ACCESSIBILITY AND UNIVERSITY POPULATIONS:

LOCAL EFFECTS ON NON-MOTORIZED TRANSPORTATION

IN THE TUSCALOOSA-NORTHPORT AREA

by

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ABSTRACT

This research examined the local bicycle and pedestrian networks through Geographic Information Systems (GIS) and survey data, using the Tuscaloosa and Northport, Alabama, area as a case study. The local non-motorized travel networks were analyzed in GIS to measure the overall network connectivity and accessibility. Results of the measures of network connectivity and modeling of accessibility indicated that areas within one mile of the UA's campus have the highest levels of bicycle and pedestrian network connectivity and accessibility. As a travel distance increases from UA, connectivity and accessibility for the bicycle and pedestrian networks decreases. An on-line survey was administered to the University of Alabama (UA) students and employees, and the results of the survey were used to formulate an understanding of how UA's population views non-motorized travel and the respective networks. Survey results show that individuals within the sample population use non-motorized travel methods to commute to UA but their use is significantly lower than automobile use. In addition, the survey data was considered alongside evaluations of network connectivity and accessibility, thus providing a powerful tool for studying the local bicycle and pedestrian travel networks.

DEDICATION

To my parents.

LIST OF ABBREVIATIONS AND SYMBOLS

AASHTO	American Association of State Highway and Transportation Officials
ACSM	American College of Sports Medicine
AHA	American Heart Association
CDC	Centers for Disease Control and Prevention
DEM	Digital Elevation Model
ERSI	Environmental Systems Research Institute
FHWA	Federal Highway Administration
GIS	Geographic Information Systems
ICTs	Information and Communications Technologies
IRB	Institutional Review Board
ISTEA	Intermodal Surface Transportation Efficiency Act
MET	Metabolic Equivalents
MPO	Metropolitan Planning Organization
NAIP	National Agriculture Imagery Program
NED	National Elevation Dataset
NTPP	Non-motorized Transportation Pilot Program

OR	Odds Ratio
SAFETEA-LU	Safe Accountable, Flexible, Efficient Transportation Equity Act: a Legacy for Users
SPSS	Statistical Package for the Social Sciences
TEA-21	Transportation Equity Act for the 21st Century
TIGER	Topologically Integrated Geographic Encoding and Referencing
TOD	Transit-Oriented Development
UA	The University of Alabama at Tuscaloosa
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
WARC	West Alabama Regional Commission
WBC	Walkable and Bikeable Community

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1.0 INTRODUCTION

Movement and transportation play a large part in our daily lives, as the various methods of transportation and route choices dictate the speed, travel time, and the manner in which one arrives at a given location. While automobile transport is decidedly the most common among American populations, there is a growing interest in the development and use of non-motorized travel in urban areas. Accordingly, this research seeks to explore the local bicycle and pedestrian networks within Tuscaloosa and Northport, Alabama, by analyzing measures of connectivity and accessibility through Geographic Information Systems (GIS) and survey data. Connectivity and accessibility are important concepts in the study of mobility and transportation. Travel is considered to be a demand-derived function in that individuals travel because they want to access different locations on the urban landscape. Connectivity is the primary purpose of transportation networks which link locations that individuals want to travel between. Higher connectivity and accessibility have been linked to higher rates of mobility, which then enables individuals to move with less impedance across the urban environment (Chin et al., 2008). Hansen (1959) defined accessibility as the ease of reaching desirable destinations and identified a link between activities at a destination, land-use, and available transportation networks. Connectivity and accessibility are particularly important to bicycle and pedestrian travel and network design.

In the U.S., Europe, and other developed nations, quality of life, movement of goods and services, employment opportunities, and other elements depend on a high level of accessibility and mobility. Currently in developed countries an increase in mobility and accessibility is heavily dependent on automobiles and efficient mass transit systems. This is especially true in areas of the U.S. that have experienced urban sprawl and suburban development.

The automobile was first introduced in the 1890s but ownership rates in the U.S. did not increase until the 1920s (Rodriguez et al., 2009). After the 1920s, growth and urban transportation planning was mostly tailored around the automobile and, over the years, this type of planning created economic prosperity along with a higher standard of living. However, the current automobile-centered transportation system is not sustainable (Black, 1996) and has been home to growing concerns regarding the increased consumption of natural resources, including the burning of fossil fuels. Other concerns include longer travel times and congested roadways; rising operational and infrastructure costs; increased number of individuals diagnosed with obesity and diabetes; decreased mobility of the economically disadvantage; and lack of physical activity.

After the 1960s' environmental movement and the 1970s' oil-embargo, the U.S. public's recognition of issues related with the internal combustion engine and automobile transportation reached a tipping point. There was a movement to develop and employ alternative means of transportation with: trains, buses, carpools, bicycles, and walking (Samimi et al., 2009; Greene and Wegener 1997). Perhaps the easiest and least expensive alternative to automobile travel is to develop and employ bicycling and walking (Tolley, 1996). Recently, metropolitan areas including Denver, CO; Minneapolis, MN; Boston, MA; and Seattle, WA (Amiton, 2001; FHWA, 2010; Kaiser, 2010), as well as many colleges and universities across the country (Balsas, 2003), have turned to the promotion of more sustainable modes of transportation such as bicycle and pedestrian travel as a means to help address many of today's challenging issues.

American colleges and universities are faced with a number of challenging issues as they continue to work towards growth and expansion. This growth and expansion is often experienced through increased enrollment, land acquisitions, and the construction of new buildings and facilities. The University of Alabama in Tuscaloosa (UA) exemplifies all three types of growth. Since 2004, the UA has spent some $1 billion dollars on construction and improvements to the Tuscaloosa campus (Dialog, 2010), including the new Capstone College of Nursing building, Riverside Residential Complex, Ferguson Center Parking Deck, and the acquisition of Bryce Hospital. Growth is also evident in the Fall semester enrollment rates. From 2000 to 2011, enrollment increased from 19,277 to 31,747 (University of Alabama, 2011), and UA is aggressively seeking to add enrollment in the future (Greene, 2011). While growth is considered encouraging and positive, such rapid growth can also have disadvantages, as expansion and increased enrollment tend to clog college campuses (Holland, 2011) and change the overall accessibility of the campus (Crompton, 2011; Evans, 2011). Transportation accessibility, especially, is affected by poor planning, inadequate infrastructure, reductions in capacity, and the lack of viable alternatives to automotive transportation, the standard of modern American society. However, non-motorized transportation is a viable and sustainable alternative that has become a part of the growing movement to counter the increasing amount of negative externalities associated with an automobile-centered transportation system (Greene & Wegener, 1997; Black, 1996; Tolley, 1996). Non-motorized transportation can include, but is not limited to: walking, running, bicycling, roller skating, skateboarding, and using foot-powered scooters. Recently, increased accessibility of non-motorized transportation has been used to help combat the downfalls of automobile transportation (de Geus et al., 2007; Vuori et al., 1994). Populations associated with colleges and universities display higher than average use of non-motorized transportation, in terms of daily commuting (WARC, 2007; University of Alabama, 2007; Pucher et al., 1999). However, factors including individual's perception of safety, accessibility, the built environment, proximity to destinations, attitude toward physical activity, and other factors have been shown to limit the overall development and implementation of non-motorized transportation (Moudon et al., 2005; Plant, 2005; Zahran et al., 2008).

By employing GIS and survey data, this research ultimately asks the question: how accessible is UA for individuals that live within 3 Euclidian miles of campus and use non-motorized travel? This research is comprised of three components that relate to non-motorized transportation in the Tuscaloosa-Northport area. The first component uses GIS to measure the connectivity of the bicycle and pedestrian networks for each individual's neighborhood within the sample population. The second component involves modeling bicycle and pedestrian accessibility along the non-motorized transportation network in GIS. The third component includes the statistical analysis of results from an on-line survey administered to students and employees of UA who live within 3 Euclidian miles of the UA campus.

2.0 RESEARCH BACKGROUND

Over the last three decades, there has been an increasing amount of interest and research relating to bicycle and pedestrian travel. Non-motorized travel is seen as an inexpensive, efficient, and healthy mode of travel for covering short distances (Black, 1996). Several factors have been identified that affect the rates of non-motorized transportation within a transportation network. Network connectivity (Berrigan et al., 2010) and accessibility (Iacono et al., 2010) are two main factors affecting rates of bicycle and pedestrian travel. Additionally, other factors can affect rates of bicycling and walking including the built and natural environments (Moudon et al., 2005), socio-economic and demographic variables (Zahran et al., 2008), as well as an individual's perception (Plant, 2005). Since the use of non-motorized transportation involves a choice and individual preferences, there are certain limitations to studying human behavior; the choice to use non-motorized transportation is a continually advancing field.

2.1 Connectivity

The primary purpose of transportation networks is to link locations that individuals want to travel between and allow ease of movement. Connectivity is a measure of the degree to which a network provides direct travel and additional travel options. Connectivity, like accessibility, is particularly important for bicycle and pedestrian travel. As connectivity increases, distances and travel times between destinations decreases and route options increase. In addition, increased connectivity provides greater overall network capacity. Shorter blocks and a grid-like network were found to be correlated with higher rates of active transportation when compared to networks that contain many cul-de-sacs and longer blocks (Berrigan et al., 2010). Thus, transportation networks that incorporate more dead-ends, longer blocks, and fewer intersections are assumed to be less conducive to non-motorized travel. A more connected transportation network is thought to make bicycle and pedestrian travel more appealing. Bicycle and pedestrian connectivity is a measure of the degree to which a public network provides direct and safe travel options. Travel distance is a primary factor in determining whether an individual will use non-motorized travel and increases in connectivity help decrease the travel distance to a destination. Assessing network connectivity requires consideration of the entire available infrastructure in a study area.

Recently, tools like GIS have enabled researchers to employ measures of connectivity of transportation networks over larger and larger study areas. Within GIS, a transportation system consists of a network of line segments and end points. Line segments represent avenues in which traffic flows and in GIS these are called links or edges. End points represent junctions or intersections along the network and in GIS these are call nodes or vertices. Nodes can exist at the junction of two line segments (intersections) or at the end of a line segment (cul-de-sacs). It is important to distinguish between the two when employing measures of connectivity.

There are numerous methods for evaluating network connectivity. Table 2.0 summarizes several methods earlier research has identified for measuring network connectivity.

Table 2.0
Various measures of connectivity

Measure	Definition	Calculation	Comments
Intersection Density	Number of interactions per unit of area.	Number of real nodes / area	Higher density indicates higher connectivity.
Network Density	Number of linear miles of a network per unit of area.	Total network length / area	Higher density indicates higher connectivity
Connected Node Ratio	Number of street intersections divided by the total number of all intersections.	Number of real nodes / number of total nodes	Values range between 0 and 1. Higher number indicates higher connectivity.
Link-Node Ratio	Number of links divided by the number of nodes.	Number of Links / Number of Nodes	A perfect grid has a ratio of 2.5.
Average Block Length	Measures the street length from center of intersection to center of intersection.	Sum of link length per unit area / number of nodes per unit area	Shorter blocks indicates more intersection.
Effective Walking Area	Ratio of the number of parcels within a 1/4-mile walking distance from an origin.	Taxlots within 1/4 mile walking distance of origin / total taxlots	Higher value indicates higher connectivity.
Route Directness	Ratio of route distance to straight-line distance	Route distance / straight-line distance	Numbers closer to 1 indicate more direct route
Gamma Index	Ratio of the number of links to the maximum possible number of links between nodes.	Number of links per unit of area / 3*(number of nodes - 2)	Values range between 0 and 1. Higher number indicates higher connectivity.
Alpha Index	Ratio of the number of actual circuits to the maximum number of circuits.	Number of links - number of nodes - 1 / 2*(number of nodes) -5	Values range between 0 and 1. Higher number indicates higher connectivity.

Note. Adopted from Berrigan et al. (2010) and Tresidder (2005).

While numerous measures of connectivity exist, earlier research has yet to identify a single or group of measures that should be used when evaluating a non-motorized travel network (Kim, 2007). Rather, most research uses a combination or group of measures when studying a transportation network (Berrigan et al., 2010; Dill, 2004). Using a combination of the various measures of connectivity has been shown to effectively assess non-motorized travel networks by incorporating not only measures that evaluate links and nodes, but also routes, distance, and land-use.

Intersection Densities calculate the number of intersections within a given area. Higher densities within an area indicate a high number of intersections, thus allowing an increase in route options and choice. Network Densities evaluates the concentration of available infrastructure by calculating the amount of network miles within a given area. Higher densities within an area indicate high amounts of network availability, thus allowing for more routes and options when traveling. Connected Node Ratio is a ratio of real nodes to all nodes. Real nodes are considered to be intersections in the real world while other nodes are found at the endpoints of line segments (cul-de-sacs). Thus, a higher ratio indicates more real nodes (intersections) which increase connectivity by increasing the number of available intersections and routes. A higher Connected Node Ratio identifies networks with few dead-ends. Poorly connected networks have values less than 0.5 while values of 0.7 or higher are ideal. Link-Node Ratio is a ratio of links to nodes. A grid-type network generally has a Link-Node Ratio between 2.3 and 2.5. A perfect grid has a ratio of 2.5. A curvilinear-type network has ratios between 1.4 and 1.8, while conventional-type networks have ratios between 1.0 and 1.2. For planning purposes and network design a Link-Node Ratio of 1.4 is considered a target. Route Directness is a ratio of route distance to straight-line distance. The lowest possible value for Route Directness is 1.0, where the route distance along the network is the same as the "crow flies" distance. Numbers closer to 1.0 indicate a more direct route, theoretically representing a more connected network. Gamma Index is a ratio of number of links in a network to the maximum possible number of links between nodes. Gamma Index ranges from 0 to 1 where a value of 1 is a completely connected network where no more links are possible in a network. The Alpha Index measures and compares the number of loops to the maximum possible number of loops. This index ranges from 0 to 1, where 0 has no loops and 1 is a completely connected network.

While earlier research is undecided over the best method for evaluating network connectivity, earlier research has also identified a difference in the type of desired network connectivity associated with the purpose of an individuals' trip. Trip purpose has an effect on an individual's need for network connectivity (Stinson & Bhat, 2003). For example, research has shown that individuals want a highly connected network coupled with a high degree of available destinations when related to either work or school trips (Xing et al., 2010; Stinson & Bhat, 2003). Dill (2009) found that bicyclists commuting to work would make frequent stops on along their route (coffee shop, grocery store, or day care). Additionally, non-motorized users seek out the routes with lower travel times (Stinson & Bhat, 2003). For exercise purposes, individuals have been shown to prefer routes that incorporate longer and uninterrupted segments which allow users to maintain a constant speed for exercise (Larsen & El-Geneidy; 2011, Krizek & Johnson, 2006).

2.2 Accessibility

Accessibility is an important concept in the study of transportation. The traditional measure of accessibility deals with the spatial distribution of potential destinations, the convenience of reaching these destinations, and the character of the activities at a particular destination determine overall accessibility (Handy & Niemeier, 1997). This traditional view of accessibility is heavily dependent on the impedance of distance or the cost of travel. However, accessibility can be measured through a number of elements. These include: travel time, travel distance, cost of travel, or ease of reaching a destination. Perhaps the most common traditional measure of accessibility is a gravity-based measure (Iacono et al., 2010) which is derived from the gravity model:

$$A_i = \sum_j a_j f(t_{ij})$$

where A_i denotes the accessibility as zone i, a_j denotes activity in zone j, t_{ij} denotes travel impedance between i and j, which can be expressed as a cost, distance, or time, and $f(t_{ij})$is a function of t_{ij} introduced to express the effect of impedance. A portion of the gravity-based measure deals with the attraction (size and distance to) of different zones or activities at a particular destination across the urban landscape.

Evolving from this traditional measure of accessibility, centered on distance, place, or zones, researchers have recognized the need to improve the view of accessibility for the 21st century. This updated view identifies the advances in information and communications technologies (ICTs) such as the internet and mobile phones as they relate to individual accessibility (Schwanen & Kwan, 2008; Kwan & Weber, 2003). Space-time accessibility measures are seen as the nest step in modeling movement and travel behavior (Kwan & Weber, 2003). Along with ICTs, the availability of economical and improved computing power, GPS devices, and GIS software have also enabled researchers to rethink accessibility models. These advancements in computing power have led to improved models that can incorporate more detailed variables and more complex equations.

Space-time accessibility measures are believed to more accurately measure individual accessibility due to an increasing complex relationship between an individual's mobility, the urban environment, and ICTs (Kwan & Weber, 2003). ICTs and today's smart mobile phones have allowed individuals access an enormous amounts of resources via the internet; improved communications through text, video, and picture messaging; and even on-the-go traffic updates. Researchers identified that ICTs have an increasing effect of individual accessibility (Line et al., 2011; Schwanen & Kwan, 2008; Kwan & Weber, 2003). These mobile devices and ICTs have greatly altered the traditional view of travel and accessibility (Schwanen & Kwan, 2008; Kwan & Weber, 2003). Space-time accessibility measures have an advantage over the traditional measure of accessibility by incorporating a flexible model that not only uses distance and place but also integrates the effect of technology and personal, social, and transportation constraints.

No matter which measure of accessibility is being implemented, accessibility is greatly affected by scale, land use patterns, and transportation networks (Kwan & Weber, 2008). Increasing the number of potential destinations, allowing for a variety of travel modes, and reducing travel cost constraints (time, distance, or money) within a given range will increase the level of accessibility. This allows individuals in the same place to calculate their accessibility differently (Church & Marston, 2003). Furthermore, the arrangement, capacity, and structure of transportation infrastructure are important elements when determining accessibility.

In addition, accessibility can also be measured in the form of access along transportation networks; for example, access to retail, jobs, and housing; and to other goods and services which can affect an individual's flexibility and standard of living. Different levels of accessibility have been found to be related to work travel (Wang, 2000; Levinson, 1998) verses non-work travel (Handy, 1992). To be effective, a transportation network must allow the greatest number of individuals access to a particular resource without diminishing capacity or flow rates. Since accessibility plays such an important role in creating transportation and planning goals, it is useful to translate the concept of accessibility into measures of accessibility for evaluating policies and programs (Handy & Niemeier, 1997).

Even given identical characterizations of accessibility, there will still be variation in the overall landscape and network use. Individuals with different abilities and viewpoints will travel, use, and access the urban environment in different ways. For a disabled individual, a landscape will have barriers and routes that a non-disabled individual might overlook. Church and Marston (2003) examined the components of accessibility as it relates to disabled individuals and identified an important difference between absolute and relative access. Absolute access refers to the opportunity for destinations to be reached while relative access reflects the differences in access relative to individual users and the effort needed to overcome certain obstacles when traveling. When employing measures of accessibility, researchers must pay close attention to barriers, obstacles, and routes (Church & Marston, 2003). Some barriers or obstacles related to bicycle and pedestrian travel include disconnected bike lanes or sidewalks, lack of crosswalks, non-cut curbs, or rough pavement.

Recently, the availability of digitized public data from federal, state, and local resources have allowed for measures of accessibility to be employed through the use of GIS. This data can come in the form of transportation networks; landmarks; waterways; buildings, property, and parcel information; political boundaries and zones; and U.S. Census zones. However, earlier research has identified problems with employing measures of accessibility that are associated with polygon or zonal data in GIS (Hewko et al., 2002; Kwan & Weber, 2008). Zonal data, such as U.S. Census tracks, block groups, blocks, or traffic analysis zones (TAZ), have been found to underestimate or overestimate overall accessibility (Biba et al., 2010). Sample populations can be inaccurately portrayed by zones when half of a population falls within one zone and the other half of the population is in an adjacent zone. Solutions to these problems include using point data or smaller zones (Tresidder, 2005). In addition, a lack of data relating to bicycle and pedestrian infrastructure often leaves researchers creating their own datasets. In GIS, numerous models have been developed over the years to measure and test the accessibility of networks and destinations. The Walkable and Bikeable Community (WBC) (Lee & Moudon, 2006) study is one such model. This model incorporates numerous variables including: block size; residential density; household size, sidewalk availability; number of schools, restaurants, bars, grocery stores, and shopping complexes; and distances to these destinations. Other models incorporate these variables as well as parks, bike lanes, sidewalks, trails, and other spatial information.

Impedance values of time, cost, distance, or safety are commonly used when measuring accessibility for use of bicycle and pedestrian travel. The spatial distribution of bicycle and pedestrian travel can be expressed using distance decay functions (Iacono et al., 2010) as travel distance is a limiting factor for implementing use (Larsen & El-Geneidy, 2011). Distance decay functions describe the effect of distance on spatial interactions and typically express distance as a function of travel impedance (time or cost). Rybarczyk and Wu (2010) identified the importance of the spatial patterns of bicycle facilities and connectivity of a local network when studying accessibility. Furthermore, increased connectivity within a network also allows for increased accessibility.

2.3 Bicycle and Pedestrian Travel

In addition to factors such as accessibility and connectivity along bicycle or pedestrian networks, a variety of factors affect the probability of using non-motorized travel. These factors can be grouped into three main themes: the built environment, the natural environment, and an individual's perceptions and habits. These themes are discussed in the following section.

Bicyclists and pedestrians state that safety is an overwhelming concern when using modes of non-motorized travel. In 2009, only 4,092 pedestrians and 630 bicyclists were killed in traffic crashes, while some 59,000 pedestrians and 51,000 bicyclists were injured in traffic related accidents in the U.S. (NHTSA, 2009). On average, a pedestrian is injured every 8 minutes and killed every 2 hours. These are astounding numbers when considering that in 2009, walking accounted for only 10.9% and bicycling accounted for only 1% of all trips in the U.S. Within urban areas 53% of all trips are 3 miles or less and automobiles account for 72% of trips 3 miles or less (NHTS, 2009). However, even in our automobile-driven society, bicycle and pedestrian travel experienced a 25% increase nationwide from 2001 to 2009 (NHTS, 2009). In the state of Alabama, 65 pedestrians and 6 bicyclists were killed in traffic accidents, while 511 pedestrians and 167 bicyclists were injured in traffic related accidents in 2009 (CAPS, 2009).

To help local governments and municipalities address and encourage the use of non-motorized transportation, the federal government has provided funding for non-motorized transportation improvement projects through provisions like the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 and the Transportation Equity Act for the 21st Century (TEA-21) of 1998. Federal funding for projects continued through the Safe Accountable, Flexible, Efficient Transportation Equity Act: a Legacy for Users (SAFETEA-LU) of 2005. As a result of these broad initiatives, Federal-Aid Highway Program obligations for bicycle and pedestrian projects grew from $22.9 million on 50 projects in 1992 to $1,036.6 million on 3,007 projects in 2010 (FHWA, 2010). Within the state of Alabama, the Federal-Aid Highway Program funded $107.4 million in bicycle and pedestrian facilities between 1999 and

2010 (FHWA, 2010). SAFEATEA-LU Section 1807 established the Non-motorized Transportation Pilot Program (NTPP) to help increase levels of bicycling and walking by providing $25 million to each of the following communities: Columbia, MO; Marin County, CA; Minneapolis, MN; and Sheboygan County, WI. A final report of these pilot programs is scheduled for the fall of 2011(FHWA, 2011). Across the country, programs and initiatives at the local, state, and federal level are undertaking the challenge of encouraging non-motorized travel through increasing public awareness and building infrastructure geared towards bicycle and pedestrian travel. Good network design must incorporate safety, comfort, directness, and attractiveness. In addition, one underlying trait that these networks must include is that they ensure that they accommodate users of all ages and skill levels. When comparing the cost of infrastructure and facilities and the cost of building, using, and maintaining, non-motorized transportation modes are substantially lower than automobiles (Fels, 1975; Saelensminde, 2004). Furthermore, increases in the rates of bicycling and walking can off-set the use of automobiles, thus reducing the need to add additional lanes to roads or building parking garages and lots.

Research illustrates that specifically designated bicycle and pedestrian facilities and infrastructure promote higher perceptions of safety in addition to encouraging new and infrequent users (Larsen & El-Geneidy, 2011; Xing et al., 2010). This infrastructure can come in the form of bicycle racks, signage, separate routes, pathways, sidewalks, lanes, boulevards, trails, and bridges. Higher amounts of bicycle-friendly infrastructure, such as bicycle lanes, paths, bicycle boulevards, or trails, have the potential to increase the likelihood of bicycling (Dill, 2009; Moudon et al., 2005; Stinson & Bhat, 2003). Additionally, proximity to this bicycle-friendly infrastructure significantly increased the likelihood of individuals using modes of non-motorized transportation (Krizek & Johnson, 2006; Moudon et al., 2005). Other factors associated with the built environment that have been shown to affect rates of bicycle travel include: distance from automobile traffic, buffers or barriers from automobile traffic, volume of automobile traffic, grade, presence of parallel parking, pavement type, width of road way, and one-way streets (Allen-Munley et al., 2004; Stinson & Bhat, 2003). For pedestrians, not only does the mere presence of sidewalks and trails encourage foot travel, but studies found that the width and condition of sidewalks, proximity to automobile traffic, speed and volume of automobile traffic, buffers or barriers from vehicle traffic, land-use, and connectivity are correlated with higher amounts of use (Guo, 2009; Landis et al,. 2001; Zahran et al., 2008).

Factors that are associated with the natural environment have also been shown to affect bicycle and pedestrian travel. These factors include: weather, temperature, shade, aesthetics, and slope. The type of weather an individual has to travel through has been identified as a principal factor in the decision process for employing non-motorized travel modes. The pinnacle conditions that individuals consider using non-motorized travel include dry weather and pleasant temperatures (60^{o} to 75^{o}F) (Zacharias, 2001). High amounts of shade cover over a network and available aesthetics along a route increase the rates for non-motorized travel (Zahran et al., 2008). Slope has an impact, no matter the method of travel. Individuals will travel out of their way to by-pass segments with steep slopes. For bicyclists and pedestrians, small positive increments in slope decrease travel speeds while increasing energy use and travel time.

Bicycle and pedestrian travel choice is also affected by an individual's perception and view. How an individual views movement and traveling can affect the mode of travel. In addition, an individual's perception of distance and time can also influence the use of motorized or non-motorized travel choices. Other factors include: amount of available time to travel, amount of education, and view towards physical exercise. For daily non-motorized commuters the shortest path is the mostly likely; however studies show that commuters will travel out of their way to use bicycle- and pedestrian-friendly infrastructure since they provide a more comfortable and safer avenue in which to travel (Dill, 2009; Larsen & El-Geneidy, 2011; Tilahun et al., 2007). For exercise purposes, the availability of separate facilities for bicycling and walking increases travel distance and time spent using the facilities (Dill, 2009; Larsen & El-Geneidy, 2011; Tilahun et al., 2007).

Bicycling skills varies greatly from person to person and, because of this, the Federal Highway Administration (FHWA) groups bicyclists into three types of riders: advanced bicyclists (Group A), basic bicyclists (Group B), and children (Group C). Because of the varying degree of skill level, infrastructure and facilities must be built in such a way that it allows everyone to use the facilities. Table 2.1 summarizes various mean travel speeds of bicyclists which earlier studies have identified for bicycling in an urban setting. Methods for determining travel speeds include radar guns, videotaping, GPS, and stopwatch timing. A bicyclist's speed is also based on a number of variables including facility type, route characteristics, the individual, slope, and weather. Off-street bicycling facilities and longer trips have been shown to increase travel speeds of participants (Allen et al., 1998; El-Geneigy et al., 2007). Allen et al. (1998) reviewed earlier work and concluded summarized free-flow bicycle speeds averages between 6.2 mph and 17.4 mph. El-Geneidy et al. (2007) found that the average bicycle travel speed was between 9.7 mph and 10.8 mph. The American Association of State Highway and Transportation Officials (AASHTO) recommend that bicycle facilities have a design that accommodates speeds up to 20 mph (AASHTO 1999).

Table 2.1
Bicycling speeds, previous research

Author	Speed (mph)	Facility Type	Location
Dill, 2009	10.8	Urban setting	Portland, OR
Lindsey & Doan, 2002	13	Greenway trail	Indianapolis, IN
Khan & Raksuntorn, 2001	15.4	Bicycle path	Denver, CO
Virkler & Balasubramanian, 1998	13.3	Multi-use trail	Columbia, MO
	12.9	Multi-use trail	Brisbane, AU
Thompson et al., 1997	9.2	Closed road	Seattle, WA
Wei et al., 1997	11.3	Off-street path	China
	8.6	On-street	China
Botma, 1995	11.2	Off-street path	Netherlands
	7.5	On-street	Netherlands

While bicycle facilities should be designed to allow for a multitude of skill levels, so should pedestrian infrastructure and facilities. Within the urban landscape, pedestrian travel speeds will vary greatly from individual to individual. Numerous variables affect the speed at which an individual will walk, including commute time, age, sex, ability, weather, slope, facility type, temperature, automobile traffic, safety concerns, and other factors (Guo, 2009; Zacharias, 2001). Table 2.2 summarizes the various pedestrian speeds identified in earlier studies and reports.

Table 2.2
Pedestrian speeds, previous research

Author	Speed (mph)	Facility Type	Location	Demographic
FHWA, 2010a	1.9	Sidewalk	U.S.	Elderly
Guo, 2009	3.0	Sidewalk	Boston, MA	Mean
FHWA, 2009	2.7	Clear traffic signals	U.S.	Mean
Dewar, 2002	2.4	Sidewalk	U.S.	Handicapped
Botma, 1995	2.8	Pedestrian Path	Netherlands	Mean
Pandolf et al., 1977	2.9	Off-street	U.S.	Mean

While earlier research suggests a correlation between non-motorized travel and the built and natural environments, other studies have identified the importance and impact of the social environment (Forsyth et al., 2009). Local bicycle advocacy groups, bicycle-oriented individuals, and other social community groups help contribute to the importance of non-motorized transportation as part of the community culture (Bonham & Koth, 2010; Xing et al., 2010; Zahran et al., 2008). These groups offer support, out-reach, and voices for advocates of non-motorized travel within a community. If an individual hears that someone at school or work uses a non-motorized method of travel, this may bring about psychological changes and may increase the chance of bicycling or walking. Local groups also offer a form of social learning where individuals can increase their desire or motivation to bike or walk through the exchange of information (Krizek et al., 2009). Social groups, friends, and "being seen" can also affect the travel and route choices an individual will make. Social behavior, especially with a university population, is important. Some individuals will make route choices in which they will be seen or have the chance of running into friends or others along their route.

However, earlier research dealing with bicycling in the Tuscaloosa area found that bicycling carries a negative stereotype or stigma (Lange, 2007). In addition, even pedestrian travel carries a negative stereotype. Non-motorized is viewed as a "poor" person's mode of travel (Rogalsky, 2010). When deciding on a travel mode, this negative stereotype has an influence on an individual's decision process (Lange, 2007).

When compared to the national population, college and university populations have displayed higher rates of bicycle and pedestrian use (Boham & Koth, 2010; Plaut, 2005; Pucher et al., 1999). Demographically, university populations tend to live closer to their main destination (college campus) and have greater access to a non-motorized transportation network.

They also tend to be younger in age, rent their residence, and non-automobile owners. Berrigan & Troiano (2002) found that individuals living in neighborhoods with homes built before 1973 were significantly more likely to walk at least a mile 20 times a month because these neighborhoods are more likely to have a high concentration of pedestrian infrastructure (e.g., sidewalks). Over the years, changes in land-use, local zoning ordinances, and urban sprawl have decreased the amount of pedestrian facilities in newer neighborhoods. Within Tuscaloosa, the University of Alabama's (UA) campus is surrounded by numerous historic districts and 1973 is the median year a home was built in Tuscaloosa (Areavibes, 2011). Based on the 2000 U.S. Census data, the median year housing units were built in Tuscaloosa is 1972 (Figure 2.0).

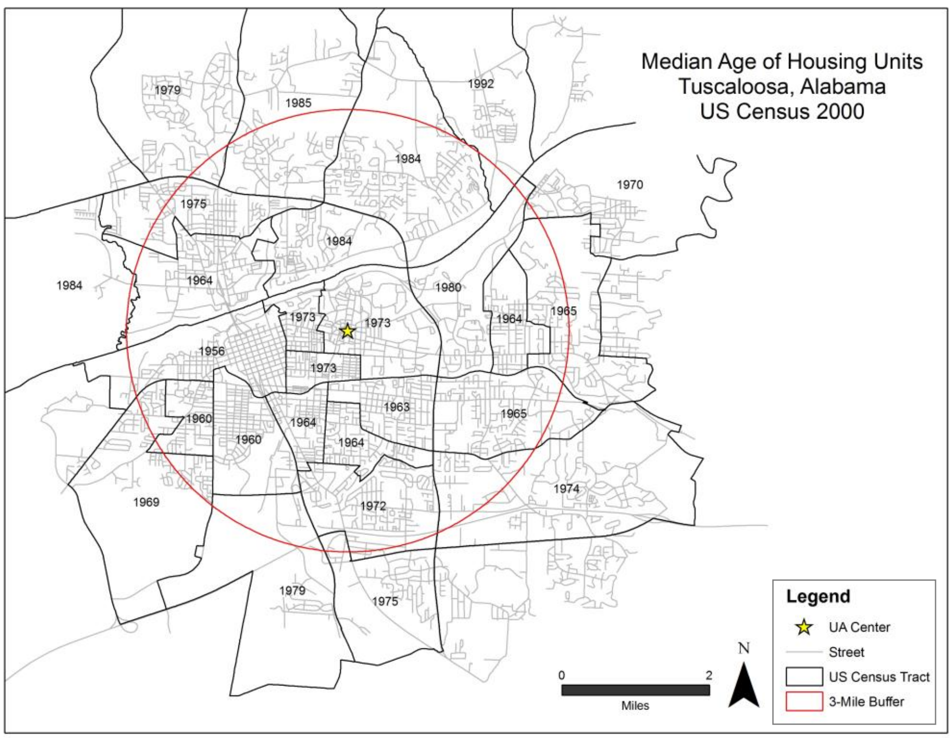


Figure 2.0 – The median year housing units were built in the study area.

Bicycle and pedestrian use also provides a sustainable and healthy mode of travel. A lack of physical activity along with a poor diet are two leading causes for the recent increase in the rates of adult obesity and diabetes in the U.S. (CDC, 2008; Haskell et al., 2007). Sallis et al. (2009) examined neighborhood environments in developed countries and found evidence to indicate an epidemic of sedentary behavior. For adults, the American College of Sports Medicine (ACSM), American Heart Association (AHA), and the Centers for Disease Control and Prevention (CDC) recommend at least 30 minutes of moderate physical activity a day. Moderate physical activity is defined as burning 3-6 metabolic equivalents (MET) (CDC, 2008; Haskell et al., 2007). Commuters that use modes of non-motorized transportation and have at least a 10 minute commute time one-way have been shown to meet the ACSM, AHA, and the CDC's recommended levels of exercise for adults while using an alternative to automobile transportation (de Geus et al., 2007; Dill, 2009; Vuori et al., 1994). Within the urban landscape, each kilometer walked reduced the likelihood of obesity by 4% and each additional hour spent in an automobile increased the likelihood of obesity by 6% (Frank et al., 2004). Data suggests that sustainable transportation modes incorporated in transit-oriented development (TOD) resulted in 0.4% decrease in obesity from a 1% decrease of automobile use (Samimi et al., 2009).

When an individual uses non-motorized travel over an automobile, they reduce the number of vehicles on the road and thus reduce automobile traffic. There are numerous benefits when automobile traffic is reduced on the roadways, including: reductions in noise, air pollution, wear-and-tear on roadways; less congestion; lower stress levels; and improved commute times.

Within the Tuscaloosa-Northport area, efforts are underway to increase the use of bicycle and pedestrian travel. WARC administers the local Metropolitan Planning Organization (MPO) which oversees the Bike and Pedestrian Committee whose purpose is to serve as a guide to improving bicycle and pedestrian travel in the area. Local advocacy groups such as Druid City Bicycle Club, I Bike Tuscaloosa, and the Alabama Bicycle Coalition (AlaBike) serve as a voice for local bicyclists which recently helped pass Tuscaloosa City Ordinance #7775 or the "3 Feet Rule.” This city ordinance states that when a motor vehicle overtakes and passes a bicycle that the motor vehicle shall pass at a safe distance of not less than three (3) feet. Other local projects and programs such as extending the Black Warrior River multi-use paths, adding eight-foot wide bicycle and pedestrian paths on both sides of McFarland Boulevard, and improving other infrastructure that help to increase non-motorized travel. In addition, the city of Tuscaloosa in hopes of increasing awareness applied to the League of American Bicyclists as a bike-friendly community (League of American Bicyclists, 2010).

Over the years, UA has embraced bicycle and pedestrian traffic on campus. In the summer of 2007, UA closed the roads surrounding the Quad to automobile traffic and introduced a transit bus system to move students and employees around campus. These measures were put in place to increase non-motorized travel safely while decease congestion on campus as well as for environmental reasons (Dialog, 2007). In the summer of 2011, UA introduced a new campus policy towards bicycles. This policy was geared towards improving bicycle safety and required individuals to register their bicycles with the university. The required bicycle registration section of the policy was met with resistance from the university population (Massey, 2011; Doherty, 2011). Recently, UA’s campus organizations have also contributed to the awareness and encouragement of non-motorized travel including, Student Government Association’s introduction of new pedestrian exercise routes and paths on campus (Locklar, 2011), Outdoor Recreation made available a bicycle commuter map and safety information on-line, and Transportation Services placed numerous bike racks and other bicycle facilities on campus. In addition, UA is currently open to suggestions and in the process of updating the Campus Master Plan. Preliminary data shows a desire to increase bicycle and pedestrian traffic.

Even despite such clear benefits, the use of bicycle and pedestrian travel is still underutilized in many communities in the U.S. With a multitude of factors affecting an individual's choice of travel, the decision process to use non-motorized transportation is a complex issue and is still not well understood. Earlier research has identified that stated-preference, cross-sectional, or other types of survey questionnaires are reliable avenues to gather empirical data pertaining to bicycle and pedestrian travel (Frank et al., 2004; Moudon et al., 2005; Tilahun et al., 2007). This information is a vital part of improving our understanding of non-motorized travel. However, self-reported data relating to travel habits is qualitative and should be approached with caution.

Transportation researchers and land-use planners are constantly trying to improve their understanding of transportation systems by studying why individuals make particular travel choices, why individuals travel, and how individuals travel, all in the hopes of gaining a better understanding of our society. This research hopes to improve our understanding of transportation networks, travel habits, and travel methods by employing GIS and analyzing survey data relating to non-motorized travel and university populations. This investigation is significant since it is the first to study non-motorized travel connectivity and accessibility in Tuscaloosa-Northport. This study aims to achieve a better understanding of how, why, or why not individuals are using non-motorized travel in the Tuscaloosa area. This research hopes to assist UA personal, transportation planners, and city officials in making more informed decisions when enacting ordinances and regulations affecting transportation and non-motorized travel. This data can also aid in the planning and design process of infrastructure and facilities tailored for bicycle and pedestrian travel. In addition, these findings can be used to increase education, awareness, encouragement, and increase use of non-motorized travel methods in the Tuscaloosa area.

3.0 METHODOLOGY

3.1 Research Problem

Research has shown that a multitude of factors including an individual's perception of safety, accessibility, the built environment, proximity to destinations, attitude toward physical activity, and other factors have been shown to limit the overall development and implementation of non-motorized transportation (Moudon et al., 2005; Plant, 2005; Zahran et al., 2008). An example of these factors affecting the use and development of bicycle and pedestrian transportation can be found in the Tuscaloosa-Northport area. Despite being a growing college-centered town, census data shows that non-automobile transportation remains underutilized in the area (AASHTO, 2010). In May 2010, the city of Tuscaloosa failed to achieve recognition from the League of American Bicyclists as a bike-friendly community due to the lack of bicycle-friendly infrastructure, bicycle related programs, and future planning geared towards bicycle transportation (League of American Bicyclists, 2010). Since the University of Alabama (UA) is currently the largest employer in the Tuscaloosa-Northport area with 5,712 employees and a student enrollment of 31,747 (University of Alabama, 2011), an increase in bicycle and pedestrian accessibility to UA's campus has the potential to enact positive changes regarding transportation in the area (WARC, 2007). Currently, the UA campus provides some facilities for bicycle and pedestrian travel as well as a bus transit system (University of Alabama, 2007). However, there is a lack of network connectivity between UA's campus and the surrounding non-motorized travel networks while areas outside of the UA's campus lack adequate infrastructure and facilities to safely support non-motorized transportation (WARC, 2007).

3.2 Research Objectives

This study utilizes GIS to measure network connectivity and accessibility of the local bicycle and pedestrian networks surrounding UA. In addition, this study uses survey data related to non-motorized travel of individuals that are associated with UA. Combining these analyses this study has the following research objectives:

a. To identify and calculate the bicycle and pedestrian facilities in Tuscaloosa-Northport.

b. To measure connectivity along the bicycle and pedestrian networks within an individual's neighborhood.

c. To measure and identify bicycle and pedestrian accessibility to UA.

d. To characterize bicycle and pedestrian travel and behavior as it relates to UA's population.

e. To measure the perceived non-motorized travel accessibility of UA's campus.

f. To address possible additions to the bicycle and pedestrian network.

g. To determine whether increased accessibility would impact UA's population in deciding to use non-motorized transportation.

3.3 Research Questions

This research seeks to explore the local bicycle and pedestrian travel networks within the Tuscaloosa-Northport area through numerous evaluations and measures. Along with the above research objectives, this research asks the following questions:

Research Question 1: How does network connectivity differ between neighborhoods in the Tuscaloosa-Northport area?

High network connectivity is an important aspect of good non-motorized travel network design. A network that contains high connectivity has been shown to increase rates of bicycle and pedestrian travel. Across an urban landscape, network connectivity can differ from neighborhood to neighborhood. It is important for city planners to identify and maintain connectivity between residential, commercial, and other land-uses, so that individuals can easily travel between sections of a city.

Research Question 2: What degree is UA's campus accessible to users of non-motorized transportation?

Evaluations of network connectivity along with accessibility measures can help identify areas of the network that have either adequate or in adequate infrastructure. If gasps in the network exist, they can greatly affect travel habits and perceptions. Assessing UA’s accessibility can help identify sections of Tuscaloosa that have high accessibility. In addition, areas of lower accessibility can be targeted with improvement projects and other programs to help encourage non-motorized travel.

Research Question 3: Does proximity to the bicycle and pedestrian network predict the use of non-motorized travel?

Earlier research has shown that individuals living in close proximity to non-motorized travel infrastructure are more likely to use them when compared to individuals that live further away from this infrastructure. Increasing an individual's proximity to bicycle and pedestrian facilities could help increase rates of non-motorized travel.

Research Question 4: Are there certain socioeconomic-demographic traits that predict the use of non-motorized travel in the area?

Earlier research has identified that a number of variables affect rates of bicycle and pedestrian travel. This research seeks to identify variables within the UA population that help predict non-motorized travel. This information can be useful to city planners and UA officials to help encourage individuals to seek healthier modes of travel.

Research Question 5: Would an increase in bicycle- and pedestrian-friendly infrastructure affect the area's transportation behavior?

Increasing the availability infrastructure tailored for non-motorized travel could affect rates of bicycle and pedestrian travel in the area. Individuals are more likely to use non-motorized travel if they perceive abundant and safe avenues in which to travel. This could help reduce automobile travel to UA. In an urban environment removing automobiles from the local road network has been shown to have positive outcomes on the quality of life. These positive outcomes include: reductions in air and noise pollution, traffic congestion, stress, a more active population, and less wear-and-tear on the local roadways.

3.4 Research Methods and Data Acquisition

3.4.0 Introduction

This research was comprised of three components that relate to non-motorized transportation in the Tuscaloosa-Northport area. The first component used geographic information systems (GIS) to measure the connectivity of the bicycle and pedestrian networks for each individual's neighborhood within the sample population. The second component was an analysis of modeling bicycle and pedestrian accessibility along the non-motorized transportation network in GIS. The third component involved the statistical analysis of the results from the on-line survey administered to students and employees of UA who live within 3 Euclidian miles of the UA campus.

The GIS software employed for this study was ERSI's ArcMap 10. The GIS components of this study involved the creation, manipulation, and management of data relating to modeling real-world connectivity and accessibility of the non-motorized networks. Three measures of connectivity were employed to appropriately analyze the non-motorized networks. Accessibility was measured as cost values of time and distance along the non-motorized networks. The on-line survey of students and employees that were associated with UA was designed to extract individual's travel habits, views towards the non-motorized networks, and identify possible improvements to the networks within the Tuscaloosa-Northport area. IBM's SPSS Statistics 19 was used to conduct statistical analyses of the GIS and survey results.

Before this research could be performed, a request was made to UA's Institutional Review Board (IRB) for approval to incorporate human subjects for a one-time on-line survey and to gain access to email and home mailing addresses for students and employees of UA. Approval was granted by the IRB # 11-OR-198-ME in June 2011 (Appendix A). Requests were then made to: Michael George in the University Registrar for information related to students and Greg Gaddis in Human Resources for information related to employees.

3.4.1 Area of Study

Located in western Alabama, the cities of Tuscaloosa and Northport are separated only by the mighty Black Warrior River (Figure 3.0). According to the 2010 U.S. Census, Tuscaloosa had a population of 90,468 and covered roughly 70 square miles while Northport had a population of 23,422 and covered 15 square miles. The University of Alabama at Tuscaloosa (UA) is located in the heart of Tuscaloosa (Figure 3.0). UA has a noticeable impact on both cities as the area's largest employer and has a large student body. Tuscaloosa and Northport have

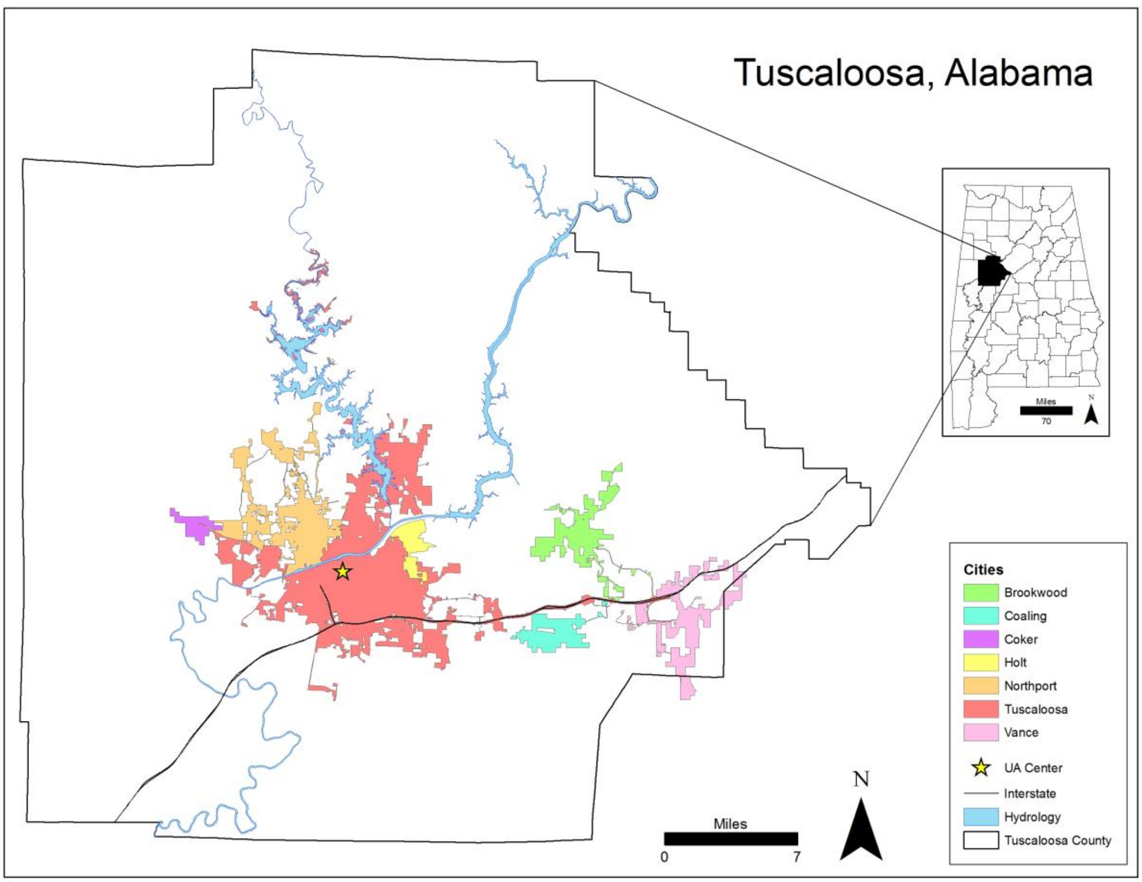


Figure 3.0 – Map of Tuscaloosa and surrounding communities.

experienced considerable growth over the years (Table 3.0). Since 1990, Tuscaloosa has seen a 14% increase in population while Northport has seen a 25.8% growth in population (U.S. Census Bureau, 2011). During the same time period, UA experienced a 37.5% increase in enrollment and a 34.8% increase in employment (University of Alabama, 2011). Table 3.1 summarizes the mileage of each of the various road hierarchies within the city limits of Tuscaloosa and Northport. Along with population growth, the Tuscaloosa-Northport area has also experienced an increase in automobile traffic. Table 3.2 summarizes the annual traffic counts for a select number of stations throughout the area. Figure 3.1 shows the spatial distribution of the traffic count stations in Table 3.2.

Table 3.0
Changes in population

Place	1990	2011	Percent Change
Tuscaloosa	77,759	90,468	+14.0
Northport	17,366	23,442	+25.9
UA - Students	19,828	31,747	+37.5
UA - Employees	3,722	5,712	+34.8

Table 3.1
Road hierarchy mileage within the study area

Road Hierarchy	Tuscaloosa	Northport
Interstate	21.18	0
Major Arterial	48.84	20.85
Minor Arterial	62.52	15.5
Major Collector	47.73	16.79
Minor Collector	1.95	0
Local	418.44	138.94
Bike Lanes	3.5	0
Multi-use Trail	6.15	2.36
Total	610.31	194.44

Table 3.2
Average annual daily traffic counts

ID #	Location	1981	1998	2007
15	SR-69 at the Warrior River	27,765	62,794	63,720
16	US-82 at the Warrior River	34,602	59,340	54,196
24	Hackberry Lane at the Norfolk Southern Railroad	16,511	18,458	20,942
26	12th Avenue at the Norfolk Southern Railroad	2,433	2,352	8,817
96	University Boulevard - east of Devotee Drive	12,779	11,782	15,425
98	University Boulevard East - east of Bryant Drive	18,020	25,186	24,402
191	15th Street - east of Hackberry Lane	25,317	34,536	43,653
306	Bryant Drive - east of 10th Avenue	14,351	12,687	15,362
358	Rice Mine Road at Snows Mill Creek	5,310	10,227	13,411

Note. Annual data from WARC (2008).

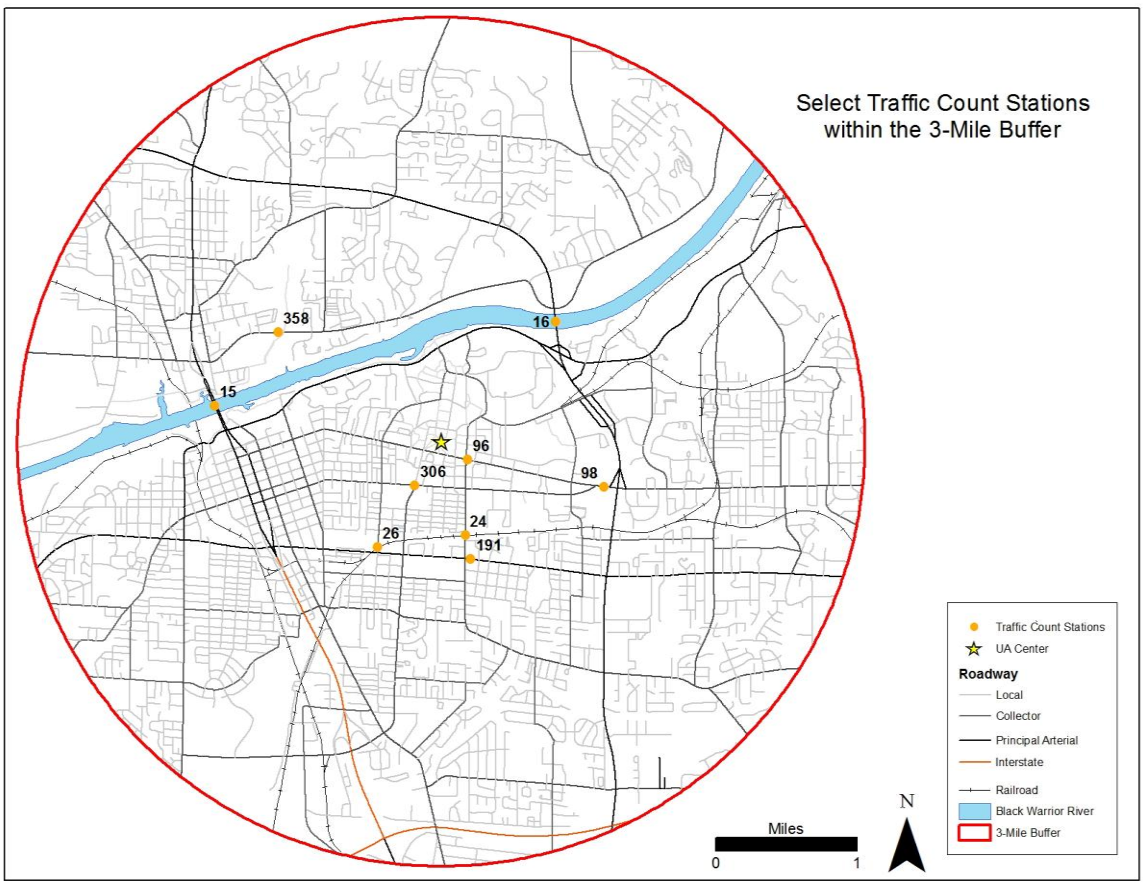


Figure 3.1 – Select traffic count stations within the study area.

3.4.2 GIS Data

The GIS data used in this study was derived from multiple sources, including federal, state, and local governments; private entities; and user created. Numerous GIS layers had to be incorporated into ArcMap before any modeling of non-motorized travel could be achieved. Base layers including street, railroad, hydrology, zip codes, and census data were derived from the 2010 U.S. Census TIGER line shapefiles. The travel network was a combination of 2009 and 2010 U.S. Census TIGER line shapefiles and user created data. Digital orthoimagery and a digital elevation model (DEM) covering the Tuscaloosa-Northport area were acquired from the USGS National Map Seamless Server. The orthoimagery was from the National Agriculture Imagery Program (NAIP), contained a 1 meter resolution, and was collected in June 2009. The DEM was part of the National Elevation Dataset (NED) and contained a resolution of a 1/3-Arc Second (9.25 meter). A percent slope raster layer was created from this DEM. The Western Alabama Regional Commission (WARC) provided a Tuscaloosa County sidewalk layer, which was updated by the researcher. Bicycle routes, bicycle lanes, multi-use trails, and an intersection layer were created from public participation and local bicycle advocacy groups in February 2010. The map projection used for this study was NAD 1983 UTM Zone 16N and all measurements are in miles.

The street network used in this research was a combination of 2009 and 2010 U.S. Census TIGER line shapefiles. New areas from the 2010 TIGER line shapefile were compared to the downloaded orthoimagery and the 2009 TIGER line shapefile. A total of 45 new miles were then added to the 2009 TIGER line shapefile. This research was only interested in the networks that surround UA and was comprised of a total of 4,601 line segments with a total mileage of 405.56 miles.

After the street network layer was created, the geocoding of student and employee’s home addresses could then take place. This research specifically targeted home addresses that were in the following zip codes: 35401, 35404, 35405, 35406, 35473, and 35487. Based on the street network layer, a new Address Locator file was created in ArcCatalog. Since the area of interest was confined to the Tuscaloosa-Northport area, the address locator style used was “US Streets.” The input address fields that were compared were “Streets” while all other default settings were used. ArcToolbox's Geocode Addresses Tool was utilized for two rounds of geocoding for each group of individuals: students and employees. The first round of geocoding identified numerous addresses that did not produce a match in the Address Locator. These unmatched addresses returned a match scored lower than 80. Before the second round geocoding, all addresses with a match score lower than 80 were manually reviewed and, when available, changes to an individual's address were made based on street spelling errors and/or missing address suffixes. The second round of geocoding produced a smaller number of unmatched addresses with a match score lower than 80. The third round of geocoding consisted of using Google Earth 6 and real estate websites such as www.zillow.com and www.trulia.com to identify UTM coordinates of unmatchable addresses from the second round of geocoding. This research was only concerned with street addresses, thus apartment numbers were not used.

Once the street network and home addresses where geocoded, the bicycle and pedestrian networks could be created. The bicycle network that was used in this study was derived from a bicycle route map that was created from public participation which incorporated UA students, and individuals from the local bicycle advocacy groups: I Bike Tuscaloosa and Druid City Bicycle Club. During February 2010, members met to discuss and finalize routes and intersections that were used most often by bicyclists within the Tuscaloosa-Northport area. This group was made up of bicyclists from different skill levels, ages, and sexes. The routes that were chosen are displayed in Figure 3.2. Off-street multi-use trails are colored purple; on-street bicycle lanes are colored blue; streets that were used by bicyclists, but had low automobile volume and low speed limits (<35 mph) are colored green; streets that were used by bicyclist, but had medium car volumes and medium speed limits (>35 mph) are colored orange; and streets that bicyclists avoided because of high automobile traffic and high speed limits (>45 mph) are colored red. The bicycle routes, multi-use trails, local streets, and minor collectors were combined to form the bicycle network for this research. Local streets and minor collectors were considered part of the bicycle network because current Alabama state law (Alabama Code 32-5A-52 (3)) deems a bicycle as a vehicle and makes it illegal to ride a bicycle on a sidewalk (Code of Alabama, 1975).

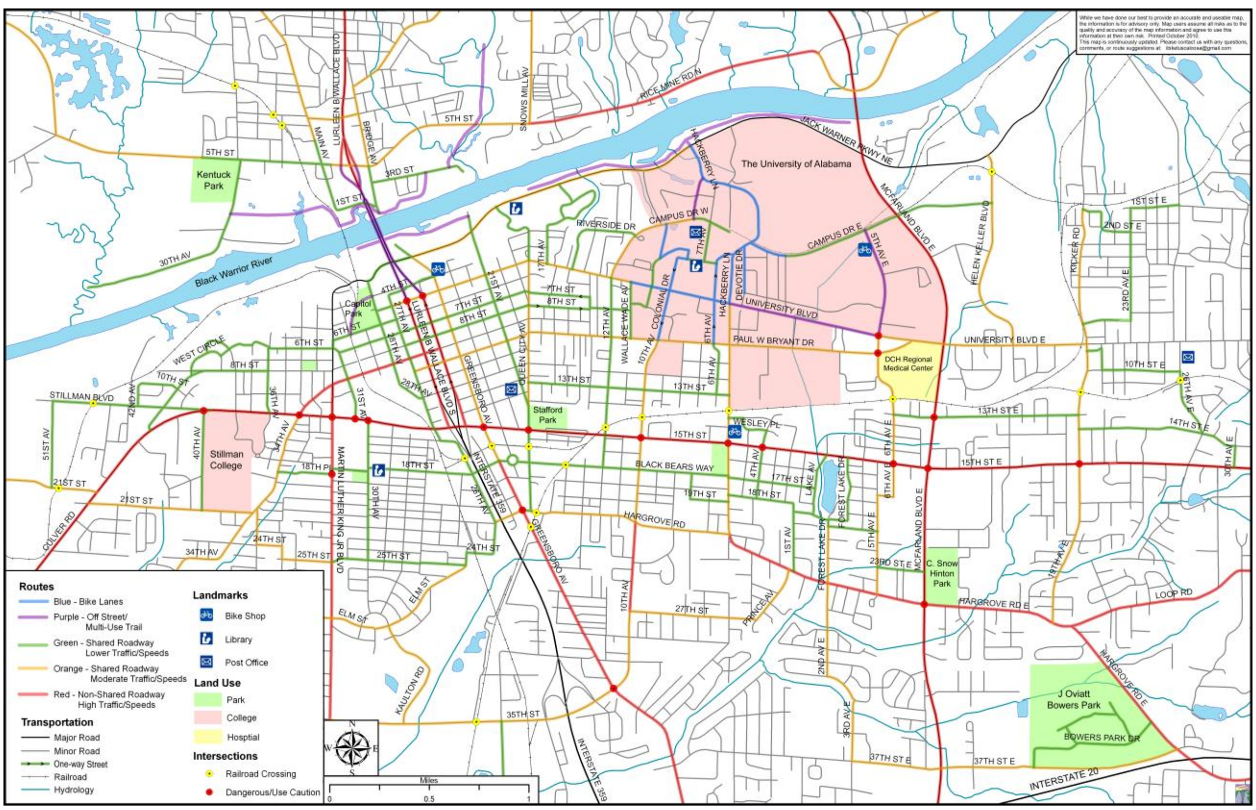


Figure 3.2 – Color-coded bicycle routes choose by local bicycle advocacy groups.

In July 2011, a sidewalk shapefile was provided by WARC and updated by the researcher via ground mapping and Google Earth 6. The satellite imagery that was used in Google Earth 6 was dated from October 3, 2010. Google Earth 6 and ground mapping was used to identify and map additional segments of sidewalks in the Tuscaloosa-Northport area. Each segment of the pedestrian network was coded for the amount of available sidewalks. This included: both sides of the street, one side of the street, local street (no sidewalk), or major road (no sidewalk) (Figure 3.3). The sidewalk layer, multi-use trails, and local streets were combined to form the pedestrian network used in this research. Once the bicycle and pedestrian networks were created, they were transferred to the street network as impedance values for modeling in GIS (Table 3.3).

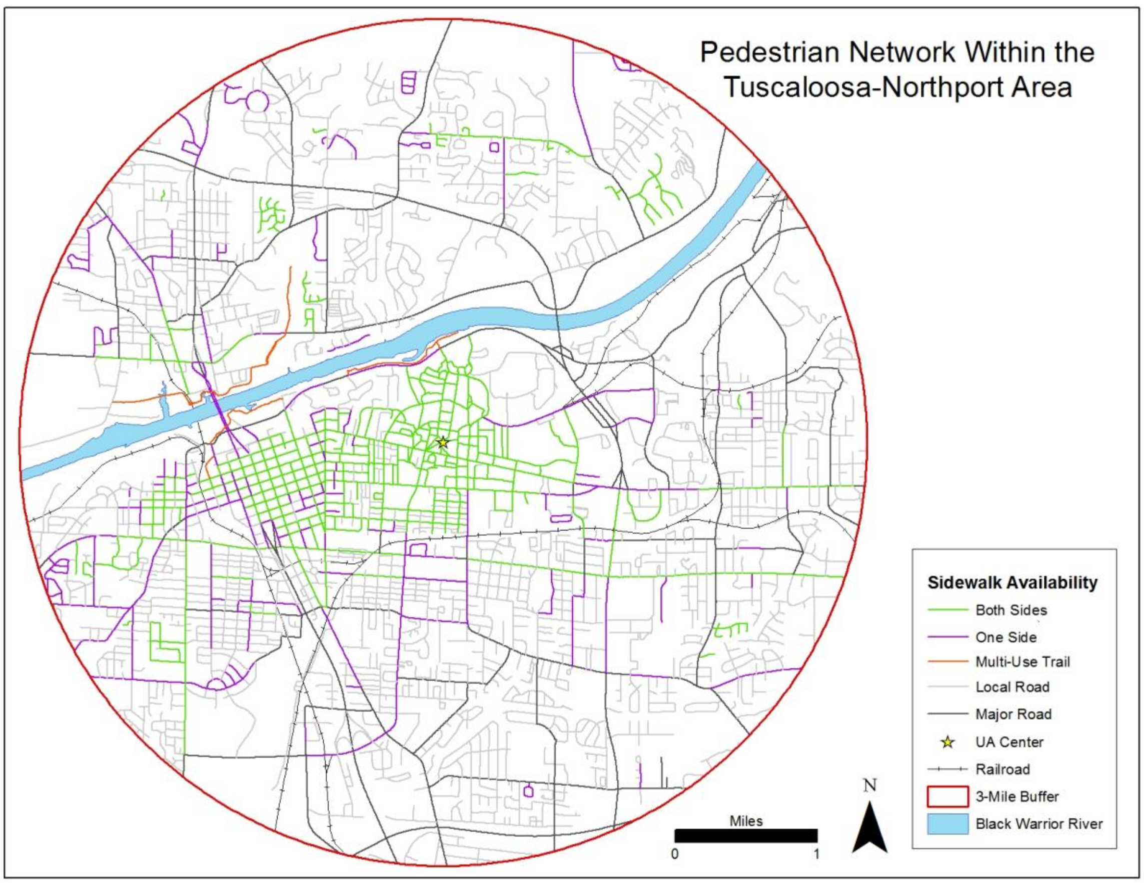


Figure 3.3 – Color-coded pedestrian network within the study area.

Table 3.3
Impedance values for non-motorized travel facilities

Color-Coded Bicycle Routes	Impedance Vaule in GIS
Purple	1
Blue	2
Green	5
Local Streets	6
Orange	10
Red	30
Color-Coded Sidewalks	**Impedance Value in GIS**
Both sides of street	1
One side of street	5
Local street	7
No sidewalk	10

The Spatial Analyst extension in ArcMap was used to derive slope from the DEM. In this research, the percent slope of the DEM ranged from 0 to 360. In ArcMap, when the slope angle equals 45 degrees, the rise is equal to the run. Expressed as a percentage, the slope of this angle is 100%. As the slope angle approaches vertical (90^o), the percentage slope approaches infinity. To calculate percent slope, this research used methods described by Price (2009). An X,Y coordinate was first calculated for the start point of each line segment. Next an X,Y coordinate was calculated for the end point of each line segment. ArcMap's 3D Analyst extension was used to convert the street network into a 3D layer, at which point percent slope could then be calculated as the Z-value for each of the line segments in the network. A Z-value (elevation) was calculated at the start points and end points of each line segment. The following equation was used to derive percent slope for each line segment:

(([End_Z] - [Start_Z]) / (([Start_X] - [End_X])^2 + ([Start_Y] - [End_Y])^2)^0.5)*100

Positive slope values indicate uphill travel while negative slope values indicate downhill travel.

As part of modeling travel time for non-motorized traffic, travel speeds were also calculated for bicycle and pedestrian travel. Within the non-motorized network, 82.7% of the line segments are within -10 and 10 percent slope. This research uses Parkin and Rotheram's (2010) findings on the impact of slope on bicycle travel speeds. Using Parkin and Rotheram's (2010) method, this research found a varying degree of travel speeds based on slope. Table 3.4 summarizes the various bicycle travel speeds used in the GIS modeling. These travel speeds are consistent with the findings of earlier research (Table 2.1).

Table 3.4
Bicycle travel speeds used in GIS modeling

Slope	**Speed (mph)**
-10	18.8
-7	17.1
-5	16.1
-2	14.5
0	13.4
2	11.7
5	8.9
7	7.2
10	4.5

Pedestrian travel speeds were also calculated based on the effect of slope. Tobler's hiking function was used to identify the effect of slope on travel speed. Tobler's hiking function has been identified as the pinnacle of modeling pedestrian speed across a landscape (Wheatley & Gillings, 2002; Gorenflo & Gale, 1990). The following equation represents the modified Tobler's formula adjusted for percent slope:

$$v = 6e^{-3.5\left|s + 0.05\right|}$$

Where *v* is velocity, *e* is the base for natural logarithms, and *s* is the slope in percent. Table 3.5 summarizes a pedestrian's travel speed used in the modeling in GIS. These travel speeds are consistent with the findings of earlier research (Table 2.2).

Table 3.5
Pedestrian travel speeds used in GIS modeling

Slope	Speed (mph)
10	1.6
7.5	2.1
5	2.4
2.5	2.8
0	3.1
-2.5	3.6
-5	3.1
-7.5	2.6
-10	2.3

The street network acted as the foundation for the non-motorized travel network. Off-street facilities were combined with the street network to represent the non-motorized network in this research. Once the non-motorized network was mapped, impedance values, distance, slope, travel speed, and travel time were assigned to the appropriate line segments in the network. Overpasses and bridges along with one-ways streets were identified and mapped. One-way restrictions were only used for modeling bicycle traffic since the current Alabama state law (Alabama Code 32-5A-52 (3)) deems a bicycle as a vehicle and makes it illegal to ride a bicycle on a sidewalk. Road hierarchy was used to identify interstate, arterial, collector, and local streets. Based on this road hierarchy, a global turn delay (seconds) feature was used to model traffic movement as turns: straight, right, and left turns. U-turns were not allowed in this modeling. Once turns, impedance values, one-way streets, speed, and all other variables were incorporated into the non-motorized network, the Network Analysis extension in ArcMap was used to build the non-motorized network dataset. This network dataset included edges (links), nodes (intersections and end points), and allowed for various traffic modeling to be performed.

Earlier research has identified that 98% of all walking trips are 3 miles or less in distance while 85% of bicycling trips are 3 miles or less, in addition half of all daily trips made in the United States are 3 miles or less in length (NHTS, 2009). Therefore, the sample population for this research included those individuals that are associated with UA and live within 3-Euclidean miles of UA. To make sure all these individuals are identified, a 3-mile Euclidean buffer around UA was calculated. A straight line ("as the crow flies") buffer will be longer than on-the-ground network miles, thus ensuring this research encompasses all those individuals that have the greatest potential to switch from driving to biking or walking (Dill, 2009). For the purposes of identifying those individuals that live within 3 Euclidean miles of campus, a polygon was created for The Quadrangle ("the quad"). The quad serves as a central outdoor meeting place and lies at the heart of UA's campus. This research will use the quad as an artificial center of campus. Once a polygon of the quad was created, a centroid was then derived to form the center of the quad and thus, the center of UA's campus (Figure 3.4). This research was not concerned with determining what part of campus individuals are actually visiting when they travel to UA, hence the need for this artificial destination center of campus used in the study. It is also understood that in some situations this would serve to either overestimate or underestimate bicycle or pedestrian travel time and distance to UA. Once the center of UA's campus was identified, a 3-mile Euclidean buffer was created (Figure 3.5). Since an individual's home address was geocoded and the center of campus was identified, only those individuals living within 3 Euclidean miles of UA could then be identified. ArcMap's Select by Location tool was used to identify those individual's living within 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 Euclidean miles of campus.

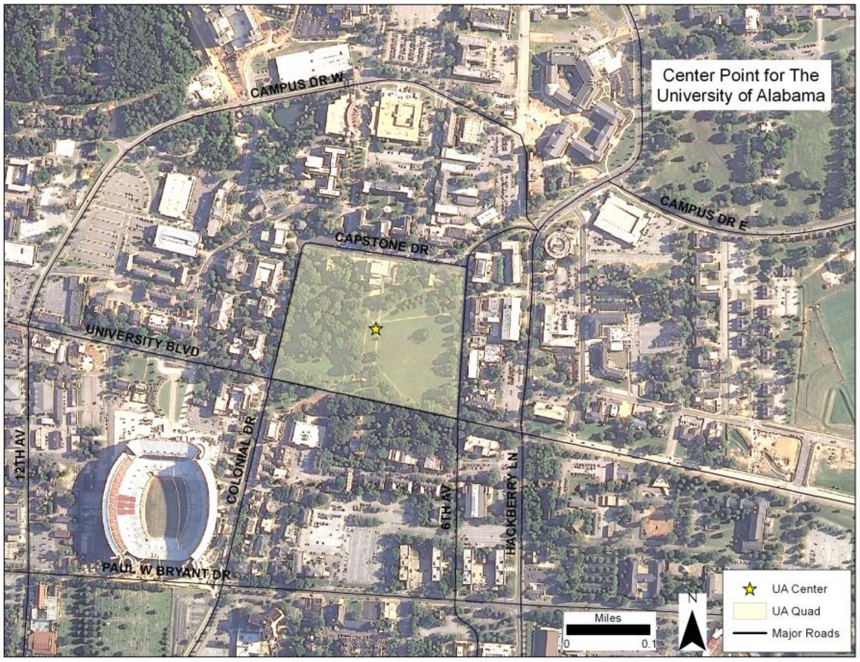


Figure 3.4 – Center point for the University of Alabama in this research.

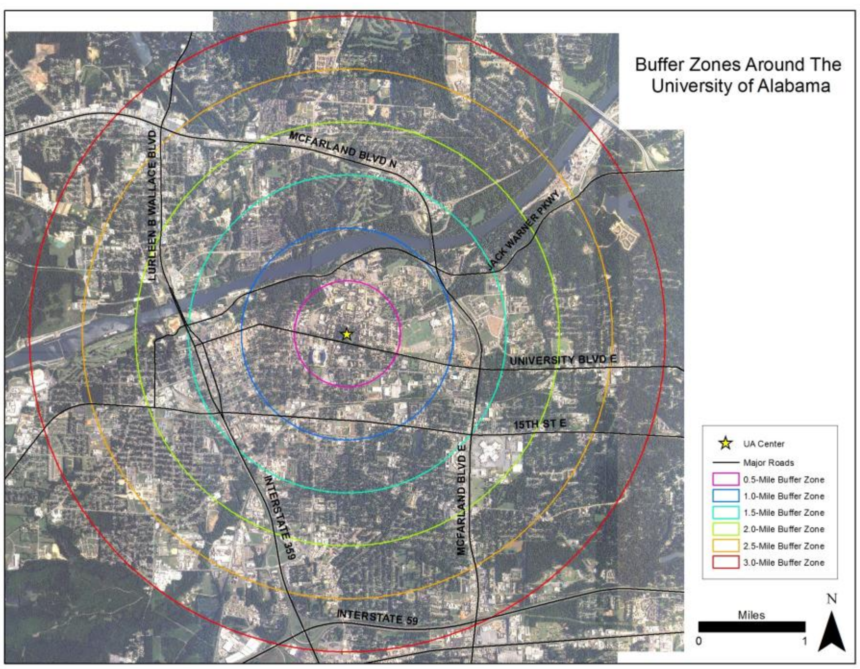


Figure 3.5 – Buffer zones around the University of Alabama.

3.4.3 Connectivity in GIS

Earlier studies have identified the role that GIS can play when analyzing connectivity for transportation networks (Berrigan et al., 2010; Chin et al., 2008). After identifying those individuals living within 3 Euclidean miles of UA and modeling the non-motorized transportation networks, connectivity measures of an individual's neighborhood along the bicycle and pedestrian networks could be employed. In GIS, a half-mile buffer around each home location represented an individual's "artificial" neighborhood. Three indices of connectivity were analyzed to measure connectivity within each neighborhood (Table 2.0).

When calculating the connectivity along the bicycle network, street segments that had at least one bicycle lane, off-street facilities, and local and minor collector streets were used. Street segments that did not contain on-street facilities and that were classified as major collector, arterial, or interstate, were not used when measuring connectivity since earlier research has identified that individuals typically avoid medium to high speed/volume automobile traffic routes (Landis et al., 2001). When calculating connectivity along the pedestrian network, street segments that had at least one sidewalk, off-street facilities, and local street segments were used.

Within each neighborhood buffer, the number of links, number of nodes, number of real intersections, total link length, and buffer area were calculated. Once these variables were calculated, the Spatial Join tool in ArcMap was used to apply these measurements to each of the neighborhood buffers. While a number of measures of connectivity have been utilized in earlier studies (Berrigan et al., 2010; Dill, 2004), this research utilized three measures to evaluate connectivity within each half-mile neighborhood buffer. The connectivity measures utilized include: Intersection Density, Network Density, and Route Directness. These were utilized since they are widely cited in earlier research as providing the density of intersections and network mileage while identifying the most direct route available to individuals (Berrigan et al., 2010; Kim, 2007; Dill, 2004).

3.4.4 Accessibility in GIS

GIS can also play a role in the analysis of transportation accessibility (Biba et al., 2010; Chin et al., 2008). While there are various measures of accessibility, this research will utilized two different cost measures: time (minutes) and distance (miles). The bicycle and pedestrian networks were based on mapped non-motorized facilities in the Tuscaloosa-Northport area.

With the non-motorized travel network datasets built, the measures of accessibility were calculated from an individual's geocoded home address to UA's center using the previously identified bicycle network and pedestrian network. Within the Network Analysis extension of ArcMap, the Closest Facility tool was used to calculate a shortest path based on travel time (minutes) and travel distance (miles) for each network. UA's center acted as the "Facility" and home addresses acted as the "Incidents." These measures were conducted for students and employees living with the different buffer distances from UA: 0.5-miles, 1.0-miles, 1.5-miles, 2.0-miles, 2.5-miles, and 3.0-miles. Since the Lurleen Wallace Bridge is currently the only bridge over the Black Warrior River that is conducive to bicycle and pedestrian traffic, barriers were placed at the other bridges over the river. After calculating the shortest paths, ArcMap's Geostatistical Analyst extension was used to create contoured maps displaying accessibility. Accessibility was quantified into five levels of access (Table 3.6). For travel time, this study used a limit of 45 minutes since U.S. Census data shows that the majority of bicycle and pedestrian travel is less than 45 minutes (U.S. Census Bureau, 2010). For travel distance, this research used a limit of 3 miles since the majority of non-motorized travel is less than 3 miles (NHTS, 2009).

Table 3.6
Quantified accessibility for travel time and distance

Quantified Accessibility	Travel Time (minutes)		Travel Distance (miles)	
	Bicycle	Pedestrian	Bicycle	Pedestrian
Very High	0 to 10	0 to 15	0 to 1	0 to 1
High	10 to 20	15 to 30	1 to 2	1 to 2
Medium	20 to 30	30 to 45	2 to 3	2 to 3
Low	30 to 40	45 to 60	3 to 4	3 to 4
Very Low	40 to 51	60 to 210	4 to 8	4 to 8

3.4.5 On-line Survey

A 20-question on-line survey (Appendix B) was developed to sample those individuals whose addresses were geocoded within 3 Euclidean miles of UA. A total of 1,195 employees were contacted via campus email on September 7, 2011 and 2,536 students were contacted via campus email on September 13, 2011. Each survey was left open for one week, allowing individuals adequate time to complete the survey. The on-line survey was developed as an inexpensive and accessible method to sample the UA population. UA has numerous computer labs that are available 24-hours a day to both students and employees. Participants could use any computer with an internet connection to partake in the survey. The survey questionnaire was comprised of questions relating to travel habits and views on non-motorized travel, accessibility, and demographic information. The survey was intended to identify travel habits and characterize views on non-motorized accessibility for the population related to UA.

Since one component of this research involved the participation of human subjects, it was necessary to work in accordance with UA policy. An on-line ethical training course was completed by the researcher and researcher's advisor according to UA's policy. UA's IRB approved the use of human subjects for this research as IRB # 11-OR-198-ME (Appendix A). Once the survey was closed, the results were downloaded from a secure server from SurveyMonkey. IBM's SPSS 19 was used to statistically analyze the results. Binary logistic regression and odds ratio (OR) was used to predict which factors contributed to an individual's choice in deciding between various travel methods when commuting to UA. Main travel method to UA was used to separate the survey data into three different groups: bicycle, pedestrian, and car. Odds ratio was used to determine if there were variables that predicted whether an individual will be likely to use a method of non-motorized transportation.

Another analysis of the survey results included comparing answers relating to how an individual views the non-motorized networks, self-reported distance to UA, and the calculated neighborhood connectivity measures. This analysis was performed to associate patterns in the response rates of the participants and the connectivity measures. Self-reported distance to UA was used to group individuals and then identify the percentage of individuals that found infrastructure relating to the pedestrian and bicycle network adequate. In addition, a comparison between the connectivity and accessibility measures in each buffer zone was performed using Pearson correlation coefficients.

4.0 RESULTS AND DISCUSSION

4.1 GIS Data

The geographic information systems (GIS) phase of this research has provided key data regarding the connectivity and accessibility of the non-motorized travel networks surrounding the University of Alabama (UA). This was achieved through evaluating measures of connectivity and accessibility, modeling travel movement in transportation networks, geocoding the addresses of survey participants, and surveying a representative sample of individuals who reside in the study area. This chapter will present the results of these analyses.

4.1.0 Geocoding

UA's University Registrar made available home mailing addresses for students while UA's Human Resource Department made available home mailing addresses for employees. These addresses were geocoded and given real-world coordinates, although some addresses were unverifiable due to common errors, such as incorrect spelling, lack of street suffixes, or unidentifiable address. Such issues are consistent with earlier research (Zandbergen, 2008). Beyond reporting issues, the study was impacted by other factors as well, including the lag between real-world data being digitized, incomplete address, street name changes, and missing information. For example, a number of individuals used different street names for areas just west of UA's Bryant-Denny Stadium, this included sections of 12th, 13th, and 14th Avenues. These streets were recently renamed Frank Thomas, Red Drew, and Gene Stallings Avenues (Jones, 2010). Furthermore, a handful of the addresses had a Tuscaloosa zip code however, street addresses were for different towns within Alabama. Such cases could not be used in this study.

UA's University Registrar made available home mailing addresses for some 4,388 students. After the first round of geocoding student addresses, some 332 (7.6%) addresses returned a match score lower than 80 because of errors with address spelling and street suffixes. Address match results less than 80 are considered unverifiable and must be matched in another method (Zandbergen, 2008). These unmatched addresses were then manually reviewed, compared to existing address information, and when possible, fixed by adjusting street spellings or adding suffixes. The second round of geocoding produced 233 (5.3%) addresses that scored lower than an 80. For the remaining unreferenced addresses, Google Earth 6 was used to identify UTM coordinates for the addresses. A total of 26 (0.6%) addresses could not be used because 10 addresses were unidentifiable, 11 were U.S. Post Office Boxes, and 5 were associated with non-residential buildings on UA's campus. A total of 4,362 (99.4%) student addresses were geocoded.

UA's Human Resource Department made available home mailing addresses for some 2,925 employees. After the first round of geocoding employee addresses, some 181 (6.2%) addresses returned a match lower than 80 because of errors with street spelling and street suffixes. Many such errors were rectified during manual comparison and individual review of each questionable address. During a second round of geocoding, 77 (2.6%) addresses returned a match score lower than 80. Google Earth 6 was then used to identify UTM coordinates of the remaining 77 addresses. After identifying UTM coordinates for the remaining addresses, a total of 13 (0.4%) addresses could not be used due to lack of information. Of the 13 unreferenced addresses, 3 were unidentifiable and 10 were U.S. Post Office Boxes. A total of 2,912 (99.6%) employee addresses were geocoded.

Of the 4,362 geocoded student addresses, some 2,536 (58.1%) addresses were within 3-Euclidean miles of UA and were included in the analysis. Of the 2,912 geocoded employee addresses, 1,195 (41%) addresses were within 3-Euclidean miles of UA. Once the addresses were geocoded and rectified, a total of 3,731 addresses fell within 3 Euclidean miles of UA; the number of individuals living within each half-mile buffer around UA can be found in Table 4.0.

Table 4.0
Summary data for geocoded addresses

Buffer Zone	Students	Employees	Total
0.5-Mile	171	23	194
1.0-Mile	456	136	592
1.5-MIle	587	203	790
2.0-MIle	522	201	723
2.5-Mile	503	362	865
3.0-Mile	297	270	567
			3,731

4.1.1 Connectivity

A half-mile buffer was created to define an artificial neighborhood around each individual's home address in the sample population. Within each projected artificial neighborhood, street, bicycle, and pedestrian networks were analyzed through three measures of network connectivity. These measures included Intersection Density, Network Density, and

Route Directness. Table 4.1 summarizes the average value for each connectivity measure within the artificial neighborhoods located in their zonal distance (buffer) from UA. Considering all three of the measures together provides a comprehensive evaluation of connectivity, but it is also useful to consider each measure in turn.

Table 4.1
Average neighborhood network connectivity value

Buffer Zone	Network Type	Intersection Density	Network Density	Route Directness
0.5-Mile	Street	189.47	24.74	1.27
	Bicycle	186.61	24.46	1.35
	Pedestrian	187.50	24.51	1.28
1.0-Mile	Street	175.13	24.11	1.34
	Bicycle	167.67	23.38	1.45
	Pedestrian	171.11	23.55	1.41
1.5-Mile	Street	113.89	18.79	1.75
	Bicycle	95.82	16.91	1.89
	Pedestrian	96.41	16.80	1.90
2.0-Mile	Street	98.54	17.56	1.59
	Bicycle	83.34	15.67	1.87
	Pedestrian	71.60	14.42	1.87
2.5-Mile	Street	77.22	15.68	1.62
	Bicycle	66.65	14.42	1.92
	Pedestrian	57.49	13.19	1.89
3.0-Mile	Street	55.74	12.42	1.43
	Bicycle	49.66	11.47	1.66
	Pedestrian	43.33	10.22	1.65
Whole Study Area	Street	91.92	13.58	-
	Bicycle	64.37	10.06	-
	Pedestrian	80.64	11.76	-

Intersection and Network Densities evaluate the concentration of available infrastructure within a given network. Earlier research has not led to an established criterion for measuring high versus low connectivity, however, comparatively, higher densities indicate a higher measure of connectivity, thus allowing for more routes and options when traveling. For each three network types, the 0.5-mile buffer has the highest Intersection and Network Densities, followed by the 1.0-mile and then 1.5-mile buffer. All three of these buffer zones can be considered to have high measures of network connectivity when examining the entire study area. As expected, Intersection and Network Densities decrease as distance from UA increases, indicating that network connectivity lessens when moving away from campus.

Route Directness is a ratio of total route distance to straight-line distance. The lowest possible value is 1.0, where the route distance along the network is the same as the "crow flies" distance. The bicycle and pedestrian networks within the 0.5-mile and 1.0-mile buffers contain Route Directness values that are closer to 1.0, which indicate a more direct route and, in turn, a more connected network. Values for Route Directness share a similar pattern to Intersection and Network Densities, Route Directness changes significantly after the 1.0-mile mark. Route Directness increase as distance from UA increases, which correlates with a decrease network connectivity.

Figure 4.0 displays the data from Table 4.1 in graph form. The most noticeable pattern that emerges from Figure 4.0 is the drop in the measures of connectivity for bicycle and pedestrian networks after the 1.0-mile buffer zone from UA’s campus. This is likely due to the changes over the years as the metropolitan area increased, which resulted in automobile-dependent changes in land-use and zoning, including longer road segments, more cul-de-sacs, and a diminished grid-type street layout. These effects of land-use and zoning changes have helped diminish the attractiveness of non-motorized travel in the area. In addition, values for the Route Directness are inverse to the other measures of connectivity, meaning that a more direct route is dependent on increased connectivity. The dip in Route Directness at the 3.0-mile buffer zone can be attributed to an increase in the number of individuals living along major avenues in that zone.

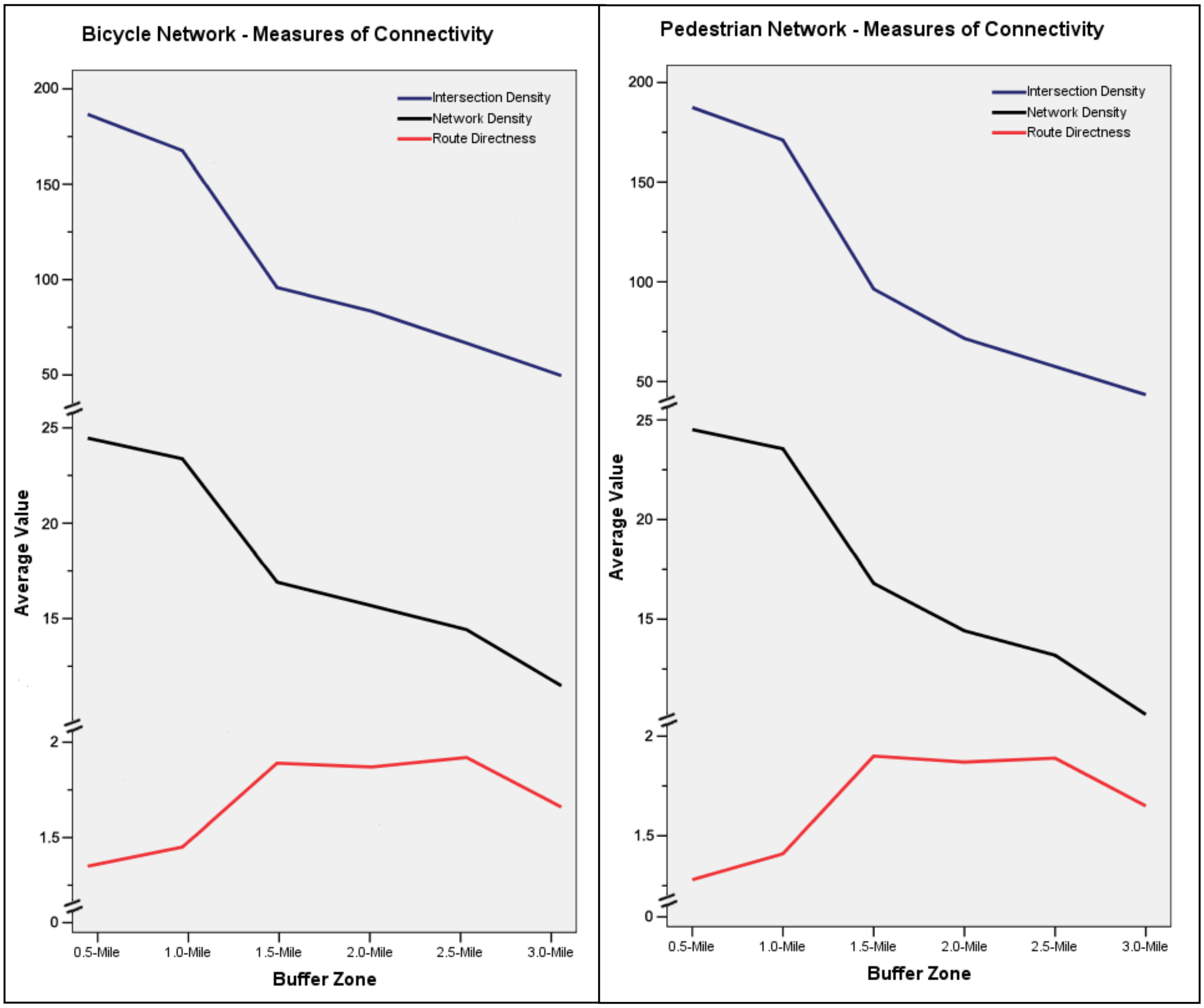


Figure 4.0 – Average neighborhood value for the measures of connectivity.

Pearson correlation coefficients were used to identify relationships between the measures of connectivity for each network, including street, bicycle, and pedestrian networks (Table 4.2). For each type of network, Pearson correlation coefficients show that Intersection Density and Network Density have a strong positive correlation. This strong correlation between Intersection Density and Network Density highlights that these evaluations measure the amount of available network infrastructure. This positive relationship is consistent with earlier research and demonstrates that increases in the number intersections increases the amount of network miles. Increases in the amount of available intersections and network mileage have been found to increase an individual's available route options. Route Directness was found to have a negative weak correlation to Intersection Density and Network Density. This negative correlation is also consistent with earlier research and shows that decreases in network connectivity increases Route Directness. These results highlight that efficient non-motorized travel network design needs to achieve high connectivity to increase route options and encourage travel.

Table 4.2

Pearson correlation coefficients for the connectivity measures within each network type

Street Network			Bicycle Network			Pedestrian Network		
	Intersection Density	**Network Density**		**Intersection Density**	**Network Density**		**Intersection Density**	**Network Density**
Network Density	0.969 (0.00)		**Network Density**	0.971 (0.00)		**Network Density**	0.967 (0.00)	
Route Directness	-0.350 (0.00)	-0.350 (0.00)	**Route Directness**	-0.354 (0.00)	-0.371 (0.00)	**Route Directness**	-0.382 (0.00)	-0.407 (0.00)

Note. Values in parentheses are 2-tailed significance values.

The three measures of connectivity are displayed for the bicycle (Figure 4.1) and pedestrian (Figure 4.2) networks. Results of the network connectivity measures are displayed spatially for the purpose of identifying sections of the study area that contain high and low values of network connectivity. These color-contoured maps show the distribution of the measures of connectivity within each “artificial” neighborhood in the study area. Interestingly, when comparing Figures 4.1 and 4.2, the older sections of the study area (Figure 2.0) have the highest network densities, while the newer areas of the study area have the lowest network densities. Earlier research has also identified that older neighborhoods (pre-1973) have higher densities of non-motorized travel facilities when compared to newer neighborhoods (post-1973) (Berrigan & Troiano, 2002). The areas with high network densities between downtown and UA can be attributed to the fact that the center of campus is highly bicycle- and pedestrian-friendly with numerous sidewalks and areas closed to automobile traffic. In addition, these areas represent the grid pattern of downtown Tuscaloosa and the older neighborhoods which have a higher concentration of non-motorized infrastructure. Additionally, the natural barrier that is the Black Warrior River is also quiet distinguishable in Figures 4.1 and 4.2. Within each network, the distribution of Intersection Density and Network Density share similar patterns, which is also observed in the Pearson correlation coefficients.

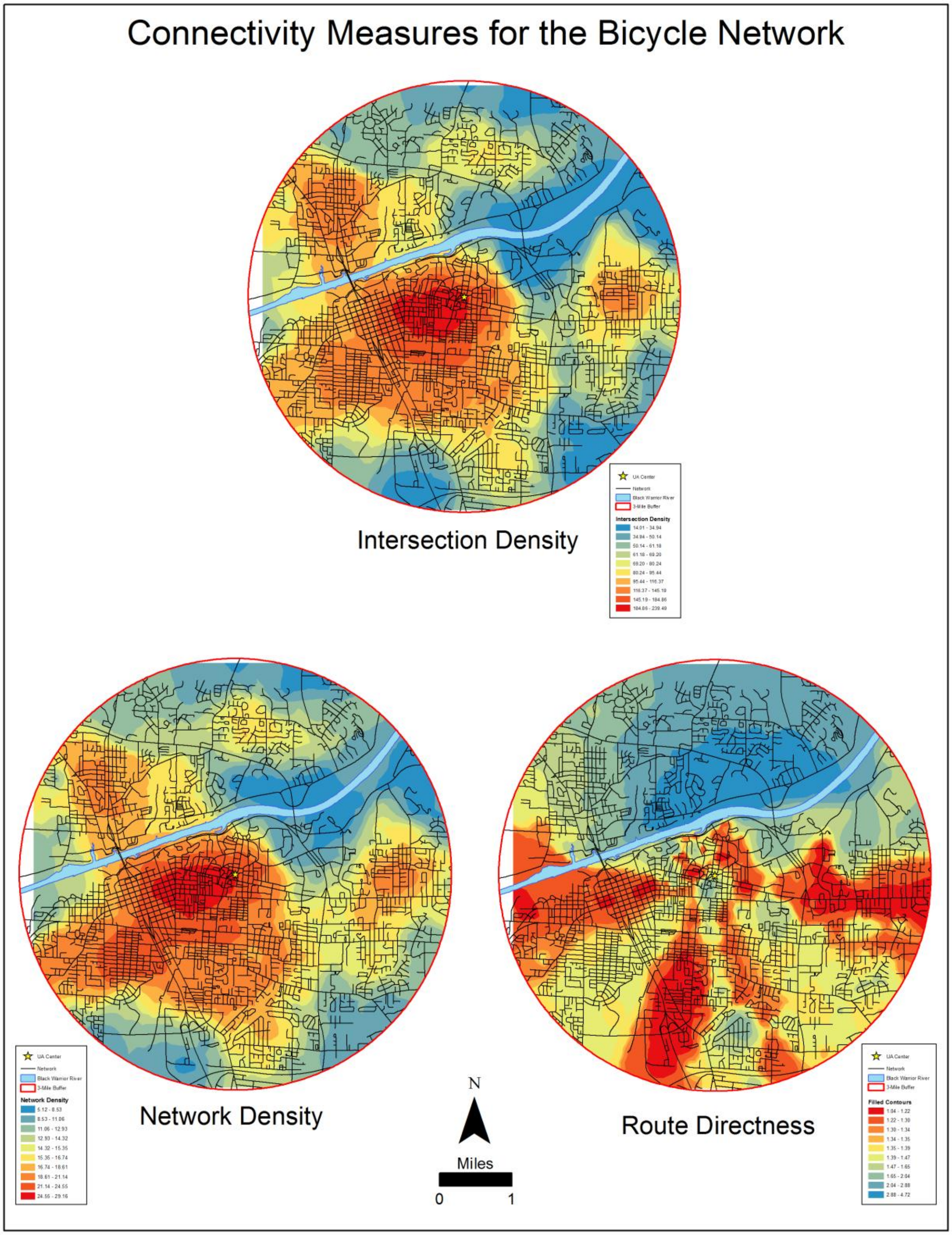


Figure 4.1 – Contoured neighborhood values for measures of connectivity along the bicycle network.

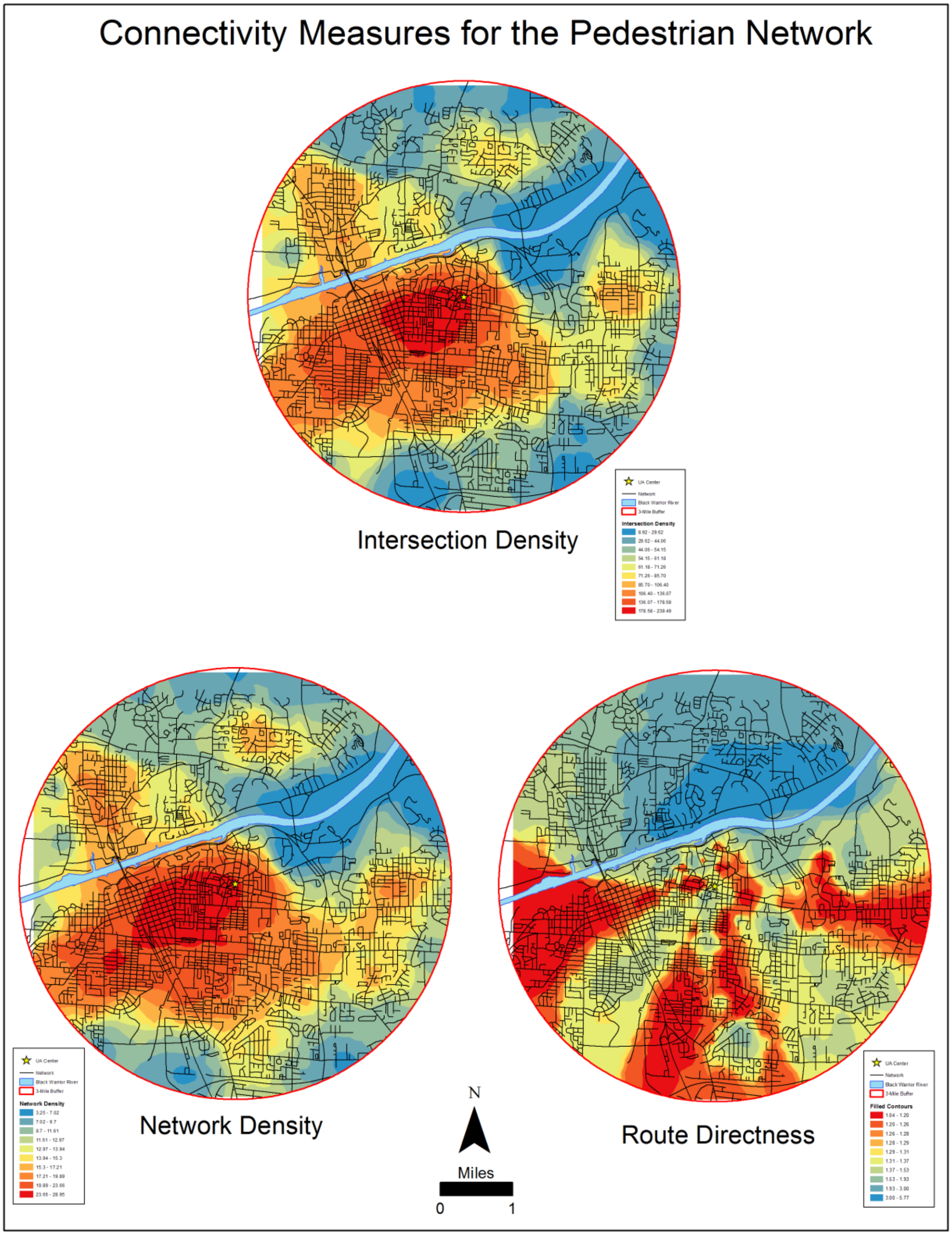


Figure 4.2 – Contoured neighborhood values for measures of connectivity along the pedestrian network.

When considering Figures 4.1 and 4.2, both networks share similar patterns for the measure of Intersection Density, as both networks have higher concentrations of intersections in the downtown Tuscaloosa-UA area with islands of high density values in downtown Northport and Alberta (density on the eastern edge of the study) area. Interestingly, Intersection Density and Network Density measures also show that both the bicycle and pedestrian networks along the north side of the Black Warrior River are less connected than the networks on the south side of the river where there is greater development of non-motorized infrastructure. In addition, the sections closest to the edge of the 3-mile limit of the study area are poorly connected. For the most part, there is a concentration of high network connectivity between downtown Tuscaloosa and UA, which is identified in Figures 4.1 and 4.2.

Route Directness was also analyzed for each neighborhood within the study area. The lowest possible value for a measure of Route Directness is 1.0, where the route distance along the network is the same as the "crow flies" distance. Numbers closer to 1.00 indicate a more direct route, theoretically representing a more connected network. Within both the bicycle and pedestrian networks, areas south of the Black Warrior River have more direct routes (noted in red) to UA. Route Directness is concentrated along major roads including University Blvd East, 10^{th} Ave, Stillman Blvd, and Hargrove Road East. Areas along the north side of the Black Warrior River have a high Route Directness along the bicycle and pedestrian networks which contribute to travel distances that are much greater than straight-line distances to UA, likely due to the lack of infrastructure for non-motorized travel.

Within the 3-mile buffer of UA, there is an available transportation network of 405.56 miles. Off-street facilities designed for bicycle travel only account for 6.3 miles, or 1.6%, of the total local transportation network, while on-street facilities designed for bicycle travel cover only

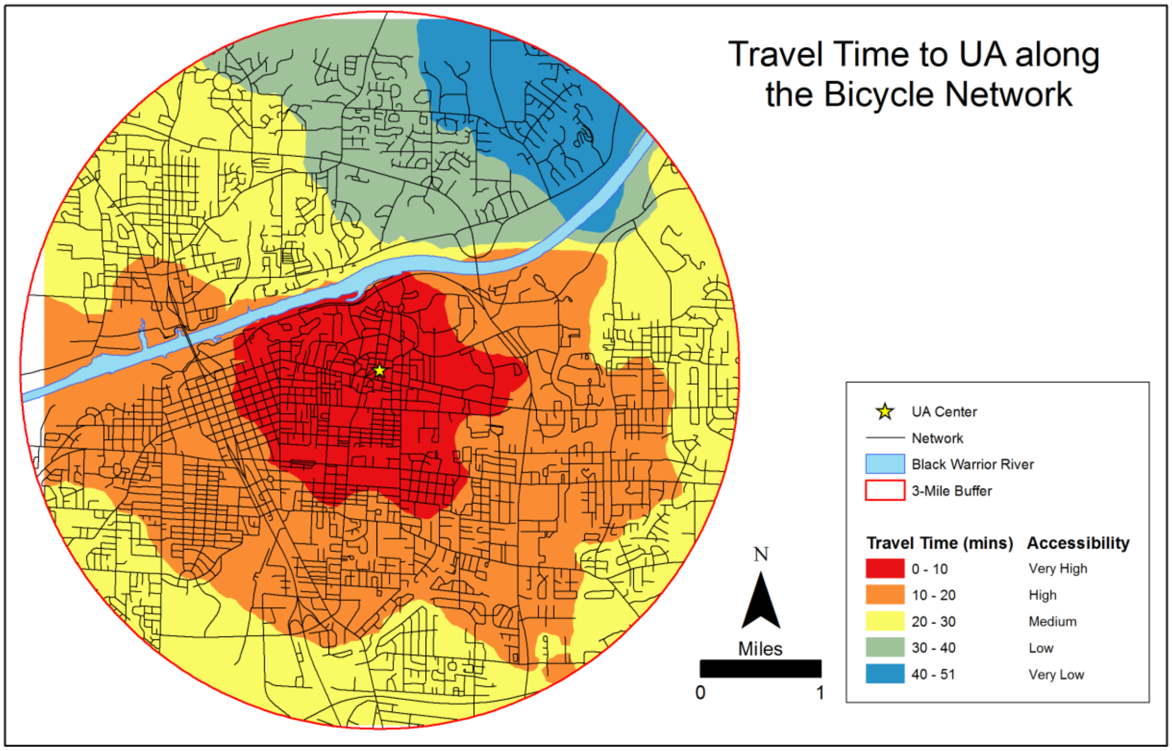
3.5, miles or 0.9%, of the local network. UA's campus currently has the only on-street facilities in the study area that are geared towards bicycle travel. The rest of the bicycle network is comprised of local streets and minor collectors without specifically designated bicycle facilities. For the pedestrian network, some 110.58 miles, or 27.3%, of the local transportation network, have segments with at least one side having a sidewalk. Off-street facilities designed for pedestrians consisted of only 6.3 miles or 1.6%. In the study area, sidewalks follow the main corridors of road traffic, and they tend to decrease in frequencies or disappear altogether as distance from the main transportation corridors increase. Interestingly, neighborhood and subdivision planning play a role in network connectivity. New housing developments in the northern section of the study (Northport) have sidewalks (Figure 3.3); however these areas lack non-motorized connectivity and access to other areas of town (Figure 4.2). When comparing these new developments with older neighborhoods located south of the Black Warrior River (Figure 2.0), the older neighborhoods were more connected and better able to support non-motorized travel.

Overall, when considering all of the included indices of network connectivity, the 0.5-mile and 1.0-mile buffers contain networks that are the most connected (Table 4.1), thus allowing more route options and choices for travelers. In addition, as distance increases from UA, the network connectivity decreases for all three types of networks. This reduction in network connectivity offers fewer options in terms of route choices and theoretically increases travel time and distance.

4.1.2 Accessibility

In GIS, two measures of accessibility, including travel time (minutes) and travel distance (miles), were applied to the bicycle and pedestrian networks in order to measure and identify differences between the two. This analysis modeled and measured non-motorized travel from an individual's home to UA. The modeling was based on numerous variables including: the availability of non-motorized travel facilities, slope, speed, travel distance, and travel time. Accessibility for each transportation network is quantified by categorizing travel time and distance into five levels, very low, low, medium, high and very high (Table 3.6), with the very high category being the most accessible.

Results based on time accessibility modeling show that traveling along the bicycle network has a higher accessibility compared to walking along the pedestrian network. For example, travel times along the bicycle network (Figure 4.3) are consistently lower than travel time based on pedestrian networks (Figure 4.4). This is linked to the travel speeds used in the GIS modeling (Tables 3.3 and 3.4). Thus, the bicycle network allows a broader section of the study area to have a higher accessibility when commuting to UA. For both networks, the areas of high accessibility (noted in red) are also associated with the highest measures of network connectivity (Table 4.1). For both networks, increases in the densities of available non-motorized infrastructure and facilities around UA can increase the levels of travel time accessibility. Interestingly, neither network contains colored contours that have symmetrical shapes. The lack of symmetrical shapes would suggest that there are areas within the study area that contain gaps in infrastructure. The most notably is the protrusion along the east side of the red contour in the bicycle network (Figure 4.3). Areas within this protrusion contain adequate facilities, while areas on either side of the "arm" lack sufficient facilities. Within the pedestrian network, a gap along the northwest side of the red contour in Figure 4.4 displays the opposite type of pattern. Accessibility based on time also shows that the Black Warrior River acts as a natural barrier to non-motorized travel for both networks, likely due to the lack of infrastructure on the north side of the river. Time accessibility is a major factor limiting the implementation of non-motorized travel. A decrease in travel time allows individuals to spend more time participating in activities at their destinations. For areas along the north side of the Black Warrior River increases in the amount of available infrastructure could profoundly improve UA's accessibility.



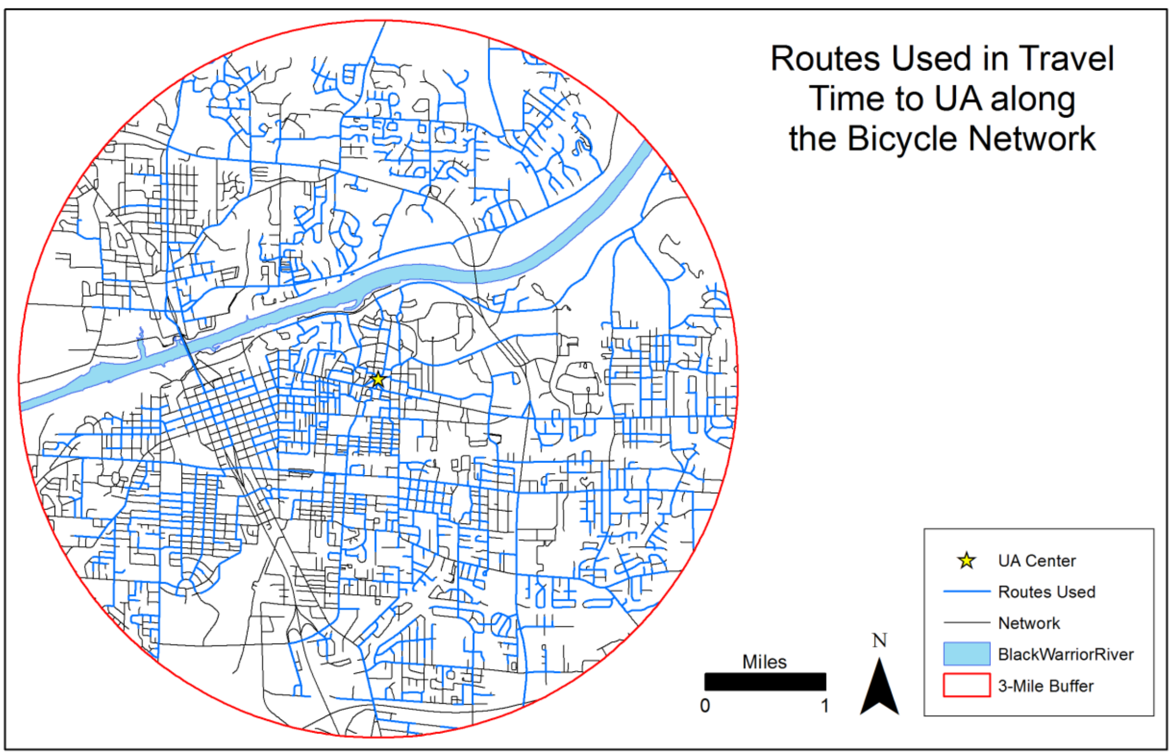


Figure 4.3 – Accessibility results based on travel time to UA along the bicycle network.

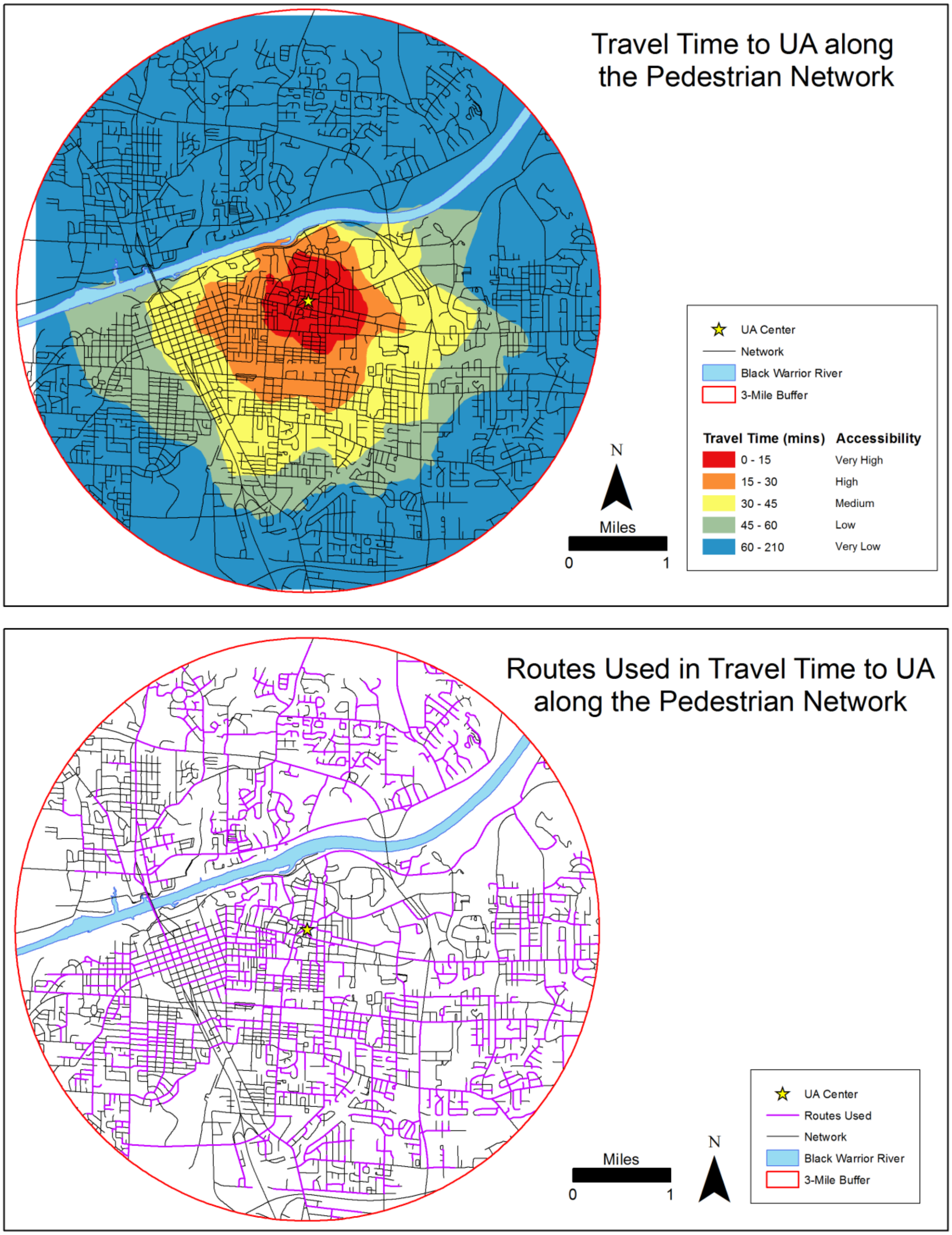


Figure 4.4 – Accessibility results based on travel time to UA along the pedestrian network.

Accessibility measured through distance is similar for both the bicycle and pedestrian networks, however overall bicycle travel distance (Figure 4.5) is slightly lower than pedestrian travel distance (Figure 4.6). The bicycle network has lower rates of accessibility along the southern edge of the study area when compared to the pedestrian network. This lower accessibility is based on the lack of bicycle-friendly infrastructure in those areas. For both networks, travel distance accessibility patterns are confined to the amount of available non-motorized infrastructure. Again, for both networks, areas along the north side of the Black Warrior River are less accessible to UA in terms of distance. This decrease in accessibility is a result of the lack of bicycle- and pedestrian-friendly infrastructure bridging the river.

Using GIS to measure and model connectivity and accessibility indicates that those individuals within one mile of UA have the highest accessibility along the bicycle or pedestrian networks. This high accessibility is based on decreased travel time and travel distance alongside higher rates of network connectivity. In addition, those individuals living on the south side of the Black Warrior River have a higher accessibility to UA when compared to those individuals living on the north side of the river, when holding distance constant.

This research shows that GIS can be used for quantitative analysis of real world non-motorized transportation networks through identifying and modeling network connectivity and accessibility. This information, coupled with survey data relating to an individual's behavior and travel habits, can be used to provide a powerful tool when studying non-motorized travel networks.

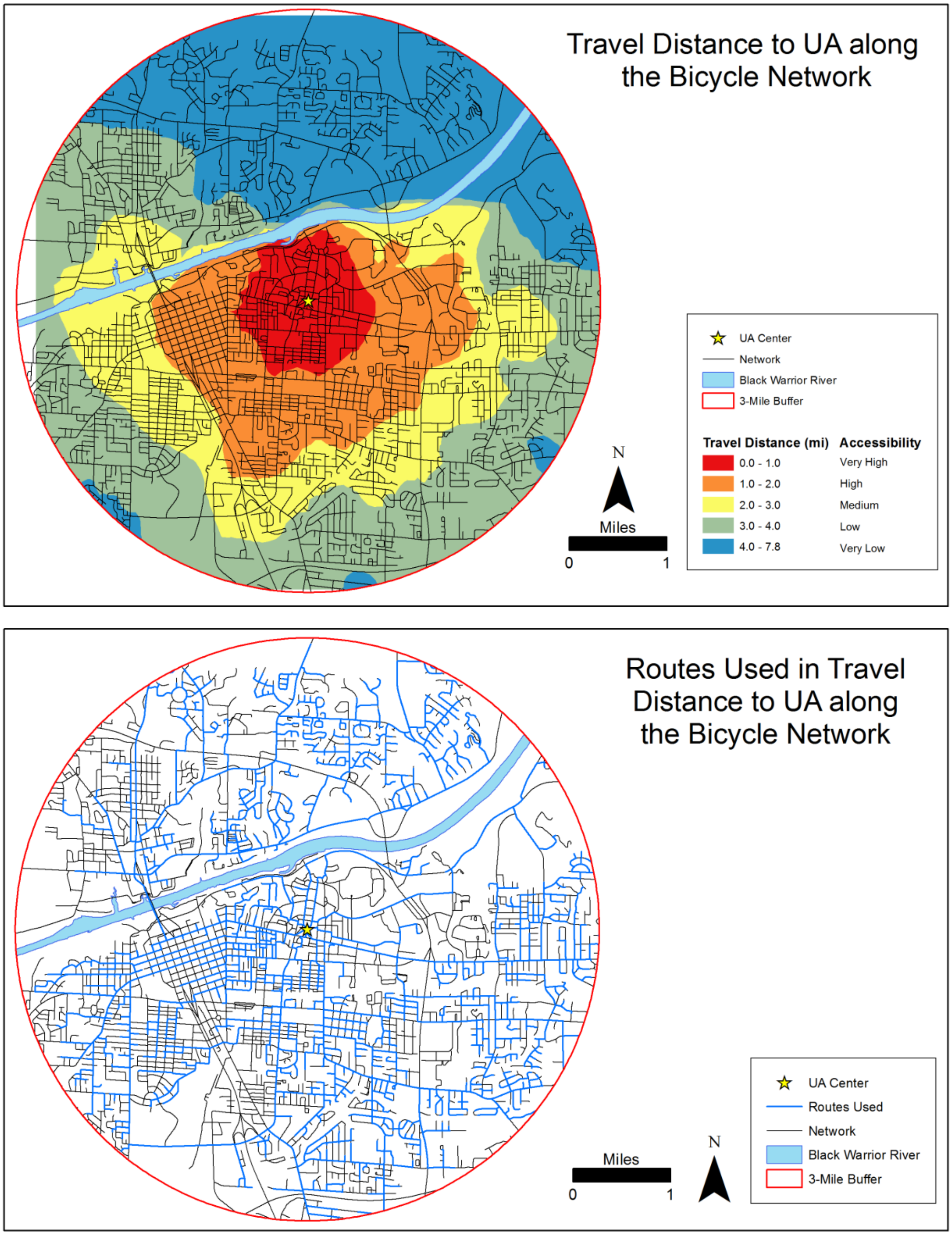
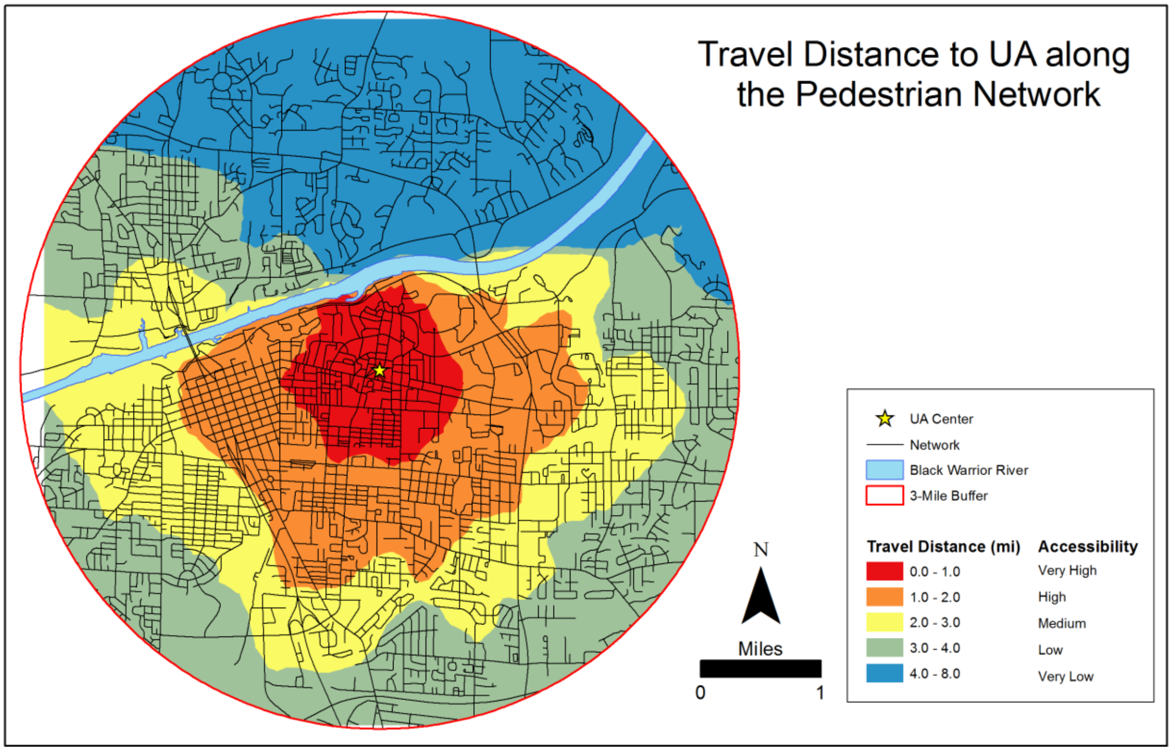


Figure 4.5 – Accessibility results based on travel distance to UA along the bicycle network.



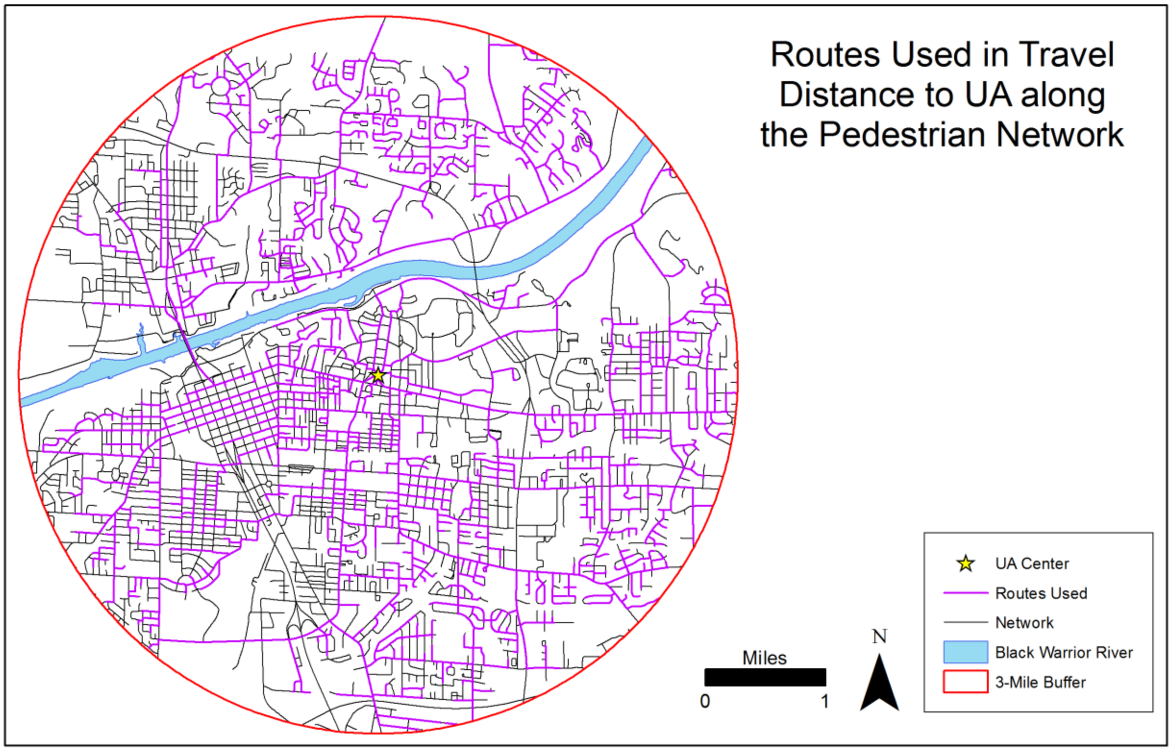


Figure 4.6 – Accessibility results based on travel distance to UA along the pedestrian network.

4.2 On-line Survey

The 20-question on-line survey (Appendix B) was administered to UA employees on September 7, 2011, and students on September 13, 2011. The survey was closed on September 20, 2011. A total of 3,731 individuals were contacted via campus email and asked to participate in the on-line survey. A total of 378 individuals participated in the survey. However, due to unanswered questions or incomplete surveys a total of 30 entries were not used. The final survey sample consisted of 348 completed surveys. Since the survey sample population consisted of 3,731 individuals and had a response rate of 348, this study has a confidence interval of +/-5 at a 95% confidence level. A summary of demographic information for the survey participants can be found in Figure 4.7. Based on this demographic data, some interesting trends occur: 74.2 % of the survey consisted of graduate students and employees, while 61.5 % of the survey consisted of individuals under the age of 34, and 46 % lived 3 miles or more from UA. While this surveyed aimed to have a sample population more evenly distributed throughout the survey area, individuals living under 3 miles from campus were under-represented in the survey.

The survey data was then grouped according to an individual's stated main travel mode to UA. Descriptive statistics of survey results based on main travel mode to UA for the multiple choice questions are displayed in Table 4.3.

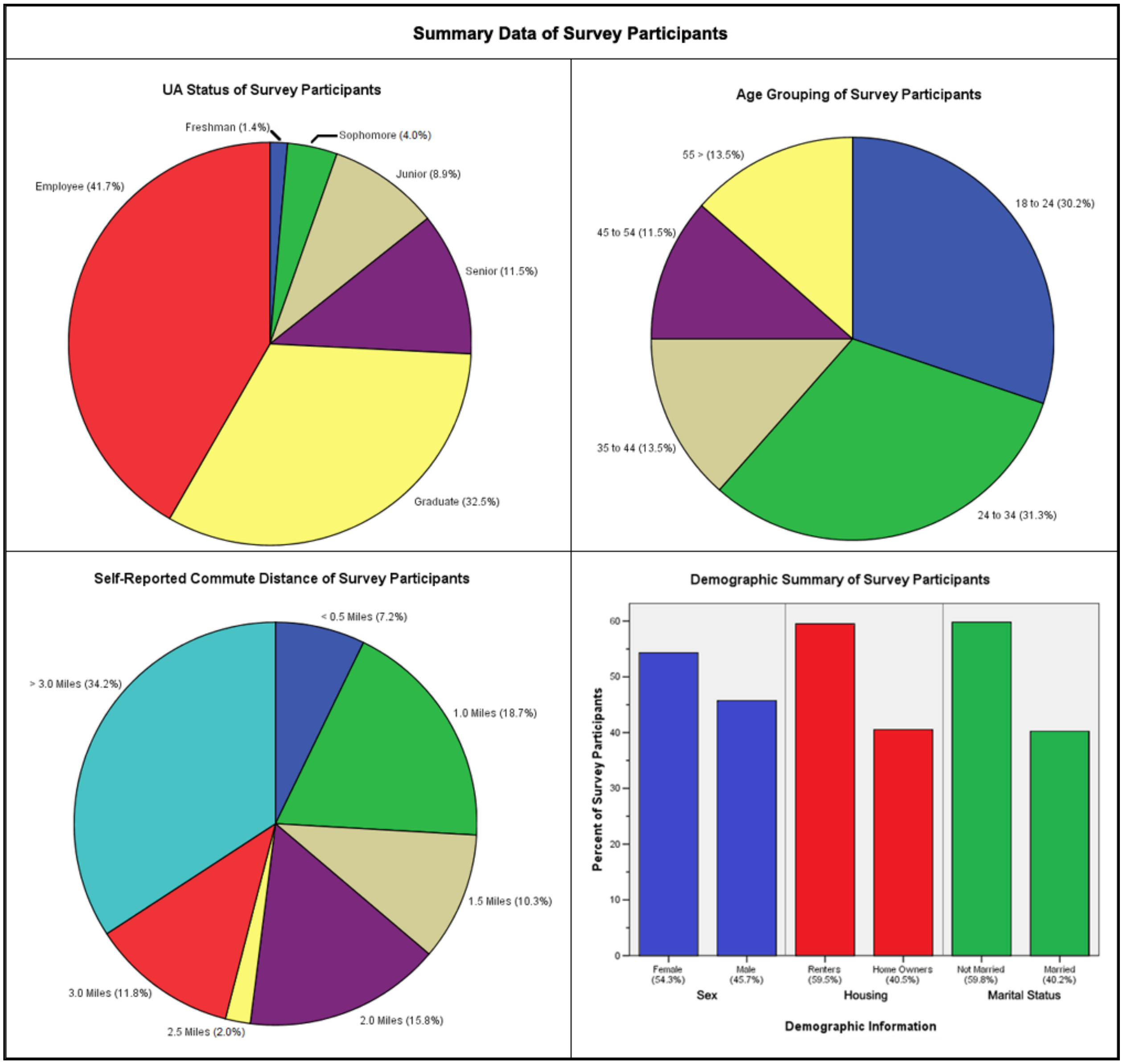


Figure 4.7 – Summary demographic information of the survey participants.

Table 4.3
Descriptive statistics of the survey results

	Bicycling Commuters	Walking Commuters	Car Commuters	Other* Commuters
Numbers in sample	74	47	218	9
Percent owning a bicycle	100.0%	42.6%	48.2%	22.2%
Percent bicycling on a weekly basis	100.0%	21.3%	16.5%	22.2%
Percent owning no cars	10.8%	14.9%	0.0%	0.0%
Percent owning 1 car	48.6%	53.2%	33.5%	11.1%
Percent owning 2 cars	32.4%	21.3%	45.4%	22.2%
Percent owning 3+ cars	8.1%	10.6%	21.1%	66.7%
Percent traveling 1-3 times a week to UA	1.4%	6.4%	5.5%	22.2%
Percent traveling 4-5 times a week to UA	35.1%	23.4%	33.5%	11.1%
Percent traveling 6-7 times a week to UA	28.4%	36.2%	41.7%	44.4%
Percent traveling 8+ times a week to UA	35.1%	34.0%	19.3%	22.2%
Percent female	35.1%	46.8%	61.9%	66.7%
Percent male	64.9%	53.2%	38.1%	33.3%
Percent married	29.7%	21.3%	48.6%	22.2%
Percent not married	70.3%	78.7%	51.4%	77.8%
Percent own housing	20.3%	8.5%	55.0%	22.2%
Percent rent housing	79.7%	91.5%	45.0%	77.8%
Percent freshman	2.7%	2.1%	0.9%	0.0%
Percent sophomore	4.1%	8.5%	2.8%	11.1%
Percent junior	16.2%	10.6%	5.5%	22.2%
Percent senior	20.3%	27.7%	5.5%	0.0%
Percent graduate	37.8%	36.2%	29.4%	44.4%
Percent employee	18.9%	14.9%	56.0%	22.2%
Age				
Mean	28.7	27.5	38.4	33
Min	19	18	19	19
Max	61	58	70	60
STD	8.6	9.3	13.9	15
Commute distance (miles)				
Mean	1.7	1.6	3.6	2.6
Min	0	0	0	1
Max	8	7	16	5
STD	1.4	1.7	2.3	1.5

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	Bicycling Commuters	Walking Commuters	Car Commuters	Other* Commuters
Percent find walking to be:				
Safe	33.8%	44.7%	22.0%	22.2%
Convenient	28.4%	53.2%	17.0%	11.1%
Efficient	24.3%	46.8%	16.1%	11.1%
Low-cost	73.0%	87.2%	50.0%	44.4%
Healthy	73.0%	83.0%	53.7%	55.6%
Respected by motorists	9.5%	19.1%	9.2%	0.0%
Percent find pedestrian infrastructure adequate:				
Strongly disagree	25.7%	27.7%	33.5%	22.2%
Disagree	28.4%	36.2%	39.0%	33.3%
Undecided	12.2%	6.4%	9.2%	11.1%
Agree	33.8%	21.3%	17.9%	33.3%
Strongly agree	0.0%	8.5%	0.5%	0.0%
Percent that would increase walking if pedestrian infrastructure was improved:	74.3%	78.7%	56.4%	55.6%
Percent find bicycling to be:				
Safe	10.8%	2.1%	5.0%	11.1%
Convenient	55.4%	38.3%	11.5%	22.2%
Efficient	64.9%	40.4%	15.6%	33.3%
Low-cost	82.4%	63.8%	52.8%	44.4%
Healthy	77.0%	57.4%	45.9%	33.3%
Respected by motorists	9.5%	2.1%	3.7%	22.2%
Percent find bicycle infrastructure adequate:				
Strongly disagree	64.9%	51.1%	51.4%	22.2%
Disagree	29.7%	25.5%	33.0%	44.4%
Undecided	2.7%	17.0%	12.4%	22.2%
Agree	2.7%	6.4%	2.8%	11.1%
Strongly agree	0.0%	0.0%	0.5%	0.0%
Percent that would increase bicycling if bicycle infrastructure was improved:	90.5%	66.0%	57.8%	44.4%
Percent that did not know that the Code of Alabama makes it illegal to ride a bicycle on a sidewalk	46.0%	72.4%	72.9%	77.8%

Note. *Other commuters = bus/motorcycle/scooter/bicycle+bus.

Survey results show that those individuals who walk to UA have a lower average age (27.5) and commute distance (1.6 mi). Bicycle commuters had an average age of 28.7 and a commute distance of 1.7 miles while those individuals who drove had the highest average age (38.4) and commute distance (3.6 mi) to UA. A higher percentage of non-motorized users were found to travel to UA more than 6 times a week when compared to automobile commuters, who were found to travel less frequently to UA. In addition, a higher percentage of non-motorized users were male and non-home owners while motorized commuters were female and home-owners. A large group of commuters (61.1%) to UA viewed bicycle and pedestrian travel in Tuscaloosa as low-cost and healthy modes of travel while they are not safe, convenient, efficient, nor respected by motorists. At the same time, bicyclists had a more positive perspective on bicycle travel while walking commuters had a more positive perspective about pedestrian travel. The majority of participants (87.4%) also described the bicycle and pedestrian infrastructure as inadequate in its current form. Furthermore, some 70.6% of participants answered that improvements to the current bicycle and pedestrian networks would increase their use of non-motorized travel. An overwhelming (67.3%) number of individuals lacked knowledge concerning the Code of Alabama and the laws regulating bicycle use.

Survey results show that individuals within the sample population use non-motorized travel methods to commute to UA but their use is significantly lower than automobile use. Commuters to UA identified that bicycling and walking is neither respected by motorists nor a safe mode of travel. These negative views are consistent with earlier assessments of bicycling in Tuscaloosa (Lange, 2007) and can likely contribute to the lower rates of non-motorized travel and decreased accessibility by discouraging use and causing individuals to seek out other travel methods.

The survey also consisted of two open-ended questions which asked individuals to identify possible improvements or additions to the bicycle and pedestrian networks. The results of the two open-ended questions can be found in Appendix C. The question relating to the bicycle network had an 80.5% response rate while the question relating to the pedestrian network had an 82.8% response rate. Responses relating to the bicycle network are quantified in Figure 4.8. The top three responses relating to bicycle travel include: more bicycle lanes, increased public awareness/education of proper traffic laws relating to operating bicycles, and increased respect/safety for bicyclists. Responses relating to the pedestrian network are quantified in Figure 4.9. The top three responses relating to pedestrian travel include: more sidewalks, improved infrastructure (pavement, cut curbs at intersections), and more crosswalks. For both questions, an overwhelming amount of participants stated that the area needs additional non-motorized travel infrastructure and facilities. Some repeated suggestions to improve non-motorized travel in the area, including: more off-street facilities, better signage, marked street crossings, better lighting, and other amenities to help make travel safer. The need for a pedestrian bridge over the Black Warrior River was mentioned numerous times. Additionally, respondents noted that having a better connected non-motorized travel network throughout the area would be beneficial so that users could safely travel from one side of town to the other. Participants also indicated that bicyclists and pedestrians, in addition to motorists, need to be educated about proper protocol when traveling on and sharing the roadway.

Responses to these survey questions are consistent with earlier research, in which individuals state that when they choose to use non-motorized travel methods, they want safe avenues in which to travel (Xing et al., 2010; Krizek & Johnson, 2006; Krizek & Roland, 2005; Stinson & Baht, 2003). Additionally, increasing the perceived safety of a travel method could increase the use. In this survey, individuals overwhelmingly state that they would like to see additional improvements to the non-motorized travel facilities.

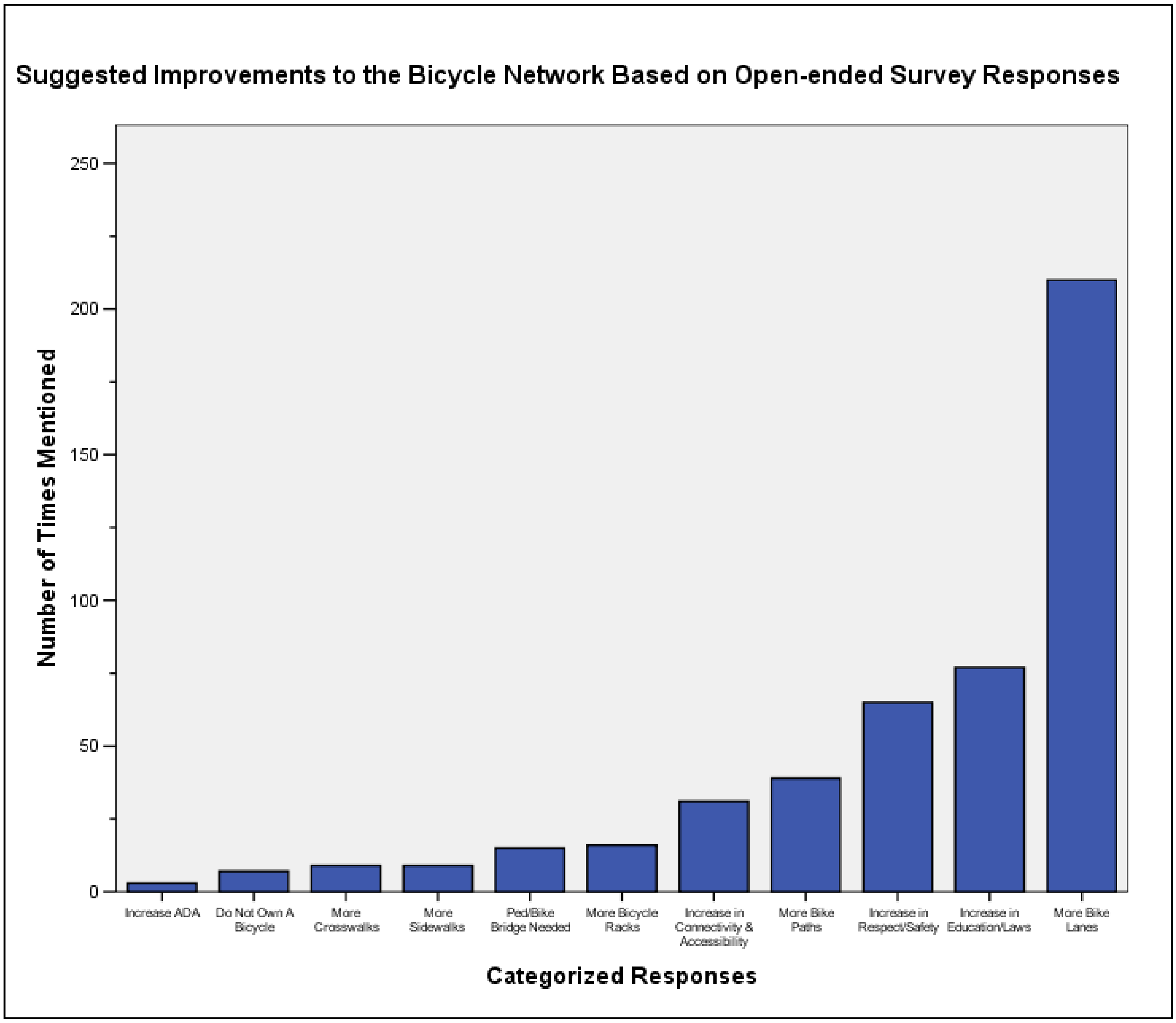

Figure 4.8 – Suggested improvements to the bicycle network.

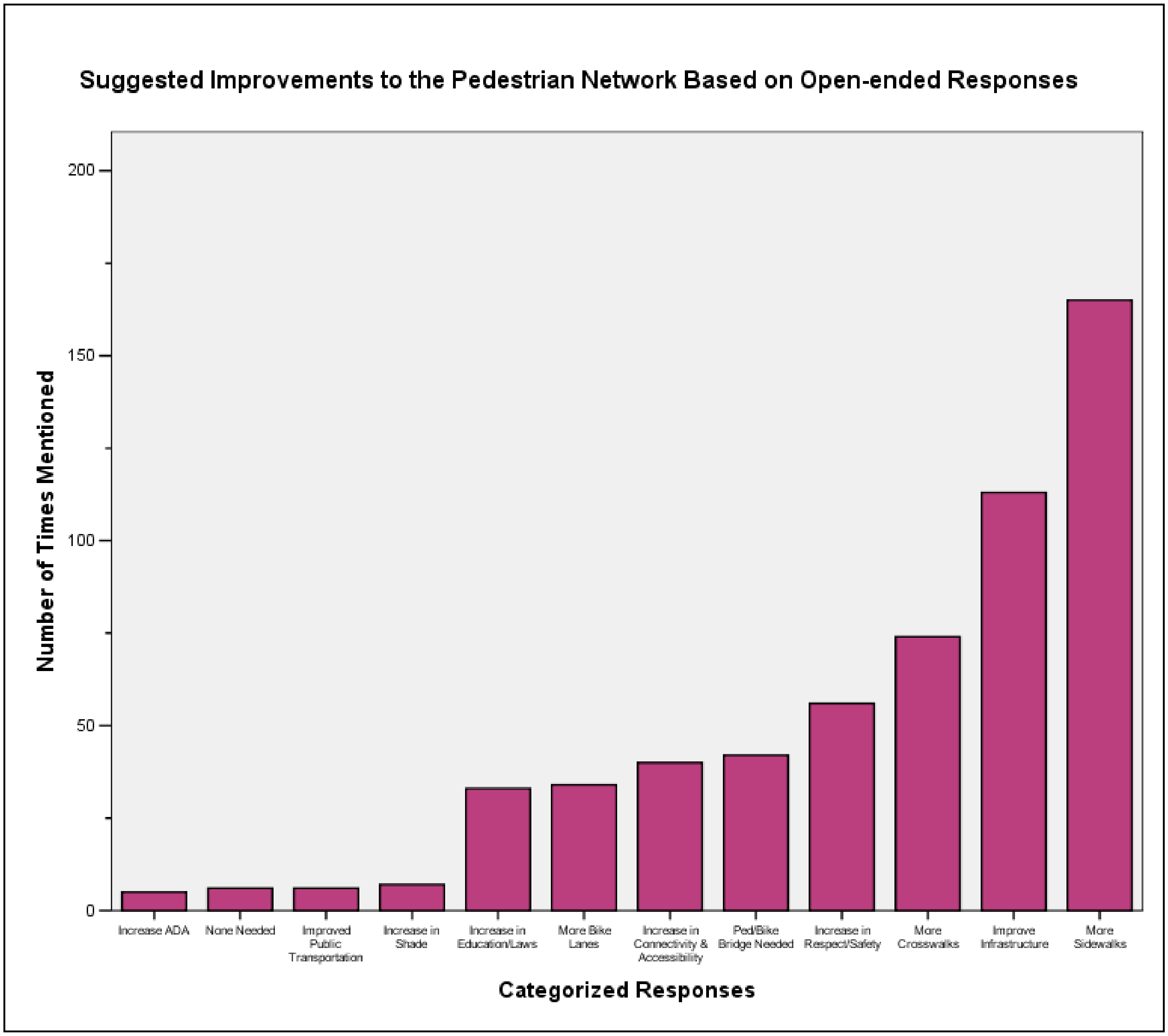

Figure 4.9 - Suggested improvements to the pedestrian network.

As this research was also geared towards identifying whether any particular perspective or behavior could predict whether an individual was more likely to utilize non-motorized transportation, binary logistic regressions was used to predict an individual's travel mode when traveling to UA. The two open-ended questions were not used in the regression modeling. The rest of the responses to the survey questions were recoded for use in the statistical analysis. Table

4.4 displays the independent variables used in the regression models with significant variables (p-value) at the 0.05 level.

Table 4.4
Independent variables used in the binary logistic regression models

Independent Variables	Bicycle	Pedestrian	Car
Weekly travel, how often	NS	NS	NS
Bicycle ownership	**S**	**S**	**S**
Bicycle use	**S**	**S**	**S**
Knowledge of the Code of Alabama	**S**	NS	NS
Cars per household	**S**	**S**	**S**
Commute distance	NS	**S**	**S**
Find bicycling to be:			
Safe	NS	NS	**S**
Convenient	**S**	NS	NS
Efficient	**S**	NS	**S**
Low-cost travel	NS	NS	NS
Healthy travel	NS	NS	NS
Respected by motorists	NS	NS	NS
Bicycle infrastructure adequate	NS	NS	NS
Improvements to bicycle network	**S**	NS	NS
Find walking to be:			
Safe	NS	NS	NS
Convenient	NS	**S**	NS
Efficient	**S**	NS	NS
Low-cost travel	NS	**S**	NS
Healthy travel	NS	NS	NS
Respected by motorists	NS	NS	NS
Pedestrian infrastructure adequate	NS	NS	NS
Improvements to pedestrian network	NS	**S**	NS
Sex	**S**	NS	NS
Age	NS	NS	NS
Marital status	NS	NS	NS
Own or rent home	NS	NS	**S**
Status	NS	**S**	NS

Note. Significant at .05 = S; Not Significant = NS

The predictive modeling was used through binary logistic regression and odds ratio (OR) in order to predict which variables contribute to the decision to utilize non-motorized travel. The survey data was separated into different groups based on main travel method to UA: bicycle, pedestrian, and car. The binary logistic regression was used to find the OR of using each travel method. The Forward Conditional method produced the best model using the independent variables from Table 4.4. Appendix D through F displays the SPSS binary logistic regression output tables for each travel mode.

The OR that was conducted for bicycling highlighted interesting trends in the data. All the independent variables from Table 4.4 were used for the OR modeling. However, bicycle ownership and bicycle use were the only two variables not used in the regression model, since it was assumed that individuals owned and used a bicycle if they bike to UA. The significant variables for the bicycle OR are found in Table 4.5. The regression model was able to correctly predict 48.6% of bicycle commuters and 94.9% of non-bicycle commuters with an overall correct percentage of 85.1 (Appendix D). The bicycling OR model in Table 4.5 was compared against those individuals that: had more than 3 cars per household, found walking not efficient, found bicycling not convenient or efficient, lacked knowledge of the Code Of Alabama, undecided if improvements to the bicycle network would increase bicycle use, and female. Certain trends appear for the bicycle commuters. For example, an individual who has knowledge of the Code of Alabama will be 3 times more likely to bike, while not having a car in the household carries a 9.8 times greater likelihood to bike. Also, individuals are 2.6 times greater to bike if they find walking to be efficient, and individuals are 11.5 times more likely to bike if they indicated that additions to the bicycle network would be beneficial. Interestingly, there appear to be some gender distinctions within the biking population surveyed here, as males are 2 times more likely to use a bicycle. In addition, the view of bicycling as convenient and efficient carries a negative OR, which indicates these views are less likely to be associated with individuals that use a bicycle.

Table 4.5
Binary logistic regression results for bicycle commuters

Variable	B	p	OR
Code of Alabama		**0.005**	
Knowledge of law	1.111	**0.001**	**3.037**
No knowledge of law	0.073	0.925	**1.076**
Cars per household		**0.008**	
0	2.288	**0.006**	**9.859**
1	1.553	**0.006**	**4.724**
2	0.868	0.132	2.382
Views on Walking: Efficient	0.989	**0.019**	**2.688**
Views on Bicycling: Convenient	-0.99	**0.009**	**0.371**
Views on Bicycling: Efficient	-1.549	**0.000**	**0.212**
Additions to the bicycle network		**0.000**	
Yes	2.444	**0.003**	**11.523**
No	0.878	0.357	2.406
Male	0.705	**0.035**	**2.025**

Note. Results significant at the 0.05 level are in bold and italicized at the 0.10 level.

Modeling the bicycle commuters separately shows interesting trends among this group. The most noticeable is the effect of the number of automobiles per household and views on improving the area's bicycle infrastructure. As expected, these trends illustrate that individuals are utilizing or seek to utilize alternative travel methods to the automobile when commuting in the area. In addition, participants state that increasing the bicycle-friendly infrastructure could increase bicycle use. Knowledge and understanding of the laws associated with bicycle use in the area also increased the likelihood of bicycle commuting, which suggests that bicyclists want to travel safely and research regulations associated with their use. Males were twice as likely to bike which is consistent with earlier research (Zahran et al., 2008; Plaut, 2005). However, bicycling was viewed as not convenient or efficient, which could be why improvements to the bicycle network were viewed with a high OR. This suggests that non-car owning males that have knowledge of the Code of Alabama and want improvements to the bicycle network are the most likely to bike to UA.

Pedestrian travel was also analyzed using OR. All the independent variables from Table 4.6 were used for the pedestrian OR. The significant variables are found in Table 4.4. The regression model was able to correctly predict 61.7% of pedestrian commuters and 97.3% of non-pedestrian commuters with an overall correct percentage of 92.5 (Appendix E). The pedestrian OR model in Table 4.6 was compared against those individuals that: did not own a bicycle, had more than 3 cars per household, commuted more than 3 miles to UA, found walking not to be convenient or low-cost travel, undecided if improvements to the pedestrian network would increase walking, and were an employee at UA. When considering pedestrian travel to UA, an individual was 266.7 times more likely to walk if the household has no cars, 15.1 times more likely to walk if an individual lives within a 0.5 mile of UA, and 3.1 times more likely to walk if an individual lives within 1.0 mile of UA. Furthermore, if an individual found walking to be convenient, they are 5.2 times more likely to walk, if an individual finds walking to be a form of low-cost travel they are 3.3 times more likely to walk to UA. Overall, seniors are 55.8 times more likely to walk, while freshman are 15.7 times more likely to walk, and graduate students are 3.4 times more likely to walk. In addition, views toward improvements to the pedestrian network carry a negative odds ratio which indicates this view is less likely to be associated with individuals that walk.

Some interesting patterns develop with the results of the pedestrian OR. Commute distance and cars per household have large effects on pedestrian travel, which is to be expected. Daily bicycle use also had a negative OR, suggesting that individuals that used their bicycles on a daily basis are less likely to walk to UA. When compared to employees, student class status at UA shows that across the broad students are utilizing pedestrian travel. Viewing pedestrian travel as convenient and low-cost travel increased the likelihood of walking to UA. However, viewing improvements to the pedestrian network produced a negative OR, which might suggest that individuals have reached their limit on walking distance.

Table 4.6
Binary logistic regression results for pedestrian travelers

Variable	B	p	OR
Use a bicycle		**.000**	
Daily	-5.035	**.000**	**0.007**
Weekly	-0.114	0.876	0.892
Monthly	1.198	0.128	3.314
Yearly	0.234	0.784	1.264
Cars per household		**.000**	
0	5.586	**.000**	**266.661**
1	2.114	**0.008**	**8.284**
2	0.181	0.825	1.199
Distance to campus		**0.034**	
0.5	2.716	**0.002**	**15.124**
1	1.132	*0.081*	*3.103*
1.5	0.182	0.837	1.200
2	0.640	0.394	1.897
2.5	-16.891	0.999	.000
3	-1.300	0.305	0.273
Views on Walking: Convenient	1.650	**0.002**	**5.207**
Views on Walking: Low cost travel	1.195	*0.060*	*3.303*
Additions to the pedestrian network		**0.042**	
Yes	-0.452	0.524	0.637
No	-2.332	**0.012**	**0.097**
Status		**.000**	
Fresh	2.756	**0.051**	**15.742**
Soph	1.928	0.113	6.878
Junior	2.400	**0.015**	**11.025**
Senior	4.022	**.000**	**55.796**
Grad	1.231	*0.081*	*3.424*

Note. Results significant at the 0.05 level are in bold and italicized at the 0.10 level.

The third group of travelers that were analyzed using the OR was automobile commuters. All the independent variables from Table 4.4 were used for the car OR. The significant variables for the car OR are found in Table 4.7. The regression model was able to correctly predict 91.7% of car commuters and 73.9% of non-car commuters with an overall correct percentage of 85.1 (Appendix F). The car OR model in Table 4.7 was compared against those individuals that: did not own a bicycle, had more than 3 cars per household, lived more than 3 miles from UA, found bicycling not be safe or efficient, and owned their home. The survey results show that when considering car travel to UA, an individual is 2.4 times more likely to drive if they viewed bicycling as efficient and 3.8 times more likely to drive if they rent their home. In addition, bicycling daily; living within 0.5, 1.0, and 2.0 miles of UA; and viewing bicycling as safe travel carry a negative OR which indicates that these variables are less likely to be associated with individuals that commute by car.

Interestingly, renters had the largest effect on the OR for predicting car use. Commute distance, namely living 0.5, 1.0, and 2.0 miles from UA, had a negative OR and suggests that individuals living closer to UA's campus are less likely to drive to UA. This would be consistent with the OR for pedestrian travel. Daily bicycle use also had a negative OR, suggesting that individuals that used their bicycle on a daily basis are also less likely to drive to UA. Again, the OR did not use demographic information when predicting car use, which might suggest that car use is not limited by age, sex, or student status at UA.

Results of the on-line survey show that travel mode is heavily dependent on commute distance, cars per household, bicycle use, and views on the non-motorized travel networks. Pedestrians tend to live closer to UA's campus while bicycle and car commuters live further away. Demographic information such as sex, age, and marital status failed to be a good predictor of non-motorized travel, with the exception of males and bicycling. One element that stands out from the survey results includes a lack of knowledge about the Code of Alabama and the laws relating to proper bicycle use. In addition, numerous participants noted in the open-ended questions that the public lacked knowledge of suitable commuting abilities. This suggests that the public could benefit from a public service announcements relating to the proper way to share travel infrastructure. For efficient and safe shared roadways, all commuters need a clear understanding of the local laws and show courtesy towards others.

Table 4.7
Binary logistic regression results for car commuters

Variable	B	p	OR
Use a bicycle		**.000**	
Daily	-3.301	**.000**	**0.037**
Weekly	-0.827	*0.096*	*0.437*
Monthly	-1.630	0.778	0.850
Yearly	0.670	0.338	1.954
Cars per household		0.459	
0	-20.422	0.998	.000
1	0.083	0.862	1.086
2	0.652	0.192	1.920
Distance to campus		**.000**	
0.5	-3.217	**.000**	**0.040**
1	-1.424	**0.003**	**0.241**
1.5	-0.901	0.120	0.406
2	-1.065	**0.041**	**0.345**
2.5	-0.032	0.977	0.968
3	0.503	0.476	1.654
Views on Bicycling: Safe	-1.960	**0.012**	**0.141**
Views on Bicycling: Efficient	0.892	**0.018**	**2.439**
Rent a home	1.324	**0.001**	**3.758**

Note. Results significant at the 0.05 level are in bold and italicized at the 0.10 level.

4.3 Combined Analysis

The results of the survey were also considered in light of how an individual views the non-motorized travel networks, his/her self-reported distance to UA, and the overall neighborhood connectivity measures (Table 4.8). These results show that an individual's positive perception of the bicycle and pedestrian networks decreases within an increase in commute distance to UA. For example, individuals living within a 0.5 mile of UA have a more positive view of the non-motorized networks when compared to those individuals living 3.0 miles from UA. The large spike in the 2.5 mile distance in the bicycle network (Figure 4.10A) can be contributed to the small sample size (n=7).

Table 4.8
Perception of adequate infrastructure

Commute Distance	Bicycle Network	Pedestrian Network	Number in Sample
0.5	4.0%	48.0%	25
1.0	6.2%	24.6%	65
1.5	2.8%	27.8%	36
2.0	3.6%	29.1%	55
2.5	28.6%	14.3%	7
3.0	2.4%	14.6%	41

Figure 4.10B displays the percentage of individuals who indicate that improved non-motorized facilities would increase the use of bicycling and walking. For bicycle users, it is promising to see a positive trend out 1.5 miles from UA. This suggests that increasing bicycle lanes and other safe infrastructure out 1.5 miles could encourage more bicycle use. Additionally, for walkers, there is a slight positive trend out 1.0 mile from UA. Again this suggests that extending and improving the safe infrastructure would result in a positive change by encouraging would-be users of non-motorized transportation. Other survey data shows that participants'

perception of the bicycle (Figure 4.10C) and pedestrian (Figure 4.10D) networks decrease with an increase in travel distance to UA. The survey participants' perception of the non-motorized travel networks correlates well with the measures of connectivity, as distance from UA increases, the both network were found to be less connected (Table 4.1).

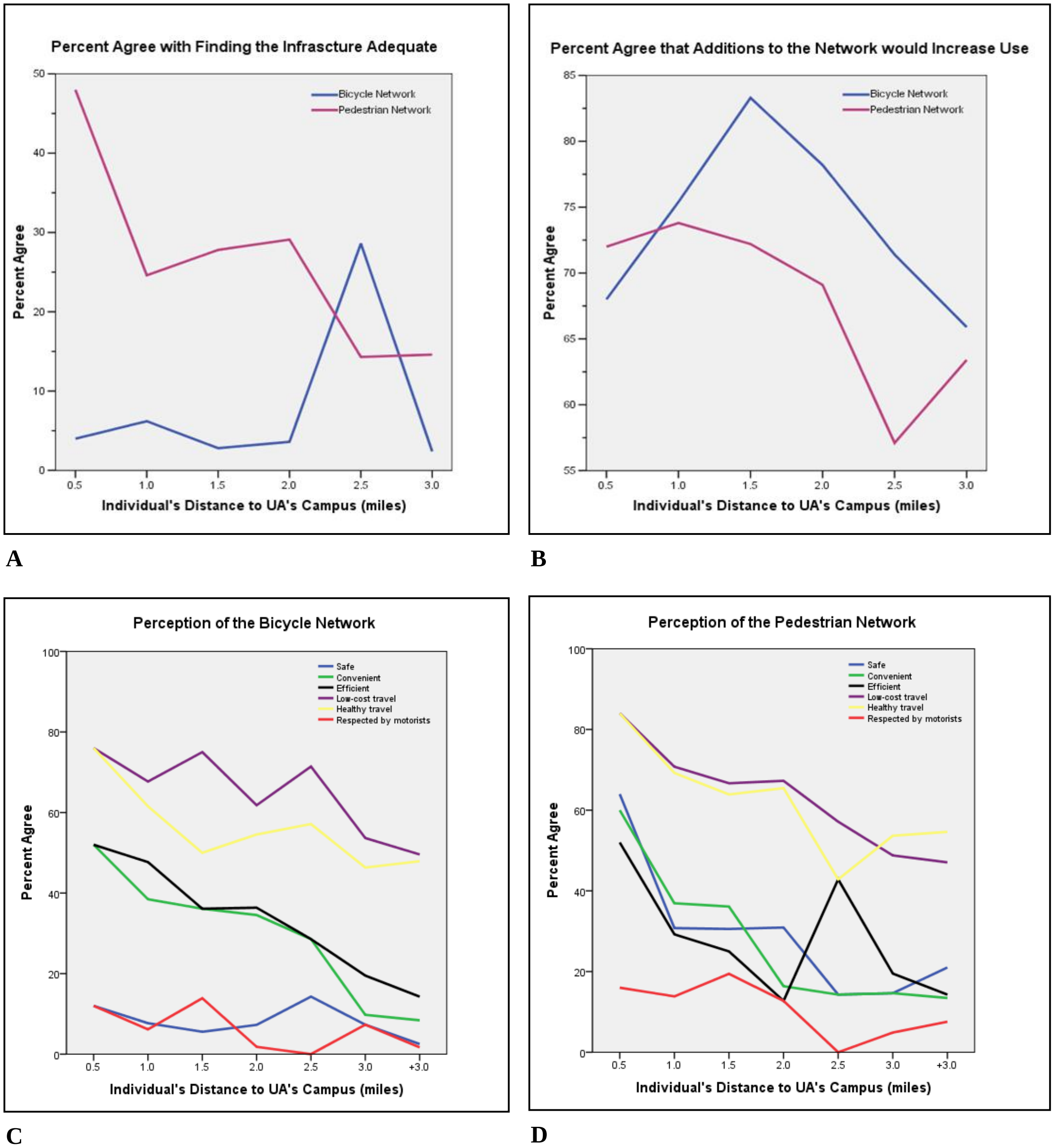

Figure 4.10 – Perception of adequate network infrastructure. A. Percent agree with finding infrastructure adequate, B. Percent agree with needed additions, C. Perception of the bicycle network, and D. Perception of the pedestrian network.

Results of the Pearson correlation coefficients between the measures of accessibility and connectivity are shown in Table 4.9. There is a moderately negative correlation between the connectivity measures and travel time and distance, with walking having a slightly stronger negative correlation. Route Directness shows a strong positive correlation with travel time and distance, with walking having a slightly stronger correlation. These relationships illustrate that increases in connectivity would help decrease travel time and distance which increases overall accessibility to UA. Increases in connectivity correlate with allowing higher rates of accessibility. As noted previously, the relationship between Route Directness and travel time and distance is likely a function of the lack of bicycle- and pedestrian-friendly infrastructure in the study area.

Table 4.9
Pearson correlation coefficicents between connectivity and accessibility

		Accessibility Measures			
		Bicycle Travel Time	**Walk Travel Time**	**Bicycle Travel Distance**	**Walk Travel Distance**
Connectivity Measures	**Intersection Density**	-0.637 (0.00)	-0.665 (0.00)	-0.682 (0.00)	-0.691 (0.00)
	Network Density	-0.632 (0.00)	-0.666 (0.00)	-0.680 (0.00)	-0.690 (0.00)
	Route Directness	0.753 (0.00)	0.789 (0.00)	0.733 (0.00)	0.761 (0.00)

Note. Values in parentheses are 2-tailed significance values.

This research shows that individuals living within 1.0 mile of UA's campus have a higher accessibility to more connected bicycle and pedestrian networks. Participants living within one mile of UA also view these non-motorized networks as providing a safe, convenient, and efficient method when commuting to UA compared to those individuals living further away from UA. The bicycle and pedestrian networks centered in downtown Tuscaloosa and UA have adequate network connectivity and accessibility while the surrounding areas (greater Tuscaloosa and Northport) achieve a lower level of non-motorized accessibility. Participants' perception correlate well with the GIS results for connectivity and accessibility modeling, in that, the bicycle and pedestrian networks decline as distance from UA increases.

Measures of accessibility show that bicycle commuters have a higher accessibility to UA compared to pedestrians. However, survey results show that individuals feel that there is a lack of bicycle-friendly infrastructure, bicyclists are not respected by motorists, and bicycling is not safe which could be a limiting factor for bicycle use and thus lowering the actual level of bicycle accessibility to UA. Participants had a slightly more positive view on pedestrian travel and the pedestrian network. Survey results suggest that individuals view of both non-motorized travel networks as inadequate and insufficient. An overwhelming number of participants state that improvements to the bicycle and pedestrian networks would in fact increase their use of non-motorized modes of transportation.

5.0 CONCLUSION

This research examined the local bicycle and pedestrian networks through the use of Geographic Information Systems (GIS) and survey data, using the Tuscaloosa and Northport, Alabama, area as a case study. This investigation is significant since it is the first comprehensive study of non-motorized travel relating to the UA population. This study shows the benefit of not only studying a transportation network, but also of sampling those individuals who use or have the potential to use the network. This type of study is important because it can identify gaps or problems with a travel network while at the same time providing researchers and planners with feedback from travelers that use network in their daily lives. City officials and transportation planners can use these tools and data to help improve a travel network and the overall quality of life. Additionally, this research is important because it supports earlier research by identifying certain factors that can affect bicycling and walking rates. These factors include: increases in connectivity, accessibility, and proximity to non-motorized facilities, and decreases in commute distance and cars per house, which all have positive effects of non-motorized travel. Furthermore, this research contributes to an improved understudied field of university populations and non-motorized travel.

Measures of network connectivity were utilized to identify the sections of the bicycle and pedestrian networks that have the greatest amount of connectivity within the study area. The network connectivity measures identified high concentrations of connectivity within downtown Tuscaloosa, Northport, and Alberta. Additionally, the area between downtown Tuscaloosa and UA had the highest density of network connectivity. Furthermore, when travel distance increases from UA, connectivity of both the bicycle and pedestrian networks decrease. This decrease reflects the changes in zoning, neighborhood planning, and land-use that incorporate longer segments, more cul-de-sacs, and a diminished grid-type network. In addition, areas along the north side of the Black Warrior River have a considerable decrease in network connectivity when compared to areas south of the river. Results also show that when Intersection and Network Densities decrease, values for the Route Directness increases, illustrating that a more direct route is dependent on increased connectivity. Increases in network connectivity allow for increased travel options and route choices, thus decreasing travel times and distances between destinations.

Within the study area, high levels of non-motorized travel accessibility are associated with high levels of network connectivity. Those individuals living adjacent to concentrations of high network connectivity have a higher accessibility to UA along the bicycle and pedestrian networks compared to those individuals living further from the areas with greater network connectivity. Assessments of accessibility indicate that the pedestrian network allows for highest accessibility within one mile of UA, while the highest accessibility to UA along the bicycle network covers a larger section of the study area.

The network connectivity and accessibility measures combined with the survey data suggest that large sections of the study area have high connectivity and accessibility to UA, however, the public’s perception of travel safety is discouraging individuals from utilizing non-motorized travel. Furthermore, survey data shows that individuals would like to see improvements to existing non-motorized travel facilities and additions in the form of new infrastructure that safely supports bicycle and pedestrian use. Additionally, this data suggests that these improvements would positively affect the sample populations' use of bicycling and walking when traveling to UA. This is consistent with earlier findings (Lange, 2007) and reinforces the suggestion that individuals seek alternative travel methods when commuting to UA. If designed and engineered properly, such improvements could improve and rebrand the public's perception of non-motorized travel as convenient, efficient, and safe, thus encouraging increased bicycling and walking rates.

Regression modeling of survey data was able to identify certain factors that helped predict whether an individual was likely to use non-motorized travel methods. Commute distance, cars per household, and bicycle use were the strongest predictors for travel mode to UA. Additionally, the bicycle regression model found males twice as likely to bike to UA, the pedestrian regression model found underclassmen had a higher probability to walk to UA, and the car commuter regression model found renting a home increased the likelihood of driving to UA. However, for the most part, the regression models failed to include demographic information. Interestingly, survey participants' perception of non-motorized travel networks diminished as distance from UA increased. This correlated well with the measures of connectivity and accessibility. Due to the lack of underclassmen that participated, the survey was found to be a better representation of seniors, graduate students, and employees.

There were limitations to this study, primarily with the traffic modeling phase of this study. Since an artificial destination center of UA's campus was used as the point from which all trips were measured, in some situations the traffic modeling would either overestimate or underestimate bicycle or pedestrian travel time and distance to UA. In addition, average bicycling and walking speeds were used to derive travel time (minutes) over each segment in the bicycle and pedestrian networks. Human movement ranges broadly due to fitness levels and personal preference, among other factors, and this research recognizes that these connectivity and accessibility measures employed in this study are estimates and that more research is needed to accurately understand the local non-motorized networks on a more individual level. Skill levels and travel speeds vary greatly from person to person. Future research dealing with travel options and route would benefit greatly from employing GPS to help track an individual's actual route and travel speeds. The use of travel dairies could also shed light on an individual's travel habits. This study could also benefit from a more in-depth survey as well as more detailed modeling of travel routes. Finally, part of this research was dependent on self-reported information, which is dependent upon accurate reporting of an individual's behavior and perspectives.

This study focused on those individuals within 3 miles of UA's campus, a distance which accounts for the majority of non-motorized travel in the U.S. (U.S. Census Bureau, 2010). By characterizing the overall attitudes of the same population within the 3 miles of UA, this research has demonstrated that there is a clear potential for motorized commuters to switch and use non-motorized travel where certain conditions are met. For example, more bicyclists and pedestrians lived in areas with high connectivity, and non-bicyclists and non-pedestrians often cited the lack of infrastructure as a limiting factor. As a result, improving network connectivity, accessibility, and infrastructure would likely encourage individuals within this area to incorporate non-motorized travel in their daily lives. Other factors would also help to increase the frequency of bicycle and pedestrian use including: bicycle- and pedestrian-friendly facilities; public service announcements and education; and progressive policies and regulations. Supportive communities and local governments can also actively help encourage the use of bicycle and pedestrian travel.

Additionally, this research is important because it is applicable to municipal governments, city officials, and transportation planners who can use these evaluations of the network to help plan and design new infrastructure and upgrades to existing facilities. For example, in the Tuscaloosa-Northport area this research could help determine the location of a pedestrian bridge over the Black Warrior River or the installation of a new multi-use trail. The placement of a bridge and connecting trails could increase the connectivity and accessibility to individuals living along both sides of the Black Warrior River while benefiting the entire community. Other strategically placed bike lanes, sidewalks, trails, signage, and lighting have the potential to improve a non-motorized network.

Large sections of Tuscaloosa were devastated by the spring tornadoes in April of 2011, including large segments of urban and residential areas. In the aftermath of these events, the community of Tuscaloosa came together to form the Tuscaloosa Forward Strategic Rebuilding Plan. This plan was designed to create a vision that would drive reconstruction and restoration of the areas affected by the storms (Tuscaloosa Forward, 2012). Within the recovery zones, the plan identifies and recommends potential land-uses and infrastructural improvements that would enhance neighborhoods and create more connections between neighborhoods. Along with rebuilding commercial and residential areas, the plan calls for improved connectivity within the street network. Additionally, the plan calls for numerous bicycle and pedestrian trails to be built in the affected areas of town (Figure 5.0). As this research identifies, not only is it important to build non-motorized travel facilities so that they can provide safe travel, but it is also important that these facilities be properly connected to other infrastructure throughout the area as to encourage non-motorized travel so all citizens can share their benefit. This research indicates that individuals would likely utilize such developments, which would have clear benefits for both individuals and for the community as a whole.

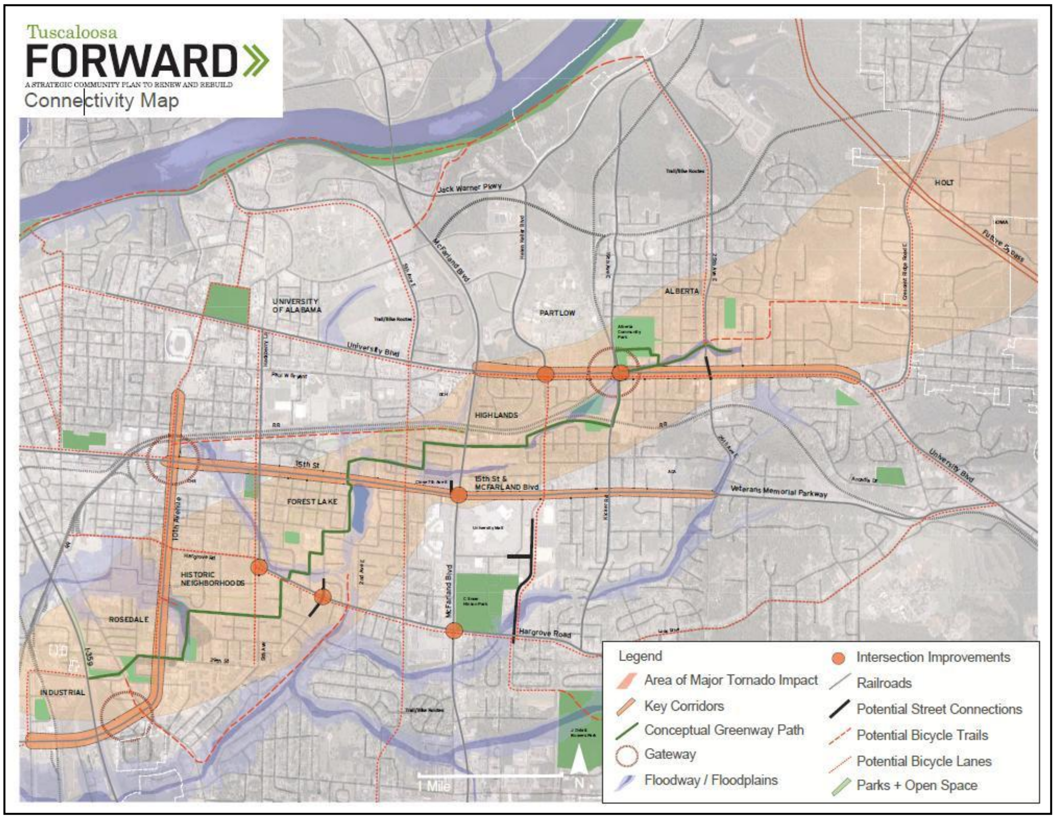

Figure 5.0 – Connectivity Map from the Tuscaloosa Forward Strategic Rebuilding Plan.

Additionally, the Tuscaloosa Forward Plan also recommends the use of complete streets (Figure 5.1). Complete streets allow for an increase in the amount of shared-roadway between automobiles, bicycles, pedestrians, and, when available, mass transit. Complete streets have been used in other communities across the nation to increase the amount of non-motorized travel while reducing automobile congestion and increasing the quality of life within a community (NCSC, 2011). The city of Tuscaloosa has a chance to fundamentally change large sections of the urban environment by leaving behind automobile travel and single-use zoning for non-motorize travel and mixed-use zoning. These changes would reduce traffic congestion and stress while promoting healthier modes of travel, more community interaction, and increasing the quality of life within the city.

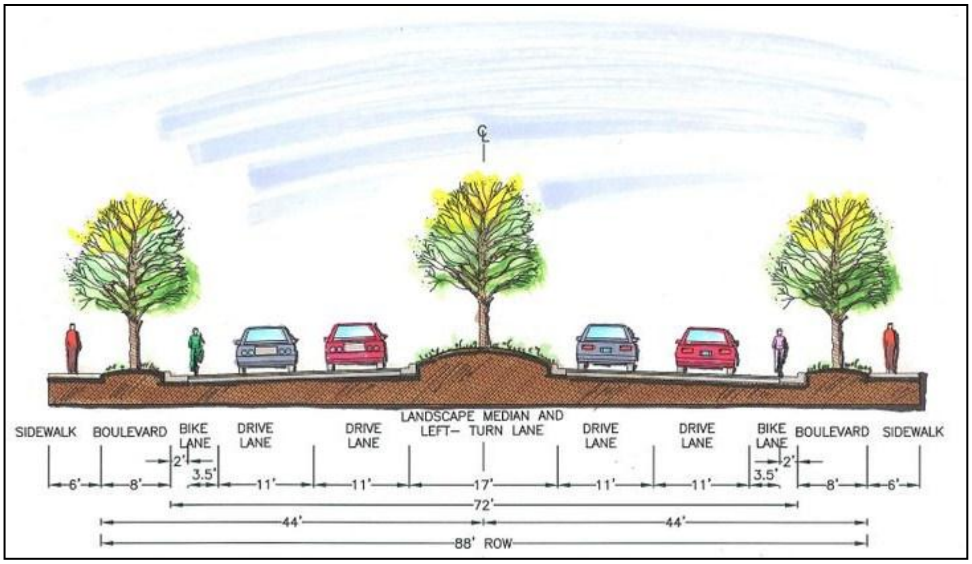

Figure 5.1 – Cross-sectional view of a complete street (NCSC, 2011).

As UA's campus continues to grow, the need to promote increased accessibility and sustainable travel modes has been recognized by UA. By studying connectivity and accessibility of bicycle and pedestrian travel of a sample of UA's population, this research helps lay a foundation for UA to make informed decisions regarding how to move forward. This information can be used by transportation planners, city officials, and UA to help plan for the future. Studies like this outline the importance of understanding travel behavior and provide a case study to allow the public, local municipalities, and community institutions, such as UA, to make smarter decisions when forming a comprehensive transportation plan and setting transportation goals.

Local metropolitan planning organizations (MPOs) and city officials could also use this research to target and identify areas that would benefit from improved connectivity and non-motorized travel infrastructure developments. In the target areas with low connectivity, improved infrastructure could help encourage the use of bicycling and walking in hope of reducing automobile traffic and, in turn, air and noise pollution. As local governments, municipalities, and transportation planners continuously seek to offer more services with fewer resources, implementing programs and projects that include non-motorized travel offer healthy modes of travel while reducing wear-and-tear on the local roadways.

REFERENCES

Allen, D. P., Rouphail, N., Hummer, J. E., & Milazzo II, J. S. (1998). Operational analysis of uninterrupted bicycle facilities. *Transportation Research Record,* 1636, 29-36.

Allen-Munley, C., Daniel, J., & Dhar, S. (2004). Logistic model for rating urban bicycle route safety. *Transportation Research Record,* 1878, 107-115.

American Association of State Highway and Transportation Officials. (2010). Census Transportation Planning Program. Retrieved from http://download.ctpp.transportation.org/profiles_2005-2007/ctpp_profiles.html

American Association of State Highway and Transportation Officials. (1999) *Guide for the Development of Bicycle Facilities, 3rd Edition*. Retrieved from https://bookstore.transportation.org/Item_details.aspx?id=1529

Amiton, R. (2011, January). Biking catches up. *Planning*, 77(1), 34-35.

Areavides. (2011). Tuscaloosa Housing, Homes and Rentals. Retrieved from http://www.areavibes.com/tuscaloosa-al/housing

Balsas, C. J. L. (2003). Sustainable transportation planning on college campuses. *Transport Policy,* 10(1), 35-49.

Berrigan, D., Pickle, L. W., & Dill, J. (2010). Associations between street connectivity and active transportation. *International Journal of Health Geographics,* 9(20), 20-37.

Berrigan, D., & Troiano, R. (2002). The Association between urban form and physical activity in U.S. adults. *American Journal of Preventive Medicine*, 23(2), 74-79.

Biba, S., Curtin, K. M., & Manca, G. (2010). A new method for determining the population with walking access to transit. *International Journal of Geographical Information Science*, 24(3), 347-364.

Black, W. R. (1996). Sustainable transportaiton: a US perspective. *Journal of Transport Geography*, 4(3), 151-159.

Bonham, J., & Koth, B. (2010). Universities and the cycling culture. *Transportation Research Part D,* 15(2), 94-102.

Botma, H. (1995). Method to determine level of service for bicycle paths and pedestrian-bicycle paths. *Transportation Research Record,* 1502, 38-44.

Center for Advanced Public Safety. (2009). *Alabama Traffic Crash Facts 2009*. Retrieved from http://caps.ua.edu/crashfactsbook.aspx

Centers for Disease Control and Prevention. (2008). *Physical Activity Guidelines for Americans*. Atlanta, GA: U.S. Department of Health and Human Services.

Chin, G. K. W., Van Niel, K. P., Giles-Corti, B., & Knuiman, M. (2008). Accessibility and connectivity in physical activity studies: The impact of missing pedestrian data. *Preventive Medicine*, 46(1), 41-45.

Church, R. L., & Marston, J. R. (2003). Measuring accessibility for people with a disability. *Geographical Analysis*, 35(1), 83-96.

Code of Alabama. (1975). The Code of Alabama 1975. Retrieved from http://alisondb.legislature.state.al.us/acas/codeofalabama/1975/coatoc.htm

Crompton, T. (2011, July). Parking issues not unique to UA. *The Crimson White*. Retrieved from http://cw.ua.edu/2011/07/06/parking-issues-not-unique-to-ua

De Geus, B., De Smet, S., Nijs, J., & Meeusen, R. (2007). Determining the intensity and energy expenditure during commuter cycling. *British Journal of Sports Medicine*, 41, 8-12.

Dewar, R. (2002). Chapter 18: Pedestrians and Bicyclists. *Human Factors in Traffic Safety*. Tucson, AZ: Lawyers & Judges Publishing Company.

Dialog. (2010). The University of Alabama. Retrieved from http://dialog.ua.edu/2010/08/campus-changes-reflect-uas-growth-with-quality

Dialog. (2007). The University of Alabama. Retrieved from http://dialog.ua.edu/2007/04/new-transit-system-expected-to-help-ease-universitys-rapid-growth

Dill, J. (2004, January). *Measuring Network Connectivity for Bicycling and Walking*. Paper session presented at the Transportation Research Board Annual Meeting, Washington, D.C.

Dill, J. (2009). Bicycling for transportation and health: The role of infrastructure. *Journal of Public Health Policy,* 30(S1), S95-S110.

Doherty, B. (2011). Bike policy unfair. *The Crimson White*. Retrieved from http://cw.ua.edu/2011/07/20/bike-policy-unfair-3

El-Geneigy, A., Krizek, K. J., & Iacono, M. (2007, January). *Predicting bicycle travel speeds along different facilities using GPS data: A proof of concept model*. Paper session presented at the Transportation Research Board Annual Meeting, Washington, D.C.

Evans, W. (2011, March). Campus Wi-Fi a growing issue. *The Crimson White*. Retrieved from http://cw.ua.edu/2011/03/27/campus-wi-fi-a-growing-issue

Federal Highway Administration. (2011). The Non-motorized Transportation Pilot Program (NTPP). Retrieved from http://www.fhwa.dot.gov/environment/bikeped/ntpp.htm

Federal Highway Administration. (2010). Federal-Aid highway Program Funding for Pedestrian and Bicycle Facilities and Programs. Retrieved from http://www.fhwa.dot.gov/environment/bikeped/bipedfund.htm

Federal Highway Administration. (2010a). Pedestrian Safety Strategic Plan: Recommendations for Research and Product Development. Retrieved from http://safety.fhwa.dot.gov/ped_bike/pssp/fhwasa10035

Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices. Retrieved from http://mutcd.fhwa.dot.gov/pdfs/2009/pdf_index.htm

Fels, M.F. (1975). Comparative energy costs of urban transportation systems. *Transportation Research*, 9(5), 297-308.

Forsyth, A., Oakes, J. M., Lee, B., & Schmitz, K.H. (2009). The built environment, walking, and physical activity: Is the environment more important to some people than others? *Transportation Research Part D,* 14, 42-49.

Frank, L. D., Andresen, M. A., & Schmid, T. L. (2004). Obesity relationships with community design, physical activity, and time spent in cars. *American Journal of Preventive Medicine,* 27(2), 87-96.

Gorenflo, L. J., & Gale, N. (1990). Mapping regional settlement in information space. *Journal of Anthropological Archaeology*, 9, 240-274.

Greene, A. (2011, October). Witt State of university. *The Crimson White*. Retrieved from http://cw.ua.edu/2011/10/13/witt-state-of-the-university

Greene, D. L., & Wegener, M. (1997). Sustainable transport. *Journal of Transport Geography,* 5(3), 177-190.

Guo, Z. (2009). Does the pedestrian environment affect the utility of walking? A case of path choice in downtown Boston. *Transportation Research Part D*, 14, 343-352.

Handy, S. L. (1992). Regional versus local accessibility: Variations in suburban form and the effects on non-work travel. *Transportation Research Part A: Policy and Practice*, 29(1), 78-79. (Order No. DA93-30570)

Handy, S. L., & Niemeier, D. A. (1997). Measuring accessibility: an exploration of issues and alternatives. *Environment and Planning A,* 29, 1175-1194.

Hansen, W. (1959). How accessibility shapes land use. *Journal of American Institute of Planners*, 25(1), 73-76.

Haskell, W. L., Lee, I., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A., . . . Bauman, A. (2007). Physical Activity and Public Health: updated Recommendation for Adults from the American College of Sports Medicine and the American Heart Association. *Medicine and Science in Sports and Exercise* 39(8), 1435-1445.

Hewko, J., Smoyer-Tomic, K. E., & Hodgson, M. J. (2002). Measuring neighborhood spatial accessibility to urban amenities: does aggregation error matter? *Environment and Planning A,* 34, 1185-1206.

Holland, T. (2011, March). Expansion a growing problem? *The Crimson White*. Retrieved from http://cw.ua.edu/2011/03/02/expansion-a-growing-problem/

Iacono, M., Krizek, K. J., & El-Geneidy, A. (2010). Measuring non-motorized accessibility: issues, alternatives, and execution. *Journal of Transport Geography,* 18(1), 133-140.

Jones, A. (2010, July). Streets near stadium to be renamed to honor coaches. *Tuscaloosa News*. Retrieved from http://www.tuscaloosanews.com/article/20100721/NEWS/100729954

Kaiser, L. S. (2010, July). Denver launches bike sharing. *Planning,* 76(6), 3.

Khan, S. I., & Raksuntorn, W. (2001). Characteristics of passing and meeting maneuvers on exclusive bicycle paths. *Transportation Research Record*, 1776, 220-228.

Kim, J. (2007, June). *Testing the street connectivity of new urbanism projects and their surrounding s in metro Atlanta region*. Proceedings, 6th International Space Syntax Symposium , Istanbul, Turkey.

Krizek, K. J., Handy, S. L., & Forsyth, A. (2009). Explaining changes in walking and bicycle behavior: challenges for transportation research. *Environment and Planning B: Planning and Design*, 36, 725-740.

Krizek, K. J., & Johnson, P. J. (2006). Proximity to trails and retail: Effects on urban cycling and walking. *Journal of the American Planning Association*, 72(1), 33-42.

Krizek, K. J., & Roland, R. W. (2005). What is at the end of the road? Understanding discontinuities of on-street bicycle lanes in urban settings. *Transportation Research Part D*, 10(1), 55-68.

Kwan, M.-P. & Weber, J. (2008). Scale and accessibility: Implications for the analysis of land use-travel interaction. *Applied Geography*, 28(2), 110-123.

Kwan, M.-P. & Weber, J. (2003). Individual accessibility revisited: Implications for geographical analysis in the twenty-first century. *Geographical Analysis*, 35(4), 341-353.

Landis, B. W., Vattikuti, V. R., Ottenberg, R. M., McLeod, D. S., & Guttenplan, M. (2001). Modeling the roadside walking environment. *Transportation Research Record*, 1773, 82-88.

Lange, J. (2007). *Assessment of cycling as a mode of transportation in Tuscaloosa, AL* (Non-thesis paper). Available from the University of Alabama.

Larsen, J., & El-Geneidy, A. (2011). A travel behavior analysis of urban cycling facilities in Montreal Canada. *Transportation Research Part D*, 16, 172-177.

League of American Bicyclists. (2010). Bicycle Friendly Communities. Retrieved from http://www.bikeleague.org/programs/bicyclefriendlyamerica/communities

Lee, C., & Moudon, A.V. (2006). Correlates of walking for transportation or recreation purposes. *Journal of Physical Activity and Health*, 3(Suppl I), S77-S98.

Levinson, D. M. (1998). Accessibility and the journey to work. *Journal of Transport Geography*, 6(1), 11-21.

Line, T., Jain, J., & Lyons, G. (2011). The role of ICTs in everyday mobile lives. *Journal of Transport Geography*, 19(6), 1490-1499.

Locklar, A. (2011, April). SGA plans new exercise trails for fall semester. *The Crimson White*. Retrieved from http://cw.ua.edu/2011/04/07/sga-plans-new-exercise-trails-for-fall-semester

Massey, S. (2011). UA encourages bike registration. *The Crimson White*. Retrieved from http://cw.ua.edu/2011/07/13/ua-encourages-bike-registration

Moudon, A. V., Lee, C., Cheadle, A. D., Collier, C. W., Johnson, D., Schmid, T. L., & Weather, R. D. (2005). Cycling and the built environment, a U.S. perspective. *Transportation Research Part D*, 10, 245-261.

National Complete Streets Coalition. (2011). Complete Streets. Retrieved from http://www.completestreets.org/

National Highway Traffic Safety Administration. (2009). Traffic Safety Facts. Retrieved from http://www.nhtsa.gov

National Household Travel Survey. (2009). National Household Travel Survey. Retrieved from http://nhts.ornl.gov

Parkin, J., & Rotheram, J. (2010). Design speeds and acceleration characteristics of bicycle traffic for use in planning, design, and appraisal. *Transport Policy*, 17(5), 335-341.

Plaut, P.O. (2005). Non-motorized commuting in the US. *Transportation Research Part D*, 10, 347-356.

Price, M. (2009). Using 9.3 functionality and scripts. *ArcUser*, 12(1), 50-52. Retrieved from http://www.esri.com/news/arcuser/0109/winter2009.html

Rodriguez, J. P., Comtois, C., & Slack, B. (2009). *The Geography of Transport Systems*, London, UK: Routledge.

Rogalsky, J. (2010). The working poor and what GIS reveals about the possibilities of public transit. *Journal of Transport Geography*, 18(2), 226-237.

Rybarczyk, G., & Wu, C. (2010). Bicycle facility planning using GIS and multi-criteria decision analysis. *Applied Geography*, 30(2), 282-293.

Saelensminde, K. (2004). Cost-benefit analyses of walking and cycling track networks taking into account insecurity, health effects and external costs of motorized traffic. *Transportation Research Part A*, 38, 593-606.

Sallis, J. F., Bowles, H. R., Bauman, A., Ainsworth, B. E., Bull, F. C., Craig, C. L., . . . Bergman, P. (2009). Neighborhood environments and physical activity among adults in 11 countries. *American Journal of Preventive Medicine*, 36(6), 484-490.

Samimi, A., Mohammadian, A. K., & Madanizadeh, S. (2009). Effects of transportation and built environment on general health and obesity. *Transportation Research Part D*, 14, 67-71.

Schwanen, T. & Kwan, M.-P. (2008). The Internet, mobile phone and space-time constraints. *Geoforum*, 39(3), 1362-1377.

Stinson, M. A., & Bhat, C. R. (2003). Commuter bicyclist route choice. *Transportation Research Record*, 1828, 107-115.

Thompson, D. C., Rebolledo, V., Thompson, R. S., Kaufman, A., & Rivara, F. P. (1997). Bike speed measurements in a recreational population: validity of self-reported speed. *Injury Prevention*, 3(1), 43-45.

Tilahun, N. Y., Levinson, D. M., & Krizek., K. J. (2007). Trails, lanes, pr traffic: Valuing bicycle facilities with an adaptive stated preference survey. *Transportation Research Part A*, 41, 287-301.

Tolley, R. (1996). Green campuses: cutting the environmental cost of commuting. *Journal of Transport Geography*, 4(3), 213-217.

Tresidder, M. (2005). *Using GIS to measure connectivity: An exploration of issues*. School of Urban Studies and Planning, Portland State University. Retrieved from http://web.pdx.edu/~jdill/Tresidder_Using_GIS_to_Measure_Connectivity.pdf

Tuscaloosa Forward. (2012). Recovery Planning. Retrieved from http://tuscaloosaforward.com/recovery-planning/

University of Alabama. (2011). Office of Institutional Research & Assessment. Retrieved from http://oira.ua.edu/d

University of Alabama. (2007). Campus Master Plan, Draft Date: May 2007. Retrieved from http://www.uafacilities.ua.edu/planning/pages/master-plan/campus-master-plan-5-07-1.pdf

U.S. Census Bureau. (2011). American FactFinder. Retrieved from http://factfinder2.census.gov

U.S. Census Bureau. (2010). American Community Survey 2008-2010. Retrieved from http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_10_3YR_B08134&prodType=table

Virkler, M. R. & Balasubramanian, R. (1998). Flow characteristics on shared hiking/biking/jogging trails. *Transportation Research Record,* 1636, 43-46.

Vuori, I. M., Oja, P., & Paronen, O. (1994). Physically active commuting to work-testing its potential for exercise promotion. *Medicine and Science in Sports and Exercise,* 26(7), 844-850.

Wang, F. (2000). Modeling commuting patterns in Chicago in a GIS environment: A job accessibility perspective. *The Professional Geographer,* 52(1), 120-132.

West Alabama Regional Commission. (2008). *Tuscaloosa County Traffic Counts*. Retrieved from http://warc.info/index.php/transportation-planning/tuscaloosa-area-mpo/documents

West Alabama Regional Commission. (2007). *Tuscaloosa Are Bicycle and Pedestrian Plan 2007*. Retrieved from http://warc.info/index.php/transportation-planning/tuscaloosa-area-mpo/documents

Wei, H., Huang, J., & Wang, J. (1997, January). *Models for estimating traffic capacity on urban bicycle lanes*. Paper session presented at the Transportation Research Board Annual Meeting, Washington, D.C.

Wheatley, D., & Gillings, M. (2002). *Spatial Technology and Archaeology*, London, UK: Taylor & Francis.

Xing, Y., Handy, S. L., & Mokhtarian, P.L. (2010). Factors associated with proportions and miles of bicycling for transportation and recreation in six small US cities. *Transportation Research part D,* 15, 73-81.

Zacharias, J. (2001). Pedestrian behavior and perception in urban walking environments. *Journal of Planning Literature*, 16(3), 1-18.

Zahran, S., Brody, S. D., Maghelal, P., Prelog, A., & Lacy, M. (2008). Cycling and walking: Explaining the spatial distribution of healthy modes of transportation in the United States. *Transportation Research Part D*, 13, 462-470.

Zandbergen, P. A. (2008). A comparison of address point, parcel and street geocoding techniques. *Computers, Environment and Urban Systems*, 32(3), 214-232.

APPENDIX A – IRB Approval

Office for Research

Office of the Director of
Research Compliance

THE UNIVERSITY OF
ALABAMA
RESEARCH

June 14, 2011

Benjamin Lundberg
Dept. of Geography
College of Arts & Sciences
Box 870322

Re: IRB # 11-OR-198-ME "Accessibility and University Populations: Effects on Non-Motorized Transportation in the Tuscaloosa-Northport Area"

Dear Mr. Lundberg:

The University of Alabama Institutional Review Board has granted approval for your proposed research.

Your application has been given expedited approval according to 45 CFR part 46. You have also been granted the requested waiver of written documentation of informed consent for the online survey participants. Approval has been given under expedited review category 7 as outlined below:

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Your application will expire on June 13, 2012. If the study continues beyond that date, you must complete the IRB Renewal Application. If you modify the application, please complete the Modification of an Approved Protocol form. <u>Changes in this study cannot be initiated without IRB approval, except when necessary to eliminate apparent immediate hazards to participants</u>. When the study closes, please complete the Request for Study Closure form.

Should you need to submit any further correspondence regarding this application, please include the assigned IRB application number.

Good luck with your research.

Sincerely,

Carpantato T. Myles, MSM, CIM
Director & Research Compliance Officer
Office for Research Compliance
The University of Alabama

152 Rose Administration Building
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Tuscaloosa, Alabama 35487-0104
(205) 348-5152
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APPENDIX B – On-line Survey

Pedestrian and Bicycle Survey - Tuscaloosa Edit this survey

1.

This survey is intended to identify travel habits and characterize views on non-motorized accessibility of populations related to the University of Alabama.

The information collected will be used for a University of Alabama student's masters thesis entitled "Accessibility and University Populations: Effects on Non-Motorized Transportation in the Tuscaloosa-Northport Area."

The information gathered is confidential. No direct references will be made to individual names or email addresses. A summary of the results will be provided to any participant who makes a request. Please send any requests to: bjlundberg@crimson.ua.edu

1. What is your main mode of travel to the University of Alabama?

- Walk
- Bicycle
- Bus
- Car
- Other (please specify)

2. On a weekly basis, how often do you travel to the University of Alabama?

- 1-3 times
- 4-5 times
- 6-7 times
- 8-10 times
- +10 times
- Never

Other (please specify)

3. Do you own a bicycle?

- Yes
- No

4. If you own a bicycle, how often do you use it?

- Daily
- Weekly
- Monthly
- Yearly
- Never

Other (please specify)

5. Does the current Code of Alabama make it illegal to ride a bicycle on a sidewalk?

- Yes
- No
- I don't know

6. How many cars are in your household?

- 0
- 1
- 2
- 3
- 4
- 5+

7. How far do you live (in miles) from the University of Alabama's campus?

8. In the Tuscaloosa area, you find Walking to be: (please mark all that apply)

- Safe
- Convenient
- Efficient
- Low-cost travel
- Healthy travel
- Respected by motorists
- None of the above

Other (please specify)

9. Do you find pedestrian infrastructure (e.g. sidewalks) to be adequate in the Tuscaloosa area?

Strongly disagree | Disagree | Undecided | Agree | Strongly agree

10. In your opinion, what improvements or additions does the pedestrian network need in the Tuscaloosa area?

11. When traveling to the University of Alabama, would improvements or additions to the pedestrian network in your area increase your use of non-motorized travel?

- Yes
- No
- Undecided

12. In the Tuscaloosa area, you find Bicycling to be: (please mark all that apply)

- ☐ Safe
- ☐ Convenient
- ☐ Efficient
- ☐ Low-cost travel
- ☐ Healthy travel
- ☐ Respected by motorists
- ☐ None of the above

Other (please specify)

13. Do you find bicycle infrastructure (e.g. bike lanes) to be adequate in the Tuscaloosa area?

○ Strongly disagree ○ Disagree ○ Undecided ○ Agree ○ Strongly agree

14. In your opinion, what improvements or additions does the bicycle network need in the Tuscaloosa area?

15. When traveling to the University of Alabama, would improvements or additions to the bicycle network in your area increase your use of non-motorized travel?

- ○ Yes
- ○ No
- ○ Undecided

16. What is your sex?

- ○ Female
- ○ Male

17. What is your age?

18. What is your marital status?

- ○ Married
- ○ Not Married

19. Do you currently rent or own your home?

- ○ Own
- ○ Rent

20. What is your status at the University of Alabama?

○ Freshman ○ Sophomore ○ Junior ○ Senior ○ Graduate ○ Employee

Done

APPENDIX C – Survey results from the open-ended questions

Q10. In your opinion, what improvements or additions does the pedestrian network need in the Tuscaloosa area?

1. More sidewalks.
2. More jaywalking punishments, and when it says don't walk have fines for people who walk when it says not too.
3. Make all sidewalks wide like the one along University Blvd.
4. Wider sidewalks
5. Better accessibility for bicycles.
6. Pedestrian bridges in highly transited streets or avenues, i.g. 15st or McFarland Blvd.
7. Most of the sidewalks outside, but around campus are in complete and total disarray. If someone was in a wheelchair, travel on them would be pretty much impossible.
8. More sidewalks
9. At least 80% of Tuscaloosa does not have sidewalks, so constructing more and making the city as a whole safer would be nice.
10. More sidewalks and sidewalk repairs - sidewalks that end with few or no options to continue are a problem - same for bike lanes
11. Pedestrian bridges over multi-lane roads and highways
12. A walking bridge over the train tracks
13. Better sidewalks
14. More sidewalks, especially on main roads that lead towards campus. Would be nice to have a sidewalk on BOTH sides of the road
15. A pedestrian bridge crossing 15th street needs to happen for all of the people that live in Forest Lake.
16. Sidewalks on both sides of the road down Hackberry Rd.
17. Crosswalks are so few and far between that jay walking is encouraged.
18. More sidewalks and crosswalks
19. Here are some gaps between sidewalks and road. So it's difficult to ride a bike on the sidewalks all the time.
20. Bigger sidewalks, and ramps.
21. More respect from the, largely, uneducated, drivers that rush Willy nilly through streets in hopes of getting to their destination faster.
22. Street lights, bike lanes, stronger pedestrian rights safety
23. More sidewalks
24. MORE CATWALKS, MORE SIDEWALKS.
25. It would be nice if there was a sidewalk from Mars Spring Road (campus) to River Road Park on the Black Warrior River. Someone will, sadly, sooner or later, get hit by a car there.
26. More sidewalks on busy roads
27. Sidewalks in older neighborhoods tend to be uneven or crumbling.
28. Widen the sidewalks in certain areas.
29. Fix some badly broken / bumpy sidewalks
30. Red lights in high-traffic areas such as the large crosswalk coming off the Ferg plaza--it is VERY difficult to get across when you are in a car, as pedestrians do not ever allow cars through, it is dangerous for them too because cars have to try and find a break and fly through gaps
31. Sidewalks all the way up and down 15th street. I want to buy a bike to ride to class, but there are large sections without sidewalks, and since it is such a busy road, I am afraid to walk/ride a bike to campus.
32. More crosswalks that REQUIRE motorists to stop, more sidewalks in general.

33. They need to be updated and re-done. There are also places where sidewalks just end and you have to walk on the grass or street.
34. Accessibility needs to be improved at intersections; cars around student housing frequently blocks sidewalks; sidewalks need to be wider
35. There are some areas where crosswalks have been removed and it is more difficult and inconvenient for pedestrians to get where they need to go.
36. On Caplewood Drive- the infrastructure between me and campus is fine. The suburban neighborhoods put pedestrians on the street, an abysmal situation and indicative of the excessive influence of the developers in this town.
37. More GOOD sidewalks, with curb cuts, regular grass-cutting and edging, lighting, signage, etc.
38. You must be kidding. Go drive around Tuscaloosa and count how many people you see crossing multiple lanes of traffic on foot, walking in the street where there is no sidewalk, etc. etc. etc.
39. If we could actually have sidewalks in both sides of the street and crosswalks at red lights....particularly the 15th Street/Hackberry intersection. Sidewalks down 15th street would be nice as well.
40. There needs to be more ADA compliancy. Lots of sidewalks lack handicap ramps, and some are not wide enough. However, for the most part, the infrastructure is fine for walking. Tuscaloosa needs more bike lanes/paths in general though
41. More trees for shading would be nice but bicycle lanes are a must!
42. Place less emphasis on cars, better crossings
43. More sidewalks on smaller roads (avenues, streets, etc.) as well as more crosswalks and crosswalk signs for major roads (McFarland and Skyland Blvd.)
44. Repairs in downtown area. Greater access to sidewalks along University Boulevard. Improved sidewalks between University Boulevard and 15th street.
45. More comprehensive and undamaged sidewalks as well as crosswalks and walking paths/trails.
46. More sidewalks that avoid traffic, eg., are not immediately adjacent to busy roads. Most of commercial Tuscaloosa is built as a series of separate "islands" that are made to be navigated by car without any thought given to other modes of transportation. How would one walk from Midtown to Univ Mall, for instance? Sidewalks, such as they are, are discontinuous and not attractive to pedestrians.
47. More sidewalks and safer means of crossing major roads like 15th and Paul Bryant. Many cars will ignore crosswalks that are not at an intersection, so it is very dangerous and unnecessary to use crosswalks.
48. I don't have any.
49. Bike lanes, better public transit options
50. More bike paths, more sidewalks and more information given to inform people of the laws and regulations regarding pedestrian and bike travel example: 3 feet rule for those riding their bike on the road
51. More sidewalks, crosswalks, educated motorists
52. Add ramps to the curbs. Plenty have them, but there are plenty that don't. They abruptly drop off over the curb and this is a problem and potentially dangerous for people in wheel chairs, on bikes, pushing strollers, or toting rolling loads.
53. More sidewalk lighting
54. More crosswalks
55. More sidewalks.
56. More driver education on the safety and welfare of pedestrians. Also, more education to pedestrians that just because they have the right of way in some instances they may still want to make sure that the 4000+ lb vehicle will stop for them.
57. More crosswalks
58. Sidewalks mandated in new construction areas
59. They are pretty good as is
60. Nothing
61. More routes, better marking, public awareness campaigns

62. People do not stop when pedestrians are crossing the road. There needs to STOP sign at certain places where one cannot see if there is any vehicle coming from the either side, as many cars are parked in the view of sight.
63. More sidewalks
64. Continuous sidewalks through main areas of town in addition to bike lanes.
65. Undoubtedly, adequate sidewalks within the Tuscaloosa city area.
66. Needs to be better suited for all communities not just near the University or student population.
67. Sidewalks, crosswalks, and bridges [US 82 etc...]
68. There are many places where sidewalks could be added or improved.
69. More sidewalks and walking paths.
70. More bike lanes and sidewalk lights
71. Look first at the most dangerous intersections: 15th and McFarland, or Mid-town Village and McFarland for examples. The lights do not take into account a bicycle--I have often waited for a green light for ages until a car comes.....--or a walker--the light often turns while I am still in the middle of the street...
72. Need More
73. More crosswalks, more sidewalks in general, larger sidewalks
74. Bike lanes and pedestrian walkways, specifically on 15th Street and Hargrove. It is so dangerous to ride a bike. I only live one mile from campus, but am terrified to ride a bike or walk.
75. Sidewalks (with cross walks connecting when the sidewalks change from sides of street, and continuous sidewalks; crosswalks at intersections with lights, cross walk across McFarland (especially, from snow Hinton park/ mall, Bruno’s mall to other side)
76. More cross walks, especially over 15th street (Near hackberry) More sidewalks. Also, how about pedestrian flyovers/walkways over parts of 15th and especially McFarland connecting the shopping areas with Snow Hinton Park?
77. More sidewalks
78. More roads with sidewalks and trees.
79. Easier access to shaded pedestrian network. UA did not think of pedestrians when opening the new road from the campus to Jack Warner Pkwy.
80. The Woolsey Finnel Bridge, where McFarland Blvd crosses the river, is impossible to cross on foot or bicycle. That is why I do not own a bicycle: even though I could easily ride it downtown in a few minutes, I cannot cross the river. It would add about two miles for me to bike down to Lurleen Wallace.
81. Sidewalks need to be added in many places. Existing sidewalks need to be maintained. There are too many cracks, bumps, uneven paving, and other poor maintenance.
82. More and better links between the Midtown Shopping area and campus, specifically along Edward Hillard Drive.
83. More sidewalks all over town! More bicycle lanes too--drivers are not too friendly with the cyclists.
84. More sidewalks are needed. I often have to walk in the street which is dangerous.
85. More interconnectivity of pedestrian corridors.
86. More and better crosswalks, road signs for pedestrians ("share the road", etc.), more sidewalks around shopping locations
87. More walking/biking paths. More sidewalks in the neighborhoods.
88. Improvements needed to safely cross bridges
89. Many locations are not connected by sidewalks
90. The first is better public transportation, so that I can get close to a destination and then walk. Also better and more sidewalks.
91. More sidewalks, more crosswalks
92. No sidewalks by most main streets (eg, McFarland, Rice Mine Rd, Northridge Road) and bridges (eg, the Finnell Bridge over the river).
93. More sidewalks; walking trails
94. Sidewalks, pedestrian bridges, lighting

95. More sidewalks and lighting
96. Bike lanes and more sidewalks
97. Crosswalks and sidewalks to make walking possible and safe.
98. Sidewalks would be a good starting point.
99. Bicycle lanes on 15th and McFarland, and sidewalks on both streets that are protected with metal poles in case of a car having a wreck, and a much safer way of crossing 15th
100. Perhaps more sidewalks or crosswalks in the area in safe & appropriate places.
101. Safety
102. While walking is healthy it is not safe and certainly not a mode of transportation respected, convenient, efficient, or safe. It is certainly not viable and motorists, law enforcement, and the university do nothing to promote it.
103. I think drivers need to be more aware of walkers. I also think that pedestrians need to use crosswalks.
104. For one thing, I can't get to the park that's right behind my house, because the mall and the Target roads are not connected. The sidewalks down Kicker don't go all the way down the road. There is no safe place to walk anywhere near my house without driving there first. To get to campus, I would have to cross University and Veteran's.
105. More sidewalks, especially in high traffic areas.
106. Students need to be trained that a no-cross sign is dangerous to cross the road and bicyclists should get tickets if in the middle of the fast lane of a 4 lane road. It is extremely dangerous and at some point I fear a student is going to get hit by a car.
107. More residential/business area blending to allow for pedestrian travel to and from work, we're currently very divided which has positives and negatives, however in regards to pedestrian travel, it would be considered a negative.
108. Sidewalk repair
109. I'd like to see stoplights that actually change soon after a pedestrian presses the crosswalk button. I honestly don't believe those buttons do anything at all, because I'll press one several times and the light won't change, even when no cars are coming.
110. The very best outcome of your study, in my opinion, would be some pedestrian bridges or tunnels to allow passage over/under 15th Street and McFarland Blvd.
111. More sidewalks, and sidewalk improvements where sidewalks are not up to par.
112. Lighted sidewalks and crosswalks
113. We need to have much more sidewalks and sidewalk crossings with traffic lights in the area.
114. On Rice Mine Rd. between McFarland and Highway 69 there needs to be sidewalks where there currently aren't. Also there needs to be a more pedestrian friendly way to travel from Northport into Tuscaloosa. Perhaps a suspension bridge that crosses the river to Queen City Park or to the Park at Manderson Landing.
115. More access to downtown
116. Sidewalks need to be replaced. Branches need to be trimmed. Areas need to be better lit. More ramps should be put in--try crossing street at 15th Street and Hackberry! The only good thing is that the cross-walk buttons actually work in this town.
117. Protected walking areas over all bridges; sidewalks in all residential areas;
118. I have never see a city with so few sidewalks ever! Even on campus there are streets with no sidewalks or sidewalks only on one side.
119. Connected sidewalks, wider paths
120. Thought needs to be given to how to facilitate pedestrian crossing at busy intersections. For example, pedestrian cross-overs (above the street) or "scramble lights" (where traffic in all 4 directions stops to allow for pedestrians only to cross) may provide solutions that enhance safety and traffic flow.
121. It needs to be safer to cross 15th street.
122. Covered walkways, not having to worry about getting hit by a bike or car
123. Bike/moped routes, or other alternate modes of transportation besides buses, which just clog up the roads as it is.

124. 1. Completed walkways without having to switch sides of a road or areas that do not have walkways at all. 2. Better access across several bridges and safe travel across several major thoroughfares
125. More sidewalks.
126. More sidewalks
127. There are gaps where the sidewalk ends and the picks up much later. They are poorly maintained in some areas.
128. Many more sidewalks, and sidewalks that don't just end!
129. I think some areas are excellent--others are NOT.
130. Improvement in sidewalks and other designated walking paths.
131. More sidewalks or RUNNING PATHS
132. Cleaner Pedestrian/Bicycles-Ways (On my way over the bridge it is unbelievable dirty and risky to drive!) Traffic lights for pedestrians in between Midtown Mall and University Mall
133. They need more lighting to make sure that sidewalks and areas are safe to walk along.
134. Most of the sidewalks when they do exist are uneven. There is not even a full sidewalk running from McFarland on 15th Street to campus if one wanted to walk. The sidewalks are not contiguous or even continuous in most places. The sidewalks and are often broken up in a way that does not make sense to a pedestrian.
135. Larger sidewalks and more crosswalks are required.
136. More sidewalks especially in neighborhoods, better streetscapes in neighborhoods, sidewalks that connect various sections of town
137. Bike paths and better walking options
138. Pedestrians need more sidewalks. Maybe even a skywalk or two on busy roads like McFarland Blvd.
139. More sidewalks or bike lanes
140. Better access and safety across main thoroughfares
141. More sidewalks and alternative walking routes. One or more walking/bike bridges over the Warrior River would make those living north of the river able to give more consideration to biking to work.
142. Sidewalks/ safe means of crossing busy streets (i.e. McFarland near shopping and restaurants)
143. Sidewalks that aren’t broke as shit.
144. There is a need for more sidewalks. In my neighborhood, there are no sidewalks. People have to walk in the street.
145. More consistent sidewalks up and down 15th St.
146. Safer walking access to places of interest NOT connected to University Blvd. Getting around the community is impossibly difficult without a car--multiple challenges exist, including: aggression/negligence of drivers (especially true if one must cross 15th street or other high traffic areas); distance between places of interest/utility; lack of safe sidewalks in many areas. For more people to walk, it frankly must be much safer, more accessible, and involve some sense of community (expanding pedestrian gathering areas/parks/restaurant areas to encourage rather than discourage walking, etc. etc.).
147. On campus there are plenty of sidewalks. Downtown and the neighborhoods surrounding campus are ok, but could use more sidewalks and sidewalk repair. Outside of those areas, the pedestrian infrastructure is pretty much nonexistent, especially with regard to safe crosswalks. More bike lanes are needed everywhere, including campus. Also, more shade trees along sidewalks would be super.
148. More sidewalks on Hargrove. Bike lanes to make the sidewalks safer. More crosswalks.
149. More tree-lined sidewalks.
150. More push buttons at traffic lights to allow safe crossing.
151. Smarter pedestrians
152. Needs to connect to UAs campus in multiple locations. Sidewalks need to be wide enough for cyclists and walkers.
153. Maybe more sidewalks within the city itself. I ride my bike much more often than I walk though.
154. More complete sidewalk network
155. Sidewalk or walkways over the bridges so walking or riding a bicycle would be safe.
156. There need to be better sidewalks and pedestrian areas in high volume areas

157. More sidewalks
158. Better lighting for night travel. Pedestrian bridges at high traffic or large intersections. More, better, and bigger sidewalks.
159. City-wide bike paths/lanes; city-wide walking paths/greenways with connective walking paths; The Riverwalk is a good start, but definitely not adequate for the size of Tuscaloosa
160. More sidewalks in addition to street crossovers where crossing is a potential hazard-Specifically over multiple lanes of traffic.
161. 1) Bridges over major roles. 2) Cheap long-distance public transit (buses) 3) Clearly marked stops for public transit areas 4) Parking Close to Buildings for Bicycles and Fuel-Efficient Vehicles 5) Better Lighting / More Blue-Lights on Campus and in the nearby areas.
162. Repairs to broken or worn-down areas of sidewalks.
163. I live less than a mile from a grocery store and shopping centers, but the sidewalks are unkept and crossing McFarland is unsafe, so I don't feel I can walk, even though I would prefer to walk.
164. Sidewalks that do not just end abruptly
165. Sidewalks available on both sides of main roads- McFarland, 15th St., University-to Alberta City on Univ. Blvd., etc.
166. Add sidewalks on both sides of the road and make them the most efficient route to a destination. Landscaping is pretty, but people will walk straight across a grassy knoll rather than take the sidewalk around it.
167. Bridges over 15t, more crosswalks
168. Better ways to cross major roads such as McFarland Boulevard, ideally pedestrian bridges over those.
169. More sidewalks, pedestrian overpasses and crosswalks through major thoroughfares
170. There need to be more sidewalks, and existing sidewalks need to be of more even quality. There also need to be wheelchair ramps at every intersection (especially at busy intersections such as 10th Ave and 15th St).
171. Pedestrian overpasses over busy streets, better traffic lights with pedestrian only travel, more sidewalks!!!! MORE buses!!! I would LOVE to take a bus to work. Hargrove to Hackberry through campus would be a huge step forward. Please, please, let's make these changes.
172. More and continuous sidewalks
173. Tuscaloosa needs more sidewalks along the major roads such as 15th Street and McFarland Boulevard. I live just off of 15th Street and cannot ride my bike from my house to the University Campus due to lack of sidewalks.
174. It needs to be established
175. Safe, wide, continuous sidewalks. Safe ways to cross streets such as 15th.
176. Sidewalks! Get rid of McFarland
177. Better crosswalks, crossover bridges
178. More sidewalks; greater promotion of pedestrian rights outside the UA campus community; city officials could promote/encourage walking as a form of transportation--however, the city's infrastructure would need to reflect that as well.
179. Sidewalks, crosswalks, lighting
180. There are hardly any sidewalks. Pedestrian crossings are non-existent. Crossing McFarland, for example, puts one’s life in danger.
181. Sidewalks or bike paths. Also a safe way to get over the river and to the university
182. Safer crossing areas, enforcement of keeping bikes off of sidewalks.
183. There need to be sidewalks on major roads such as Jack Warner and McFarland, as well as on the bridges crossing over into Northport.
184. The midtown area (McFarland/15th to McFarland/Skyland) is not easy or safe to walk down.
185. I sold my bike and felt I needed a car in Tuscaloosa. I live near the Home Depot and when I attempted to walk to campus, I was confronted with a busy intersection (McFarland / 15th) that has NO crosswalks and NO walk signals. In order for me to feel safe, I walked south on McFarland, "jaywalked"

across the northbound lanes to the safety of the grassy median, then jaywalked to the opposite side of McFarland, across the south-travelling lanes, then double-backed towards 15th again only to find crossing 15th is even more threatening. Pre-tornado, I walked down Hilliard, but when I got to the railroad tracks there was no protected walking space across the tracks. So, I bought a car.
186. Around the campus, there are gaps which make it inaccessible by bike
187. While campus strives for improving pedestrian and cycling infrastructure the city should extend these into the neighboring areas of campus
188. Crosswalks over main intersections...such University Blvd & 15th street, bike lanes on streets such as 15th street, Hackberry, 10th avenue, Hwy 82
189. More sidewalks and paved walking trails between neighborhoods.
190. Better sidewalks, pedestrian crosswalks, and pedestrian bridges
191. More defined cross walks; cross walk signals
192. Limit the amount of bicycle activity on the sidewalks.
193. Tuscaloosa and Northport should work together to create a walking environment where one can travel from one side of the river to the other better. A great example of this would be something like the pedestrian bridge in Chattanooga. People that live on the Northport side of the river can then travel over to Tuscaloosa without the danger of walking or biking on a major highway.
194. More complete sidewalks along 15th, and also on the jack warner parkway.
195. More consistent sidewalks -- both sides of Hargrove (between 10th and Hackberry), for example.
196. More sidewalks and eliminating bicycles from sidewalks.
197. The problem is the people who are driving. I run around campus and no one will yield to runners, even when they are supposed to. You really have to be careful.
198. Cars should not park across sidewalks. Sprinklers should not water pedestrians on sidewalks. Ideally, sidewalks should not become flooded and impassable after rain.
199. Improved lighting, sidewalks and bicycling lanes throughout the town
200. More sidewalks
201. More crosswalk signals and signs alerting motorists of who has the right of way
202. More, wider, better (level, even) sidewalks - separate area for bikers - tree lined
203. More sidewalks. There is not one on sections of 15th which is horrible.
204. Lots more sidewalks & easier ways to get across the street. over passes are an option in some locations. walking is only o.k. around UA - not o.k. or safe most other places.
205. We need more sidewalks in the business areas away from downtown, and we need more safe crossings for busy intersections.
206. More interconnections
207. Sidewalks need to exist. Bike lanes. Signs for cars to yield.
208. Crosswalks at major intersections
209. Sidewalks, cross walk lights, and drivers who pay attention.
210. Sidewalks that are continuous, not partial and that switch from one side of the road to the other. Designated cross walk signs and areas at major intersection. (Examples: Hargrove and McFarland and McFarland and 15th.)
211. More sidewalks
212. The city is desperate for a full network of sidewalks and crosswalks in neighborhoods and major intersections. A matrix that doesn't allow pedestrians to cross (or bridge) McFarland and 15th safely will be incomplete and a waste.
213. Easier access for students not in the university quadrant (bounded by 15th Street, McFarland, Lurleen Wallace and the Black Warrior River) to walk or bike to campus. Perhaps a bypass pedestrian path, like an overpass bridge.
214. Sidewalks, bike lanes, neighborhood stores
215. Sidewalks going from 15th into the University and bridges built over the railroad tracks to reduce traffic.

216. Pedestrian bridges over busy streets longer green lights for pedestrians crossing busy streets Pedestrian bridge/path over McFarland
217. Walk/Don't Walk lights with frequent enough "Walks" so people don't run out into traffic.
218. More of the major roads, such as Hargrove and 15th Street need sidewalks and some of the existing sidewalks need to be resurfaced (i.e., 10th Ave) because of cracking and folding.
219. More sidewalks, easier ways to cross bridges and highways safely as pedestrians.
220. Not sure
221. I can't think of any.
222. Not all the roads have sidewalks
223. Sidewalks, only few areas have them
224. Around campus, there are plenty of sidewalks. I wish there were more "walking trails" and/or sidewalks in the Tuscaloosa area. I live on Kicker Road and there are no sidewalks near me, which is very inconvenient. I think more walking trails would be beneficial to Tuscaloosa
225. The vast majority of sidewalks in Tuscaloosa are missing or inadequate. Many streets near campus do not have sidewalks, or the sidewalks are unsafe because they have many bumps, holes, or uneven surfaces that are tripping hazards. Worse than that, the sidewalks often have a very high curb that is not wheelchair accessible, and thus also not a viable alternative to our non-existent bike paths because the huge curbs, which should be level with the street but are not, make it nearly impossible for a wheelchair or a bicycle to roll up over the hump and onto the sidewalk.
226. N/A
227. The sidewalks are decent around the University, but I live right off of Hargrove, and there is no sidewalk on either side of the street for much of Hargrove. People drive fairly fast on this road, so while I could easily walk to nearby businesses, I rarely do because there is no sidewalk. I would also enjoy walking for exercise, but I don't feel it is safe to do so without a sidewalk.
228. Difficult crossing (Warner) River Rd.
229. More sidewalks
230. There are no safe sidewalks on 10th on the other side of the rail road tracks. It would not be safe at all for me to walk from my apartment to school. I park on campus and walk to class from there.
231. Pedestrian bridges over major roadways. Sidewalks or bicycle lanes in residential areas
232. Sidewalks, street lights, and pathways not adjacent to road ways where we breathe exhaust fumes.
233. Enclosed sidewalks and pedestrian areas especially crossing the river and along both sides of the river from the entire length of the river. More sidewalks and bike lanes and less racism
234. Legal mandate the all new developments must have sidewalks. Add sidewalks to existing areas where they're lacking.
235. Broad and shaded sidewalks (of the kind that were built downtown over the last few years). Because of where I live (The Highlands) I would like to see sidewalks along Helen Keller Blvd., as well as a safer way to cross University near DCH.
236. I don't know
237. More crosswalks and sidewalks, maybe bridges to cross busy roads. The city seems to be built for cars though so it probably wouldn't be worthwhile.
238. More connective sidewalks. Sidewalks will switch across busy thoroughfares with no crosswalks or safe walking area.
239. More sidewalks and more options for crossing busy multi-lane roads.
240. More of them, and more signage informing drivers of the need to share the road.
241. More sidewalks with crossings at lights
242. More sidewalks and crosswalks. Bridges for foot traffic only spanning busy intersections
243. Needs a comprehensive union from neighborhood to neighborhood. A safer and more accessible structure needs to run parallel to the McFarland Bridge over the river into town from North River.
244. More cross walks, correctly timed cross outside of UA campus, law enforcement adhering to the laws of pedestrians
245. Additional sidewalks

246. The pedestrian network is set up as a destination activity---you drive to a park and walk around. Infrastructure is needed to allow pedestrians to use walking as a mode of transportation.
247. Bigger sidewalks so people that are coming and going can walk without having to move off the sidewalk make sure there is a bike lane so I don't have to move off the sidewalk for bikes
248. Stop jaywalkers!
249. We need to find a way around the intermingling of pedestrians and traffic at intersections. It's dangerous for pedestrians and a hug inconvenience for drivers. Also, there are many areas where a pedestrian is forced into the street by lack of sidewalks surrounding outlying areas of campus.
250. Sidewalks
251. More crosswalks so people don't jump out to cross and you aren't expecting it
252. More sidewalks, more convenient crosswalks, more punishment of drivers who fail to stop at crosswalks
253. More safe options. The Riverwalk is FANTASTIC but it seems to be the only pedestrian friendly area in town (other than immediately downtown)
254. More bike lanes would be nice on the more congested roads such as McFarland or Veterans Memorial. Bikers feel unsafe and end up on the sidewalk on Veterans, which is unsafe for pedestrians.
255. Marked crosswalks.
256. Sidewalks and bikeways are strongly desired.
257. Better community bus service (Tuscaloosa Trolley, etc.), which can help make more walking possible; Better crosswalks (as it is very difficult to cross some large intersections in the city, such as on McFarland Blvd).
258. Sidewalks, pedestrian lights, restriction of right turn on red for cars
259. More sidewalks, safer crossings e.g. 15th Street
260. More sidewalks along major thorough fares with room to walk without fear of getting hit by cars or other vehicles; better traffic control for pedestrians
261. There needs to be sidewalks on every street and bicycles should be allowed on them. The corners of the streets should have the ramps instead of curbs.
262. More sidewalks!
263. We need crosswalks at big intersections. I saw someone try to cross McFarland Blvd. yesterday to get to the Mall -- that's taking your life in your hands. We also need more trees to make walking pleasant. It goes without saying that sidewalks everywhere would be a huge improvement.
264. More sidewalks everywhere except campus proper.
265. Lights along all sidewalks
266. More wide spread.
267. Walk overs at rail road crossings on Hillard Drive and 10th Ave and the intersection of McCorvey and Paul Bryant Drive.
268. Bike lanes on main roads.
269. Much better street lighting, much better connections among sidewalks from street to street and neighborhood to neighborhood.
270. More sidewalks and more cross walks
271. Sidewalks need to be consistent in size and shape and with drop-offs and upswings across streets, for the differently-abled. Sidewalks need to be EVERYWHERE.
272. More sidewalks, bike lanes, buses would reduce the need to drive everywhere
273. Better Lighting
274. Sidewalks in some areas are uneven making walking more difficult
275. Sidewalks need to be repaired in the downtown area and to be constructed in business districts like McFarland Boulevard.
276. Some of the sidewalks in neighborhoods around campus and cracked and uneven which makes them very difficult to walk on at night. Additionally, many areas are lacking sidewalks all together. There are also areas that are surrounded by sidewalks yet are not linked by an area with sidewalks.
277. More sidewalks, bigger sidewalks, improved sidewalks

278. Need to build more sideways and if necessary pedestrian bridge in outer area of UA. i.e. highways and wide streets.
279. More bike paths that don't just run out putting you on a dangerous street
280. There needs to be more sidewalks everywhere. I live not 2 miles from my old high school, yet I couldn't walk to my high school because there were no sidewalks from my house to the school.
281. More / better repaired sidewalks
282. More crossing lights for pedestrians
283. Limit vehicular traffic on campus
284. More sidewalks and better upkeep of the sidewalks that do exist. Many more pedestrian crossings, and motorists need to respect the right of way in the crosswalk.
285. An increase in the number of safe sidewalks outside of the campus area would be a nice start.
286. Sidewalks on both sides of the street and more crosswalks
287. The Tuscaloosa area would have a shot at actually being a "sustainable" and "go green" city if it offered safer pedestrian usability. There are people running across McFarland Blvd because there isn't another way to get to Snow Hinton Park. It's pitiful. There are students who have to drive ONE mile to campus in a car, because it’s not safe to walk or bike. Things need to change.
288. More sidewalks and crosswalks, better-planned sidewalks and crosswalks that accommodate walking paths.

Q14. In your opinion, what improvements or additions does the bicycle network need in the Tuscaloosa area?

1. A bike lane on the road that connects Jack Warner Pkwy from River Road Park to Mars Spring Road would make things safer. There's currently nowhere to walk, and biking is risky because the road is narrow in this high traffic area by the new dorm's parking structure. More places to lock a bike near Alston and Bidgood Hall would be an improvement.
2. More bike lanes and bike paths - the old rail bed would make a great bike path from downtown to the university
3. Less rednecks trying to kill you in their trucks
4. Bicyclists need to be more aware that they are supposed to follow all traffic laws and then adhere to them. When they ignore stop signs and red lights they are breaking the law and infuriating drivers. I would be less annoyed with bicyclists if they didn't ride their bike like crazy people. I'm also sick of almost getting hit by bikes when I am walking to and from class.
5. Bicyclists need bike lanes.
6. More clearly marked bike lines, more advertised rules for bike travel (always on sidewalks) - articles in CW and signage...Do buses on campus even have bike racks?
7. More bike lanes.
8. More bike paths
9. Bike paths and lanes
10. More, safe bike lanes. It is BS we have to share a bike lane on campus with buses, and the lanes are limited, in terms of number, at best. In addition, on game weekends, everyone uses the bike lanes as unloading zones. I have pictures on my cell phone of numerous vehicles parked in the bike lane. From what I understand, in a pedestrian zone on campus (e.g., sidewalk), we are supposed to walk our bikes. I agree, but they need to make more bike lanes and restrict their use to bikes. Finally, they need more bike lanes throughout the city. I have almost been hit several times by motorists not paying attention on a street without a bike lane.
11. To have a system of bike lanes that covers a large part of the city

12. Have a network, even on campus, bike lanes exist only in parts, you bike, and suddenly there is no more bike lane, in front of the theater towards ten hoot is one example, at high traffic time it is dangerous. And motorists have to be educated that riding a bicycle IS a mode of transportation, not just recreational.
13. EDUCATION!!! Most of the campus's bicyclists do NOT know how to properly ride their bikes in accordance with current laws. They ride on sidewalks, run stop signs, etc. It is dangerous for themselves, as well as others around them. Just this morning, two cars (mine and another) nearly ran into a bicyclist when he ran a stop sign at full speed. I think it's ironic that student bicyclists are demanding to be taken seriously, when most aren't taking current laws seriously and with a sense of maturity.
14. We need more bike lanes and paths interconnecting through the city. We have a dysfunctional car culture in Tuscaloosa. I would like to bike to work, but feel that it would be unsafe to.
15. Bike lanes or wider sidewalks
16. More lanes; public awareness campaigns; better marking
17. There should be dedicated bicycle lanes serving all major centers where bicyclists are likely to use them. Especially important in campus areas.
18. People that ride bicycles do not understand that you are supposed to ride on the street and may attention to traffic laws. I have seen and/or heard of many accidents involving bicycles.
19. Ramps at road crossings (ADA law and for bikes!), Bikes lanes that serve campus! We have a parking crisis on campus with non-helpful shuttle options and almost no safe bike routes. Recipe for frustration or injury... We rode to the football game last weekend and it was an adventure even without tornado-damaged roads. No clear lanes, no way to cross McFarland, no lanes or sense of the best bike route (even if it's not the most direct). Awful.
20. More dedicated paths, more awareness from drivers
21. More bike lanes. Bike lanes that are continuous and that do not abruptly end.
22. More bike lanes and a more direct and safer route from Northport to campus. A pedestrian/bike bridge.
23. Do not own a bicycle
24. Since I don't ride a bike I really can't say.
25. The railroad crossing on Hackberry is especially treacherous for bikers... need a good bike lane along here as it a main artery into the campus. The drivers fly down this road. How about some speed bumps.
26. Large, safe, clearly marked bicycle paths should be added to the entire downtown core and all the streets around campus. It is extremely unsafe to ride a bicycle to campus in this town because motorists not only lack respect but are outright aggressive towards people on bicycles. I live less than a mile from campus, yet even in travelling that short distance I have often been yelled at by passing motorists, told to ride on the sidewalk because the cars and the large, environmentally unfriendly SUV's, often driven by frat boys, seem to think that they own the entire road. In the area immediately close to campus, on a small, quiet side street, I have on multiple occasions been shot at with a water gun by bands of roving frat boys in large SUV's simply for riding my bike down a small, quiet street rather than on the sidewalk, which is inaccessible to bicycles anyway. The town and university need to improve the infrastructure, and they also need to undertake a *massive* public education campaign to better inform motorists that they do not in fact own the road.
27. Bike paths, efforts to change mindset of drivers to respect bicyclists and share the road with them
28. Bike access across river
29. Bike lanes need to be added to new roads. Other safety measures such as sharrows should be incorporated which help both bicyclists and motorists become more aware of each other.
30. I'm not sure. I've never lived in a city where this was true.
31. Bike lines need to be prevalent and unobstructed. It's a major lapse of judgment for the U to allow vehicles to park in bike lines almost constantly; of course, game days are some of the most blatant uses of bike lines for non-bikes.
32. More bicycle lanes should be constructed. Considering the inconvenience of congestion, the rising price of fuel, and a growing concern for the environment, it is inconceivable that the city would not move forward in making bicycle transportation safer and more convenient.

33. Addition of consistent bike lanes on both sides of the road. An actual accommodation for them; not just squeezing them in wherever convenient and allowing them to end randomly. It seems like bicyclists are treated much more as a nuisance to be put up with by even the city, rather than respected and allowable operators on the roads.
34. Clearly marked bike lanes and public education about rights of way, turning, etc.--for cyclists and for autos.
35. Need more of it, and more continuous safe routes.
36. increased police activity on 8th St/Gene Stallings, etc
37. More bike lanes especially across the river. More closed bike lanes on all major roads (jack warner from the jw bridge to the amphitheater, on McFarland and Lurlene Wallace, and on university and 15th from five points to still man college
38. More bike racks, better paths that connect every area on campus
39. Bike lanes, educate the public, motorists
40. Is there a bicycle network - have one to begin with - areas just for bicycles
41. Bike lanes need to be added
42. Bike infrastructure is worse than pedestrian infrastructure. Shocking bad is the bike infrastructure. the university put some bike lanes on campus but they are utterly disconnected to the off-campus infrastructure and hence almost useless. Bike lanes from nowhere.
43. Better lighting at night. Bike lanes throughout the city.
44. Do we have bike lanes? Bike lanes would be great
45. better than it was 20 years ago but has a long way to go
46. Dedicated bike/pedestrian paths perhaps along old railroad tracks or bridges.
47. See response to Question 10 Above.
48. I think the addition of greenways and bike lanes down 15thst and wide sidewalks down McFarland Blvd. would help.
49. Bike paths/lanes are the most basic addition needed; I feel education, more than anything, should be a priority if the city wants to increase the bicycle/walking traffic in the city; the more people actually know about the law, opportunities, etc. the more their behavior will be influenced
50. Build bike lanes into all future development projects. Put them into existing development. Tactically place bike racks throughout the city, particularly in commercial areas.
51. More bike lanes and alert motorists
52. Police to ticket the car drivers if they nearly run over some bicyclists. Somebody to repair the broken beam barrier next to the parking lot, Lurleen B. Wallace Corner to the University Blvd (It is crashed over the pedestrian way since weeks!) A BRIDGE ONLY FOR PEDESTRIANS AND BICYCLISTS BETWEEN THE TWO MAIN CAR BRIDGES!!!!! A bridge close by would help a lot students to take their bike and safe a lot of parking fees. I am very surprised that there is no better system for bicyclist
53. More bike lanes
54. Same comments as stated under the "Walking" category
55. Bike lanes and alternative routes for biking within the city. One or more walking/bike bridges over the Warrior River would make those living north of the river able to give more consideration to biking to work.
56. More bike lanes on roads coming into the "campus" area
57. More bike lanes
58. Crosswalks over main intersections...such University Blvd & 15th street, bike lanes on streets such as 15th street, Hackberry, 10th avenue, Hwy 82
59. More bike lanes
60. In Tuscaloosa, we need more bike lanes and bike racks outside of local businesses. I find cycling in Tuscaloosa to be quite unsafe. I've lived in several cities across the US and in my opinion; Tuscaloosa is one of the least bike friendly.
61. Allow bikes to ride on sidewalks. Bikes need lots of lights on front and back. Bikes shouldn't weave in and out of cars. Cyclers aren't as visible to drivers of motorized vehicles as the cyclers seem to think.

62. Major arterial roads (McFarland, university, 15th, Hargrove/hackberry, queen city, and jack Warner) need more usage of bike lanes. Some of these roads have them, but only in certain areas, and some just lack them altogether
63. Bike lanes and pedestrian walkways, specifically on 15th Street and Hargrove. It is so dangerous to ride a bike. I only live one mile from campus, but am terrified to ride a bike or walk.
64. Bike lanes, street lights
65. bike lanes or sidewalks with bike lanes, cross walks to safe crossing as it is really difficult to get into traffic, for example on McFarland, and cross with the light and cars, extremely dangerous
66. Clearly, more bike lanes, signs, and bicycle awareness from motorists.
67. Whatever is done, it must not further congest or hinder current vehicular conditions. We already do not have enough lanes for current traffic.
68. I have students who have bicycled to Wal-Mart. How? I don't know. Even bicycling to University Mall is hard. People need more possibilities to bike to areas like these. Areas for recreational, leisurely bicycling for fun/exercise would be great too.
69. On campus it's fine, around town it's non-existent
70. BIKE LANES! Reserved only for bikes, I don't want to have to compete with bus traffic.
71. Need more bike paths and access lanes on major roads.
72. The bicycle infrastructure is shockingly out of date. There are a few bike lanes that are around the University but even those re-route (incredibly illegally) onto sidewalks when they end. There needs to be more bicycle lanes and mixed used paths that are marked as such and education and law enforcement about the illegality of riding on sidewalks and going the wrong direction.
73. They need to have lanes everywhere and it needs to be enforced that they use them so they do not hold up car traffic
74. There need to be designated areas that the cyclist should adhere to in order to avoid injury or loss of life. Narrow streets that do not have bicycle lanes are very dangerous to all involved.
75. Bike lanes on the university tend to end suddenly. Bike lanes throughout Tuscaloosa are mostly non-existent.
76. They move from sidewalk to street around campus...where marked clearly it looks very attractive
77. More bike lanes and better education for drivers of cars about how to respect the rights of bikers.
78. Create a network. Even on campus the bike network is broken up and not continuous.
79. Bike lanes! all throughout the areas near the university in particular, but everywhere would be useful. Most places in Tuscaloosa and Northport are within biking distance of one another but drivers are NOT respectful of bicyclists and the roads are NOT safe.
80. More bicycle lanes and paths.
81. Do not block off extended contiguous areas to motorized traffic (one-way streets), e.g., the area around the Quad. Motorized vehicles can easily cope with the slightly longer travel distance in avoiding one-way streets in the wrong direction, but the bicycle is powered by humans and can't travel distances as easily. Slight increases in travel distance may not be a problem or motorists, but they are a disproportionate burden for bicyclists, especially in rainy weather, heat and humidity in the summer, and cold in the winter. As a result, many bicyclists who would otherwise use traffic lanes are riding on pedestrian walkways in order to gain access to areas blocked off to motorized traffic.
82. A basic change in the way this is regarded, so that cyclists are seen as just as entitled to use the roads as those who are driving vehicles. The single specific change that would help greatly would be bike lanes.
83. More education as to bicycle travel both for the person on the bike and the cars. Bike Lanes
84. Need more
85. There is a bicycle network in Tuscaloosa? In short, there need to be bike paths in places besides campus, and the ones on campus should not be on sidewalks or in bus lanes.
86. Bicycle lanes, pedestrian overpasses over busy streets.
87. Specifically designated biking lanes in major portions of the town. Racks in the downtown area. Better access across major bridges

88. Bike lanes on roads leading towards campus
89. DRIVER AWARENESS AND EDUCATION. There are a lot of people who do not understand that bikes are allowed on the road. They become hostile and make the roads unsafe for everyone. There have been improvements on certain streets incorporating bike lanes, but this is very limited. In some cases, pedestrians even walk in the bike lanes causing cyclists to abruptly stop or venture out into motor traffic. We also need WAY MORE bike racks.
90. Better bike lanes, increase in bike lanes outside of campus, education on the rules of sharing the road for both bikers and motorists
91. WE NEED MORE BIKE LANES CLOSER TO CAMPUS!!!!
92. Specified bike paths along favorites routes
93. More bike lanes
94. More bike lanes, better enforcement of bike laws
95. Protected bike lanes
96. A bike lane for every road and making sure that people riding bikes are in the bike lane and if not, citation, ticket. etc.
97. More ramps and sidewalks throughout
98. Main roads need lanes. College drivers are Terrible which makes it unsafe to bike on roads as it is now.
99. Bike lanes
100. Bike paths and rules to keep them off of sidewalks
101. Bike/moped routes, or other alternate modes of transportation besides buses, which just clog up the roads as it is.
102. More places to park bikes, less congested areas to ride bikes
103. There's a bicycle network? I find all my Tuscaloosa bicycling done in the road.
104. Difficult crossing (Warner) River Road
105. Easier access for students not in the university quadrant (bounded by 15th Street, McFarland, Lurleen Wallace and the Black Warrior River) to walk or bike to campus. Definitely more bike lanes on all downtown streets, not simply the main thruways.
106. Safe bicycle paths
107. More bike racks
108. Larger bike lanes, especially downtown and on the strip.
109. For the sidewalks to become more bike friendly.
110. I don't know
111. Just like sidewalks, I have never see a city with no bike lanes outside of campus, and so few bike lanes on campus. It is the least bike-friendly campus I have ever been on.
112. The bike lanes I see are not safe and not sufficient. I intended to buy a bike when I moved here and bike to UA, but that isn't reasonable.
113. I'm not aware of any bicycle lanes.
114. More bike lanes and racks to lock up bikes. Perhaps a bike program like Amsterdam or Copenhagen.
115. More bike lanes
116. More consistent bicycling lanes throughout the community
117. Improvements needed to safely cross bridges
118. It needs to be established
119. safer on 15th street
120. It needs more bicycle lane and lower speed limits. On most of the roads it is too dangerous to ride a bicycle.
121. Lights and biker roads
122. We need adequate bike lanes everywhere and signage to educate drivers; there must be a way to fix the sensors on traffic lights to accommodate bikes! The bike lanes have to be smooth and free of detritus (metal things that fall off moving vehicles); crossing the train tacks is hazardous, especially on Hackberry.

123. Every street should have a bike lane.
124. There is essentially no bicycle network.
125. Lanes, Motorist knowledge and care, anti-theft parking
126. More bike lanes
127. Not enough bike lanes in downtown
128. Same as above (repeated questions?)
129. More lanes and commercials about how bikers should be respected because they are actually doing their part to reduce pollution and traffic
130. More bike lanes would be nice on the more congested roads such as McFarland or Veterans Memorial. Bikers feel unsafe and end up on the sidewalk on Veterans, which is unsafe for pedestrians.
131. More bike paths more education to both bike riders about obeying the rules for the road (stopping at red lights) and to motorist to watch out for bike riders
132. MORE LANES DEDICATED TO BICYCLE TRAFFIC.
133. More bike lanes
134. The bicycle lanes should not just abruptly stop or be faded into the curb. Cyclists shouldn't be directed towards sidewalks when bicycle lanes end as that is illegal in the city of Tuscaloosa. They should instead be merging with traffic. Motorists should be made aware of that.
135. Same as above. I would prefer to ride on a sidewalk where I am somewhat protected from car traffic. I rather get a ticket then end up "dead right" on the road.
136. Bike lanes should not abruptly end and merge with automotive traffic. This is dangerous and confusing and only makes people not want to use the bike lanes.
137. Law enforcement upholding the law on bicycling, bike lanes, bike crossings, licensed drivers respecting bicyclist
138. Add more lanes for bikes
139. N/A
140. More bike lanes. Better upkeep of roads. More signage ("Share the Road")
141. More bike lanes, space reserved at junctions, reminding car users to respect cyclists. A critical mass of cyclists off campus might make a big difference. Crossing 15th St is hard.
142. More areas for bikes only but not at the expense of motorist lanes
143. I generally ride on the sidewalk because motorists honk and swerve and curse at me if I'm on the road. Most motorists don't seem to know that cyclists are supposed to be on the road. Pedestrians are nicer to me when I'm on my bicycle.
144. More of them, and on campus they should not be the same as the bus lanes
145. More bike lanes should be added to roads. Again, education of all parties to ensure the safety of both cyclists and drivers
146. More bike lanes. It's much better than it was five years ago, but more could still be done.
147. More racks.
148. More bike lanes and crosswalks are needed. More of the bicyclists also need to learn where they are supposed to ride as well as beginning to obey traffic laws instead of running stop signs, red lights, etc and endangering themselves.
149. More of them, and more signage informing drivers of the need to share the road.
150. More bike lanes and educated bicyclists.
151. More bicycle paths or wider sidewalks. More bicycle racks outside of businesses. Crossing bridges on a bicycle would be terrifying with other traffic.
152. More bike lanes, especially on campus. I love the extra wide bike/pedestrian sidewalks (i.e. Univ Blvd from Hackberry to the Student medical center) but there are so many other areas that need the access.
153. More bike lanes
154. More bike lanes
155. Most importantly bike lanes but also bicyclist education about rules and regulations bicycles fall under. I find bicyclists in town to be respected by motorists but continually breaking laws about where

and when to cycle. They serve a danger to both pedestrians, motorists and themselves but choosing where and when they want to be treated as motor vehicles. I see bicyclists riding on the sidewalks when bile lanes are present, riding on the wrong sides of the roadways and disobeying traffic signs and traffic light. There is no apparent consequences or accountability for following any existing traffic ordinances.
156. A lot more bicycle lanes, at UA specifically, MORE BIKE RACKS!!!
157. More bike lanes
158. On and off campus could use wider roads to allow cyclists and motorists to better share the travel lane. In my experience, bike lanes are not safe, not respected and not maintained.
159. More lanes
160. More sidewalks and/or bike lanes
161. Bicycle lanes
162. More bicycle lanes
163. More bike lanes in heavily traveled areas and main roads
164. The main reason I have not replaced by bicycle in Tuscaloosa is because of the number of people I know who have been hit by cars.
165. More biking lanes or road-share awareness, more bike racks and places to store bikes, incentives to ride bikes to work or school
166. More bike lanes with a defined separation between the vehicle traffic and the bicycle traffic (i.e. concrete barriers)
167. More bike lanes or wide shoulders.
168. More bike only lanes and bike trails
169. Needs MANY more bike lanes/shared sidewalks. I know that bicyclists are not supposed to be on sidewalks, but it is too dangerous for them to be elsewhere. The problem is that when bicycle are on sidewalks, then the chance of a pedestrian related accident is likely (my husband has been hit by a bike).
170. Riding a bike in Tuscaloosa is frightening! Ideally, every road should have a bike lane. I think people should be able to get anywhere in town on a bike, without having to compete with motorized traffic. p.s.: putting up signs asking motorists to share the road with bikers is NOT a solution to the problem.
171. What bicycle network??? how about rails to trails.. more bike lines education on bicycling culture and rules. The problem here is that neither drivers nor cyclers have any respect for each other... there is no cycling culture
172. Wider road lanes or bike lanes/routes
173. BIKE LANES
174. More bike lanes
175. More noted "bike lanes" and the bikers to actual be in them.
176. There is no bike lanes, which makes it difficult for cars and bicyclists to share the road
177. More bike lanes!
178. More than three bike lanes would be nice. The lack of bike lanes is literally laughable and makes it incredibly dangerous for motorists, bicyclers, and pedestrians. It's irresponsible to have the bike network in such a manner.
179. They need to be respectful
180. More bike lanes, more signs about cycling and more enforcement of traffic laws so cyclists will obey the law and stay off sidewalks and not hog the road.
181. Increase in bike lanes around Tuscaloosa. Especially on the major roads that lead toward campus
182. More bicycle lanes
183. Better and more bike lanes.
184. More bike lanes.
185. More bicycle lanes; bicycle lanes that do not interfere with motorists travels (e.g., won't slow traffic, reduce the number of driving lanes, create risks for drivers and cyclists, etc.).
186. More bike lanes and a change in the culture of the community. Most motorists don't know how to share the road with a bicyclist.

187. BIKE LANES!!!!!!!!! I've been hit 3 times (twice on campus) so I refuse to ride my bike on the road.
188. It needs expanding.
189. Bike lanes on 15th, and McFarland would be nice, but the seeming lack of respect from motorists in Alabama (and the south generally) might not make them very useful
190. First of all biking does not seem safe in its current state and this is often just as much the fault of the bicyclist. They drive in the middle of the road, weave in and out of traffic, run red lights as if they aren't meant for them, and have rushed out in front of my car at times where I had to slam on the brakes to keep from hitting them. There need to be rules and ones that are enforced. Perhaps a bicycle lane is the best solution.
191. More bike lanes all over campus and enforcement of no parking in the bike lanes.
192. Providing separate lanes for bicycles in outer area of Tuscaloosa.
193. More comprehensive union from neighborhood to neighborhood. Definitely need some protected parallel bike path over the river on McFarland from North River.
194. Add bike lanes.
195. How can you improve something that does not exist??
196. Not sure
197. Adding a sidewalk area to Jack Warner/River Road it's one mile from campus but I wouldn't feel safe riding a bike to class.
198. More bike lanes. Increased awareness of traffic rules for cyclists, motorists, and pedestrians. More bike racks.
199. More bicycle lanes in areas outside the university campus.
200. Easier crossing of major roadways. Parallel pathways for congested roadways.
201. Bike lanes on campus are new and irregularly located. Bike lanes off campus don't exist.
202. More bicycle lanes, except for some parts of university, there is no bicycle lanes anywhere else.
203. The bike lanes appear to be unsafe & confusing. However, I believe that the problems with the bicycle network in the area pertain more to the cyclists themselves rather than conditions to ride bikes in the area.
204. Bike lanes, bike lanes, bike lanes. Less social stigma for cyclists.
205. Dedicated bike lanes that enable biking throughout the city particularly to shopping areas and the University
206. More bike lanes and improved sidewalks in areas where bike lanes are impractical or dangerous.
207. Safe bike lanes. Mandatory helmet law.
208. As with walking, biking is troublesome for a number of reasons, the main, for me, being: safety and accessibility. Drivers are again VERY aggressive to bikes, very distracted/negligent, and road conditions in certain areas make bike travel difficult and potentially hazardous. Increased bike lane accessibility or indicating multiple use stripes (as has been done in many Western cities--see Portland, Salt Lake City, Denver, etc.) on roads too narrow to accommodate bike lanes, would also help.
209. Build a bike-friendly road like northern school campuses
210. Paths or sidewalks to ride on to keep from getting run over by other vehicles
211. Lanes
212. Bike lanes for all of campus, not just portions of it.
213. Bike lanes available on both sides of main roads- McFarland, 15th St., University-to Alberta City on Univ. Blvd., etc.
214. More sidewalks
215. Not familiar enough with the bicycle network to say
216. It is not safe for bicycles to share current busy roadways with automotive traffic, and there are not safe bikeways. Even on the University of Alabama campus, bike lanes sometimes abruptly end and bikers must suddenly merge with motorized traffic.
217. Where to begin???????? ADD BIKE LANES!!! There are no bike lanes in this city. There are no bike racks. At least put up more bike signs so motorists are warned to be aware. There are areas that need

more stop-lights, such as on Hackberry near the JACK's restaurant, Some streets narrow without warning. TV commercials to teach drivers and cyclists how to behave around each other. Cyclists need support from the city and from the police. One of the best bike cities in the USA is Madison, Wisconsin. We can borrow a lot of ideas from that city--such as extensive bike lanes, and rental bike vending machines.
218. Same as in 10.
219. Bike lanes on Tuscaloosa's major streets. A way to get safely from Tuscaloosa to Northport via bike. The other problem is that I'm often bumped to the sidewalk for riding my bike but the sidewalk along McFarland is not wheelchair or bicycle accessible. (There is an established curb at every driveway.) Education about bicycle laws would be great too. -- I would LOVE to be able to ride my bike the three miles to and from campus (for class and for game days) but it's currently not safe for me to do so. I really hope improvements can be made and that bike lanes can be incorporated into the city's rebuilding plan.
220. We don’t have a bicycle network
221. Not enough bike lanes and the ones that are present end abruptly
222. We have a network?
223. More bike lanes?
224. Bike lanes, bike paths, and signs
225. More bike lanes. Bicyclists need training on safety, etiquette, and laws for bicycling.
226. Real bicycle paths that are separate from car, truck & pedestrian traffic. The so-called bicycle paths on campus are dangerous & ridiculous---some are shared with buses and/or turn lanes, some end abruptly all are used as stopping lanes by students (and others) driving their friends to class. I have not seen any form of bicycle routes anywhere else in Tuscaloosa.
227. More bicycle lanes.
228. Bike lanes are few and far between and are often not linked together. Even when there are bike lanes, they are often of poor quality and sometimes blocked by cars. Additionally, I often feel no safer riding in a bike lane versus cycling in the road due to lack of driver education.
229. There are not enough, students on bikes are at risk of getting hit or causing a car crash.
230. Must be more comprehensive
231. Bike lanes or sidewalks in the midtown area.
232. I've noticed very few bike lanes in Tuscaloosa. I'd love to ride a bike from my house to class and would if I thought it would be safe to do so. I would have to travel down Hargrove and across 15th Street, but I feel that people drive too quickly and are inattentive to pedestrians and cyclists on these roads (and in general to be honest). If there was a bike lane all the way down Hargrove/Hackberry to the University I'd probably ride a bike.
233. Same as # 10 above.
234. More bike paths, better ability to cross bridges
235. More bike lanes- public education about cyclists
236. Bicycle network is even worse than pedestrian. Zero bike lanes, unenforced speed limits, narrow roads and poorly planned strip malls make biking EXTREMELY dangerous. So much so that I haven't used my bike once since moving here over a year ago. Nascar nation rules Tuscaloosa.
237. Motorists need to recognize that cyclists have a right (by law) to use the road and are prohibited (by law) from using the sidewalk.
238. Cyclists need to be educated on where they can and cannot drive, in addition to what traffic laws they must obey. They randomly ride all over sidewalks and streets without caring about motorists and pedestrians. They often hit pedestrians or are hit by cars. They don't stop at stop signs or traffic lights like they are require and police do nothing.
239. Remove the gaps between sidewalks and road so we can ride a bike on the sidewalks
240. There is a need for more bike lanes on roads in the Tuscaloosa area.
241. There needs to be sidewalks on every street and bicycles should be allowed on them. The corners of the streets should have the ramps instead of curbs.
242. Need bike lanes

243. We need more. If one wants to go places on a bicycle, and lanes are not available, the bicyclist has little choice between risking riding with traffic or risking pedestrian traffic by riding on the sidewalks.
244. It should be linked with Northport and expanded further.
245. Tuscaloosa needs more sidewalks along the major roads such as 15th Street and McFarland Boulevard. I live just off of 15th Street and cannot ride my bike from my house to the University Campus due to lack of sidewalks.
246. More bike-friendly paths that are clearly labeled. It is actually impossible for me to bike from my apartment to campus--not because of distance, but for safety reasons.
247. Like walking biking is not respected, safe or convenient. I felt better about biking when I saw the university police doing it, (they did have regular bike patrols) but since they quit I have quit. I am sure that the University doesn't like or want bikes around campus and the recent forcing of registration only reinforces my thinking about transportation. The University, like the city, talks a good game, but does little or nothing to promote non-motorized transportation. Bikes lanes that work only on campus with no law enforcement. (cars and buses use them as turn lanes all the time.) Come on! It is clear that both the city and the university only tolerate people using some sort of transportation other than cars.
248. The addition of bike lanes along common roadways or allowing bicycles to be used one widened sidewalks.
249. Marked bike lanes that are connected
250. There needs to be more bike racks especially on campus where it is impossible to drive anyway so you need to be able to ride a bike. The bus system is not very efficient to use.
251. More bike lanes. More respect
252. I think there are enough bike lanes, at least on campus, they just don't span far enough down the road. They don't continue on as long as I need them to.
253. Bike lanes and tickets for those you do not follow traffic laws.
254. Bike paths off campus
255. Bike lanes are a huge problem that I find myself involved with during my travel to and from the campus. There are no roads near the outskirts of campus that consistently keep a bike lane. I don't like to ride my bike on the road with cars, but I also am not entirely comfortable with riding my bicycle through pedestrians on the sidewalk. On the outskirts of town, sidewalks are also not consistent. You could be riding along, and then all of a sudden the sidewalk ends, leaving you riding/walking along in usually heavy traffic.
256. More bike lanes. More awareness of cyclists as respected travelers.
257. More bike lanes.
258. More bike lanes need to be placed.
259. More marked bike lanes or road signs marking to share the road
260. Make continuous biking trails connected to the housing areas of off-campus students. And also avoid the sudden interruption of a biking lane just because there is a high traffic road. That just doesn't make sense! What are we supposed to do when the bike lane stops; just walk next to the bike from there to where we need to go?
261. Make laws known to car drivers about the bike riding. More bike lanes next to car lanes.
263. Additional bike lanes added
264. Better bicycle paths off campus. The bike lanes on campus are few and very sparse, as soon as you leave campus they become nonexistent.
265. I feel we need more bike lanes in Tuscaloosa. The bike lanes end either in turn lanes or end in a two lane street. Also, I feel drivers need to be more aware of cyclists in the Tuscaloosa area and on campus.
266. More bicycle lanes, I do not ride a bicycle but it makes me nervous when I am driving and a bicyclist is in the road because there is no bicycle lane
267. Bike lanes. That are connected to each other and usable.
268. Bike lines on Bryant Drive; education for motorists about the legal rights of bicyclists; tell University employees they can't park their work trucks in the bike lane

269. I cannot ride my bike from my apartment to anywhere in town because there are no sidewalks OR bike lanes on the road.
270. There are hardly any bike lanes outside of campus.
271. Dedicated bike lanes, awareness amongst motorists
272. Bike lanes
273. Bicyclists are not welcome or safe in the street. Cars do not respect them, they do not wear helmets for the most part, and they do not use common sense at street crossings. Bicycle lanes like those in place on UA campus would help this problem somewhat.
274. Bike lanes on all roads!
275. I would choose to bike to work often except that I live north of the river. There is no way to get across without cycling along major roads.
276. More clearly marked bike lanes.
277. We need bike lanes!
278. More bike lanes outside of campus. There is nothing south of campus (Snow Hinton area).
279. Able to ride on the sidewalk, which I do anyway. Down with the man!
280. More bike lanes

APPENDIX D – Regression Output Tables for Bicycle Commuters

Table D1
Omnibus Tests of Model Coefficients for Bicycles

		Chi-square	df	Sig.
Step 1	Step	51.021	1	0.000
	Block	51.021	1	0.000
	Model	51.021	1	0.000
Step 2	Step	22.734	2	0.000
	Block	73.755	3	0.000
	Model	73.755	3	0.000
Step 3	Step	11.904	2	0.003
	Block	85.659	5	0.000
	Model	85.659	5	0.000
Step 4	Step	15.318	3	0.002
	Block	100.978	8	0.000
	Model	100.978	8	0.000
Step 5	Step	6.083	1	0.014
	Block	107.060	9	0.000
	Model	107.060	9	0.000
Step 6	Step	5.898	1	0.015
	Block	112.959	10	0.000
	Model	112.959	10	0.000
Step 7	Step	4.513	1	0.034
	Block	117.472	11	0.000
	Model	117.472	11	0.000

Table D2
Model Summary for Bicycles

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	309.116[a]	0.136	0.212
2	286.382[b]	0.191	0.296
3	274.478[b]	0.218	0.338
4	259.159[b]	0.252	0.391
5	253.077[b]	0.265	0.411
6	247.178[b]	0.277	0.430
7	242.665[b]	0.286	0.444

a. 5 parameter estimates changed by less than .001.
b. 6 parameter estimates changed by less than .001.

Table D3
Hosmer and Lemeshow Test for Bicycles

Step	Chi-square	df	Sig.
1	0.000	0	.
2	3.519	4	0.475
3	5.110	6	0.530
4	3.515	8	0.898
5	4.932	7	0.668
6	5.967	8	0.651
7	9.454	8	0.305

Table D4

Classification Table for Bicycles[a]

			Predicted		
			Main Travel Mode		Percentage
Observed			No Bike	Bike	Correct
Step 1	Main Tavel Mode	No Bike	274	0	100.0
		Bike	74	0	0.0
	Overall Percentage				78.7
Step 2	Main Tavel Mode	No Bike	235	39	85.8
		Bike	32	42	56.8
	Overall Percentage				79.6
Step 3	Main Tavel Mode	No Bike	263	11	96.0
		Bike	48	26	35.1
	Overall Percentage				83.0
Step 4	Main Tavel Mode	No Bike	257	17	93.8
		Bike	40	34	45.9
	Overall Percentage				83.6
Step 5	Main Tavel Mode	No Bike	258	16	94.2
		Bike	39	35	47.3
	Overall Percentage				84.2
Step 6	Main Tavel Mode	No Bike	261	13	95.3
		Bike	42	32	43.2
	Overall Percentage				84.2
Step 7	Main Tavel Mode	No Bike	260	14	94.9
		Bike	38	36	48.6
	Overall Percentage				85.1

a. The cut value is .500

Table D5

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 7	Code of Alabama			10.668	2	0.005	
	Knowledge of law	1.111	0.345	10.37	1	0.001	3.037
	No knowledge of law	0.073	0.77	0.009	1	0.925	1.076
	Cars per household			11.911	3	0.008	
	0	2.288	0.829	7.616	1	0.006	9.859
	1	1.553	0.565	7.542	1	0.006	4.724
	2	0.868	0.577	2.263	1	0.132	2.382
	Views on Walking: Efficient	0.989	0.421	5.517	1	0.019	2.688
	Views on Bicycling: Convenient	-0.99	0.378	6.863	1	0.009	0.371
	Views on Bicycling: Efficient	-1.549	0.395	15.354	1	0.000	0.212
	Additions to the bicycle network			15.61	2	0.000	
	Yes	2.444	0.823	8.816	1	0.003	11.523
	No	0.878	0.953	0.849	1	0.357	2.406
	Male	0.705	0.335	4.437	1	0.035	2.025
	Constant	-4.481	1.054	18.078	1	0.000	0.011

APPENDIX E – Regression Output Tables for Pedestrian Commuters

Table E1
Omnibus Tests of Model Coefficients for Pedestrians

		Chi-square	df	Sig.
Step 1	Step	42.945	6	0.000
	Block	42.945	6	0.000
	Model	42.945	6	0.000
Step 2	Step	26.079	4	0.000
	Block	69.024	10	0.000
	Model	69.024	10	0.000
Step 3	Step	18.218	1	0.000
	Block	87.243	11	0.000
	Model	87.243	11	0.000
Step 4	Step	11.509	1	0.001
	Block	98.751	12	0.000
	Model	98.751	12	0.000
Step 5	Step	14.339	3	0.002
	Block	113.090	15	0.000
	Model	113.090	15	0.000
Step 6	Step	17.655	5	0.003
	Block	130.746	20	0.000
	Model	130.746	20	0.000
Step 7(a)	Step	-1.494	1	0.222
	Block	129.252	19	0.000
	Model	129.252	19	0.000
Step 8	Step	8.210	1	0.004
	Block	137.462	20	0.000
	Model	137.462	20	0.000
Step 9	Step	7.728	2	0.021
	Block	145.190	22	0.000
	Model	145.190	22	0.000

a. A negative Chi-squares value indicates Chi-squares value has decreased from the previous step.

Table E2
Model Summary for Pedestrians

Step	-2 Log likelihoo	Cox & Snell R Square	Nagelkerke R Square
1	232.594[a]	0.116	0.212
2	206.514[a]	0.180	0.329
3	188.296[a]	0.222	0.405
4	176.787[a]	0.247	0.452
5	162.448[a]	0.277	0.507
6	144.793[a]	0.313	0.573
7	146.287[a]	0.310	0.567
8	138.077[a]	0.326	0.597
9	130.349[a]	0.341	0.624

a. Estimation terminated at maximum iteration 20. Final solution cannot be found.

Table E3
Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	0.000	4	1.000
2	12.313	7	0.091
3	9.547	8	0.298
4	8.439	8	0.392
5	11.192	8	0.191
6	2.655	8	0.954
7	3.189	8	0.922
8	3.463	8	0.902
9	5.607	8	0.691

Table E4
Classification Table for Pedestrians[a]

Observed			Predicted: Main Travel Mode: No Walk	Predicted: Main Travel Mode: Walk	Predicted: Percentage Correct
Step 1	Main Travel Mode	No Walk	301	0	100.0
		Walk	47	0	0.0
	Overall Percentage				86.5
Step 2	Main Travel Mode	No Walk	298	3	99.0
		Walk	35	12	25.5
	Overall Percentage				89.1
Step 3	Main Travel Mode	No Walk	295	6	98.0
		Walk	34	13	27.7
	Overall Percentage				88.5
Step 4	Main Travel Mode	No Walk	287	14	95.3
		Walk	23	24	51.1
	Overall Percentage				89.4
Step 5	Main Travel Mode	No Walk	292	9	97.0
		Walk	23	24	51.1
	Overall Percentage				90.8
Step 6	Main Travel Mode	No Walk	295	6	98.0
		Walk	21	26	55.3
	Overall Percentage				92.2
Step 7	Main Travel Mode	No Walk	292	9	97.0
		Walk	19	28	59.6
	Overall Percentage				92.0
Step 8	Main Travel Mode	No Walk	293	8	97.3
		Walk	19	28	59.6
	Overall Percentage				92.2
Step 9	Main Travel Mode	No Walk	293	8	97.3
		Walk	18	29	61.7
	Overall Percentage				92.5

a. The cut value is .500

Table E5
Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 9	Use a bicycle			25.962	4	0.000	
	Daily	-5.035	1.06	22.551	1	0.000	0.007
	Weekly	-0.114	0.731	0.024	1	0.876	0.892
	Monthly	1.198	0.788	2.313	1	0.128	3.314
	Yearly	0.234	0.855	0.075	1	0.784	1.264
	Cars per household			20.247	3	0.000	
	0	5.586	1.415	15.584	1	0.000	266.661
	1	2.114	0.8	6.981	1	0.008	8.284
	2	0.181	0.819	0.049	1	0.825	1.199
	Distance to campus			13.669	6	0.034	
	0.5	2.716	0.864	9.879	1	0.002	15.124
	1	1.132	0.649	3.04	1	0.081	3.103
	1.5	0.182	0.887	0.042	1	0.837	1.200
	2	0.64	0.751	0.727	1	0.394	1.897
	2.5	-16.891	13,403.35	0	1	0.999	0.000
	3	-1.3	1.267	1.053	1	0.305	0.273
	Views on Walking: Convenient	1.65	0.536	9.486	1	0.002	5.207
	Views on Walking: Low cost travel	1.195	0.636	3.524	1	0.060	3.303
	Additions to the pedestrian network			6.354	2	0.042	
	Yes	-0.452	0.709	0.406	1	0.524	0.637
	No	-2.332	1.009	5.345	1	0.021	0.097
	Status			24.61	5	0.000	
	Fresh	2.756	1.41	3.824	1	0.051	15.742
	Soph	1.928	1.217	2.509	1	0.113	6.878
	Junior	2.4	0.984	5.944	1	0.015	11.025
	Senior	4.022	0.835	23.175	1	0.000	55.796
	Grad	1.231	0.706	3.041	1	0.081	3.424
	Constant	-5.871	1.24	22.416	1	0.000	0.003

APPENDIX F – Regression Output Tables for Car Commuters

Table F1
Omnibus Tests of Model Coefficients for Cars

		Chi-square	df	Sig.
Step 1	Step	133.152	4	0.000
	Block	133.152	4	0.000
	Model	133.152	4	0.000
Step 2	Step	52.394	6	0.000
	Block	185.545	10	0.000
	Model	185.545	10	0.000
Step 3	Step	15.542	1	0.000
	Block	201.087	11	0.000
	Model	201.087	11	0.000
Step 4	Step	16.011	3	0.001
	Block	217.098	14	0.000
	Model	217.098	14	0.000
Step 5	Step	5.032	1	0.025
	Block	222.130	15	0.000
	Model	222.130	15	0.000
Step 6	Step	5.539	1	0.019
	Block	227.670	16	0.000
	Model	22.670	16	0.000

Table F2
Model Summary for Cars

Step	-2 Log likelihoo	Cox & Snell R Square	Nagelkerke R Square
1	326.783[a]	0.318	0.434
2	274.389[a]	0.413	0.564
3	258.847[a]	0.439	0.599
4	242.836[b]	0.464	0.633
5	237.804[b]	0.472	0.643
6	232.264[b]	0.480	0.655

a. Estimation terminated at iteration 5, estimates changed by less than .001.

b. Estimation terminated at maximum iteration 20. Final solution cannot be found.

Table F3
Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	0.000	3	1.000
2	2.617	7	0.918
3	9.094	8	0.334
4	11.292	8	0.186
5	13.675	8	0.091
6	8.592	8	0.378

Table F4

Classification Table for Cars[a]

Observed			Predicted: Main Travel Mode No Car	Predicted: Main Travel Mode Car	Percentage Correct
Step 1	Main Travel Mode	No Car	71	59	54.6
		Car	9	209	95.9
	Overall Percentage				80.5
Step 2	Main Travel Mode	No Car	88	42	67.7
		Car	15	203	93.1
	Overall Percentage				83.6
Step 3	Main Travel Mode	No Car	87	43	66.9
		Car	17	201	92.2
	Overall Percentage				82.8
Step 4	Main Travel Mode	No Car	94	36	72.3
		Car	15	203	93.1
	Overall Percentage				85.3
Step 5	Main Travel Mode	No Car	102	28	78.5
		Car	19	199	91.3
	Overall Percentage				86.5
Step 6	Main Travel Mode	No Car	96	34	73.8
		Car	18	200	91.7
	Overall Percentage				85.1

a. The cut value is .500

Table F5

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 6	Use a bicycle			46.112	4	0.000	
	Daily	-3.301	0.523	39.843	1	0.000	0.037
	Weekly	-0.827	0.497	2.772	1	0.096	0.437
	Monthly	-0.163	0.577	0.079	1	0.778	0.850
	Yearly	0.670	0.699	0.919	1	0.338	1.954
	Cars per household			2.589	3	0.459	
	0	-20.422	8570.5	0.000	1	0.998	0.000
	1	0.083	0.474	0.030	1	0.862	1.086
	2	0.652	0.500	1.701	1	0.192	1.920
	Distance to campus			26.070	6	0.000	
	0.5	-3.217	0.763	17.764	1	0.000	0.040
	1	-1.424	0.487	8.543	1	0.003	0.241
	1.5	-0.901	0.580	2.419	1	0.120	0.406
	2	-1.065	0.522	4.165	1	0.041	0.345
	2.5	-0.032	1.117	0.001	1	0.977	0.968
	3	0.503	0.706	0.508	1	0.476	1.654
	Views on Bicycling: Safe	-1.960	0.777	6.362	1	0.012	0.141
	Views on Bicycling: Efficient	0.892	0.378	5.571	1	0.018	2.439
	Rent a home	1.324	0.412	10.308	1	0.001	3.758
	Constant	2.747	0.875	9.845	1	0.002	15.590