The Bicycle, the Unsuitable Substitute: A Feasibility Study Based in Fayetteville, AR Using a Bicycle as a Year-Round Replacement for an Automobile

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The Bicycle, the Unsuitable Substitute:
A Feasibility Study Based in Fayetteville, AR Using a Bicycle as a Year-Round Replacement for an Automobile

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Geography

by

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Abstract

Can a bicycle can be used in place of an automobile for everyday transportation and commuting needs? Fayetteville, Arkansas is a bicycle friendly and they plan continue to expand the current trail system improve other components in the future. Alternative transportation forms like the bicycle are important but only if bikes are integrated into traffic which needs to be done in some way that all involved understand their place in the system. By actively participating in this system I have attempted to show that a bicycle is just not feasible as a form of daily transportation in a city like Fayetteville. There are just some errands that cannot be physically accomplished by bike. Additionally, some days are not bikeable due to weather. Fayetteville poor infrastructure conditions, sidewalks come and go, trails go nowhere, and some just stop abruptly. Furthermore, it is my opinion that the on-street portion of the bicycle network is in such disrepair that it needs an overhaul.

This study focused on comparing the transportation plans to the bike system they describe. Questions include: is ridership affected by topography, weather, infrastructure, or integration in to the network. Many factors were considered such as the distance to improved bicycling facilities which may influence ridership. (Walk Bike, 2015) Other factors included the distances between features, accessibility of destinations, the law and its presentation, and misconceptions about the rights and purpose of the road. A firsthand experience of commuting regularly was a crucial component of this study and the only way to capture the truly qualitative aspects of this project. Riding journeys were captured with video and GPS documentation. This provides georeferenced data for some of the qualitative GIS analysis.

These previously mentioned conditions except for weather can be used as input to GIS. There are many questions to answer with a GIS which include: can voids in the system,
proximity to components, topography, and areal arraignment be represented for a visual examination of the project. Mapping will create the visual tool needed to show that a bicycle is not a feasible year-round alternative form of transportation in Fayetteville, AR.
Acknowledgments

Dr. Beth Schweiger for teaching me to write and to Dr. Sonja Toudji for encouraging me to pursue further education. Finally, I want to thank Dr. Fiona Davidson for guiding me in this process.
Dedication

To Karen, without you this would not have been possible.
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Chapter 1: Introduction

As a regular bicycling commuter, I have always wondered why there are such a limited number of people traveling in the same fashion. The more I considered this problem the more the realization dawned that I was an outlier in the realms of transportation. Riding and talking to other people who ride bike, seems to reinforce the idea that bicycling is not a feasible transportation alternative for most citizens of Fayetteville, AR for a variety of reasons. Unfortunately, this topic can quite quickly spiral out of control if you do not constrain the scope. There many factors to consider and the following seemed like they would have the greatest influence or impact on bikeability: is it topography, infrastructure conditions, traffic integration, or proximity to trail components. The last component that cannot be mapped as a static entity is the weather. There many different opinions about what makes riding a safe and or pleasurable experience and these factors may limit ridership. It is my hypothesis that it is one or a combination of these factor that makes the bicycle an unsuitable year-round alternative to an automobile in Fayetteville, AR.

Sometimes, in a city as large as Fayetteville, a cyclist really must be aggressive to make it through traffic to their destination. Even though the city has designated some streets as shared roadways, in general the car drivers do not seem to know or understand the rules pertaining to bicycles and traffic. An example of this is the 3-foot rule which is clearly marked on signs along these shared routes. Car drivers hesitate when they get behind a bicyclist and often impede traffic because they do not really know how to “share the road”. This ignorance of the law causes many problems the greatest misconception is that they (car drivers) feel that they are more entitled to the road than bicyclists.
Bicycling is currently being promoted by some members of our society as both a family friendly recreational activity and an alternative form of transportation. There are many positive effects of a more bicycle oriented society. Unfortunately, we have been a car oriented society for so long that it is often not easy to make the switch to a bike oriented lifestyle. Where once people lived close to where they worked it is common for some in Fayetteville to commute 18-20 minutes to work each day by car. (WNYC 2016) The money saved not driving would not be worth the lost time commuting by bike.

The transportation plans that have been released so by the City of Fayetteville seem to focus on the recreation aspect. Others plans, including the State of Arkansas’s Bicycle and Pedestrian Plan and the Northwest Regional Council fail to address integration. It is understandable that cities and private businesses want to encourage bicycling as a recreational pastime because bicycle based tourism can and will add to the local economy but recreational development plan will not help alleviate current transportation loads.

The end goal of this study is to determine if bicycling is feasible as a car replacement, the term feasible requires definition within this study. Feasibility will mean that a task that can be carried out by car can also be carried out on bike regardless of conditions, including weather. There are many ways to accommodate for the differences or limitations of a bicycle. For instance, a family errand to the grocery store with a car could easily bring home five days’ worth of food. To accomplish the same task might take one or two trips with a single bicycle trailer (depending on the design) but would require four or five sets of saddle bags to carry the same load. A 2017 Toyota Camry has 15.4cu.ft. of trunk space vs a set of bike bags which hold 1-2cu.ft.(U.S. News 2017; Sierra 2017)
Figure 1: This image shows residential address density in Fayetteville, Arkansas. This type of mapping is referred to as heatmapping. Density is represented by color and is determined by proximity to comparable items. This map shows density of residential addresses within 660’, the darker the color the greater the density. Qgis 2017.
Chapter 2: Literature Review

Section 2.1: Law & Codes

To determine feasibility of cycling as a car replacement, I started by looking at the laws that applied to cyclists in Fayetteville. The hierarchy exists in bike laws as elsewhere, the local laws cannot take away state or federal rights. Federal regulations overrule those of states which overrules the local level. These local codes and regulations can be more restrictive to the cyclist unless prohibited by federal law. What is unusual about Arkansas is that a bicycle does not meet the definition of a vehicle but at the same time the rider has all the rights and responsibilities of a car driver. (ARK_DRV 2016) Arkansas is one of two states where bicycles have equal access to the road the other is North Carolina. (Gutierrez; Mionske 2007)

Fayetteville and the State of Arkansas have each partnered with online firms to host their laws and codes. Most of Fayetteville’s bicycle regulations are contained in one chapter or section (Chapter 73:Bicycles) and the hosting platform allows you to download an entire chapter in a Word® document format. This makes for easy searching and allows the user to combine or compress the code into a more compact form. If you examine the code online the interface is clumsy and does not allow for easy comparison of one section or line to another.

Arkansas State code is hosted on a web-based platform by LexisNexis and is also in a searchable form. The output is crude and closely resembles the printed form. The website is cumbersome but if you use a specific term like bicycle the results are compiled as a list and are complete. In searching this way, I found that most mentions or instances of the word bicycle are actually in sections pertaining to motorized bicycles. Others include sections that are about cars and how they are expected to interact with bicycle traffic. The language of the law is so specific that an individual item has limited context. There are several websites that have actually posted
the relevant code sections. Usually there is an interpretation of these same codes to help clarify the original. Some sites like AllAboutBiking.com have links to the official Arkansas.gov sites as they do for all states. (gorsar.com) Others like the League of American Bicyclists offer a summary of issues they consider important i.e. helmet laws. (bikeleague.org, 2017)

Federal laws are covered by the Manual of Uniform Traffic Control Devices 2009 (MUTCD) and by US Department of Transportation (DOT) publications which are recommendations, not laws. There are very few limitations for bikes covered by federal law other than the 20mph e-bike speed limit and signage requirements set forth in the MUTCD.

Bob Mionske, JD wrote specifically about bicycling and the law and how the law sometimes contradicts itself. His book Bicycling and the Law; Your Rights as a Cyclist, was a valuable resource in understanding how laws are interpreted. Mionske is a former Olympian, lawyer, and founder of the Constitutional Rights for Cyclists Center (CRCC). He uses many actual cases to show how the law works, making this an excellent learning aid along with being a reference.

Laws pertaining to bikes are becoming more common especially those specifically about e-bikes. Current e-bike regulations were examined in a publication by PeopleforBikes.org. They summarized the new in 2016 California regulations which are complex due to the number of variations in e-bike design. California chose to separately address e-bikes because a previous law had classified them as mopeds and had limited their access to the bikeways. (PeopleforBikes 2016) This mode of transportation or type of bicycle is becoming more common locally and California’s laws might eventually influence codes here in Fayetteville.

Another source was a series of publications produced by the International Mountain Bicycling Association (IMBA) Trail Solutions Program. These papers were produced as
information brochures for those in the forestry management industry and the two I feel are important because they cover the wear and tear caused by power assisted bicycles. (IMBA 2015) These are titled Trail Use and Management of Electric Mountain Bikes: Land Manager Survey Results 2015 and A Comparison of Environmental Impacts from Mountain Bicycles, Class 1 Electric Mountain Bicycles, And Motorcycles: Soil Displacement and Erosion on Bike-Optimized Trails in a Western Oregon Forest 2015. Also included was a briefing by the US Forest Service about the same topic which includes their decision to continue to classify an e-bike as a motor vehicle. (USFS 2015) Fayetteville has many miles of unpaved trails and those located at Lake Fayetteville could be used as a transportation corridor from Crossover to 71B.
Section 2.2: Transportation Theory

There are a limited number of peer reviewed journal articles that focus on bicycling as a form of transportation. These vary in nature from health focused pieces to those of that discuss access restrictions. I started with the writings of Glen Norcliffe and others he has cited. Many of his works are about the economics of the bicycle trade but a considerable number were relevant to transportation and feasibility.

Norcliffe’s *Critical Geographies of Cycling* is a collection of his papers that describe various evolutions in the bicycle industry. While focused primarily on the history of bicycling, it also demonstrates examples how people relate to bicycling environments. The chapter of greatest interest, *Neoliberal Mobility and Its Discontents: Working Tricycles in China’s Cities* 2015, covers the hypermobility of the individuals in China who are tricycle delivery persons. What Norcliffe was focusing on was the public’s perception of obsolescence or anachronism in using tricycles as delivery vehicles in a modern world. In contrast, in places like China the delivery bikes are utilized regularly and more efficient. (Norcliffe 2015) This paper was relevant because it focuses on the perceptions of human powered transport and how it is actually a positive way to move goods through a city. An example of this implementation is the delivery service offered by Jimmy John’s sub sandwich shop. In some areas, including Fayetteville, they hire bicycle riders as their delivery crew.

Another piece also authored by Norcliffe is the *Right to the Road* 2007 where the subject is the long history of reintegrating bicycles into the regular flow of traffic. Norcliffe focuses on the infrastructure changes that put cars first and the impact that this has had on other transportation forms; this unfortunately is the case with Fayetteville. (Norcliffe 2007) Although
The compendium *Cycling and Society* 2015 edited by Dave Horton et al. is a collection of nine journal articles. Many of these are historical in nature but still are relatable to transportation feasibility. There have always been a few constants in cycling and this is an excellent source. An example relevant to Fayetteville is Justin Spinney’s concept of the non-place in his paper *Cycling the City: Non-Place and the Sensory Construction of Meaning in a Mobile Practice* 2017. “It is the place we are in as travelers where we occupy space together but do not interact except in the most rudimentary of ways.” (Spinney 2007) This is applicable because there is a real disconnect between the way a driver and a rider see the interactions in Fayetteville.

Parkin, Riley, and Jones wrote about the need to quantify the barriers to cycling. *Barriers to Cycling* 2007 focused on the fact that in the UK the government has lowered its targeted ridership multiple times and have now taken the position that any increase in ridership would be a good thing. (Parkin 2007) The authors found that many people do not ride bikes for a few quantifiable reasons. What they found though in their research was that the range of data available is not inclusive enough to allow for accurate quantification but if there were further collection of this data it would be useful. (Parkin et.al. 2007) The authors discuss different techniques for collection this data including using mathematical models to aggregate available data like census tract data to predict possible usage. The also recommend a second method that of aggregating the rider level decision making when using the existing transportation system. (Parkin et.al. 2007)
Women and the elderly are the lowest demographic when it comes to bicycle ridership. Does Cycling Mean More Diversity in Cycling, Rachel Aldred et.al. 2016, indicates that European declines in cycling that seems to be centered around two demographic groups. The first and most important is women and the second is the elderly both of which seem to decline at faster rates when compared to younger groups and just males. (Aldred et.al. 2016) This paper is one of many examples that I used when looking at the ridership in Fayetteville.

The City of Fayetteville is actively collecting this type of ridership data both through face to face surveys and a web based GIS application that allows residents to input ideas and concerns based on location. (FayGIS, 2016) Fayetteville is also continuing with trail counts using pneumatic counters placed at different locations on the trail. the most recent was encountered on 5/16/2017. Active counting and study of usage might help to address the perceptions people have of the trail system if these counts are released to the public with explanation. Counting may just address usage at specific points not the feasibility of the system.

Bicyclists are often hyperaware of flaws in the transportation network. This immediate interaction also means that near misses and other miscommunication in traffic are far more frightening. You do not have the protection of a steel cage nor the cushion of an airbag system. If you run over an uneven seam in the concrete in a car it makes a small noise but the suspension absorbs most of shock and the sound dampening controls the noise. On a bicycle, the bump can be jarring even with suspension (shocks). Because you are outside you will see that the bump is really a gap where road sealer has fallen out.

Hell is Other Cyclists 2007 written by Dave Skinner and Paul Rosen, was also included in Cycling and Society. They studied the relationship between perception of bicycle riders by car drivers and other cyclists and the interactions that follow. (Skinner et.al. 2007) They also looked
at how the perception of cycling in the workplace affects whether someone will ride their bike to work. (Skinner et. al. 2007) Much of the research that went into the writing of this paper is applicable to Fayetteville even if the original study area was in the UK.

What you see in a car vs. on a bike. When we travel in a car it is almost like watching TV. (Spinney 2007) In a car, the glass distorts the perception and the pillars supporting the roof block portions of your view. In some vehicles, you also must look past headrests and shoulder straps for multiple seats in more than one row. On a bicycle, your sight is only limited by the movement of your own neck. Furthermore, you have the additional benefit of being able to locate the origin of sounds. The smells from the passing cars are not usually pleasant but they might be a clue (burnt brakes) that someone is driving a vehicle with problems and they could be distracted. The disconnect from the environment is subtle but important. (Spinney 2007) When you travel by bicycle you are part of the environment and unless you are foolish enough to wear headphones you cannot escape or disconnect from that argument until your destination is reached.

Non-place or the void between destinations is a concept talked about by Justin Spinney. His contribution to Cycling in Society 2007 was a paper focusing on the areas of a city that are between destinations. He uses the example of wide concrete plazas between office buildings where no one walks because parking is in the building. (Spinney 2007) This failure to interact with the environment and each other might be caused by separation due to the large metal containers in which we travel. He feels like the way cities are designed they force us into isolation even when outdoors. This is compounded by being in a vehicle. (Spinney 2007)

Car drivers notice each other and have very brief sterile interactions with each other. (Spinney 2007) Unfortunately, this isolation is directly translatable to the bike trail where an “on
your left” or “beautiful day” is not really an interaction but instead is merely a reaction. Furthermore, when there are small interactions between bike rider and car driver, one is never sure how the other is going to react in this situation. This could be attributed to ignorance of the laws by both parties but also may be a side effect of not requiring driver education courses in Arkansas.

Dave Horton’s Fear of Cycling 2007 focuses on fear because it is a part of biking in a way that only motorcyclists could appreciate. Separating bicycles from cars and other exclusionary tactics are not beneficial. The effect these changes have on the infrastructure do not actually make the experience less dangerous. (Horton 2007) Instead it makes people even more aware of potential risks which leads to even more dramatic modes of separation of traffic, like the Razorback Greenway. Separated trails are excellent until it must interact with regular street traffic. (Horton 2007) At the point of convergence there is often a complicated intersection that includes more lanes and signs for both riders and drivers to interpret.

What the author is pointing out is that the fears felt by cyclists may influence policy and design of roadways. (Horton 2007) Often these take the form of separate bikeways removed from roadways which seems to be the current mentality in the planning put forth by the City of Fayetteville. (Fay 2009)

One final selection from this compendium is the piece Bicycle Messengers: Image, Identity, and Community, (Fincham 2007) which focuses on the mentality behind bike messaging. This article is about the riders themselves and is a revealing source for a real enthusiast attitude for riding. (Fincham 2007) These are the people who I see on the streets and rarely do I see them on the trails unless they appear to be training. Unfortunately, not actual messengers, we may not have a compact enough city to support crosstown document delivery.
Some of the other aspects were in papers covering motorists and how they perceive their own understanding of the law. One piece that stood out was *I am a Better Driver Than You Think: Examining Self-Enhancement for Driving Ability*. In this paper, Roy and Liersch 2013 measure peoples’ perceptions of their own driving. The one factor they examine that is most relevant to the study of feasibility is interpretation of the law. Some people feel that their own judgement is superior to the law. (Roy and Liersch, 2013) This attitude was considered when examining the laws that pertain to Fayetteville.

There is a downward trend in cycling in countries that have seen increased ridership in the recent past. *Cycling as Transport*, 2016 by Elliot Fishman, of the Institute for Sensible Transport of Melbourne Australia, is about both positive and negative trends focusing on what seems to be working. Fishman also addresses ridership totals versus desired ridership quoting similar vacancies in some demographics that matched Fayetteville. (Fishman 2016) The paper is a survey of the state of infrastructure, it avoids site specifics so it is easily applicable to Fayetteville. We are seeing some demographic increases in ridership while others stagnate or decline. This ridership decline is not just a local phenomenon nor are spotty increases. (Walton, 2015, Alta P + D 2015)

The paper *Walking and Cycling for Healthy Cities*, discusses the downward trend in cycling and in walking among most industrialized countries. (Pucher and Buehler, 2010) The US has a much larger walking population vs bike riding which relates to Fayetteville. If people are only going to walk then maybe the focus should be on sidewalks and pedestrian bridges. (Walton 2015) Still this paper was relevant as it discusses many similar issues covered in *Walk Bike* and furthermore, focuses on the health aspects behind outdoor activity. (Pucher and Buehler 2010)
It seems that getting people out of their houses and onto a trail or even a sidewalk is a complicated process. Ann Forsyth and Kevin Krizek wrote about this exact problem in the Built Environment Vol. 36. They titled the piece Promoting Walking and Bicycling: Assessing the Evidence to Assist Planners, 2010, but it is a poor title. The actual subject is not so much about the assessment but the failures endemic this type of transportation system. (Forsyth and Krizek 2010) They looked at all current research (numbering more than 300 papers) and summarized the problems that were associated with low ridership. The authors also examined many different policies and identified six common strategies which are similar in structure to Fayetteville’s and the NWA Regional Council’s policies and plans. (Forsyth and Krizek 2010, Alta P + D 2015)

The most important strategy that Forsyth and Buehler 2010 identified for increased ridership is increased availability, not the quality of infrastructure. This paper looks at so many different strategies that they can recommend with some surety which methods are likely to have the greatest return on investment. This was very useful when looking at the data collection methods used and described in the Walk Bike plan. (Alta P + D 2015)
Section 2.3: Non-Academic Sources

I have chosen to include a few bicycling guides and bicycling repair books that are aimed at different skill levels of cyclists. These vary from books that are “how-to” in nature to others that are include commentary on the current state of bicycling. These are not peer reviewed nor do they meet academic standards of citation and structure but nonetheless are a valuable resource.

A book like Bike Snob: Systematically & Mercilessly Realigning the World of Cycling 2010, will have wide appeal and will reach many potential and current riders. This very stylized guide is carried by book stores and of course on-line, the intended audience is the casual biker. These books are often meant to be an introduction guide including everything from bike selection to security and safety. People will buy books like these to learn about cycling and some of these readers may ride Fayetteville’s trail system. BikeSnobNYC is the moniker that Eben Wiess writes under and although his books are bitingly sarcastic at times he does offer some real insights to the problem at hand by addressing traffic interaction. (Wiess 2010)

The Urban Cycle Survival Guide, 2015 by Yvonne Bambrick is another example of snarky but informative guides to cycling in the city. There are many common themes in these books and all of the authors borrow from the same academic sources that I am using. Bambrick lists City Cycling in her references and a number of other reliable sources which helps to validate the information in her book. (Bambrick 2015) This type of book is good example of readability and was compared to the publications produced by city and state for both readability and information dissemination.

In comparison, Grant Peterson’s book does not quote any sources but he is the owner of Rivendell Bicycle Works and has been in the industry since the early 1980s. He wrote Just Ride: A Radically Practical Guide to Riding Your Bike, written as a maintenance guide, this book adds
commentary about the poor state of bicycling. (Peterson 2012) Peterson offers extensive
comments about fit of bikes and this was very helpful when setting up the test bike. (Peterson
2012)

The City of Bikes 2012 by Pete Jordan is a novel based upon the author’s experiences
living in Amsterdam. I chose this as background reading because Amsterdam is supposed to be
the pinnacle of bicycling cities. He offers some insight into the persistence of cycling and how
integration of bicycles took time and has an extensive history. (Jordan 2012) He also implies that
part of the reason that the Dutch do cling so to their bicycles, is that they (the bikes) were taken
away by the Germans during WWII. (Jordan 2012)

Sloane’s Complete Book of Bicycling has a very long subtitle touting that this is the bible
for you, if you bike. This is denser than the other books as far as the complexity of repairs,
completeness of the explanations and is geared to the mechanic at heart. (Sloane 1995) This book
has fewer safety recommendations but still offers some general tips. This is more of an enthusiast
level book but still relevant because it discusses many of the things that affect bicycling
feasibility. This may be the only source that discusses nutrition and diet with some depth and
would be an excellent resource for the person who will ride. (Sloane 1995)

The final book that I looked at out of this group was Bike Mechanic: Tales from the Road
and the Workshop 2014. This book is oriented at the enthusiast and is all about bike repair.
These men worked on a race team and had to tear down and rebuild numerous bikes each day.
(Andrews and Dubashi 2014) In the same way that auto racing influences car design, bike racing
has an enormous effect on consumer bicycles. Racing fans are often avid local racers and may be
advocating for bicycling facilities and access in the city. (Andrews and Dubashi 2014) I wanted
to see how these people talk about bikes and how this talk shapes their perspectives of cycling.
Books like these mentioned will help to increase ridership but they will not overcome the other problems like aggressive drivers, bad roads, topography, and weather.

When you are sitting in your car with the windows up or down there are so many noises and dampening of noises that you really do not have a direct connection to your surroundings. When you are standing over your bike you can hear every vehicle around you, feel the heat from their engines, and taste their exhaust in the air.

Arguably, bike design did influence the viability of some of the data collected. Not all bicycles are the set up in the same way skills vary with different bike riders. Many riders will choose a mountain bike because of its abilities to leave the paved trail, while others might ride a road bike or touring bike because of the speed and handling. What this means is that in the hilly areas of Fayetteville the mountain and city bike styles might be more useful and therefore more ridable because of lower gearing. In contrast roads like Garland Ave or MLK are much flatter and the traffic speed is much faster, in these situations the road or touring style would be more ideal. Some trails are obviously going to more difficult that others especially when your destination is on top of the hill. The maps in Appendix B and C show many of these conditions at a scale that is more understandable.
Section 2.4: Plans, Designs, Current Conditions

I looked at many different bike infrastructure guides in order to fairly judge the local City of Fayetteville plan and the Alta NWA Walk Bike 2015 plan. These have many different origins as some are government publications, some for profit books, and others plans from other cities. The first three publications I have listed are often the basis for all others and are heavily cited as the source for standards and information.

The Urban Bikeway Design Guide (UBDG) is a 2014 publication produced by the National Association of Transportation Officials. This resource combines many techniques from successful bicycle integration programs in the US and abroad. It closely mirrors many of the recommendations and design elements contained in the NWA Regional Bicycle and Pedestrian Master Plan | 2015. Unlike the Alta NWA plan this book focuses more on bicycle infrastructure than it does pedestrian travel. The UBDG was first published in 2011 and has become a standard in the industry.

Next is the Manual of Uniform Traffic Control Design (MUTCD 2009). This book is produced in a digital format which is freely distributed by the Federal Highway Administration. This 800+ page book covers almost every aspect of transportation infrastructure and corresponding signage. This design standard is issued by the United States Department of Transportation in 2009 with addenda in 2012 and 2014. Many of the bicycle specific recommendations in this book are often included in a section for automobiles. (MUTCD 2009) Still this is an important work because it governs the placement and type of all traffic control devices in the US. (MUTCD 2009) This is a relevant source as it lists both Federal laws and recommendations. The MUTCD was used to confirm the proper placement of trail and on-street marking devices.
The previously mentioned AASHTO Guide for the Development of Bicycle Facilities provides many similar layout diagrams for street design. This book is produced by the American Association of State and Highway Transportation Officials with the most recent update being released in 2017. One helpful thing about this guide is that it includes complete definitions and classifications, this is beneficial when reading the text especially when identifying study factors. (AASHTO 2017) This work is more theoretical which is common for many if not all plans and guides but was a good reference for examining the newer street designs. This guide was designed as a universal handbook and because it refers to the MUTCD regularly in its text it makes an excellent companion book because of its simplified presentation.

A non-independent analysis of the Northwest Arkansas Regional Council’s bicycle and pedestrian plan titled Walk Bike: Northwest Arkansas 2015 was released by the Walton Family Foundation. They sought to offer an analysis of the Alta NWA plan that they had funded in part for and what the results mean. (Walton 2015) This might be somewhat tilted in viewpoint but it offers some curious insights into trail usage.

Walk Bike: Northwest Arkansas 2015 was prepared for the Northwest Arkansas Regional Planning Commission by Alta Planning + Design. This bike/pedestrian plan is subtitled: NWA Regional Bike and Pedestrian Master Plan | 2015. This colorful 254-page document was funded by The Walton Family Foundation and it involved “800+ local residents, business leaders, and government staff that participated in the development of this Plan.” (sic) This was achieved through “meetings, events, volunteering, interviews, online mapping, comment forms, and plan review”. (Alta P + D 2015) There are sections covering the analysis of trails and streets covering the geographic region extending from the Missouri border south
through all of Benton county and a substantial portion of the northern half of Washington County, Arkansas.

I also examined the plans released by Fayetteville and a few other cities for comparison that describe how they plan to increase bikeability and walkability. There are two different plans currently covering Fayetteville. The first is the Active Transportation Plan 2015 issued by the City of Fayetteville. This was designed as an educational guide for local citizens to inform them of the direction in planning. This is a long-range plan with an end date of 2040 at which point there should be access within ½ mile to a trail for 97% of citizens in Fayetteville. (Fay Active 2015)

Some of the other cities I looked at nationwide included Boston which released a comprehensive plan in 2013 titled Boston Bike Network Plan. This is similar to the Walk Bike plan and allowed for comparison of recommendations. This plan is somewhat unique among those viewed because it contains different length actions plans (i.e. 5-year plan, 10-year plan) that are clearly laid out and not hypothetical. (Boston 2013)

Fargo-Moorhead Council of Governments in North Dakota and Minnesota respectively, produced a similar plan to those above titled Fargo-Moorhead Downtown Framework Plan Update. Its release date of 2007 might lead you to believe that it would be outdated but it includes actual destinations and how they will be serviced. (Fargo 2007) This is very sight specific and is really an excellent resource for correct procedure. Even though this is an update to a previous plan the complete information makes referring to the original unnecessary. (Fargo 2007) Fargo-Morehead’s plan has many similarities to Fayetteville’s plans and was an excellent source for identifying the shortcomings in the later presentation.
Portland, Oregon has produced a 258-page bicycle plan that is specifically geared towards the needs of bicyclists. One of the reasons that this particular transportation plan was chosen was the inclusion of heatmaps demonstrating areas of need. A heatmap is a density map where a high or low-density area can be shown with color coding. Portland Bicycle Plan For 2030 is unusual in this aspect as most plans identify areas that need expansion without including a visual representation. (Portland 2011) The Walk Bike 2015 plan includes a similar heatmap and was compared to Portland, Oregon’s. (Alta P + D 2015) The Bureau of Transportation included theory, history, and proposed area improvements driven by need. (Portland 2011) I felt that this was one of the best plans and even though is covers a smaller areal extent than the NWA Walk Bike 2015 plan was far more thorough and useful as a planning tool.
Chapter 3: Site Location

Section 3.1: Topography

I chose Fayetteville as the study location because of the convenience of already living here. The physical limits of my study are those parts of the trail system that fall within the City of Fayetteville. A second reason was that there is an established trail system and bike culture even if both need work. Fayetteville is a hilly college town located at the northern end of Washington County, Arkansas. (USGS 2016) Town might be too small of a descriptor as the population fluctuates between the high 70,000 in summer to nearly 100,000 when school is in session. (US Census 2015, U of A 2016) This city is large for Arkansas and because it is

Figure 2: Fayetteville city limits with parks, major roads, and topography of the city. This map was produced in ArcMap using Fayetteville data. (Voorhees 2016, Esri 2016)
transected by rivers, rail, and hills, actually has a small town feel in much of the city. There are a few wide vistas where you can get a feel for the scale of human development but most areas of the city have large mature trees that obscure the houses and businesses underneath. This region is commonly known as Northwest Arkansas (NWA) and is marketed in the same fashion.

Fayetteville is located on the western end of the Ozark Plateau in the Springfield Plateau subdivision. (Bolton 1998, AGS 2015) Which means that there are very large erosional mountains that dominate the landscape and funnel road and home development. This Mississippian era rock is home to some spectacular views, beautiful forests, and wild rivers. (AGS 2015) The Ozark Plateau is an enormous uplift that covers most of the northern third of the state. Much of this region is an elevated ancient seafloor and coastal margin that has been eroded into mountain forms. (AGS 2015) Fayetteville straddles a saddle or ridge that trends East to West. The western end of the saddle has two small mountains and then opens into a wide valley floor to the northwest. The other end of the saddle ends at Mt. Sequoyah which is the middle of town 1000 feet from the historic downtown square. (AGS 2015)

There are many of these hills and mountains within the limits of the city. (USGS 2014) Of those located within Fayetteville: Mts. Sequoyah, Pierce, and Archias effectively divide the town along an East/West axis. Most of the historic buildings on The University of Arkansas campus are located on this saddle. Much of historic Fayetteville sits upon this saddle including the town square, the Dickson street entertainment district, the Mt. Nord neighborhood, and the 1904 Washington County courthouse. (Google Maps 2016)
Section 3.2: Fayetteville Demographics

Fayetteville is in the center of what was originally the Arkansas Territory. This large area covered all the current state of Arkansas, part of Louisiana, and some of Oklahoma. (Bolton 1998) In 1855 the Public Land Survey System began in Arkansas east of Little Rock. (Bolton 1998) By 1832 the population of Arkansas had grown so much the General Land Office opened a branch in Fayetteville and in Washington, which is a small town near Hope, AR. (Bolton 1998) In typical Arkansas fashion there was a serious argument among politicians for remaining Arkansas Territory before the admittance to the Union in June 1836. (Bolton 1998)

University of Arkansas Land Grant college or more specifically a university built because of the Morrill Act This act provided land grants “to establish agricultural and mechanical colleges”. (Encyclopedia Ark 2017) Once the southern states reentered the union they were eligible for the funding provided. Washington County introduced a $100,000 bond issue, and

Figure 3: Demographic data from verified US Census website. 2015 is still being verified but indicates increases in most sections of the population. (US Census 2010)
Fayetteville another for $30,000 for a college. (Moneyhon 1997) Fayetteville’s proposal for a school was selected and in 1872 Arkansas Industrial University opened. This university was renamed in 1899 by the state legislature to the University of Arkansas (Encyclopedia Ark 2017).

The pie charts in figures 3 and 4 were created using data from the U.S. Census Bureau’s Quick Facts website. This data was examined and adjusted for errors by the Census Bureau and any possible deviations are noted and provided. There is a projected population increase of 12% by the Census and I could assume that the increase was uniform but this is highly unlikely. (US Census 2015) One of the key facts I found on the US census was the percent of people below the poverty line in Fayetteville. The total for 2010-2015 is ~24% which means that if we do have a higher than normal ridership among the poor then maybe resources should be focused on this.

Figure 4:2010 US Census demographic breakdown of ethnicities in Fayetteville. (US Census)
demographic. (US Census 2017) (Walton 2015) We have a very high 1300 people per square mile density and a lower than state average age. (US Census 2010) We also have the second highest rate of college education in the state. (US Census 2015) This is supposed to be one of those indicators that you will have a larger ridership. There is a rather low 7% foreign born part and more than 80% identify as white. A full 64% of the people 16+ are shown to be employed and the total for women alone is 57.9%. (US Census 2010)
Chapter 4: Methods

Section 4.1: Academic Theory

The hypothesis that bicycling is not a feasible alternative to cars for daily transportation required more than one approach. The methods of this study were broken into three parts. The first part was an examination of academic writings along with the commercial literature. This subject is intertwined with transportation laws which required the review of legal codes and laws that pertain to Fayetteville. Geographers that focus on transportation as a science were sought out as primary sources. Additional sources included information from researchers who are looking at the more qualitative aspects of bicycling. Some of these authors focus on ease of access while others look at safety. Originally, an attempt was made to eliminate papers concerning perceived benefits. These were qualitative in nature and usually contained an interview component. I hoped that the problem could be examined by focusing only on physical factors like trail quality or the separation of bicycles from traffic.

Commercial literature refers to plans produced by non-governmental agencies. These are the plans and maps relating to the City of Fayetteville’s and the regional bicycle trail systems. Most of these were produced either by Alta Planning + Design or the City of Fayetteville. (Alta P + D 2015, FayActive 2015) An attempt was made to relate the laws that covered design to the biking proposals adopted by local cities. The main comparison to make between these two plan sets (Walk Bike and Fay. Active Plan) is conformity to the standards and ideas set forth in the Federal guidelines. (MUTCD 2009) The private sources are using the same set of concepts for the most part, so much that a page from Portland Oregon’s plan is almost identical to one from Fayetteville’s. (Portland 2011) The current plans being implemented by the City of Fayetteville will not increase the feasibility of riding a bike as a replacement for a car.
Section 4.2: Data Collection

There is a possibility that separate but equal bikeways may be more dangerous because they add a level of complexity to intersections where they are interacting with cars. (Horton 2007) The second part of this study was riding a bike in the trail system. A plan was established to experience the physical state of the current trail system. To confirm the hypothesis that bicycling is not really a feasible form of transportation in Fayetteville when compared to a car, required many contrived or actual journeys. These were intended to simulate the commuting, shopping, or going to a service destination like a doctor’s appointment. One example of a regular trip in this study was commuting to and from work (my office at school); a second example was regular trips to the grocery store.

Some of these journeys contained multiple destinations because it was important to replicate the needs of other transportation forms. Each of these journeys had, when possible, the use of an actual designated bicycle route. This designation was based on the Fayetteville’s transportation department designations. These were provided in the downloadable files (shapefiles) from the city’s interactive GIS website. (FayGIS 2016) The outer limits of the study were also defined by the GIS files. (FayGIS 2016) There are a few trails that start inside the limits of the city but travel beyond the borders. These were examined up to the point that they exit the city. Sometimes the design of the system caused leaving the city for short periods and distances. An example is the intersection of Scull Creek Trail and Clear Creek Trail which occurs outside city limits. This is the point where the Razorback Greenway splits to either continue North to the City of Johnson or East to Lake Fayetteville. (FayGIS 2016)

An additional constraint was the type of surface material of the trail or route. If the trail’s surface was paved then the trail was included. All other types were excluded unless it was a short
section under repair or a connection trail that was still being built. Some trails like those on the East face of Mount Sequoyah or those on the north ridge of Mount Kessler are dirt and are maintained in part by private individuals like Mt Kessler Greenways and Ozark Off Road Cyclists, who want to keep the right of access. Neither of these trail sets were meant for travel or transportation but are recreation oriented. These were also eliminated from the study group.

To track the position of specific problems the test vehicle had a Garmin eTrex 30+ GPS interfaced with twin Garmin Virb cameras. This allowed for the pinpointing of problems and features with a Lat-Long location. The GPS also produced other data including time, day, date, temperature, and crude elevation. The output from this equipment setup was geotagged photos and videos. A second output was .shp (Shapefiles) that are importable into Qgis. This will

Figure 5:This is the bike that I did my data collection with. Because of rain I eventually added a fairing to protect some of the equipment on the front of the bike. Voorhees 2016.
produce ride data such as elevation changes over distance, stop points (traffic signs or other obstructions), and direction of the data ride.

The test vehicle for this project was a Diamondback Insight 1 which is a midrange bicycle designed for city transportation. This is a lightweight aluminum frame and fork bicycle that has 21 speeds and an upright riding position which is a normal design for a city or hybrid bike.

During the initial planning of this study one of the things that seemed important at the time was that each trail should be ridden its entire length. It proved to be nearly impossible when planning the routes because the system is disconnected. Furthermore, by making it a requirement of riding each trail as a separate entity you are creating a destination instead of a journey. I considered the same method for the on-street designated routes but finally chose to combine the two in a unique way. Other abandoned plans included a selection of sidewalk and neighborhood routes to see if they are rideable and safe but a quick assessment of the sidewalks by Google street view changed this plan too. (Google 2016) The riding portion of the study allowed for the beginning development of a rideability index. Each trail section condition will be scored by a combination of the above factors which will result in a number on a scale in an index.
Section 4.3: GIS

A database was created in the program Qgis which is a geographical information system or GIS. The intention of this GIS was to test the hypothesis that the City of Fayetteville’s data could show voids or unsuitable conditions that are affecting the feasibility of biking. This GIS should produce images that will assess the following questions: ‘Is the trail system within an accepted distance to all addresses?’, ‘Is topography a factor in feasibility?’, and ‘Is the placement of current components serving the appropriate areas?’.

This free software is an open source version of GIS and it will duplicate many of the functions of pay-to-play software like the Esri suite. (Qgis 2016) A GIS allows the user to build a virtual world where data can be entered in three dimensions. In this case, the City of Fayetteville has produced most of the files needed to create this 3D environment. (FayGIS 2016) Fayetteville provides and uses a web-based version of Esri software that allows for the sampling and downloading of data. This database has an easy web interface where anyone can access the information and can download the portions that they desire. (FayGIS 2016) Using this web tool, the current shapefiles for streets, trails, sidewalks, building footprints, and the city limits were downloaded and imported into the Qgis database and map.

Two additional files added into the database were georeferenced .tif files, also called DEMs, sourced from the USGS Earth Explorer website. This image type is from the Shuttle Radar Topography Mission (SRTM) and the type is the 1 Arc-Second Global. NASA and the National Geospatial-Intelligence Agency (NGA) worked together to acquire radar data which were used to create the first near-global set of land elevations. (USGS 2016) This image has the actual elevations above sea-level encoded into itself which allows a program like Qgis to build a 3D map where 2D shape files can have the z axis (elevation) added to any processing.
The Walk Bike 2015 regional plan included maps that were made with GIS software but the image quality in the report is so poor and at too small of a scale to have any value. The first goal of the GIS created for this project was to be able to recreate necessary maps. Some of these are from the Walk Bike plan and others are from Fayetteville’s Active Transportation Plan 2015. The second goal is to allow the data collected for this study to be combined with the existing City of Fayetteville data. This will allow for the creation of trail specific maps with identified problems located on the map. Eventually the final goal is to link an active map to a database of images and videos.
The data collected through the Garmin GPS and its cameras was downloaded into a program called VIRB Edit. It converts the video and pictures on the cameras to geotagged versions. The output overlays information onto the image that includes GPS coordinates, current temperature, elevation, speed if moving, direction of travel if moving, and a polyline showing the current track. These are the images to be linked into the map database in the Qgis program in the future.

Figure 7: This is a still image from the Garmin Virb Edit program. The location is Garland Ave. and I was traveling North. (Voorhees 2016)
One of the simple tools in GIS is the buffer. This is usually a color polygon surrounding a feature. In this study buffers were created around all trail and on-street bicycle features. (Shellito 2014) GIS software allows for the creation of a buffer at any distance and for this study 660’ was chosen. In the map in fig. 8 there are breaks in the buffer where it follows I49 along the frontage road. A buffer creates a rounded end shape that extends out a known distance from the line. In this image in fig. 8 the trail is shorter than the buffer because it extends from the end of the line as well as the side. (Shellito 2014)

The creation of buffer maps for the entire system showed pockets of no access to trails and in some case limited access to the rest of the city (Appendix B and C). Some of the unsuitable conditions are caused by the mountains and hills and will never have easy access.
Other pockets are in newer areas of the city limits and may take a while to get any form of trail system because of population density. Additionally, areas near Rupple Road are getting separate bike lanes at the same time they are having a high-density housing boom.

Several problems have arisen when trying to analyze the data in Qgis. The software does do most of the functions that ArcGIS does but fails in this respect. There is a simple tool in ArcGIS called “Near”. This tool looks at one single item at a time (an address point) and then calculates the distance to the nearest object type that you specify (in this case a trail). (Esri 2016) This works very well in the ESRI software where the address field has thousands of entries and the trail system has many segments or lines to be included into this calculation. The City of Fayetteville GIS website was the source for addresses used in processing. (FayGIS 2016)
shapefile has a complete address column along with a segmented address so that you could
search by street or house numbers. There are 48840 entries or rows which need to be sorted by
whether the city designated the address as being residential.

Once the data was classified into these two groups the Near processing tool was used in
ArcMap to add a distance to trail and in a second shapefile the distance to on-street designated
routes from all residential addresses. This same process was repeated with the business addresses
or those designated as nonresidential. A visual check was made using Google Maps and Bing to
verify that the locations were indeed business or commercial in some aspect. (Google 2016) This
does include some addresses that are strictly storage yards for industry and others that seem to be
fallow lots. On the other hand, the residential addresses do match up with actual homes and
apartments in the city. (Google 2016, FayGIS 2016)

The download function of the city’s GIS website allows you to specify an area of interest
using a couple of different border shapes. A simple rectangle tool was used which meant that all
of the layers except the city limits contain data outside of the city. I used Qgis to trim or clip this
data so that what remains are only those features that exist within the city. This is a standard
function in GIS and both Qgis and ArcMap can do this operation without error.

There is a somewhat curious aspect about how the City of Fayetteville creates the
metadata in there GIS file output. Some of the column names are confusing or cryptic and many
of the entries are left blank for individual features. (FayGIS 2016) When looking at columns the
obvious choice for the residential homes would have been to label this column either residential
or with the heading “type”. Qgis and Arc work well with binary data so either heading would
work. Fayetteville labeled the column “Resi” and then gave the binary choice of “Y” or “N”.
(FayGIS 2016) This did make the sorting easy as the software can look at a specific attribute like
this column and choose only those that had “Y” as an entry but it adds to the human interpretation time.

Once the data was sorted, previously mentioned Near tool was used in ArcMAP to generate the distances. (Esri 2016) Qgis does not have a comparable tool that works but a python code work around might be possible. The ESRI tool takes several common python functions and converts them in to a single GUI for functionality. (Esri 2016) There is a possibility that the tool can be recreated with script in python and might have to run outside of Qgis to function. This is a topic that I plan to research in the future because of the functionality of the rest of the software.

Figure 10: This map shows an area that is undergoing rapid growth that includes bicycle infrastructure. The red addresses in the lower left are older homes along roads built without sidewalks, curbs, or shoulders. (Qgis 2017, Google 2017),
The fact that the tool does not currently exist is unfortunate because it means there are limitations to the low-cost alternative of using an open source software for this type of analysis.

The original Near tool allows for the selection of specific features (address points) to measure the distance from and which other features (this time a polyline representing trails) that are the target locations. The tool then looks at each individual point and that is incorporated into Arc using Arcpy which is according to the ESRI help pages:

“This package provides a rich and native Python experience offering code completion (type a keyword and a dot to get a pop-up list of properties and methods supported by that keyword; select one to insert it) and reference documentation for each function, module, and class.” (Esri 2016)

I am currently working in collaboration with Boundless, which is a Qgis fork that is focusing on education and collaboration, to create a tool or plug-in solution for nears limitations.
Section 4.3: GIS Data Sources

Building a GIS or geographic information system requires a certain type of computerized data. A GIS is a virtual world where geolocated items can have data associated to themselves. An example is a point or dot on a map. (Shellito 2014) This point is called a feature and can have information like an address stored in a table. The table will contain columns with headings like: Address, Address Number, Build Date, Residential v Commercial, etc. This is simplified for clarity because GIS operators often use much more cryptic headings like “Add_Res” eliding two words together with and underscore. This is done in part to make the name more computer friendly but often makes them far less user friendly.

The City of Fayetteville hosts their GIS data in a web based platform. (FayGIS 2016) As a user you have many options, you can select the area of interest often abbreviated A.O.I. or AOI. Next the types of data you desire are selected, for example streets and buildings, followed by the format that you need to download. I chose the ESRI standard .shp file (shapefile) because both Qgis and ArcMap can readily open them without conversion. I selected layers for the city limits, streets, sidewalks, trails, on-street bike routes, plots, addresses, building outlines, and parks. (FayGIS 2016) Of course, the actual names are formatted more like this: “Structures___Building_Footprint_2016”. This gave me a flat virtual world where the items have a georeferenced location.

Elevation data was produced by downloading Shuttle Radar Topography Mission (SRTM) digital elevation models (DEM). (Ramirez 2014) A simple explanation is that the Space Shuttle flew around the world for a period of 11 days in February of 2000. It used a system called Synthetic Aperture RADAR (SAR)

On September 23, 2014, the White House announced that the highest-resolution topographic data generated from NASA’s Shuttle Radar Topography Mission
(SRTM) in 2000 was to be released globally by late 2015. The announcement was made at the United Nations Heads of State Climate Summit in New York. Since then the schedule was accelerated, and all global SRTM data have been released. See the full JPL Release 2014-321. Previously, SRTM data for regions outside the United States were sampled for public release at 3 arc-seconds, which is 1/1200th of a degree of latitude and longitude, or about 90 meters (295 feet). The new data have been released with a 1 arc-second, or about 30 meters (98 feet), sampling that reveals the full resolution of the original measurements. (Ramirez 2014)

The release of finer resolution data means that this DEM set can be used for free to simulate the actual terrain in a GIS. As the satellite or Space Shuttle flew over the surface it sent out a radar pulse that bounced back from objects on the surface. (Shellito 2014) As the shuttle moved along its flight path it received a return of the original signal creating a simulated larger antenna. The repeated returns or bounced back signal to the antenna allows for finer precision of detail and location. (USGS 2016)

All other layers, features, and rasters were generated using Qgis processing functions. The Only exception to this is the address layer was processed using ArcMap because of the Near function which is discussed elsewhere in this paper. (ESRI® 2017) These layers include trimmed city files that are limited to the city limits. Also generated was a series of rasters showing density in the form of a heatmap, ruggedness (slope percent), relief (simplified colorized elevation), and aspect. These maps and others are contained in appendices.
Chapter 5: Results and Conclusions

Section 5.1: Law Analysis

One of the first issues that I want to focus on is the law and how bicycles are supposed to fit into the transportation network. I feel that in general there is a misunderstanding or ignorance of the laws, statutes, and codes which is a real driving factor of feasibility. If there is not a definite place or role in this network that everyone understands then how can the average bike rider feel safe or feel that they are part of this network?

The first results I want to discuss deals with the search for the laws and codes that cover bicycles in Arkansas and more specifically, Fayetteville. Initially, this was going to be an analysis of the laws but I realized it needed to contain a review of how these laws and rules are disseminated to the public. There are of course, multiple layers to these codes and not all of them are very clear in their intent. At the local level, the Fayetteville city code has a specific bicycle section Title VII, Chapter 73, which is divided into ten sub-sections each dealing with a specific subtopic. (FayCode Ch.73) The law is vague at times and required me to make assumptions. In the example below this city code does require some clarification of the terms reasonable and prudent.

73.06 Speed No person shall operate a bicycle at a speed greater than is reasonable and prudent under the conditions then existing. (FayCode Ch.73)

I lived in Montana when the speed limit was reasonable and prudent, we traveled everywhere at 90+ mph.

Fayetteville’s code regarding bicycles recently underwent several revisions at the end of 2015 due to a disagreement as to whether bicycles have equal access to the roadways in the state. (FayCode Ch.73) In the previous incarnations of the code §73.04 and §73.05 limited a bicyclists access to a roadway if there was a parallel bike trail, “Whenever a usable path for bicycles has
been provided adjacent to a roadway, bicycle riders shall use such path and shall not use the roadway.” (FayCode Ch.73) The second section referred to sidewalk usage, “No person shall ride a bicycle upon a sidewalk within a business district, except those sidewalks which run along a collector street or a minor or major arterial street when so designated and marked as a bicycle route.” (FayCode Ch.73) These sections drew complaints from locals but was also mentioned in the study commissioned by the Walton Family Foundation.

Fayetteville’s codes were compared to state laws pertaining to bicycles in order to determine if Fayetteville’s code does not exceed its authority as it did in the above-mentioned section 73.04. It is important to remember that the local codes can be more stringent than those at the state or national level. What they cannot do is limit access that is guaranteed at the state level.

Figure 11: This map shows that Arkansas is one of two states where a bicyclist has complete access to the road. Arkansas excludes bikes in the definition of a vehicle. Used with Permission. Gutierrez 2017.
In the future, it would be prudent to establish a database of local, regional, state, and national level laws along with the many codes. This would allow a comparison of codes between other cities of roughly the same demographics.

Arkansas is one of two states where bicycles have equal access to the road the other is North Carolina. (Gutierrez 2017; Mionske 2007) We as Arkansans are lucky in this aspect because if you look at Gutierrez’s maps or examine the laws in Mionske’s book you will see that most states are very restrictive concerning bike access to the roadway. Gutierrez summarized all the restrictions in the excellent map shown in fig.11. Nebraska might be the most restrictive as they are the only state with a mandatory single file always law. A larger version of this map in fig.11 is included in Appendix A. Nebraska also includes Far to Right, Mandatory Side-path, and Local Regulation Allowed. (Gutierrez 2017) It appears the officials in the rest of these states feel that bicycling is somehow a hindrance that needs to be curtailed at the side of the road.

An early assumption in preparing for this study was that the laws either local or state were in some way restricting the ridership levels. There is not a helmet mandate, a requirement to wear a helmet, in Arkansas or Fayetteville for adults, which can sometimes affect ridership levels. (Washington Post 2013) There is a state and local requirement for a headlight that has to be seen from 500’ and the added cost of this equipment might limit the poorer members of the populace from riding after dark. (A.C.A. § 27-36-220)

The State of Arkansas publishes the Arkansas Driver License: Study Guide to prepare drivers for obtaining a license to operate a car. There is no state requirement for drivers training so the average citizen will be relying on this book for their understanding of the road rules and laws. (Arkansas 2016) There is a small four-page section covering interaction with bicycles named “Sharing the Road with Bicycles”. In this section, we see in the first line that bicycles
have equal access to the road. The book states that “Bicycles”, not bicyclists, “have the same rights and responsibilities on the street that drivers do”. (Arkansas 2016) This is not the only grammatical error in the book but if you can look past these you will see that the book does a decent job explaining the rules and some of the actions that the typical rider might take and why.

An example of this is;

> when cyclists are traveling past parked cars, they tend to move away from the cars, toward the center of the lane. This is to avoid injuring or being injured by, persons getting out of those cars. (Arkansas 2016)

Other sections cover topics such as “Safety Tips For Motor Vehicle Drivers”, “Residential Areas Are Danger Zones”, and “Lane Position For Bicycles”. (Arkansas 2016)

The “Safety Tips” portion cover how to interact with the bicyclists while driving on the same street. (Arkansas 2016) While many possible dangers or conflicts are pointed out the description are either too brief or really should have an accompanying diagram or image for clarification. Almost all of the situations described in this section point out that the car driver is usually the problem in the meeting between bike rider and car operator. (Arkansas 2016) Why this is important in the scope of this study is that almost every situation described in the list occurred while collecting data for this thesis. For example, there was elderly woman who did not have her left-hand turn signal on and nearly ran into the front of my bike. She intended to turn left and her entire focus was on looking both ways and not straight across. Once she left the stop sign at Spring and College she looked forward with surprise.

A second incident involved multiple problems. I was at a stop sign waiting to proceed straight ahead. A small car pulled up to the left of my bike at the same sign. Once cross traffic was through the intersection I started forward and so did the car, it was attempting to outrun and turn in front of me to go to the right. Halfway through the intersection the car driver finally came
to a complete stop and threw up his hands in disgust because I was in his way. It is very unlikely that the driver even knew that he was in the wrong or that the law would give me the right-of-way in this case. (Arkansas 2016) The state law does include a section for cars that deals with overtaking a bicycle rider. It clearly explains the minimum of 3 feet required between the vehicle and the cyclist when passing and that if this space is not allowed that there is a fine up to $100. This section also limits the state fine for killing or injuring the cyclist to $1000. (A.C.A. § 27-51-311)

Who has the right of way at an intersection has long been a point of contention on American roadways. Bob Mionske mentions this in bicycling and the law, he mentions that It has long been law that a bicyclist must place at least one foot on the ground to be called a legitimate stop. (Mionske 2007) I had stopped in this fashion and because of the cross traffic so it was obvious that I was waiting at the intersection. On the other hand, the car driver only stopped momentarily and then preceded forward at the same time as I did. Technically, I was in the right but the law does not guarantee that I have the “right of way”. This is clearly defined or made more obscure by the following passage taken from the Driver License: Study Guide.

Where vehicles or pedestrians are likely to converge, and there are no signs or signals to regulate traffic, there are rules that indicate which vehicle must yield the right-of-way. These rules indicate which vehicles goes first and which vehicle must wait in different traffic situations. AR Governor’s Commission on People with Disabilities April 2007

The law indicates which vehicle must yield the right-of-way; it does not give anyone the right-of-way. A driver must do everything possible to prevent striking a pedestrian or another vehicle, regardless of the circumstances. (Arkansas 2016)

I point this out because not only do drivers fail to realize that these laws do apply to unusual vehicles like bicycles, they do not seem to understand the rules at all.
I am a Better Driver than You Think: Examining Self-Enhancement for Driving Ability

2013 by Roy and Liersch is cited by many other publications and is quoted in many articles. This attention may be due in part to the fact that these researchers have attempted to prove what we all seem to know. Most people overrate or overestimate their own ability to drive and they believe that others do not understand the skills and rules of driving. (Roy and Liersch 2013) If this is true can we expect the average Fayetteville driver to be any better than average? Roy and Liersch focus on the fact that people have a self-assessment but feel that others would misjudge those skills and not rate the driver as high in ability. (Roy and Liersch 2013) Furthermore, these same people still rated themselves high in ability even after being given definitions by produced by the National Safety Council (NSC) that contradicted their own ideas. (Roy and Liersch 2013) The participants only assessed themselves honestly when instructed to use only the NSC guidelines and not their own definitions. (Roy and Liersch 2013)

Arkansas has provided the law and the education materials to drivers but may still need to focus on more public education about bicycles and their place in the transportation infrastructure. Much of this State produced material covers the points where bicycles interact with automobiles and is not specifically about bicycles. The City of Fayetteville has codes that cover bicycles and there are even some federal guidelines to consider along with the state laws and it would be useful to put them all in one place or book. Neither the federal or local laws are readily available to the public, at least not in an easy to get book form.
Section 5.2: Transportation and Trail Implementation

The second aspect to focus on is the difference between theory and practice concerning bicycle integration. This will include some pieces on perception, space utilization, marketing and a few other social factors that seem to have driving influences on participation and feasibility.

Many of the integration ideas are similar to but not included in the American Association of State Highway and Transportation Officials (AASHTO 2014) Guide to Bikeway Facilities. There are also hints of the Urban Bikeway Design Guide 2014 which is also cited in many of the transportation plans I examined. The authors do point out that the recommendations contained within the Urban Guide do fall within the recommendations of the MUTCD. These three publications provide a framework for any city or urban area to incorporate bicycles into the transportation network. Instead it is common to unintentionally treat cycling as a strictly recreation activity even if the intention was transportation. Although the Urban Guide is a recent publication 2014 it is not offering any groundbreaking ideas but is instead providing a visually based manual that has diagrams, charts, and photos that help the reader to assess and design the needs for the individual sections of street. (AASHTO 2014)

In most cases, it is unlikely that any books or guides produced will contain site specifics unless you are the example site being used in the text. It is one thing to make a cursory overview of the problem but another far more serious task to categorize every flaw in a transportation system. Walk Bike: Northwest Arkansas 2015 was supposed to do this in part and may at some level that was not released to the public. They may have been privy to the GIS generated during the study which would also allow them to generate their own suggestions and run further analysis.
The design recommendations in the *Walk Bike* 2015 plan are taken from other sources that are readily available and are ideas or concepts not specific suggestions. The actual street traffic control designs are taken directly from either the MUTCD or the AASHTO guide. The type of analysis done by Alta Planning + Design should have already been understood by the local planning engineers. These are basic GIS functions and they already had most of the necessary GIS built for other purposes.

The main source for these guidelines here in the US is the MUTCD which is published by the U.S. DOT. Most the design changes that Alta Planning + Design recommended came from this book and the American Association of State and Highway Transportation officials or AASHTO Guide for the Development of Bicycles Facilities. (AASHTO 2014) So, if the money that the Walton Family Foundation donated only purchased this information then it was not well spent.

On the other hand, if you consider the organization that went into the town hall style meetings, questionnaires, and general data collection and analysis then it is money well spent. It was the news coverage and word of mouth alone helped to generate a lot of support for the idea if not the practice. (Alta 2015) Here is the rub. If you can muster support to build a trail system and even continue to expand the same system without vocal opposition, then why are the ridership numbers so low? The summary covers some of the data collection methods and states that the numbers for ridership were based off the collection and aggregation of the three busiest trails. (Walton 2015) They collected data at many more locations but only a few came close to these ridership totals. (Walton 2015)

What they do not say is what was ridership like in the comparison cities on the rest of their systems. If we really only have 7-8 busy routes but the other cities have twenty then this is a
poor comparison. The city wants to spend money to improve the share of bicycle transportation on the road. If they are using inflated numbers or questionable numbers to make these decisions then we will not see an increase in bikeability or feasibility. (Walton 2015)

What we find in these publications is a how-to guide to organize a street system often with the perception of bicycling as an afterthought. What very few of these plans address is ridership. Furthermore, they fail in providing concrete plans to get people on bikes who are willing to commute daily. The lack of solid numbers for commuters will continue to sideline bicycling as a recreation activity instead of a form of transportation. (Walton 2015)
Section 5.3: Weather

The weather has proved to be one of the greatest contributing factors in daily commuting by bicycle. During the summer, it was not unusual for the temperature to reach the 90s and even approached 100º on a few days. Preparing to ride on these hot days required extra steps that would not be required in a car. First, I needed to find sunblock, a hat, and sunglasses. These things might be desired by the car driver but are not really necessities in the same way they are for a cyclist. Second, I carried a large amount of water or took the time to have preplanned stops where water was available, this was crucial and quite difficult to judge. For example, I brought two liters of water on the data collection ride on Crossover Rd. I consumed the entire amount by the time I reached the halfway point of this journey on the southern end of Springdale. Knowing that the temperature and humidity were both forecasted to be high, I planned additional water stops for the return trip.

Prior planning does increase the feasibility of traveling even when the weather was very hot. There are very few free public water fountains in Fayetteville which is a further limiting factor in refilling water supplies on the go. On the Crossover Rd. ride, the return trip was planned so that two water fountains were on the way. Both were provided by the city and located on trailheads in the Lake Fayetteville Park. Unfortunately, and each of these locations is only available seasonally.

There are other sources for water when the park fountains are off for winter. Many of these locations are public or semi-public like the fountains in the Northwest Arkansas Mall or those on the University of Arkansas campus. Neither of these locations shows water access on their maps but a local rider should be able to locate these facilities. Cyclists could also use the fountains in grocery stores and fast food establishments but this might be frowned upon by the
management if you are not making a purchase. Furthermore, it assumes that private businesses should take the responsibility for providing services that should be included in bicycle system design.

Once the decision has been made to ignore or deal with the intense heat, I then set off for the destination. If this was a short (less than a mile), easy (little if any elevation change) ride, then I might get a little warm but the water I brought with helped keep me cool and energized. On a longer hard run like the five miles from MLK to the NWA Mall on the Razorback Greenway which has two climbs of 30 and 40 meters, I was sweaty and tired by the time this journey was finished even though it was a nice day.
Subsection 5.3.1: Rain, Fog, and Other Precipitation

As the subsection heading indicates it is time to talk about rain. There are two very important sides to rain and rain type events. The first is the condition of the streets and the second is the equipment of the rider. The condition of the street is crucial for safety because of the need to be able to avoid the other commuters. Take offs are not really a problem as it is rare the rider will spin out the traction tire, unlike with cars and light trucks. Turning though can be a big problem, especially on fresh black-topped asphalt, because of reduced grip caused by water and suspended road grit. Stopping becomes the most problematic because of reduced traction and reduced efficiency of the bicycle’s brakes. The cars surrounding the rider will be having many of the same problems but do not have the added risk of toppling over onto their sides.

The second side is the rider’s equipment. A raincoat can be good for keeping dry but the material that keeps out the rain also keeps in the heat. This is actually mentioned in a few of the

Figure 12: A very high humidity day caused excessive condensation on both sidewalks and streets. Voorhees 2016.
non-academic sources in fact Grant Peterson swears by a poncho instead of a jacket because of sweat. (Peterson 2012) I think riding bike with a raincoat is feasible if it is not too long or has a hood because the length will interfere with mounting and dismounting and the hood reduces peripheral visibility to the point of being dangerous. On the other hand, I can see Peterson’s point since a coat will not protect the fronts of the rider’s thighs or the shins both of which catch a lot of rain. Rain pants can be worn to combat this but will also add to the heat containment and could produce a dry but sweaty rider.

Sunglasses are a must for keeping out the sun but yellow tinted ones work well if the amount of rain is light. There is a point though, in a downpour, where the glasses become a liability because the water will not shed fast enough to see. A proper hat with a brim is the only way to ride when the rain is this heavy. The bicyclist should be going slow enough due to other conditions that keeping a hat on their head will not be a concern. The final piece of gear to consider is the shoes. I often brought an extra pair of shoes on most rain event ride days because it seems impossible to keep my feet dry.

Several modifications were made to the bicycle to limit the spray from the tires and impact of the rain. A set of fenders was installed front and back, this helped reduce the water splash above the ankle but are still ineffective on the bottom at shoe level. Further modification can and will be made to reduce the drenching effect of riding through water but there is a limit to what can be deflected without dramatically increasing wind drag. The bag and rack system I use is quite water repellant and the items stored inside arrive dry even in a heavy downpour. The trailer system has a built-in rainfly that deploys from a bag mounted to the frame. This is very effective in keeping the water out of the trailed goods. When used with the supplied bag
things stay dry if I take care in deep puddles. These additions have made wet weather commuting and errand running more feasible because some things can be kept dry even if I could not be dry.
Subsection 5.3.2: Snow and Ice

Although I have a lot of life experience riding a bicycle in the ice and snow so far, as of 2/4/2017 I have only been able to ride in these conditions one time. Because ice and snow are so infrequent here it does not make a lot of sense to modify the bike to match the conditions. When I lived in Minnesota we made our own studded ice tires because we might have to ride on slippery streets for months at a time. Snow and ice tires are available for most common adult tire sizes but the price is much higher than that of a normal tire. A cursory search on Nashbar, REI, and Niagara Cycle shows starting prices of ~$37 at Niagara which carries many discount off-brands to well over $200 for some of the larger 29-inch tires. (Nashbar, REI)

This is very close to the same price you would pay for a small car tire but most bike tires are rarely rated for more than 2000-4000 miles. (Williams 2017, Livestrong 2017) Tire life is a common topic on biking fan websites, riders of course all have personal favorites and usually brag about high mileage. A similar quality tire that is not studded but has a more aggressive

Figure 13: The snow and ice cover is very thin but this was very difficult to ride on because my rear tire did not have any traction. Spring St. at Washington Ave. Voorhees 2016.
snow pattern can be had for about half the cost but this may not be ideal since we are more likely
to get icing than we are to get snow. (Nashbar, REI)

This is the “crux of the biscuit” to quote the late Frank Zappa. Bike riding can be done
safely in winter if the surface is loose or packed snow and you have an aggressive tread. I have
years of experience riding in the winter in Wisconsin and Minnesota on different bike types and
never felt the need for studs until later in the winter when the freeze thaw cycle happened every
day. Ice is an entirely different problem and without studs the tires will slide sideways throwing
off the balance of the rider and possibly causing a spill.
Section 5.4: Sidewalks

There are those who prefer to ride on the sidewalks when traffic is difficult or heavy. While this might seem like a safer alternative the actual condition of the walks varies dramatically in condition and structure. At times while doing data collection I chose to use this alternative for the same reasons and sometimes just because I was too tired to maintain a reasonable speed in traffic. West Wedington Dr. and both the north and south portions of Crossover Rd. are examples of 4-5 lane streets with wide sidewalks that work well as side-paths. There are other streets scattered throughout the city, where this type of sidewalk would be desirable because of traffic loads. Many of these like MLK jr. Blvd., 15th St., Garland Ave. and portions of College Ave have very poor-quality sections of sidewalk. Most have sections where there is not a sidewalk nor is the shoulder wide enough to allow the rider to stay out of the main traffic.

Figure 14: Example of crumbling sidewalks along S. School, this section eventually ends in grass without leveling. Voorhees 2016.

Figure 15: This section has a better surface but the cracks are continuous and the weeds harbor bits of glass and other sharp trash. Voorhees 2016.
These two images show the opposite ends of existing older structures. The road edge in fig. 16 is very common inside of city limits, entire sections of the city do not have sidewalks, curbs, or water control. This area in fig. 16 has a number of townhome developments that have sidewalks with handicap cuts at corners. Once they leave the development they are faced with this type of road to bike on.

The sidewalk shown in fig. 17 is located in an area with very few houses but it has a wide path, a 2 foot grass boulevard, a curb, and water runoff control. If you look close at the surface the black staining on the concrete is mold or similar because the surface never gets used.

This was actually something I noticed in older residential neighborhoods. The sidewalks turn
black because they are not used but the driveways stay gray because the tires scrub the concrete.

I have seen a number of obstructions placed on the sidewalk like the sign in fig. 18. Often it is a sale sign either for the property of for a special price at a business. I think that not walking is so common that many people would not think it is rude to put their sign on the sidewalk. In fact they might be trying to save the lawn sprinkler from damage because this sign is huge and heavy.

This is also a problem on the city square at times and along Dickson St. because businesses use sandwich boards to display special prices and sales.

Figure 18: This sign was on the sidewalk at the Northwest Arkansas Mall. The small amount of buildup at the base might indicate that is had been there for a while but that could have been from the lawn care experts. Voorhees 2016.
Section 5.5: Intersection Flaws

One of the many problem intersections within Fayetteville is the intersection of Spring Street and College Avenue. Spring St. is two-way and runs East and West. College is a four-lane trending North to South. The bicyclist riding on Spring has good signage letting you know how far it is to other trails and locations. Unfortunately, there is not any signs or markings informing the cross traffic on College street that you might cross.

Upon approaching College, the rider is not warned about the number of lanes to cross but there is a stop sign so you will have time to look at the intersection. The same conditions apply when approaching the intersection from either direction except that the eastern approach has a steeper grade. You do have four lanes of traffic to cross so fatigue could be a factor.
While the rider is approaching this intersection, they can should be relaxed about the fact that they have equal access to the road and should be able to cross when it is their turn. Let me repeat that, there is not any crosswalk paint, crossing lights, or even a bike crossing ahead sign to warn the auto drivers that they might have to interact with a bicyclist or pedestrians at the next intersection. The MUTCD has clear requirements for this type of crossing and unlike many of the bicycle crossing recommendations these are mandatory. (MUTCD 2009)

What this intersection needs first is the cross-walk markings. If this is done at an off-peak time it might not be noticed at first but will help drivers to realize there might be someone crossing at the intersection. The second step should be to install signs along the North/South route (College Ave.) to warn the drivers of possible crossing attempts. The third step would be to install a crossing light or a standard traffic light to aid the bicyclists. This of course should only

Figure 20: A map of a proposed change for the Spring street on-street shared route. North is the top of the map and this is also the direction with the lower elevation change. Voorhees 2016.
happen after an actual traffic study with load calculation has been completed. The cost of a light might not be worth it if there is limited traffic crossing or attempting to cross here.

An alternate plan would be to redirect this portion of on-road bicycle traffic through the old library parking lot and out onto Dickson Street (fig. 19). Part of this is already a bike route with signs and some remaining sharrows. The intersection at Dickson has crosswalks that are already marked, a people button to aid walkers, and sensors that are sensitive enough to pick up a bicycle when in the correct lane position. Not only would this save cost as far as the crossing is concerned but would make the travel easier as the Dickson/College intersection is much flatter and therefore easier to take off and get up to speed than the one just a block away at Spring.

A second problem with this location is that it does not seem to actually have the numbers to support making any changes. Rarely do I see more than one or two riders in a day and this hardly justifies the expense of any form of light. It makes sense to move this route one block to

Figure 21: The intersection of College Ave. and Dickson Street. This is one of the few lights in this section of town that has both people buttons and sensors that will see bikes. Voorhees 2016.
the North where the grades are less steep and the light system is already in place. Furthermore, Dickson is supposed to be the entertainment district so why not make it more bicycle friendly?

I do feel that Spring street should stay or remain as a dedicated on-street route from College to N. West Avenue where the rider can join the Razorback Greenway. This is also a nice low traffic route to access several popular entertainment locations in this area. This section of the city is relatively flat and allows for easy travel. Furthermore, the streets in this area are wide and well-marked so there are not any questions about the rider’s place in the system.

The Fayetteville recently installed a miniature roundabout at the intersection of Spring Street and N. School St. They removed all four stop signs and installed many directional and caution signs in their place. This new form of traffic control is a very old idea but one that has little adoption in the area. This experiment only lasted a few months and I did not notice any mention in the local newspaper or on a Google news feed about the removal or the results.

Figure 22:A temporary roundabout, Spring St., and N School Ave. This experiment only lasted for about three months. Voorhees 2016.
College avenue has a complete bicycle/pedestrian crossing with signs and a stoplight for cars and trail users between 6th and 15th avenues. The Razorback trail system intersects with the street but there is not a cross street at this same location. The trail originates from Walker Park to the East. Walker Park lies between W/E 7th street on the North side and W/E 15th on the South. To the West are connections to go North on the Greenway or West on Tsa-La-Gi.

Figure 23South School Ave. the Razorback Greenway is 300 feet ahead and this is your only warning about the pushbutton controlled crossing. This sign is considered optional by Federal regulations. Voorhees 2016.

This image in fig. 23 shows the only warning sign for car drivers that they are approaching the Razorback Greenway where it crosses S School. The crosswalk lights do have signs but they are not legible at this distance of ~300’. According to the MUTCD there should be an additional sign at the crossing itself depicting both a bicycle and a pedestrian or just a bicycle.
There needs to be an arrow sign directly below this pointing at the crossing. (MUTCD 2009) The crossing is the connection for Walker park and the surrounding neighborhoods to the area along MLKjr Blvd. west of School Ave. This was College Ave at the top of the hill but as you head south and down the hill this street changes name. First, it becomes Archibald Yell named after the second governor of Arkansas. It winds down to the bottom of the hill traveling four blocks south and five blocks west on a winding chicane where it becomes S. School Ave.

One of the aspects that is mentioned in the summary of the NWA Trail Usage Report is that the number of low income ridership is higher than normal. (Walton 2015) If the Walton summary is correct and we have a larger percentage of the poor population riding bikes, then placement of multiple crossings in this area was money well spent. (Census 2010) Another group that might benefit are the residents of two very large student oriented apartment complexes that have easy access to the trail. One of these on School Ave. is currently being used by the University of Arkansas and the sign on the front proudly names the building Varsity House. This is a demographic that is far more likely to ride bike or walk if they are not taking the bus. (Pucher 2010) A combination of the high use group and the high need group might help to increase funding and expansion in this area of town. Many of the on-street designated trails and some of the off-street trails enter into an area inhabited by the poor and by university students. (Census 2010) These are the demographics that the city of Fayetteville should be focusing on for increasing ridership.
Section 5.6: Signs and Traffic Control Devices

One of the main problems with wayfinding in Fayetteville is the poor state of the signs and street markings on the older parts of the system. There are some problems with the new section but these are related to design and not wear. As you can see in these four images the on-street markings for shared roads, called “sharrows”, are in varying states of disrepair. Each of these is on a road that needs to be resurfaced in the near future so hopefully these will be replaced at that time. The first and clearest symbol is from Willow Ave. and even though it looks intact has very little reflectivity left in the paint. (Fig. 24)

The second more faded symbol is from Spring St. where it climbs the hill from Willow to College Ave. This one might actually reflect if it was washed, it is as much dirty as it is worn away. (Fig. 25) The next symbol on the following page in fig. 26 is an example of very extreme wear or damage. The majority of the older symbols are more likely to look like the

Figure 24: This sharrow on Willow Ave. no longer reflects light, this might be residue because a puddle builds here when it rains. Voorhees 2016.

Figure 25: The paint is worn on this sharrow but it also has a very thick residue built up on it. This is a point on Spring St. where people accelerate to make the hill towards college. Voorhees 2016.
first two but occasionally I found symbols like this. (figure 26) This sharrow is on a short section of Washington Ave. and has been repaired a number of times. The entire street really needs to be resurfaced as there were other areas not in the photo in similar states. The top surface of the asphalt has actually torn and flowed sideways leaving a rough crumbly section.

Wear like this is dangerous because it will hold water during and after rain. Sometimes organics and mud build up in the cracks and pits making the whole thing slippery. This makes riding more difficult and increases the chance that you will get something nasty on your bike and clothes.

The following signs are considered waymarkers or wayfinders and have certain regulations they must meet. The pair are from Spring St., one near Block St. and the other near College Ave. The first one is mounted correctly for height but is too close to the road. (Figure 27) The MUTCD says that this setback should be at least two feet for all sign types.

Figure 26: This is an example of excessive wear along with surface failure underneath the symbol. Voorhees 2016.

Figure 27: Spring Street near N. Block Ave. Poor sign placement increases hazards and damage. Voorhees 2016.
regardless of function. (MUTCD 2009) The sign could include a bicycle symbol but this is a recommendation in most of the guidelines not a requirement. (MUTCD 2009)

The Washington Ave. sign post has a second sign (fig. 28) that is a good example of proper layout and contrast. (MUTCD 2009)

This is mounted at the mouth of a small road that is more like an alley. The post is only a few inches away from the roadbed. (MUTCD 2009)

It is interesting that the sign directs the rider toward Dickson St. as one of the possibilities since it is not a bike route. It is ideal as a future route and planned this way in the Walk Ride plan. (Alta D+P 2015)

The sign in fig. 29 is one of many new ones installed along the Razorback Greenway. This sign does not conform to the standards set forth in the MUTDC. Chapter 9, which is specifically about bicycle traffic control devices which states “Section § 9B.01 02, All signs shall be reflectorized for use on bikeways, including shared use paths and

Figure 28: Washington Ave./Spring St. intersection bike direction sign. Voorhees 2016.

Figure 29: New direction sign in Walker Park for the Razorback Greenway. This sign does not conform to Federal standards or recommendations. Voorhees, 2016
bicycle lane facilities”. (MUTCD 2009) The sign color is not standard but is acceptable by regulation. The placement is at the correct minimum height and minimum distance from the trail. (MUTCD 2009). It is visually stange that the sign points away from the trail especially when viewed from the west. Furthermore, the contrast between the cream or tan color background and the thin blue letters is not striking enough to be legible at any great distance. Another portion of the sign that is pushing the rule is the arrow in the upper section. By regulation there should be a single arrow for each destination on the route. (MUTCD 2009) Also, 9B.20 07, states that each bicycle destination should have a bicycle symbol before the name.

The new signs may not conform to the standards but they are a vast improvement over the previous version in figure 30. This sign is four feet from the trail and faces the trail but not the people traveling on the trail. It is reflective so that is better than the replacement but the N and the S in the arrow are only one inch high and difficult to read unless you slow down.

Figure 30: Older style of Razorback Greenway guide signs. This one is too close from the ground and is only legible at slow speeds and close distances. Voorhees 2016.
Section 5.7: GIS Results and Output

The hypothesis for the GIS portion stated that the output of this software should produce a visual representation of the City of Fayetteville that would demonstrate regions of limited access or unsuitability. There are four appendices that contain this output. The first shows general conditions on a city-wide scale. The second set shows elevation and aspect. The first part, elevation, was derived from SRTM data and is accurate enough to show dramatic changes. Aspect was also derived from this same dataset. This is the direction that the hill slope faces. This is crucial knowledge for visibility at sunset and sunrise. The second set also shows elevation but has a slope change characteristic represented at the same time. If an area stays within an elevation range but constantly pitches up and down it may not be the most feasible route. The software could show proximity with some errors. GIS also produced topography and rate of slope change both of which are considered key factors in rideability which affects feasibility.

Figure 31: Although this looks like a strange elevation of Fayetteville, it is actually the population density of houses per 660 feet and then representing that figure as an elevation. (Qgis 2016)

One of the many outputs that I can generate from Qgis and the data from the City of Fayetteville is a Java based display based on map features. (Fig. 31) This output produces images based on the data but allow for some visual manipulation of data in non-standard ways. In fig.
31, I used the address file from the city to see how close houses were to each other and where were the greatest concentrations. I chose the distance of 660 feet for the calculation which is half the comfortable distance. (Alta 2015) As you can see in this image there are extremely large population clusters near the University and on the western side of I49 due to apartment building groupings. The green color in the image represents a buffer of ¼ mile around all trails. In places where the trail placement matches density the tops of the peaks are green.

Figure 32: Population density calculated by using residences address features. This is not the actual population by address. (Qgis 2017)

As I stated before the 3D image in figure 31 used a heatmap as the data for the peaks. This same data is shown in fig. 32 except that the projection is flat or 2D so the variations in data are represented by corresponding variations in color. The address file from the city was sorted
for those classified as residential or not. (FayGIS 2016) Once this was finished two new shapefiles were created one for business the other residential. This allows for two separate heatmaps to be created one for each set.

The simplest explanation for what a heatmap is starts with the color. The darker can mean either a whole lot (cluster of zombies) or very little (gas stations in the high plains). If it is something dire it is often represented in red or orange but this is a Western interpretation of the colors, so it is important to know your audience. Each pixel of the map is supposed to represent a measurable value in the map. (Esri 2016) If the algorithm for the heatmap is crude there may be

![Heatmap Image]

Figure 33: Population density calculated by using non-residence address features. This is not the total number of businesses because some entities have more than one location. (Qgis 2017) some blending of data which will lead to misrepresentation and misinterpretation. Like the map for the residential addresses, this map in figure 33 used the 660’ measurement to look for other
Figure 34: This map shows that the majority of the trail system components falls within a certain elevation band (365-420 meters) in the city. (Qgis 2016, SRTM 2016)

businesses within the radius. There are fewer businesses so the size of the high-density areas is more compact and follows 71B closely. If you review the larger version of this map in the appendix you will more readily see that the trails and on-street routes are west of this strip where they closely follow the riparian zones. Accessibility between the trail system and 71B is limited by the hills and other physical obstructions for both cars and bikes.

This map shows a simplification of the elevations along with the trail and on-street components of the bicycle system. The majority of these components follow or rest within a narrow range of elevations. Another thing to notice is that the bike system does not extend into the eastern arm or the southern end of the city. (FayGIS 2016) There are many low to mid
income homes in parts of both sections but neither has access to the inner portions of city by bike. (US Census 2010)

Figure 35: The topography and waterways of Fayetteville. The darkest brown region in the center of the map is Mount Sequoyah. (Qgis 2016, Fay GIS 2016)

One of the biggest factors in making quick time while running errands is the hills. Fayetteville’s grade changes can be subtle but are often quite long. The slope for individual areas are too complex to represent at this scale or the larger scale version in Appendix B. The elevation variation in this map is <200 meters, the highest and lowest points occur outside of the city limits. Substantial portions of the city are at a similar level and the cycling is actually quite excellent. A topographical problem is that the riparian zones and the hills limit the options for traveling from one region or area to another, add in the railroad running North through the center of the city and the options or improvement are further restricted.
The image above shows the riparian zones that are in the limits of the city. A riparian zone is that area that abuts a stream, river, or other waterway. If it is healthy and wide enough it protects the stream and helps with flood control. The city has put a number of trails in this zone especially parts of the Razorback Greenway. When we have rain events or rapid melts from snow and ice these streams swell and the trail goes under water. This is very common on Scull Creek Trail which is the backbone of the system here in town. If the main roadway in town became impassible when it flooded would people complain?
The map in figure 37 shows a muted City of Fayetteville boundary with all the data collection routes placed on top. Each of these routes has a report that occurs in Appendix D that details the length, route taken (with map), elevation profile, and temperature if I brought that sensor with me for the ride. I have included a reduced size sample in figure 37 to show some of the output from the Garmin reports. (Basecamp 2016) This particular sample covers the Razorback Greenway which is supposed to be the backbone of this system here in Fayetteville. (Garmin 2016, Qgis 2017)
This same report is included in the appendix, along with one for each route. I had hoped to use the maps from these reports but the output is limited by copywrite limitations in the software. (Garmin 2016) The same maps when viewed in Basecamp show more streets and other details, but the output does not.
Section 5.8: E-Bike or Electric Bicycle

Using an electric bicycle instead of a standard pedal powered bicycle might increase ridership because it would help to flatten the hills or at least the effort needed to climb the hills. There are a few limitations to this transportation form including a mandatory federal speed limit of 20 mph. Electric bicycle have become a hot topic and have inspired new legislation in some unusual places. California has one of the most clearly described set of laws. One thing that they seem to be doing better than anyone else is classifying the many types of two wheeled transportation available. Although it is not mentioned in Fayetteville’s code, there are state and federal laws that limit the speed of an electric bicycle but not a human powered one.
Section 5.9: Conclusion

If you consider all the variables that go into riding a bike and compare them to those of driving a car you will see that the infrastructure for most cities is set up to benefit the cars. In Fayetteville, this is very true and it is unfortunate. When you look at the several factors that have been discussed it is easy to see that riding a bike on many days is very feasible if you do not have a large hill in your way. If you compare biking to a driving a car, you will see that you eliminate many of the minor problems because a car is an enclosed environment. Rain does not soak your clothes when you drive a car especially if you have an umbrella to get you from house to car then from car to destination. Because of the infrastructure problems, topography, and weather it is not feasible to ride a bike as an everyday replacement for an automobile.

Most of the factors that I have pointed out are minor and would not affect the feasibility of repeated trips. In combination, the task becomes unwieldy on some days and impossible on others. For example, even if the signage is horrible in your part of town you should be able to find your way to the store faster the second time. Your own wayfinding skills whether literal (written directions with street names) or visual (that house with the red door looks very familiar) will shorten the time required and if you have good spatial skills you may find alternatives that are faster.

All the weather extremes discussed can be dealt with no matter what the conditions. If it is too hot more water and sun blocking clothes will help and if it is too cold more layers will work on most days. Unfortunately, having to bring extra clothes for a day when it is raining heavily or just too hot not to sweat is an inconvenience. This requires extra preparation in clothing before and after, may add to the laundry bill, and adds to the time required each day.
The city is rapidly improving sidewalks along portions of 71B between Prospect and E North St. This may be because of the plans to put in a crossing at Rebecca which falls on the South end of these improvements. Although they are continuing to strive for an improved bicycle transportation system, they are not actually fixing the current street network. Over time the city will become more accessible but there are hundreds of miles of improvements that will have to happen before it is ever really feasible.

For an occasional trip or even a majority of trips biking is a feasible alternative to a car. There are far too many variables to be able to say without doubt that a bike could not be ridden every day. The enthusiasts of the world will always make the rest of us look lazy or weak. For the average person in good health it is not feasible to ride a bike as a complete replacement for a car.

If it were possible, a recommendation would be made to the City to change their current expansion plans into a one of maintenance and overhaul. The currently approved plans still focus on riparian zones as the main component and do not address the failures in the central portions of the city. Endless beautiful trails are nice but when there are less than 1000 people riding on them in a week it makes more sense to spend money on the streets not trails. The city needs to finish with sidewalk expansion, road resurfacing, and remarking of the current on-street routes. Other problems like failure to place signs were needed also need to be addressed as this is a Federal requirement and not an option. (MUTCD 2009) There is plenty of opportunity for improvement in this system and over time some of these infrastructure problems will be solved. Until then ride carefully.
Bibliography


Websites


Authors AGS. *Ozark Plateaus* Arkansas Geology Survey. © 2015 State of Arkansas.  


Appendix A

City of Fayetteville, AR Named Bicycle Routes.

Below is a partial chart of the named trails inside of Fayetteville city limits. The second and third columns are designations applied by the city and will require clarification of several of the terms. This is only a partial list because in some locations or trails the city data set divides the trail at each intersection creating duplicate listings in this chart. This data was extracted from an attribute table that was downloaded from the City of Fayetteville. (City of Fayetteville 2016)

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<tbody>
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Appendix B: GIS Maps

The following series of maps shows the relationships between various portions of the bicycle system and addresses classified as either being residential or business by the City of Fayetteville in the attribute tables. No differentiation is made between business addresses that would or would not receive customers or visitors, also some addresses are future homes that have not been built but an address has been assigned. This is more common in sub-divisions but is seen where a house has been torn down. An example for business is a storefront where customers stop vs. a cross-town warehouse where they store overstock. This data was downloaded through the City of Fayetteville GIS Website and USGS Earth Explorer. All maps in this series use the following coordinate system for projection: NAD83(2011) / UTM zone 15N.

Series A

City Limit Conditions. The first Maps (Series A) cover the city as a whole and are designed to show one or more conditions. This series includes a general road map, city street map, data collection routes, address density and natural factors.

Series B

Elevation and Aspect. These maps show addressees classified by proximity to the trails, buffers on the trails, and other features. The base map is an Elevation DEM combined with an Aspect DEM. The first shows elevation above sea level and the second shows the cardinal direction of Slope. The elevation is displayed with some transparency so that the Aspect can accent the look of the slope. This is like the hillshade effect but allows for more subtlety in design and hopefully more clarity about the topography.

Series C

Ruggedness/Slope Aspect. This series shows some of the same features as the Elevation and Aspect but also includes the ruggedness of individual pixels. There are going to be areas
where the topography will not match precisely but trends over long areas are more accurate. An example is the long grade on the Razorback Greenway that intersects with Maple St.

**Series D**

**Parks and Their Influence on Near Function Output.** This series shows how a trail that is located in a park but does not exit a park can influence the near tool output. These isolated parks have a proximity to the nearby houses and this causes addresses with poor connectivity to the rest of the city to be symbolled “green”.
GIS Maps:

Series A: City Limit Conditions

Maps:                                                                                          Page

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- The City Streets, Fayetteville, AR .......................................................... 93
- City Wide Map of Data Collection Rides, Fayetteville, AR ...................... 94
- Density and Trails, Fayetteville, AR (Business) ...................................... 95
  o Heatmap based on 660’ radius
- Density and Trails, Fayetteville, AR (Residential) .................................. 96
  o Heatmap based on 660’ radius.
- The Natural World, Fayetteville, AR ...................................................... 97
  o This is a simplified elevation overlaid with ponds, lakes, and rivers.
- Trails and Hills, Fayetteville, AR .......................................................... 98
  o Further simplification of elevation with trails showing that a majority occur in a very narrow band.
- Bicycle Trails in Riparian Zones ............................................................. 99
- Equitable Bicycle Laws, (Dan Gutierrez 2016) ....................................... 100

All maps in this series use the following coordinate system for projection: NAD83(2011) / UTM zone 15N.
These are the combined data collection routes overlayed onto the City of Fayetteville. I attempted to cover as many areas of the city as possible especially those areas that have limited service from the bicycle system.
The greatest density or concentration of businesses happens to the east of the Razorback Greenway. There is little access to this area from the Greenway and once you get to the 71B corridor there are no bike lanes and incomplete sidewalks.
Trails and Hills
Fayetteville, AR

The hills and saddles that cross the center of the city have shaped placement of many parts of the current bicycle trail system. Almost all of these routes are on level surfaces or areas with limited grade changes...

Elevation Groupings
Vector Simplification
- 310 - 365
- 365 - 420
- 420 - 474
- 474 - 529
- 529 - 584

Trails and Hills
- Grid
- Fayetteville City Limits
- On Street Routes
  - Trail Type
    - 4
    - 6

Each section of this Grid is 2.5 miles wide (13200 Feet) by 2 miles tall (10560 Feet).
Figure 39: Only two US states, Arkansas and North Carolina have equitable bicycling movement laws. All the rest either allow local regulation, or have FTR and other bicyclist specific restrictive/discriminatory movement laws. (Gutierrez 2016)
**Series B: Elevation and Aspect.**

The following maps include a grid key to show placement of the maps within the city. These maps also feature buffers of 660’ to show coverage of the trail system. The trails are coded by type. Elevation is keyed by color and is in meters using SRTM images. Aspect is the compass direction the slope is facing but helps to accent sudden elevation changes. All maps in this series use the following coordinate system for projection: NAD83(2011) / UTM zone 15N.

<table>
<thead>
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<th>Maps:</th>
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<td>Razorback Greenway North</td>
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<td>Northwest Central Residential</td>
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<tr>
<td>Joyce Shopping 71B</td>
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<tr>
<td>North Crossover/Botanical Gardens</td>
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<td>Northwest Wedington</td>
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<td>North Central Wedington</td>
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<td>University Farm I49</td>
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<td>I49/71B Junction</td>
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<tr>
<td>South Central</td>
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<tr>
<td>Southeast/Pump Station</td>
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The blue number in the upper corner of each Grid section indicates the number of addresses contained in the section.

Each section of this Grid is 2.5 miles wide (13200 Feet) by 2 miles tall (10560 Feet).
Series C: Ruggedness/Slope Aspect. This series of maps includes Ruggedness which is a change in slope expressed as a %. Also included is a buffer that represents 660’ from the centerline of the trail to show coverage of the trail system. The points representing the addresses are color-coded by their distance from a trail component. Elevations are in meters and are produced from SRTM images. All maps in this series use the following coordinate system for projection:
NAD83(2011) / UTM zone 15N.

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Series B: Parks and Their Influence on Near Function Output.

This is not the total number of parks within the limits of Fayetteville. Only those that had a City of Fayetteville designated trail inside the park that also influenced the near calculation have been included. The data from the other parks in this series has been preserved. All maps in this series use the following coordinate system for projection: NAD83(2011) / UTM zone 15N.

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Appendix C: Route Descriptions/Maps Garmin Basecamp Reports

The following pages contain the output reports from Garmin’s Basecamp software these were originally multi-page pdf’s but have been cut down in size by eliminating the individual waypoints. This data has been preserved in its original GPX format and in the output pdf format. I used BaseCamp version 2.3.1.0 © 2008-2016 Garmin Ltd. This software is downloadable and allows for the home user to review and plan trips. The information available in the raw files includes the Lat-Long for the points along the route and an estimated elevation based on location and triangulation by the GPS and GLONASS satellite networks. The following copyrights cover the output of the software and the software itself.

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The reports each carry a title that I have carried over into Qgis and have the summary statistics. The raw unfiltered reports vary in length from just a few pages to more than fifty depending on the length of the trips. Unfortunately, each report does generate a page number and there is no way to turn this off during export. Please continue to use the page numbers at the bottom of the page.
Graph

Statistics

Summary
Points: 336  Distance: 4.6 mi  Area: 0.1 sq mi

Time

Speed
Avg: 3.7 mph  Avg Moving: 6 mph  Min: 0.0 mph  Max: 25 mph

Elevation
Min: 1275 ft  Max: 1417 ft  Ascent: 332 ft  Descent: 324 ft  Grade: 0.0 %
Graph

Statistics

Summary
Points: 754  Distance: 10.4 mi  Area: 0.1 sq mi

Time

Speed
Avg: 8 mph  Avg Moving: 9 mph  Min: 0.1 mph  Max: 24 mph

Elevation
Min: 1223 ft  Max: 1429 ft  Ascent: 677 ft  Descent: 670 ft  Grade: 0.0 %
Graph

Statistics

Summary
Points: 217  Distance: 3.0 mi  Area: 742519 sq ft

Time
Elapsed Time: 0:44:36  Moving Time: 0:20:56  Stopped Time: 0:23:40

Speed
Avg: 4.0 mph  Avg Moving: 9 mph  Min: 0.0 mph  Max: 22 mph

Elevation
Min: 1317 ft  Max: 1570 ft  Ascent: 248 ft  Descent: 345 ft  Grade: -0.6 %
Graph

Statistics

Summary
Points: 106  Distance: 1.5 mi  Area: 0.1 sq mi

Time
Elapsed Time: 0:12:52  Moving Time: 0:12:52  Stopped Time: 0:00:00

Speed
Avg: 7 mph  Avg Moving: 7 mph  Min: 0.9 mph  Max: 23 mph

Elevation
Min: 1238 ft  Max: 1393 ft  Ascent: 174 ft  Descent: 75 ft  Grade: 1.3 %
Graph

Statistics

Summary
Points: 1177  Distance: 16.2 mi  Area: 0.1 sq mi

Time

Speed
Avg: 8 mph  Avg Moving: 9 mph  Min: 0.0 mph  Max: 22 mph

Elevation
Min: 1227 ft  Max: 1413 ft  Ascent: 779 ft  Descent: 788 ft  Grade: -0.0 %
Harps Grocery Run: 14 JUN 2016 10:11

Graph

Statistics

Summary
Points: 403  Distance: 5.5 mi  Area: 0.4 sq mi

Time

Speed
Avg: 2.0 mph  Avg Moving: 5 mph  Min: 0.0 mph  Max: 16 mph

Elevation
Min: 1319 ft  Max: 1456 ft  Ascent: 402 ft  Descent: 437 ft  Grade: -0.2 %
Graph

Statistics

Summary
Points: 691  Distance: 9.6 mi  Area: 2.8 sq mi

Time

Speed
Avg: 1.9 mph  Avg Moving: 8 mph  Min: 0.0 mph  Max: 21 mph

Elevation
Min: 1249 ft  Max: 1486 ft  Ascent: 758 ft  Descent: 678 ft  Grade: 0.2 %
Graph

Statistics

Summary
Points: 510  Distance: 7.2 mi  Area: 1.3 sq mi

Time
Elapsed Time: 0:51:27  Moving Time: 0:41:58  Stopped Time: 0:09:29

Speed
Avg: 8 mph  Avg Moving: 10 mph  Min: 0.1 mph  Max: 103 mph

Elevation
Min: 1188 ft  Max: 1447 ft  Ascent: 397 ft  Descent: 221 ft  Grade: 0.5 %
Graph

Statistics

Summary
Points: 1421  Distance: 20.2 mi  Area: 0.1 sq mi

Time

Speed
Avg: 8 mph  Avg Moving: 11 mph  Min: 0.0 mph  Max: 23 mph

Elevation
Min: 1197 ft  Max: 1517 ft  Ascent: 1121 ft  Descent: 1240 ft  Grade: -0.1 %
Graph

Statistics

Summary
Points: 249  Distance: 3.3 mi  Area: 0.1 sq mi

Time
Elapsed Time: 1:16:06  Moving Time: 0:30:52  Stopped Time: 0:45:14

Speed
Avg: 2.6 mph  Avg Moving: 6 mph  Min: 0.0 mph  Max: 25 mph

Elevation
Min: 1139 ft  Max: 1409 ft  Ascent: 292 ft  Descent: 351 ft  Grade: -0.2 %
Graph

Statistics

Summary
Points: 924  Distance: 12.8 mi  Area: 4.0 sq mi

Time

Speed
Avg: 6 mph  Avg Moving: 8 mph  Min: 0 mph  Max: 29 mph

Elevation
Min: 1201 ft  Max: 1495 ft  Ascent: 993 ft  Descent: 928 ft  Grade: 0.1 %
Graph

Statistics

Summary
Points: 244  Distance: 3.2 mi  Area: 0.4 sq mi

Time
Elapsed Time: 0:39:00  Moving Time: 0:35:17  Stopped Time: 0:03:43

Speed
Avg: 5 mph  Avg Moving: 5 mph  Min: 0.4 mph  Max: 20 mph

Elevation
Min: 1413 ft  Max: 1546 ft  Ascent: 345 ft  Descent: 382 ft  Grade: -0.2 %
Graph

Statistics

Summary
Points: 399  Distance: 5.6 mi  Area: 0.3 sq mi

Time
Elapsed Time: 0:51:27  Moving Time: 0:48:31  Stopped Time: 0:02:56

Speed
Avg: 7 mph  Avg Moving: 7 mph  Min: 0.2 mph  Max: 22 mph

Elevation
Min: 1357 ft  Max: 1735 ft  Ascent: 671 ft  Descent: 682 ft  Grade: -0.0 %
**Statistics**

**Summary**
Points: 311  Distance: 4.4 mi  Area: 0.1 sq mi

**Time**

**Speed**
Avg: 5 mph  Avg Moving: 8 mph  Min: 0.0 mph  Max: 26 mph

**Elevation**
Min: 1355 ft  Max: 1524 ft  Ascent: 461 ft  Descent: 461 ft  Grade: 0 %
Neighborhood ride south of center: 21 JUN 2016 12:39

Graph

Statistics

Summary
Points: 410  Distance: 5.7 mi  Area: 0.7 sq mi

Time
Elapsed Time: 0:41:55  Moving Time: 0:40:40  Stopped Time: 0:01:15

Speed
Avg: 8 mph  Avg Moving: 8 mph  Min: 0.1 mph  Max: 22 mph

Elevation
Min: 1142 ft  Max: 1297 ft  Ascent: 315 ft  Descent: 365 ft  Grade: -0.2 %
Graph

Statistics

Summary
Points: 1656  Distance: 23.1 mi  Area: 13.6 sq mi

Time

Speed
Avg: 7 mph  Avg Moving: 9 mph  Min: 0.0 mph  Max: 26 mph

Elevation
Min: 1155 ft  Max: 1500 ft  Ascent: 983 ft  Descent: 1177 ft  Grade: -0.2 %
Graph

Statistics

Summary
Points: 690 Distance: 9.6 mi Area: 2.6 sq mi

Time

Speed
Avg: 5 mph Avg Moving: 8 mph Min: 0.0 mph Max: 21 mph

Elevation
Min: 1249 ft Max: 1486 ft Ascent: 744 ft Descent: 674 ft Grade: 0.1 %
Statistics

Summary
Points: 243  Distance: 3.4 mi  Area: 0.8 sq mi

Time
Elapsed Time: 4:27:24  Moving Time: 0:27:07  Stopped Time: 4:00:17

Speed
Avg: 0.8 mph  Avg Moving: 7 mph  Min: 0.0 mph  Max: 18 mph

Elevation
Min: 1212 ft  Max: 1423 ft  Ascent: 206 ft  Descent: 254 ft  Grade: -0.2 %
Graph

Statistics

Summary
Points: 107  Distance: 1.5 mi  Area: 401033 sq ft

Time
Elapsed Time: 0:58:24  Moving Time: 0:12:40  Stopped Time: 0:45:44

Speed
Avg: 1.6 mph  Avg Moving: 7 mph  Min: 0.0 mph  Max: 18 mph

Elevation
Min: 1360 ft  Max: 1465 ft  Ascent: 161 ft  Descent: 215 ft  Grade: -0.7 %
Graph

Statistics

Summary
Points: 592  Distance: 8.6 mi  Area: 0.4 sq mi

Time

Speed
Avg: 0.4 mph  Avg Moving: 6 mph  Min: 0.0 mph  Max: 22 mph

Elevation
Min: 1253 ft  Max: 1555 ft  Ascent: 495 ft  Descent: 351 ft  Grade: -0.3 %
Graph

Statistics

Summary
Points: 996  Distance: 13.7 mi  Area: 2.7 sq mi

Time
Elapsed Time: 2:02:43  Moving Time: 1:34:45  Stopped Time: 0:27:58

Speed
Avg: 7 mph  Avg Moving: 9 mph  Min: 0.0 mph  Max: 27 mph

Elevation
Min: 1199 ft  Max: 1428 ft  Ascent: 607 ft  Descent: 593 ft  Grade: 0.0 %
Appendix D: Physical Factors for Rideability Index

These are the factors that will be used in the creation of a rideability index number. A number of physical factors will be considered when examining the condition of a route including:

Surface Material
  Asphalt
    New,
    Cracked or other damage
    Repaired with top coat
  Concrete
    New
    Cracked or broken
    Spalling
    Too slick (either wear or surface prep)
  Unfinished

Color and Type of TCD Marking Material
  Paint
    New
    Old Damaged
    Non-Existent
    Reflectivity
  Curbing
    When separating from traffic only
  Sharrows
    Condition
    Reflectivity
  Signs and Signage (Directional and TCD)
    New and meets MUTCD
    Old faded or damaged (legibility)
    Stolen/Missing
    Not Present

Width of trail or lane
  MUTCD and AASHTO guidelines

Intersections
  TCDs
  Surface

Lighting
  Trail Only Areas (not part of normal street system i.e. Scull Creek Trail)
The physical factors listed above will be weighted so that a final score can be generated for each section of a trail system. Some factors not covered above but that will also be included is slope changes over distance, proximity of trail system components to addresses, and connectivity. The last two will be generated in a GIS using density for address placement and routing for the trail system components. Routing means to follow the designated paths or streets to a destination. If the trail system is placed out of the way like the Razorback Greenway the connections to the street system can be inconvenient and add distance to the trip.

Once the physical portion of the index is created it can be applied to a city to score the system. A score might cause some routes to be used while others are avoided. A second portion of a really effective index would include perceptions of the system by all levels of rider ability. With a large enough sample size individual traits or comments about the system can be quantified. Then the identified factors can be located in the GIS if they exist in the city. An example would be a dislike of crossing a four-lane road like College Ave. without the protection of a crossing signal. The Spring street intersection does not have a crossing aid and would warrant a low score whereas Dickson St. has a crossing aid and would receive a higher score.

The final goal is a plugin or standalone tool for use in ArcMap or Qgis that can be hosted on a webpage with a searchable address/score function. Additionally, a score along a chosen path will be generated and individual sections can be rated for rideability.