessee Comptroller of the Treasury. We chose this data source since it has the most comprehensive record of home values, at the same time, it is also the real data for tax purpose. We use the 2010-2014 American Community Survey (ACS) for estimates of socioeconomic variables that would describe the neighborhood surrounding a residential parcel such as median age, unemployment rate and median income. A neighborhood is defined as a Census Block Group (CBG). A CBG is a cluster of Census blocks and generally contains between 600 and 3,000 persons. The population in each CBG is the aggregate of a cluster of census blocks. There are 1035 CBGs in our ten-county study area. The average size of a CBG is 4469.63 acres and the largest CBG in the study area is 38548.5 acres while the smallest one is 31.15 acres. According to Shultz and King (2001), CBG-level data is be preferable to county level aggregation when applied to hedonic pricing models, which would eliminate omitted variable problem using a better control of fixed effect.

The open space cover types were determined using the National Land Cover Database (NLCD) 2011 which is produced by the Multi-Resolution Land Characteristics Consortium. According to their measure, open space could be classified into ten types as Table F.2. The data provided by the NLCD was divided into five major categories to create the open space variable types. Below is a list of open space areas used. All descriptions were used from the NLCD listings.

- **Agriculture**: Agriculture was used from a mixture of the hay/pasture and cultivated crops NLCD layer. This can include grasses, legumes, corn, soybeans, vegetables, cotton, and the crops or pasture account for greater than 20% of their respective area.
- **Forest**: A combination of deciduous, evergreen, and mixed forests. These are areas dominated by trees greater than 5 meters tall.

- **Developed, open**: Areas with some construction but primarily grassland. The area must have less than 20% impervious structure. Examples include large lawns and golf courses.
- **Wetlands**: Includes both woody and emergent herbaceous wetlands. Areas where the soil or substrate is saturated or covered with water periodically.
- **Herbaceous Shrubland**: Includes the grassland/herbaceous as well as the shrub/scrub layer from NLCD. This includes areas dominated by shrubs or herbaceous vegetation.

The shapefiles for open space are from the Tennessee Wildlife Resources Agency (TWRA). We also get local parks and greenway layers from TWRA for Davidson County. For all other counties, we received data on local parks and greenways from the Tennessee Recreation and Parks Association. More details on the open space dataset is available in Technical Appendix A.

Using the data provided, ArcMap 10.5 was then used to find the nearest distance from the housing parcel data to the nearest open space plot in each category. Separate analyses were run for finding the nearest state-owned, federally-owned, locally-owned, conservation easement, forest, developed open, wetlands, herbaceous shrubland, and agricultural land to the housing data in each county. The distances were able to cross county borders. So, for instance, if a housing parcel in Cheatham County was closer to a wetland in Davidson County, the distance was calculated for that parcel-to-wetland proximity.

Tables F.2 through F.11 provide summary statistics of the dependent and independent variables in our model for each county. To prevent outlier problem, we trimmed out house which belongs to at least one of the categories: 1) age is greater than 200; 2) acreage is greater than 20000; 3) square footage is greater than 25000. Among all the counties, Davidson County has the largest share of the total property value, while Williamson County has the highest average house value. For more details, please refer to the following tables.

Table F.2. Cheatham County Summary Statistic

Variable Name	Obs	Mean	Std.Dev	Min	Max
Dependent Variable					
House Value	12017	185825.8	123256.3	14100	7566500
House Level Independent Variable					
Age	12017	34.91429	23.31491	0	192
Sf_finished	12017	1652.216	673.1968	0	8365
Acreage	12017	6.664221	27.1433	0	1379.194
Swim pool (dummy)	12017	0.0442706	0.2057043	0	1
Fireplace (dummy)	12017	0.3475909	0.4762251	0	1
Attach garage (dummy)	12017	0.2687027	0.4433034	0	1
Attach carport (dummy)	12017	0.0660731	0.2484201	0	1
Census Block Level Independ Variable					
Total population	12017	2239.526	1032.631	822	4215
Median Age	12017	40.10607	6.04868	31.3	56.1

Unemployment	12017	7.790745	4.304616	0	18.19788
Vacancy	12017	7.583502	4.840427	0	16.36364
Prct Renter	12017	17.49789	8.224744	1.803051	36.99128
Median year moved in	12017	2002.511	3.404499	1994	2009
Moved in before 2007	12017	0.9003911	0.2994903	0	1
Prct move in before 2010	12017	74.90799	8.483716	54.35897	90.6404
Housing density	12017	0.1268143	0.0817117	0.0204001	0.3568517
Median Income	12017	54621.49	13165.59	34342	91313
Prct White	12017	95.39085	3.746876	86.98469	100
Prct 130 minutes travel	12017	59.81605	9.902986	30.46919	83.49056
Prct Bachelor	12017	19.77866	7.306611	10.20408	51.11748
Distance Measure					
Agriculture Land	12017	326.204	434.4872	0	2650.505
Forest	12017	28.85354	54.29137	0	415.7147
Shrub	12017	1673.828	852.3588	0	4547.943
Wetland	12017	1872.352	1490.554	0	6866.213
Development open space	12017	129.9646	228.9048	0	2074.902
Private owned	12017	6679.482	3561.9	0	14240.43
Public open space	12017	3148.241	2463.815	0	12141.83
Area Measure					
Agriculture land	12017	127268.9	239266.3	576.3428	2571025
Forest	12017	536000000	605000000	576.3428	1590000000
Shrub	12017	15828.94	15862.82	576.3428	109429.3
Wetland	12017	9786.598	18666.09	576.3428	200496.3
Development open space	12017	69331.44	161992.5	576.3428	993973.6
Private owned	12017	554588.5	399460.3	25959.57	1682308
Public open space	12017	13800000	26400000	13060.14	80500000
Instrument Variable					
Mean slope	12,017	7.19009	2.391131	1.663489	14.44947
Mean elevation	12,017	186.8772	17.70044	162.1838	228.3402
Total travel time to work	12,017	1010.913	570.5609	286	2177
Prct of water	12,017	1.105917	1.541276	0	5.062259
CB size	12,017	10606.05	8041.153	1691.937	34873.18

Table F.3. Davidson County Summary Statistic

Variable Name	Obs	Mean	Std.Dev	Min	Max
Dependent Variable					
House Value	144349	298060.7	303201.7	0	11500000
House Level Independent Variable					
Age	144349	45.50666	25.99334	0	197
Sf_finished	144349	1972.252	1068.511	0	21014

Acreage	144349	0.4537831	1.45639	0	474.59
Swim pool (dummy)	144349	0.0276344	0.1639236	0	1
Fireplace (dummy)	144349	0.5766649	0.4940892	0	1
Attach garage (dummy)	144349	0.4024275	0.4903889	0	1
Attach carport (dummy)	144349	0.0425012	0.2017302	0	1
Census Block Level Independ Variable					
Total population	144349	1969.792	1893.597	0	11592
Median Age	144338	38.21959	7.619496	14.4	62.3
Unemployment	144303	7.064219	6.144851	0	54.07726
Vacancy	144338	7.397552	6.861243	0	43.40278
Prct Renter	144338	30.22924	19.93186	0	100
Median year moved in	143720	2005.498	3.972061	1984	2012
Moved in before 2007	143720	0.68145	0.4659156	0	1
Prct move in before 2010	144338	65.89869	14.86257	4.750594	100
Housing density	144349	1.863448	1.36424	0	18.01702
Median Income	142835	62405.23	33020.99	6829	227734
Prct White	144338	66.10736	26.21002	0	100
Prct 130 minutes travel	144303	33.94038	15.31749	0	74.14966
Prct Bachelor	144338	38.55807	21.74038	0	93.33334
Distance Measure					
Agriculture Land	144349	683.5369	670.2439	0	3762.42
Forest	144355	212.6542	276.4174	0	2092.029
Shrub	144349	866.0977	700.3047	0	4753.6
Wetland	144349	1647.658	1069.547	0	7375.585
Development open space	144349	19.65314	33.01109	0	1076.964
Private owned	144349	4925.96	3069.178	0	15328.99
Public open space	144349	1112.485	960.5638	0	12308.98
Area Measure					
Agriculture land	144349	76286.26	233045.6	576.3428	3736499
Forest	144355	14400000	142000000	576.3428	1590000000
Shrub	144349	7112.611	8561.592	576.3428	128122.3
Wetland	144349	4651.558	5015.465	576.3428	108734.4
Development open space	144349	3182356	9673543	576.3428	36400000
Private owned	144349	178404.9	237652.6	1857.792	1311165
Public open space	144349	8460704	15800000	3772.241	86200000
Instrument Variable					
Mean slope	144,349	3.948314	2.037191	1.105807	14.44947
Mean elevation	144,349	168.1002	23.80711	123.9223	258.8557
Total travel time to work	144,349	972.8319	1093.905	0	6709
Prct of water	144,349	2.061857	7.210446	0	69.58105
CB size	144,349	1059.18	1861.837	31.14624	12490.04

Table F.4. Dickson County Summary Statistic

Variable Name	Obs	Mean	Std.Dev	Min	Max
Dependent Variable					
House Value	14737	163438.3	98116.38	13900	2055600
House Level Independent Variable					
Age	14737	40.03054	27.22094	0	197
Sf_finished	14737	1613.132	646.0827	180	7778
Acreage	14737	9.786364	33.29568	0.0066268	1547.107
Swim pool (dummy)	14737	0.0360318	0.1863755	0	1
Fireplace (dummy)	14737	0.2423831	0.4285394	0	1
Attach garage (dummy)	14737	0.2707471	0.4443608	0	1
Attach carport (dummy)	14737	0.107281	0.3094807	0	1
Census Block Level Independ Variable					
Total population	14737	1949.326	753.8959	454	3375
Median Age	14737	40.09313	4.969436	26.6	51.3
Unemployment	14737	7.378541	4.185395	0	17.62523
Vacancy	14737	11.7702	5.105751	0	21.16461
Prct Renter	14737	22.55811	13.96169	7.735849	70.88608
Median year moved in	14737	2003.87	2.621418	1995	2011
Moved in before 2007	14737	0.9113117	0.284303	0	1
Prct move in before 2010	14737	73.52818	11.87228	35.44858	90.06116
Housing density	14737	0.2105138	0.3189724	0.0185159	1.689767
Median Income	14737	47289.31	13641.82	18438	86287
Prct White	14737	92.6866	7.045351	72.28117	100
Prct 130 minutes travel	14737	48.56739	15.0144	3.401361	86.04336
Prct Bachelor	14737	14.93595	6.549693	1.58371	30.25048
Distance Measure					
Agriculture Land	14737	176.5116	254.0609	0	2089.332
Forest	14740	38.74962	61.08178	0	436.0738
Shrub	14737	1532.847	875.9086	0	5647.955
Wetland	14737	2829.969	1276.208	0	7826.639
Development open space	14737	77.12445	117.6207	0	1293.818
Private owned	14737	7577.028	4151.343	0	24222.88
Public open space	14737	7721.05	4929.566	0	24743.3
Area Measure					
Agriculture land	14737	169807.1	282397.8	576.3428	2393812
Forest	14740	6.63E+08	7.68E+08	5.76E+02	1.59E+09
Shrub	14737	15538.15	21960.11	576.3428	239812.6
Wetland	14737	3648.163	2669.602	576.3428	80264.39

Development open space	14737	55162.8	87771.54	576.3428	478936.8
Private owned	14737	869502.3	499951.2	25959.57	2781799
Public open space	14737	8026185	7222320	581333.5	80500000
Instrument Variable					
Mean slope	14737	5.570545	1.423464	2.265068	9.988881
Mean elevation	14737	225.3089	19.47082	153.2649	262.7099
Travel time	14737	812.0328	331.8668	177	1465
Prct of water	14737	0.2890248	0.6507054	0	3.7506
CB size	14737	12507.08	9962.675	278.7522	33142.76

Table F.5. Maury County Summary Statistic

Variable Name	Obs	Mean	Std.Dev	Min	Max
Dependent Variable					
House Value	27277	149101.9	96075.87	4900	1735200
House Level Independent Variable					
Age	27277	38.36335	29.33822	0	195
Sf_finished	27277	1727.372	735.3853	0	12528
Acreage	27277	6.89354	28.58918	0.0287025	675.2798
Swim pool (dummy)	27277	0.0353778	0.1847362	0	1
Fireplace (dummy)	27277	0.3781941	0.4849453	0	1
Attach garage (dummy)	27277	0.4374381	0.4960797	0	1
Attach carport (dummy)	27277	0.0802141	0.2716293	0	1
Census Block Level Independ Variable					
Total population	27277	2750.826	2325.093	424	11343
Median Age	27277	39.79091	7.399493	24.8	56.2
Unemployment	27277	7.538947	5.268971	0	27.1875
Vacancy	27277	8.177449	6.628077	0	34.90909
Prct Renter	27277	25.91372	14.39477	2.888087	63.28125
Median year moved in	27277	2004.928	3.381602	1998	2012
Moved in before 2007	27277	0.7517322	0.4320159	0	1
Prct move in before 2010	27277	69.0986	11.88713	25.69444	91.17043
Housing density	27277	0.4727259	0.691109	0.0205366	3.142827
Median Income	26807	52209.87	16966.94	16698	110815
Prct White	27277	84.23301	14.0759	17.69802	100
Prct 130 minutes travel	27277	44.47605	13.8678	13.61868	77.92642
Prct Bachelor	27277	19.88788	11.00536	0	56.95364
Distance Measure					
Agriculture Land	27277	149.3843	215.2301	0	1528.639
Forest	27,279	167.0933	181.1276	0	1067.147

Shrub	27277	481.7088	505.6831	0	5049.927
Wetland	27277	1333.388	949.2379	0	8648.81
Development open space	27277	56.33802	108.0338	0	1383.159
Private owned	27277	5428.41	2692.566	0	18490.22
Public open space	27277	3274.515	2291.218	0	13766.64
Area Measure					
Agriculture land	27277	482774.9	952001.8	576.3428	5235869
Forest	27,279	2.82E+07	2.06E+08	576.3428	1.59E+09
Shrub	27277	6981.013	8720.375	576.3428	127418.2
Wetland	27277	11305.88	25319.37	576.3428	280897.5
Development open space	27277	355115.8	842079.3	576.3428	4301379
Private owned	27277	681097	481175.4	185431	1629083
Public open space	27277	12500000	20800000	2296.483	53100000
Instrument Variable					
Mean slope	27277	4.834972	2.110771	1.209408	14.47239
Mean elevation	27277	216.0252	17.35331	182.7274	273.8896
Travel time	27277	1253.804	1238.876	141	4599
Prct of water	27277	0.2711675	0.6461057	0	4.401294
CB size	27277	10608.1	9300.761	119.0465	33284.96

Table F.6. Montgomery County Summary Statistic

Variable Name	Obs	Mean	Std.Dev	Min	Max
Dependent Variable					
House Value	53409	154036.4	74610.02	3100	1179700
House Level Independent Variable					
Age	53409	27.65734	20.86354	0	197
Sf_finished	53409	1735.474	702.109	0	10124
Acreage	53409	0.8464822	2.000982	0.00000071	301.9526
Swim pool (dummy)	53409	0.048269	0.2143361	0	1
Fireplace (dummy)	53409	0.4767549	0.499464	0	1
Attach garage (dummy)	53409	0.5355277	0.4987409	0	1
Attach carport (dummy)	53409	0.0473328	0.2123518	0	1
Census Block Level Independ Variable					
Total population	53409	3120.807	1811.112	102	7047
Median Age	53409	32.58869	6.190677	21.6	55.1
Unemployment	53408	9.5746	6.281448	0	57.38758
Vacancy	53408	11.03375	6.481078	0	38.03922
Prct Renter	53408	30.70035	15.21656	0	92.47626
Median year moved in	52894	2007.559	3.101955	1995	2012

Moved in before 2007	52894	0.4505615	0.4975545	0	1
Prct move in before 2010	53408	56.34736	15.07181	13.89961	100
Housing density	53409	0.914788	0.751601	0	3.203268
Median Income	53289	55540.37	16385.84	14688	98984
Prct White	53409	72.53856	16.14877	15.19608	100
Prct 130 minutes travel	53409	33.79628	13.57087	0	86.04336
Prct Bachelor	53409	25.54053	11.36812	4.141104	52.2673
Distance Measure					
Agriculture Land	53409	335.2137	490.3125	0	2783.906
Forest	53,417	99.21659	134.3958	0	1007.446
Shrub	53409	1452.868	838.9518	0	4617.264
Wetland	53409	1286.942	952.2172	0	7618.731
Development open space	53409	33.6706	66.6516	0	879.8061
Private owned	53409	6142.777	2871.504	12.55849	14211.99
Public open space	53409	4311.916	2599.008	18.06991	13744.38
Area Measure					
Agriculture land	53409	235500	522667	576.3428	5752400
Forest	53,417	7.15E+07	3.13E+08	576.3428	1.59E+09
Shrub	53409	10533.32	10281.61	576.3428	172703.2
Wetland	53409	13035.27	28343.55	576.3428	320606.3
Development open space	53409	72031.78	142931.7	576.3428	906479.9
Private owned	53409	243927.4	287996	74886.7	2485080
Public open space	53409	39700000	72600000	45394.99	175000000
Instrument Variable					
Mean slope	53,409	3.781656	1.658955	0.8014579	12.49981
Mean elevation	53,409	158.112	12.64172	125.4727	211.2842
Travel time	53,409	1326.804	817.8434	71	3063
Prct of water	53,409	0.5161138	1.358752	0	9.581434
CB size	53,409	4215.616	6000.247	146.4354	38548.45

Table F.7. Robertson County Summary Statistic

Variable Name	Obs	Mean	Std.Dev	Min	Max
Dependent Variable					
House Value	20969	159992.7	108760.3	6900	7370400
House Level Independent Variable					
Age	20969	36.55081	28.77811	0	198
Sf_finished	20969	1705.032	700.1433	336	13562
Acreage	20969	6.045393	27.0072	0.0000124	1859.349
Swim pool (dummy)	20969	0.0477848	0.2133157	0	1

Fireplace (dummy)	20969	0.3100291	0.4625162	0	1
Attach garage (dummy)	20969	0.3796557	0.4853128	0	1
Attach carport (dummy)	20969	0.0633316	0.2435642	0	1
Census Block Level Independ Variable					
Total population	20969	2377.401	967.8034	568	4215
Median Age	20969	38.6725	5.462933	27	50.6
Unemployment	20969	8.282577	4.120404	1.309329	16.66667
Vacancy	20969	6.30075	4.61158	0	20.60811
Prct Renter	20969	21.47907	11.97768	4.897959	55.46559
Median year moved in	20969	2004.078	2.545794	1997	2010
Moved in before 2007	20969	0.937813	0.2415007	0	1
Prct move in before 2010	20969	73.25873	8.29732	47.37609	93.66516
Housing density	20969	0.3147255	0.381913	0.0199246	1.689736
Median Income	20969	54427.14	13185.75	18796	99301
Prct White	20969	89.03909	12.69894	40.37012	100
Prct 130 minutes travel	20969	46.96345	10.72225	29.12482	79.69151
Prct Bachelor	20969	18.34053	6.910171	4.00641	38.98444
Distance Measure					
Agriculture Land	20969	93.03953	149.0157	0	1913.663
Forest	20,978	81.57289	98.10554	0	860.5664
Shrub	20969	1618.858	812.2195	0	4724.195
Wetland	20969	4135.654	2173.454	19.69908	12570.9
Development open space	20969	55.91002	90.44135	0	1086.114
Private owned	20969	6809.556	2736.546	0	13049.3
Public open space	20969	7456.556	4071.015	0	18304.55
Area Measure					
Agriculture land	20969	340846.5	587836.1	576.3428	5752400
Forest	20978	4.57E+07	1.45E+08	576.3428	5.20E+08
Shrub	20969	19481.29	23467.44	576.3428	78998.52
Wetland	20969	6982.081	8464.662	576.3428	53102.64
Development open space	20969	131882.9	228027.9	576.3428	1076280
Private owned	20969	707051.1	407454.6	179443.8	1620370
Public open space	20969	4069409	2338199	9189.11	7183327
Instrument Variable					
Mean slope	20,969	3.3654	1.574035	1.258977	11.80672
Mean elevation	20,969	218.4981	22.91302	164.2077	258.5181
Travel time	20,969	1022.592	406.9503	287	2177
Prct of water	20,969	0.0856327	0.2281517	0	1.230999
CB size	20,969	10019.01	9681.125	355.4514	34873.18

Table F.8. Rutherford County Summary Statistic

Variable Name	Obs	Mean	Std.Dev	Min	Max
Dependent Variable					
House Value	72284	177396.8	88084.98	9900	3326900
House Level Independent Variable					
Age	72284	25.29899	18.94029	0	197
Sf_finished	72284	146.3753	611.2015	0	9877
Acreage	72284	1.377825	1.9153	0	295
Swim pool (dummy)	72284	0.03323	0.179238	0	1
Fireplace (dummy)	72284	0.4152786	0.4927734	0	1
Attach garage (dummy)	72284	0.7070721	0.4551088	0	1
Attach carport (dummy)	72284	0.048849	0.2155537	0	1
Census Block Level Independ Variable					
Total population	72284	3295.37	2426.446	622	12069
Median Age	72284	35.44005	6.38794	15.3	57.8
Unemployment	72284	6.419069	4.907569	0	30.57269
Vacancy	72284	5.552576	4.762467	0	22.58883
Prct Renter	72284	23.86164	18.47891	0	95.86864
Median year moved in	71790	2005.856	3.497906	1991	2012
Moved in before 2007	71790	0.6821006	0.4656634	0	1
Prct move in before 2010	72284	66.37094	15.27088	12.56281	96.96262
Housing density	72284	0.9479405	0.894308	0.0176195	11.22775
Median Income	72246	65409.16	20425.05	12270	146500
Prct White	72284	81.66256	11.37502	27.39322	100
Prct 130 minutes travel	72284	43.32958	11.08197	5.208333	73.53215
Prct Bachelor	72284	31.00959	12.76617	2.479339	81.20894
Distance Measure					
Agriculture Land	72284	215.1759	221.3723	0	1393.795
Forest	72469	251.7623	212.0462	0	1357.08
Shrub	72284	433.2543	287.2708	0	1592.187
Wetland	72284	1356.5	1033.975	0	5594.906
Development open space	72284	35.636	55.92288	0	944.5479
Private owned	72284	7912.019	3998.19	16.65675	19307.22
Public open space	72284	2713.041	2468.876	0	17593.49
Area Measure					
Agriculture land	72284	230520.8	545339.2	576.3428	5273430
Forest	72469	70344.02	525748.6	576.3428	19200000
Shrub	72284	6689.448	9527.475	576.3428	154024.7
Wetland	72284	9230.157	12342	576.3428	182368
Development open space	72284	192306.5	472840	576.3428	2566114

Private owned	72284	320889.8	478436.3	35927.79	1587426
Public open space	72284	9489277	1.44E+07	2624.104	4.95E+07
Instrument Variable					
Mean slope	72280	1.95344	2.167499	0.2712771	15.54719
Mean elevation	72284	185.8337	18.48125	154.3243	264.9519
Travel time	72284	1562.619	1300.321	257	6577
Prct of water	72284	0.4109998	2.162106	0	19.6726
CB size	72284	3484.699	4732.809	84.13329	36064.25

Table F.9. Sumner County Summary Statistic

Variable Name	Obs	Mean	Std.Dev	Min	Max
Dependent Variable					
House Value	50289	207649.9	140118.2	0	5173800
House Level Independent Variable					
Age	50289	30.63873	21.54031	0	192
Sf_finished	50289	2106.784	960.1904	0	17976
Acreage	50289	6.511662	24.99931	0	315.0274
Swim pool (dummy)	50289	0.0597347	0.2369971	0	1
Fireplace (dummy)	50289	0.5417686	0.4982573	0	1
Attach garage (dummy)	50289	0.5314085	0.4990175	0	1
Attach carport (dummy)	50289	0.0400087	0.1959817	0	1
Census Block Level Independ Variable					
Total population	50289	2131.37	834.3288	497	4074
Median Age	50289	40.36835	6.339991	18.9	57.7
Unemployment	50289	5.757607	3.372027	0	24.34302
Vacancy	50289	6.369224	5.914922	0	28.36735
Prct Renter	50289	20.94745	16.24199	0	100
Median year moved in	50288	2004.61	3.301247	1996	2012
Moved in before 2007	50288	0.8386693	0.3678394	0	1
Prct move in before 2010	50289	70.57318	12.73676	17.00405	92.85714
Housing density	50289	0.6687145	0.6980679	0.0356648	3.227803
Median Income	49343	66305.83	21729.71	21076	119583
Prct White	50289	89.6823	9.695984	24.8062	100
Prct 130 minutes travel	50289	45.41784	9.539974	10.59322	67.84314
Prct Bachelor	50289	26.477	15.27437	2.40481	59.89418
Distance Measure					
Agriculture Land	50289	958.8284	1251.239	0	7370.797
Forest	50293	344.5826	383.4811	0	2944.29
Shrub	50289	5493.458	3023.846	0	19763.11

Wetland	50289	9268.875	5524.182	0	45487.7
Development open space	50289	118.3884	249.2006	0	5031.308
Private owned	50289	18308.44	8501.88	29.58895	55288.64
Public open space	50289	20256.31	13651.43	0	61944.63
Area Measure					
Agriculture land	50289	300158.6	724106.5	576.3435	5501069
Forest	50293	25000000	101000000	576.3138	520000000
Shrub	50289	10236.31	10880.22	576.3428	54403.51
Wetland	50289	7209.663	9096.006	576.3428	71703.01
Development open space	50289	311915.7	599466.8	576.3132	2573877
Private owned	50289	563438.1	464437.9	125090.1	2148774
Public open space	50289	3838035	6040018	9189.11	86200000
Instrument Variable					
Mean slope	50289	3.52542	2.578204	0.6383141	13.36066
Mean elevation	50289	183.6698	39.57935	139.3336	275.2477
Travel time	50289	936.8099	395.1913	128	1744
Prct of water	50289	6.482839	12.60353	0	56.70541
CB size	50289	3613.294	4045.935	173.23	24510.79

Table F.10. Williamson County Summary Statistic

Variable Name	Obs	Mean	Std.Dev	Min	Max
Dependent Variable					
House Value	60462	476044	426156.2	0	19000000
House Level Independent Variable					
Age	60462	22.95989	21.15904	0	199
Sf_finished	60462	2935.314	1470.072	0	24548
Acreage	60462	2.919027	18.27143	0	2371.919
Swim pool (dummy)	60462	0	0	0	0
Fireplace (dummy)	60462	0.7097847	0.4538654	0	1
Attach garage (dummy)	60462	0.6705203	0.4700282	0	1
Attach carport (dummy)	60462	0.0291257	0.1681603	0	1
Census Block Level Independ Variable					
Total population	60462	3470.599	2510.374	760	11343
Median Age	60462	39.10778	5.566989	29.7	57.8
Unemployment	60462	4.229376	2.872736	0	11.52495
Vacancy	60462	3.494423	3.511253	0	22.58883
Prct Renter	60462	14.36812	13.77759	0	73.11234
Median year moved in	60462	2005.162	3.264286	1995	2011
Moved in before 2007	60462	0.7195263	0.4492344	0	1

Prct move in before 2010	60462	69.84019	12.66038	33.21267	91.80888
Housing density	60462	0.6487668	0.6705898	0.0235551	4.487523
Median Income	60462	105876.5	34888.5	39426	203750
Prct White	60462	90.48864	6.995432	61.0929	100
Prct 130 minutes travel	60462	45.66451	15.14801	17.41803	84.03909
Prct Bachelor	60462	55.96289	15.40766	7.579462	90.60606
Distance Measure					
Agriculture Land	60462	206.9135	242.9735	0	2936.77
Forest	60521	67.16491	119.8815	0	1941.974
Shrub	60462	594.0192	678.7483	0	4179.634
Wetland	60462	2002.306	1471.547	0	12428.38
Development open space	60462	67.09078	119.8053	0	1941.974
Private owned	60462	3252.115	2070.568	0	9295.056
Public open space	60462	2288.493	1521.539	0	9150.336
Area Measure					
Agriculture land	60462	392236.3	858754.9	576.3428	8728938
Forest	60521	555616.2	1569002	576.3428	7511070
Shrub	60462	6922.622	8861.049	576.3428	119161.2
Wetland	60462	7988.659	7542.14	576.3428	53006.68
Development open space	60462	555993.2	1569635	576.3428	7511070
Private owned	60462	473202.2	661759.2	13081.47	2781799
Public open space	60462	9661223	19900000	4102.06	86200000
Instrument Variable					
Mean slope	60462	4.061631	2.072906	0.779241	11.47078
Mean elevation	60462	226.3344	19.66451	175.199	267.7373
Travel time	60462	1434.27	1030.704	361	4599
Prct of water	60462	0.2850407	1.307293	0	13.48045
CB size	60462	5375.569	6234.859	146.5266	31660.5

Table F.11. Wilson County Summary Statistic

Variable Name	Obs	Mean	Std.Dev	Min	Max
Dependent Variable					
House Value	39069	242305.6	134706.1	8500	4155600
House Level Independent Variable					
Age	39069	30.22875	23.02746	0	117
Sf_finished	39069	2048.503	842.061	0	12016
Acreage	39069	4.901412	22.47053	0.038418	1270.883
Swim pool (dummy)	39069	0.047992	0.2137521	0	1
Fireplace (dummy)	39069	0.3993192	0.4897647	0	1
Attach garage (dummy)	39069	0.5916967	0.4915261	0	1

Attach carport (dummy)	39069	0.0489391	0.2157434	0	1
Census Block Level Independ Variable					
Total population	39069	2480.209	1265.709	610	6645
Median Age	39069	40.94842	7.069535	28.6	63.4
Unemployment	39069	6.186524	4.788278	0	28.23276
Vacancy	39069	6.57836	6.561199	0	27.38239
Prct Renter	39069	17.04218	14.51614	0	77.45454
Median year moved in	39069	2004.876	2.720754	1998	2011
Moved in before 2007	39069	0.8203947	0.3838633	0	1
Prct move in before 2010	39069	71.66986	11.87964	30.43478	94.84241
Housing density	39069	0.4844357	0.5574592	0.0176195	3.552212
Median Income	39069	66318.81	19572.16	16292	106111
Prct White	39069	89.86829	8.521099	44.93784	100
Prct 130 minutes travel	39069	47.98405	13.39958	13.35079	79.96918
Prct Bachelor	39069	29.96612	12.16117	3.903559	52.61401
Distance Measure					
Agriculture Land	39069	145.0884	183.0979	0	1349.004
Forest	39069	141.7652	161.3879	0	1297.629
Shrub	39069	303.8643	216.5773	0	3508.158
Wetland	39069	1690.035	1041.22	0	5825.426
Development open space	39069	51.65377	94.35343	0	1335.29
Private owned	39069	8604.835	4416.279	0	20521.96
Public open space	39069	70.9845	52.57366	0	178
Area Measure					
Agriculture land	39069	540844.1	1033559	576.3428	6448188
Forest	39069	127368.1	1101289	576.3428	2.46E+07
Shrub	39069	6529.95	7752.575	576.3428	126489.3
Wetland	39069	7231.126	8000.885	576.3428	108734.4
Development open space	39069	402354.7	1036801	576.3428	4465819
Private owned	39069	447451.8	252662.6	41800.28	1587426
Public open space	39069	15300000	11300000	81162.66	51000000
Instrument Variable					
Mean slope	35632	3.11493	1.395869	0.7015349	8.24723
Mean elevation	39069	177.9304	21.55573	145.529	257.4254
Travel time	39069	1089.003	564.0742	272	2955
Prct of water	39069	3.310595	8.575522	0	41.63971
CB size	39069	6755.726	7881.031	99.45263	36064.25

Results

We apply the 2SLS model separately to the 10 counties. To maintain the comparability and consistency, we use the same choice of the instrumental variable across different counties. The regression results are displayed in Table F.12. One star means the coefficient is significant at the 10% level, the double star means the coefficient is significant at the 5% level, while triple star means the coefficient is significant at the 1% level. We use 5% cutoff as a selection criterion for identify which coefficients are statistically significant from zero. With the semi-log function form, our result of distance could be interpreted as “one-meter increase in distance would lead to a certain percentage change in house value”. To convert the coefficient to the implicit price, we multiply the percentage changes by the median house value in each county, which we think is a better overall measure compared with average house value. To calculate the total loss in each county, we use the housing density and size of the parcel’s CBG to calculate the average distance between homes. A total loss of open space constitutes the removal of open space within this radius around a parcel.

Table F.12. 2SLS regression results

	Cheatham	Davidson	Dickson	Maury	Montgomery
Distance					
Agriculture	-0.00192***	-0.00285***	0.000655***	-0.000450**	0.00108***
Forest	-0.0278***	0.00144***	-0.00216	-0.000882***	0.00423***
Shrub	0.00349***	-0.00178***	0.000339	0.00131***	-0.00472***
Wetland	0.00000972	0.000145***	-0.000107*	-0.000180***	0.000233***
Developed open space	-0.000363	0.00135**	-0.00434***	-0.000410**	-0.00381***
Public open space	0.00000397	0.0000156	2.02E-06	0.0000121*	2.14E-06
Private open space	0.0000127	-0.0000221**	-6.6E-06	0.00000215	-2.8E-06
Interaction with area					
Wetland	6.17E-11	1.49E-10	1.99E-10	3.79e-10**	-2.3E-12
Shrub	-6.22E-10	-2.09E-10	8.83E-11	1.42E-10	2.95E-10
Forest	-5.33E-13	6.65E-14	3.1E-13	4.07E-14	-2.28e-13**
Agriculture	1.54E-11	1.26E-11	3.36e-10***	1.37e-10***	-1.4E-11
Developed open space	-2.37E-10	1.03e-10***	-9.5E-10	3.91E-11	1.09E-09
Public open space	-9.54E-14	3.66E-14	-3.7E-14	-4.07E-15	7.23e-14**
Private open space	1.43E-12	-2.21E-12	3.09E-13	-5.70e-12**	-1.6E-12
Control Variables					
age	-0.00734***	-0.00256***	-0.00742***	-0.00586***	-0.00845***
sf_finished	0.000454***	0.000265***	0.000450***	0.000412***	0.000353***
acreage	0.00356***	0.0148	0.00413***	0.00441***	0.0184
fireplace	0.110***	0.0659***	0.0945***	0.113***	0.0569***
swim pool	0.104***	0.0794***	0.0922***	0.0983***	0.0807***
attach garage	0.0857***	0.0369***	0.149***	0.114***	0.0920***
at carport	0.0826***	0.0299***	0.0716***	0.0904***	0.0608***
Total Population	0.000145***	-0.000264***	0.000206***	0.0000725***	0.000167***
Median Age	-0.000825	-0.00798**	0.0304***	0.00724***	0.0207***
Prct Unemployment	-0.00166	-0.0111***	0.00321*	0.00420***	0.00367***
Vacancy	0.00485***	0.0111***	0.0219***	-0.00819***	-0.00159
Prct of Renter	0.00716*	-0.00964***	0.00871***	0.00965***	0.00303**

Median year moved in	-0.00742**	0.00593**	-0.00875	0.0209***	-0.0500***
Moved in before 2007	0	0.574***	0.296***	0.275***	-0.0585
Prct move in before 2010	0.00051	-0.0159***	-0.00093	0.00276***	-0.0134***
Housing Density	0	0.0159***	-0.312***	-0.121***	-0.198***
Median income	0.000000538	-0.00000904***	1.35E-06	3.56E-07	0.00000148*
Prct White	0.0132***	-0.00415***	-0.00324	0.00624***	0.00376***
Prct 130 minutes travel	0.0101***	0.00871***	-0.00597***	-0.00842***	-0.00888***
Prct of Bachelor	0.0108***	0.0199***	0.000957	0.000791	-0.00407***

t statistics in parentheses
*** p<0.05, ** p<0.01, *** p<0.001**

Table F.12. Continued

	Robertson	Rutherford	Sumner	Williamson	Wilson
Distance					
Agriculture	0.000597	0.00141	0.0000583	0.000301	-0.000313
Forest	0.000428	0.000237	-0.00023	0.00119	0.000427***
Shrub	-0.0267	0.00208	-0.0000198	0.000179	0.0000077
Wetland	-0.0000326	-0.0000561	-0.0000273**	-0.0000880***	-0.000249***
Developed open space	0.000408	0.000452	-0.0198	-0.000457*	0.000226
Public open space	-9.52E-08	0.00000368	-0.000000263	0.0000262**	-0.00000092
Private open space	-0.00000615	-0.00000518	0.00000237	-0.00000539	0.00000507
Interaction with area					
Wetland	-3.12E-10	-4.18E-10	-4.52E-11	3.76E-12	2.05E-10
Shrub	2.18E-10	-1.65E-09	6.73E-11	-1.11E-10	-5.69E-09
Forest	8.55e-13*	1.11E-11	1.64E-13	3.52e-10*	-2.49E-11
Agriculture	3.48e-10**	8.92E-11	1.14E-12	3.82E-11	9.13e-11*
Developed open space	-1.17e-09**	-4.36E-10	1.03E-11	-6.35e-10*	-5.38E-12
Public open space	2.79E-15	-4.62E-13	1.25E-13	3.11e-13*	5.68E-14
Private open space	5.58e-12**	2.57E-12	-2.26E-12	2.35E-12	2.05E-12
Control Variables					
age	-0.00613***	-0.00646***	-0.00761***	-0.000807	-0.00649***
sf_finished	0.000422***	0.0000717***	0.000320***	0.000262***	0.000359***
acrage	0.00463***	0.0336*	-0.000107	0.00664***	0.00404***
fireplace	0.0605***	0.207***	0.0593***	0.102***	0.0446***
swim pool	0.104***	0.398***	0.106***	0	0.0907***
attach garage	0.129***	0.135***	0.0999***	0.104***	0.0750***
at carport	0.0406***	0.0895***	0.0486***	0.0367*	0.0494***
Total Population	0.000184	-0.0000382	-0.0000982	0.00000696	0.0000181
Median Age	-0.0149*	0.00166	0.00208	0.0237***	0.00425***
Prct Unemployment	-0.0000646	0.00699***	0.00364***	0.0316***	-0.00487***
Vacancy	0.00649***	-0.0101***	-0.00854***	0.0120***	-0.0185***
Prct of Renter	-0.00253	-0.00217***	0.00174	0.00686***	-0.00990***

Median year moved in	0.0126	-0.00588	0.00256	0.0527***	0.0069
Moved in before 2007	0	0.268***	-0.111**	0.146***	-0.191***
Prct move in before 2010	-0.000493	-0.00811***	0.00324	0.0133***	0.00234*
Housing Density	-0.189***	0.0111***	0.0415	-0.160***	0.0243***
Median income	-0.00000144	0.00000110**	0.00000132	-0.00000343***	-0.00000528***
Prct White	0.00997***	0.00714***	0.00989***	-0.00388***	0.00539***
Prct 130 minutes travel	-0.00168***	0.000146	0.00294**	0.00146**	0.00228***
Prct of Bachelor	0.00189	0.00535***	0.00522*	0.0120***	0.00109**

t statistics in parentheses
*** p<0.05, ** p<0.01, *** p<0.001**

The effect of controlling for endogeneity

To give a direct picture about the bias avoided by correcting for the endogeneity of open space variables in our study, Table F.13 presents the regression result without controlling for endogeneity (OLS results). Even though the coefficients of the control variables in the **X** matrix are consistent, compared with the 2SLS result, there are three major changes in the open space variable coefficients. First, the number of significant open space distance variables dropped. For example, the influence of distance to wetland is significant at 5% level for most counties. However, without controlling for endogeneity only the wetland distance coefficient for Montgomery County is significantly different from zero at the 5% significant level. Second, the magnitude of the influence is much smaller than 2SLS. As we could see from the two tables, the magnitude of the coefficients on the open space variables in the OLS results are about one-tenth of the coefficients in the 2SLS results. Third, the sign of coefficients differ between the two models. In the 2SLS result, we find increasing distance to developed open space will lead to decreasing home value in Dickson, Maury, Montgomery and Williamson Counties. However, without the control of endogeneity, we would conclude that developed open space detracts from property values in all ten counties. Failing to account for endogeneity in the open space variables would lead to drastic underestimates of the impact of open space on property values.

Table F.13. OLS regression results that do not control for endogenous open space variables

	Cheatham	Davidson	Dickson	Maury	Montgomery
			Distance		
Agriculture	-0.000026	-0.00000668	-0.0000562*	-0.000162**	0.00000841
Forest	0.000103	-0.0000354	-0.0000684	0.0000454	0.0000141
Shrub	0.0000172	0.0000125	-0.00000304	-0.0000157	0.00000698
Wetland	-0.00000289	0.00000596	-0.00000342	-0.00000253	-0.0000203**
Developed open space	0.0000487	0.000147*	0.000380***	0.000385***	0.0000848
Public open space	0.00000155	0.0000144	0.0000014	0.0000120*	0.00000179
Private open space	0.0000155	-0.0000220**	-0.00000682	0.00000179	0.000000527
			Interaction with area		
Wetland	1.65E-10	-6.17E-11	7.7E-10	2.42E-10	-1.13E-10

Shrub	-4.16E-10	1.23E-11	1.33E-10	-8.84E-11	7.69e-10**
Forest	1.75E-13	-8.32E-15	2.09e-13*	-3.82E-14	-1.01E-13
Agriculture	-1.27e-10*	2.14E-11	-7.47E-11	2.49E-11	-6.04e-11***
Developed open space	4.77e-10*	-2.83E-11	1.54E-09	-8.38E-11	2.53E-10
Public open space	-1.16E-13	2.08E-14	-7.85E-15	-6.15E-14	7.30e-14***
Private open space	-1.26E-13	-1.97E-12	5.86E-13	-6.13e-12**	-3.59E-13
Control Variables					
age	-0.00739***	-0.00254***	-0.00729***	-0.00576***	-0.00834***
sf_finished	0.000453***	0.000264***	0.000444***	0.000405***	0.000349***
acrage	0.00354***	0.0143	0.00370***	0.00378***	0.0177
fireplace	0.109***	0.0660***	0.0911***	0.115***	0.0549***
swim pool	0.103***	0.0782***	0.0886***	0.0979***	0.0822***
attach garage	0.0808***	0.0370***	0.152***	0.118***	0.0921***
at carport	0.0824***	0.0300***	0.0751***	0.0889***	0.0631***
Total Population	0.0000247	-0.000142***	0.000131***	0.0000325***	-0.0000236***
Median Age	0.00624	-0.0276***	0.0297***	0.0142***	0.000971
Prct Unemployment	0.00322	0.0188***	0.00885***	0.0113***	0.00173***
Vacancy	-0.0102***	0.0142***	0.00437*	-0.0167***	-0.00306**
Prct of Renter	0.00557	0.00546***	-0.00283**	0.00287***	0.00285*
Median year moved in	0.0177***	0.0501***	-0.00589	0.0503***	-0.0252***
Moved in before 2007	0.321***	-0.992***	0.389***	0.209***	-0.218***
Prct move in before 2010	0.00588**	0.0378***	-0.00918***	0.00780***	-0.0007
Housing Density	0	0.0163***	0.100**	-0.0787***	0.0386**
Median income	0.00000384	0.00000174***	-0.00000390***	0.000000963	0.00000542***
Prct White	-0.0167***	0.00675***	-0.00275***	0.00525***	0.00495***
Prct 130 minutes travel	0.00323***	0.0166***	-0.00327***	-0.00566***	-0.00143***
Prct of Bachelor	0.00844**	0.0230***	-0.00659***	0.00019	0.00230**

t statistics in parentheses
*** p<0.05, ** p<0.01, *** p<0.001**

Table F.13. Continued

	Robertson	Rutherford	Sumner	Williamson	Wilson
Distance					
Agriculture	-0.000145*	-6.1E-05	-0.0000187*	-0.000100*	-0.0000563
Forest	0.000134*	-0.000107**	-0.0000406**	0.000166	-0.000105*
Shrub	4.33E-06	0.000045	-4.1E-06	2.11E-05	0.0000860**
Wetland	-5.1E-06	-1.6E-05	2.12E-06	-9E-06	-0.0000267*
Developed open space	0.000615***	0.0002	1.51E-06	0	0.00000960*
Public open space	1.02E-06	5.08E-06	-8.1E-07	0.0000247**	-7.13E-08
Private open space	-0.00000599*	-4.9E-06	1.54E-06	-4E-06	0.00000592
Interaction with area					
Wetland	2.92E-11	-4.9E-10	1.91E-11	-2.7E-10	4.49E-10
Shrub	4.57e-10*	-1.99e-09*	4.63E-11	9.97E-11	-3.65E-09

Forest	6.31E-13	-1.3E-10	1.72e-13**	8.41E-11	4.41E-11
Agriculture	-2.4E-10	2E-11	-2.84e-11*	7.48e-11***	-5.52E-11
Developed open space	6.21e-10**	4.38E-11	-1.1E-11	0	-7.54E-12
Public open space	2.14E-14	-3.3E-13	1.19E-13	2.99e-13*	3.77E-14
Private open space	3.82e-12*	2.54E-12	-2.3E-12	2.09E-12	3.61E-12
Control Variables					
age	-0.00591***	-0.00640***	-0.00762***	-0.00073	-0.00649***
sf_finished	0.000409***	0.0000688***	0.000319***	0.000260***	0.000358***
acrage	0.00409***	0.0319*	1.49E-05	0.00643***	0.00401***
fireplace	0.0596***	0.206***	0.0612***	0.103***	0.0438***
swim pool	0.0986***	0.395***	0.105***	0	0.0899***
attach garage	0.131***	0.135***	0.100***	0.104***	0.0760***
at carport	0.0430***	0.0887***	0.0455***	0.0329*	0.0480***
Total Population	-0.0000161**	2.55E-07	-0.000111***	-5.9E-06	-4.46E-07
Median Age	0.00111	-0.00491	0.00794*	0.0153***	0.00548***
Prct Unemployment	0.0116***	0.00670***	0.00708	0.0024	0.00459***
Vacancy	0.00456***	-0.00104	-0.00316	0.0102	-0.0107***
Prct of Renter	-0.00069	-0.00142**	0.00780***	0.0103***	-0.00927***
Median year moved in	0.0380***	-0.0233*	-0.00081	0.0293***	0.0170*
Moved in before 2007	-0.0331	0.403***	-0.125*	-0.0572	-0.172***
Prct move in before 2010	0.00575***	-0.0155***	0.00857**	0.0121***	0.00405**
Housing Density	-0.161***	0.00393	0.0950**	-0.0963***	0.0354*
Median income	-0.00000108*	0.00000424***	0.00000487*	0.00000301***	-0.00000347***
Prct White	0.00703***	0.00363**	0.00863***	-0.0101	0.00536***
Prct 130 minutes travel	-0.00200*	-0.00696***	0.00321	0.00267	0.00646***
Prct of Bachelor	0.0022	0.00357*	0.00807***	0.00571***	0.00208**
t statistics in parentheses					
*** p<0.05, ** p<0.01, *** p<0.001**					

The effect of accounting for county-level heterogeneity

The results in the report are derived from county-level models which allow the coefficients on open space variables to vary across counties. This approach captures heterogeneity in the housing stock, housing density, socioeconomic characteristics, and open space availability across counties but taking this approach also assumes that the relevant housing market is equal to the county. For example, someone considering a home in Wilson County will only consider purchasing other homes in Wilson County. Alternatively, the person considering a home in Wilson County may also be willing to purchase a home in any of the other ten counties in the study area. In this case, a regional model in which a single open space coefficient is estimated for the entire study area would be more appropriate. The hedonic price framework provides no guidance on how to determine the relevant size of the housing market. Instead, we present the summary statistics (Table F.14) and regression results from the regional model (Table

F.15) and compare them to the county-level results in Table F.13 to highlight potential discrepancies.

With around half million observations, we estimate the regional level regression with an OLS model. Based on the estimated result, we find that reducing the distance to forest or agriculture space would lead to an increase in house value. Combined with the median home value ($188,500), the implicit price is about $6 per meter. Similar to the county-level results, the ownership of open space does not have a statistically significant influence on property values.

Table F.14. Regional Summary Statistics

Variable Name	Obs	Mean	Std.Dev	Min	Max
Dependent Variable					
House Value	494,862	252252.2	256752.7	0	1.90e+07
Structural Variables					
Age	494,866	33.96326	25.13137	0	199
Sf_finished	494,866	1774.068	1229.045	0	24548
Acreage	494,866	2.920139	16.72919	0	2371.919
Swim pool (dummy)	494,866	0.0341062	0.1815022	0	1
Fireplace (dummy)	494,866	0.5032676	0.4999898	0	1
Attach garage (dummy)	494,866	0.5158952	0.4997478	0	1
Attach carport (dummy)	494,866	0.0480332	0.2138366	0	1
Socioeconomic Variables					
Total population	494,866	2593.996	1989.588	0	12069
Median Age	494,855	37.95558	7.122073	14.4	63.4
Unemployment	494,819	6.797275	5.287853	0	57.38758
Vacancy	494,854	7.005693	6.257233	0	43.40278
Prct Renter	494,854	24.28123	17.77867	0	100
Median year moved in	493,227	2005.377	3.57685	1984	2012
Moved in before 2007	493,227	0.7154779	0.451187	0	1
Prct move in before 2010	494,854	67.28343	14.42728	4.750594	100
Housing density	494,866	1.014957	1.106032	0	18.01702
Median Income	491,778	66610.54	30132.83	6829	227734
Prct White	494,855	79.79801	19.91423	0	100
Prct 130 minutes travel	494,820	41.20113	14.97103	0	86.04336
Prct Bachelor	494,855	33.22561	19.20526	0	93.33334
Distance Measure					
Agriculture Land	494,866	426.5189	649.4459	0	7370.797
Forest	494,866	178.4585	244.3973	0	2944.29
Shrub	494,866	1308.986	1855.357	0	19763.11
Wetland	494,866	2516.116	3145.154	0	45487.7
Development open space	494,866	56.96863	143.9676	0	4563.714
Private owned	494,866	7168.39	5780.297	0	55288.64

Public open space	494,866	4759.218	7402.841	0	61944.63
Area Measure					
Agriculture land	494,866	251688.2	638049.1	576.3428	8728938
Forest	494,866	5.08E+07	2.56E+08	576.3138	1.59E+09
Shrub	494,866	8647.607	11437.26	576.3428	239812.6
Wetland	494,866	7656.836	13829.37	576.3428	320606.3
Development open space	494,866	1113522	5436238	576.3428	3.64E+07
Private owned	494,866	382500.6	455017.1	1857.792	2781799
Public open space	494,866	1.23E+07	2.96E+07	2296.483	1.75E+08
Instrument Variable					
Mean slope	491,425	3.699286	2.259081	0.2712771	15.54719
Mean elevation	494,866	186.0225	32.49099	123.9223	275.2477
Total time to work	494,866	1172.808	999.3032	0	6709
Prct of water	494,866	1.726226	6.464981	0	69.58105
CB size	494,866	4469.634	6565.01	31.14624	38548.45

Table F.15. Regional Regression Result

Distance	
Agriculture	-0.0000279***
Forest	-0.0000406**
Shrub	-2.1E-06
Wetland	-5.5E-07
Developed open space	0.0001000***
Public open space	7.35E-07
Private open space	-5.7E-07
Interaction with area	
Wetland	-6.66E-11
Shrub	1.95e-10*
Forest	7.79E-14
Agriculture	-1.93E-11
Developed open space	-2.91E-11
Public open space	8.09e-14***
Private open space	-2.20E-12
Control Variables	
age	-0.00491***
sf_finished	0.000276***
acreage	0.00401***
fireplace	0.106***
swim pool	0.177***
attach garage	0.0996***
at carport	0.0569***
Total Population	0.0000823***
Median Age	0.0273***

Prct Unemployment	-0.000888*
Vacancy	0.0306***
Prct of Renter	-0.00299***
Median year moved in	-0.0446***
Moved in before 2007	-0.206***
Prct move in before 2010	-0.0208***
Housing Density	0.122***
Median income	0.000000247*
Prct White	0.0127***
Prct 130 minutes travel	-0.0277***
Prct of Bachelor	0.000197

t statistics in parentheses

*** p<0.05, ** p<0.01, *** p<0.001**

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