GIS ANALYSIS OF IMPACTS OF TVA DAMS ON UPSTREAM RESIDENTIAL PROPERTY VALUES IN EASTERN TENNESSEE

A Thesis
by
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Abstract

GIS ANALYSIS OF IMPACTS OF TVA DAMS ON UPSTREAM RESIDENTIAL PROPERTY VALUES IN EASTERN TENNESSEE

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According to the US Army Corps of Engineers (USACE), the United States has 81,134 dams, 13,990 of which have a high hazard risk of failure. There are approximately 5,500 large dams (50+ feet in height) in the US, the second most number of large dams in the world. As these structures continue to age (and more are added to the list of high hazard risk each year) research on large dams is important due to their potential impact upon the built environment. As cost benefit analyses are conducted by agencies such as the USACE and Tennessee Valley Authority (TVA), potential decline in upstream property value due to a large dam failure or removal should be addressed. The data used in this research include TVA owned and operated dam structures obtained from the USACE National Inventory of Dams (USACE NID), assessed property GIS parcel data from Blount County, Tennessee, and Median Household Values from the 2010 US Census. Analysis of the Median Household Value and USACE NID data indicate there is not a significant correlation between the lake storage capacity and median household value. Spatial analysis of the county-level land parcel data was conducted to determine impacts of reservoir depletion on upstream residential property values and potential usage within a future cost-benefit analysis for a dam structure's removal or mitigation. Results show that properties within the studied buffer areas will become greater in distance from the water once a dam removal or failure resulted in depletion of the lake. This increased distance results in decline in overall property value, average property value, and decreased county property tax revenue.

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Chapter 1: Introduction

According to the U.S. Army Corps of Engineers (USACE) there are 81,134 dams in the United States. Of this number, 13,990 are listed as having a high hazard potential and 12,662 as having a significant hazard potential. Just over half of the high hazard dams, 7,103, and barely more than a quarter of significant hazard dams, 2,922, have an Emergency Action Plan (EAP) in place for possible failure (USACE NID, 2011). What may be the most startling aspect of risk is that 33% of all dams in the United States have either a significant or high hazard risk of failure and only a third of these 33%, representing 12% of all dams, have an EAP in place. Due to these hazard risks, aging infrastructure, the cost of repair or remediation, and the environmental effects of large dam structures there is now a push for controlled removal of many of these structures and restoration of the previously natural environmental state.

Currently, the United States has the second largest number of dams in the world, with approximately 5,500 of these structures being large dams (International Rivers, 2011). The USACE defines a large dam as a structure at least 15 meters or 50 feet in height. Currently there are three large dam removal projects in the United States, all of which are in Washington: the Condit Dam on the White Salmon River and the Elwha and Glines Canyon Dams along the Elwha River on Washington's Olympic Peninsula (American Rivers, 2011). When investigating research into the removal of large dams, the vast majority of it focuses on dams of the western United States, with little or no research into large dam removal in the eastern part of the country. In the east, there are dam removal projects underway but they consist of much smaller, less impactful dams.

A key characteristic of large dams in the U.S. is their geographic location in public lands and urban areas. In the west, large dams are primarily located in federally or state owned land, far from development. Dam structures in the east, such as those owned and operated by the Tennessee Valley Authority (TVA) are located in urban metropolitan regions and pose a more significant impact on surrounding human development, particularly on adjacent property values due to a potential failure or removal. This research aims to study the possible effects of removal or failure of a large TVA dam on upstream property values and how it affects the overall median household value for the area. The methods and results demonstrated can be applied to any future cost-benefit analyses conducted in regards to remediation or removal.

The furthest upstream dam of the Tennessee River, Fort Loudoun Dam, lies outside of Knoxville, TN. What makes this large dam structure significant for study is that the TVA recently re-evaluated all of its dams to determine the Probable Maximum Flood (PMF) levels. Due to changes in assumptions involving river operations, higher reservoir water levels that are maintained under current TVA reservoir operating policy, and revised spillway water flow rates, it was found that four of their large dams were now too short to hold back a PMF: Fort Loudoun (Figure 1), Cherokee (Figure 2), Tellico (Figure 3), and Watts Bar (Figure 4) (TVA, 2012).

Figure 1: Fort Loudoun Dam (Photo by TVA)

Figure 2: Cherokee Dam (Photo by TVA)

Figure 3: Tellico Dam (Photo by TVA)

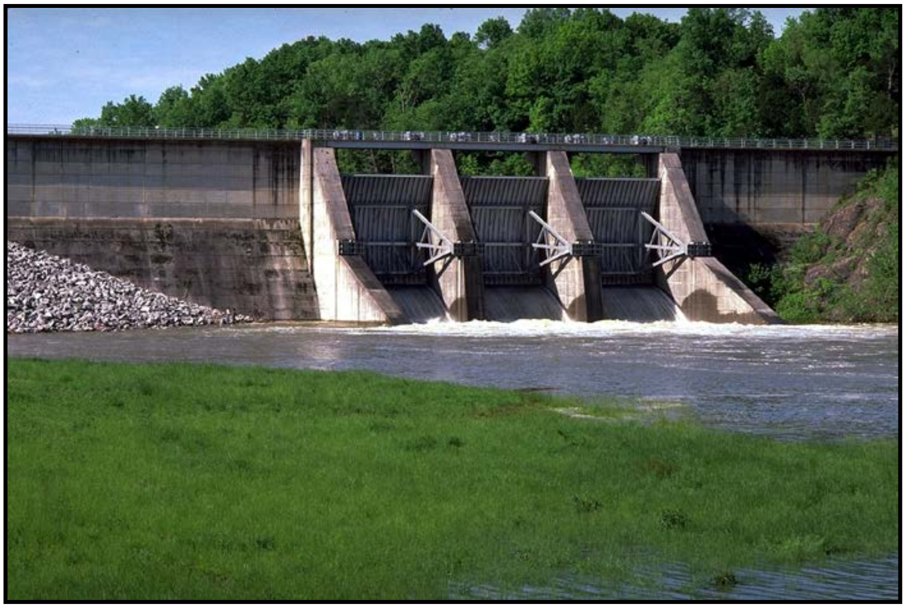
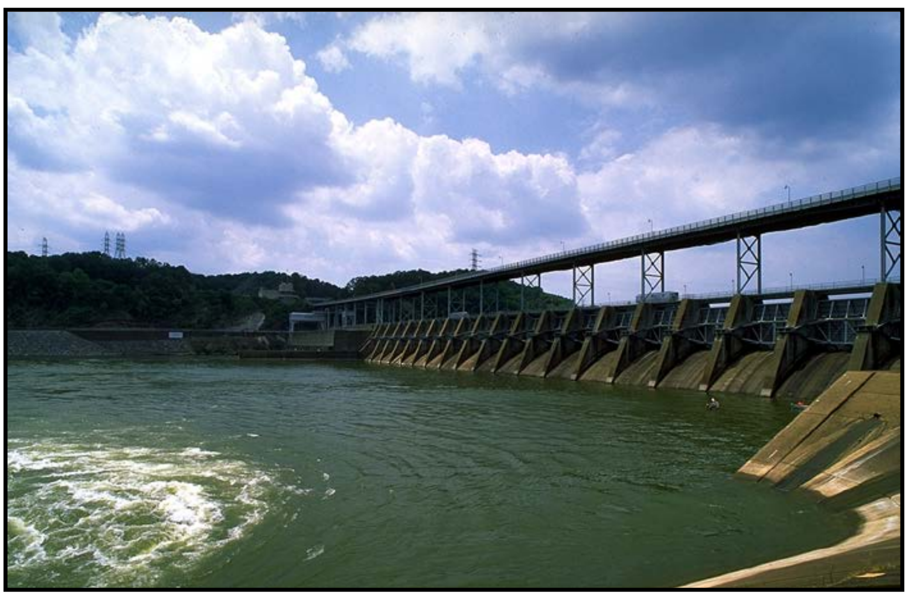


Figure 4: Watts Bar Dam (Photo by TVA)



Fort Loudoun (Figure 5), in particular has a difference of 2.1 feet between the previous PMF elevation of 833.5 ft., as determined by the National Geodetic Vertical Datum of 1929, and the revised PMF elevation of 835.6 ft., calculated by TVA in 2008. Normal pool elevations for Fort Loudoun range between 812-813 ft. in the summer and 807-809 ft. in the winter (TVA, 2012). Fort Loudoun Dam also is significant due to the amount of development along Fort Loudoun Lake, above the dam. At 125 ft. in height and a storage capacity of 393,000 m^3, Fort Loudoun holds back a reservoir which extends northeast between Lenoir City and Knoxville, TN with large developments of neighborhoods and housing along the shoreline. TVA has issued a Draft Environmental Impact Statement of the problem and installed temporary, sand-filled HESCO bastion barriers (Figure 6), manufactured by British company HESCO Bastion Ltd., along the top and in the vicinity of Fort Loudoun Dam while they determine the best course of action from the following alternatives:

1) No Action

2) Permanent Modifications of Dam Structure with Concrete Floodwalls and Earthen Embankments/Berms

3) Permanent Modifications of Dam Structures with All Concrete Floodwalls

As TVA conducts assessments and cost-benefit analyses to determine the best course of action, one that has only been looked at in cases of small dam is how reservoir depletion, due to a dam removal or failure, affects the value of properties along the reservoir.

Figure 5: Fort Loudoun Dam (Photo by Author)

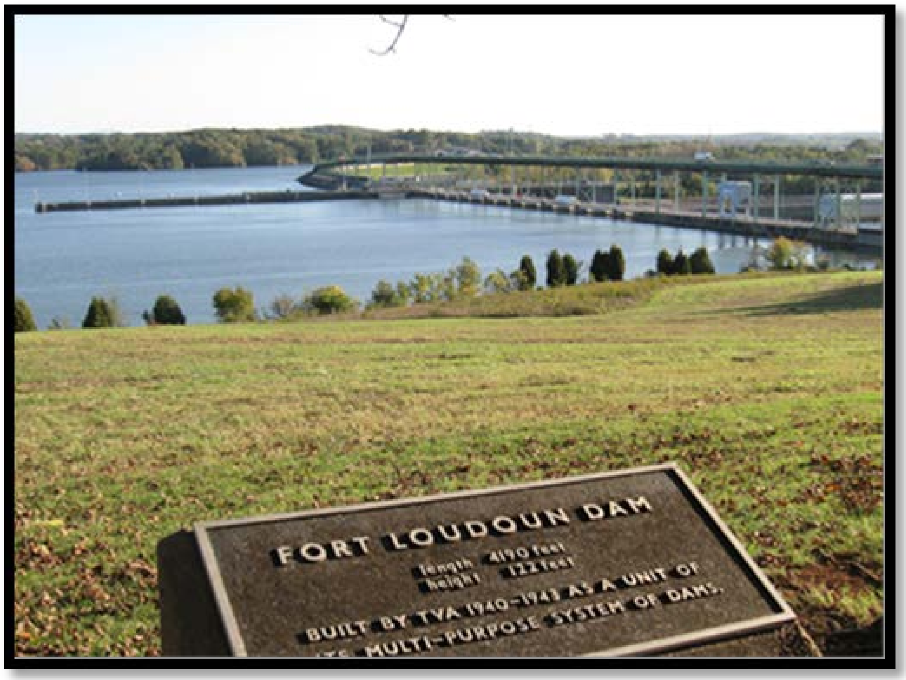


Figure 6: HESCO Bastion Barriers (Photo by Author)

As the 81,000+ dam structures in the United States begin to show the signs of their age, more research has been conducted into the mitigation steps necessary for either repair or removal; however, in the eastern United States research has primarily focused on small dams less than 50 ft. in height. The downside of this focus is that large dam structures hold back the larger reservoirs, which serve a larger geographic region and population and have more of an impact upon the surrounding populations and land. As land in the east is more highly developed than in the west this means that many aspects of large dam removal/mitigation that are not studied in the west must be looked at in the east. A major aspect that needs to be evaluated in the eastern United States is the impact of these large dam structures and their reservoirs on residential property values.

As previously stated, a significant portion of dam structures in the United States are at risk of failure (USACE NID, 2011), so all aspects of their possible removal should be examined. Understanding how upstream property values would be affected by reservoir depletion is vital for use in a cost-benefit analysis. A key related question centers on the assumed loss in assessed tax value and possible decrease in local tax base. This potential loss in upstream property value and local tax revenue could be the difference between cost-justification of removal or remediation. Fort Loudoun Dam presents a perfect case study for understanding this impact due to the significant property development along its reservoir and TVA's recognition of the serious problems with the height of Fort Loudoun Dam and their on-going study of potential solutions.

This area of research is significant due to the fact that most, if not all, studies of impacts from large dam failure or removal have focused on the western United States where development is sparse in comparison to the eastern United States. In turn, the few relevant studies in the eastern United States into the effects on upstream property values have only focused on small dam structures. The lack of previous research on this specific subject area creates a gap in the known possible outcomes of a dam structure's failure or removal. Closing this gap is essential for local, regional, state, and federal government bodies to conduct better informed decision-making when weighing the costs associated with a removal or mitigation project. As infrastructure continues to age, more cost-benefit analyses will be conducted and understanding the potential impacts upon upstream property values will be essential as there could be changes resulting in decreased property value around a reservoir, decreased median household value for the surrounding communities, and decreased tax revenue as a result of the decreased property values. Key terminology which will be used frequently throughout this paper is the following:

- Shoreline – the area at which Fort Loudoun Lake and the surrounding land meet
- Reservoir – the man-made body of water, Fort Loudoun Lake, created through impoundment of water by Fort Loudoun Dam
- Reservoir Size – the man-made body of water's surface area
- Upstream – everything that is above and behind the dam and in the direction that is opposite to the flow direction of the Tennessee River
- Storage Capacity – the volume of water in cubic meters (m^3) that a reservoir can hold due to impoundment from a dam
- Property Values – assessed values calculated by a county assessor for purposes of local tax collection. Property valuation for Blount County, TN is categorized as Residential, Forest, Agricultural, Farm, Industrial, Education/Science/Charitable, Commercial, Religious, Federal, State, City, County, and Other Exempt

This research answers the following questions:

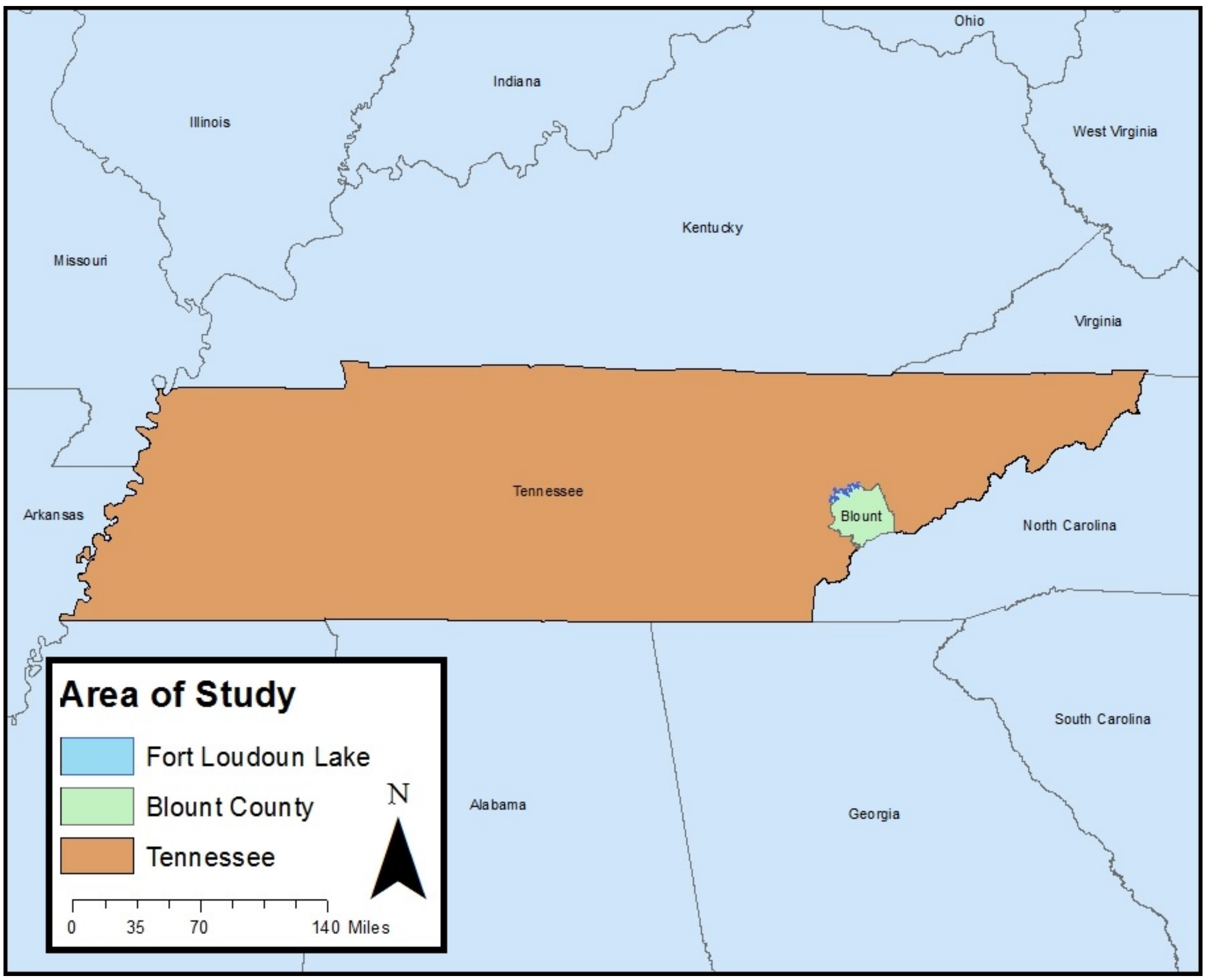
1) Does the size of a dam and/or its reservoir affect property values?

2) Does the distance from a lake's shoreline affect property values?

3) How will upstream residential property be affected by the depletion of the reservoir due to either a failure or removal of the dam structure?

4) What are the economic impacts on upstream residential property value and tax revenue due to a depletion of a reservoir?

Figure 7: Map of Area of Study (Tennessee, Blount County)



Chapter 2: Literature Review

Recently, a lot of emphasis has been placed on the negative side of dam structures, such as the environmental impact of impounding a waterway. Most people see a dam as a producer of hydroelectric energy, but fail to note other key purposes, including flood control, navigation, public drinking water supply, and recreation. There are also social and economic benefits to a dam structure, due to impounded lakes presenting an aesthetic, scenic value and the navigable waterway's use for shipping of goods. However, to better understand the benefits afforded to an area by the building and operation of dam structures, one can find no better example than the large dam system of the Tennessee Valley Authority (TVA). Created in 1933, the Tennessee Valley Authority was envisioned as a way of producing cheap electricity and controlling frequent, destructive floods within its namesake river valley. TVA came to fruition during the Great Depression, where 2.3 million people lived within the mostly rural conditions of the Tennessee Valley region. There were several medium sized cities along the Tennessee River, such as Knoxville and Chattanooga in Tennessee, Muscle Shoals in Alabama, and Paducah in Kentucky. However, in 1933, less than 25% of the 2.3 million people in the area lived in urban environments. The geographic area that TVA became responsible for is a watershed that is roughly the size of Great Britain - a large physical area to develop and maintain (Holland, 1988).

In the 1930s, when TVA was established, the Tennessee River was not the navigation-friendly waterway that it is today. Large flooding events occurred on a frequent basis and the river was subject, in many areas, to extremely shallow depths as low as half a meter in some places and shoals that placed a danger upon navigation of any larger vessels (Holland, 1988). This lack of navigation capabilities drastically hindered economic and social development of the Tennessee River Valley and prevented the region's connectivity to the rest of the eastern United States through its valuable river system (Holland, 1988). With the building or purchase of numerous existing dam structures, TVA has been able to create a system of navigation locks and a channel of at least 3.5 meters depth for the Tennessee River's 1,050 kilometer length. TVA's creation of a navigable Tennessee River now provides the region with direct access to 21 other states, the Gulf of Mexico, and the Atlantic Ocean (Holland, 1988).

With a storage capacity in its reservoirs of approximately 14.8 billion cubic meters, TVA has been able to effectively operate its numerous dams and reservoirs to prevent massive, destructive flooding along the Tennessee River's waterways (Holland, 1988). TVA manages flood control by lowering the levels of their reservoirs in the fall, prior to the typical flood season during the winter. Following the increased rainfall of the winter and spring, the reservoir levels are then slowly drawn down during the summer months, in order to increase water flow for navigation, hydroelectric energy production, and downstream water supply. Once down to lower levels, the reservoirs are then prepared to begin the cycle once again (Holland, 1988). Looking at TVA's flood control program from an economic standpoint one easily sees the benefits gained. The city of Chattanooga, due to its location in a bend of the Tennessee River, has a long history of major flooding. Since TVA built its first dam, Norris in 1936, flood damages from 1936 – 1986 have totaled $39 million. This is in comparison to the estimated damages of $2.6 billion Chattanooga would have faced and over $3 billion in damages that would have occurred within Chattanooga and other parts of the Tennessee, Ohio, and Mississippi River systems (Holland, 1988).

A key benefit of dams is the social benefit provide through recreational and scenic opportunities afforded by the large reservoirs which they impound and their surrounding lands. TVA's reservoirs and their shorelines contain more than 253,000 hectares of surface water and 17,700 kilometers of shoreline, respectively. These large areas have allowed for the creation of numerous public parks, wildlife management area and refuges, and parts of the Great Smoky Mountains National Park. Upon these reservoirs and surrounding lands are more than 37,000 boats or houseboats, over $300 million in economic influx from second home owners, boat manufacturing, and vacationers, and hunting grounds for more than 40,000 visitors (Holland, 1988).

Finally, what is probably the most recognized and known benefit of these dams is the hydroelectric energy production. Although not the largest method of energy production employed by TVA, hydroelectric generation represents approximately 14% of the agency's 32,089 megawatts of power generation capabilities of nearly 4,500 megawatts (Holland, 1988). This hydroelectric energy production in the Tennessee River Valley has allowed for cheaper utility rates that have encouraged economic development within the area.

Unfortunately, as often is the case with man-made structures that manipulate the natural environment in some way, there are negative aspects that counter the benefits. A worst-case scenario, when it comes to the building and maintaining of dams is the possible failure of the structure. Most work that investigates mitigation for dam failure has focused on smaller dams, as few larger dams have failed. For instance, in the United States, the only large dam to fail has been the Teton Dam in Utah. Although there is still no consensus within the scientific and engineering communities as to what caused the failure, there was limited economic impact caused by the failure (other than the dam itself) due to its western location and its lack of proximity to developed areas. Also, the Teton Dam failed as the reservoir was being filled for the first time so did not have its maximum reservoir capacity being held back (Seed & Duncan, 1987). Although no deaths occurred as a result of the Teton Dam's failure, a large dam's failure can have an extreme impact on the population, as demonstrated by the August 8, 1975 failures of the Banqiao and Shimantan Dams in China that resulted in the failure of 60 other, smaller dams and the deaths of over 85,000 people (ENR.com, 2003).

An excellent example of research and methodology into dam failure mitigation was conducted in Australia. While at the Centre for Resources and Environmental Studies at the Australian National University, David Smith conducted research into the economic impact of a failure of the Googong Dam on the cities of Queanbeyan and Canberra in the Australian Capital Territory. Smith was able to calculate the financial worth of making improvements to the dam compared to potential losses from annual flooding and a potential failure. He made these calculations by using maps of worst-case flooding caused by a failure of the Googong Dam and data collected on the structures within the limits of flooding in Queanbeyan and Canberra that investigated building locations and materials they were made from. Smith also concluded that even after improvements are made to the dam structure, emergency plans and warning systems for failure need to be maintained. He stressed that 35 percent of all dam failures involve water overtopping the structure (Smith, 1990).

Another method for mitigating the impact of a dam failure is by modeling the potential flooding caused by a dam-break. Using GIS and Light Detection and Ranging

(LiDAR) data, Gallegos, Schubert, and Sanders (2009) were able to create the first accurate 2D Digital Terrain Model (DTM) of flooding that could occur from a dam failure. The group studied the Baldwin Hills Reservoir in Los Angeles, California and the dam-break that occurred on December 14, 1963. Using the observed data on areas of flooding and comparing to their DTM, they accurately matched up their predicted flood areas with the true extent of flooding (Gallegos, et al., 2009).

As stated previously, most work on dam removal has occurred with smaller dams and the work that has been completed or is underway on large dams is in the western United States. Kuby, Fagan, ReVelle, and Graf (2005) conducted a study on modeling for large dam removal in the Willamette Valley of Oregon. Using dam information from the Columbia Basin Ecosystem Management Project (ICBEMP), upstream watershed size from the US Army Corps of Engineers National Inventory of Dams (USACE NID), and storage and hydroelectric capacity from both the USACE NID and Oregon Water Resources Department, they modeled the positive and negative effects dam removal may have. The study concluded that while there may be negative environmental impact of dams, there also can be positive environmental impact. The major emphasis was placed on salmon passage through the area and how the dam removal would positively and negatively affect the population while considering the decrease in reservoir levels and hydropower production as the key trade off. While the story determined that removing only 12 dams from the Willamette River would reconnect 52% of the watershed, that action would only decrease 1.6% of hydroelectric energy production and reservoir capacity (Kuby, et al., 2005). In terms of a dam's positive effects, the authors concluded that there are some environmental benefits to dam removal, such as preventing spread of invasive species and extending salmon breeding grounds.

Removal of a dam should only be done after studying the impact of removal on a river's entire watershed (Kuby, et al. 2005).

In studying the effects of dam removal on the fluvial geomorphology of the original river channel, a 10 kilometer area of the Pine River in Michigan was investigated before and after removal. Changes of the river channel were studied annually from 1996-2003 while the Stronach Dam was being removed and then from 2004-2006, after removal. The study determined that the majority of sediment in the upstream reservoir remained in place and resulted in the reservoir reverting back to the original river channel, with a slightly deeper channel and faster flowing water (Burroughs, Hayes, Klomp, Hansen, & Mistak, 2009).

In previous research conducted on property values and dam removal on the Kennebec River in Maine, Lewis, Bohlen, and Wilson (2008) acknowledge that their study is possibly the first investigation into this aspect of dam removal. Bohlen and Lewis (2009) also conducted research into the effects of a dam's removal on adjacent property values using GIS. Their research into dam removal in Maine was conducted by using ESRI ArcGIS and ArcView to map geographic data, real estate data from Multiple Listing Service (MLS), income information from the US Census Bureau, and information on hydropower dams in the area from the Department of Environmental Protection. Using these data sources, they were able to statistically analyze the data to determine that removal of dams can result in a negative effect upon a reservoir's adjoining land. Any land that may be along a reservoir would no longer be waterfront if a dam was to be removed or fail, due to the lowering of water levels. Ultimately, Bohlen and Lewis (2009) concluded that to understand the impact of a dam removal project, economic considerations must be taken into account along with the environmental considerations.

Another study conducted on the effects on property value from dam removal took place in Wisconsin. In the study, the researchers used hedonic economic analysis of residential property sales to determine differences between property values in three types of areas: where a small dam exists, where a small dam was removed, and where the water feature has been free flowing for the past 20 years (Provencher, Sarakinos, & Meyer, 2008). Hedonic economic analysis entails calculating the impact that aesthetic values such as a scenic view or proximity to a park or water body have upon residential property value. The analysis determined that there is no significant difference in prices between properties located on an impounded reservoir and those on a free-flowing river or stream. The researchers also determined that properties that were located within the vicinity of a free-flowing river or stream were more valuable than those found at similar distances and locations near impounded reservoirs (Provencher, et al. 2008).

In another study, Joshua Wyrick and his colleagues researched the social impacts that can occur when a dam is removed. Investigating small dams removed in New Jersey, the researchers used stream flow data from the USGS, land use data from the New Jersey Department of Environmental Protection (NJDEP), and non-scientific questionnaires of residents to conduct their study. A major problem identified in the removal of small dams is numerous private individuals that are involved and impacted. The dams that are removed are usually privately owned, while the reservoirs or lakes they hold back have shoreline properties that are owned by other private individuals. One private owner removing a dam can have a negative impact on other private owners upstream of the dam. Wyrick and his fellow researchers found in their study that residents were more worried about the negative impacts of dam removal, such as declining property values and loss of aesthetic benefits, whereas policy makers were more worried about the impact of a dam's failure (Wyrick, Rischman, Burke, McGee, & Williams, 2009).

Key to understanding the full environmental impacts of a dam's removal is to compare different, yet similar, areas over different times. That way one observes changes on a long and short term scale and accounts for variables that can skew observations. Martin Doyle and his colleagues conducted research into the impact of the removal of small dams in Wisconsin. In the study they researched multiple waterways that were at different stages of dam removal recovery. By doing this the authors were able to see the impacts on riparian vegetation, fish, macro-invertebrates, and mussels, and nutrients after a removal project. Studying the recovery of various aquatic ecosystem attributes provided the authors with better understanding of what does and does not work when planning for and executing a removal project and restoring the natural, surrounding environment. Also, the study provides an idea of the timeframe each project requires for any form of recovery/restoration to be noticed. Because of this difference in recovery/restoration times, the authors conclude that observers could mistakenly assume that there was no positive impact of dam removal on a particular attribute. They also conclude that environmental assessment of both full and partial recovery, as well as determination of attributes that will have no recovery, should be conducted in order to decide whether a dam should be removed and how (Doyle, 2005).

Another method at determining response over time involved use of aerial photography by Denine Schmitz and colleagues. In the study, using aerial photography of two different sites from various years, as well as two opposite sites, one that was a failure and one that was a removal, allowed the researchers to give varying perspectives for comparisons. Knowing that a dam failure typically occurs at peak flow and removal is done in stages for gradual increase in flow, they were able to better understand how the difference in amount of flow was ecologically beneficial. The researchers concluded that the effects of dam removal depend on how responsive the ecosystem is to the change in flow and the timing and size of flow. Also, they determined that aerial photography is a valid way to determine ecological response to dam removal (Schmitz, Blank, Ammondt, & Patten, 2009).

When investigating the planned removal of a dam, understanding the environmental condition prior to removal compared to the condition post-removal allows for comparison of changes. Wildman and MacBroom (2005) studied the pre- and post-removal conditions of two dams in Connecticut. In their study, they researched how the downstream bed channels were affected by the removal of the Anaconda and Union City dams. They conducted a hydraulic analysis of 43.5 km of the river and created a geomorphic model of the predicted future characteristics of the river bed. The pair also conducted analysis of the sediment and channel stability. As both dam removals were planned well in advance, extensive studies were undertaken on the pre-removal conditions. However, prior to the planned removal, the Anaconda Dam was breached and had to have an emergency removal of the spillway within a four-day span. The authors concluded that although not ideal or according to plan, the dam's premature failure provided excellent observation and analysis of the upstream and downstream channel to use for comparison to the planned removal of the Union City dam. Both of the river channels eroded just as predicted (Wildman & MacBroom 2005).

Another component to investigating the downstream effects of a dam on the ecological system is to account for the effects of downstream land use that is unrelated to the dam's operations. Eric Gordon and Ross Meentemeyer, in their study, used data collection of the downstream channel, vegetation, mapping of land use, and stream gauging as part of their research. By using the data collected, they were able to determine the effects on specific areas from land usage, particularly agriculture, and then use the data to determine the effects from the Warm Springs Dam. They saw that both land use and the dam had an effect and determined that downstream land use must be factored in when studying the environmental impact of a dam (Gordon & Meentemeyer, 2006).

Finally, realizing that removing a dam has an impact not only on its own watershed, but on others as well, William Graf specifically researched the interconnectivity to other watersheds and the downstream effects large dams have. Graf made an effort to detail just how impactful dams are on American waterways. He says that more than 75,000 6ft+ high dams impound some part of every American watershed. By using data on 36 of the larger dams in the country from the US Army Corps of Engineers (USACE) and US Geological Survey (USGS), Graf was able to study the effects on the downstream hydrology and geomorphology. His analyses concluded with four different aspects looked at: hydrology, geomorphology, correlations between hydrology and geomorphology, and regional aspects of the analysis. He shows that large dams have an effect on national stream flow, effectively maintain flood control on the short-term scale, and create large-scale changes in riparian vegetation that can be dependent upon the floods that dams hold back (Graf, 2006).

The previous studies undertaken into the varying aspects of dam removal or failure are vital to this study. As it has been stated that little to no research has been conducted into the impacts of large dam failure or removal in the eastern United States, studies of large dam structures in the western United States and small dam structures in the eastern United States can be combined to form a basis for this study into large dam structures in the eastern United

States. Each individual study provides the basis by which the methods involving georeferencing, determination of reversion of Fort Loudoun Lake to the pre-dammed Tennessee River, and calculation of changes of residential property values within this study are conducted.

Chapter 3: Methods

This study is composed of two parts. First, examination is conducted into the relationship between all 44 large dams in the TVA system and the median household values for the counties in which those dams lie. Second, examination is conducted into the relationship between upstream residential property values in Blount County, TN and its distance from Fort Loudoun Lake's shoreline today and where the shoreline would be, based on the location of the Tennessee River in pre-dam 1936. The methods for this research use IBM SPSS for statistical analysis and geographic information systems (GIS). Using information from the USACE, US Census Bureau, and county parcel data of assessed property values, a statistical regression model of the relationship between all 44 large TVA dams and median household value for the surrounding counties was created. This method enables an understanding of the impacts the size of a dam structure and/or reservoir have on current overall property value in a county that includes a TVA dam. Data on TVA owned dam structures was obtained from the US Army Corps of Engineers National Inventory of Dams (USACE NID) database and Median Household Value from the 2010 US Census.

The purpose of this research is to determine what effect the failure or removal of a large dam structure would have on upstream residential property values. In particular, the goal is to estimate the potential change in property values and the resulting change in property tax revenue for the county. With these values determined, the results will then be used within a cost-benefit analysis to allow decision-makers to have an additional variable by which to judge whether a future mitigation or removal project should be undertaken. Other studies have been conducted to determine the economic impacts from a dam's failure or removal on downstream areas, but through the methods undertaken in this research, it may be determined that the costs associated with property value decreases and lost property tax revenue could sway the results of a cost-benefit analysis from one side to the other.

This study was conducted in order to answer the following preliminary research questions:

1) Does the size of a dam and/or its reservoir affect property values?

2) Does the distance from a lake's shoreline affect property values?

Initial analysis consisted of using the USACE NID data of the large dams within the TVA system and Median Household Value data of each dam's county, taken from the US Census' 2006-2010 American Community Survey to understand any effects that a dam structure and its reservoir may have on residential property value and to determine average property values of the counties in which TVA has a large dam structure. The American Community Survey data was used, as opposed to the decennial Census, in order to have numbers from the US Census that was produced as close as possible to the same time as the information from the USACE NID. The following steps were conducted to understand this relationship:

1) USACE NID

- Ensured that only large structures (50+ ft.) were included
- Eliminated dam structures with no reservoir capacities, such as those used only as emergency spillways

- Sorted through data to include only the following relevant information for analysis: Dam Name, County/State of Location, Dam Height, and Reservoir Storage Capacity

2) US Census Bureau

   - Sorted through Median Household Value data to include only information for the states in which TVA has dam structures: Alabama, Georgia, Kentucky, North Carolina, Tennessee, and Virginia
   - Once this data was collected I then sorted through to include only the counties in which dam structures are located

The two data sets were combined and implemented into IBM SPSS 19 to conduct statistical analysis, beginning with a Kolmogorov-Smirnov Test to determine the normality of the distribution. Once normality among the distribution of the variables was determined correlation tests between dam height and reservoir capacity and between reservoir capacity and median household value were conducted. Additional statistical analysis was conducted on the residential properties along Fort Loudoun Lake, within each 2012 and 1936 buffered distances in relation to appraised value vs. acreage. This analysis was conducted, as well, in order to determine what effects, if any, the size of a property's lot size had upon value. The following (Figure 8) is the combined dataset by which statistical analysis of TVA's 44 large dam structures and the counties in which they lie was conducted:

Figure 8: Large TVA Dams and County Median Household Value

County	State	Dam Name	NID Height (ft.)	NID Storage Capacity (m3)	Total Households	Median Household Value ($)
Colbert	AL	Wilson	137	640200	16293	94700
Franklin	AL	Cedar Creek	96	105740	8557	78200
Franklin	AL	Little Bear Creek	84	45320	8557	78200
Franklin	AL	Bear Creek	68	37800	8557	78200
Lauderdale	AL	Wilson	137	640200	27521	107400
Lauderdale	AL	Wheeler	72	1071000	27521	107400
Lawrence	AL	Wheeler	72	1071000	10558	97600
Marion	AL	Upper Bear Creek	85	37400	9665	74700
Marshall	AL	Guntersville	94	1048700	24955	101300
Fannin	GA	Blue Ridge	175	195900	8498	172400
Union	GA	Nottely	197	174300	7392	197000
Livingston	KY	Kentucky	206	6129000	2943	76800
Marshall	KY	Kentucky	206	6129000	10481	96900
Cherokee	NC	Hiwassee	307	434000	9569	146100
Cherokee	NC	Apalachia	150	57800	9569	146100
Clay	NC	Chatuge	150	240500	3756	163000
Graham	NC	Fontana Lake	480	1443000	2948	119000
Graham	NC	Fontana/Emergency Spillway	55	587328	2948	119000
Swain	NC	Fontana Lake	480	1443000	4474	114600
Anderson	TN	Norris	265	2552000	22202	116400
Bedford	TN	Normandy	110	72000	10977	114400
Campbell	TN	Norris	265	2552000	11366	86400
Carter	TN	Watauga	332	677000	17543	92700
Carter	TN	Wilbur	76	715	17543	92700
Coffee	TN	Normandy	110	72000	15080	119200
Franklin	TN	Tims Ford	175	608000	12177	110700
Grainger	TN	Cherokee	175	1541000	7113	89900
Greene	TN	Nolichucky	94	2630	20887	104200
Hamilton	TN	Chickamauga	129	739000	87802	147200
Hardin	TN	Pickwick Landing	113	1105000	8112	86600
Jefferson	TN	Cherokee	175	1541000	14663	122600
Loudon	TN	Tellico	129	447300	15149	166400
Loudon	TN	Fort Loudoun	125	393000	15149	166400
Loudon	TN	Melton Hill	103	126000	15149	166400
Marion	TN	Raccoon Mountain	230	36340	8706	107400
Marion	TN	Nickajack	81	252400	8706	107400
Meigs	TN	Watts Bar	112	1175000	3445	107000
Polk	TN	Ocoee No. 1	135	85200	5094	96300
Polk	TN	Ocoee No. 3	110	2870	5094	96300
Rhea	TN	Watts Bar	112	1175000	8837	102600
Roane	TN	Melton Hill	103	126000	17367	118900
Sevier	TN	Douglas	202	1461000	25813	155500
Sullivan	TN	South Holston	285	658000	50445	110500
Sullivan	TN	Boone	160	193500	50445	110500
Sullivan	TN	Fort Patrick Henry	95	26900	50445	110500
Warren	TN	Great Falls	92	51300	10949	90400
Washington	TN	Boone	160	193500	33341	136700
White	TN	Great Falls	92	51300	7526	94600
Washington	VA	Beaver Creek	85	5020	16853	126100
Washington	VA	Clear Creek	51	2825	16853	126100

The second part of this study provides a spatial analysis of the case study area (Fort Loudoun Dam) and the surrounding lake front and lake view property, conducted through parcel data of county assessed property value and use of GIS. Through ArcMap 10, lakefront, lakefront-1/4 mile, 1/4-1/2 mile, 1/2-3/4 mile, 3/4-1 mile, and 1-2 mile buffers from the shoreline were created in order to analyze distance relationships between the current shoreline and the upstream properties. This spatial analysis provides insight into the role distance from the reservoir's shoreline has upon property values. The analysis utilizes TVA maps from 1936 to identify residential parcels along the Tennessee River, prior to the dam's construction, and how shoreline has changed from its pre-reservoir state to the present. This analysis between past and present shorelines provides insight into the likely locations that the current reservoir will recede to after Fort Loudoun Dam either fails or is removed. Comparing the pre-reservoir Tennessee River shoreline to the current Fort Loudoun reservoir shoreline allows understanding of the distance increase that current properties become from the lakefront, allowing for estimation of property value declines. Properties that are at a current distance calculated based on the current 2012 shoreline, other than the 36 that were lakefront to begin with in 1936, will become located at a greater distance based on where the shoreline would be after depletion of Fort Loudoun. For example, a vast majority of the properties that are currently lakefront or within a quarter-mile will become located three-quarters of a mile to a mile or one to two miles away from the shoreline. Finally, using the decreased amounts of property values, calculated by comparing the average and sum totals of residential property values within each 2012 and 1936 shoreline-based buffered distance estimates of losses within each buffered distance, the two mile area as a whole and the potential loss in county-collected property taxes are presented.

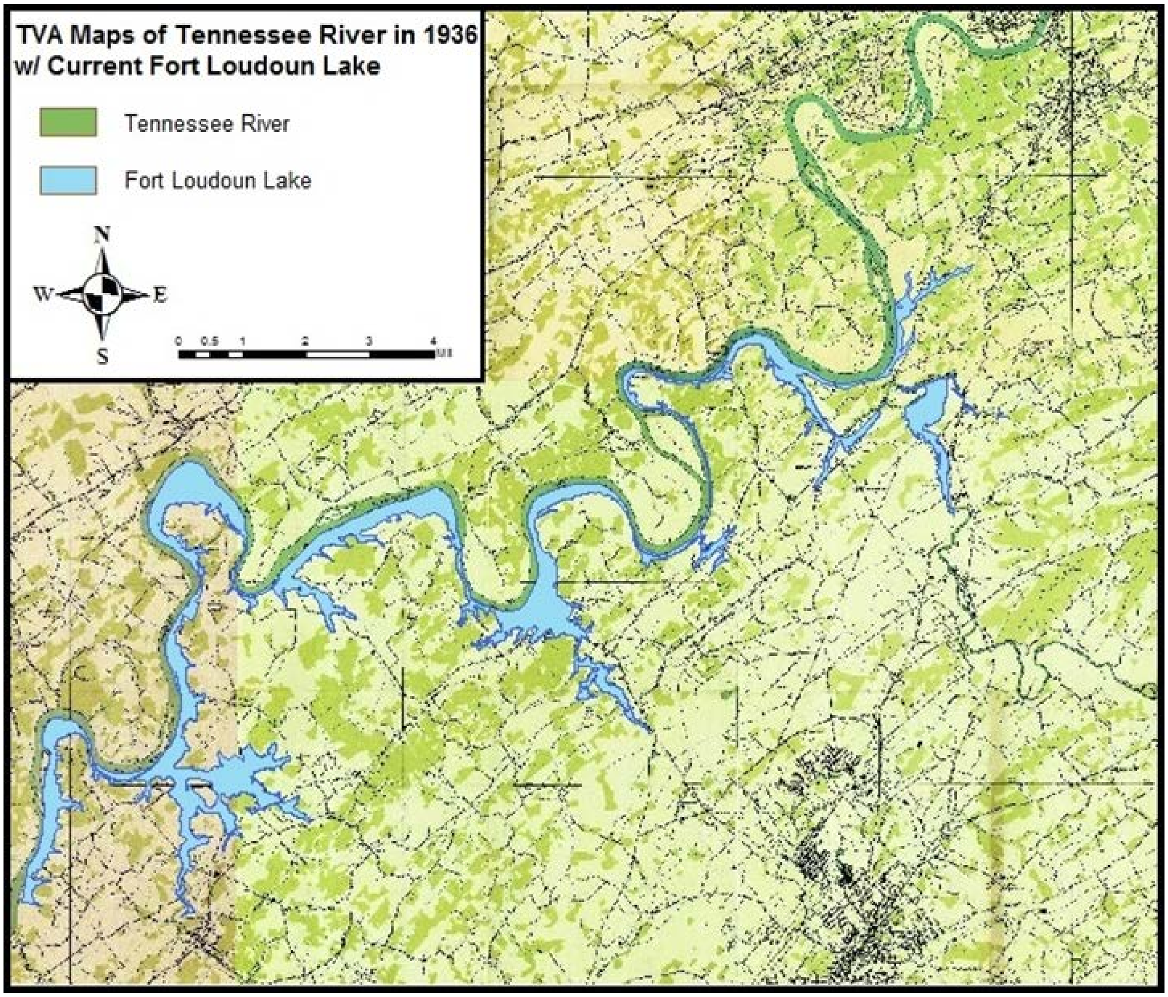
This study includes residential parcels from one of three counties that have shoreline on Fort Loudoun Reservoir. Using data from Blount County, TN this research provides a demonstration or case study of the methods by which future study can be conducted to examine the impact of the removal of a dam on a reservoir. Parcel data was not available from the other two counties that border Fort Loudoun Lake, Knox and Loudon. The data used in this research came from GIS parcel data provided by the Blount County GIS Group (2012), courtesy of GIS Manager Mr. Raymond Boswell, GISP. The parcel data file included the entire county's property information, ranging from parcel property size to appraised values used for assessed property tax values for 2012. Of this parcel data, the following attributes were used within this study: property size (in acres), land value, improved value, and 2012 appraised value. In accordance with the Constitution of the State of Tennessee, the Blount County Property Assessor's Office is tasked with creating a roll of assessment for their approximately 60,000 parcels on an annual basis (Blount County, 2012). Additionally, historical maps of the Tennessee River in 1936, prior to the construction of Fort Loudoun Dam, were provided by the Tennessee Valley Authority (TVA) and used to determine the location of the Tennessee River's shorelines prior to the reservoir's existence.

Geospatial analysis was conducted in order to answer the following primary research questions:

1) How will upstream residential property be affected by the depletion of the reservoir due to either a failure or removal of the dam structure?

2) What are the economic impacts on upstream residential property value and tax revenue due to a depletion of a reservoir?

Figure 9: Combined Study Area Map of TVA Quadrangle Maps (Bearden, Concord, Knoxville, Louisville, Lovell, and Maryville) (U.S. Geological Survey 1936)



Using the 1936 TVA maps of the study area as base maps (Figure 9), georeferencing was conducted to identify where the Tennessee River's historic river channel existed in comparison to current maps and aerial imagery from Google. Where the river once existed, according to previously mentioned research into river channel geomorphology, by Burroughs, et al. (2009), can be determined to be where the reservoir would revert. Once this process was completed, buffered distance layers were created within ESRI ArcMap 10 of the Blount County parcel data, based upon where Fort Loudoun Lake's shoreline exists today and where the Tennessee River's shoreline existed prior to the dam's construction. Creating a shape file of the current area of Fort Loudoun Lake in relationship to the previous Tennessee River allowed for visualization of a TVA flooded lands layer that displayed those areas of Blount County that were, prior to the construction of Fort Loudoun Dam, not underwater and make up the current lake.

Buffered distance layers of Fort Loudoun Lake include:

1) Lakefront
2) Between Lakefront and a quarter mile
3) Between quarter and half mile
4) Between half and three-quarters mile
5) Between three quarters and one mile
6) Between one and two miles from Fort Loudoun's shoreline

Buffer layers, reflecting residential parcels, were then created in order to compare parcel property values by distance from the shoreline (Figures 10 and 11). In order to account for errors in digitization of the Tennessee River's 1936 shoreline and ensure quality-control, as outlined by Favretto (2012), a ten foot margin of error was created in regards to the buffered selection of parcels that were defined as lakefront in 1936. Within the selected parcels, filtering of the data was then conducted to create layers only consisting of residential property parcels. Some properties were designated by the count as farm or agricultural areas; these parcels are not included in this study. Even though many of the agricultural and farm designated parcels include residential structures, we determine to exclude them from this study. Agricultural and farm designated properties have a lower property assessment value and would not accurately reflect a comparable value to residential properties. The county assesses the value of farmland and agricultural properties using different rates and methods to those used to assess residential property value. This study uses only residential property for analysis and will also provide conclusions that impact a greater amount of the population that lives upstream from the dam structure. Within each buffered distance layer, the total values of all residential properties and the average value was determined in order to conduct comparison between the values within each buffered distance from the 2012 and 1936 shorelines. This comparison was necessary so that the changes in total values and average values of residential properties could be determined.

Once the total and average prices of all residential property parcels within the buffered distances for the 2012 and 1936 shorelines were determined, the total property tax revenues and potential losses within each buffered distance were calculated using the current formula by which Blount County assesses residential property, $2.36 per $100 of 25% of assessed value. For example, using the formula by which Blount County assesses for property taxes, a residential property with an assessed value of $100,000 would be taxed $590 ($100,000 * 25% = $25,000 / $100 = $250 * $2.36 = $590).

Using the values within the different distance buffer layers based on the 2012 and 1936 shorelines, a comparison was made to determine the possible loss in property values and revenue from property taxes. It should be noted that a key assumption in this study is that residential property values are influenced by their distance from the shoreline. If the shoreline changes as a result of the removal of the dam and the reservoir shoreline changes, then the distance of a parcel from the shoreline might also change. This study thus compares the actual value of residential parcels within five buffers with a set of residential parcel buffers constructed from the 1936 Tennessee

River shoreline. Note that the constructed 1936 parcel buffers are based on current parcel values.

Figure 10: Map of Properties Based on 2012 Shoreline Distances

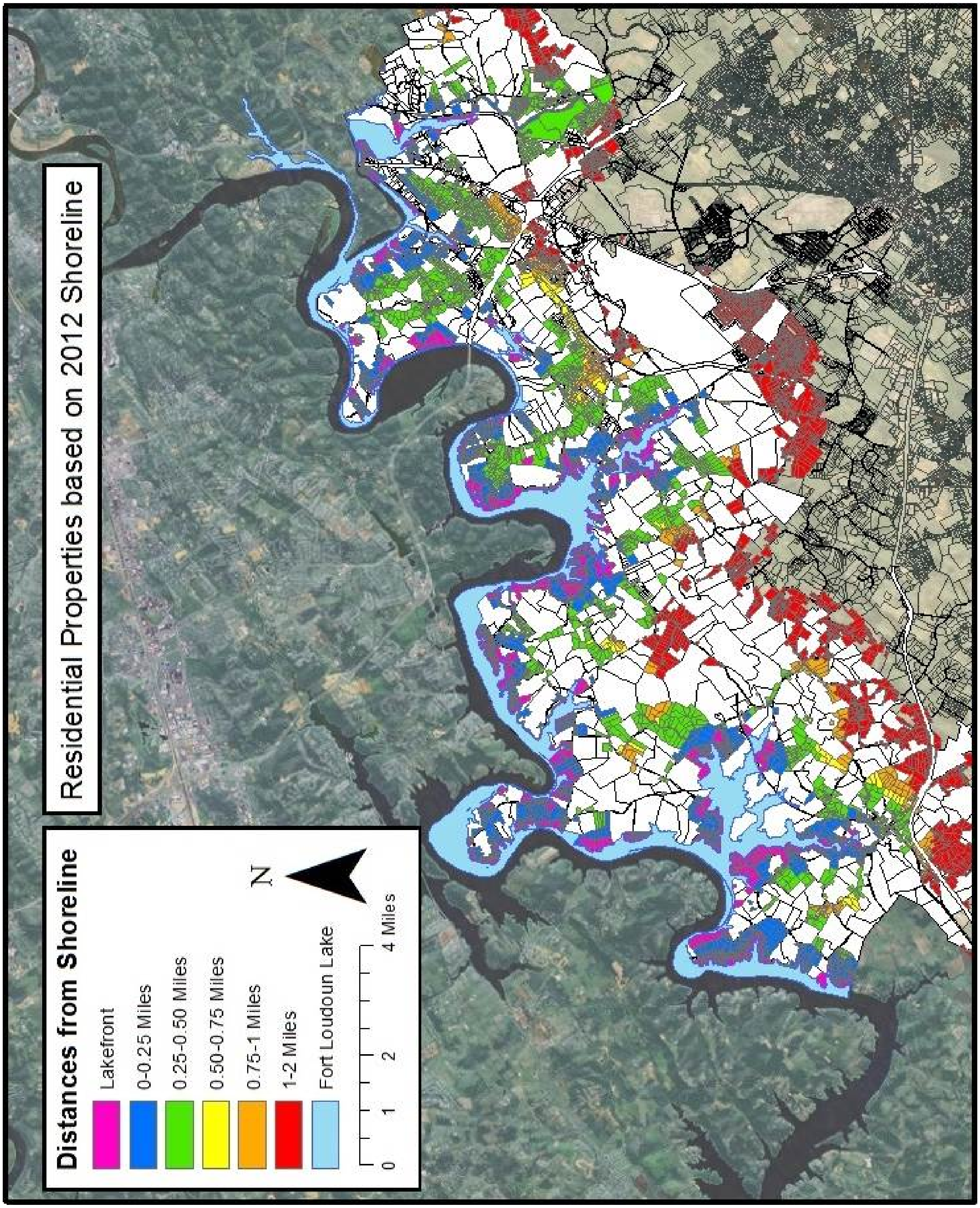
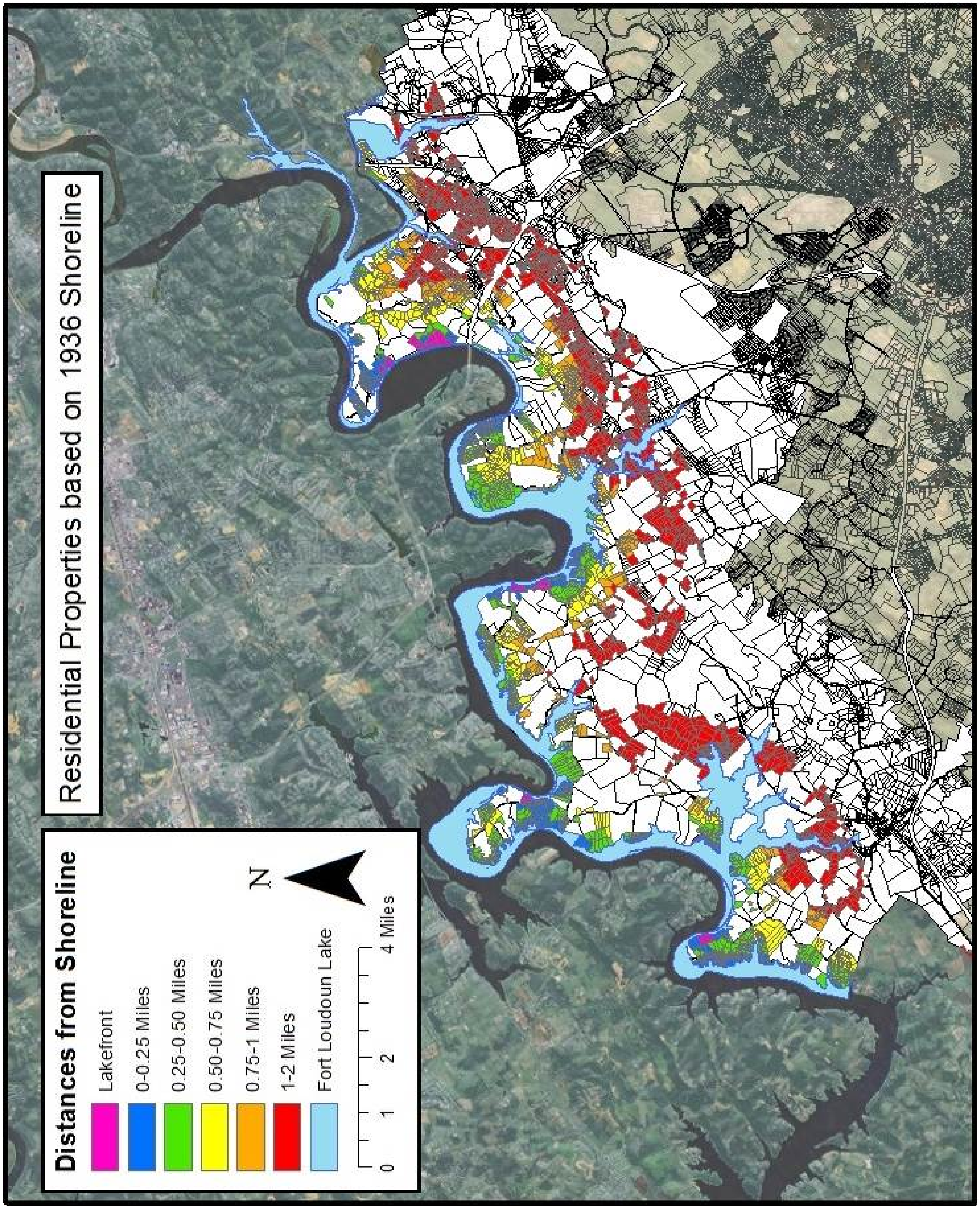


Figure 11: Map of Properties Based on 1936 Shoreline Distances



Chapter 4: Results and Discussion

1) Does the size of a dam and/or its reservoir affect property values?

Determining the answer to this question began with comparing the height of the 44 large TVA dam structures to the storage capacity of their upstream reservoirs. Using a Pearson Correlation test, results of .339 Pearson Correlation, 2-tailed significance of 0.16, and N value of 50 (height in feet) show that there is a significant correlation at the 0.05 level between the height of the structure and the reservoir storage capacity created by the dam. So, as can be assumed, the larger the dam structure the larger the reservoir. Next, when analyzing the correlation between the reservoir storage capacity and median household value of the 37 counties which large TVA dams exist, results of -.221 Pearson Correlation, 2-tailed significance of .122, and N value of 50 determine that there is not a significant relationship between the two variables and the relationship between the two is fairly random, with no noticeable commonalities. This lack of correlation can be attributed to median household value's inclusion of property values of an entire county and not specifically including only those properties where the value is impacted by proximity to the lake, such as localized parcel data. After analyzing the relationship between the dam structures and their reservoirs and then between the reservoirs and median household value, it is determined that the size of a dam and/or its reservoir's storage capacity does not have any effect on upstream property value. Future analysis could follow the same steps but use localized parcel data for each county instead of median household value, in order to ensure that only those properties within a certain distance of the reservoir and dam are analyzed.

2) Does the distance from a lake's shoreline affect property values?

In order to answer this statistical question, the correlation between the distance from the shoreline and property value is calculated based upon the distances to the 1936 shoreline, there is no significant correlation between distance and value at any of the six studied distances (Table 1). However, when the same analysis is made of the current, 2012 shoreline, there is significant correlation between the quarter mile and one mile distances (Table 2). This analysis shows that the distance that a residential property is from Fort Loudoun Lake has, for the most part, no statistical correlation to the residential property value. In order to understand, in part, why no correlation exists between the distance from the water and property values, the question could then be raised as to whether other factors could contribute to residential property value in terms of proximity to the shoreline.

Table 1: Pearson's Correlation: Property Values and Distance (1936)

Residential Property Values based on Distance from Fort Loudoun Lake (1936 Waterline)

		1936 - 2.00 Mile - Appraised Value	1936 - 1.00 Mile - Appraised Value	1936 - 0.75 Mile - Appraised Value	1936 - 0.50 Mile - Appraised Value	1936 - 0.25 Mile - Appraised Value	1936 - Lakefront - Appraised Value
1936 - 2.00 Mile - Appraised Value	Pearson Correlation	1	-.041	.032	-.016	.048	.108
	Sig. (2-tailed)		.304	.303	.455	.215	.532
	N	2863	635	1014	2273	668	36
1936 - 1.00 Mile - Appraised Value	Pearson Correlation	-.041	1	.014	-.024	-.055	.053
	Sig. (2-tailed)	.304		.727	.549	.166	.760
	N	635	635	635	635	635	36
1936 - 0.75 Mile - Appraised Value	Pearson Correlation	.032	.014	1	.049	-.037	-.243
	Sig. (2-tailed)	.303	.727		.122	.334	.153
	N	1014	635	1014	1014	668	36
1936 - 0.50 Mile - Appraised Value	Pearson Correlation	-.016	-.024	.049	1	-.020	-.274
	Sig. (2-tailed)	.455	.549	.122		.610	.106
	N	2273	635	1014	2273	668	36
1936 - 0.25 Mile - Appraised Value	Pearson Correlation	.048	-.055	-.037	-.020	1	.152
	Sig. (2-tailed)	.215	.166	.334	.610		.376
	N	668	635	668	668	668	36
1936 - Lakefront - Appraised Value	Pearson Correlation	.108	.053	-.243	-.274	.152	1
	Sig. (2-tailed)	.532	.760	.153	.106	.376	
	N	36	36	36	36	36	36

Table 2: Pearson's Correlation: Property Values and Distance (2012)

Residential Property Values based on Distance from Fort Loudoun Lake (2012 Shoreline)

		2012 - Lakefront - Appraised Value	2012 - 0.25 Mile - Appraised Value	2012 - 0.50 Mile - Appraised Value	2012 - 0.75 Mile - Appraised Value	2012 - 1.00 Mile - Appraised Value	2012 - 2.00 Mile - Appraised Value
2012 - Lakefront - Appraised Value	Pearson Correlation	1	.006	-.040	-.004	-.016	-.007
	Sig. (2-tailed)		.825	.171	.906	.678	.819
	N	1200	1200	1200	1014	635	1200
2012 - 0.25 Mile - Appraised Value	Pearson Correlation	.006	1	-.022	-.049	.084*	.006
	Sig. (2-tailed)	.825		.296	.122	.033	.728
	N	1200	3029	2273	1014	635	2863
2012 - 0.50 Mile - Appraised Value	Pearson Correlation	-.040	-.022	1	.040	-.023	.022
	Sig. (2-tailed)	.171	.296		.202	.564	.286
	N	1200	2273	2273	1014	635	2273
2012 - 0.75 Mile - Appraised Value	Pearson Correlation	-.004	-.049	.040	1	-.021	-.002
	Sig. (2-tailed)	.906	.122	.202		.596	.961
	N	1014	1014	1014	1014	635	1014
2012 - 1.00 Mile - Appraised Value	Pearson Correlation	-.016	.084*	-.023	-.021	1	-.039
	Sig. (2-tailed)	.678	.033	.564	.596		.328
	N	635	635	635	635	635	635
2012 - 2.00 Mile - Appraised Value	Pearson Correlation	-.007	.006	.022	-.002	-.039	1
	Sig. (2-tailed)	.819	.728	.286	.961	.328	
	N	1200	2863	2273	1014	635	2863

*. Correlation is significant at the 0.05 level (2-tailed).

As there was no statistical correlation between residential property value and distance from the shoreline, countering what could be common belief that being closer to water has a positive correlation with value, further statistical analysis was conducted using one possible, major impacting variable: lot size. Using a Pearson's Correlation test (Tables 3-14), it was determined that correlation was significant in all of the 2012 shoreline distances and all but one of the 1936 shoreline distances: the properties that are lakefront, based on the 1936 shoreline. Statistical testing found no correlation between residential property values and distances from the shoreline, but did find correlation between residential property values and lot size in all study areas, except that of lakefront properties based on the location of the 1936 shoreline. In the case of this study, the properties within the lakefront buffered distance of the 1936 shoreline would be the only properties to remain as waterfront properties, albeit on a flowing river, if Fort Loudoun Lake were no longer to exist. Another possible explanation of why the properties that would remain lakefront would have no correlation between their values and the lot size could be that, historically, the properties have always been waterfront and the prices have reflected that over time. However, without a more detailed analysis like that offered through hedonic economics, the explanation for this buffered distance's difference in correlation compared to all of the others can only be left to assumptions and educated guesses. According to Nijkamp and Batabyal (2011), hedonic analysis of property value consists of the following steps:

1) …obtain as much information as possible about the traits: structural, neighborhood, and environmental quality of all houses (in what is hopefully a large sample), along with their property values and/or contract rent. In an ideal world, the property value (the dependent variable) would be the actual sales price,

but sometimes information is used from multiple-listing books, scaled up or down by the going ratio of list price to exchange price.

(2) Next, regress the dependent variable, property value, against its structural and neighborhood determinants. Note that this examination involves many possible functional forms and that non-linearities, synergisms, etc. may be important. …there is little theoretical guidance on the nature of the functional relationship between property values and their determinants which enables researchers accidentally, and advocates intentionally to publish very different conclusions, even from identical raw data.

(3) The coefficients on the environmental quality variables reveal how much impact a given change in environmental quality has on property values for average households. That is, the trade-off between environmental quality and other goods can be directly measured, and since higher environmental quality is a desired trait, we expect to observe higher house prices or rents in cleaner areas, other things equal. (Nijkamp and Batabyal, 2011)

Table 3: Pearson Correlation: Lakefront Values and Acreage (1936)

Lakefront Properties (1936 Shoreline)

		1936 - Lakefront - Acreage (Acres)	1936 - Lakefront - Appraised Value
1936 - Lakefront - Acreage (Acres)	Pearson Correlation	1	.217
	Sig. (2-tailed)		.203
	N	36	36
1936 - Lakefront - Appraised Value	Pearson Correlation	.217	1
	Sig. (2-tailed)	.203	
	N	36	36

Table 4: Pearson Correlation: Values within 0.25 Miles and Acreage (1936)

Properties within 0.25 Miles (1936 Shoreline)

		1936 - 0.25 Mile - Acreage (Acres)	1936 - 0.25 Mile - Appraised Value
1936 - 0.25 Mile - Acreage (Acres)	Pearson Correlation	1	.171**
	Sig. (2-tailed)		.000
	N	668	668
1936 - 0.25 Mile - Appraised Value	Pearson Correlation	.171**	1
	Sig. (2-tailed)	.000	
	N	668	668

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5: Pearson Correlation: Values within 0.25-0.50 Miles and Acreage (1936)

Properties within 0.25-0.50 Miles (1936 Shoreline)

		1936 - 0.50 Mile - Acreage (Acres)	1936 - 0.50 Mile - Appraised Value
1936 - 0.50 Mile - Acreage (Acres)	Pearson Correlation	1	.293**
	Sig. (2-tailed)		.000
	N	825	825
1936 - 0.50 Mile - Appraised Value	Pearson Correlation	.293**	1
	Sig. (2-tailed)	.000	
	N	825	825

**. Correlation is significant at the 0.01 level (2-tailed).

Table 6: Pearson Correlation: Values within 0.50-0.75 Miles and Acreage (1936)

Properties within 0.50-0.75 Miles (1936 Shoreline)

		1936 - 0.75 Mile - Acreage (Acres)	1936 - 0.75 Mile - Appraised Value
1936 - 0.75 Mile - Acreage (Acres)	Pearson Correlation	1	.206**
	Sig. (2-tailed)		.000
	N	751	751
1936 - 0.75 Mile - Appraised Value	Pearson Correlation	.206**	1
	Sig. (2-tailed)	.000	
	N	751	751

**. Correlation is significant at the 0.01 level (2-tailed).

Table 7: Pearson Correlation: Values within 0.75-1.0 Miles and Acreage (1936)

Properties within 0.75-1.0 Miles (1936 Shoreline)

		1936 - 1.00 Mile - Acreage (Acres)	1936 - 1.00 Mile - Appraised Value
1936 - 1.00 Mile - Acreage (Acres)	Pearson Correlation	1	.273**
	Sig. (2-tailed)		.000
	N	552	552
1936 - 1.00 Mile - Appraised Value	Pearson Correlation	.273**	1
	Sig. (2-tailed)	.000	
	N	552	552

**. Correlation is significant at the 0.01 level (2-tailed).

Table 8: Pearson Correlation: Values within 1.0-2.0 Miles and Acreage (1936)

Properties within 1.0-2.0 Miles (1936 Shoreline)

		1936 - 2.00 Mile - Acreage (Acres)	1936 - 2.00 Mile - Appraised Value
1936 - 2.00 Mile - Acreage (Acres)	Pearson Correlation	1	.310**
	Sig. (2-tailed)		.000
	N	2460	2460
1936 - 2.00 Mile - Appraised Value	Pearson Correlation	.310**	1
	Sig. (2-tailed)	.000	
	N	2460	2460

**. Correlation is significant at the 0.01 level (2-tailed).

Table 9: Pearson Correlation: Lakefront Values and Acreage (2012)

Lakefront Properties (2012 Shoreline)

		2012 - Lakefront - Acreage (Acres)	2012 - Lakefront - Appraised Value
2012 - Lakefront - Acreage (Acres)	Pearson Correlation	1	.244**
	Sig. (2-tailed)		.000
	N	1200	1200
2012 - Lakefront - Appraised Value	Pearson Correlation	.244**	1
	Sig. (2-tailed)	.000	
	N	1200	1200

**. Correlation is significant at the 0.01 level (2-tailed).

Table 10: Pearson Correlation: Values within 0.25 Miles and Acreage (2012)

Properties within 0.25 Miles (2012 Shoreline)

		2012 - 0.25 Mile - Acreage (Acres)	2012 - 0.25 Mile - Appraised Value
2012 - 0.25 Mile - Acreage (Acres)	Pearson Correlation	1	.171**
	Sig. (2-tailed)		.000
	N	3029	3029
2012 - 0.25 Mile - Appraised Value	Pearson Correlation	.171**	1
	Sig. (2-tailed)	.000	
	N	3029	3029

**. Correlation is significant at the 0.01 level (2-tailed).

Table 11: Pearson Correlation: Values within 0.25-0.50 Miles and Acreage (2012)

Properties within 0.25-0.50 Miles (2012 Shoreline)

		2012 - 0.50 Mile - Acreage (Acres)	2012 - 0.50 Mile - Appraised Value
2012 - 0.50 Mile - Acreage (Acres)	Pearson Correlation	1	.202**
	Sig. (2-tailed)		.000
	N	2273	2273
2012 - 0.50 Mile - Appraised Value	Pearson Correlation	.202**	1
	Sig. (2-tailed)	.000	
	N	2273	2273

**. Correlation is significant at the 0.01 level (2-tailed).

Table 12: Pearson Correlation: Values within 0.50-0.75 Miles and Acreage (2012)

Properties within 0.50-0.75 Miles (2012 Shoreline)

		2012 - 0.75 Mile - Acreage (Acres)	2012 - 0.75 Mile - Appraised Value
2012 - 0.75 Mile - Acreage (Acres)	Pearson Correlation	1	.282**
	Sig. (2-tailed)		.000
	N	1014	1014
2012 - 0.75 Mile - Appraised Value	Pearson Correlation	.282**	1
	Sig. (2-tailed)	.000	
	N	1014	1014

**. Correlation is significant at the 0.01 level (2-tailed).

Table 13: Pearson Correlation: Values within 0.75-1.0 Miles and Acreage (2012)

Properties within 0.75-1.0 Miles (2012 Shoreline)

		2012 - 1.00 Mile - Acreage (Acres)	2012 - 1.00 Mile - Appraised Value
2012 - 1.00 Mile - Acreage (Acres)	Pearson Correlation	1	.151**
	Sig. (2-tailed)		.000
	N	635	635
2012 - 1.00 Mile - Appraised Value	Pearson Correlation	.151**	1
	Sig. (2-tailed)	.000	
	N	635	635

**. Correlation is significant at the 0.01 level (2-tailed).

Table 14: Pearson Correlation: Values within 1.0-2.0 Miles and Acreage (2012)

Properties within 1.0-2.0 Miles (2012 Shoreline)

		2012 - 2.00 Mile - Acreage (Acres)	2012 - 2.00 Mile - Appraised Value
2012 - 2.00 Mile - Acreage (Acres)	Pearson Correlation	1	.104**
	Sig. (2-tailed)		.000
	N	2973	2863
2012 - 2.00 Mile - Appraised Value	Pearson Correlation	.104**	1
	Sig. (2-tailed)	.000	
	N	2863	2863

**. Correlation is significant at the 0.01 level (2-tailed).

2) How will upstream residential property be affected by the depletion of the reservoir due to either a failure or removal of the dam structure?

Using GIS software, the created layer of lands flooded by TVA, and Blount County parcel data, the following maps (Figures 12-17) visually display the differences in residential property distances compared to the 1936 and 2012 shorelines. As can be expected, other than the properties that are along the main channel of the Tennessee River and were along the initial river's shorelines, all properties will become further in distance from the shoreline if Fort Loudoun Dam either failed or was removed and the reservoir reverted back to the original Tennessee River channel. As one can see, in most areas of Blount County, properties that are currently within a quarter mile of the reservoir will become approximately one quarter to half mile from the shoreline, those currently one quarter to half mile from the shoreline will become approximately one half to three-quarters of a mile from the reservoir, and so forth. The biggest difference comes with those properties that a lakefront due to being located upon the edge of large areas that were flooded by TVA. In this case, many of the properties go from being lakefront to upwards of three-quarters of a mile to two miles. The increased distances between the 2012 and 1936 shorelines result in significant loss in number of residential parcels in each examined buffered area:

1) Lakefront: 1164 parcels lost
2) Between Lakefront and a quarter mile: 2361 parcels lost
3) Between quarter and half mile: 1448 parcels lost
4) Between half and three-quarters mile: 263 parcels lost
5) Between three quarters and one mile: 83 parcels lost
6) Between one and two miles: 403 parcels lost

Figure 12: Map of Lakefront Properties

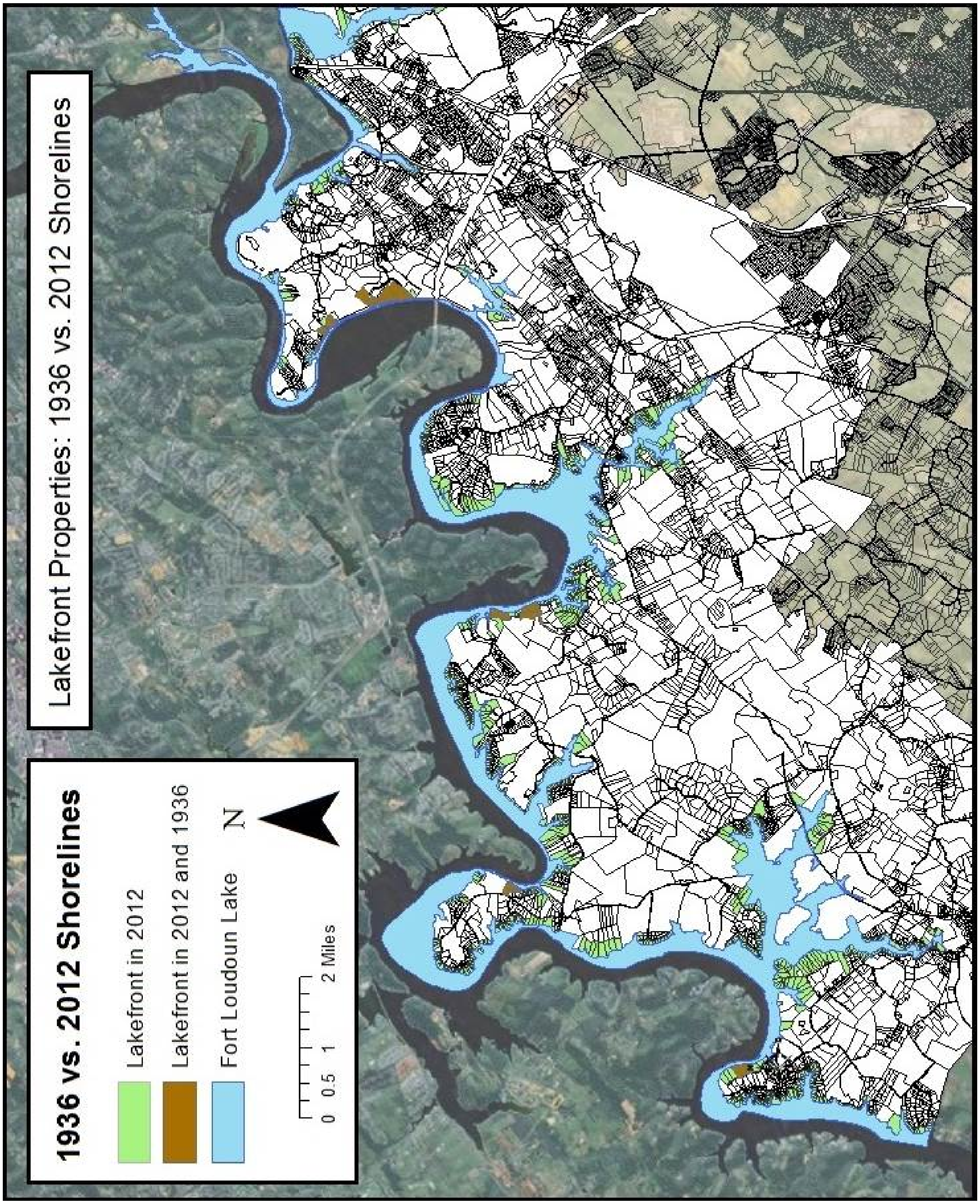


Figure 13: Map of Properties within 0.25 Miles

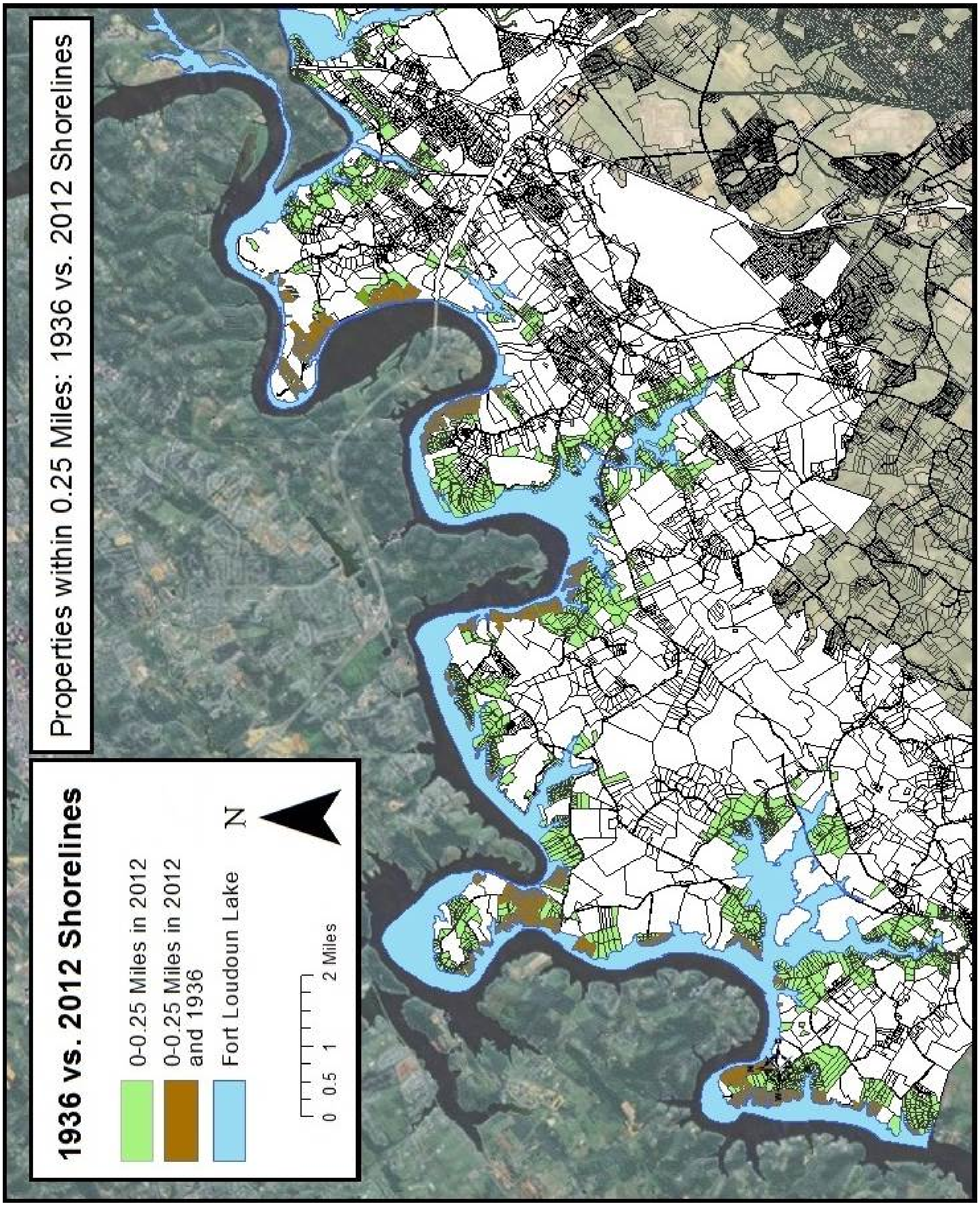


Figure 14: Map of Properties between 0.25-0.50 Miles

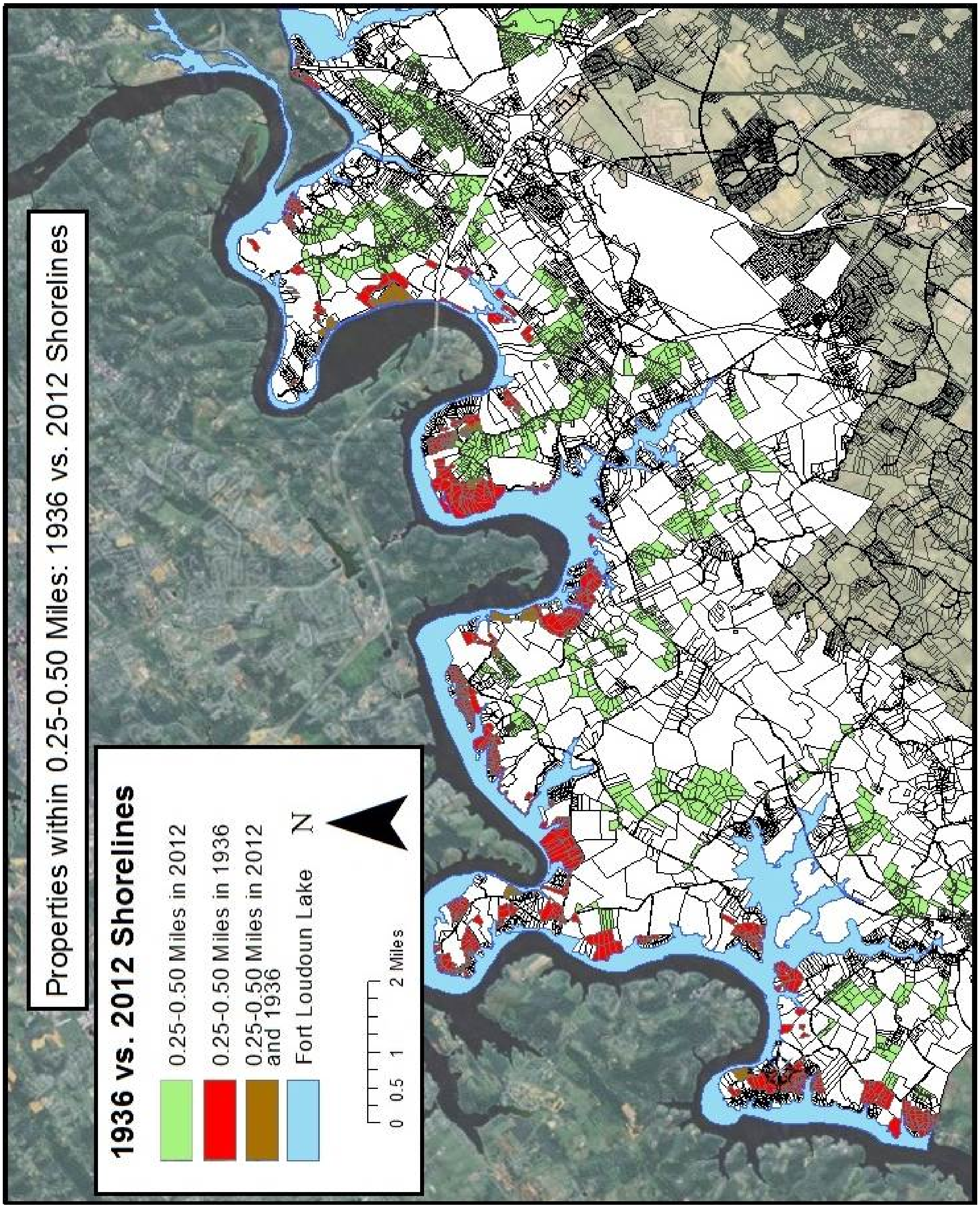


Figure 15: Map of Properties between 0.50-0.75 Miles

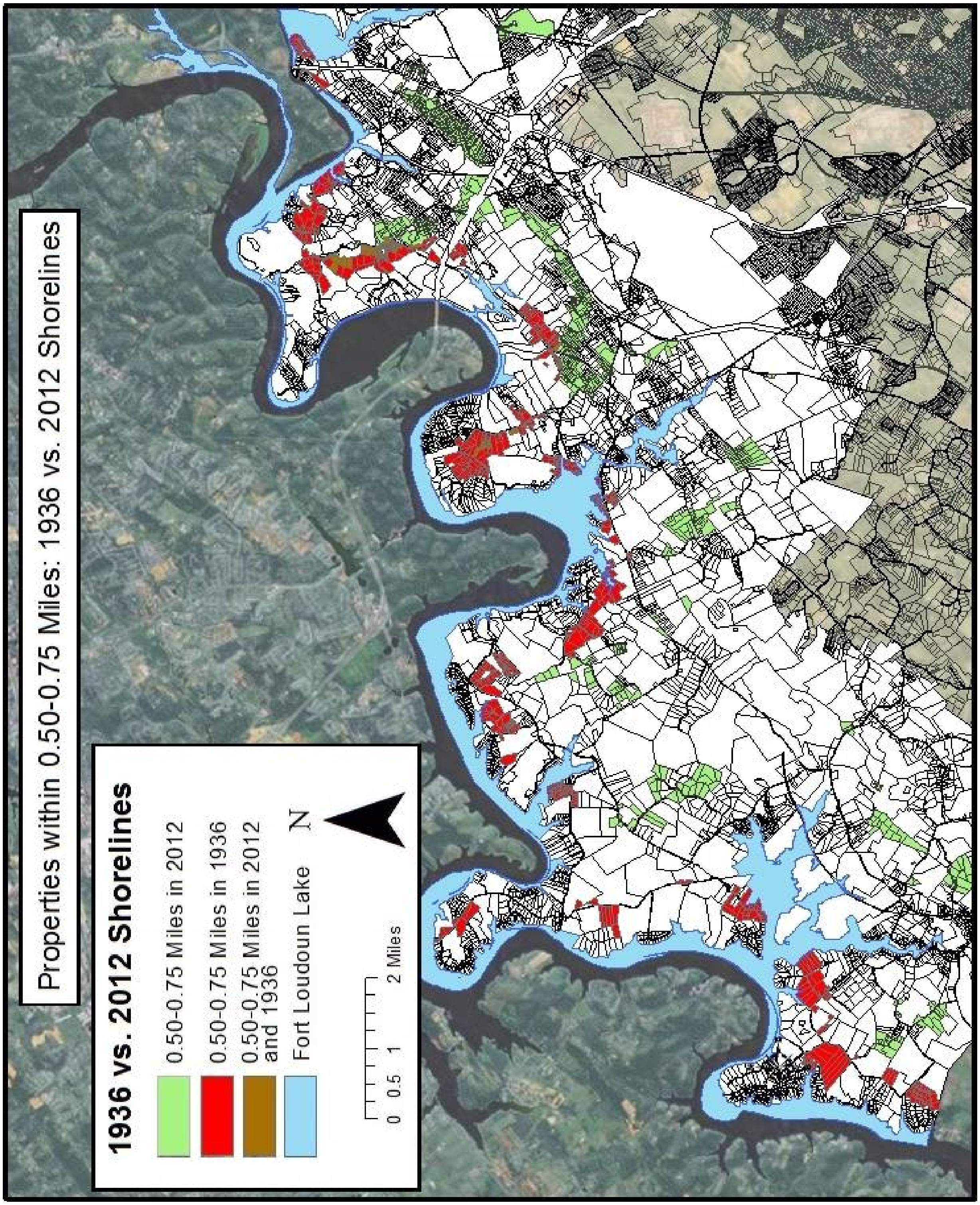


Figure 16: Map of Properties within 0.75-1 Miles

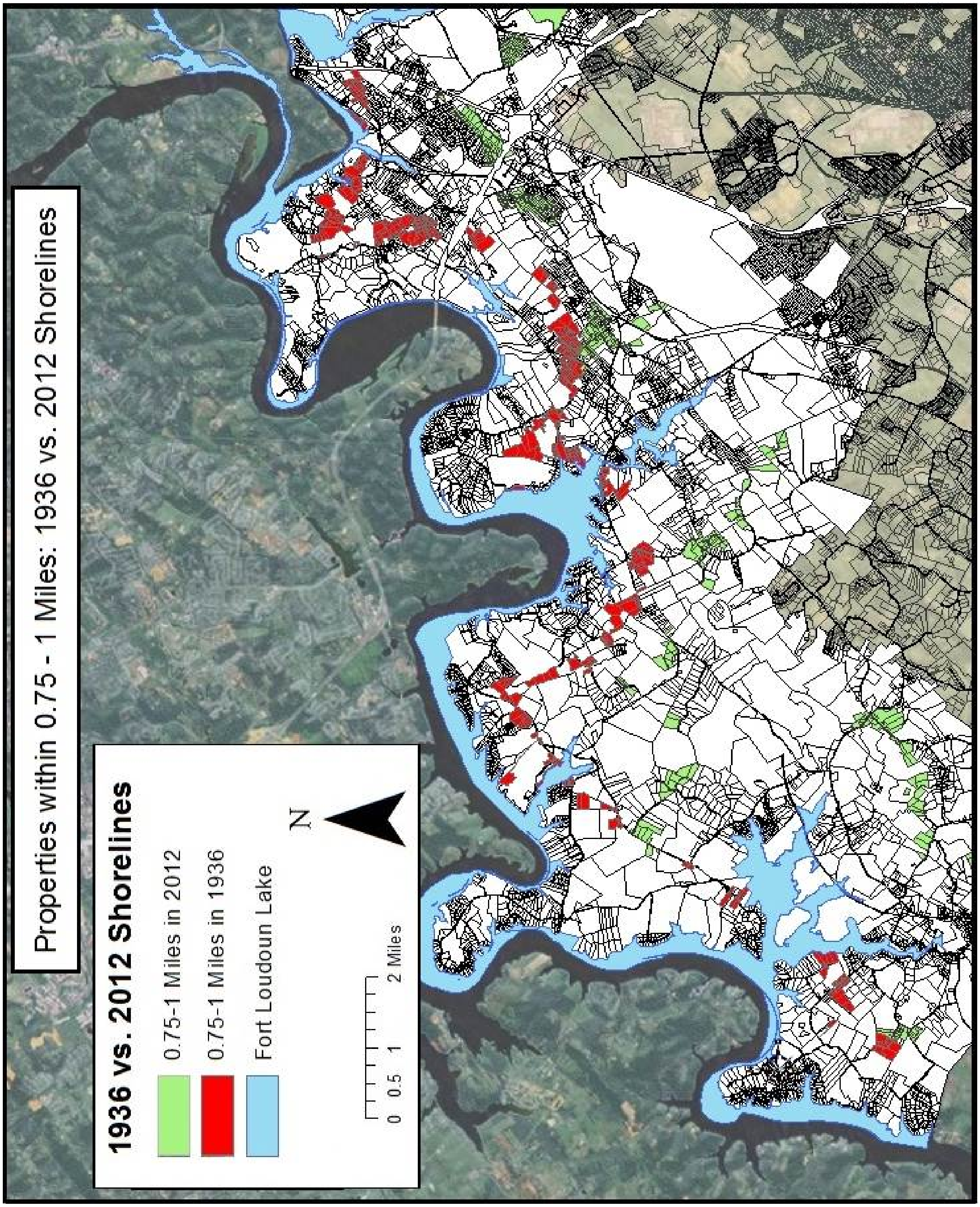
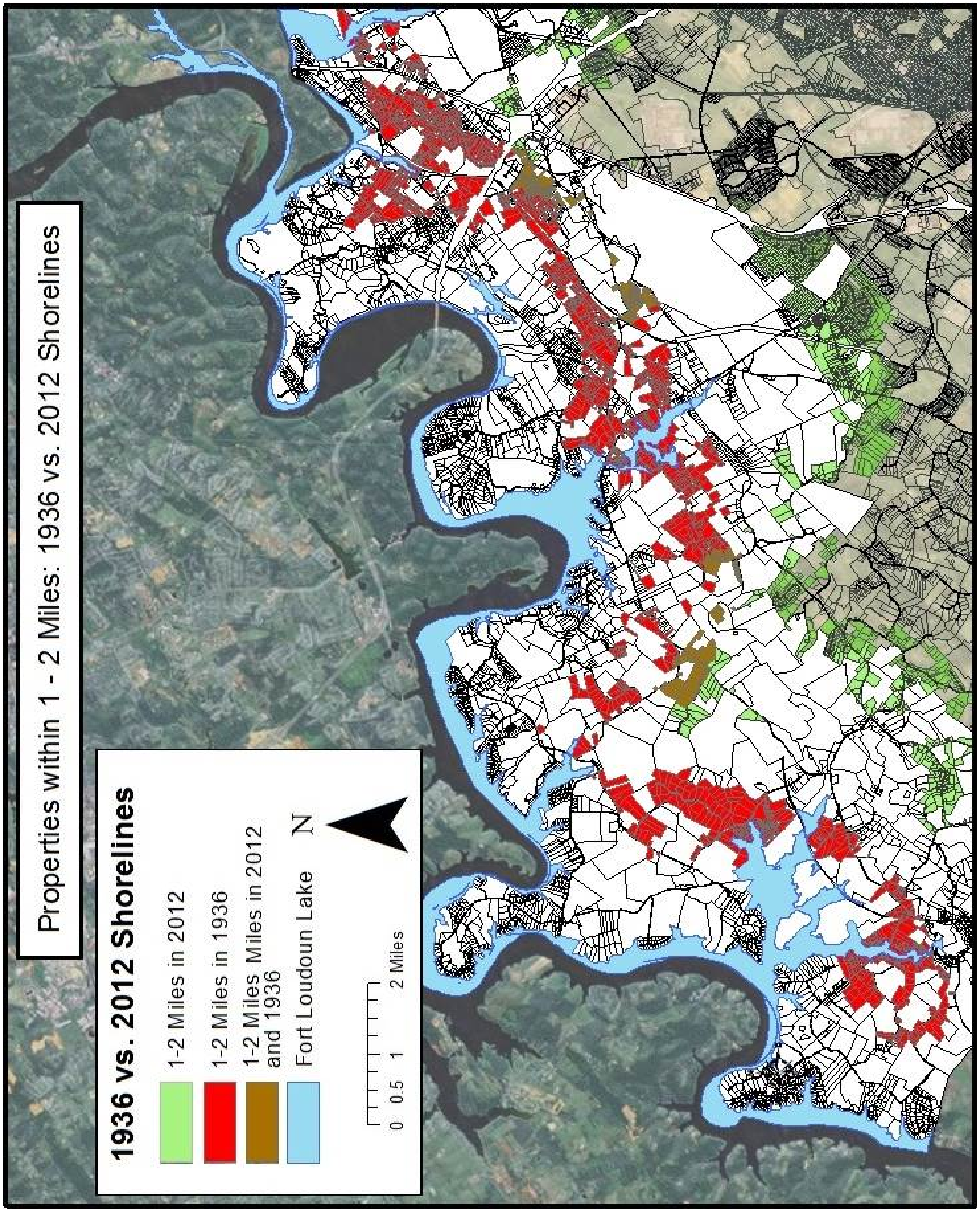


Figure 17: Map of Properties within 1-2 Miles



3) What are the economic impacts on upstream residential property value and tax revenue due to a depletion of a reservoir?

This study looked solely at residential property values within a two mile buffer of Fort Loudoun Lake's shoreline in 2012 and 1936 (Figures 18-29). Excluding parcels designated as Forest, Agricultural, Farm, Industrial, Commercial, Education/Science/Charitable, Religious, Federal, State, City, County, and Other Exempt, 11014 parcels of residential property at the 2012 shoreline distances and 5292 parcels at the 1936 shoreline distances were examined and determined to have the following sum and average values for each buffered distances based on the 1936 and 2012 Tennessee River shoreline (Tables 15 and 16):

Table 15: Average and Total Residential Property Values (1936)

	Average and Total Residential Property Values (1936 Shoreline)					
	1936 - Lakefront	1936 - 0.25 Miles	1936 - 0.50 Miles	1936 - 0.75 Miles	1936 - 1.0 Miles	1936 - 2.0 Miles
Average	$321,458	$339,769	$307,971	$186,898	$158,392	$136,781
Sum	$11,572,500	$226,965,500	$254,076,000	$140,360,500	$87,432,300	$343,860,100
# of Parcels	36	668	825	751	552	2460

Table 16: Average and Total Residential Property Values (2012)

	Average and Total Residential Property Values (2012 Shoreline)					
	2012 - Lakefront	2012 - 0.25 Miles	2012 - 0.50 Miles	2012 - 0.75 Miles	2012 - 1.0 Miles	2012 - 2.0 Miles
Average	$377,218	$248,891	$123,473	$131,431	$146,664	$141,864
Sum	$452,661,400	$753,889,600	$280,654,700	$133,271,200	$93,131,800	$406,156,400
# of Parcels	1200	3029	2273	1014	635	2863

With the average and sum residential property values for each buffered distance at the different possibly shorelines, the change in values and number of parcels was determined, as displayed in Table 17, while the total values for the 1936 and 2012 totals and calculated tax revenue was determined. Finally, with the determination of the total values and tax revenues of the 1936 and 2012 distances, it was calculated that overall there would be over one billion dollars in lost residential property value and over six million dollars in lost annual tax revenue due to the depletion of Fort Loudoun Lake and the increased distances residential properties would become from the shoreline (Table 18). This is significant loss in property value as the total value of all residential property in Blount County is $8,025,640,600. This loss in property value results in a decrease of 13% in residential property value for the county as a whole and 13% of the county's $47,351,280 in residential property taxes collected (Blount County, 2012). Logically, in order to make up for this loss in tax revenue, Blount County would be forced to either increase tax rates in other areas or subject themselves to major budget cuts in order to cover the 13% shortfall incurred from the loss of Fort Loudoun Lake and the massive decrease in residential property value.

Table 17: Change in Average and Sum Values and Number of Parcels

	Change in Average and Sum Values and Number of Parcels of Residential Property for Each Buffered Distance Between 2012 and 1936 Shorelines					
	Lakefront	0.25 Miles	0.50 Miles	0.75 Miles	1.0 Miles	2.0 Miles
Average	($55,760)	$90,878	$184,498	$55,467	$11,728	($5,083)
Sum	($441,088,900)	($526,924,100)	($26,578,700)	$7,089,300	($5,699,500)	($62,296,300)
# of Parcels	-1164	-2361	-1448	-263	-83	-403

Table 18: Total Losses in Residential Property Values and Tax Revenue

Lost Residential Property Values	$1,055,498,200
Lost Tax Revenue	$6,227,439
Total Losses (Property Value and Tax Revenue)	$1,061,725,639

With over one billion dollars in estimated impact upon the residential property of Blount County, the impact would be far greater when including other types of private property and the other two counties along Fort Loudoun Lake's shores. Knox County would be more impacted due to a much higher population and Loudon County due its higher median household value, as shown in the Table 19.

Table 19: Blount, Knox, and Loudon County Population, MHV, and MHI (U.S. Census 2013)

	Population	Median Housing Value	Median Household Income
Blount County	123,010	162,300	47,298
Knox County	432,226	154,900	47,277
Loudon County	48,556	173,300	50,458

Figure 18: Map of Lakefront Values (1936 Shoreline)

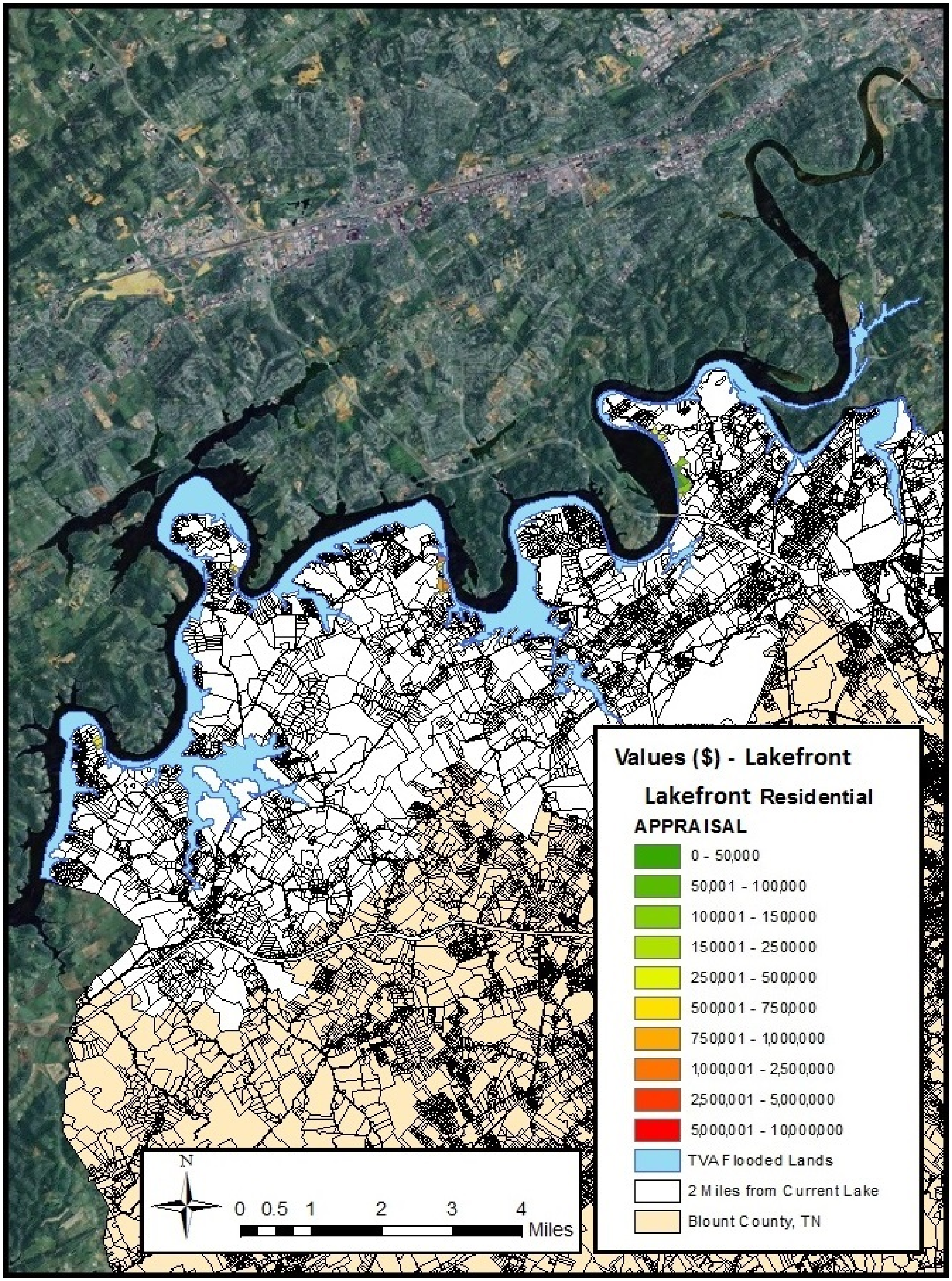


Figure 19: Map of Values within 0.25 Miles (1936 Shoreline)

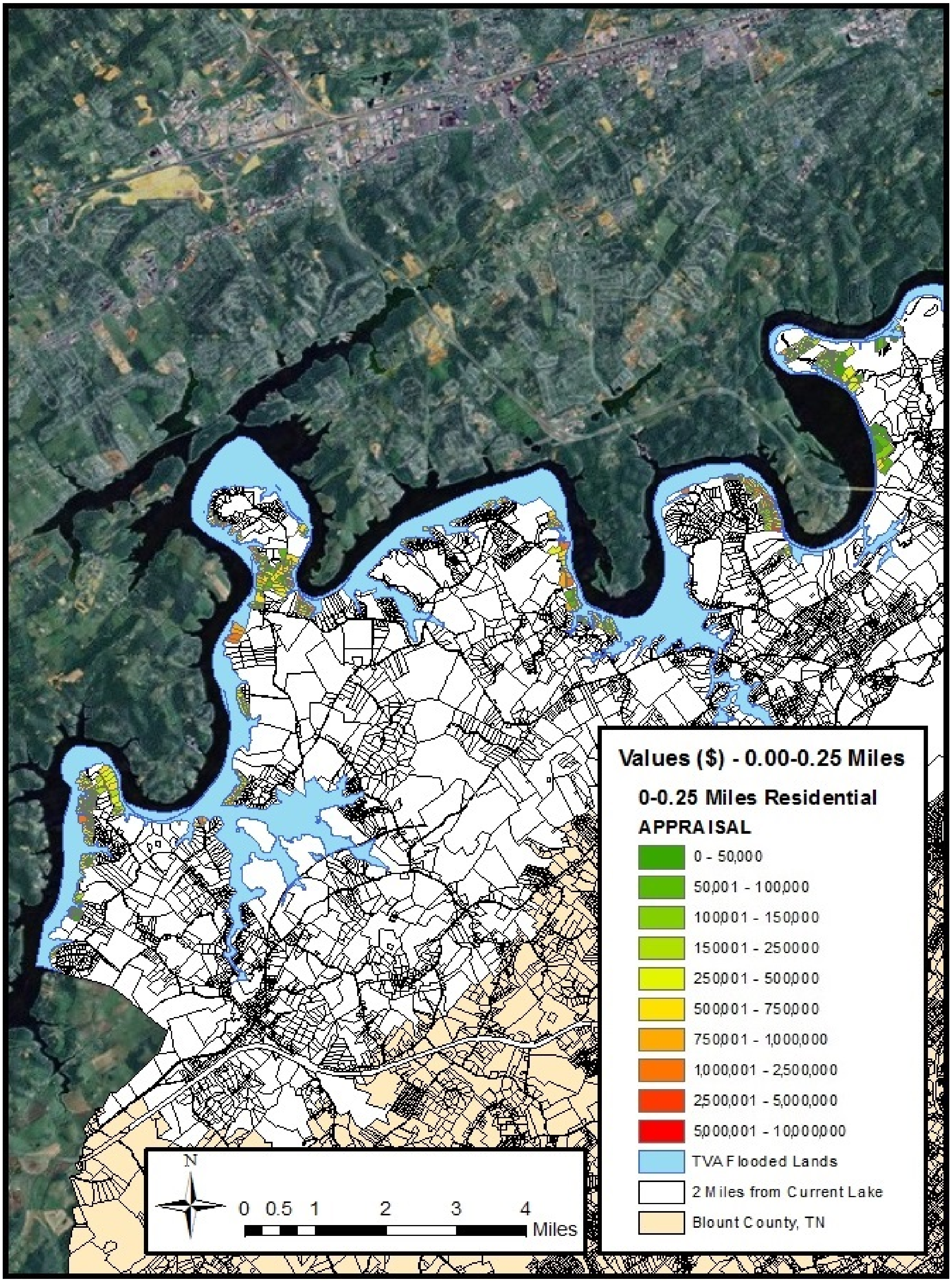


Figure 20: Map of Values between 0.25-0.50 Miles (1936 Shoreline)

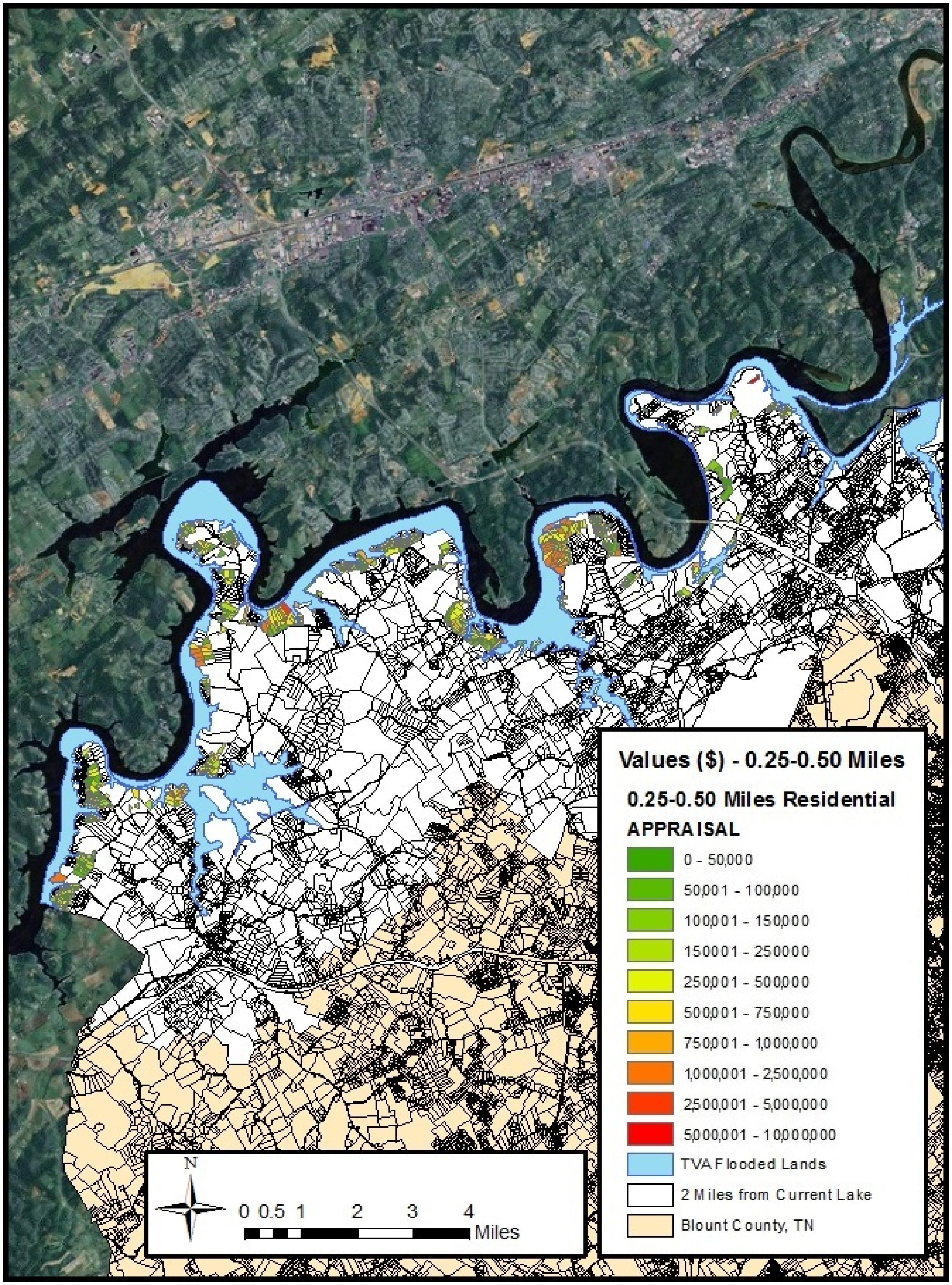


Figure 21: Map of Values within 0.50-0.75 Miles (1936 Shoreline)

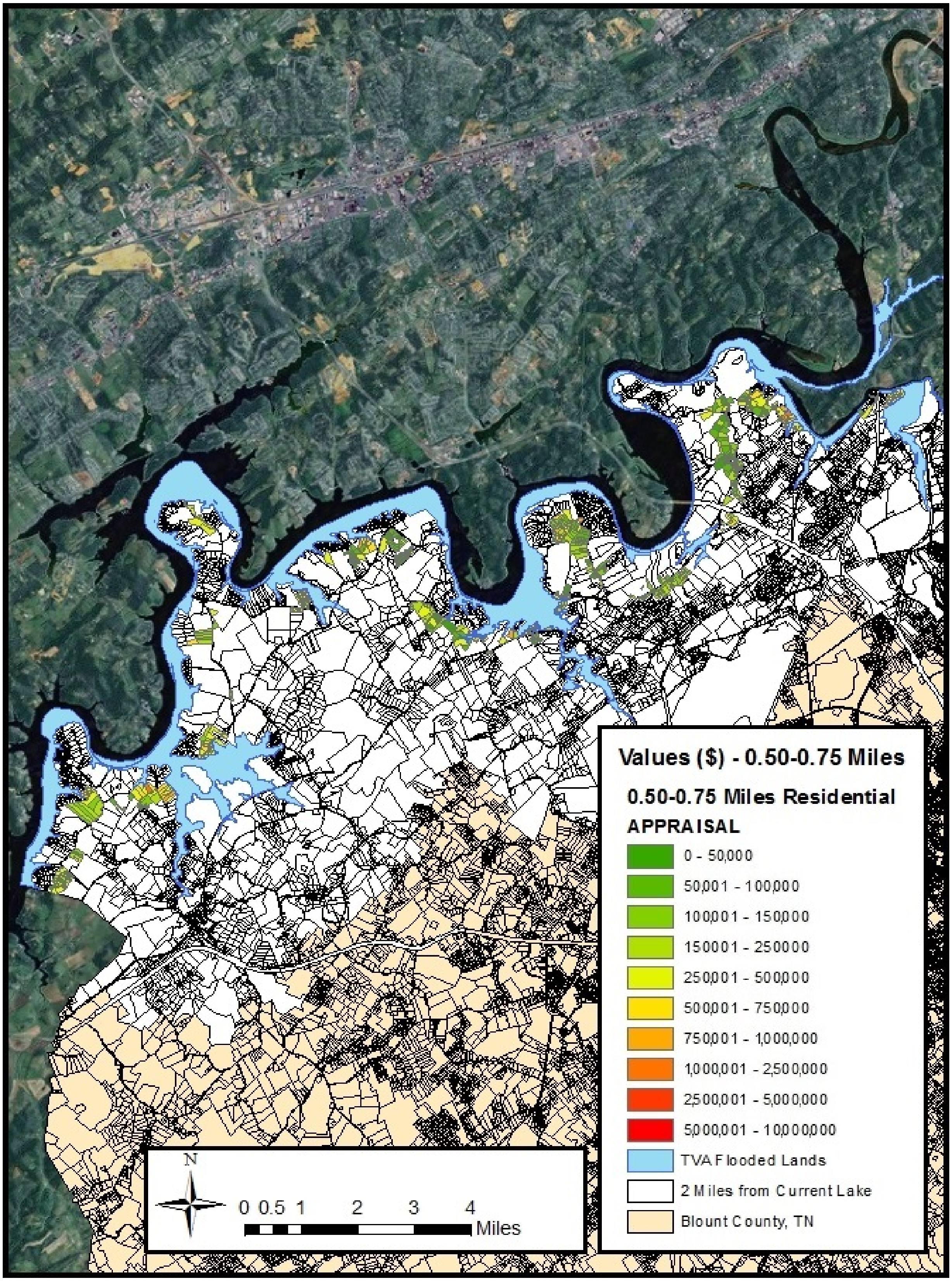


Figure 22: Map of Values between 0.75-1.0 Miles (1936 Shoreline)

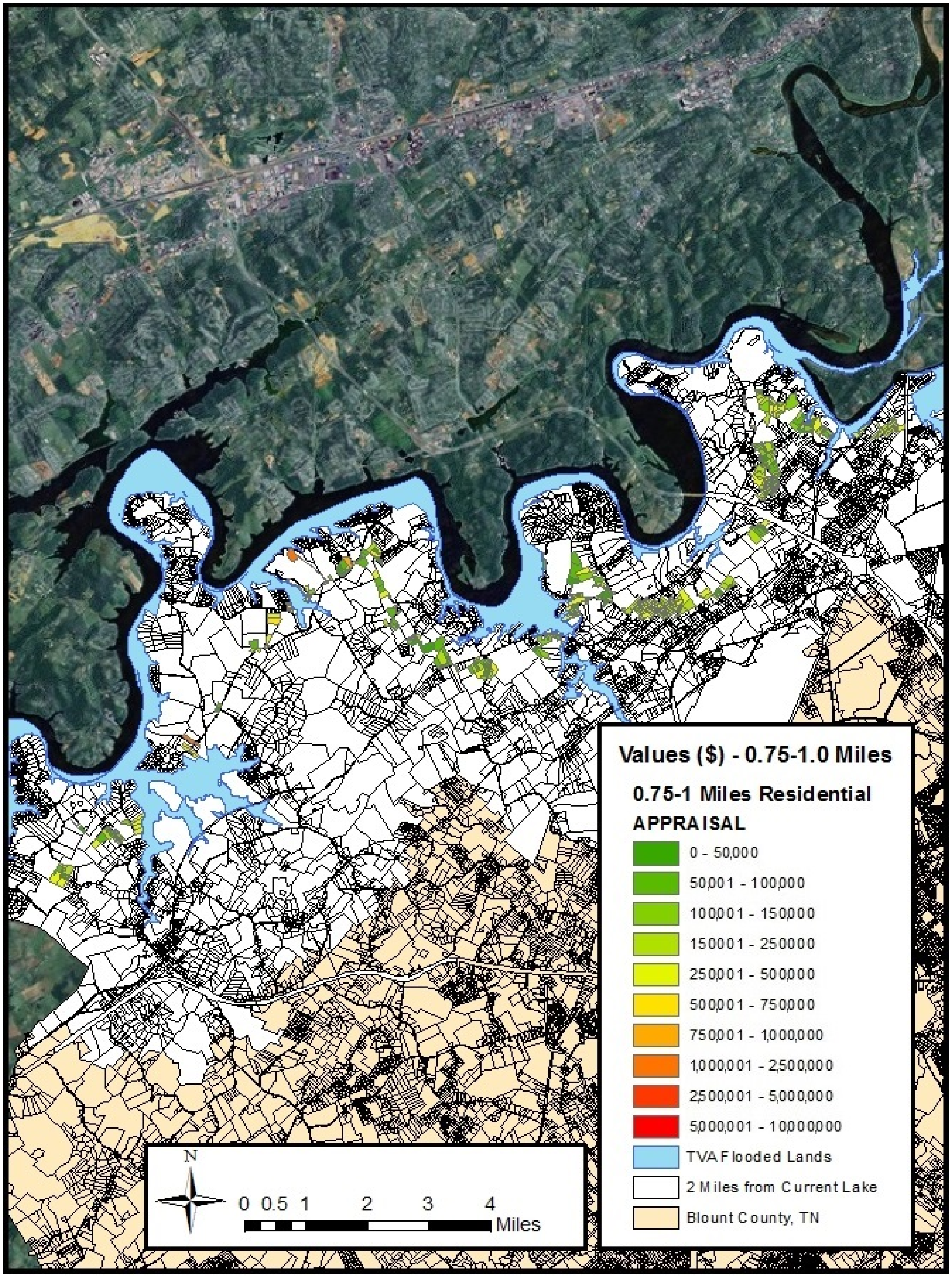


Figure 23: Map of Values between 1.0-2.0 Miles (1936 Shoreline)

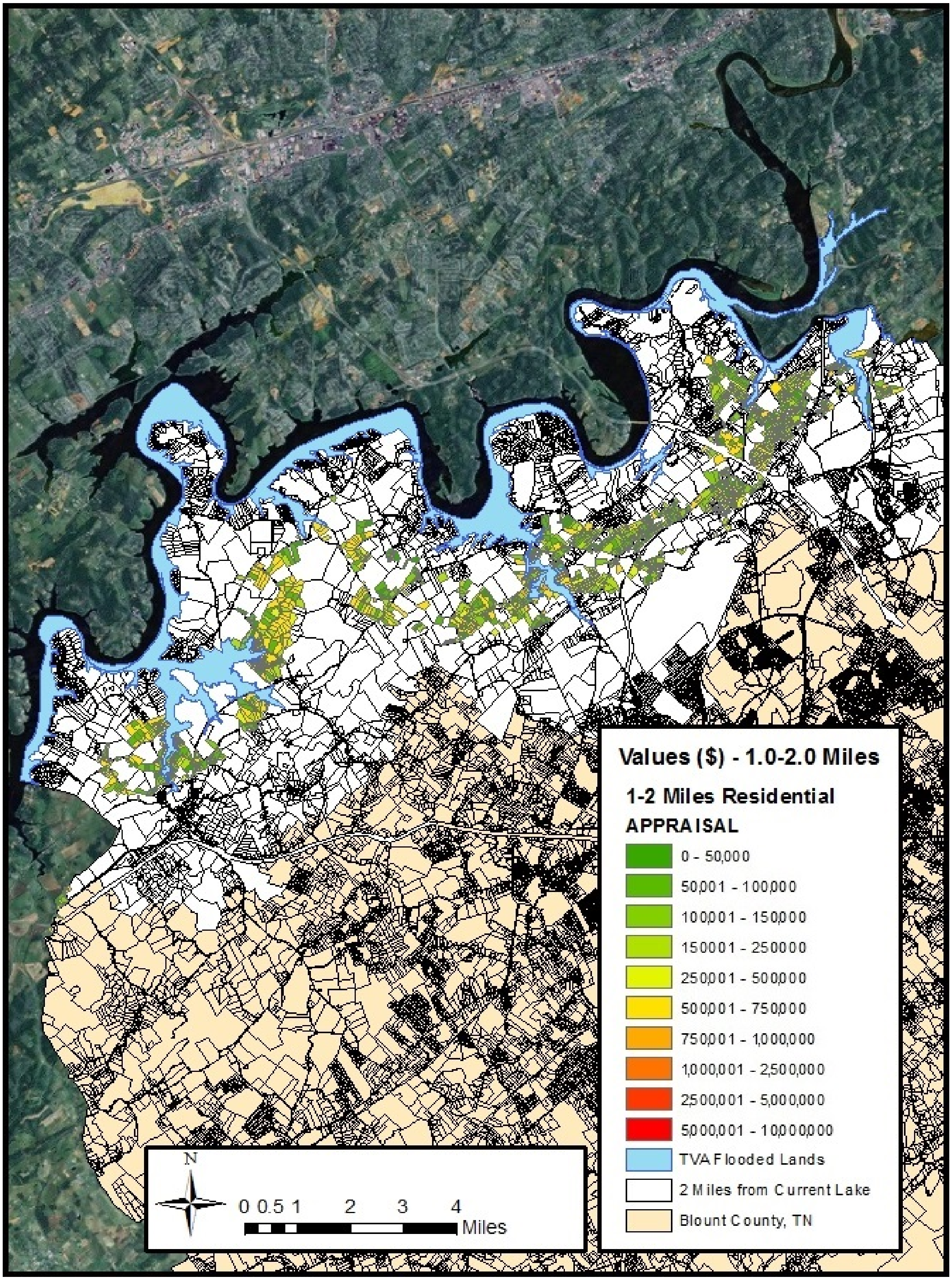


Figure 24: Map of Lakefront Values (2012 Shoreline)

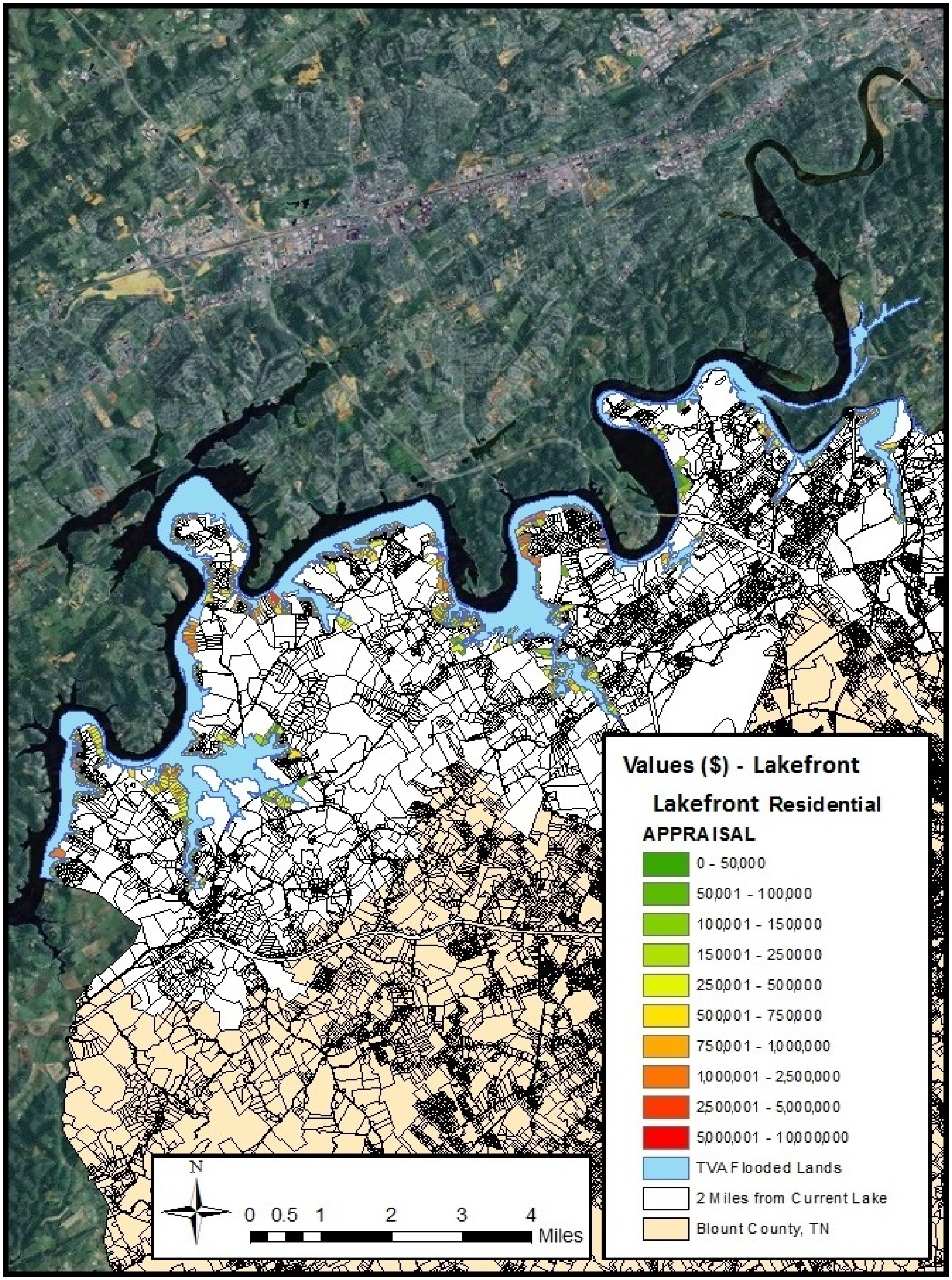


Figure 25: Map of Values within 0.25 Miles (2012 Shoreline)

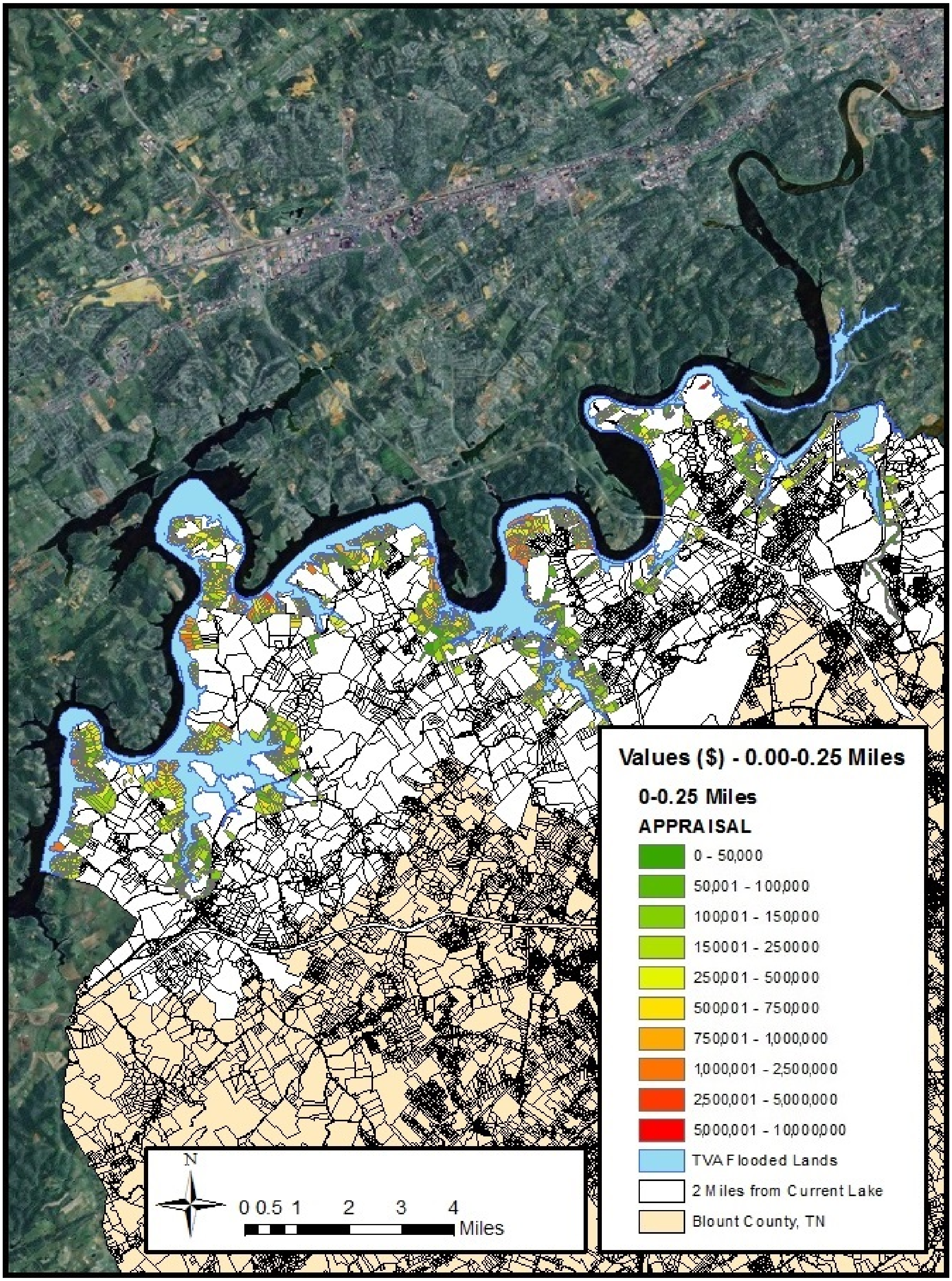


Figure 26: Map of Values between 0.25-0.50 Miles (2012 Shoreline)

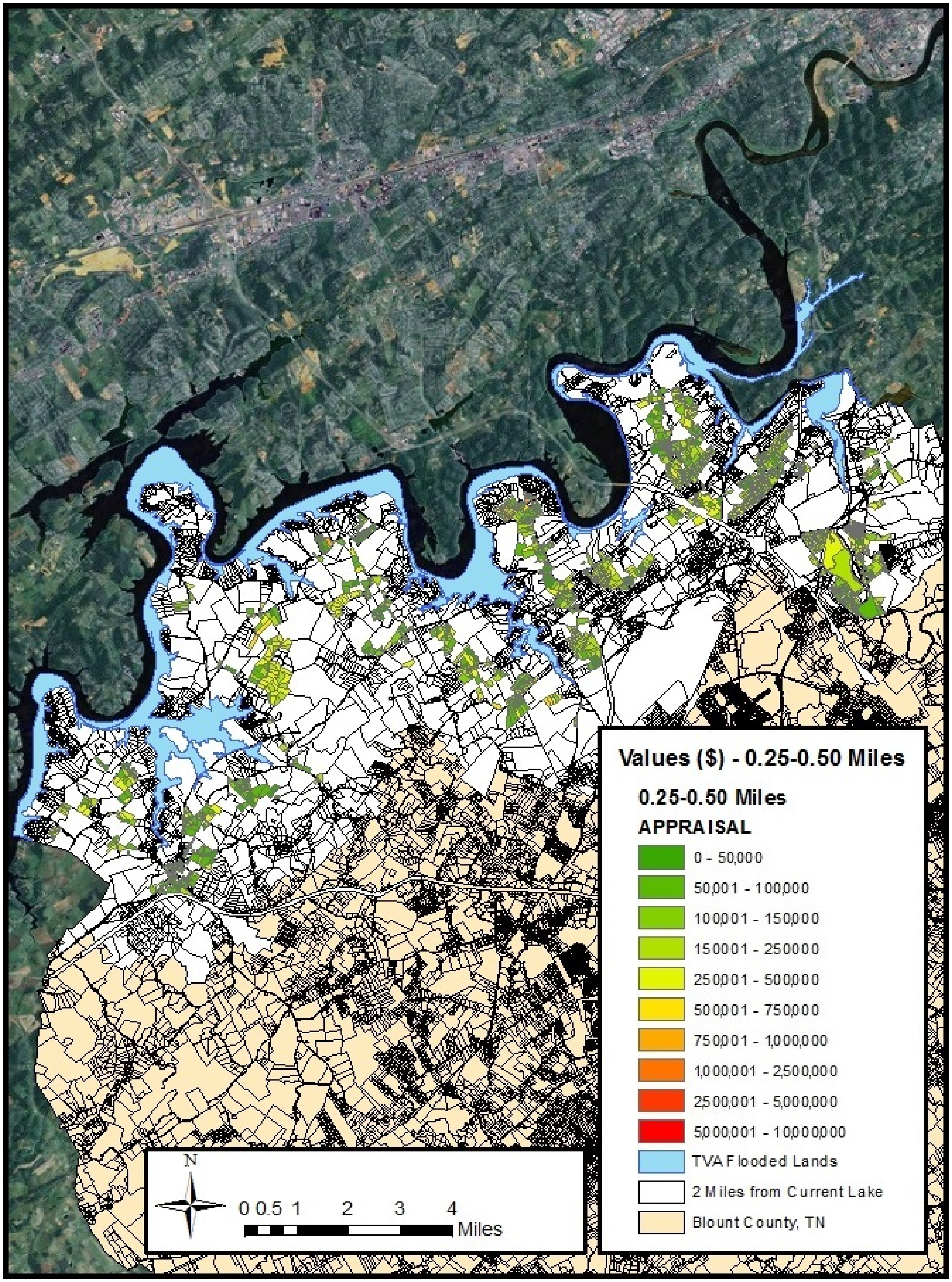


Figure 27: Map of Values between 0.50-0.75 Miles (2012 Shoreline)

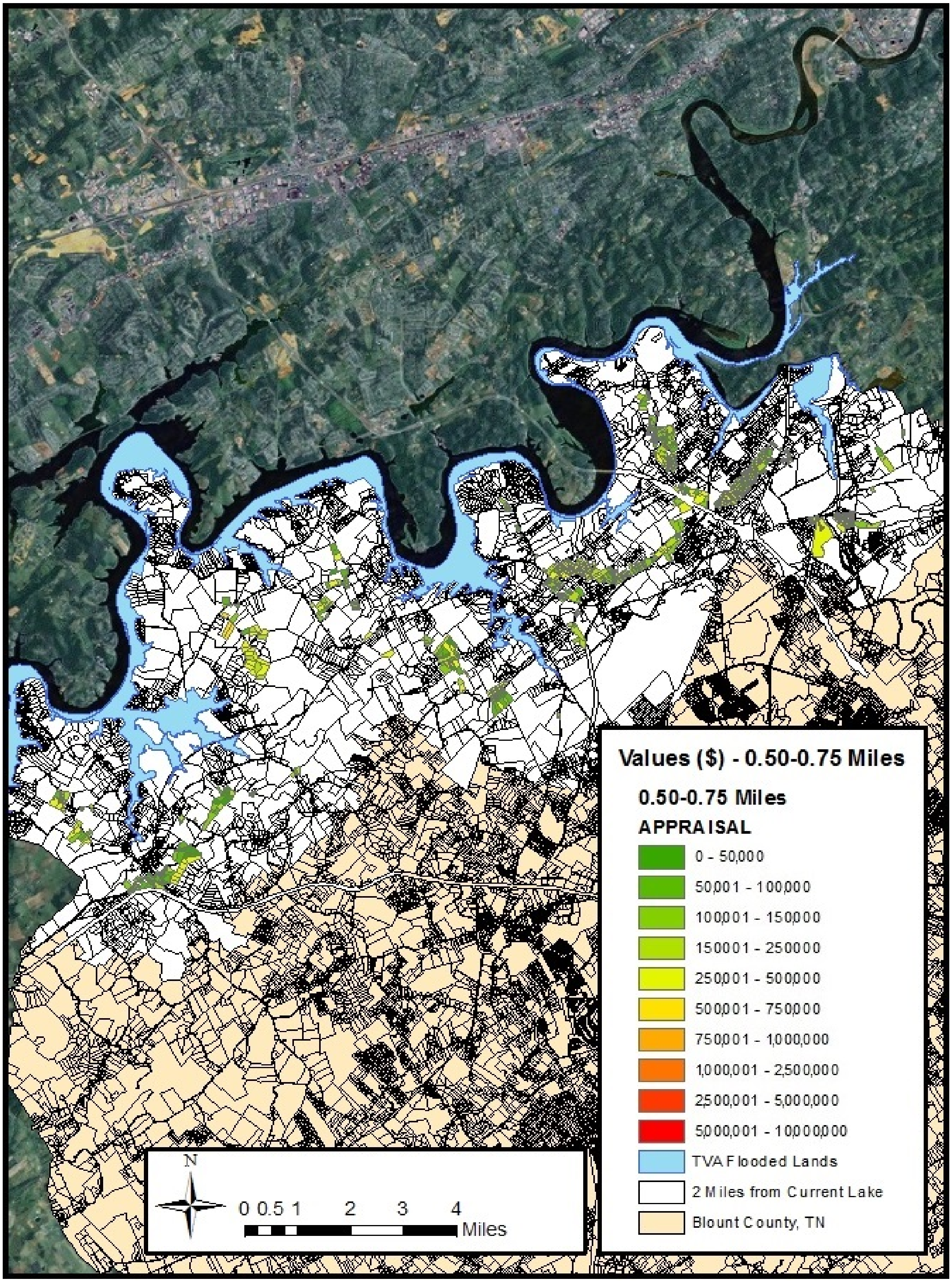


Figure 28: Map of Values between 0.75-1.0 Miles (2012 Shoreline)

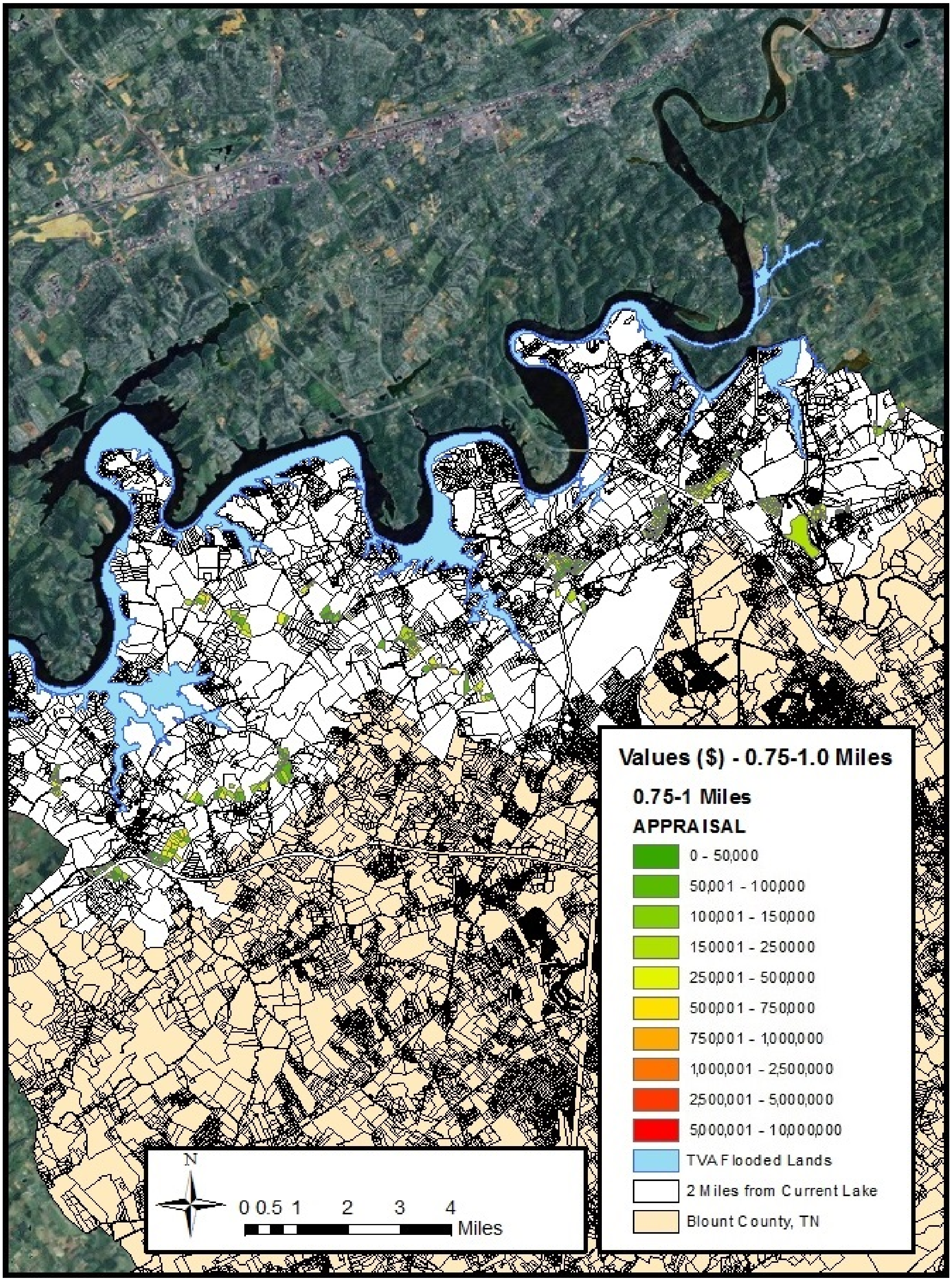
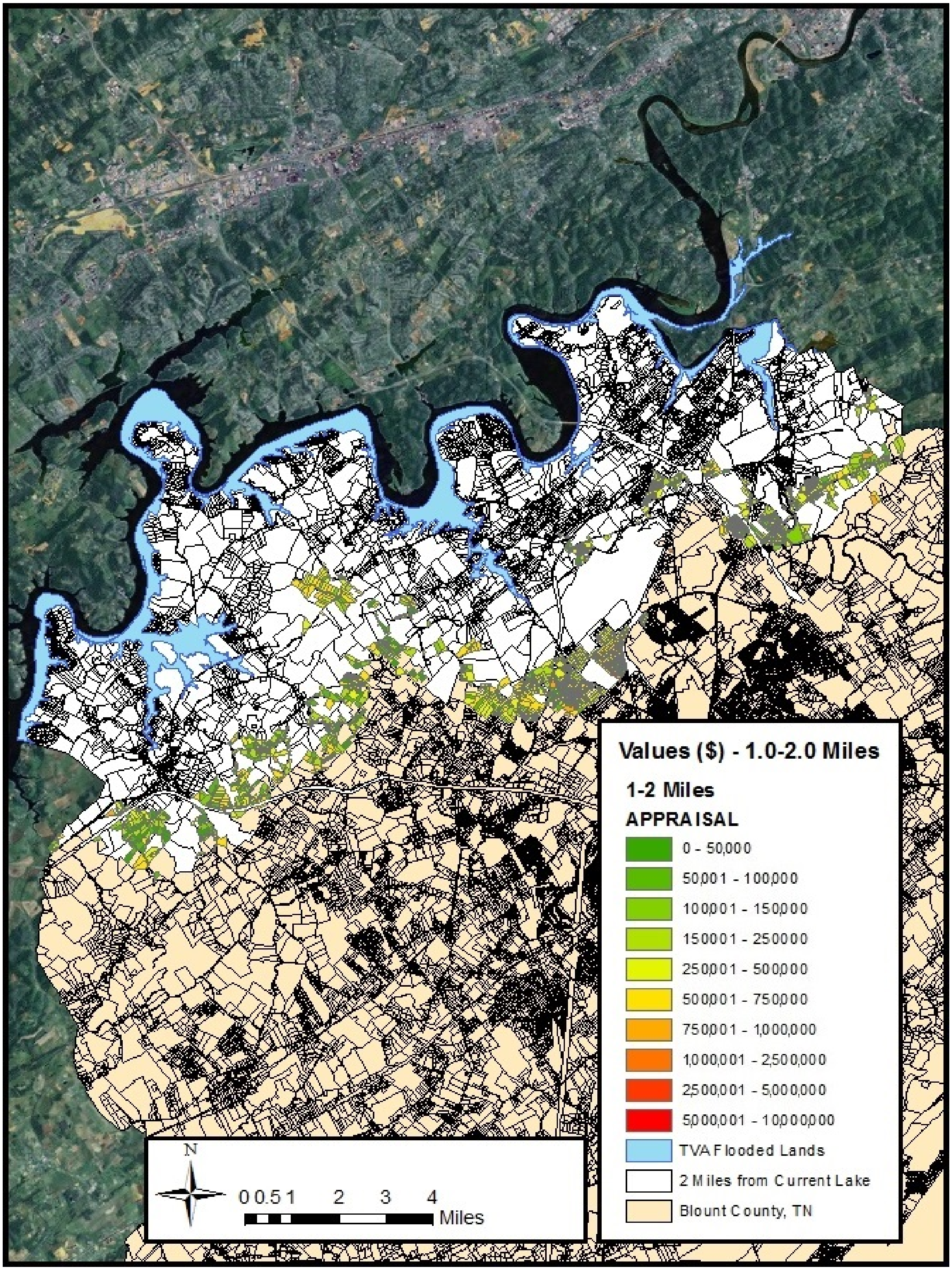


Figure 29: Map of Values between 1.0-2.0 Miles (2012 Shoreline)



Chapter 5: Conclusion

This study has shown, through GIS and statistical analysis, that property along and near Fort Loudoun Lake will become further in distance from the shoreline and decrease in value if reservoir depletion occurs. Through the results of this study it is estimated that the residential property values in Blount County, Tennessee will decline $1,055,498,200, or by 13% for the county as a whole, and county residential property tax revenues will decrease by $6,227,439 annually. The results of this study affirm that when agencies, such as TVA, conduct cost-benefit analyses to weigh the mitigation of a dam structure, there needs to be consideration of the economic impacts on upstream properties.

These potential decreases in property values and taxes can then be used as additional factors when conducting a cost-benefit analysis to determine the economic impacts of a dam failure or removal. If the methods undertaken in this study are to be used within a future cost-benefit analysis of this dam structure, or any other large structure within the eastern United States, it could very well result in costs that far exceed, and encourage, the cost of mitigation. In *Dam Removal: Science and Decision Making*, produced by The H. John Heinz III Center for Science, Economics and the Environment (2002), when it comes to understanding the economic impacts of a dam removal or failure, it is stated that "dam removal is not unambiguously good, but attaching a more precise valuation is difficult because formal benefit–cost analysis procedures do not necessarily apply to dam removals". If current procedures don't necessarily fit in their application within a dam mitigation or removal project, perhaps the procedures and methods need to be adapted to provide the whole picture of potential economic impacts?

The rationale for this study, besides the lack of previous research, also includes the desire to inform decision-makers and planners on the possible economic impacts that are not typically considered, the risk management that should be considered, and the goal of serving the public through the building and maintaining of resilient communities. Key decision-makers and planners should understand that when conducting a cost-benefit analysis of a dam mitigation project, other aspects besides the downstream impacts are possible. In the case of TVA's assessment of Fort Loudoun Dam, or any of its other dam structures, it could very well be possible that the steps shown in this study could be undertaken and result in outcomes that could sway a cost-benefit analysis from one conclusion to another. The concepts of risk management and creation of resilient communities should also be considered as any possible, future dam structures are built or upstream development along their reservoirs occurs. Plans and considerations should be in place, with a focus on how planners and communities allow and regulate residential development along or near a dammed reservoir.

In addition to the methods and area of study included in this research, future studies could be conducted to determine the total economic impact of Fort Loudoun Dam's removal or failure on all properties and counties near or along its shores. As stated previously, with over one billion dollars in economic impact upon a single county and type of private property, the overall impact on the three surrounding counties, incurred due to removal or failure of the dam structure, could potentially be massive.

In particular, the following three areas are suggested for future research on this topic: 1) use of MLS data, 2) use of hedonic analysis, and 3) integration of flood risk potential to the analysis. Even though GIS parcel data was used in this study in order to more accurately the impacts on tax revenue, use of MLS data could provide more detailed calculations of the impacts on property values, based upon recent sales history. Hedonic analysis, without a doubt, would provide more details regarding property values and the variables that impact those values. This type of economic analysis would also aid in determining the true impact distance from the shoreline has upon property values. Finally, integration of flood risk potential could also add another potential impact by determining if any upstream land areas are at risk of flooding due to shifting locations of water due to reservoir depletion.

Organizations such as TVA, should consider these upstream impacts on upstream residential properties, and all areas overall, as there is the potential for required buyouts of upstream properties and/or payouts from civil judgments. The impacts researched and economic findings within this study will continue to become more important and necessitate further research, as dam infrastructure in the United States continues to age and cost-benefit analyses are conducted to determine whether mitigation is the suitable strategy to undertake.

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Vita

Jeffrey C. French was born in Maryland, outside of Washington, D.C. and grew up in Maryville, TN. He graduated from Maryville High School and the University of Tennessee, Knoxville, where he received a Bachelor of Arts degree in Political Science and a Bachelor of Arts degree in Geography. In the fall of 2011, he began studies towards a Master of Arts degree in Geography at Appalachian State University, while conducting research and teaching assistantships and serving as Graduate Senator for the Department of Geography and Planning.

During his time at Appalachian State University, Mr. French was awarded multiple grants from the Office of Student Research, the Graduate Student Association Senate, the Cratis D. Williams Graduate School, and the National Aeronautics and Space Administration (NASA). He was also awarded the Outstanding Poster Contest Award for Best Cartographic Product from the North Carolina ArcUsers Group.

The M.A. was awarded in May 2013. Following graduation, Mr. French was commissioned as a Second Lieutenant in the United States Army. Mr. French is a member of Gamma Theta Upsilon International Honor Society, the Association of American Geographers, the Southeastern Association of American Geographers, the North American Cartographic Information Society, and the National Eagle Scout Association. He currently serves as an Officer in the United States Army.