CYCLING AND THE CITY: AN ANALYSIS OF THE URBAN DESIGN - URBAN CYCLING RELATIONSHIP

by

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(Under the Direction of Mary Anne Akers)

ABSTRACT

This thesis explores the relationship between urban design and urban cycling. It begins with a historical review of the bicycle in urban environments and then sets out to answer two central questions; How does urban design affect cycling? and How does cycling affect urban design? Urban design features play an important role in whether people choose the bicycle as their mode of transportation. This thesis seeks to identify ways that cities influence cycling. Alternatively, cycling can have a significant impact on urban design. This thesis explores how and where cycling affects urban design, and the implications of increasing cycling's modal share. A series of case studies are used to highlight current design efforts on a domestic and international scale. Finally, the thesis takes a local focus and through a design component, applies the theoretical framework to the Prince Avenue corridor in Athens, Georgia.

INDEX WORDS: City, urban, design, bike, bicycle, cycle, landscape architecture

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

If one were to look, they would find that in the United States, cycling is used as a mode of transportation for a small percentage of all trips taken. A few cities have managed to significantly increase the local volume of cycling, but on the national level cycling represents just one percent of the modal share.[1] This is despite more than thirty years of advocacy for cycling in this country. During the 1970's, the advocacy for cycling increased at the local level. By the 1990's, the U.S. Government took a prominent role in promoting cycling with the passage of the Inter-modal Surface Transportation Efficiency Act (ISTEA) in 1991, and with the Transportation Equity Act for the Twenty-first Century (TEA-21) in 1998. Together, these acts substantially increased the amount of funding for bicycle and pedestrian facilities; but even with this additional funding, attracting cyclists in urban environments has proven difficult.

Designers of cycling facilities struggle with the issue of where and how to safely accommodate cyclists on roadways. Facilities range from fully separate bicycle lanes to bicycle lanes in the roadway and on sidewalks. Another common goal of many bicycle master plans is the development of a city-wide network of bicycle routes. More recent efforts include the incorporation of items such as bicycle traffic signals and roadway painting treatments that guide cyclists through complex intersections. The common theme running through all these efforts is that the focus of cycling design is on the roadway itself. Providing a safe space for cyclists is and should be a priority for cycling, however, there are many examples of safe and spacious bicycle lanes that fail to attract a significant volume of cycling.

Attracting new cyclists must include education, training, and promotion, and cannot rest with the construction of facilities. Simply creating cycling facilities does not necessarily translate into a demand for their use. However, in many instances it is the supply of cycling facilities that precedes the physical demand for them. In such cases, bicycle lanes and other facilities are constructed before a significant volume of cyclists exist and rely on a predicted cycling load. At times this "if you build it they will come" approach does satisfy an existing demand for cycling facilities, however, in many cases the demand portion of the equation does not materialize. The result of this approach is the proliferation of underutilized bicycle facilities that fuel criticism of spending on such facilities. Greater efforts at advocacy and promotion are needed to make bike lanes successful, but even these do not guarantee an increase in cycling.

One reason that cycling facilities fail to attract significant volumes of cyclists, even with promotion, is that designs focus on providing a place for cyclists in the road. The problem with this approach is that it neglects the fact that existing streets could easily accommodate thousands of bicycles. "As cycle activists are fond of saying, 'we already have a comprehensive system of cycle routes, covering the whole city and connecting every origin with every destination: the problem is that it is full of cars.'"[2] While this statement provides a different view of urban streets, the point that it makes is somewhat simplified. It is true the existing streets go everywhere that cyclists need to go, but the problem is not that the roads are full of cars. The problem is that people either cannot, or do not, choose to cycle.

An individual's decision to cycle is based on many factors. Space and safety are two considerations, but there are many others. When making a transportation decision, individuals weigh the costs and benefits of walking, bicycling, transit, and driving. Time, distance, comfort, convenience, cost, safety, environmental stewardship, and status are just a few of the factors that go into the decision. Bicycle lanes may provide cyclists with a greater sense of safety, but this is not enough. Ultimately, the choice of transportation is based upon a comparison of the alternative modes, and the one that is most compatible with an individual's needs is selected. If cycling is to become a significant mode of transportation in the United States, then it must be competitive in the factors that influence a person's choice of transportation. Unfortunately, design efforts which focus solely on the road are not sufficient to address all the issues relevant to the decision making process. A broader framework for cycling design is needed.

In this thesis, cycling design is explored as a relationship between urban design and urban cycling. Approaching the subject from this perspective provides a framework for understanding not only how to design for cycling, but also how cycling influences urban design. The following chapters examine the relationship between cycling and the city, and focus on two central questions; "How does urban design affect cycling?" and "How does cycling affect urban design and urban living?" Chapter Two provides a brief history of cycling, with a focus on the United States. In Chapter Three, the effects of urban design on urban cycling are discussed. Urban characteristics such as urban form, architecture, vegetation, weather and topography are just a few of the elements that influence urban cycling. These features ultimately contribute to a positive or negative cycling experience and consequently determine the attractiveness of urban cycling. Chapter Four examines the impact of bicycles on the urban environment and the opportunities they present. One finds that bicycles save space (compared to automobiles), move silently through the city, and produce no air pollution. These elements provide an image of how urban cycling can affect cities. In Chapter Five, a series of case studies are explored in order to provide a clearer image of the urban design - urban cycling relationship. Both domestic and international examples are profiled, and the cities range in size from small college towns to large metropolises. Chapter Six begins the design portion of this thesis and applies the principles discussed in the previous chapters to the Prince Avenue corridor in Athens, Georgia. Through this approach, an alternative view of cycling design is presented, which considers the roadway not simply as a medium, but rather as a place. In this thesis the roadway as a medium is considered, but as part of a larger relationship between cycling and cities.

Chapter 1: Notes

[1] Charles Komanoof and John Pucher, "Bicycle transport in the US: Recent trends and Policies." Sustainable Transport. ed Rodney Tolley (Cambridge: Woodhead, 2003) 450.

[2] Rodney Tolley, The Greening of Urban Transport. (New York: John Wiley and Sons, 1997) 18.

CHAPTER 2

HISTORICAL PERSPECTIVE

The bicycle has gone through many evolutions before transforming into its present form. The first iterations of the bicycle appeared as early as 1791 in Paris. This early form was "probably a development of a children's toy, in the form of a wooden horse with wheels for hooves, it consisted of a rough wooden bar supported on two sizeable wheels and carrying a padded saddle. The rider propelled it by thrusting his feet alternately against the ground and could only deviate from a straight course by leaning or banking."[1] This form took the name of "Celerifere," but many other names have been used to describe the bicycle over its history. Hobbyhorse, Swiftwalker, Dandy-horse, Draisine, Celeriped, Velocipede, and bone shaker are just a few of the names by which various versions of the bicycle have been called.[2] (Figure 2.1)

The work of successive inventors' versions of the bicycle created improvements which slowly transformed the bicycle from an advanced form of walking into a fully independent mode of propulsion. Around 1816 or 1817, Karl von Drais added the steering mechanism to the bicycle and by 1838 Kirkpatrick Macmillan devised a method to propel the bicycle without touching the ground.[3] Rubber tires were widely available by 1869 and replaced earlier iron clad versions.[4] By 1879, the earliest form of the modern bicycle complete with pedals, rear wheel chain drive, saddle, and rubber tires appeared.[5] (Figure 2.2) These transformations made cycling popular, and by the 1890's cycling entered its Golden Age.

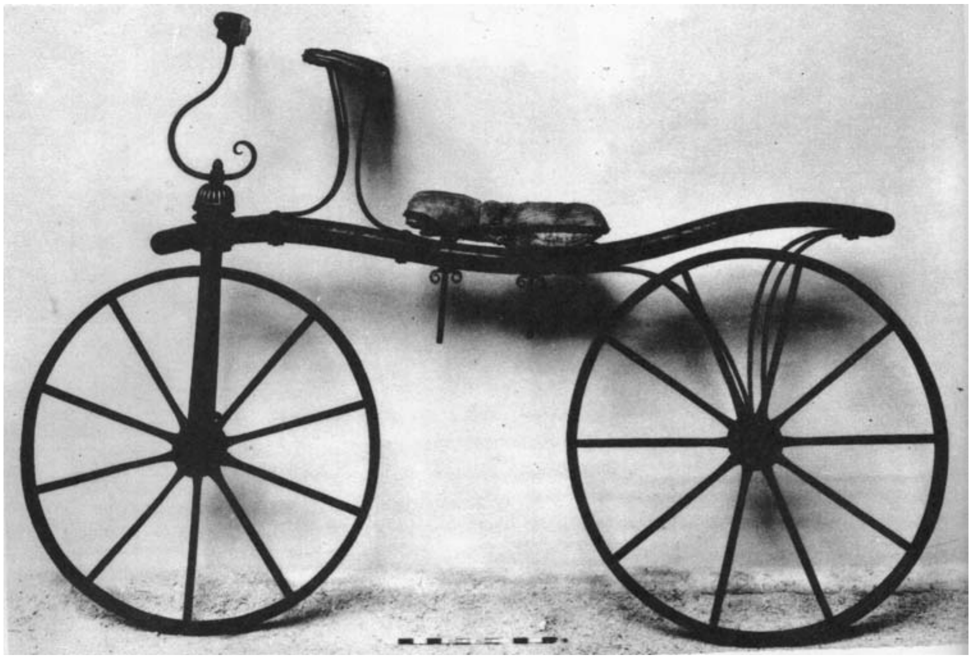

Figure 2.1: Early bicycle, circa 1818. Source: Palmer 1956, 28.

Figure 2.2: Bicycle circa 1885. Source: Palmer, 1956, 89.

Despite the growing volume of bicycles in the 1890's, there are few accounts of the history of bicycle use in urban environments. Historical accounts typically focus on the bicycle as an invention, or as a form of recreation (Figure 2.3). This is in part due to the fact that bicycles evolved during a time when many other mechanized modes of transportation were also coming into their own. The effects of trains, street cars, and automobiles on the urban environment are more widely available. Unlike walking and driving, which have shaped urban form for extended time periods, the hey-day of the bicycle appears to have been too brief and too small to substantially alter the urban fabric of American cities. However, cycling did bring about some important developments for cities.

In the 1870's, the League of American Wheelmen (LAW) formed and began advocating for better roads. Roads with smooth surfaces were very important for early cyclists, and in the late 1880's a "good roads movement" formed to advocate for better road conditions. This development aided the advancement of cycling, but also improved roads for the soon-to-come automobile. Aside from roadway improvements, there are also accounts of early cycling-pedestrian conflicts, and a few accounts of the volume of cycling that existed at its height.

"The number of cyclists in America grew from 100 in 1878, to about 50,000 in 1889, to over five million in 1898, mainly because more women were riding bicycles."[6] The growth in cycling was seen across the country, even in large cities such as New York. "One historian said that there were 1,200 makers of bicycles and parts in New York City with 83 bicycle shops within a one mile radius around lower Broadway."[7] Clearly, the volume of cycling in New York and other cities must have had some impact on the city, but historical accounts do not discuss how and where the bicycle affected the urban environment. An exception is an earlier account of Scottish bicycle inventor MacMillan being arrested in 1842 and fined five shillings for knocking

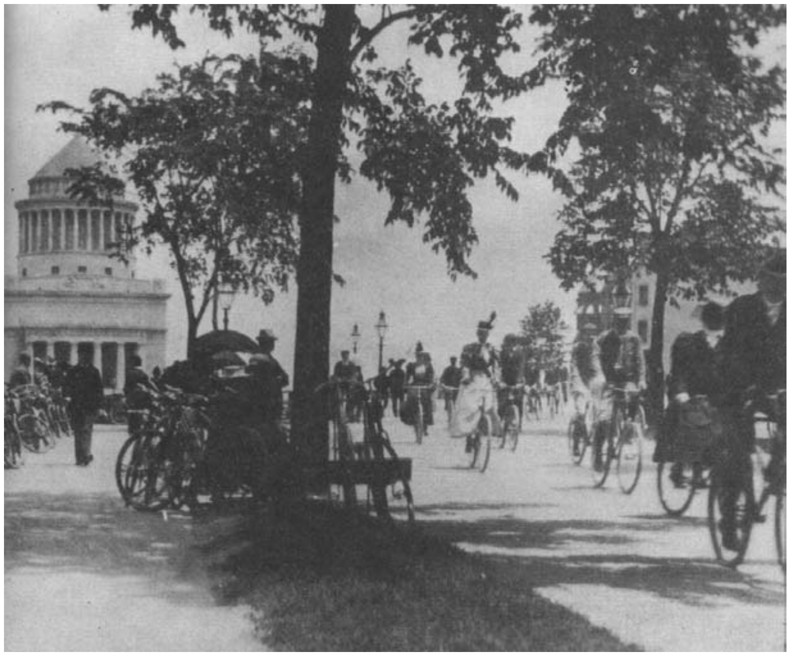

Figure 2.3: Early recreational cycling. Riverside Drive, New York City (1900). Source: Palmer 1956, 119.

down a girl on a sidewalk.[8] Apparently, bicycle and pedestrian conflicts were common even in the early years of cycling.

Even with strong roots in the development of the bicycle as a machine, cycling still struggles to gain momentum in the United States. In this country, cycling is largely viewed from a recreational stand point because in the United States this is its most common historical role. At the turn of the century, cycling in the United States was more of a recreational activity than a mode of transportation. Early bicycle facilities reflect this fact:

> The first major bike path in America was Brooklyn's Coney Island cycle path, going from Grand Army Plaza through Prospect Park, along Ocean Parkway to the beachside boardwalk at Coney Island. Originally landscaped by Frederick Law Olmstead and Calvert Vaux, the path was 7 1/2 miles long, fourteen feet wide, and made of crushed limestone. It opened on June 15, 1895. . . .[9]

Despite its appeal as a recreational vehicle, the bicycle struggled to find its place in transportation planning.

Incorporating cycling into planning is difficult, in part due to the fact that the automobile appeared shortly after the height of cycling and any effect that cycling may have had on cities was short lived. While American cities never fully experienced the impact of cycling on urban living, many European countries were slower to convert to driving and have a longer history of cycling for transportation. Forrester notes that:

> In the United States, the motoring transition occurred so early and so rapidly that the United States never had a time when cycling and motoring coexisted. In Europe, on the contrary, cycling and motoring coexisted for six decades (in Britain in 1952 bicycle supplied 25% of the vehicle-miles) and motoring did not effectively supersede cycling until the 1960's.[10]

The lack of a historical role for cycling in U.S. transportation suggests that efforts to incorporate cycling into U.S. cities will be difficult for people to envision because a historical view of cycling in American cities, as a major mode of transportation, does not exist. Consequently, cities that do wish to incorporate cycling into their transportation plans have a great deal of learning and teaching to do if they wish to convince people that the bicycle can be more than just a recreational vehicle. The following chapters explore the role of cycling in cities and describe both the requirements for cycling and the effects of it. Through this discussion a vision for cycling in cities is presented and its role and benefits are defined.

Chapter 2: Notes

[1] Frederick Alderson, Bicycling: A History. (New York: Praeger, 1972) 12.
[2] Arthur Judson Palmer, Riding High. (New York: E.P. Dutton, 1956) 29.
[3] Palmer 33.
[4] Palmer 58.
[5] Palmer 87.
[6] Perry David B. Perry, Bicycle Cult. (New York: Four Walls Eight Windows, 1995) 244.
[7] Perry 37.
[8] Palmer 34.
[9] Perry 251
[10] John Forrester, Bicycle Transportation: A Handbook for Cycling Transportation Engineers. (Cambridge: MIT, 1994) 16.

CHAPTER 3

THE INFLUENCE OF URBAN DESIGN ON URBAN CYCLING

The design of a city is an evolutionary process that involves thousands of decisions made over the course of many years. The city is a palimpsest on which history is written, erased, and rewritten. Homes and buildings are constructed only to be replaced as technology and needs dictate. This mixture of visions and inspirations creates an eclectic and fascinating urban environment beyond the capacity of any one individual, but as Anne Whiston Spirn indicates, this loose and flexible process comes with very real costs.

> The builders of cities rarely appreciate the cumulative impact of their incremental actions. Design and planning professionals normally concern themselves with a single scale, that of an individual building or project or that of planning for metropolitan-wide services. Landscape architects, engineers, or architects usually have no concept of how their projects will affect the environment of the city as a whole or how the problems with which they are grappling could be more efficiently resolved by off-site intervention. Planners often work within a single dimension--transportation, sewage treatment, water supply--with only a hazy notion of how their actions relate to other spheres.[1]

The compartmentalization of the urban planning process that Spirn describes has significant effects on the urban environment. In this chapter the cumulative effects that urban design decisions have on urban cycling are explored. Issues of urban form, architecture, urban features, transportation, demographics, the urban sensory experience, and street design are discussed. Together these elements impact the role that cycling plays in a city, but few are given full consideration in cycling design. This approach recognizes the combined influence of the urban environment on urban cycling so that a better understanding of the urban design - urban cycling relationship is possible.

3.1 URBAN FORM

Understanding how and where cycling fits into a city begins with an understanding of urban form. The shape and scale of a city is largely determined by its land use and its transportation choices. Marcia Lowe writes that it is land use, and the resulting urban form, that determines the success of cycling and other modes of transportation:

> A city's land use defines its transport system more than any traffic planner or engineer can. The pattern of urban development dictates whether people can walk or cycle to work or whether they need to travel dozens of kilometers; it determines whether a new bus or rail line can attract enough riders.[2]

The land use patterns that Lowe describes have changed over time and have evolved with advancements in transportation technologies.

In the world's earliest cities, walking was the primary mode of transportation. It is also the most natural form of transportation since it requires no other "inputs" beyond what humans are born with. Newman and Kenworthy describe this urban form as the "walking city." According to them, the walking city emerged 10,000-7,000 years ago in the Middle East and continued until the mid 1800's. These cities are characterized by high density, mixed land use, and narrow organic streets. They were usually than less 5 km across or a half an hour walk.[3] Newman also refers to the work of Manning, Zahavi, and Ryan who conclude that "this journey time appears to be built into human psychology/biology and urban economy as a fundamental organizing force."[4] The point that these authors agree on is that the urban form, from its very beginning, was shaped by the dominant form of transportation. With walking cities, the size of the city is limited due to the time constraints of walking and human desire. This constraint requires that density increases in order to achieve urban growth. John Forester describes how, “the inability to walk long distances daily limited the spread of such cities and pushed up the value of land close to the city center (because land further out was valuable only for agriculture)."[5] These remarks further reinforce the characterizations that Newman and Kenworthy make about the density of walking cities. Walking cities had to become denser and to foster mixed use because this arrangement minimizes walking distances. By the mid 1800's, however, the walking city came under the pressure of street cars, trains, and soon thereafter, the automobile.

Street cars brought the freedom to leave the city center and to travel greater distances. City dwellers were no longer confined by the margins of the walking city. Lewis Mumford describes the expansion of urban boundaries:

> The street car and then the automobile made it possible to work in the city and live outside for the first time, many could afford to "create an asylum, in which they could, as individuals, overcome the chronic effects of civilization while commanding at will the privileges and benefits of urban society. This utopia proved to be, up to a point, a realizable one: so enchanting that those who contracted, failed to see the fatal penalty attached to it - the penalty of popularity, the fatal inundation of the mass movement whose very numbers wiped out the good each individual sought for his own domestic circle."[6]

In the migration out of the city, the street car and the automobile expanded the traditional urban form. Unlike walking cities that were constrained by walking distances, street cars provided outward urban expansion along linear corridors (Figure 3.1). Growth and development concentrated around stops along the lines. The automobile, however, provided individual transportation that was unrestrained by rails and largely unaffected by gradient. With the use of the automobile, the urban form expanded beyond the human scale, and is now limited only by the willingness to remain in the vehicle. The automobile dominates transportation in the United States, and it is still in the process of shaping American cities. It is within this context that the influence of urban form on cycling must be considered.

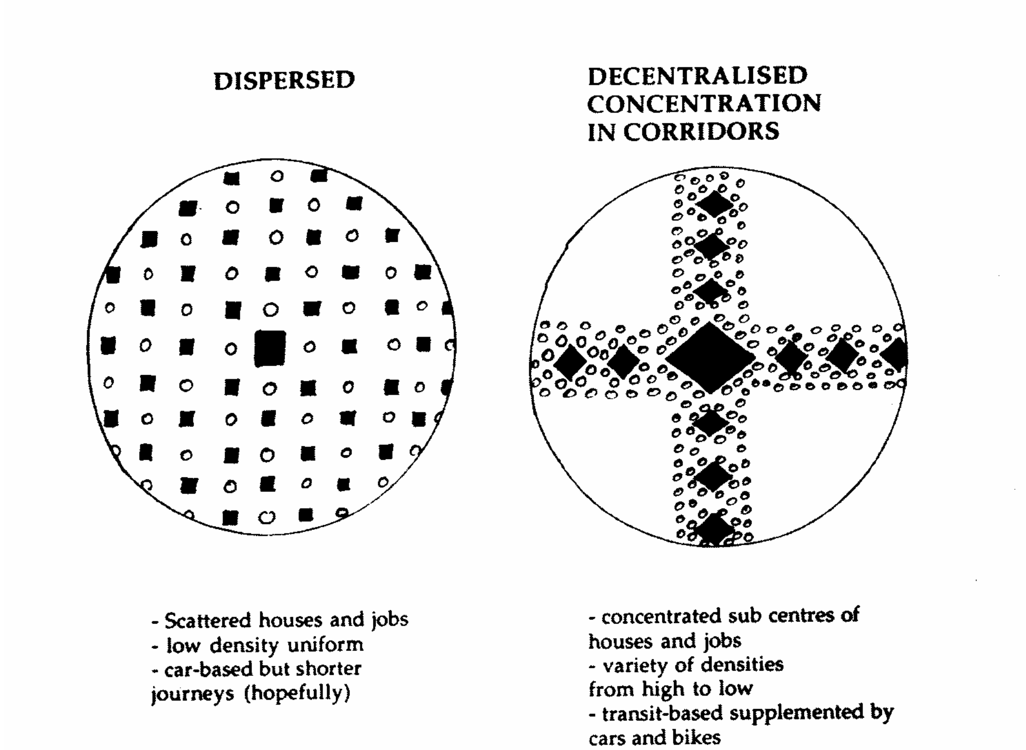

Figure 3.1: Alternate urban forms. Source: Newman and Kenworthy 1999, 105.

Urban form plays a significant role in whether cycling is convenient and enjoyable, but it also determines to what extent cycling is reasonably possible. Newman and Kenworthy indicate that "One characteristic people have shown that has been important in shaping the nature of our cities is that they do not like to commute, on average, more than half an hour to major urban destinations."[7] This human characteristic has remained constant even with the shift from walking to the automobile. However, the important part of this information is that time is the determining factor and not distance. The distance a car covers in thirty minutes is much different than the distance a person walking or cycling can cover. As a result the automobile has expanded the 5-8 km urban boundaries of walking cities and can cover distances up to 50 km in all directions in the same thirty minutes.[8] In this environment, the 5-15 km bicycle ride simply does not reach the desired destinations. The resulting urban form creates an environment that is out of scale and incompatible with other modes of transportation. This landscape is characterized by low density development and is commonly referred to as urban sprawl.

The expanding distances and low densities of sprawling landscapes subvert other modes of transportation. In the context of urban cycling, a sprawling landscape presents an incredible design challenge. In such a landscape, destinations are further apart and conveniently reached only when traveling at high rates of speed. The effect then of an urban form based on automobiles is to reduce the effectiveness of other modes of transportation including the bicycle. Lowe summarizes the effects of poorly planned urban design:

> In short, a city's transport system functions better if things are closer to home. Despite this obvious link many cities' layouts look as if no one had tried to coordinate land use with transportation. By failing to see land use planning as a transport strategy, many of the world's cities have allowed the automobile to shape them.[9]

The consequence of allowing automobiles to shape cities to the needs of the automobile becomes a self-reinforcing cycle. Destinations become further apart to accommodate parking and to take advantage of lower land prices, higher speeds are needed to reach all destinations, less congestion is needed to maintain higher speeds, roads are widened to reduce congestion, wide roads with high speeds make it more difficult to walk and bicycle and thus encourage driving. Whitelegg describes this process as the consumption of distance:

> We are effectively consumers of distance, and distance has become a commodity. Unlike some other commodities, distance establishes its own logic on spatial structures and behaviour so that it becomes impossible or very difficult for individual consumers to exercise choice and reduce their consumption level.[10]

For all practical purposes, a sprawling landscape requires an automobile. Individuals cannot forego automobile ownership and still meet family, work, household, and social needs. In many cases there is no choice available. Even the dense urban cores of older cities have become thinner and no longer provide all the services needed for residential living. "Use of an automobile became not so much a choice but a necessity in the Auto City."[11] Similarly Whitelegg describes the effect of automobile dependence:

> Increasing dependence on transport, year on year, increases miles traveled for all journey purposes. The erosion of friction of distance is expensive and it changes perceptions and psychology; it fundamentally alters lifestyles and expectations and creates land use patterns and spatial structures that require even greater inputs of distance and energy to sustain them.[12]

Walking in this environment takes too long. Transit has the capacity for speed, but cannot reach all the widely dispersed destinations. Cycling, like the automobile, has the flexibility of motion, but does not offer the speed or comfort. However, it is in this very environment that many cities try to encourage and design cycling facilities.

Cycling facilities, in sprawl conditions, are unlikely to attract cyclists, but many cities attempt to do exactly this. Consider, for example, the common practice of adding bicycle lanes during road widening and construction projects. These projects are typically intended to relieve sprawl-induced congestion. The Transportation Planning Handbook describes this situation as an opportunity to add bicycle lanes and suggests that "when adding lanes and improving intersections to ease motor vehicle congestion additional width can be provided for bike lanes or wide curb lanes."[13] However, reducing congestion increases speed. Increased speed means that land outside the urban boundary becomes attractive for development because people can now live in these areas and still reach their destination within the half an hour time frame that humans find acceptable. Adding new development outside the city places jobs, homes, and businesses even further apart and the added cars simply increase congestion again. This cycle means that cities cannot build their way out of congestion no matter how wide the roads get, and attempting to do so will only worsen conditions for cycling and other modes of transport. Perry describes the problems with this method of transportation planning:

> For many years it seemed logical that more roads for motor vehicles would ease congestion, so traffic planners, government officials, and the highway lobby went on a road building spree. The result was more congestion. This is an example of Braess's paradox, also known as the "traffic paradox," a statistical theorem that came to light in 1968 with the work of Dr. Dietrich Braess of the Institute for Numerical and Applied Mathematics in Munster Germany. Dr. Braess found that when one street was added to a network of streets, all the vehicles took longer to get through. The reason traffic slows is that when drivers are in crowded conditions and a new street is opened, the opportunity inspires more drivers to crowd their way toward the open road, thus adding congestion. This is consistent with the principles of game theory: if everyone participating in a game plays selfishly, everyone loses.[14]

Unfortunately, roadway expansion projects are still utilized in an effort to reduce congestion. However, it is not the congestion that is the primary problem for cycling, but instead the ever-expanding distances between destinations and the high rate of speed needed to reach them. Producing cycling facilities, while simultaneously making cycling more difficult, is an illogical, irrational, and wasteful act. Decision-makers must be aware of the inherent consequences of their actions, but as Spirn indicated, many are not. Cycling facilities under sprawl conditions will only attract riders for whom the cost of owning an automobile outweighs all time considerations, and for those that cycle for ideological reasons. Additionally, critics of cycling see these unused facilities as a wasteful expenditure designed to appease special interest groups. In the long-term this makes it more difficult to get legitimate designs implemented and also leaves less funding for other cycling projects. Furthermore, the added pavement on unused bicycle lanes intensifies stormwater runoff. Cities that are serious about increasing cycling must be cognizant of the overwhelming effect that urban form has on cycling and begin to manage urban growth.

Managing urban growth and urban form are key elements for cycling design. Evidence shows that automobile-dependent cities grow to a large size with low density development such that other modes of transportation, including cycling, are precluded.

> Newman and Kenworthy's recent study of 32 of the world's major cities confirms that the shorter travel distances inherent in medium- and high-density urban areas correspond with much more walking and cycling. In the Western European and Canadian cities in the study--which had an average of roughly 85 people per hectare--more than 21 percent of workers walk or cycle to work. But in the study's U.S. and Australian cities, with about 20 people and jobs per hectare, only 5 percent of workers walk or cycle to their jobs.[15]

These findings indicate that cities with higher density development are conducive to cycling. The reasons are obvious. Density places destinations closer together and decreases trip distances. However, political and economic pressures in the United States make growth management difficult. If a neighboring city or county is willing to accept sprawl development, then there is an incentive for a city to accommodate this development or to lose out on tax dollars. Congestion is another tool that impacts urban form and favors the bicycle, but it too is politically unpopular. Congested streets reduce the speed of automobiles and the distance they can travel in thirty minutes. The isochronical distance is the distance at which competing modes of transport take equal time.[16] Design measures that reduce the speed of the automobile increase the distance over which the bicycle is competitive. Reducing speed limits, traffic calming, and foregoing roadway expansions are just a few methods to encourage other modes of transportation. These options are rarely considered as a tool for cycling design. Barring an energy crisis or an ideological revolution it is unlikely that cycling design will attract many cyclists until it begins to account for the effects of urban form on urban cycling.

3.2 URBAN DENSITY AND ARCHITECTURE

Closely tied to the issue of urban form and urban sprawl is the related architecture and density that emerge. As mentioned earlier, sprawl spreads jobs, businesses, and homes further apart making walking, transit, and cycling inefficient. Even urban areas that were not designed for the automobile have been adapted to accommodate it. "The amount of land given to motor vehicles is astounding, almost half in typical American cities, 45 percent in New York, and 60 percent in Los Angeles, compared to 20 percent in London."[17] To make space for the automobile urban buildings are taken down and replaced with parking garages and parking lots. As a result the effects of the automobile on issues of urban density do not just apply to the suburban landscape, but also apply to traditional urban areas. The space requirements of automobiles force traditionally dense urban areas to become thinner. The amount of space in cities that is devoted to cars forces everything else to become further apart, and this increased distance alters urban living patterns. All of these adaptations for the automobile change urban architecture, and consequently, make urban cycling more difficult and less appealing.

The accommodation of the automobile, and dispersal of buildings in traditional urban areas, impacts how and when buildings are used. Jane Jacobs discusses the effects of sprawl on small stores and businesses in cities. She warns that "Once they are unable to be supported at close, convenient intervals, they lose this advantage."[18] The advantage she refers to is that of businesses being close to residents and capable of serving local demand. Furthermore, she suggests that "When distance inconvenience sets in, the small, the various and the personal wither away."[19] Under such circumstances the bicycle is not an equal alternative, but a vehicle of last resort. Daily tasks such as grocery shopping and commuting to work become unattractive and difficult. Once a person's essential daily tasks require the regular use of an automobile, the financial benefits of cycling are instantly diminished. A main reason for this is that once car ownership is required the marginal cost of each additional trip is minimal. Monthly payments, registration fees, and insurance are fixed costs of automobile ownership and do not change based on the amount of use. If a driver decides not to drive for a month, the insurance company does not refund the monthly premium, and the bank does not forego its monthly payment. The result is that the cost difference between cycling and driving is not based on the total cost of car ownership, but is instead based only on the variable costs that increase with use. These include expenses such as gasoline, parking, tolls, and maintenance. Parking is often free, few roads have tolls, gas is relatively inexpensive, and maintenance costs are irregular. Urban conditions that require the regular use of an automobile make cycling less appealing. The affordability of cycling is best in circumstances where the need for an automobile can be substituted with the use of taxis, public transit, rental cars, or where families can function with only one vehicle instead of two or three. For the total cost of car ownership to be a factor in the decision-making process, a car must be optional and not necessary. To achieve such conditions where cycling is possible and car ownership is optional, cities must commit to increasing urban density, and to adapt policies that allow for transportation alternatives.

Design for cycling that focuses on density is often overlooked and politically unpopular. People often cringe when asked about living in dense urban conditions. The typical response is that they do not want to live that close to other people. Of course, many Americans have never lived in such an environment, but have already formulated opinions about the experience. It is often the density itself that is given as the reason. Forester notes that historically people lived in cities to be close to their work and not because they liked the dense urban conditions. He points to the experiences of characters in the works of Charles Dickens as evidence of what city life is like.[20] Cities today are a far cry from the days when sewage flowed freely through the streets, however, they are not perfect environments, and density is often blamed for the imperfections:

> Public opinion polls and consumer purchasing behavior indicate that, almost universally, people dislike living in higher-density settings. It is not the density per se that people dislike (at least at modest levels), however, but what often accompanies density - congestion, noise, graffiti, street crimes, overcrowded schools, and so on. The challenge

> is to create more attractive compact places, partly through high-quality design but also partly through community rebuilding that focuses on solving deeply rooted social problems as well. [21]

A focused effort to increase urban density is needed to facilitate cycling, and there are options that can make density more appealing. However, some people such as Forester suggest that efforts to increase density will be difficult. He argues that "In the simplified case of a roughly circular metropolitan areas with employment at the center, the residential density must be quadrupled to halve the average distance to work."[22] At first glance this change in density seems to paint a bleak picture, but the reality is not necessarily that drastic. Forester makes a few assumptions in his rough model which he does not explain. First, his model is based on the assumption that a city's density is equal from its center all the way to its edge. Thus, the quadrupling of density that he prescribes does not account for existing densities that may already exist closer to the urban core. Second, he assumes that everyone needs to travel to the very center of the city. Mixed used development and density arranged around multiple nodes can also shorten trip distances. These nodes would function as small units with housing, retail, and employment all clustered together. Such methods are already used in many countries. "In a strategy to ease dependence on the automobile, planners in Canadian cities such as Toronto and Vancouver have achieved such a many-centered layout. Each of these metropolitan areas includes a number of high-density, diverse centers focused around public transport links."[23] This concept has the capacity to increase density and reduce travel distances without requiring drastic changes in a city's character. Likewise, there are opportunities to maintain the look and feel of a town while simultaneously increasing density. Cervero points how density can be achieved while the perception of density can remain unchanged.

> Only recently have designers begun to recognize that actual and perceived densities can vary widely. Studies show effective ways of making higher-density projects seem less

> dense: extensive landscaping; adding parks, civic spaces, and small consumer services in neighborhoods; varying building heights, materials and textures to break the visual monotony of structures; detailing rooflines; adding rear-lot, in-law units; and designing midrise buildings on podiums with tuck-under below-grade parking.[24]

Certainly there are different methods of achieving density, not all of which are equally appealing and produce mixed results.

The idea of density is often closely associated with the idea of large high-rise sky scrapers, but this may not be the best solution if the encouragement of cycling is the goal. In Great Streets Allen Jacobs profiles the attributes of the world's greatest streets and concludes that "Except for buildings along the Grand Canal, those along the best streets are generally of a similar heights. There are rarely big jumps or drops."[25] Likewise he indicates that "The height of buildings along the best streets is less than 100 feet."[26] While Jacobs' research is primarily from an aesthetic and sensory approach there is other evidence and reasoning to support his findings. Christopher Alexander indicates that in buildings over four stories people lose touch with the street and the social interactions that come with street life. The result is that people feel more isolated and consequently have higher degrees of mental health problems.[27] Additionally, Spirn addresses building height and the consequences of designing tall buildings that catch and intensify wind in cities.[28] In Experience of Place, Tony Hiss laments the shadows and shade that tall buildings cast across urban streets and the resulting street level microclimates. Finally, research into defensible spaces suggest that in taller buildings residents have less connection to and less control over the activity outside of their buildings than in lower buildings and consequently less of an ability to police their own community.[29] All of these factors play into the role of cycling in the city. Density is needed to make cycling possible, but it is pointless to create density in such a way that the city becomes unattractive, unhealthy, and unsafe. Density under such circumstances does not facilitate cycling because these factors are many of the reasons that people fled the city for the suburbs in the first place and moving to the suburbs prescribes the need for automobiles. So it is both density and the accompanying scale and style of architecture that must be considered when attempting to reduce trip distances and facilitate cycling.

In addition to scale and size of the architecture the details of urban architecture are also important to cyclists. The architecture of sprawl is that of big box retail, shopping malls, and cul de sac communities. While these elements are tailored to the automobile, they create an environment that is uninviting, boring, and prohibitive for cycling. Robert Venturi's book Learning from Las Vegas describes the fundamental changes to architecture that the automobile creates. Parking becomes the priority for patrons of businesses and in order to accommodate and reassure drivers of the availability of parking all lots are placed in front of the building. This, in turn, requires that buildings sit back a great distance from the edge of the road.[30] At this distance windows become unnecessary since passers by cannot see into the building until they have parked and left their vehicle. By this time they have already committed to going inside a store and window displays are unnecessary advertisements. Meanwhile, signs become bigger and more important to attract customers traveling in automobiles at high rates of speed. In many cases, the building itself becomes the sign. Similarly, Untermann describes how the scale of architecture has changed from "narrow fronted, deep, and intricate" in walking cities to "wide fronted, smooth, and shallow" in the automobile city.[31] All of these factors do not just mean that the architecture creates a situation that is inconvenient for pedestrians and cyclists, but it also contributes to an environment that does not stimulate their interest.

> There is some justification for simplifying auto-oriented environments and making pedestrian spaces more complex. The human eye visually encompasses about three objects every second. Fewer than three per second can induce boredom, while more are likely to create confusion. A driver traveling at 25 mph passes a 30-foot-wide shop in

> slightly less than one second, distinguishing two or three objects. On the other hand, a pedestrian traveling at 3 mph can distinguish and comprehend 21 different objects in the same 30 feet. The average bicyclist travels about 10 mph and can perceive about six objects in the same distance. Thus, motorists benefit from decreased complexity of visual messages, while pedestrians and bicyclists benefit from increased message complexity.[32]

As Untermann indicates, the bicyclist travels at speeds that are visually more comparable to walking than to driving. This difference means that environments built for automobiles are visually oversimplified when considered from the cyclist's perspective. Architecture that is visually stimulating is important because the cycling experience is determined by the environment though which one cycles and not by stimuli inside the vehicle. Thus, the physical spacing of buildings becomes important. Large monotonous buildings with large expanses of asphalt between them do little to encourage cycling. This architecture is common to suburbia, but the automobile has also developed its own architecture in the urban core.

In the urban core the automobile transforms architecture to meet its needs. Gas stations and parking decks are just two of many structures devoted to the service of the automobile. Other examples include the service facilities required to support automobile use such as dealerships, repair stores, scrap and junking facilities. In his book City, William Whyte discusses the effects of blank walls in urban architecture. He notes that parking garages are notorious creators of blank walls. These structures, like the blank walls of the suburban shopping malls, also create a dull sensory environment for cyclists and pedestrians. He describes how "An owner who turns a blank wall to the street not only deadens his part of the frontage, he breaks the retail continuity of the block."[33] Again the cycling experience is determined by the surrounding environment and things such as the stores along a street. The cumulative effect of such structures is an unappealing urban aesthetic which detracts from the quality of life in cities and in turn adds to the appeal of suburban living. Consideration of the automobile in cities is still needed, but the architectural solutions designed for the automobile need to respect and not detract from the quality of urban life.

3.3 URBAN ELEMENTS

The quality of life in cities and the feasibility of cycling is impacted by urban form and architecture, but there are also other urban elements that play a role. Among the most influential of these urban features are wind, trees, topography, and weather. So much of cycling design focuses on the road that the influence of these elements is often overlooked. However, even the most perfectly designed roadway facilities can fail to attract cyclists if these factors are not considered. Together these elements combine to create conditions that either favor urban cycling or that can make the cycling experience miserable.

3.3.1 WIND

Wind in cities is a major factor that affects the cycling experience. Often wind is considered the same thing as weather. It is viewed as something that happens naturally and is beyond the realm of design, but design does have significant effects on wind. In appropriate amounts wind ventilates and cools a city, but when directed and concentrated, wind in a city becomes a powerful force. Wind that is magnified and channeled makes cycling difficult because strong gusts can affect the balance and tracking of cyclists, as well as their speed. "The winds in plazas and in arcades beneath tall buildings may accelerate to quadruple the speed in protected streets nearby. Since wind force increases exponentially with speed, wind four times as fast hits pedestrians with sixteen times the force."[34] A tail wind propels a cyclist along the road, yet the opposite is true for cyclists traveling into the wind. A head wind can significantly decrease a cyclist's speed and make it physically more difficult because:

> Wind resistance increases as a square of velocity with a cyclist's speed, and as a cube of velocity with a cyclist's power output. When penetrating the air, making a headwind in still air, a cyclist must double the energy expenditure for each additional six mph (ten kph).[35]

While most drivers of automobiles are unaware of wind, cyclists immediately feel the effects and must work harder to achieve the same speed. Perry sums up the cumulative effects of wind on cyclists:

> Some say the speed of a cyclist and the headwind can be added together to estimate a cyclist's wind speed, so the effort of a cyclist going fifteen mph into a ten mph headwind is the same as going 25 mph in still air. Others say that the wind changes a cyclist's speed by about half the wind speed, so a ten mph headwind slows a cyclist by about five mph.[36]

The overall effects of wind in urban environments suggest that greater planning and testing of new architecture is needed and that wind breaks may be necessary. Some cities, such as San Francisco, have made the connection between their architecture and excessive wind gusts, but many cities do not even consider wind as a factor during project development. In San Francisco, buildings are tested for both their effect on sunlight and wind altering factors before they are built.[37] Additionally, cities may need to consider design elements that help to mitigate wind gusts. In the Dutch Bicycle Master Plan of 1992, funding was allocated to study design elements for wind breaks.[38] Consideration of the effects of wind is rarely included in U.S. cycling design, not because the concepts are difficult, but rather because U.S. cycling design does not typically include factors beyond the roadway.

Considering the effects of new architecture is one method that would benefit both cyclists and other urban inhabitants. Another way to reduce high velocity wind gusts is with the use of trees. Henry Arnold suggests that, "A street where both sides are lined with trees, even where there are buildings, is noticeably less windy. Because of the permeable quality of tree crowns, they slow wind rather than produce a venturi effect where urban spaces are constricted."[39] Likewise, Spirn discusses studies of Dayton, Ohio and how the lack of trees at the city's edge contributed to especially gusty wind conditions in downtown areas.[40] The use of trees to reduce powerful wind gusts is only one of the many benefits urban trees provide cyclists.

3.3.2 TREES

Trees have the power to calm forceful winds, but they also offer other physical and psychological benefits to cyclists. Allen Jacobs points out that "Climate-related characteristics of comfort are reasonably quantifiable and there is every reason that they should be a part of great streets."[41] Urban trees can have a significant impact on the air temperature, especially above asphalt surfaces, and yet they are often the last consideration because they are often seen as a luxury and not a necessity. Looking at the benefits trees provide quickly reveals their value. According to one study "Trees in Davis, California parking lots reduced surface asphalt temperatures by as much as 36°F."[42] Likewise Christopher Alexander indicates that "On hot summer days the air over the grass surface is 10 to 14 degrees cooler than the air over an asphalt road."[43] This temperature difference can mean the difference between cyclists having an enjoyable trip or arriving at their destination drenched in perspiration. Cyclists, unlike drivers, cannot simply turn on the air conditioning when the weather heats up. For cyclists, physical exertion in summer temperatures is bad enough on its own, but the effect of asphalt collecting and intensifying temperatures compounds the problem. To address issues arising from physical exertion, many cycling advocates call for greater access to showers and locker rooms at the work place, but perhaps a more efficient use of resources would be to provide cooling shade and to prevent the need for a shower in the first place. The benefits of trees for cycling do not just include cooler air and less windy conditions, but also extend to the sensory experience.

Bicycle paths in parks and greenways often travel along winding shady paths while many city streets lack trees all together. Such disparate conditions may explain why Americans flock to bike paths and underutilize urban bicycle lanes. Clearly more trees are needed in urban areas, but not all trees are created equal. Certain varieties cannot handle the air pollution in urban environments, while other low growing under-story trees never get large enough to provide shade on the street. To be effective and provide shade, street trees need to be species that will grow large, and be planted in enough soil so that they can remain healthy. Arnold writes that "Small trees interrupt and fragment the street space, while large trees cover and contain the space."[44] Unfortunately, street trees in the United States are poorly treated, and rarely get the chance to shade a street. It is common practice for utility companies to severely prune trees away from power lines and to prohibit the planting of trees below them. Arnold suggests that if power lines cannot be buried, then the space directly below the power lines is actually the best place to plant trees. He argues that it is the trees planted ten to twenty feet away from the lines that cause the most damage to power lines. The branches of these trees fall *on* the lines whereas the branches of trees planted under power lines break *over* the lines.[45] Likewise he argues that "Where trees are set back in deference to the utility lines, the comfortable sense of street enclosure is weakened or lost."[46] This sense of enclosure is important not only for the aesthetic and cooling value, but also for the psychological affect it has on drivers. According to the Department of Transportation, tree canopy can create a narrowing illusion, which produces a "psycho-perceptive sense of enclosure to discourage speeding."[47] As users of the street, cyclists benefit from the environment that street trees create. To retain these benefits, local tree ordinances can be developed to protect trees from aggressive treatment, and the ordinances can encourage their use and placement.

The benefits of trees to cyclists cannot be understated. Trees provide a sense of rhythm and enclosure. They shade and protect cyclists from sun and wind. Trees create psychological effects that slow speeding traffic. Trees enhance the urban living experience for all users and create a pleasurable cycling environment. They also help filter and clean the air. After studying the great streets of the world Allen Jacobs concludes that:

> Given a limited budget, the most effective expenditure of funds to improve a street would probably be on trees. Assuming trees are appropriate in the first place (not on Stroget, for example) and that someone will take care of them, trees can transform a street more easily than any other physical improvement. Moreover, for many people trees are the most important single characteristic of a good street.[48]

Cycling design must incorporate this advice, and begin to consider the possibilities that an expanded design palate can offer. To capture the benefits of designing with trees, cycling design must extend beyond the roadway.

3.3.3 WEATHER

In addition to trees and wind, a city's weather also influences cycling. Weather is a common reason given for the lack of cycling in the United States. In the South, the weather is too hot in the summer. In the North, the weather is too cold in the winter. In the Northwest, it is too rainy all the time. Weather certainly plays a factor in whether or not people choose to cycle, but perceptions of the impact of weather are often exaggerated in the minds of individuals considering cycling. Tolley suggests that, "the obstacles to the green modes are not to be found outside in weather or topography. They are inside us, locked in our attitudes to our environment, to growth, to consumption, to sustainability, and only we can change them."[49] Some weather conditions can be ameliorated through design. Again, trees can reduce hot summer temperatures, and zoning that requires buildings to let sunlight reach the streets can help provide warmer environments on colder days. Overall, the most effective means of handling weather conditions may be through clothing and equipment. Cool loose fitting clothing in the summer and warm, layered clothing in the winter are obvious choices. Rainy weather presents different obstacles.

Rainy weather can, in part, be addressed through clothing. Lightweight parkas and ponchos can be tucked into bags and brought out during rainy conditions. Surprisingly, cyclists are more likely to get drenched from the water off the street than from rain from above. During rainy conditions, bicycle tires pull water off the street and into the air. On bicycles without fenders, the shoes and the back of a cyclist quickly get wet. It certainly does not help that bicycle lanes in the United States are placed at the edge of the road where standing water is most likely to collect. In Denmark, many bicycle lanes are elevated midway between street level and sidewalk level and have their own drainage grates. This system has its own advantages and disadvantages, but when it comes to rainy weather it seems to create more favorable cycling conditions. Other design considerations for rainy weather include the slippery conditions that wet surfaces create. Smooth metal on manhole covers, construction plates, rail road tracks, and even some street markings create hazards. Simply applying textured surfaces to these materials can help prevent slippery conditions. Despite the fear of getting wet, McClintock points out that: "It has been shown, that in a normal year in most parts of England, it is only on average on about 12 days a year that a cyclist riding to and from work will get really wet!"[50] Of course, no one wants to get wet, and a few other urban features can help. Simple awnings on buildings in urban areas can provide a place to duck out of the heavy rain and to wait for it to lighten. Likewise, covered bicycle parking can keep bicycles dry and out of the weather when not in use. When temperatures drop and rain turns to ice the conditions get worse. "The presence of icy patches is probably the greatest adverse weather deterrent to cyclists' safety."[51] Under icy conditions the best solution is to stay off the road just as sensible drivers of automobiles do. The other option is to utilize transit services. In inclement weather transit services become more popular, but in rainy conditions many cyclists still choose to cycle. In Copenhagen, "Even on rainy days, 60 percent of cyclists remain loyal to their preferred means of travel."[52] This commitment suggests that while weather is a factor it can be mitigated through individual preparation and design measures.

3.3.4 TOPOGRAPHY

Like the weather, topographic relief is also commonly cited as a reason why cycling is incompatible with American cities. While critics point to the flat landscapes of Northern Europe and suggest that this is the main reason why cycling is possible, this point is simplified. Rachel Goodman and Rodney Tolley point out that:

> Hills are cited as if they represent the ultimate deterrent to cycling, overlooking the fact that they run downhill as well as uphill, that cycles can always be pushed up steep hills – though it is rare nowadays to see cyclists walking their bikes - and that cycles nowadays have gears enabling cyclists to go uphill without dismounting.[53]

The fact remains that urban topography is unlikely to change a great deal through design measures, however, the bicycle itself can help determine how much influence topography carries. In Northern Europe, many bicycles are heavy-weight single-speed models which work well enough on the flat surfaces. Canal bridges quickly reveal the hidden topography of cities such as Amsterdam and Copenhagen, so even these cities are not as flat as they seem. It is true that many American cities have more topographic relief than Northern Europe, but most American bicycles also have ten to twenty gears capable of climbing up steeper gradients. The mountain biking craze in this country suggests that while topography may be an issue, physical fitness also plays an important role in determining the effect of topography. Urban design can do little (at least without major ecological damage) to change major topographic features, but small scale differences can improve the cycling experience. Where roadway gradients can be improved small scale topographic changes benefit cyclists. Likewise, bridges constructed without steeply arching spans favor cycling. On some steep slopes, in Norway, cable driven foot lifts are used to propel cyclists uphill. These foot lifts operate in a similar fashion to a tow rope on a ski lift. The cyclist remains seated on the bicycle and puts one foot on the lift which pushes the bicycle and rider up the hill.[54] A less extensive method that can help, is simply to provide extra space on the on the uphill side of the street to allow faster cyclists to overtake slower cyclists. This practice is common on roads designed for cars, but traffic planning engineers do not apply this same principle to cycling design. Overall, urban design should be cognizant of topographic features and their impact on cycling. If nothing else, urban design efforts should not create more challenging topographic conditions, and where possible, should find ways to mitigate the steepest gradients. However, these efforts and other design efforts should be targeted in areas where current cyclists exist and where people can be persuaded to cycle.

3.4 THE URBAN SENSOR EXPERIENCE

The overall form of a city can determine whether cycling is possible, design features may facilitate speed and safety, and demographics and culture determine the acceptability of cycling, but ultimately cycling remains a sensory experience.

> The modern car imposes a filter between the driver and the world he is moving through. Sounds, smells, sensations of touch and weather are all diluted in comparison with what the pedestrian experiences. Vision is framed and limited; the driver is relatively inactive. He has less opportunity to stop, explore, or choose his path than does the man on foot.[55]

The sensory experience of cycling is similar to that of the pedestrian and can be a wonderful thing. However, if the design of a city does not facilitate a positive sensory experience, then individuals will seek to insulate themselves from the experience. Since individuals have little control over urban design they must resort to improving their vehicle if they want to improve their situation. Accordingly, it is the automobile that gives individuals the greatest control over their sensory experience. Temperature, noise and comfort are defined by the automobile and not by the street or the city. The automobile is popular for this ability, but its popularity has extensive impacts on urban environments. While the automobile improves the sensory experience for the driver of the vehicle it is often the very source of a negative experience for those outside it. If the promotion of cycling is a goal of city planners, then a greater recognition of the sensory experience of the city needs to be considered.

3.4.1 SOUND

The influence of sound is something that is rarely considered in cycling design, but urban sounds impact the pleasure and appeal of cycling. In automobiles and aboard public transit sounds are filtered by layers of glass and metal. The noise that the vehicle does not eliminate is often drowned out by the radio. While the radio sounds like an appealing solution for cyclists it is also a potentially dangerous one. Utilizing a radio to eliminate the harsh sounds of the environment also eliminates sounds that can warn cyclists of approaching cars and impending collisions. Additionally, it is often illegal for cyclist to wear headphones. The solution then must be to lessen the impact of harsh urban noises, but the very source of many urban noises is the automobile itself.

Honking horns, squeaky breaks, and tire friction are just a few of the urban noises produced by automobiles. It may sound odd to consider these elements as urban design, but they are the result of urban design decisions. Planners and designers who create facilities to accommodate automobiles inherently design a certain level of noise into the city. Without consideration of noise during the design phase, legislation becomes the tool that is needed to improve the urban environment. Laws that limit the volume of car stereos are standard across the country. Likewise, cities such as New York have laws prohibiting honking in certain locations where the noise is unbearable. Cars without appropriate mufflers may also be ticketed and fined in many cities. Noises that have the power to penetrate inside buildings have an even greater effect on the street environment. "The noise of traffic on a busy street is rated at about 85 decibels (dBA), while the U.S. Environmental Protection Agency recommends a maximum of 70 dBA for the protection of public health."[56] Consequently, the noise produced on city streets and its effect on cyclists is not just a petty concern, but is a real issue for street users. The cumulative effect of noise on a cyclist adds unnecessary stress to an already intensive sensory experience. Car horns are especially stressful since most are designed with the capacity to warn other automobile drivers at considerable distances. Additionally, horns are often used to express roadway aggression, and their sudden and unpredictable use means that they simply do not fade into the background noise of a city street. Finally, there is the issue of noise generated by tire friction. Newman and Kenworthy suggest that "Traffic calming generally results in a reduction in vehicle noise."[57] The slower speeds that result from traffic calming do indeed generate less noise from friction. However, the spacing of the speed control devices is important. If they are too far apart drivers try to compensate for the loss of speed by slamming on the accelerator after the control measure and breaking quickly before the next control measure. The overwhelming sound then is not one of friction, but instead of shifting transmissions and squeaking breaks. If drivers obeyed posted speed limits, street noise could be reduced simply by lowering speed limits. Considering the effects of noise must become a focus of urban design, not just for cyclists, but for the cumulative detrimental effect it has on urban living.

3.4.2 SMELL

On a typical commute, cyclists may experience a wide range of smells. Some of these may be pleasant. For example, the smell of baking bread from a bakery or blooming shrubs in the spring can tempt the nose. Other scents such as those from automobile exhaust, gas stations, sewers and stagnant water can be less appealing. To the cyclist, the city is an unfiltered olfactory landscape which can either improve or detract from urban cycling. It is difficult to design for the pleasant smells of local businesses. This must come from local businesses serving a local population. Fragrant plantings along city streets may provide a pleasant surprise, but even these may be overwhelmed by competing smells. The smell of a city is a more difficult challenge for designers, which is probably best served by mitigating the effects of obtrusive smells. Designing streets with enough air flow to disperse smells is one method that can eliminate offending odors. Advance stop lines in bicycle lanes are a method that helps on a smaller scale by allowing cyclists to stop closer to the edge of an intersection than automobiles in the adjoining lane. This, in turn, means that they are not smelling and breathing the exhaust from the tail pipe before it has had an opportunity to disperse.

3.4.3 SIGHT

In addition to the scents of a city, the visual appearance is important to cyclists as well. The environment that a cyclist travels through can be monotonous or exciting depending on the surroundings. This visual environment is important not only from an aesthetic perspective, but from a temporal perspective as well.

> Offering a stimulating and aesthetically pleasing experience can help to change the perception of time. This is because our experience of time is very much influenced by our own subjective reality and not always linked to the actual time as shown by clocks. When we are immersed in an experience, time may not be an issue. It is only when the space between departure and destination is left unfilled that we become aware of time.[58]

Recall from the prior discussion on urban form that cities expanded spatially based on an average thirty minute commuting distance. In many areas, this thirty minutes is based on thirty minutes in an automobile, and as a result is incompatible with a thirty minute bicycle ride. However, as mentioned above, an individual's perception of time can vary from the actual time depending on the environment through which they move. Drivers traveling across the country through the Great Plains remark at the monotony of the landscape and fixate on the length of the journey. Appleyard, Lynch, and Mayer provide a simple explanation for such experiences. "Where surrounding objects are far off, or few, or featureless, or moving with the vehicle, then the sensation is one of floating, of no forward movement."[59] These traits describe many agricultural landscapes, such as the Great Plains, but they also describe the environment produced by urban sprawl. In sprawl development, retail complexes such as shopping malls and big box development are few, far off, and featureless. Vast stretches of unused parking pave the way to the windowless and featureless facades of sprawl structures. For a cyclist, the result of sprawl is a feeling of floating and the perception of no forward motion. The cumulative effects of sprawl are environments that are physically further apart and that also psychologically feel further apart.

The effect of this landscape on perceived speed is detrimental to cycling efforts, but understanding the effect of landscapes also offers the opportunity to manipulate the sensory experience and accelerate or decelerate the perception as needed.

Design that affects the perception of speed can be used as a tool to psychologically expand or shrink trip distances for cyclists. Shrinking psychological distances allows the bicycle to be a viable mode of transportation beyond its average thirty minute commuting range and could help attract cyclists already living in these areas. To accomplish this task, the far off, few, and featureless landscapes of sprawl need to be mitigated. Appleyard suggests that to create a sense of speed, "Objects might therefore be placed along the road simply to reassure the driver about his real motion, or even to accentuate his real motion, if it is desirable that he slow down."[60] The items that they suggest can be used to enhance a sense of speed are things such as trees, light posts, pavement joints or pavement materials, and items passing overhead. Spreading the same items further apart can reduce the sense of speed.[61] These perceptions can also be used for traffic calming. Cycling on the cobble stone streets of Europe produces a sensation of speed while the actual speed is reduced. This is especially effective in highly traveled pedestrian areas because it creates the sensation of speed, but actually reduces speed to be more compatible with the environment. Looking at these features is important to cycling design from the standpoint of time and the consideration that individuals place on it when making a transportation choice. If cycling is to be competitive with other modes of transportation, it must be able to cover the desired distance in a timely manner and feel as thought the duration is timely as well.

The sights in an urban area affect the sense of speed, but they also contribute to the pleasure and enjoyment of cycling. Objects along the roadway provide interest and stimulate thinking. They determine the beauty of a place and its visual complexity. Too few objects along the roadway creates a dull street. Too many objects can lead to a sense of chaos. All of these visual indicators send signals to cyclists, but it is important to understand how the cyclist interprets what is seen in a city. Although Appleyard, Lynch, and Mayer's studies of visual perception during motion refer to the experience in an automobile they still provide insight into how a cyclist views a city in motion. In their study, they tested the visual habits of drivers and they found:

> Along one route on which reactions were tested by us, two-thirds of all objects sighted were straight ahead, and only one-third were to either the right or left. Even then, almost all things seen to the side of the road were obliquely forward rather than perpendicular or backward to the line of travel.[62]

The authors also suggest that as speed increases the cone of vision narrows. Likewise, they conclude that it is the objects immediately to the side of the road that appear to be moving that capture the attention of the eye. This is also supported by Allan Jacobs who describes the importance of eye catching building surfaces, windows, and visually stimulating landscapes.[63] These findings suggest that in cities where a large number of buildings have been replaced with blank walls, parking lots, and stand alone architecture the visual experience is compromised. On the other hand, cities that have buildings close to the street, architectural unity, and visual complexity can improve the sensory experience of cyclists. Too often the importance of the visual environment is neglected when considering the needs of cyclists, but these findings indicate that it does have a significant impact on the sensory experience.

3.4.4 TOUCH AND TASTE

The design of a city has less of an impact on the senses of touch and taste for cyclists. Unless someone is eating a snack while cycling taste is rarely experienced and even then is beyond the control of the urban environment. Touch on the other hand is a sense that the city can have an impact on cyclists, at least in minimal ways. A cycling experience is not about reaching out and touching things, especially while in motion. Of course, unlike an automobile, this remains an option for a cyclist. For a cyclist, the sense of touch is stimulated by air upon the body and the conditions of the road. Air moving over the face and through the hair can provide a wonderful sensation. It is the same experience created when drivers of convertibles put the top down. Unfortunately, urban conditions that necessitate the wearing of helmets limit this experience and diminish the sensation. Other sources of air, such as steam vents and exhaust pipes produce less appealing effects upon the skin. A blast of hot air from a city bus can make the skin crawl. Tony Hiss also argues that the air around people also contributes to a sense of place.

> It seems our body sense of being placed in space makes use of different kinds of information. While it's based partly on the sense of touch--feeling air pressure on our skin as a way of knowing about the volume of the space around us--it's also based partly on visual cues.[64]

Thus, in addition to the visual aspects of a city the sense of enclosure and openness also connects people to places. What inherently follows from this argument is that the self contained volume of air in an automobile limits the connection drivers have with the city, whereas cyclists and pedestrians experience a greater connection with the city because their sense of space and openness are affected by the city.

3.4.5 SENSE OF SAFETY

The sense of safety that a cyclist feels is essentially the cumulative sum of all other sensory experiences. Loud threatening noises, offensive smells, blighted urban areas, and poor lighting all contribute to stress and diminish the sense of physical safety. These elements are often beyond safety measures designed to protect cyclists from automobile collision, but are equally important. It is ironic that cycling design puts so much attention into designing safe interaction between cars, bicycles, and pedestrians and yet fails to recognize the environment through which cyclists travel. The physical safety considerations of cycling are not limited to cars. If an area feels unsafe to walk through after dark, then it is also unlikely to feel safe to a cyclist. The automobile, and sprawl, contribute to such environments by taking people off the streets and leaving whole sections of the city empty after businesses close. People, including cyclists feel safer when other people are around. Recognizing the impact of the sensory experience on cycling is needed to attract and retain cyclists.

3.5 URBAN STREETS

There are volumes of text written on the technical aspects of streets and the details of cycling infrastructure. The topic is a favorite subject of transportation engineers and government officials. Of course, in their context, the street is defined in its narrowest terms, and is only considered a means of moving vehicles and not as a place in and of itself. Streets have been addressed throughout this chapter from many perspectives and are now addressed from the perspective of the transportation planning engineer. The impact of urban streets on cycling is addressed through a discussion of traffic circulation, materials, maintenance, traffic controls, and bicycle facilities. These elements are addressed last in this chapter in the recognition that they are a part of the cycling infrastructure, but also with the recognition that they are only one set of elements that affect urban cycling. The view of the road now shifts to the perspective of transportation planner and to the driver of the automobile. "For drivers, the road is a medium, while for pedestrians and bicyclists, the route is an experience."[65] In much of cycling design, the road is treated as a medium and not as a place.

3.5.1 STREET CIRCULATION

The circulation patterns of urban streets play an important role in the cycling experience. Two way streets provide access to the shortest routes and offer the choice of the most favorable topography for cyclists. Cul-de-sac streets, by definition, do not connect to an outlet. Such streets may eliminate cut through vehicles, but they also prevent cyclists from reaching adjacent streets in the shortest possible distance. One-way streets have variable impacts on cyclists depending on their location and the scale of the urban grid. Where city blocks are large and infrequent, one way streets can dramatically increase the distances traveled to reach destinations. In cities with a finer mesh of urban streets, the impact that one-way streets have is less likely to affect cycling. Additionally, one-way streets with steep up hill gradients can deter cycling. In cases where the gradient or the distance becomes significant it is typical to see cyclist riding illegally in the wrong direction on one way streets that lessen these conditions. Although illegal activity such as this is dangerous it should be seen as signal to transportation planners that something is wrong. The illegal activity can either be suppressed through enforcement of traffic laws, or accommodated by allowing two way cycling on one way streets through the addition of bicycle lanes. Bicycle lanes that allow opposite direction travel on one way streets are referred to as "contra flow" lanes. Such streets may be designed with both directions of bicycle lanes on the same side or may be designed with bicycle lanes at the right and left sides of the roads. In these locations, signs and markings are especially important because drivers do not expect head on traffic on one-way streets. In European cities, it is common practice for one way streets to allow two-way bicycle flow. On streets that are particularly narrow there may not even be bicycle lanes in either direction. Signage at the end of one-way streets indicate whether opposite direction traffic is permitted for cyclists.

3.5.2 MATERIALS AND PAVING

In addition to circulation patterns, the street material and paving patterns are important to cyclists. A smooth and even surface is perhaps the best design element that can be accomplished within the roadway itself. Asphalt or concrete streets provide relatively smooth rides. Bricks and pavers are acceptable choices when tight joints are possible. When bricks and pavers have rounded edges or wide gaps the effect is a bumpy ride where each vibration travels up the bicycle and through the body of the cyclist. The cobblestone streets common in European cities create the bumpiest ride, and quickly remind cyclists why bicycles were once named bone shakers. Regardless of the material type, it is quality materials and workmanship that provide the best roads. Allan Jacobs writes:

> All the best maintenance in the world will not make a wobbly line straight or a skewed line vertical. Nor will it cure a sloppy putty seal, make a muddy color come to life, nor make right a wrong tree. These are matters of materials, workmanship, and design, all with the word "high-quality" before them when it comes to great streets. [66]

Concrete is highly durable, very smooth and is usually favorable for cycling. However, concrete poured with waves and ripples can produce the same effect as a cobblestone street. Street resurfacing poses another problem when it is done poorly. Dangerous changes in pavement levels occur in situations where streets are resurfaced and the added pavement does not smoothly transition into the concrete gutter. Other street level materials that must be considered include stormwater drainage grates. Grates with long narrow openings parallel to the flow of traffic can trap bicycle tires and cause accidents. Grates with smaller openings are more appropriate and should be installed with openings perpendicular to traffic flow. Jacob's point about materials and workmanship is important, but equally important is the issue of maintenance.

3.5.3 MAINTENANCE

Street maintenance is imperative for cyclists' safety and comfort. There are two concepts of street maintenance that are important for cyclists. First is the condition of the roadbed. The road must provide a consistently even surface along its length. Potholes of even moderate depth can cause flat tires and damage bicycle rims. Likewise, cracks that run parallel to the direction of travel can trap bicycle tires and throw riders from their bicycles. At best, a poorly maintained road creates an annoyingly bumpy ride. At worst, bicyclists damage their bicycles or injure themselves by hitting these road hazards or by swerving to avoid them. Unfortunately, as Mayer Hillman points out, road maintenance is typically geared to the needs of cars. "Potholes are repaired only when they pose danger or damage to cars, but for cyclists the need for repair comes much earlier."[67]

The second concept of roadway maintenance involves materials that are deposited on the road. Clean roads are needed for cyclists for a number of reasons. Bicycle tires are more susceptible to puncture than the thicker treads of automobiles. Broken glass and sharp metal objects commonly litter the road. As automobiles travel down the road, debris is swept toward the edge. Of course the edge of the road is precisely where bicyclists are expected to ride, and where bicycle lanes are placed. Without regularly scheduled street sweeping, the debris continues to accumulate in the path of cyclists, especially in bicycle lanes. In addition to regular maintenance, legislative measures can help keep roadways clean. Richard Untermann writes that, “Requiring deposits and refund on all bottles reduces bicycle tire punctures and decreases maintenance. The State of Oregon's bottle law has virtually eliminated bottles from the landscape as the refund is attractive for many."[68] Such legislation provides incentives that encourage individuals to recycle glass and prevent it from littering the road. Other forms of litter may pose less of a threat to cyclists, but they do little to create a pleasing and enjoyable experience.

The proper provision and placement of trashcans along a street can reduce litter in the road. In his studies of urban street life, William Whyte concludes that the public "is good about litter if there is a place to put it. The problem is that too often there isn't."[69] In addition to being too few trash cans, Whyte also notes that [70]"We found, among other things, that trash containers are badly designed; that they are badly sited, being spotted in the same proportion on blocks with high trash loads as on blocks with low loads." These findings indicate that a better understanding of the sources and volumes of litter can help contain it and prevent it from entering the street.

Finally, there is particular danger to cyclists from loose gravel and sand in the roadway. Unpaved driveways are a common source of sand and gravel. On straight stretches of road, high velocity rainwater transports sediment, but the water slows down at intersections where streets merge. It is at these points that sand and gravel are deposited. When turning, the cyclist finds that loose materials can shift causing the bicycle to slide out from under them. The finer the particle, the more difficult it is to see and avoid. Some level of particulate matter on streets is inevitable, but the overall volume can be reduced. Reducing the number of unpaved surfaces that adjoin the roadway is one solution that would help. Because of stormwater considerations and the importance of permeable pavements it is not recommended that the entire length of gravel drives be paved. The major focus of such an effort should be on the first few feet of gravel drives and should particularly focus on drives where the gradient runs downhill into the street. The Portland Bicycle Master Plan recommends that the driveway aprons be paved a minimum of fifteen feet and preferably all the way to the edge of the right of way when possible.[71] A regular street sweeping program could alleviate the rest of the debris.

3.5.4 TRAFFIC CONTROL DEVICES

Traffic controls are a technical aspect of street design that substantially impact movement through a city. They affect both the amount of energy exerted, and time spent on a cycling trip. "The road authority can have an important influence on limiting the amount of energy lost by cyclists. Every time a cyclist is forced to stop at traffic lights or other obstacles, the kinetic energy built up by pedal power is lost."[72] The goal of engineers is to minimize congestion at intersections and reduce accidents, but this comes with the costs of time and energy. Common solutions range from simple signs indicating which traffic must stop or yield to large-scale, high-volume intersections that require traffic lights. These solutions are geared toward moving the most number of cars through an intersection in a given amount of time, but can neglect the needs of cyclists. For example, left turn arrows timed to allow only a couple cars through may not be adequate for bicycles. A bicycle at a dead stop does not have the acceleration capacity of an automobile and cannot make it through such signals during the green phase. Likewise, many traffic lights with vehicle-induced detectors require a substantial volume of metal to recognize the presence of a vehicle and to change the light. Cyclists at these intersections find themselves waiting on a light that will never turn green for them. Unless another car arrives, or pedestrians depress the crosswalk signal, the cyclist must either wait indefinitely or must run the red light. Enough frustration with a given intersection can cause a cyclist to select a different route or avoid cycling all together. Additionally, cyclists are typically forced to choose between routes on arterial roads and side streets. The arterial streets offer the greatest amount of green signal time and decrease the need for cyclists to stop, but they also have high traffic volumes and high speeds which may be unappealing. Side streets may have lower speeds and less traffic, but the number of stop signs and traffic lights guarantee that cyclists will have to stop. These traffic control devices can force cyclists to choose a route that is slower, has more hills, or is less appealing. The best solution is the installation of vehicle detectors that are capable of detecting bicycles. New signals often have this ability and are commonly included on streets with bicycle lanes, but much of the existing infrastructure at intersections does not. Attention to such details must be considered to avoid excessive inconveniences and dangerous behavior. On roads with bicycle lanes, the use of a separate set of signals for bicycles is an alternative. This approach allows cyclists to press a button to change the signal, but such signals may require cyclists to stop when they otherwise would have been free to go.

The other issue of traffic signals is that they are designed to safely direct the movement of vehicles at intersections. It is extremely important that the signals and design of intersections are as safe and simple as possible since ninety-five percent of bicycle accidents occur at intersections.[73] Unfortunately, design solutions at complex intersections often require unusual pavement markings or unique signals. Such solutions should be the exception, and the goal should be to simplify the complexity of intersections. Each intersection should not require an intimate knowledge of that intersection, but should be easily understandable based on previous experiences. Otherwise, each intersection requires cyclists to learn a different method of maneuvering which is likely to create confusion and contribute to accidents.

3.5.5 BICYCLE LANES

Bicycle lanes and wide curb lanes are the aspects of bicycle design that most people are familiar with. A *bicycle lane* is a lane in the roadway designated for semi-exclusive use by bicycles. A white stripe typically divides the bicycle portion from the adjacent automobile lane. *Wide curb lanes* are where the outside lanes have been widened to accommodate an automobile and a bicycle in the same lane. In the bicycling community there has been a great debate about whether bicycle lanes or wide curb lanes provide the best conditions for cyclists. A 1999 Federal Highway Administration report entitled "A Comparative Analysis of Bicycle Lanes Versus Wide Curb Lanes" studied these methods in order to provide a better understanding of the issues. The findings indicate that the choice of wide curb lanes or bicycle lanes does have some effects on things such as roadway positioning and cyclist behavior. However, the report concludes that both methods improve bicycling conditions. Furthermore, they suggest that bicycle lanes may be more appropriate since cyclists state a preference for them and express increased levels of comfort in them.[74] The increased sense of comfort and safety that these facilities provide makes them an important element of the urban design - urban cycling relationship. Likewise, the construction of such facilities shows a commitment by community leaders to improving cycling infrastructure. This outward expression may be a step toward changing attitudes and social perceptions toward cycling. However, as previous sections indicated, these facilities alone do not change the overarching urban conditions and must be considered as part of a more extensive program of planning and promotion.

3.5.6 PARKING

Parking is the final issue of urban street design that needs to be considered. There are two vantage points from which parking must be discussed. First, there is the issue of automobile parking. With on-street parking bicyclists are at risk of injury from car doors opening into the roadway. This situation is commonly referred to as being "doored." It is especially problematic since many cyclists have been improperly encouraged to ride as close to the edge of the road as possible. In the situation where curbside parking is provided a cyclist that rides within the zone of opening car doors will either hit the door or be forced to swerve out into the roadway. The elimination of curbside parking is the most effective way to eliminate this threat, but is also likely to be unpopular. Ultimately, cyclists must be trained and learn to ride a safe distance from parked vehicles, and bicycle lanes and markings should provide adequate clearance from opening car doors.

The second issue with automobile parking is the effect that private lots have on the number of access points along the road. Every parking lot along a roadway includes any number of entrances and exits onto the street and each driveway creates a small scale intersection where vehicles traveling in different directions come together. This presents more opportunities for collisions between bicycles and cars. Limiting the number of interactions between bicycles and automobiles traveling in different directions can help prevent accidents. Streets with fewer intersections present fewer opportunities for accidents. Likewise, curb radii and driveway widths can help limit the speed at which automobiles enter and leave the roadway and can require greater attention by drivers.

Finally, there is the issue of bicycle parking. The number and distribution of bicycle parking spaces in a city can determine whether cycling is convenient and possible. Urban environments that do not provide a place for cyclists to park essentially rule out cycling or make it very inconvenient. Bicycle parking needs to be safe, convenient, accessible, and secure. In the United States, this is typically provided in the form of an immobile bicycle rack, bar, or post. Interestingly, the need to provide an immobile fixture to attach bicycles to appears to be related to cultural issues and perceptions of theft. Throughout Denmark cyclists utilize a lock that simply immobilizes the rear wheel. This means that while the bicycle could be picked up and carried off it cannot be ridden. In parts of Germany this method is used as well, but in other areas of Germany and in Amsterdam bicycles are always attached to an immobile object (even when the bicycle has a rear wheel lock). This difference means that, depending on public perceptions, some cities can fulfill the need for parking simply by providing space in urban areas, while others may need to provide immobile racks.

The importance of secure parking is incredibly important. Unlike automobiles, most stolen bicycles are never recovered. In cities where theft is a major issue the level of cycling can be expected to decline year after year. Nicolas Mercat and Frederic Heran studied the effect of theft on urban cycling in France.

> Of the victims of bicycle theft, 23% do not buy another bicycle. Considering the fact that, over a 10 year period, 60% of cyclists are victims of bicycle theft, the potential number of urban cyclists is reduced by 14% every 10 years. Of cyclist who do replace a stolen bicycle, 46% buy a new bicycle immediately, 27% buy one a month later and 27% at least a year later.[75]

These findings indicate that even beautifully constructed bicycle lanes and fancy bicycle facilities will be underutilized when theft is a major issue. Urban environments that do not provide secure parking will lose cyclists over time.

3.6 SUMMARY

As indicated by Spirn's quotation at the outset of this chapter it is the cumulative effect of incremental decisions that have a profound impact on cities. Likewise, thousands of urban design decisions have an incremental effect on the appeal and success of urban cycling. It is within this context that planning and the design for cycling must be considered. Urban cycling is influenced by urban form, architecture, and the sensory experience and it is these factors that determine whether individuals can cycle, and whether cycling is enjoyable. This means that cycling design that only focuses on roadway elements is unlikely to produce a significant volume of cycling because it cannot address all the issues that affect cyclists. Understanding the impact of the city on the cyclist is the first step towards better design solutions and a better understanding of the urban design - urban cycling relationship.

Chapter 3: Notes

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CHAPTER 4

THE INFLUENCE OF URBAN CYCLING ON URBAN DESIGN

The urban environment impacts urban cycling, but the opposite is also true. Bicycles save space, emit no air pollution, produce minimal sound, contribute to healthy lifestyles, and can reduce social isolation. These factors suggest that the bicycle can be used as a tool to shape cities and improve urban living. As with the automobile, the bicycle can also have detrimental effects on urban spaces. For example, unrestrained bicycle use in pedestrian areas produces undesirable conflicts between cyclists and pedestrians. This chapter discusses the impact of cycling on urban space, public health, community development, social equity, and urban economics, along with the negative aspects of cycling. With an understanding of how cycling improves urban living, communities can begin to make informed design decisions. Similarly, understanding the negative impacts of urban cycling can help lead to design and policy solutions that mitigate these effects.

4.1 SPACE SAVINGS

The bicycle in urban environments is a space-saving vehicle. Consider, for example, that fifteen bicycles can occupy the same space required to park just one car. Where cars are in motion, even greater amounts of space are required for each vehicle. As speed increases the space needed for each car continues to grow.[1] The urban design implications of the difference in spatial requirements between automobiles and bicycles are astounding. Figure 4.1 demonstrates the changes in public space from 1930 to 2000.

Figure 4.1: Changes in public space. Source: Federal Highway Administration.

The impact of the spatial requirements of the automobile is a major factor that limits bicycle use, and a benefit that bicycles can provide to cities. "Because of automobile dependence, U.S. cities average twice as much road space and parking per capita as their Western European counterparts."[2] The space dedicated to automobiles also leaves less space for homes and businesses, public spaces, and parks. The lack of such items in turn contributes to the decline of urban living. Jane Jacobs argues for a judicious use of automobiles in cities and predicts the social consequences:

> What if we fail to stop the erosion of cities by automobiles? What if we are prevented from catalyzing workable and vital cities because the practical steps needed to do so are in conflict with the practical steps demanded by erosion? There is a silver lining to everything. In that case we Americans will hardly need to ponder a mystery that has troubled men for millennia: What is the purpose of life? For us, the answer will be clear,

> established and for all practical purposes indisputable: The purpose of life is to produce and consume automobiles.[3]

Similarly, Christopher Alexander suggests that "it may be that cars cause the breakdown of society, simply because of their geometry."[4] Simply put, the dimensions of a car (roughly 15' by 7') require vast amounts of urban land. The social consequences are very real, and when public spaces are devoted to automobile parking, social opportunities are reduced. Consider Copenhagen in the late 1960's. Like many other European cities at the time automobiles were squeezed into every public space possible. Decades of work were required to reduce parking and to return these spaces to the people. In one study, "the average number of people sitting and mulling around civic squares and pedestrian streets during daylight hours rose from 1,750 in 1968 to 5,900 in 1995."[5] Many of these public spaces existed in Copenhagen before the automobile invaded them and were converted back to their former use. Critics are quick to suggest that such spaces were never incorporated into modern American cities, however, this does not mean that American cities, without a history of public squares and plazas, could not benefit from automobile restraint and by turning automobile landscapes into community spaces.

In addition to the social consequences brought on by the geometry of the automobile, there are also environmental impacts. Asphalt parking lots and expanding roads take up space that could be utilized for street trees and green space. These spaces could provide enjoyable places for people, but instead the pavement collects the hot summer sun. This makes urban living less enjoyable, because cities remain excessively hot during both day and nighttime hours. The paving also contributes to stormwater runoff which carries pollution into streams and rivers and erodes soils. "Sprawling cities have higher quantities of asphalt for their cars (about eight parking spaces per car in the United States, as well as more roads per capita) and hence there is more stormwater pollution."[6] These conditions put unnecessary financial and social stress on cities, but do little to improve urban living.

The bicycle offers citizens an alternative that saves space, and can decrease the need for wider roads and impermeable parking. The space-savings can also be used to support other complementary modes of transportation such as walking and mass transit. William Whyte notes that more space is needed for pedestrians in this country. "In almost every U.S. city the bulk of the right of way is given to vehicles; the least, to people on foot. This is the inverse relationship to need."[7] Space for pedestrians in urban environments is often limited. Curbside parking and street expansion shrink sidewalk space. Parking meters and opening car doors invade what little space is left. The irony of the situation is that in many city centers, walking represents a high proportion of transportation, but receives a low proportion of the space. "In midday Manhattan two-thirds of all travel is on foot but only one-third of transport space is available to the pedestrian."[8] Use of the bicycle can improve situations such as these. Because of the space-savings that the bicycle offers, a large portion of automobile parking could be returned to pedestrians as structures such as parking meters and construction for road widening projects become unnecessary.

Another issue of space in cities that cycling can improve relates to urban spaces that are altered to accommodate driving. Consider that many U.S. city centers are a patchwork of parking and isolated buildings. Cities can return these empty patches of asphalt back into contributing spaces with homes, businesses, and shops. As described earlier, such changes further reinforce walking, cycling, and transit. However, automobile restraint cannot occur without providing alternative forms of transportation. The bicycle, combined with other modes of transportation, make parking reduction possible, and can facilitate the return of city spaces to civic uses. Such a process is likely to take a considerable amount of time and would require gradual incremental changes.

4.2 HEALTHY CITIES

The second major contribution of the bicycle to the city is its ability to facilitate healthy urban environments and healthy lifestyles. The bicycle itself does not pollute the air with toxins or noise, and at the same time provides daily opportunity for exercise. The search for healthier living conditions was a reason that many people left the cities for the countryside, but the automobile has transported unhealthy conditions from city to suburb. Now, neither environment is free of the unhealthy effects of the automobile. Increased bicycle use can restore healthy living conditions and lifestyles to cities.

Designing cities around a form of transportation that threatens people's health makes little sense. "Approximately two-thirds of the carbon monoxide, one-half of the nitrous oxide, and two-thirds of the carbon particulate emissions from human sources are created through traffic."[9] These elements destroy both civic structures and human health. Years of automobile pollution turn monuments and buildings black and create the need for extensive cleaning and repair. Likewise, the same elements that collect on building facades are also inhaled and collect in the lungs. "The dirty brown haze of photochemical smog reduces visibility, irritates eyes and noses, and causes coughing and headaches."[10] Pollution in urban areas is so bad that it has become a regular part of the television news broadcasts. Weather forecasters not only predict the daily temperature and precipitation, but also issue health warnings on days when it is not acceptable for the elderly and those with respiratory problems to go outside. If these health effects were the result of a virus or bacteria, then society would exert all means possible to develop a medical remedy, but since they are the direct result of conscious design decisions, health problems are treated with asthmatic inhalers and health warnings, while addressing the cause remains a low priority.

4.2.1 AIR

Unhealthy air in cities is nothing new, but its sources have changed over time. Historically, cities have had problems with air pollution from burning wood and coal, and from industrial production. Technologies have reduced emissions from these sources, but the automobile has stepped in to fill the gap. This pollution is not good for residents and cyclists alike. "While studies suggest that cycling along heavily traveled roads does not subject bicyclists to air pollution health hazards any greater than those to which motorists are exposed, no one wants even that level of exposure."[11] Another study finds that drivers are actually exposed to more pollutants than cyclists.[12] Such studies are somewhat reassuring and suggest that urban conditions are no worse for cyclists than for drivers, but urban air quality can and should be better. Unlike the automobile, bicycles produce no air pollution and can help improve urban air quality. Increasing the volume of cyclists can result in lower pollution emissions. With the automobile, increased use means increased air pollution. Electric cars are often suggested as a means to resolve urban air quality, but electricity from coal fired power plants simply moves the origin of the pollution. Cycling can help improve urban air quality and create healthier urban environments.

4.2.2 WATER

In addition to improving air quality, cycling also offers the potential to improve water quality. As already described, the accumulation of impermeable surfaces for parking and roads contributes to stormwater management issues. One effect of this is that streams are unable to contain the added volume of water that runs off impermeable surfaces, resulting in downstream flooding and erosion. Another adverse effect of impermeable surfaces is that water is not able to percolate back through the soils and recharge the underground aquifers that provide many cities with drinking water. Additionally, automobiles deposit considerable amounts of pollutants onto roadway and parking surfaces. With each rainfall, oil, gasoline, and other engine fluids are washed into and collect in streams, lakes, and reservoirs, poisoning aquatic life and contaminating soils and drinking water supplies. This appears largely as an environmental issue, but this issue compromises the long term ability of cities to provide safe, clean and affordable drinking water.

Cycling can help reduce the threat that the automobile has imposed on water quality in a number of ways. First, cycling dose not require gasoline, oil, transmission, steering and an array of other toxic fluids as the automobile does. This means that cycling does not inadvertently deposit these elements into a city's drinking supply. Additionally, since cycling does not facilitate sprawl, it does not require the vast amounts of pavement found in cities designed around the automobile. A reduction in the amount of pavement would also allow for the use of more expensive permeable paving without increasing overall expenditures on paving. These differences suggest that the bicycle can be used as a tool to prevent further deterioration of urban water sources.

4.2.3 NOISE

Noise is another aspect of urban health that affects urban living. As already discussed, noise has an impact on the appeal of cycling, but cycling also offers the opportunity to reduce the amount and volume of urban noises. Automobiles emit a tremendous amount of noise from their engines, horns, tires, alarms and brakes. All of this noise has an effect on urban living. At the most basic level, even conversations can become difficult. Whitelegg describes how normal conversations occur at about 55 decibels and "to be heard correctly noise in background should be at least 10 db lower."[13] However, Perry indicates that most motor vehicles are allowed to produce 80 decibels of noise and that, "at 60 dB the maximum distance for conversation is two meters. When noise rises to 80 dB the distance decreases to twenty centimeters, and at 90 dB conversation is reduced to shouting in each other's ears."[14] All of this makes urban activities less enjoyable, and urban spaces become unappealing. Table 4.1 demonstrates how noise levels affect residents of different cities:

Table 4.1: Percentage of population living with noise levels greater than 65 dB(A)[15]

Amsterdam	19
Detroit	60
Paris	50
Sydney	10

Whitelegg summarizes the effects of automobile noise and concludes that "Communication difficulties are unacceptable disturbances to normal social interaction and are a contributory factor in the abandonment of public space, abandonment of walking and loss of contact with friends, neighbours, colleagues and children in the outdoor environment."[16] These factors suggest that a quiet vehicle, such as the bicycle, can help restore pleasure to the social activities of a city, but there are also health effects of noise that need to be considered as well.

High noise levels in cities have significant effects on health. "Noise during sleep is responsible for a number of primary physiological effects. These include increased blood pressure, increased heart rate, vasoconstriction, change in respiration and cardiac arrhythmia."[17] The secondary effects include "increased fatigue, decreased mood or well-being, and decreased performance."[18] Unfortunately, there is nowhere to escape from automobile noise in cities. It is the overriding sound on most city streets, and even penetrates into homes and workplaces.

> Road traffic is the major cause of noise pollution in urban and suburban areas, from tire friction, combustion engine noise, horns, alarms, and sirens. In the Central London Noise Survey (1990), which tested 400 sites in the city, 84 percent of the noise was attributed to traffic. More than a third of the people questioned in the survey were disturbed by traffic noise at home, while one in five were disturbed by traffic noise outside.[19]

The bicycle is a quiet alternative to the automobile, and can provide healthier urban living conditions by reducing the frequency and volume of transportation based noises.

The sound of bicycles alters people's perceptions of the street environment. Bicycle bells become a defining characteristic of cities with high volumes of cycling. Unlike the aggressive and overly amplified sound of car horns, a bicycle bell offers a quieter voice. Unfortunately, the presence of street noise is so prolific that many people have come to accept it and do not even realize its adverse impact until an alternative experience is provided. Consider the following descriptions of streets in China:

> People and more people use the streets, not in automobiles but on foot, on bicycles, and in buses. Trucks keep them company. The streets may or may not be used for strolling and visiting, but mostly it seems they are used simply to get from one place to another. What a fine way to travel, amid linear boscs of trees, shaded from the sun in the summer, with an ever-changing light. The sound, overwhelmingly, is the sound of bicycle bells.[20]

> Two senators recently returned from Mainland China to report that one of the most appealing facts of Chinese urban life was the absence of traffic noise.[21]

Notice that neither description had negative things to say about the sound of bicycle bells. The bells provide a warning without resorting to aggressive tactics or abrasive volumes.

Meanwhile, studies suggest the nature and conditions of driving contribute to aggressive behavior. "A Norwegian government study indicated that the impersonality of auto traffic, coupled with the intense competition often manifested in auto congestion, results in the display of an unusual degree of ruthlessness."[22] Cyclists, unlike drivers, are not hidden from others behind a layer of steel and glass. This loss of anonymity could potentially reduce roadway aggression, and allow cycling to contribute to a more healthy and peaceful urban environment.

4.2.4 PHYSICAL ACTIVITY

The final way that cycling facilitates healthy urban living is through the regular physical exercise it provides. The U.S. and other industrialized nations with high levels of auto dependence are facing a health crisis associated with the issue of obesity. Meanwhile, exercise has vanished from daily routine. The "walking city" provided exercise as part of daily life. Today, the automobile requires virtually no physical exertion from its passengers. It is essentially a recliner on wheels that offers no opportunity for physical fitness, and it simultaneously consumes the time that was previously used for physical activity. This sedentary lifestyle that the automobile facilitates has very real costs. "In the U.S., the direct health care costs associated with inactivity have been estimated at between $24.3 and $37.2 billion."[23] Similarly, a study in the U.K. attributed 18 million sickness related absences and 30,000 premature deaths in 1998 to obesity. Furthermore, the study concluded that obesity resulted in an average loss of nine years of life.[24] The health crisis in this country is not a coincidence, but is, in part, the effect of eliminating physical activity from daily life.

Cycling provides the daily physical fitness component that many individuals lack. It also makes fitness a part of life, and unlike exercising at the gym one cannot forego fitness by deciding that it does not sound like fun anymore. Exercise that focuses only on sports and health clubs has proven unsuccessful at keeping the majority of Americans physically fit. Freund and Martin describe how exercise has changed over time: "Fitness has been commodified and, what in reality requires little equipment, technical knowledge or specialized space, has become a complex, expensive and arcane enterprise."[25] In sprawling cities, just getting to and from the gym can consume all the time an individual has available for exercise. With the bicycle, exercise is built into the daily commute, shopping trip, and social visit. The health benefits of cycling are real and measurable.

Cyclists experience improvements in a wide range of physical categories. "Cycling for about 20 minutes per day prevents cardiovascular diseases. Regular cycling can protect against coronary heart disease, strokes, non-insulin dependent diabetes, falls, fractures and injuries (through improved strength and coordination), colon cancer, overweight and obesity."[26] These are not just the expected benefits of cycling, but are observable physical traits of individuals that cycle on a daily basis. Studies, such as a Copenhagen heart study, showed that "even after adjustment for other risk factors, including leisure time physical activity, those who did not cycle to work experienced a 39% higher mortality rate than those who did."[27] These results show that cycling can help improve the urban living experience and restore physical fitness to a nation facing an obesity epidemic. It is an option that is available, but is still yet to be adopted with the full backing and support of communities and their governments. In the late 1840's, cities implemented designs for sewage systems in order to reduce water and insect borne diseases.[28] These historic outbreaks in diseases were eliminated by improvements in urban design, and the current health crisis can also be addressed through design measures. Cycling is one design element that can facilitate healthy urban living.

4.3 DESIGNING SOCIAL CITIES

Cities are inherently social spaces. Through the course of normal daily activities there are numerous opportunities to meet old friends and make new ones. The automobile erodes opportunities for social interaction. For the majority of commuters, time spent in cars is time spent alone without the opportunity to meet and talk with others. A driver can travel from home to work without ever stepping outside and meeting or talking to the people in their community. Automobiles also erode street environments, which makes it less appealing for community members to spend time outside and limits the opportunities for children to play. As described above, traffic noise limits the appeal of outdoor spaces. Cycling can help re-establish a sense of community and place by providing social opportunities for adults and children, and by reducing social isolation.

Automobile traffic has a measurable adverse impact on neighborhood streets and social interactions. In "Livable Streets" Donald Appleyard studied the effects of automobile traffic volumes on perceptions of community and street use. He looked at streets that were comparable on most measures, but varied based on traffic volume. "On LIGHT street, inhabitants were found to have three times as many local friends and twice as many acquaintances as those on HEAVY street."[29] He also found that the streets were used in fundamentally different ways. On streets with light vehicular traffic, people were more likely to gather outside, and more children played games in the street than on heavy traffic streets. This makes sense since traffic presents a danger to children playing in the streets and automobile noise makes conversations difficult and less enjoyable. Another interesting finding is that on streets with heavy traffic all the families with children had moved away.[30] Appleyard asked residents to circle their "home territory" on a map and through this exercise the effects of the automobile on community development become apparent. Figure 4.2 depicts Appleyard's findings.

The differences between the home ranges of residents on high, medium, and low traffic streets shows how cities tailored to the automobile alter social interactions. The bicycle offers the opportunity to mitigate at least some of these effects. Even with cycling, main arterials would still have heavier traffic than side streets, but the impact of the traffic would be lessened. Reducing noise volumes on high traffic streets can restore some of the social functions that transpire along the sidewalks. Street play would still be problematic in streets with heavy bicycle traffic, but space savings from cycling could return a portion of the roadway to the neighborhood for community activities and play. With this approach, cycling becomes a design tool that helps improve community living and social interaction.

4.4 DESIGNING FOR EQUITY AND ECONOMICS

The bicycle is often seen as the vehicle for poor people. This reputation has certainly not aided its advancement as a legitimate mode of transportation, but its affordability is one of the key reasons why it is a good choice for urban transportation. A bicycle can be purchased with less than a week's wage, while an automobile may require years' worth of work. This difference suggests that where urban conditions facilitate cycling, a larger number of people will have access to a relatively fast, reliable, and individualized mode of transportation. The implications of such circumstances create more equitable transportation opportunities across age, gender, and economic levels.

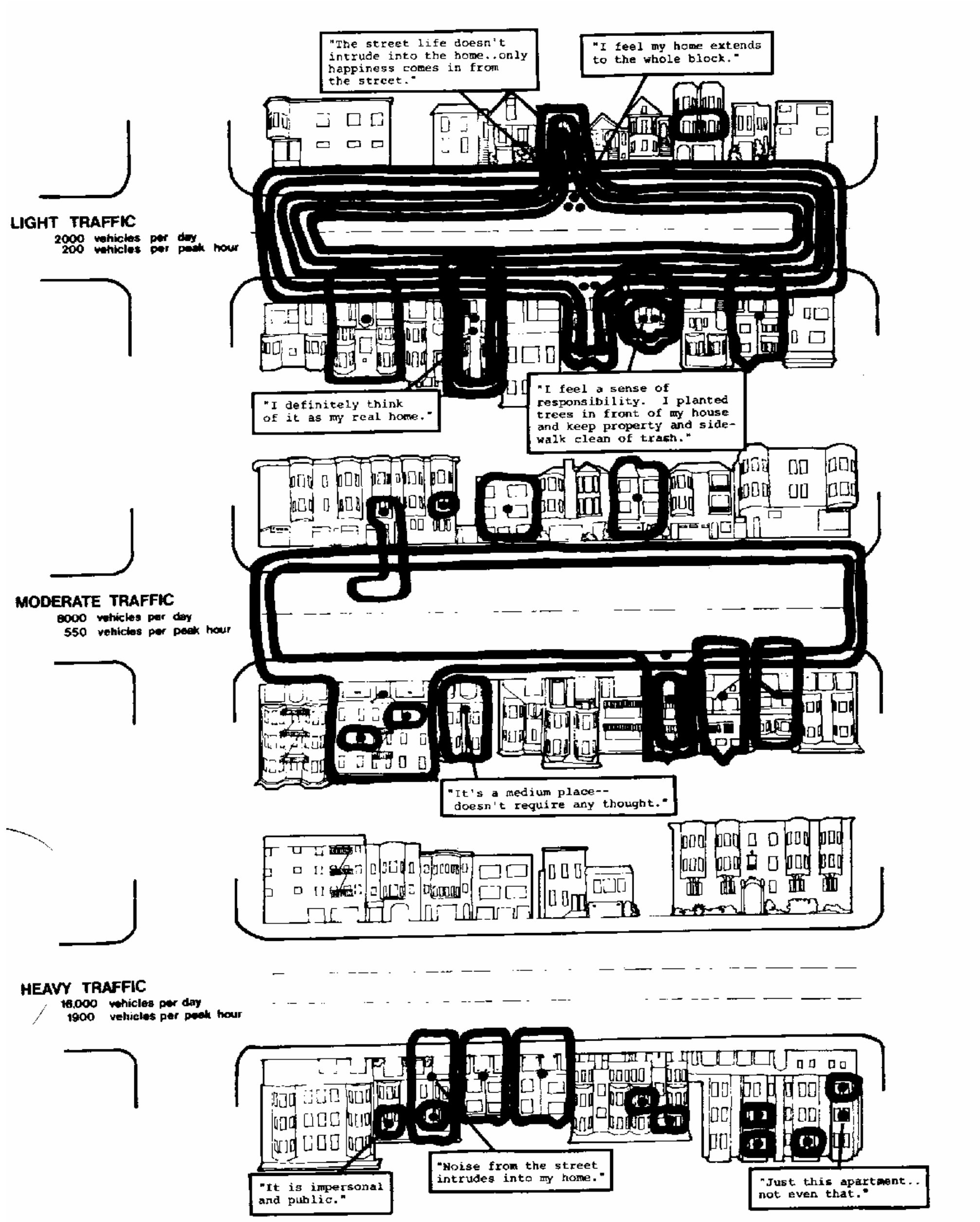

Figure 4.2**:** Effects of traffic on residential streets: Resident's depiction of their home territory on streets with light, moderate, and heavy vehicular traffic. Source: Appleyard 1981, 23.

4.4.1 TRANSPORTATION EXPENSE

On an economic level, many people are excluded from car ownership and access to certain urban destinations. "The bicycle offers the most economical means of travel. Compared to walking, cycling saves time. Compared to driving, cycling saves money. Compared to anything living or man-made that moves, cycling saves energy."[31] Cities that are accessible by bicycle provide the greatest opportunity for equitable transportation regardless of income. "Cycling in the US is also inversely correlated with income. Its modal share is 3 times higher among households earning less than $15,000 than for households earning more than $80,000."[32] Designing cities that facilitate cycling can create a more equitable and accessible transportation system.

4.4.2 EQUITY AMONG AGE GROUPS

Cycling facilitates opportunities for older and younger travelers. In many urban and suburban areas young people are excluded from the transportation system. Where public transportation is unavailable and cycling is deemed to be too dangerous, young people must rely on parents or friends to drive them around. It is no surprise that young people rush to get a driver's license and spend their savings and income on their first automobile. A third family car has become common in American households, but its presence is as much about freeing parents from the chore of driving their children around as it is about children taking control over their transportation. The bicycle offers young people a low cost means of transportation, but for its use to be acceptable, parents must feel that the urban environment is safe for their children to cycle, and cycling routes must go where children need to go.

Cycling also offers transportation opportunities for older people. Cycling is a comfortable mode of transportation that can keep older people in good physical condition while providing access to the city. An environment that is favorable for cycling is also likely to be favorable for walking, and as a result, even those who no longer wish to cycle can still maintain an active civic life. In this way, the lack of an automobile or bicycling skills does not require older individuals to be stuck at home and once again at the mercy of family members capable of driving. However, this is the reality of many older Americans. The transportation needs of the old and young are certainly not a priority of transportation planners, but should be. Consider, for example, that an estimated 40% of the U.S. population will always be without a car.[33] This fact has life changing effects for the young, old, and low wage earners. The bicycle provides affordable and convenient transportation for these groups.

4.4.3 GENDER BASED EQUITY

Along with older and younger individuals, cities designed for cycling provide many benefits for women. Ursula Lehner-Lierz studies the effects of transportation on women. She argues that automobile based transportation has negative effects that disproportionately affect women. She suggests that as primary caregivers for both young and old family members, it is women that are forced to provide the transportation needs of the family.[34] An environment that is dominated by the automobile spreads out daily trips for shopping, doctor visits, school, and work, and it is women that spend the greatest portion of their time meeting these needs. Cities with compact design facilitate short trips, provide independence for older and younger family members, and can reduce the need for women to meet everyone else's transportation needs.

Furthermore, she argues that transportation decisions, even cycling design, inherently favor the needs of men, while neglecting the needs of women:

> It is no surprise that our built environment is optimized for the employed man with a briefcase, commuting by car during the rush hour. Even cycle planning is mostly done by men from their point of view - with the results that they put too much emphasis on cycling networks and cycling facilities, which serve young, dynamic (male) people, cycling to work without any luggage or company.[35]

Cities that physically shrink trip distances, and make urban environments more pleasurable, improve cycling conditions for women. Design that focuses on the use of high-speed cycling to shrink long trip distances and showers at work, in order to provide post-trip cleanup, neglects the needs of many women. Bicycle speed is related to the weight of the bicycle, but children and packages add weight, reduce speed, and limit the bicycle's effective range for daily activities. For the commuter, showers at work can mitigate the effects of a treeless street in the summer, but they do little to provide a comfortable experience for someone whose destination is the grocery store or the doctor's office. Cycling can improve these conditions for older and younger individuals and women, but it must be done in a way that recognizes differences across age and gender groups. If cycling design does not recognize the needs of these groups, then it has the same ability as the automobile to disenfranchise large segments of the population.

4.4.4 HOUSEHOLD AND URBAN ECONOMICS

Finally, there is the issue of designing a city for both individual and citywide economic stability. Designing a city so that each individual needs to own an automobile compromises the economic competitiveness of a city's employees. Manufacturers, and now even high-tech jobs, regularly leave U.S. cities to take advantage of lower wage conditions in other countries. Part of this shift, is based on environmental and regulatory issues, but much of it is based on employee wages. Cities must make their employees more affordable if they wish to remain competitive in a global economy. However, wages must be significantly higher where individuals are forced to own a car to reach their workplace. Consider that, "in 1990 in the United States, transport (dominated by auto expense) accounted for 18.1 percent of all consumer spending."[36] In a city where cycling connects workers with their workplaces, the annual wages could fall by the percent of income spent on the automobile, and workers could still maintain happy productive lifestyles. Critics might suggest that the reduction in automobile use constitutes a decline in the standard of living. Economically speaking this may be true, but it unnecessarily correlates happiness with automobile ownership. "In 1993, compared to 1957, 'Americans [had] twice as many cars per person. . . . However, doubled affluence made them no happier. In 1957, 35% of respondents told the National Opinion Research center that they were 'very happy' compared to just 32% in 1993."[37] In addition to wages, healthcare costs also constitute a large share of employers' expenditures in the United States. Cycling improves health and consequently could reduce employers' expenditures on health insurance premiums and sick days. These changes suggest that cycling can, in part, help to develop a more stable urban economy.

In terms of designing a city for economic stability, there is also the issue of creating individual economic stability. Owning an automobile is a major expense for households. Because the automobile is fueled by a limited resource, the cost of operating an automobile fluctuates on a regular basis. The energy crisis of the 1970's showed the consequences of fuel shortages on individual consumers. Gasoline prices soared and consumers spent hours waiting in line in hopes of getting enough gas to keep their cars running. Wars, energy crises, oil cartel behavior, and increased demand with limited supply, raise fuel prices and create uncertainties for household budgets. However, even in the event of fuel shortages cycling remains a viable mode of transport. The bicycle can travel 1500 miles on the energy equivalent of a gallon of gasoline.[38] Cities designed for cycling allow their citizens to take advantage of the efficiency of cycling while simultaneously improving urban living conditions.

4.5 NEGATIVE ASPECTS OF CYCLING

For all the benefits that cycling provides to a city, there is also an equally important set of consequences of which designers must be aware of. First, cyclist and pedestrian conflicts are likely to arise where the two modes overlap. For this reason, cycling on sidewalks is not advisable. Likewise, cycling is not compatible with pedestrian malls where pedestrian volumes are high. It is ironic that in many urban areas cycling is prohibited on sidewalks, but this is exactly where most bicycle parking is placed. This arrangement sends conflicting signals. The arrangement arises from the overvaluing of curbside parking for automobiles, and the undervaluing of sidewalk space for pedestrians. Bicycles parked on the street take up space that could be used for cars, but this is unacceptable to planners. Instead, bicycles racks are placed in the sidewalk where they interfere with pedestrian flow. Somehow this is seen as a more acceptable approach. The lesson that this point illustrates is that ample space needs to be provided for pedestrians, so that they do not need to walk in cycling areas, and space needs to be provided for cycling so that there is no need to ride on the sidewalks. Clearly delineating which space is intended for which use can help eliminate conflicts. Signs, markings, and pavement materials can be an effective means in defining separate spaces for pedestrians and cyclists. Limited hours when cycling is appropriate in pedestrian malls is also an option. For example, cities may choose to allow cycling in pedestrian malls between 8 PM and 8 AM when pedestrian volumes are low and conflicts are unlikely. Enforcement of cycling prohibition is needed to ensure that cycling does not ruin public spaces intended for those on foot.

The second major issue is the placement of parked bicycles. As discussed earlier, the type of bicycle lock that cyclists utilize determines whether racks are needed, or if bicycles are locked to themselves. When bicycles utilize a lock that simply immobilizes the rear wheel, then bicycle racks are simply an organizing structure and not a security feature. In this situation, cyclists have greater flexibility in determining where to park bicycles. This flexibility also means that every place that is convenient for a cyclist becomes a potential parking space. Consequently, bicycles may obstruct sidewalks, entrances, and may accumulate in unexpected and undesirable locations. The benefit of such a system is that individuals can easily move these bicycles out of the way (even if they belong to someone else) and bicycles are less likely to be chained to things such as trees and benches where they can cause damage.

A different set of problems arises when perceptions of crime require bicycles to be locked to an immobile object. When bike racks are full or inconveniently located, cyclists will find other objects to attach their bicycle. Any immobile object to which a bicycle can be locked becomes an instant bicycle rack. Things such as trees, benches, pipes, and parking meters bear the brunt of such actions. Unfortunately, bicycles can damage trees, prevent people from sitting on benches, and block movement along sidewalks. With proper placement of racks and enforcement of local ordinances these issues can be mitigated. Designers may also select street elements that do not offer a closed loop in order to deter undesired bicycle parking.

Another issue with parked bicycles is the issue of where to put bicycle racks. Placement of bicycle racks on sidewalks inherently constricts pedestrian environments. Bicycles in cities save space compared to automobiles, but the benefits of the space savings may go unrealized if each new cyclist does not reduce automobile traffic. In the situation where cycling increases and automobile use remains constant, planners often resort to placing bicycle racks on the sidewalk. This is not an improvement for pedestrians, and the tradeoff reduces the bicycle's ability to improve urban living. If cycling is expected to improve the urban environment, then encroaching on pedestrian areas is not an option. Placing bicycle racks in former automobile spaces sends a consistent signal that bicycles do not belong on the sidewalk and that cycling is a legitimate mode of transportation that deserves a share of the street space. Additionally, placing bicycle parking on the street can increase automobile attrition by reducing the supply of automobile parking.

Parking thousands of bicycles can also require the need for multistory parking decks. As discussed earlier, parking decks are often the source of blank walls which detract from urban streetscapes. In European cities, train stations are the typical destination that require the construction of parking garages. The only positive element of this situation is that fact that cycling allows parking decks to remain smaller and accommodate more travelers than the same space would if people commuted by automobile.

Finally, abandoned bicycles can detract from city life. Due to their low costs, bicycles may be abandoned and they begin to accumulate in bicycle racks and at popular destinations. In any volume these bicycles become clutter that is visually unpleasant. Typically, abandoned bicycles are older, less valuable, or broken. When left, parts such as seats or wheels are frequently missing, stolen, or severely damaged and frames often begin to rust. Even if individuals wanted to clean up and recycle abandoned bicycles in their neighborhood, this is not an option because abandoned bicycles are often locked up. This situation requires intervention from local authorities who must determine whether a bicycle has truly been abandoned. An annual sweep of the city is one option that can help with abandoned bicycles. Under this practice, city officials post notices requiring the removal of all bicycles from a rack on a certain date and then, any bicycles remaining on the rack are removed on the prescribed day. This method requires an intensive effort to keep up with all the parking locations in a city and still allows abandoned bicycles to sit for months at a time. Another option that can help is the use of bicycle registration. Under such circumstances owners can be identified, contacted and asked to remove their bicycle. This is also helpful in recovering stolen bicycles. The negative consequences of cycling reveal the need for proper planning and design in order to mitigate these impacts.

4.6 SUMMARY

Cycling has the ability to improve urban living in social, environmental, and economic terms. Returning urban spaces to public use, providing healthy lifestyles, and equitable transportation are all possible with increased bicycle use. The benefits of cycling to an individual are easily grasped, but the higher level city-wide benefits require greater efforts and significant increases in cycling before they can be realized. Along with the benefits of increased cycling, there are also consequences that must be expected and mitigated. Embracing cycling without preparing for the consequences can deteriorate urban areas. Likewise, the benefits of cycling become less attractive when bicycles litter the streets and infringe on pedestrian spaces. Proper planning and design can help ensure that the costs of cycling do not outweigh the benefits.

Chapter 4: Notes

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CHAPTER 5

CASE STUDIES

American views of transportation, and the role of the bicycle are largely shaped by experiences in this country. Driving is the dominant mode of transportation and few Americans have experienced how cycling can affect urban living. A number of cities, both domestic and foreign, act as examples of how cycling affects urban environments, and offer guidance on how to incorporate cycling into transportation systems. Traditionally, Northern European nations are cited for their success in encouraging cycling. In this section four European cities are profiled: Copenhagen, Denmark; Odense, Denmark; Munster, Germany; and Amsterdam, Netherlands. These cities provide examples of cycling in several different nations and in cities of various scales. Asian nations also offer insight into the effects and role of cycling in cities. Unfortunately, there is generally less written about the effects of cycling on Asian cities compared to European examples. However, a discussion of cycling in urban areas would hardly be complete without discussing Asian examples. In this section, examples drawn from a number of Chinese cities are discussed rather than just one specific city. Finally, Portland, Oregon and Davis, California are discussed as American examples of bicycle-friendly cities. Through these case studies a real world view of the urban design - urban cycling relationship is presented.

5.1 EUROPEAN CITIES

When American planners look for examples of cities with high levels of cycling they often look to Europe. The countries of northern Europe, including Denmark, Germany, and the Netherlands enjoy high levels of cycling in many cities. Two large cities, Copenhagen and Amsterdam, and two small cities, Odense and Munster, are presented to demonstrate the relationship between urban design and urban cycling.

5.1.1 COPENHAGEN, DENMARK

With a population 499,000 in the municipality and 1.8 million residents in the metropolitan region, Copenhagen, Denmark is one of the largest cities to have successfully incorporated cycling as a mode of transportation.[1] The success of cycling in Copenhagen is not by accident, but is the result of decades of design and planning efforts aimed at increasing the modal share of cycling. National and local transportation policies encourage cycling throughout Denmark. Local leaders conscientiously guide transportation decisions and urban design rather than allowing the automobile to define urban environments.

Over the course of thirty years Copenhagen incrementally reduced parking in the central city.

> Since the mid 1980's, the city of Copenhagen has been expropriating car lanes and curbside parking spaces for exclusive use by bicyclists. Between 1970 and 1995, bike lanes increased from 210 to more than 300 kilometers in length. During that same period, the number of bike trips rose 65 percent. When the weather is nice, more Copenhagen residents get to work by bike (34 percent) than by car or mass transit (31 percent each).[2]

Such efforts in automobile restraint are unheard of in American cities, but have worked well in Copenhagen for a number of reasons. First, Copenhagen is a densely built city which makes walking and cycling compatible with the existing urban form. Despite its size and density, Copenhagen's skyline is not dominated by skyscrapers, but instead is defined by mixed-use, low to mid-rise buildings, where daily needs can be met by neighborhood shops and businesses. A second trait that has aided the expropriation of parking is that major sections of Copenhagen were constructed prior to the introduction of the automobile. In many cases, the automobile simply does not fit easily into these areas. Similarly, garages and on-street parking for automobiles are limited and expensive. Likewise, drivers must pay for on-street parking at vending machines located on every block, which issue a ticket to be placed in the automobile's window. This system has a couple advantages over parking meters that are commonly used on U.S. city streets. The first advantage is that there are no parking meters to obstruct the sidewalk. This means that a larger percentage of the sidewalk is actually available for pedestrians. The second advantage of this system is that parking prices can be raised electronically without the need to mechanically retrofit or replace thousands of parking meters. This arrangement gives local authorities greater flexibility over parking prices, and reduces the administrative cost of raising parking rates. The ongoing efforts of automobile restraint have resulted in visible changes within the city.

The reduction in automobile use has returned the streets to the people. Spaces once dominated by cars are now used for cycling facilities and public gathering. "Up until 1962, all the streets in the city were filled with traffic and parked cars. Old photographs of the city squares show them to have been largely inaccessible and a poor environment for pedestrians; great assets which could not be enjoyed."[3] One such street was Stroget (Figure 5.1). Today, Stroget is Copenhagen's main and longest pedestrian-only street. Images, over time, show how the street was historically used by pedestrians, was invaded by automobiles, and has since been returned to pedestrians. Even bicycles are prohibited on Stroget, since the volume of pedestrians requires the full width of the roadway. In this case the prohibition of cycling recognizes that

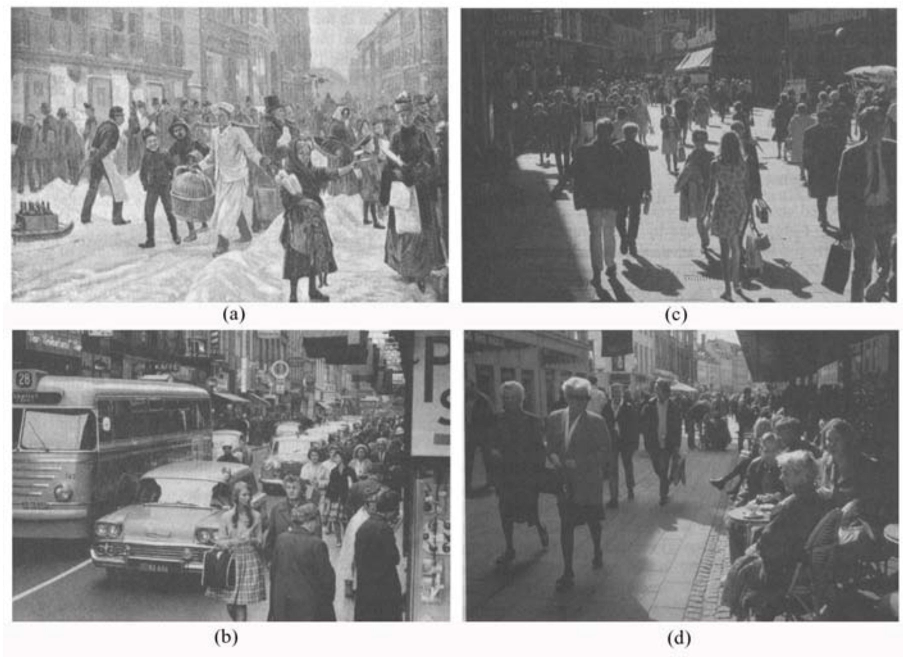

Figure 5.1: Stroget through time. a) 1880: Early view of Stroget b) 1960: Stroget with motorized traffic. c) 1968: Five years after being returned to pedestrians. d) 2000: Modern view of Stroget. Source: Tolley 2003, 104.

cycling can be just as destructive as the automobile in confined pedestrian areas, but cycling does have an effect on Stroget. Parked along the side streets leading to Stroget are thousands of bicycles. These bicycles make it possible for people to get to the area without the need for a car, and then to proceed on foot.

Another area transformed by automobile restraint is Nyhavn. "It used to be a busy part of Copenhagen harbour and a favorite pub-crawl for seamen. As harbour activities dwindled, Nyhavn became a car park. However, in 1980 the area was cleared of cars and turned into a pedestrian area."[4] The area attracts thousands of people on a clear sunny day and has become a hub of activity. Canal-side cafés line the streets and draw large crowds (Figure 5.2). In this environment, like on Stroget, the bicycle is an important element. Cycling and transit provide citywide transportation options that were once fulfilled by the automobile, but they return spaces such as Nyhavn to city life. In this way, cycling acts as an invisible aid that contributes to the success of pedestrian areas.

Figure 5.2: Nyhavn. Once used for car parking Nyhavn has since been returned to pedestrians. (Photo by author)

The lessons that Copenhagen provides for cycling design are very clear, if one is willing to look carefully for them. The first lesson is that cycling is a viable mode of transportation if city leaders are willing to seriously work towards this goal. This means that city leaders must recognize the impact of the automobile on civic life and work to mitigate its impact. A second lesson is that people will do without cars when they become inconvenient, expensive, and unnecessary. Expensive and inconvenient parking limits the appeal of the automobile. Similarly, a reduction in parking simultaneously returns space to public life while making parking more expensive and harder to find. However, car reduction is only possible if daily activities remain accessible. Cycling, walking, and transit combined with dense urban conditions and mixed-use development allow for automobile attrition while keeping daily activities nearby, but incremental change is needed to allow time for individuals and businesses to adjust lifestyles and practices.

Denmark's national strategy has improved cycling, walking, public transit and rail, and has made car ownership optional in many cities. Trains allow bicycles aboard, and provide access throughout Denmark and across Europe. Even Copenhagen's airport is accessible by bicycle. Access to rail and air travel mean that a bicycle in Denmark can provide access to global destinations. Finally, Copenhagen facilitates cycling through the addition of on-street cycling facilities, which often comes at the expense of automobile lanes and curbside parking. The provision of space for cyclists combined with policies that make the automobile unnecessary have helped facilitate cycling and restored public spaces for public use.

5.1.2 ODENSE, DENMARK

Odense is Denmark's third largest city and has a population of approximately 180,000 residents. The city has approximately 303 cars per 1000 people.[5] In 1997, it was appointed "The Cycling City of Denmark," but its efforts at encouraging cycling began many years earlier.[6] In the 1960's and 1970's the city began incorporating bicycle facilities into urban streets in an effort to reduce traffic in the town center and to make the city center quieter.[7] The city has been successful at increasing cycling through design measures, policy, and planning. In 2002, cycling was used for 24% of the trips in Odense.[8] Designing safe routes to and from schools was one of the priorities that city officials incorporated into cycling plans, and the efforts have paid off.

Figure 5.3: Cycling beneath the trees in Copenhagen. (Photo by author)

Figure 5.4: Bicycle commuters in Copenhagen. (Photo by author)

"Cycling is the most common mode of transport to and from school, and is even more dominant for trips to and from organized activities."[9] The efforts included physical improvements to the streets and a coordinated campaign that encouraged students to cycle to school. However, the city-wide focus on cycling did not come without challenges and skepticism:

> One of the main problems in planning the cycle paths through the city centre was opposition from shopkeepers, who feared a fall in their trade. To construct the paths it was necessary to restrict car parking facilities. Kerbside car parking was prohibited and traffic was reduced on the streets. . . . A comparison of the turnover for the shopkeepers along the cycle routes has shown no significant fall in trade, partly because the cycler routes were part of the new comprehensive traffic plan. Many shops have, on the contrary, increased their turnover and improved their shops.[10]

The concerns of shopkeepers and businesses over the potential loss of businesses are not limited to Odense. Such concerns appear to be universal and require the attention of planners and designers. What the efforts of Odense show is that it is people that encourage trade and commerce and not the automobile. If cities are able to provide convenient access to shops and businesses via walking, cycling, and public transit, then there is no need to expect local businesses to suffer from a transportation shift (provided of course that they are not an automobile supplier).

In Odense, the effects of cycling and the planning for it are obvious and notable. The city center is filled with pedestrian and cycling only streets. In these streets there is a noticeable difference in the noise level. Car noises simply do not exist. Likewise, the added space allows for numerous cafes and eateries to expand seating out into the street. Sculpture, public art, and fountains exist in spaces that would have been unavailable on streets designed for automobiles. City officials have embraced cycling and show a commitment to cycling infrastructure. Cycling features are well designed from both an aesthetic and functional standpoint. Bicycle counters mark the main entrance to the central core of the city and track the city's cycling volume (Figure

5.5). In addition to counting and displaying the number of daily cyclists the counters also record the cumulative total. This outward display of pride in cycling is echoed throughout the city. Air

Figure 5.5: Bicycle counter. This bicycle counter tracks the daily and cumulative cycling volume on this street. The blue bar indicates the cumulative count and the number (3664) indicates the daily volume. (Photo by author)

stations for bicycles and secure parking are not only provided, but share a common graphic identity (Figure 5.6). Likewise, materials and pavement markings in the historic city center have been carefully selected and finely crafted to match their environment (Figure 5.7). At the train station the volume of bicycles reveals the popularity of cycling and provides a glimpse of its cumulative impact (Figure 5.8). Although bicycles are not allowed in the station, they are allowed on trains via separate access to the platforms. Stairways outside the station have been constructed with ramps that allow bicycles to be walked up and down stairs (Figure 5.9). The station also boasts an underground bicycle parking facility with lockers and video surveillance.

A wonderful city park winds along a river in the central section of Odense. Leading through the park is a bike path that connects outlying homes to the city's core. Notably missing from the park is the provision of automobile parking lots. Providing a space for each park visitor to park their car would completely alter the feel of the park, and would eliminate most of the park's green space. In the evenings local residents gather in the park for conversation, games, and relaxation with their bicycles resting only a few feet away. It is a place where all ages gather and is a valuable community asset (Figure 5.10 and Figure 5.11).

Although cycling brings many benefits to the city of Odense there are also a few drawbacks. The most notable negative consequence of cycling in Odense is the effect of parked bicycles on narrow streets. Because cyclists in Odense use a lock that immobilizes the back wheel they do not need bicycle racks and can park their bicycles anywhere. Many store windows have "no bicycle parking" stickers to discourage cyclists from parking and obstructing views into the store and from damaging windows. Another problem with bicycle parking is that it can constrict sidewalk space. When racks are placed too close to the sidewalk,

Figure 5.6: Secure parking in Odense. (Photo by author)

Figure 5.7: Bike lane in central Odense. Bike lanes in the central city blend with the existing historic materials. Note the built in drainage and directional striping inlaid in the stone work. (Photo by author)

Figure 5.8: Odense, train station. The train station links cyclists with regional and global destinations. Outdoor and indoor parking is provided for thousands of bicycles. (Photo by author)

Figure 5.9: Odense stair details: Ramps allow bicycles to be rolled up and down staircases. (Photo by author)

Figure 5.10: Cycling education. A father teaching his son to cycle at the park. Note the pole in his right hand that he uses to stabilize and guide his son. (Photo by author)

Figure 5.11: Older cyclists. An older couple demonstrates the longevity of cycling. (Photo by author)

or when bicycles are parked along buildings, there is little space left for pedestrians. Typically, this type of situation occurs when narrow streets attempt to accommodate automobile traffic, bicycles, bicycle parking, and pedestrians. In many cases, the needs of pedestrians suffer. This problem is common enough that it deserves greater attention during design efforts (Figure 5.12 and Figure 5.13).

The high rate of cycling in Odense is the result of multiple approaches. The design approach focuses on improving cycling conditions from a physical, aesthetic, and experiential perspective. However, design alone is not responsible for the full increase in cycling. Odense's dense central core, and surrounding land use adds to the feasibility of cycling. Cycling is also encouraged through numerous public cycling campaigns. The city has sponsored competitions among school children and workers to encourage them to cycle to work. Public relation campaigns also highlight healthy lifestyles and encourage both older and younger people to cycle. Likewise, safety and training classes are offered, as well as the trial use of new bicycle equipment. Every spring the city holds a bicycle festival to publicly promote bicycle use and to showcase new equipment. These public campaigns show the commitment that the city has toward cycling and the need for cities to combine physical improvements with recruitment and training.

5.1.3 MUNSTER, GERMANY

Munster, Germany is a city of approximately 280,000 residents with 39,000 students at the local university. The bicycle is a popular mode of transportation in Munster and is used for 32% of all trips.[11] Cycling blends naturally into this city and takes advantage of its youthful population. The city has a compact and dense core that closely combines residential, retail, businesses, and educational uses. Munster, like many other German cities, was severely

Figure 5.12: Bicycles on the sidewalk. Parked bicycles constrict sidewalk space. (Photo by author)

Figure 5.13: Competing for sidewalk space. (Photo by author)

Figure 5.14: Car free cycling in central Odense. (Photo by author)

damaged during World War II. However, Munster was rebuilt based on the historic layout of the city and retained much of its medieval character. Narrow, organic streets make driving slow and the widths do not accommodate multiple vehicles. The location of the old city wall is now the site of a beautiful tree lined promenade that encircles the city, and it provides a fast and pleasant cycling experience (Figure 5.15). The promenade combines a central lane for cycling with pedestrian walkways on either side. In addition to these elements, the city has also invested in cycling infrastructure.

Figure 5.15: Munster's bicycle promenade. (Photo by author)

Figure 5.16: Bicycle facility at Munster's train station. (Photo by author)

Civic design and infrastructure in Munster reveal a commitment to cycling. Perhaps the most visible investment is the bicycle storage and maintenance facility outside the train station (Figure 5.16). Here, travelers can securely store their bicycles while they travel via train to neighboring cities and countries. A glass canopy lets light into the underground bicycle facility and bicycle ramps allow access from multiple points. In addition to bicycle storage, the facility also offers cleaning, maintenance, and repair services.

In the central core of the city many streets have been designated as pedestrian malls. As in Copenhagen and Odense, bicycling on pedestrian-only streets is prohibited, but again bicycles help to make pedestrian areas accessible. There are thousands of bicycles parked along the streets leading into the pedestrian areas. This restriction ensures that bicycle and pedestrian conflicts do not occur in crowded areas and is strictly enforced. Cyclists caught riding through pedestrian-only streets during restricted hours are ticketed (Figure 5.17).

In Munster, bicycles use different parts of the street depending on the type of development along the street. Where roads are narrow, bicycles typically share the roadway with cars. Separate bicycle lanes are provided where the roads are wider and buildings sit back further. Although the provision of bicycle lanes is meant to encourage cycling, the actual design of the lanes creates numerous pedestrian-cyclist conflicts. In Munster, as in the rest of Germany, bicycle lanes are placed at the sidewalk level and paved with distinct red bricks. Unfortunately, the brick has no special signage and under certain lighting conditions is difficult to distinguish from the rest of the sidewalk. Where sidewalks are narrow the width of the bike lane and the pedestrian portion are often inadequate. At street corners the potential for collision and the lack of space become obvious problems (Figure 5.18). This design style makes it incredibly frustrating for pedestrians to cross the street.

Figure 5.17: Ticketing a bicyclist in a pedestrian mall. (Photo by author)

Figure 5.18: German bike lane. The red brick band in the photograph represents typical German bicycle lane design. Corners, like this one, invite pedestrian - cyclist conflicts. (Photo by author)

Despite the drawbacks of German bicycle lane design, Munster remains a pleasant place to cycle. Design details such as ramps on public staircases provide access for bicycles. In the central core of the city curbside automobile parking has given way to bicycle parking. This system allows sidewalks to remain adequate for pedestrians. Cycling remains a fast and convenient way to reach the city center from virtually any city location. Even the country-side is just a short distance from the city center and is accessible by bicycle. These considerations, combined with the demographics and design elements, contribute to Munster's success in incorporating cycling into daily life.

Figure 5.19: Stairway bicycle ramps. (Photo by author)

Figure 5.20: In-street bicycle parking. (Photo by author)

5.1.4 AMSTERDAM, NETHERLANDS

Amsterdam is a city of approximately 750,000 residents. In this city, bicycles are everywhere and are used for approximately 23% of all trips.[12] Along with Copenhagen, it is a rare example of a large western city with high levels of cycling. "Indeed, with the exceptions of Amsterdam and Copenhagen, no very large city (one million inhabitants or greater) in either Europe or America has bike use exceeding ten percent of trips."[13] Amsterdam's compact size, high density, flat topography, and unique setting play a role in making the bicycle a frequent choice for urban transportation. The central part of Amsterdam is designed around a series of concentric canals. Along these canals are narrow streets, small bridges, and tightly spaced homes and businesses. The architecture lends itself to ground level shops and businesses with upper level residences. In this setting the bicycle plays an integral role in daily life.

Bicycles in Amsterdam provide quick and convenient access to much of the city. Places such as Vondel Park, and many other streets are off limits for cars, but provide a fast and pleasant cycling environment that connects homes and workplaces (Figure 5.21). Meanwhile, parking for automobiles in Amsterdam is limited due to the narrow streets. The canals and the architecture of the city prevent roadway expansion that automobiles typically require. This creates a situation where the bicycle is a competitive mode of transportation when compared with the automobile. While the automobile can still achieve greater overall speeds in the city, this advantage is lost in the time spent to find a parking space. Bicycle parking on the other hand is in great supply and quickly attained. Similarly, some streets are limited to pedestrians, transit, and bicycles which give these modes greater access to the city by the quickest possible routes.

The role that the bicycle plays in the city is readily apparent. Everywhere one looks there are people riding bicycles. Cyclists span the whole social and economic perspective, and it is not uncommon to see men in business suits and women in heels and dresses pedaling through the city. These cyclists help preserve the serenity and peacefulness of canal side settings. On major roads, the effect of automobile noise is obvious when compared to side streets. Cyclists move quietly throughout the city and do not detract from the urban environment. In this way, the bicycle offers a transportation solution that shrinks the urban scale and makes city destinations accessible, but its role is greater than just moving people around the city.

The bicycle allows Amsterdam to retain its density by preserving the integrity of the urban architecture. While it is common in many American cities for buildings to be replaced

Figure 5.21: Rush hour cycling. Cyclists enjoy a car free commute through Vondel Park. (Photo by author)

Figure 5.22: Family bicycle. A bicycle designed for the needs of a family and for carrying goods. Note how the cars obscure the view of the canals. (Photo by author)

with parking lots this is not the case in Amsterdam. Continuous building facades draw cyclists and pedestrians from one store front to the next. Similarly, there are no parking meters, few parking garages, and neighborhood groceries and retailers remain the rule and not the exception. Through investments in bicycling, public transit, and walking, the city has retained much of its charm despite the increased role of automobile transport.

Along with the natural conditions that facilitate cycling in Amsterdam, there are also government efforts that encourage cycling. Allocating funds for cycling is an important step. "The Netherlands spends 10 percent of its surface transportation budget on bicycle facilities, compared to countries like the United States where a very small fraction of 1 percent of all public sector spending on transportation goes to nonmotorized modes."[14] On narrow streets there is little need or space for specialized in-street cycling facilities. On these streets automobile traffic simply moves at the same pace as bicycles. Larger streets with higher automobile volume receive the bulk of specialized bicycle treatments. Bicycle lanes and separate signals exist on the busiest streets and some streets are completely closed to automobile traffic. Due to the high rates of theft, a large portion of cycling investment goes into the provision, installation, and maintenance of bicycle racks. Similarly, theft reduces the willingness of individuals to buy and maintain new bicycles. As part of the Dutch Bicycle Master Plan efforts are being made to reduce bicycle theft and to continue to encourage cycling. Such efforts show the commitment of the government to developing cycling as an integral mode of transportation.

Unfortunately, cycling does have some negative impacts upon city living. Bicycles are frequently locked to bridge and canal railings. One or two bicycles parked next to the canal make a picturesque scene, but hundreds of them can be overwhelming. The aesthetic is certainly no worse than the parked cars that line either side of the canals, but both cars and bicycles obstruct views and occupy some of the best spaces in the city. Due to high levels of theft, even the cheapest bicycles are locked to immobile objects. This approach is different from Copenhagen, Munster, and Odense, and has major implications on bicycle parking. Where bicycle racks are convenient, they are often used. However, where racks are inconvenient or are absent, bicycles are attached to railings, down spouts, trees, fences, and anything else that cannot be moved. This may reduce theft, but the effect is unpleasant. Along sidewalks bicycles constrict what limited space there is (Figure 5.23). At the train station, a bicycle parking deck accommodates the thousands of cyclists that utilize rail services. Cycling to the train station is preferable to driving and accommodating the same number of cars, but the result of a giant blank wall is still the same. Despite the negative effects of cycling on the cities, the impact is still considerably less than automobiles would produce.

5.2 CHINA

A discussion of urban cycling would not be complete without looking at cycling in Chinese cities. "Bicycles in Asia alone transport more people than do all of the world's autos."[15] This is especially true in Chinese cities where cycling constitutes the major share of urban transportation. Unfortunately, information about the effects of cycling on Chinese cities is sparse compared to the more popular examples of Northern Europe.

> Even general literature on bicycles is mostly focused on western applications with little attention given to Asia, and specifically to China. Such a paradoxical attitude found in the literature does not seem to have an obvious explanation. How can it be that the largest country on earth in terms of its population, which happens to have the highest number of bicycle users in absolute terms, is ignored? Furthermore, not only does China

Figure 5.23: Bicycles on Amsterdam sidewalk. Bicycles chained up on the sidewalks make walking difficult. (Photo by author)

Figure 5.24: Bicycles chained to canal railings. (Photo by author)

Figure 5.25: Separated bicycle lane in Amsterdam. (Photo by author)

> have the highest number of bicycles, it is also the only country in the world where bicycles constitute the highest percentage of transportation among all other modes.[16]

Despite the lack of literature on Chinese cycling the available information reveals the importance of urban cycling on a global scale. Instead of focusing on one particular city this case study will take a broader perspective and look at urban cycling in China from the national level.

The bicycle in China is an essential tool for urban living and daily commuting. In Chinese cities there is approximately one bicycle for every two people and over 300 million bicycles in the country as a whole.[17] To urban residents the bicycle is an affordable mode of transportation and a space saving vehicle as well. "For China to pave over as much land per capita as has the United States (about .06 hectares) would mean giving up a total of 64 million hectares – equivalent to more than 40 percent of the country's cropland."[18] The bicycle has helped many Chinese cities to remain compact and manageable without the need for an automobile. Consider the effects of cycling on the city of Tianjin, a city of 4.4 million people. "Tianjin uses only 4.8 percent of the land for streets, unlike Western cities that use between 40 and 60 percent."[19] The compact urban form of Chinese cities means that typical trip distances remain a reasonable 6 kilometers in length or a 1/2 hour ride.[20] This is the same thirty-minute commuting limit that defines walking cities and automobile cities. This produces a commuting pattern similar to the one in Figure 5.26, and it is this form that keeps the total area of large cities under 100 square kilometers.[21] Compact urban form and high density make cycling an effective mode of transportation in China, but increased motorization in Chinese cities may force a change in urban form and urban living.

The role of cycling in Chinese cities cannot be understated. In Beijing for example, the number of bicycles increased from 140,000 in 1949 to 8 million in 1990.[22] This volume of cycling certainly contributes to cleaner air and quieter streets than would exist if the automobile was the major mode of transportation. However, in Beijing and other major cities, the level of cycling is declining due to increased motorization. Throughout the 1990's, cycling accounted for approximately 54% of all trips, but recent reports suggest that cycling is on the decline.[23] According to the Cycling Association of China, bicycle ownership was an average of 142.7 bikes per 100 households in 2002 compared to 182.1 in 1998. In Beijing, only 20 percent of commuters rode bikes in 2002, compared to 60 percent in 1998.[24] Similarly, other cities such as Guangzhou have increased motorized transport, and as a result cycling's share fell from 34% in 1991 to just 20% in 1998.[25] The dramatic shift from cycling to driving has caught the attention of those that watch global energy consumption. However, at this point the effect of the automobile on Chinese cities is not the focus of discussion. Based on the effects of automobiles on urban living it can be expected that Chinese cities will grow in size, suffer greater air and noise pollution, and will be forced to adapt a greater number of structures and spaces to automobile use.

Increased motorization will require dramatic change to traditional Chinese cities. For cities like Beijing (approximately 43 cars per 1000 people) to adapt the approach of U.S. cities (approximately 604 cars per 1000 people) will mean drastic changes in urban form, and will compromise the ability of the bicycle to easily travel in Chinese cities.[26] Increased car ownership requires a reduction in urban density, but density is one of the components that make cycling possible in China. In 1995, the average urban population density in Beijing, Shanghai and Guangzhou was 151 people per hectare which is more than ten times the density of the average American city.[27] Clearly, a shift to automobiles from cycling brings the prospect of drastic alterations in density, form, and character to traditional Chinese cities. The magnitude of such effects on Chinese cities will depend greatly on whether the Chinese economy can continue to sustain private automobile ownership or whether rising oil prices slow the increase in motorization.

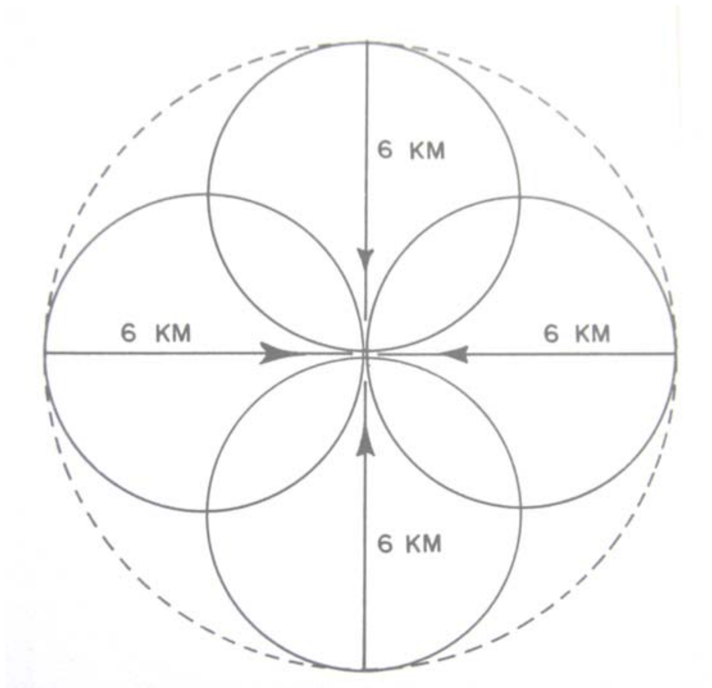

Figure 5.26: Chinese city form. Typical commuting pattern and urban form of Chinese cities as a result of cycling. Source: Transportation Research Record 1992, 27.

5.3 AMERICAN CITIES

American cities struggle to attract urban cyclists. A number of smaller cities such as Davis, California and Madison, Wisconsin benefit from the presence of universities and have relatively high cycling volumes. However, these cities are largely the exceptions to the low cycling volumes found in most American cities. Large American cities find it difficult to increase cycling volumes, but many are trying. Portland, Oregon and Seattle, Washington are among the most progressive cities when it comes to encouraging cycling. In this section one large American city, Portland, Oregon and one small American city, Davis, California are profiled.

5.3.1. PORTLAND, OREGON

Portland, Oregon is a mid-size American city with approximately 435,000 residents. It is also a city that is consciously working towards making alternative modes of transportation more attractive. In the 1970's, the city of Portland opted for a light rail system over the addition of a freeway, and has since focused its development on alternative modes of transportation including transit, walking, and bicycling. A central feature of the transportation plan has been to make the city more attractive for people. "Portland has been gradually reinvented around the idea that it should be a human, livable environment in which people can walk, sit, dine alfresco, be entertained, and find residence housing set in attractive public environments."[28] As part of this effort the city has developed a bicycling master plan that focuses on improving cycling conditions and facilities.

The city has been working on developing a cycling infrastructure since the late 1970's, and in 1996 created a new bicycle master plan. The plan focuses on attracting riders of all ages.[29] Ongoing efforts have improved conditions and attracted new cyclists, but cycling still remains a small portion of urban transportation. The national average for commuting trips remains a meager 1 percent across all groups.[30] In Portland, the bicycle accounts for approximately 2% of trips, and 3.3 percent in the more dense areas of town.[31] While these numbers pale in comparison to European and Asian examples, it is a start. Portland's efforts have increased cycling, but the increase has also coincided with an increase in automobile use.

As a result, the percentage of cycling appears to have changed little despite actual increases in the number of cyclists.

Physical improvements to cycling infrastructure combined with land use planning and urban revitalization are making Portland more attractive for cycling. "Part of the downtown revitalization process was to introduce lots of trees, seats, flower planters, sculptures, period lighting, artwork and many other elements of good urban design at the street level."[32] As part of encouraging alternate modes of transportation Portland has placed limits on the amount of parking in its Central Business District, and car restraint has made many improvements possible. Pioneer Square, a popular public space, was constructed on the site of a former parking garage. In 2001, Portland utilized $35 million in transportation funds to construct the Eastbank Esplanade, a 2-mile long bicycle and pedestrian path that runs along the Willamette River and crosses the river on two major bridges.[33] These efforts are creating an environment that is conducive to cycling.

In addition to these projects, there is also the long term goal of increasing cycling's modal share to 15% by the 20-year bench mark. The overall goals of the bicycle master plan are to provide end-of-trip facilities, complete the bicycle network, improve transit links, provide an educational component, and to develop appropriate policies. The availability of bicycle lanes, allowance for cycling on transit, and availability of parking make Portland one of America's larger cities that is accessible by bicycle. These considerations add to the cycling volume in Portland, but it is clear that other factors, such as cycling campaigns, urban density, automobile restraint, and the quality of street life can, and do, play a role in the amount of cycling in Portland. These issues are likely to determine whether Portland can reach its benchmark goals or if cycling volumes remain low. "Portland is considered one of the country’s most bicycle-friendly cities. In October 1995, it was selected by *Bicycling Magazine* as the most bicycle-friendly city in the United States."[34] Unfortunately, bicycle-friendliness in America does not necessarily translate into a high percentage of cycling. This revelation suggests that there are other factors that must be considered in order to transform bicycle-friendly cities into cities with high volumes of cycling.

5.3.2 DAVIS, CALIFORNIA

Davis, California is one of the most successful American towns for urban cycling. With a local population of 52,000 residents and another 20,000 college students, Davis has one of the highest rates of cycling in the United States. The rate in the city of Davis is more than 20%, and on the University of California campus the rate of cycling is in excess of 50% of all trips.[35] Ample bicycle parking exists throughout the city and miles of bicycle lanes and paths were constructed. Likewise, it is not uncommon for developers to incorporate cycling access into neighborhood design. Connections such as these make cycling possible not only for those living on the college campus, but also for permanent full-time residents.

The moderate Californian climate and youthful student population make Davis an ideal location for cycling, but success has also come through years of work on cycling facilities and through policy implementation. The addition of street facilities, bike racks, roundabouts, and limitations on vehicular traffic on the University of California campus create a university and city setting that is compatible with cycling. Planning and policy development were instrumental in turning Davis into a cycling city, but the presence of the university creates special circumstances.

Universities, such as UC Davis, have the unique ability to limit the amount of car parking and to control its price. Zoning ordinances that require a certain number of parking spaces per residence do not typically apply to college campuses. Furthermore, colleges have the ability to require students to live on campus. This added ability means that college campuses can control automobile use at both the origin of a trip (home) and the primary destination (school). Even when students live off-campus the university still has control over their destination. Off campus apartments are more likely to have free and easily accessible parking than university residence halls. For off-campus students, the car becomes a useful means of transportation capable of going to destinations such as work, restaurants, and stores, even though it may still not be a good way to get to campus. By controlling parking at a driver's destination universities make parking inconvenient and expensive. By controlling parking at the origin and destination, universities can make parking so inconvenient, expensive, and unnecessary that only those truly determined to have a car will go to the lengths required to maintain one. This natural monopoly on parking has the ability to encourage cycling. It also gives universities such as UC Davis greater control over the look and feel of their campus, but the effects extend into urban environments.

When college campuses limit parking, without reducing the need to drive, then the surrounding city feels the effects. Cars that are unable to park on the campus spill out into all parts of a college town, invading every possible space on city streets and filling in the remaining open space. The rates of cycling on the UC Davis campus and throughout the city suggest that on-campus car restraint has not simply pushed the cars somewhere else, but has truly reduced the need for driving. This of course, requires both the city and the university to share a commitment to make cycling viable. Clearly, both the city of Davis and the University have improved cycling opportunities and have benefited from these improvements.

5.4 SUMMARY

The cities profiled in this chapter show that cycling can be an effective mode of transportation in both small and large cities. The success of these cities suggests that the population of a city is less of factor for design than a city's urban form and overall character. The examples from Europe demonstrate that cycling can be an effective mode of transportation, even in wealthier nations, when proper planning and promotion efforts are applied. Likewise, China demonstrates the ability of cycling to become a major mode of transportation, but it also shows the fragility of cycling when the needs of cyclists are neglected in favor of the automobile. Davis, California shows the potential for smaller American towns, especially college towns, to increase the volume of cycling. Despite the low levels of cycling in larger American cities, like Portland, higher levels of cycling are attainable. This goal, however, will require significant investment and effort. These case studies suggest that cycling in the U.S. may improve when American cities consistently work to improve cycling conditions, as in Europe, or when the cost of automobile ownership excludes large segments of the population, as in China.

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CHAPTER 6

DESIGN APPLICATION

The previous chapters emphasized the influence of the urban environment on the success of cycling, and the impact of cycling on cities. This chapter applies the principles and lessons of the previous chapters to the Prince Avenue Corridor in Athens, Georgia. The first section describes the overall context of cycling in Athens. Following this is a detailed inventory of the Prince Avenue corridor based upon the elements discussed in Chapter 3 and Chapter 4. The third section in this chapter puts forward a series of design recommendations. These recommendations include methods for improving cycling in the Prince Avenue area, as well as opportunities where cycling can improve urban living conditions. The chapter provides general design recommendations with specific examples showing how these recommendations apply to Prince Avenue. Through this approach both sides of the urban design - urban cycling relationship are explored.

6.1 DESIGN FRAMEWORK

Understanding the overall context of cycling on Prince Avenue begins with a broad look at cycling in Athens. This view is necessary in order to provide a realistic perspective on the potential for cycling as a mode of transportation in Athens and to understand the impact of the city on the Prince Avenue area. This section provides a profile of Athens, a brief history of

Prince Avenue, an assessment of cycling conditions in Athens, and also describes the site selection process.

6.1.1 ATHENS, GEORGIA

Athens Georgia has a population of approximately 108,000 residents and is home to the University of Georgia.[1] The University itself has a student enrollment of approximately 33,000.[2] Located in the southeastern United States, and in northeast Georgia, Athens enjoys mild winters and hot summer months (Figure 6.1). The landscape is broadly defined as a Piedmont landscape with gently rolling hills.

6.1.2 THE PRINCE AVENUE CORRIDOR

Prince Avenue is a main arterial that runs in a northwest to southeast direction and leads directly into downtown Athens. For the purposes of this study, the Greater Prince Avenue Corridor is defined as the area outlined in Figure 6.2. The boundary roughly defines a semi-continuous area with similar densities. Within this area, short cycling trips quickly connect residential areas with the businesses located along Prince Avenue. The study area should not be seen as a border that defines the limits of cycling, but rather as the area where cyclists would reasonably be drawn to the businesses along Prince Avenue. In this context, Prince Avenue roughly divides the study area into two segments. Along Prince Avenue there is a wide variety of businesses, restaurants, and churches. While this is not the only commercial sector within the Greater Prince Avenue Corridor, it is the most centrally located and for this reason will be the focus of this chapter. Major elements along Prince Avenue include the Athens Regional Medical Center, U.S. Naval Corp Supply School, Normaltown, and the Bottleworks (Figure 6.2). The

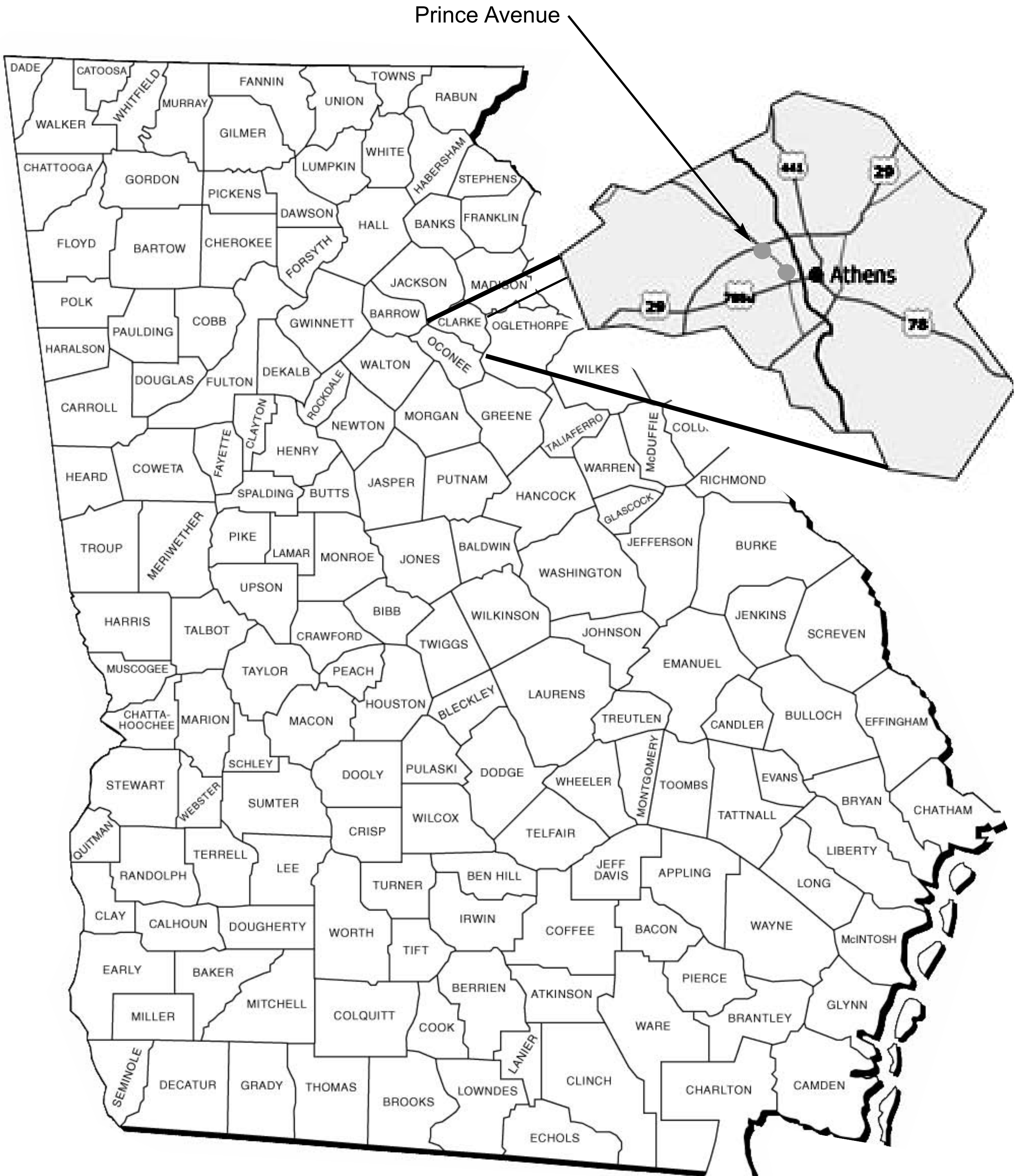


Figure 6.1: Context Map. Source: Carl Vinson Institute of Government.

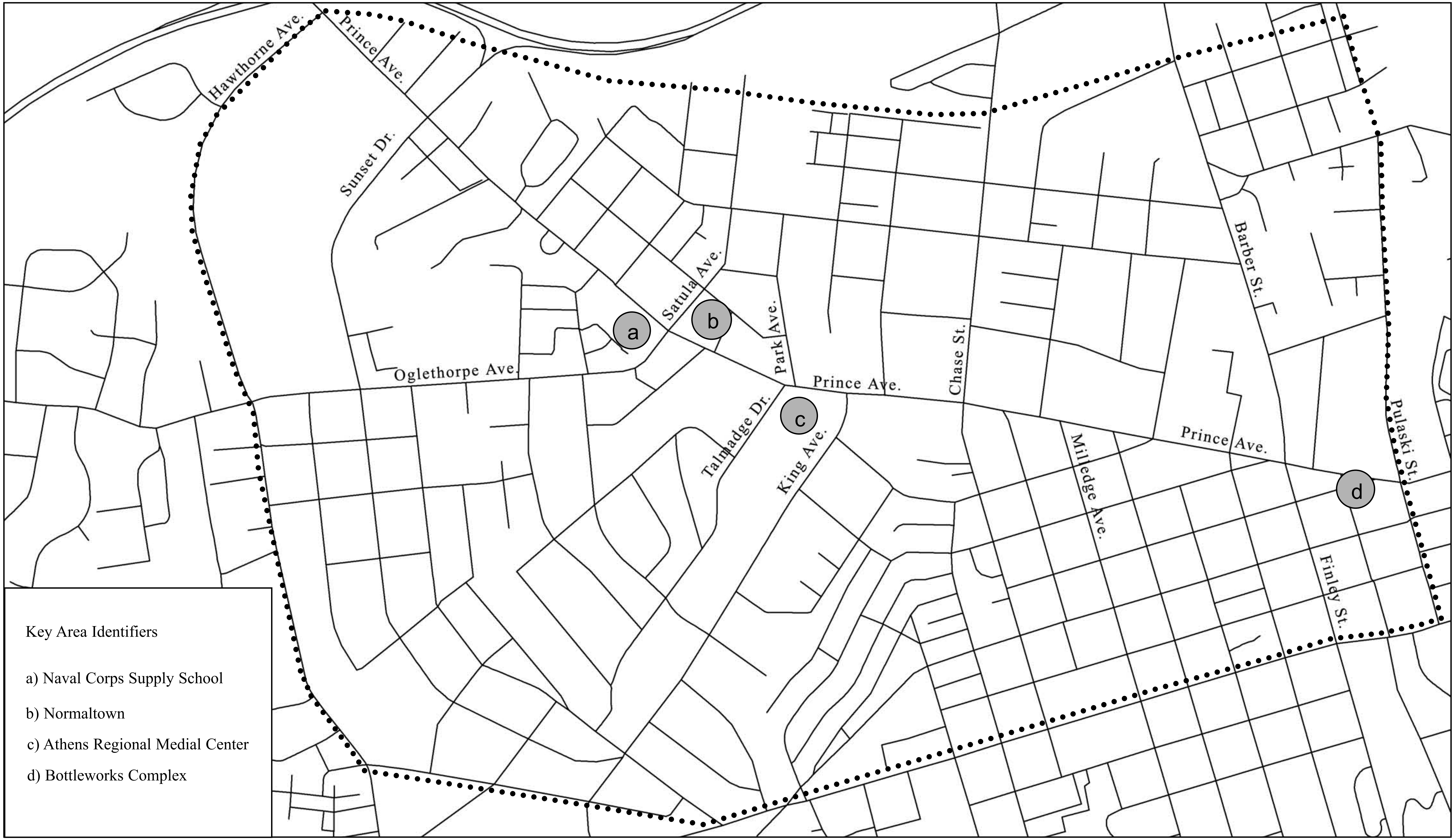


Figure 6.2: Prince Avenue study area.

neighborhoods that border Prince Avenue have a mixture of single family residences and multifamily dwellings.

Historically, Prince Avenue was the location of some of the city's finest homes. Unfortunately, many of the original structures have been lost to demolition and exist only in photographs. A number of historic homes still exist, and are in various stages of preservation. Some have been adaptively reused, while others remain residential in nature. The automobile has altered the setting around these homes, which in the early 1900's were serviced by streetcars. The current environment along the street is one of mixed architectural styles, highly variable building setbacks, and a mixture of retail/service establishments with a high concentration of medical services. The resulting urban form is relatively compact when compared to many sprawling suburbs, but is still less dense than downtown areas.

6.1.3 CYCLING IN ATHENS: A GENERAL ASSESSMENT

Before proceeding into the design phase and developing grand schemes for ways to improve cycling along the Prince Avenue corridor it is valuable to take a step back and look at the feasibility of cycling in Athens as a whole. The purpose of this assessment is to recognize the effect of the city on the overall viability of cycling before narrowing the focus to the Prince Avenue Corridor. There are a number of factors that favor cycling viability in Athens, but there is also a set of factors that work against the successful integration of cycling in the city.

A main question in determining the viability of cycling is whether individuals can reasonably meet the majority of their needs without requiring ownership of a car, and whether cycling is seen an acceptable alternative. Depending on the location of employment and residency, there are options for car-free living in Athens. Support mechanisms that favor cycling in Athens include the Athens Transit and the University of Georgia bus system that provide "free" transportation for University of Georgia faculty, staff and students (students pay a required transportation fee as part of their enrollment). Bus service is reasonably priced for those not affiliated with the university. These bus systems provide a good alternative mode especially for cyclists that prefer not to ride in inclement weather, and offers the potential to extend the range of cycling in the city. Additionally, the majority of Athens Transit buses include bicycle racks for the combination of bus/bike trips. For more direct service and for locations that do not fall along a bus line, there are a number of local taxi services. Athens also has a small airport with daily commercial flights, and the Atlanta airport is accessible by an airport shuttle. Finally, for the same price that individuals pay in automobile insurance, a person could rent an automobile for one or two weekends every month. All of these options mean that an individual can forego automobile ownership in Athens and still not feel stuck in town or confined to the portions of town that they are comfortable cycling. For families, this option could reduce the number of cars needed from two or three to just one.

In addition to the range of transportation options, there are a number of other factors that add to the viability of cycling in Athens. The local transportation advocacy group, BikeAthens, encourages and advocates for cycling improvements. Also, the large university population contributes to a youthful urban demographic that is physically suited for cycling. Furthermore, the University of Georgia has the ability to set parking rates and limit eligibility for parking and has done so in recent years. High prices for parking, low availability, and on-campus residences can encourage cycling as an alternative to driving. The mild winters are yet another factor that can encourage cycling. The combination of these factors adds to the viability of cycling in Athens.

On the other hand, there are also a number of factors that discourage cycling in Athens. For students living without a car there are few transportation options to destinations outside the city. Except for inter-city bus service such as GreyHound and the airport shuttle, there are limited travel options for students. While students can easily reach major cities serviced by air travel, getting to small and midsize towns within the southeast is more difficult. Unlike the students in Odense and Munster, where inter-city train service runs regularly and connects with many small towns, students in Athens do not have this option. Likewise, rental cars may not be available to students since the majority of rental companies require drivers to be at least 25 years old. For students without cars, this eliminates the ability to leave town, and requires the coordination of transportation during university breaks when residence halls close. In this sense students without cars may feel stuck in Athens.

Another factor that may discourage cycling is the University itself. The University of Georgia has a football stadium that seats in excess of 80,000 people. On Saturdays during the fall, an influx of people from out of town come to watch the games. Since there is no train service, or alternative modes of transportation leading into town, spectators must drive to Athens and to a large degree the University of Georgia must accommodate their vehicles. However, due to recent building expansions, the number of surface parking lots has diminished. Future plans also include new buildings on the sites of existing surface lots. These factors increase the need for parking garages in order to maintain the same number of parking spaces, but the cost per space in a parking garage is much greater than in surface lots. Consequently, it is financially unfeasible to allow parking spaces in parking garages to sit idle, and the University cannot encourage a reduction in parking because it needs the space for large events, such as football games. As a result, the University *needs* students, faculty, and staff to drive to the campus during the school year in order to subsidize the parking structures that are required for large events. Of course students, staff, and faculty are more than willing to drive, but the point is that the University does not have an incentive, or perhaps even the ability, to encourage alternative modes of transportation beyond a certain level. If the University of Georgia wanted to encourage alternative transportation it could do so via its parking rates and policies. Table 6.1 demonstrates just how inexpensive parking at UGA is when compared to UC Davis.

Table 6.1: Comparison of annual parking rates (2004)

Permit Type	UGA	UC Davis
Faculty Lot	$240-$360	$552
Student Lot	$120	$444
Remote Lot	N/A	$240
Parking Garage	$360	$6/day
Two Person Carpool	N/A	$144-$192
Three Person Carpool	N/A	$96-$120

At UC Davis, prices for individuals traveling alone are more expensive than carpool spaces. At UGA, carpool permits are not even offered. An additional restraint to driving is that at UC Davis, parking is enforced until 10 PM, while at UGA parking is only enforced until 5 PM. Finally, the same $360/year parking space in a UGA garage would cost approximately $1,000/year in a downtown Athens parking garage. These differences suggest that the University of Georgia is not realizing, or charging, the full cost of parking services and this may actually encourage driving to the campus.

Sprawling development in Athens is another major deterrent to city-wide cycling. The Atlanta Highway area is not a controlled access highway, but it is prohibitive for cycling in many other ways. Six lanes of traffic, plus turn lanes and widely spaced businesses, make cycling in this area difficult. Speed limits are in excess of 40 mph and actual speeds are likely to be higher. Businesses are spread out along the highway, which makes cycling more difficult, and the nature of the businesses are more amenable to infrequent long trips (i.e. buying a week or two weeks worth of groceries) rather than frequent short trips on a bicycle (i.e. picking up freshly baked bread). The location of a large number of businesses in these areas reduces commercial options within more urban areas of town. Despite this type of development, many equivalent services can still be found within the more urban areas of Athens. These conditions suggest that while cycling is possible in Athens, its growth still faces many challenges.

6.1.4 SITE SELECTION

The Prince Avenue Corridor was selected as the sample site for this thesis for a number of reasons. First, Prince Avenue is a main arterial that connects to downtown Athens and the University of Georgia, and it has a healthy mixture of residences and businesses. The topography along the street is relatively flat for this region and has a gentle slope that gradually increases as one travels west from downtown. Additionally, the area has a relatively young population that could be attracted to cycling. Likewise, the population density, though low compared to larger cities, is relatively high when compared to other locations in Athens. Already there is a small amount of cycling on Prince Avenue for both utility and recreational purposes. The street has four lanes for the entire length of the study, but the width varies based on the number of turn lanes and the provision of on-street parking. Finally, in the fall of 2004, a group of residents, business people, and city leaders came together to begin planning for the future of Prince Avenue. The effort was led by members of the Community Approach to Planning Prince Avenue (CAPPA). The group discussed many ideas for the future of Prince

Avenue. Among the most popular recommendations was the desire to improve conditions for pedestrians and cyclists. The existing characteristics of the area, and the community support for improvements, make the Prince Avenue Corridor an ideal location to study the urban design - urban cycling relationship.

6.2 SITE INVENTORY AND ANALYSIS

The site inventory and analysis process is based upon the relationship between urban design and urban cycling described in Chapter 3 and Chapter 4. As a result, the inventory includes an accounting of the urban elements that influence cycling. Likewise, census data and air pollution reports show the possibilities for cycling to improve urban conditions in Athens. It is also assumed that Athens would benefit from the space savings and healthy lifestyles that cycling provides. As part of the process I regularly cycled on Prince Avenue over a period of eight months. The resulting inventory provides a description of the elements needed to improve cycling along Prince Avenue, along with opportunities for cycling to improve urban conditions.

6.2.1 ARCHITECTURE

The architecture along Prince Avenue varies from historic homes and churches built in the mid to late 1800's to modern architectural creations such as gas stations and fast food restaurants (Figure 6.3). Because of the architectural differences, the setback from the street varies considerably from building to building, as does the scale of the buildings. Likewise, the spacing between buildings varies from zero lot line construction to wide sweeping lawns. Many of the current structures are no longer used for the original design function. Several old gas stations now serve different functions as the needs of the modern convenience store/gas station


Historic Homes


Retail with Parking in Front


Churches

Gas Stations


Corporate - Hospital


Medical Offices with Parking in Front


Residential


Zero Lot Lines - Continuous Facades

Fast Food Restaurant Surrounded by Parking

Figure 6.3: Architectural types.

outpaced these older structures. Likewise, medical offices, restaurants, and other services occupy buildings that once were homes. Throughout its two mile length the character of the architecture varies from urban to suburban in nature. The neighborhoods surrounding Prince Avenue are a mixture of single family residences and apartments, and architectural styles vary depending on the age of the neighborhood. Along Prince, most buildings are two stories or less with the exception of the medical center and the Bottleworks (a mixed-use residential/retail development). Automobile related architecture describes much of the newer construction that lines the street. Gas stations, fast food restaurants surrounded by parking, stores set back from the road with front parking lots, drive thru businesses, parking garages, and blank facades are a few examples of the impact of the automobile. The combination of these elements contribute to a lack of architectural unity and balance along Prince.

6.2.2 DENSITY AND DEMOGRAPHICS

The 2000 U.S. Census data provide a revealing look at demographics of the area. According to the census bureau, the average age of residents in the study area is between 25 and 30 years (Figure 6.4). This generally young age is a positive factor that could contribute to increased cycling in the area. There is also a high degree of poverty within the study area, which suggests that a large number of people could benefit from the affordability of cycling. The census blocks show poverty levels in the 22 to 66 percent range (Figure 6.5). Additionally, the average travel time to work for residents in the Prince Avenue area is relatively low. Two census blocks in the area show average travel times to work ranging from roughly 10 to 16 minutes (Figure 6.6). Not surprisingly, the census block with the highest poverty levels also has the longest travel time. In the study area, poverty level residents spend about 22 to 24 minutes

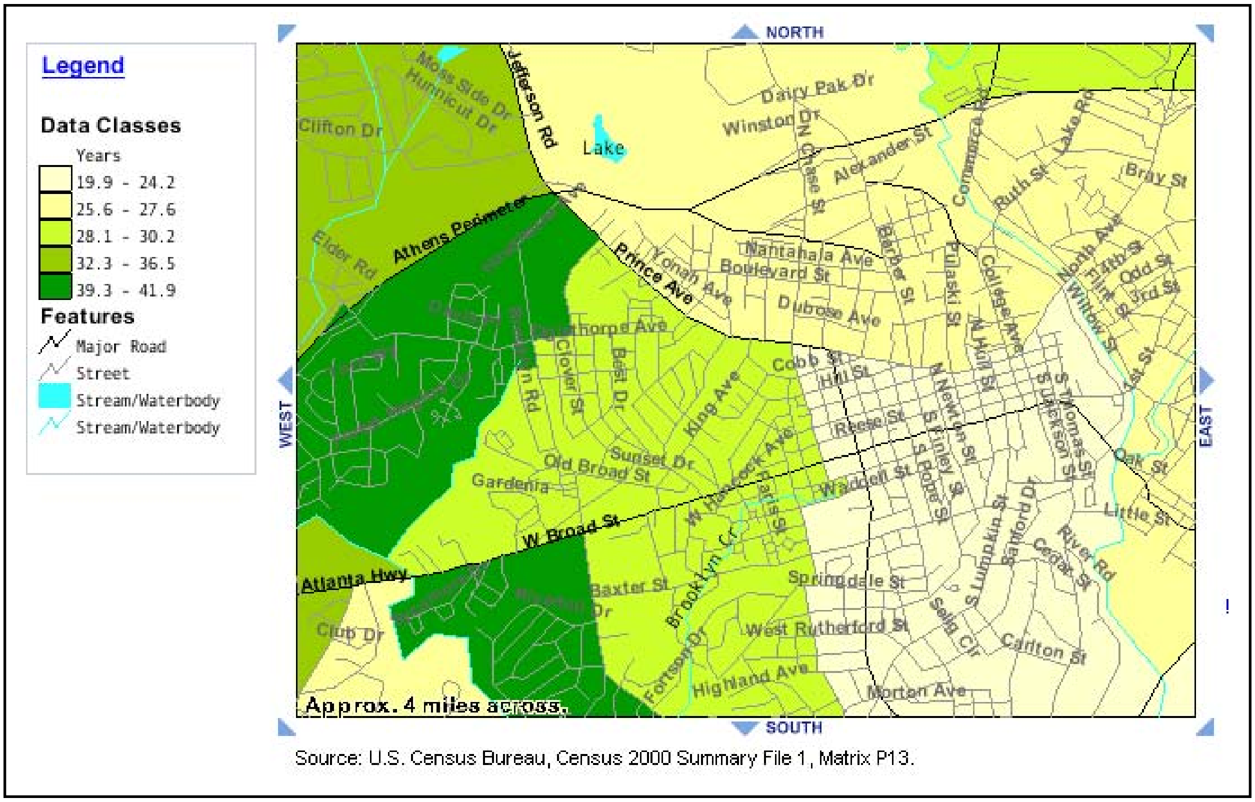


Figure 6.4: Average age.

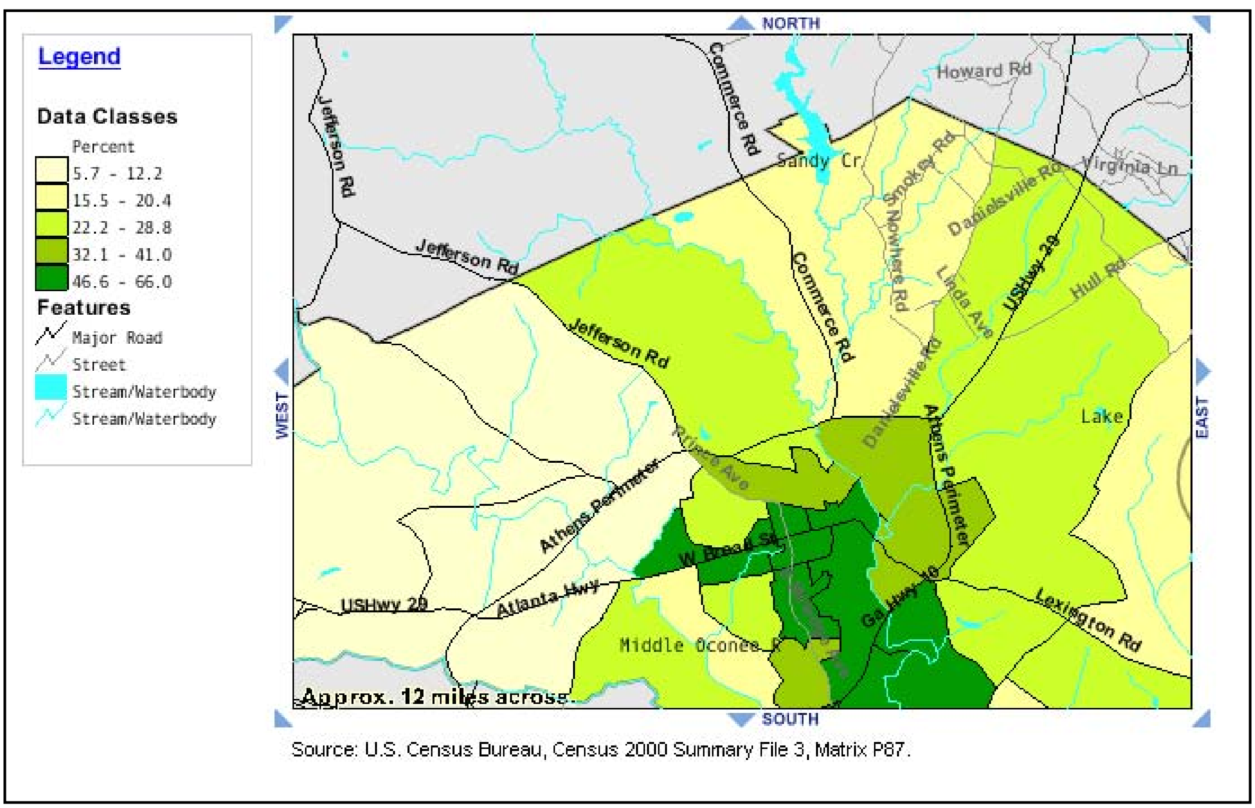


Figure 6.5: Poverty levels in Athens.

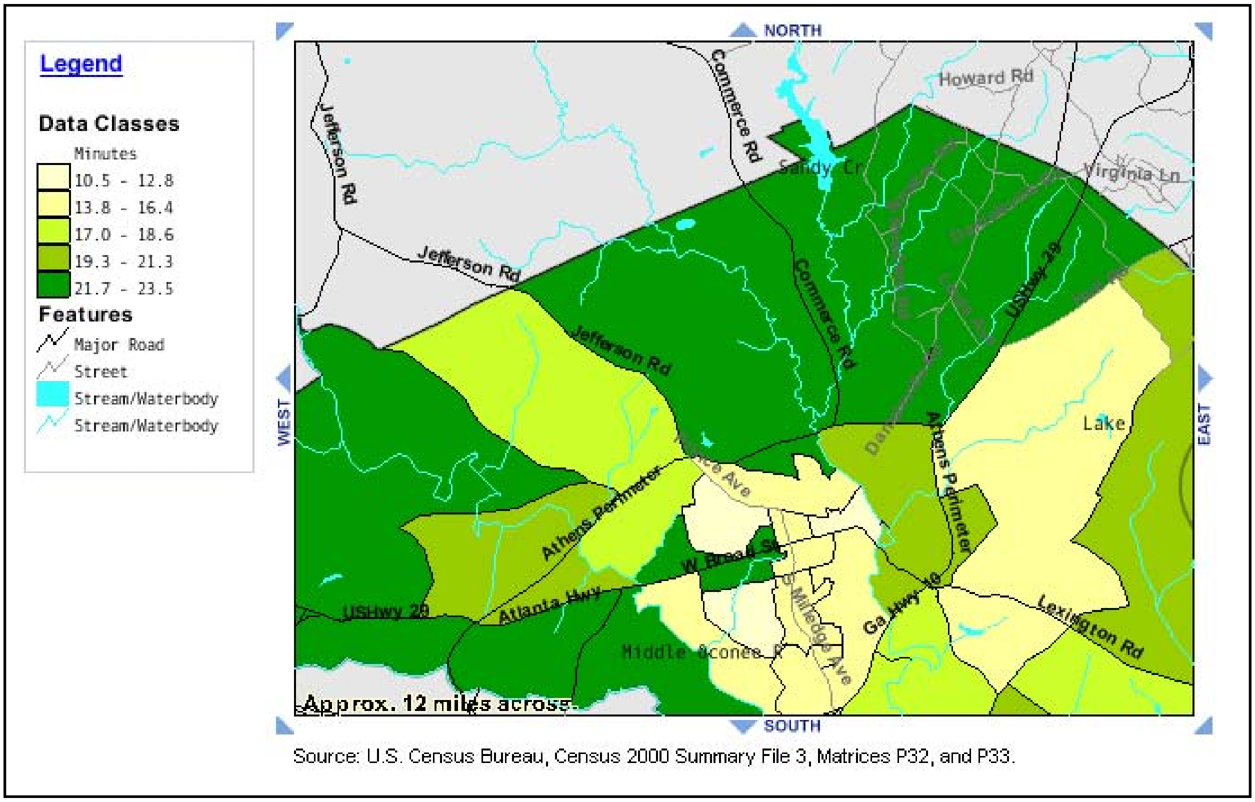


Figure 6.6: Average travel time.

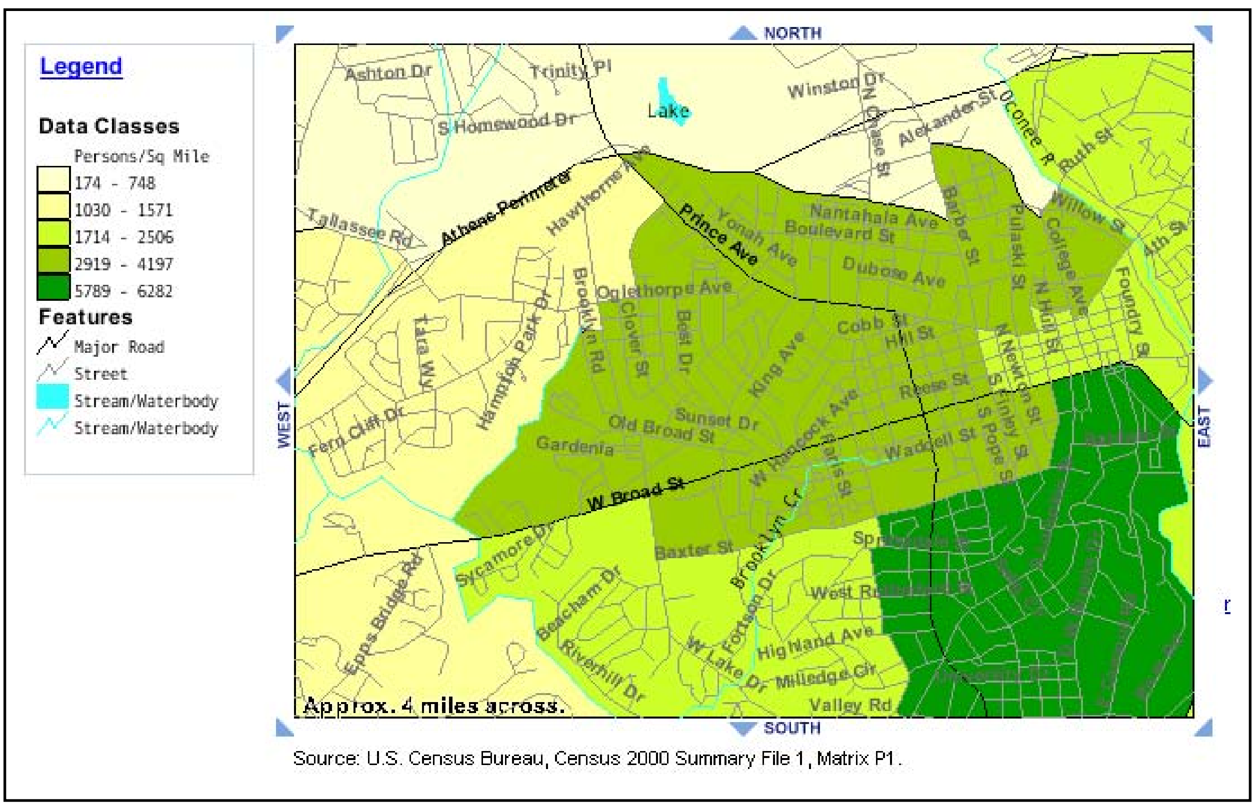


Figure 6.7: Area density.

commuting to work. If this time difference is the result of low income residents having to travel longer distances to get to work, then cycling may not be an effective alternative for this group. However, if the difference in travel is because residents living in poverty commute by bus and spend a greater amount of their time walking to stops, transferring buses, and then walking to work, then these residents may actually benefit from cycling. Finally, the census data shows that the area is one of the more dense areas in Athens with approximately 3,400 people per square mile (Figure 6.7). Compared to other cities this is relatively low, but within Athens it is relatively high. This statistic translates to approximately 13 people per hectare, which is much lower than the studies of other cities cited in Chapter 3. This difference suggests that there are opportunities, and perhaps a need, to increase density if cycling is to become successful. Figure 6.8 depicts the building density in the study area, and suggests that there are options, especially along Prince Avenue, for greater density.

6.2.3 LAND USE

The land along Prince Avenue serves many functions. Figure 6.9 depicts land use immediately along Prince Avenue. At first glance, Prince appears largely mixed, but closer inspection reveals a very high concentration of medical services in the area. Likewise, there are a large number of churches (depicted in black) mainly clustered at the eastern end of Prince. A few residences face the street, including the home of the President of the University of Georgia and a fraternity house, but many of the residential buildings have been converted for commercial use. The combination of these factors creates a different environment on the street at different times of the day. On Sundays, the area around the churches is bustling with activity. Alternatively, during the week many of the medical related businesses close around 5 PM and

Figure 6.8: Density opportunities on Prince Avenue.

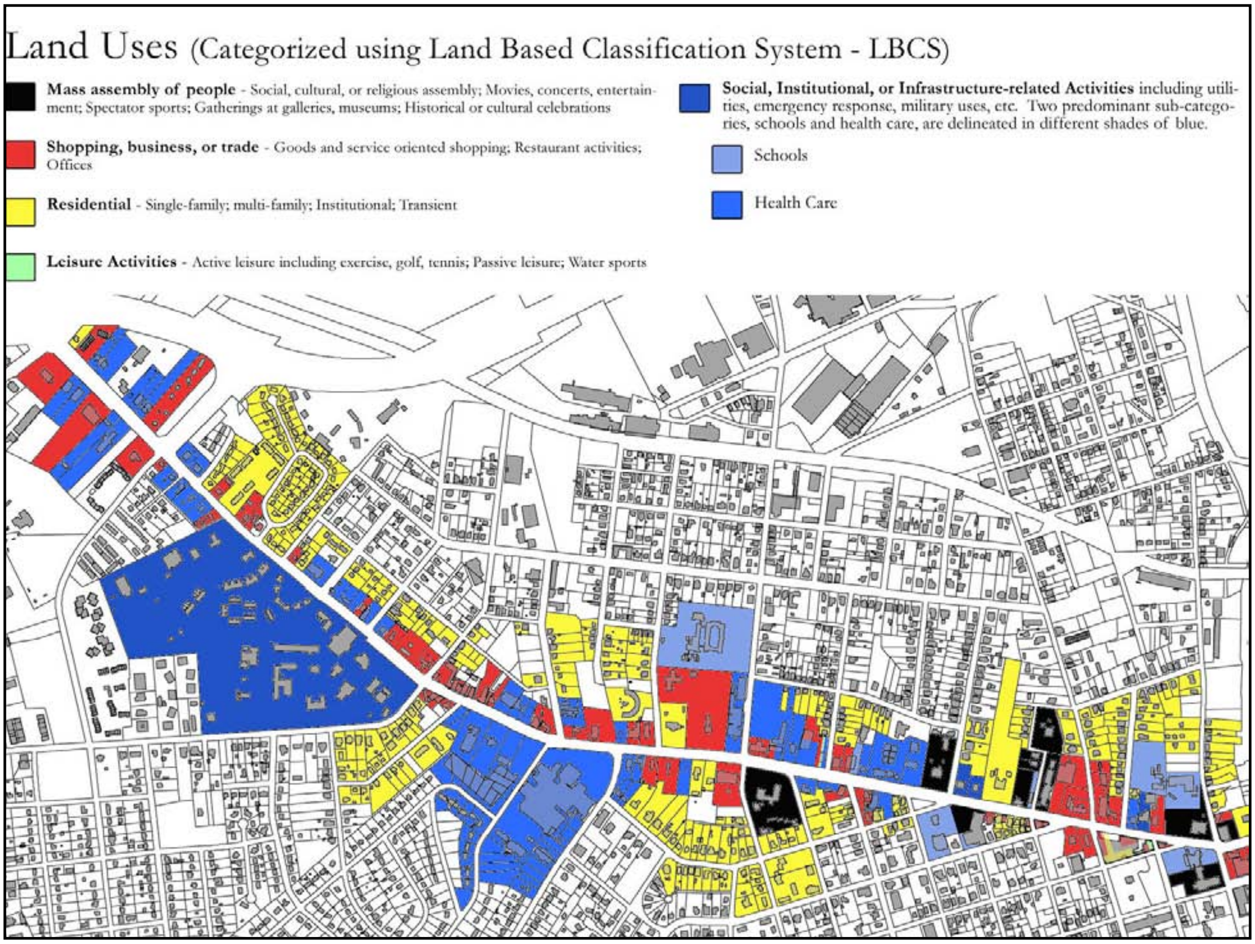


Figure 6.9: Land use. Source: CAPPA.

these areas are abandoned. Figure 6.10 shows how different Prince looks at night compared to during the day. Eight o'clock PM is still a reasonable time for people to be out, but aside from a couple of restaurants, gas stations, the hospital, and few fast food chains, most of the street is empty except for people in cars. After dark, cyclists may feel less secure due to the absence of people.

6.2.4 URBAN ELEMENTS

Wind: Cyclists traveling west along Prince Avenue are likely to encounter a headwind (Figure 6.11). Usually, the wind is relatively calm, but at times it is forceful. Pedaling into the wind may only increase travel time by a few minutes, but strong winds on Prince make cycling physically more difficult and less enjoyable. The lack of tree canopy over the street does not improve this situation and the pruning of trees away from power lines may actually increase the channelization of the wind along the street.

Weather: "The average minimum and maximum daily temperatures for January (the coldest month) are 33 and 53 degrees Fahrenheit, and for July (the warmest month) 68 and 89 degrees Fahrenheit."[3] These conditions suggest that cycling can be utilized year round for a large number of people.

Topography: The topography in Athens presents some challenging hills that require a moderate level of fitness. However, many streets, such as Prince Avenue, provide a relatively gentle grade and easy access to the city. Figure 6.11 depicts the topographic relief on Prince Avenue.

Trees: The number of trees along the edges of Prince Avenue is relatively high compared to many urban streets. Larger trees can be found in the sweeping lawns of historic

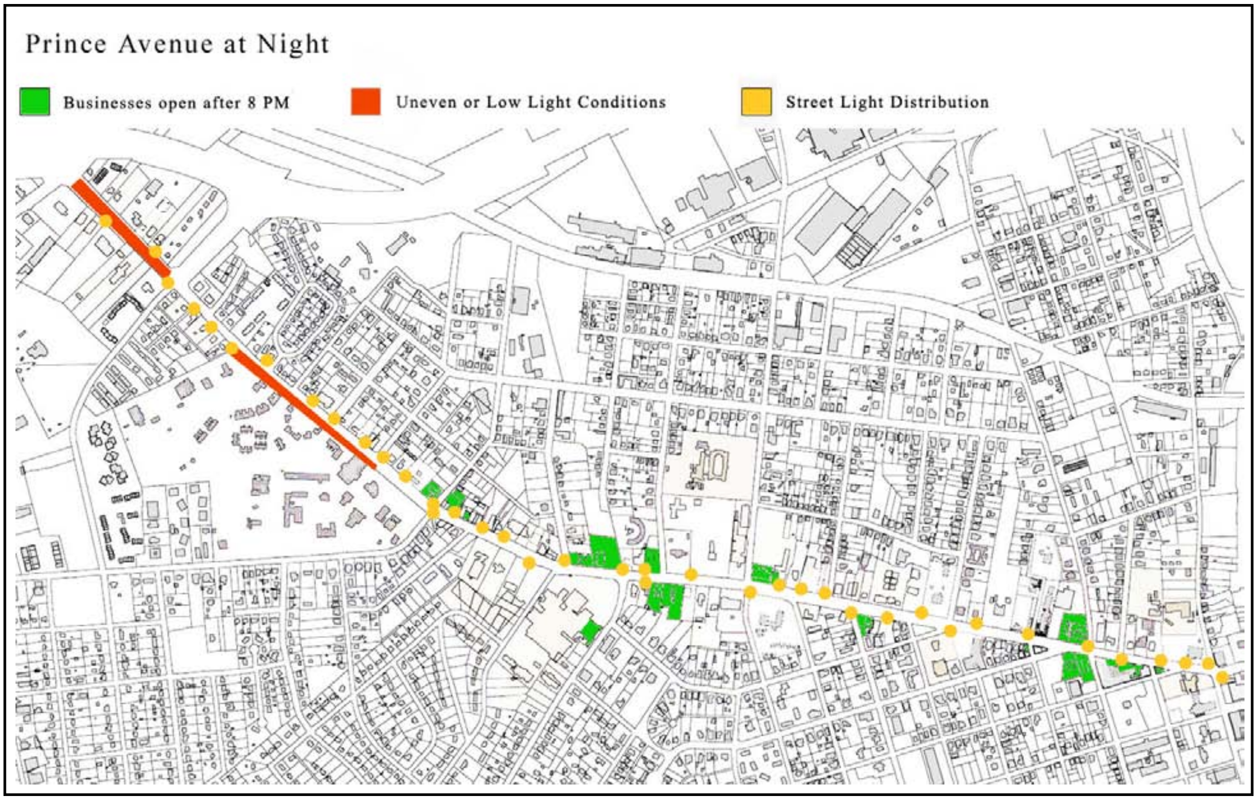


Figure 6.10: Prince Avenue at night.

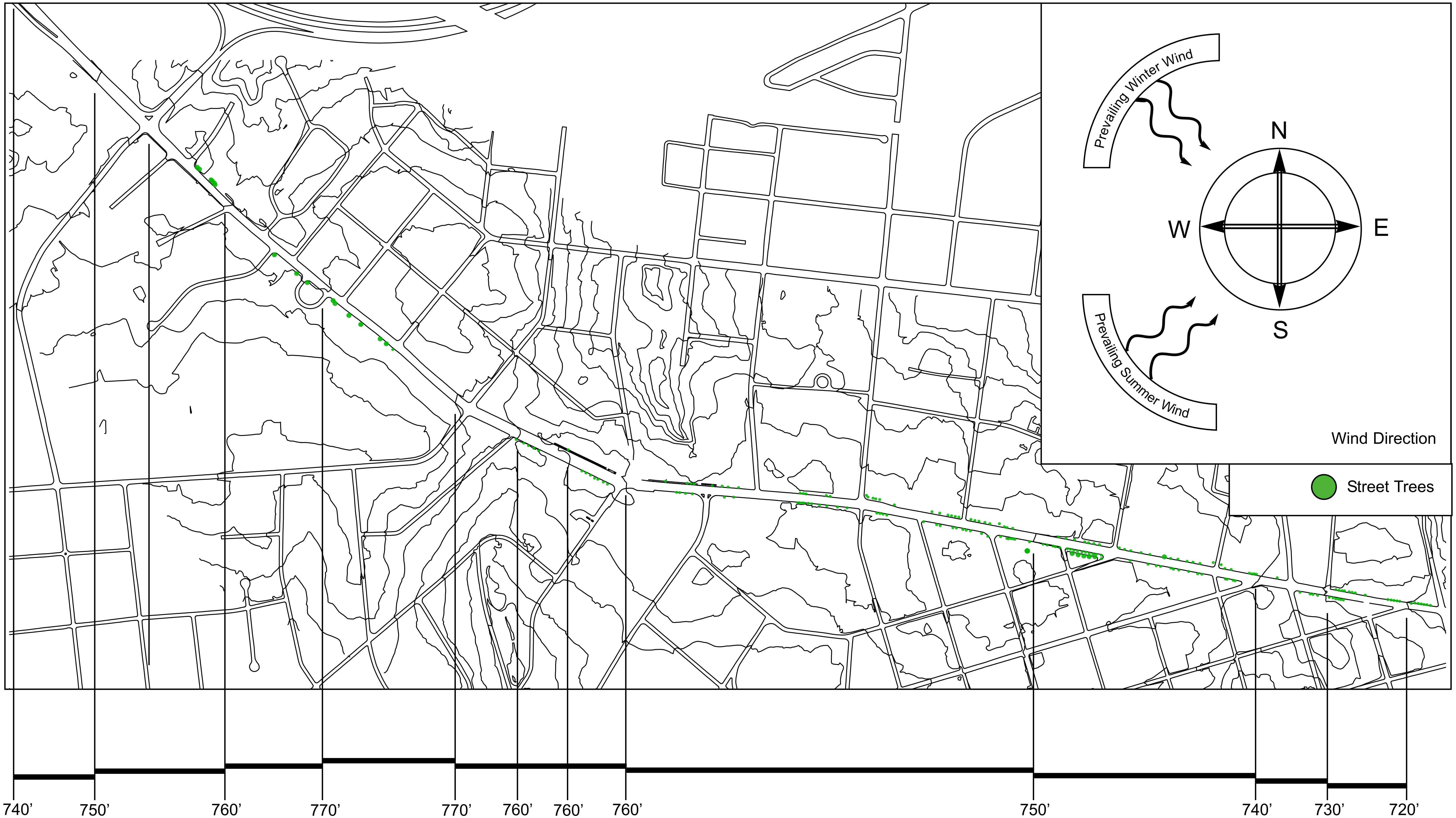


Figure 6.11: Prince Avenue, trees, topography, and wind.

homes. Street trees can provide a sense of rhythm and regularity, but they must be carefully placed to achieve this effect. On Prince Avenue, dogwoods of various size and age are used as street trees along many portions of the street. However, their placement and spacing is inconsistent, and as a result the sense of rhythm and harmony that the trees could provide is largely lost. Dogwood trees are planted between Pulaski Street and Satula Avenue, but do not continue further down the street. Long continuous planting strips on Prince Avenue provide ideal conditions for healthy tree growth. In many cases, opportunities for planting additional trees exist and are not being utilized. In other instances, street widening and driveway entrances have compromised or eliminated tree planting opportunities. Figure 6.11 shows a relatively high number of trees at the street's edge, but despite this there are very few branches that extend out over the street to provide shade. This situation is the result of selecting small street tree species (dogwoods) to avoid interference with overhead power lines. Likewise, the proliferation of parking lot entrances and exits limits the continuity of tree plantings. The tree canopy over nearby streets, such as Boulevard, shows the level of tree canopy coverage that is possible with larger tree species, but which is lacking from Prince Avenue. This absence certainly makes Prince Avenue hotter during the summer than necessary. Large canopy trees are needed, but power line conflicts exist.

Power lines: Power lines exist on both sides of the street with a few exceptions. There are no power lines in front of the Navy Corps Supply School, on the north side of the street between Sylvia Circle and Hawthorn Avenue, for a portion of the street in front of Suntrust Bank, and there is only a single power line in front of the University of Georgia President’s House. Unfortunately, the absence of power lines does not directly correlate with intensive plantings of larger trees. For example, large sections of the land in front of the Navy School could accommodate canopy trees, but do not.

6.2.5: SENSORY ELEMENTS

Noise, traffic volume and speed: Vehicular traffic volume on Prince Avenue is high and varies based on location. In 2003 the area between Hawthrone Avenue and Oglethorpe Avenue had an annual average daily traffic (AADT) of approximately 20,000 vehicles. From Oglethorpe to Milledge Avenue the volume increases to approximately 26,000 vehicles and then falls again to approximately 18,500 vehicles from Milledge to Pulaski Street (Figure 6.12).[4] These traffic volumes may be overwhelming for many cyclists and make maneuvering difficult for those with less experience. The speed limit is 35 mph for much of the street, but increases to 40 mph further from downtown (Figure 6.12). Cyclists may find riding in fast moving traffic difficult and stressful. In some places along the street the lack of traffic signals can make getting onto Prince from a side street difficult due to the speed of traffic. Due to the speed and volume of traffic the overwhelming noise along the street is that of vehicles and this noise decreases the appeal of cycling. Figure 6.12 shows noise samplings taken (with a portable decibel meter) on a week day along Prince Avenue between 4:30 and 5:30 PM. As the figure shows, the average noise levels are at the threshold of what is considered acceptable and peak readings are in excess of what is considered a healthy environment for people.

Visual character: The visual character along Prince is varied. The historic homes and automobile-oriented businesses, which sit back from the street, are largely beyond the cone of vision of cyclists. To a cyclist, these areas appear as lawn and parking lot, respectively. The Bottleworks provides interest because it sits close to the curb and businesses have large windows

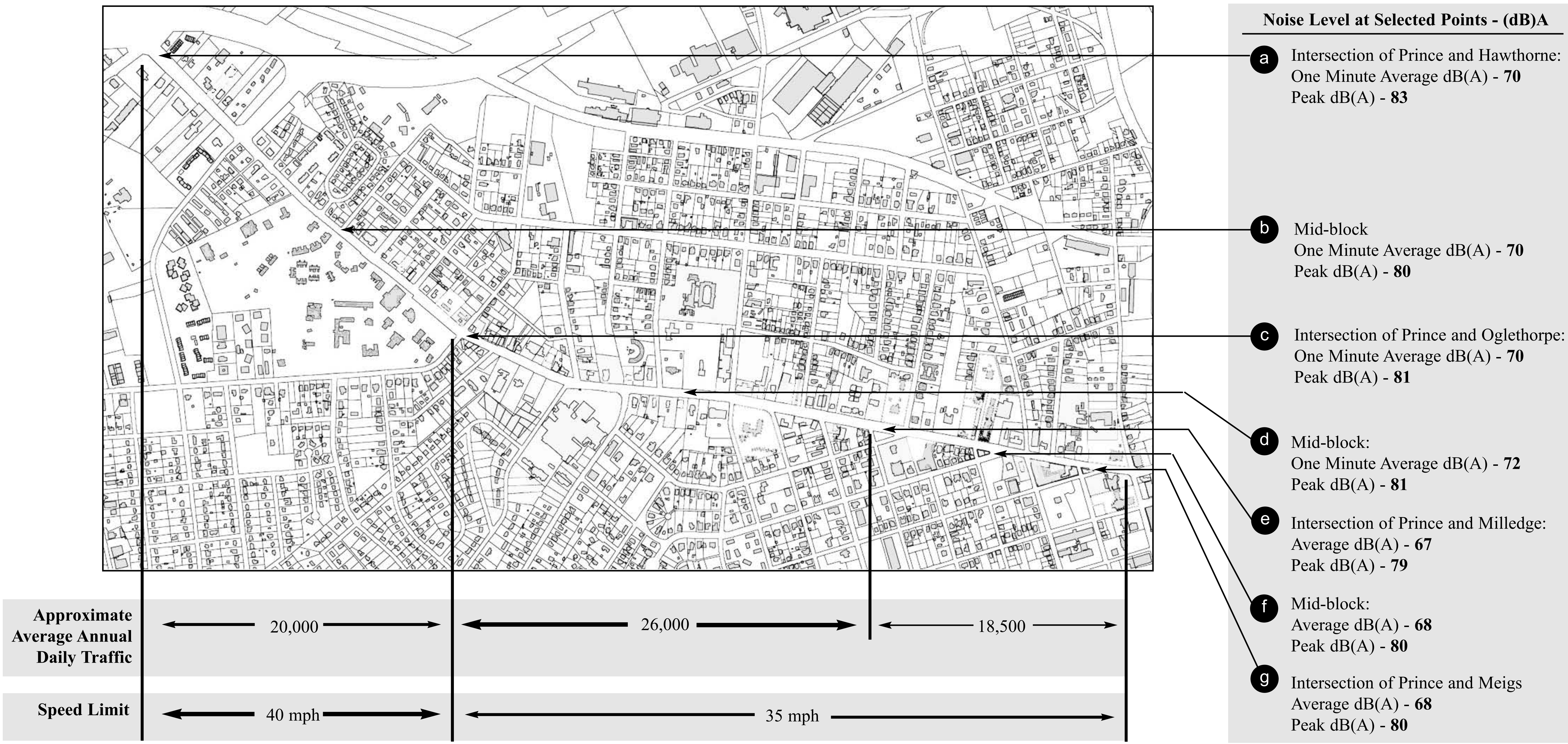


Figure 6.12: Noise levels, average daily traffic volumes & speed limits.

that cyclists can see into as they pass. Although the architecture in Normaltown is similar, in that buildings sit close to the street, the effect is completely different. On one side of the street, diagonal parking places cyclists further from the curb and requires attention to avoid cars backing into traffic. On the other side the facades are angled away from the direction of travel. In both cases, views into the stores are lost.

In addition to the buildings, the signs along Prince Avenue also contribute to the visual character. Pedestrian-oriented signs, found in areas such as the Bottleworks complex, are relatively small (Figure 6.13). Automobile-oriented signage, typical of fast food restaurants and gas stations, towers above the street and is taller than many of the buildings themselves (Figure 6.14). For a cyclist, these signs are generally too high to be seen, because of the need to look down at the street to avoid road hazards. In a few areas where street trees are planted with some regularity, there is an increased sense of motion, but these areas are generally short in length. Unfortunately, due to the large number of street-front parking lots there are few other landmarks to provide a sense of motion, and as a result the stop lights become defining elements which break down the street into smaller segments. Even the arrival at the edge of downtown is uneventful because there is little to see other than a stoplight and the parking lot of the Athens Blueprint store. Together these conditions produce a visual character that lacks balance and emphasis.

Streetlights are relatively evenly distributed along the length of Prince Avenue, but they are not evenly distributed on both sides of the street and are widely spaced between lights. In front of the Navy Corps Supply School, all the street lights are placed on the opposite side of the street, which creates uneven lighting. Between Sunset Drive and Hawthorne Avenue the distribution of streetlights is inconsistent with the remainder of the street and this area is dark.

Figure 6.13: Pedestrian scale signs. (Photo by author)

Figure 6.14: Automobile scale signs. (Photo by author)

Aside from the street lights themselves, a number of businesses have an effect on the street's night lighting. Several gas stations are illuminated to the point that the light is abrasive (Figure 6.15). Safety is surely their concern, but the lighting levels are excessive and can cause glare that makes driving difficult. Alternatively, a number of other businesses create nighttime visual landmarks with their lighting. For example, a series of blue lamp posts outside the Go Bar defines the eastern end of Prince Avenue. Other businesses in the Bottleworks and in Normaltown use strands of white or colored lights to add to the visual character of the street at night. (Figure 6.16). Conspicuously absent from Prince Avenue is the presence of pedestrian-scale lighting. Street lights are bright, widely spaced, and direct the light on the street. The lighting would be better if it provided more even illumination along the street and the sidewalk.

Touch, taste, and smell: There is less stimulation of these senses than there is for sight and sound. For the most part these senses are unaffected by the Prince Avenue environment. Cyclists that are up early might catch the scent of baked goods coming from the Black Forest Bakery and in the evening may smell wood fired pizza baking in the ovens of Bischero's. Other smells include exhaust from buses and trucks, fast food restaurants, and gasoline fumes from the gas stations.

Sense of safety: An overall sense of safety is derived from the cumulative sensory experience. Inconsistent visual elements along the street leave cyclists disconnected from their environment. Likewise, the speed and volume of traffic, which comes up quickly behind cyclists and passes them with a burst of noise, also reduces the overall sense of safety. Observation of cyclists on Prince Avenue reveals a mixture of in-street and sidewalk cycling. This suggests that while some people feel comfortable enough to ride on the road many still do not. Observations of other streets in Athens, such as Baxter street, suggest that even with bicycle lanes many

Figure 6.15: Abrasive lights. (Photo by author)

Figure 6.16: Character lighting. (Photo by author)

cyclists still choose to ride on the sidewalks. This may be the result of a lack of training and experience, or a sense that the street is still unsafe. Individuals may feel safer on sidewalks, but this is actually very dangerous. Unfortunately, it is difficult to gauge actual levels of safety along Prince Avenue since the Athens Police Department does not track street accident statistics.

6.2.6 STREET ELEMENTS

Street width: The street width on Prince varies from approximately 42 feet at Pulaski Street to more than 106 feet at the Hawthorne intersection. Center and right turn lanes add to the width in various places. The curbside parking between Milledge Avenue and Hill Street is sporadically used and often acts as a wide curb lane. On Sundays, these parking spaces are highly utilized. The angled parking in Normaltown also increases street width.

Deposited materials: Prince Avenue remains relatively free of glass, trash and other debris. This is in part due to the volume of cars, which with their movement sweep debris from the road. Additionally, sidewalk trash cans are provided between Normaltown and the Bottleworks. Along Prince, the majority of driveways and parking lots are paved, so sand and gravel are relatively insignificant. In the neighborhoods along Prince Avenue gravel driveways are more common, and sand and gravel are more likely to pose a threat to cyclists.

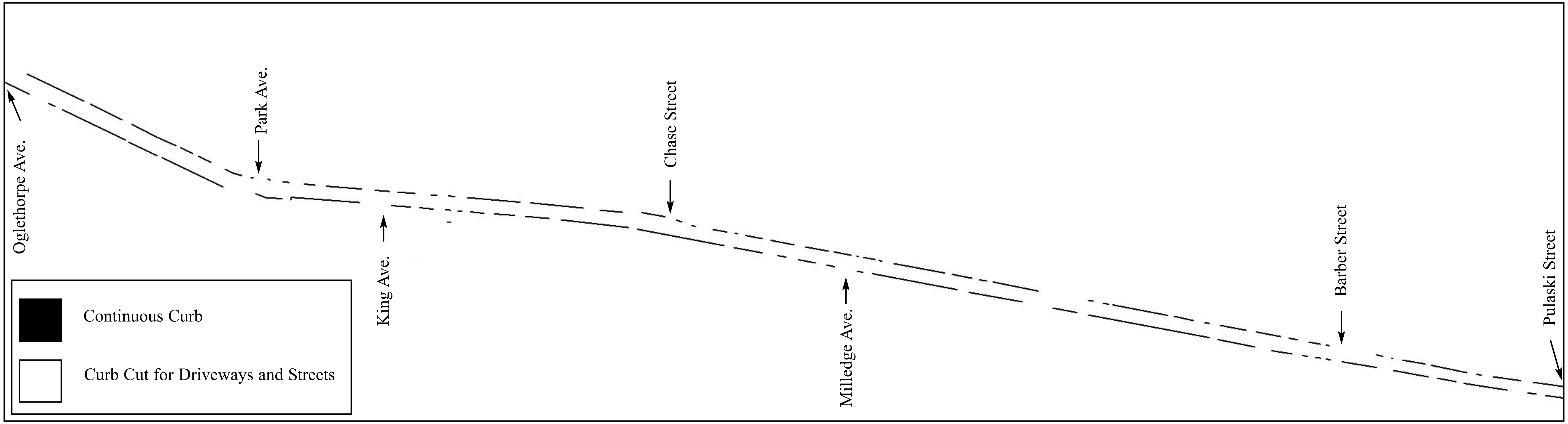
Traffic controls: The traffic controls along Prince provide the majority of green time for travel along Prince Avenue. This is beneficial for many cyclists, but may make it difficult for cyclists attempting to enter Prince via a left turn. Additionally, at least one signal (the left turn arrow at Hawthorne and Prince) does not respond to the presence of a bicycle and will never turn green. In this case, cyclists must wait for other vehicles to trigger the light. Other lights along Prince may have similar problems. Finally, the offset alignment of Park Avenue and Talmadge

Avenue creates the need for separate green phases and consequently causes additional delay for vehicles traveling along Prince Avenue.

Street edge: The edge of Prince Avenue is very permeable from the perspective of cars entering and leaving the roadway (Figure 6.17). Recall that the majority of accidents happen at intersections where vehicles are traveling in different directions, and the importance of the permeability of the street edge becomes apparent. At every entrance and exit to a parking lot, cyclists must focus their attention on the possibility of cars crossing their path. Given the number of driveways along Prince Avenue and their excessive width, this can consume a cyclist's attention and can detract from the pleasure of cycling. Likewise, the number of driveways decrease the availability of planting strips for street trees and eliminates the opportunity for evenly spaced plantings. This reduces the sense of motion and reduces canopy over the street. Finally, the number of entrances correlate with the need for turn lanes to prevent congestion, and the turn lanes increase the width of the roadway.

Drainage grates: Stormwater drainage grates are not a problem for bicycle tires on Prince Avenue because the street utilizes drop inlets on the curb face. In several places, stormwater accumulates in the right hand lane where cyclists typically ride. On many streets adjoining Prince there are parallel path drainage grates which pose potential risks for cyclists. Pavement on Prince Avenue is relatively even and in good repair.

Parking: Automobile parking is larely accommodated with private parking lots. Parallel parking is available in a few locations and in these places cyclists must be aware of opening car doors. Likewise, cyclists in Normaltown must watch for vehicles backing out of the angled parking spaces.



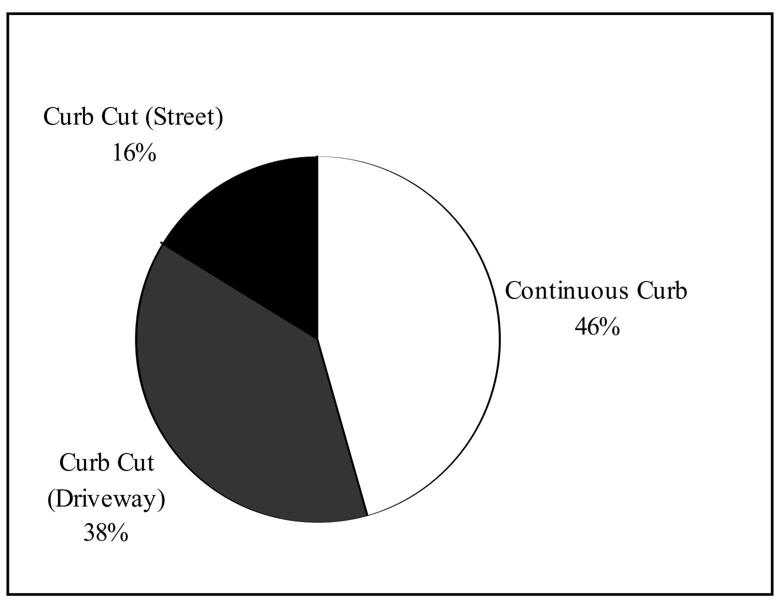


Figure 6.17: Prince Avenue: street edge vehicular permeability (from Oglethorpe to Pulaski).

Cyclists on Prince Avenue have few opportunities to lock their bicycles to objects other than trees, parking meters, and railings. Approximately five bicycle racks exist along the entire two-mile stretch of Prince Avenue and they are all clustered around the Bottleworks and near the Daily Co-op grocery store.

Bicycle infrastructure: Bicycle infrastructure and design on Prince Avenue consists of "Share the Road" signs and "Sharrows" (bicycle arrows painted in the travel lanes). Aside from bicycle lanes on Oglethorpe and some substandard lanes on a portion of Hawthorne there are no other roadway consideration for cyclists in the area.

Alternative transportation: Transit along Prince Avenue provides cyclists an alternative mode of transportation. The number of bus stops is fairly regular, however only two covered bus stops exist. Likewise, only two other stops provide benches. On the north side of the street the sidewalk ends at Pound Street, and there are no mid-block crossings between Oglethorpe Avenue and Sunset Drive. Pedestrians going to and from the bus stops on this section of the street may find it difficult to cross the street.

6.2.7 AIR POLLUTION

Air pollution is a problem in Athens. "Earlier this year, the U.S. Environmental Protection Agency proposed to designate Athens-Clarke, Oconee and Madison counties as non-attainment areas, meaning they had failed to meet a federal minimum standard for fine-particle pollution over a three-year period from 2000 through 2002."[5] Due to falling levels in the past couple years Athens has avoided this designation for now, but if levels rise again then the designation could be costly. "Affected counties would face new restrictions, including a requirement that new transportation projects, including road projects, do not set back an area's ability to reach the federal minimum standards."[6]

6.3 DESIGNING RECOMMENDATIONS FOR PRINCE AVENUE

The design section proceeds with the assumption that more cycling along Prince Avenue is desired. In doing so, the Prince Avenue corridor is explored for ways that the cycling experience could be improved, and for the potential effects of greater cycling volumes on the urban environment. That said, the design approach recognizes that Prince Avenue will always be an arterial road and that many of the changes needed to improve cycling in the Prince Avenue area will require time and incremental efforts.

6.3.1 GUIDING PRINCIPLES

The design recommendations for Prince Avenue are based on the following set of principles:

1. Cycling should be a safe, equitable, enjoyable, and accessible mode of transportation.
2. Cycling design should not worsen conditions for pedestrians, and any effects on automobile transport should be planned and gradually implemented to allow for individuals and businesses to adjust.
3. Design elements that benefit all street users should be a priority.
4. New building construction and streetscape design should unify Prince Avenue to the highest degree possible. Historic landmarks should be vigorously protected, and carefully considered in the evolution of the street.
5. Daily needs should be easily met through local shops and services.

6. The economic vitality of businesses along Prince Avenue should not be compromised, and access to these businesses by *people* must be maintained.

6.3.2 DESIGN RECOMMENDATIONS

Based on the inventory of Prince Avenue, the goal of improving cycling on Prince Avenue, and the guiding principles, the following design elements are recommended. A number of these recommendations require addressing zoning issues, cooperation between Athens-Clarke County planning and the Georgia Department of Transportation, and perhaps the application of an overlay district to implement them.

1. Change the speed limit on Prince Avenue to 30 mph or less and enforce it. This change would increase automobile travel time by less than 45 seconds over the two-mile stretch of Prince from Hawthorne to Pulaski. The reduction in speed provides a safer maneuvering environment for cyclists and can reduce noise levels. The reduction in noise levels is needed to make cycling less stressful and to improve residential opportunities along Prince Avenue.

2. Reduce the number and width of parking lot entrances and exits, and encourage shared entrances, exits, and parking. Many entrances and exits are two to three times wider than necessary. Figure 6.18 shows the excessive width and number of entrances at a former gas station on Prince Avenue. Figure 6.19 shows the excessive entrance/exit widths at two fast food restaurants on Prince Avenue. Despite being one-way, these entrances and exits are wide enough to accommodate multiple cars. Part of this width is due to the need for wider entrances for delivery trucks, but part appears to be poor planning. The excessive width of the openings eliminates planting space for street trees, which disrupts the rhythm and sense of motion that the trees provide, not to mention the canopy coverage. Figure 6.20 and Figure 6.21 demonstrate the

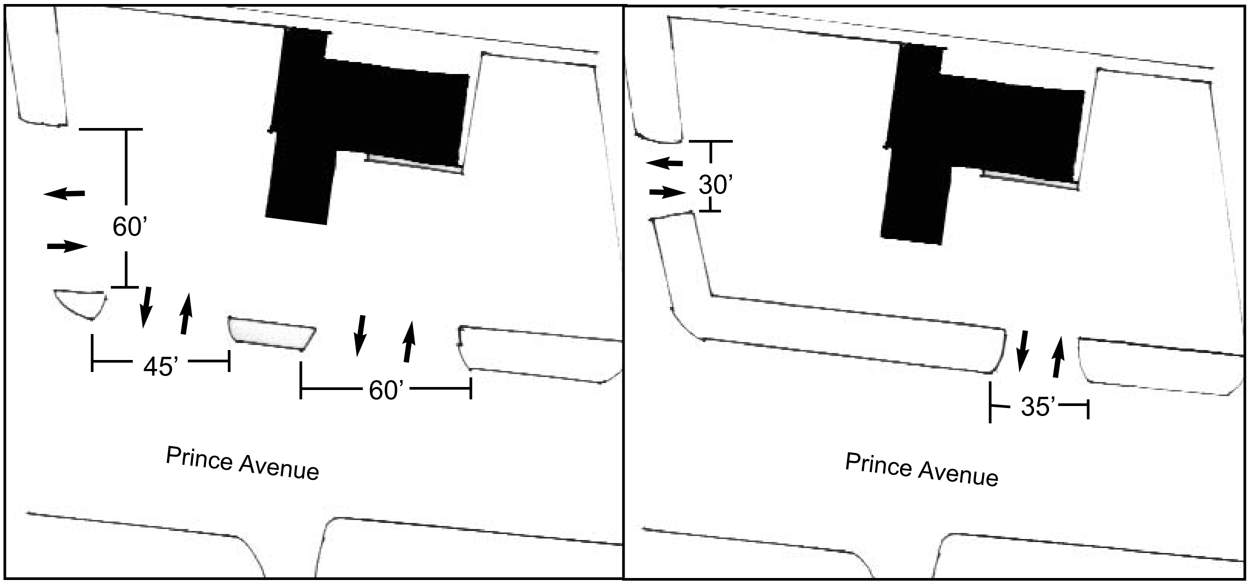


Figure 6.18: Excessively wide gas station entrances and exits.

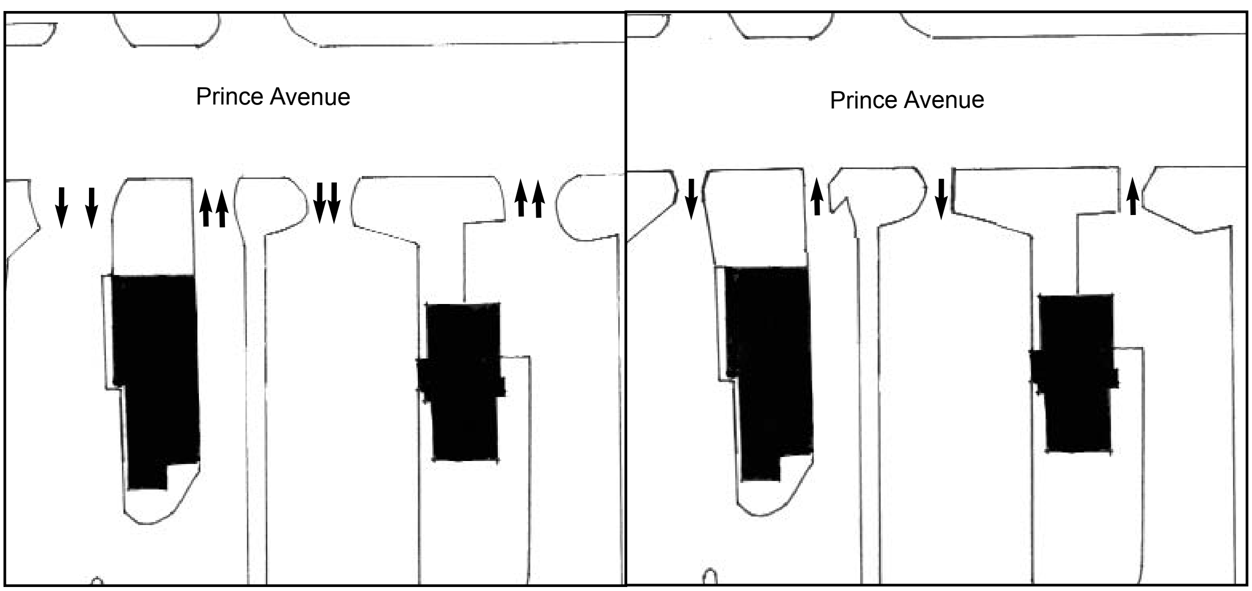


Figure 6.19: Excessively wide fast food entrances and exits.

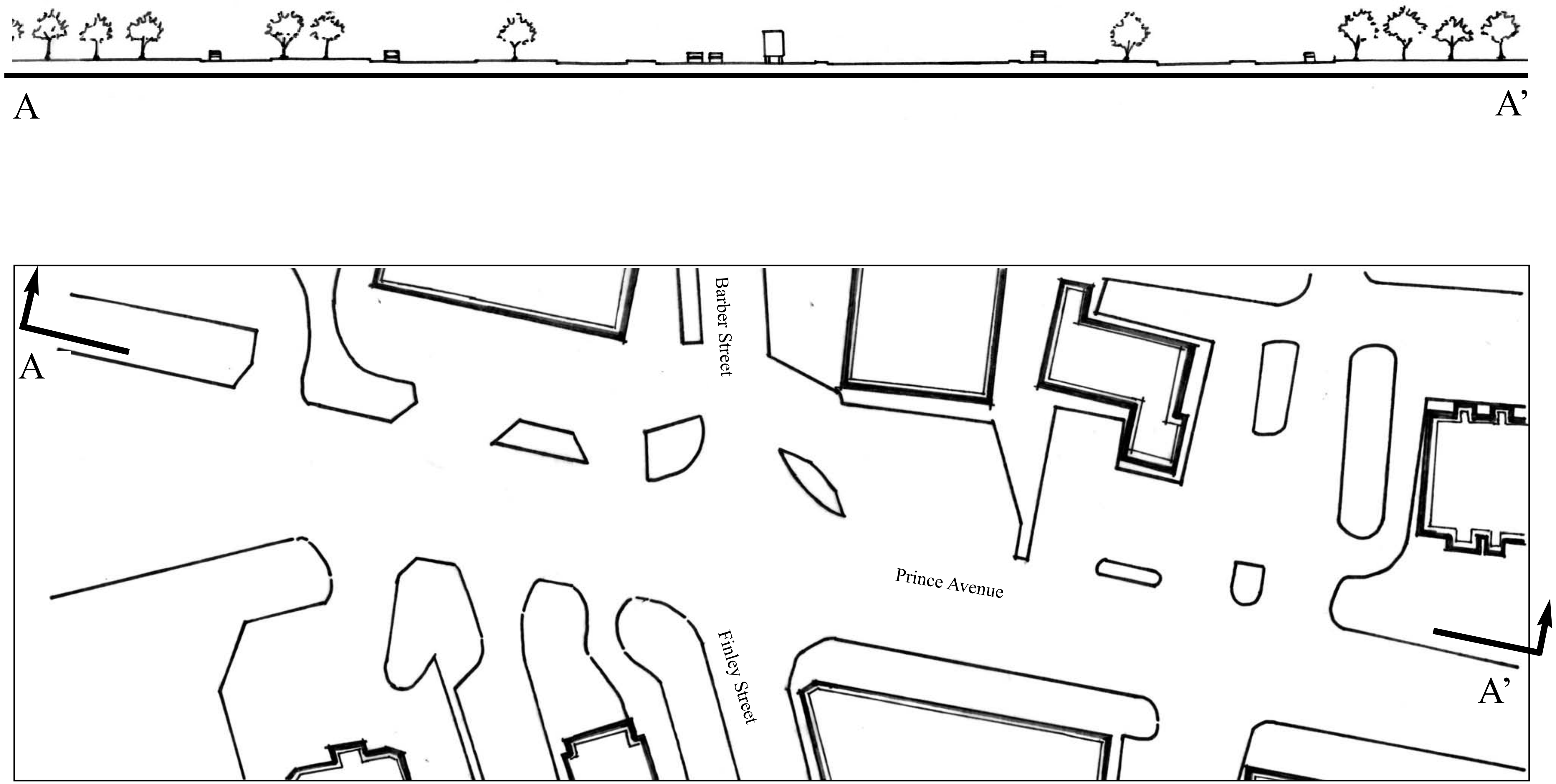


Figure 6.20: Existing street tree planting opportunities.

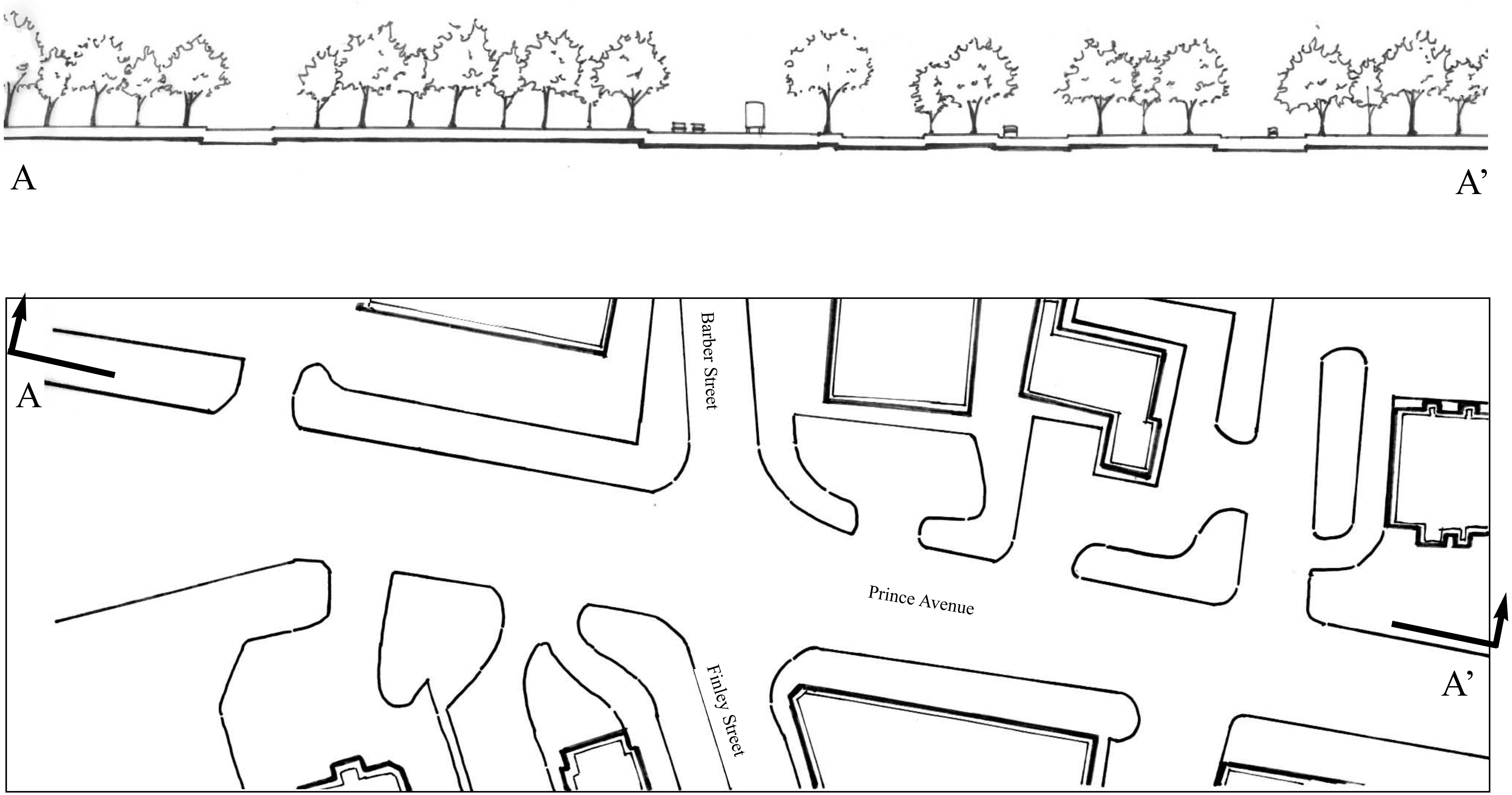


Figure 6.21: Potential street tree planting opportunities with shared entrances and no power lines.

potential for street trees under the existing conditions, and with modifications to parking lot entrances and buried utilities. Finally, the number of entrances/exits increase opportunities for vehicle-bicycle conflicts and reduction should be a priority.

3. Encourage a diversity of uses. The concentration of medical services leaves large portions of the street empty after 5 PM. Attracting businesses and services that can fulfill local resident's needs and that are open for a greater part of the day should be a priority. Likewise, developing mixed-use residential space above street level retail can return people to the street and provide a greater population to support local businesses. Again, noise levels must decline if residential living on Prince Avenue is to become successful. Mixed-uses businesses with different peak hours offer the ability to minimize the cumulative parking needs and shared parking space.

4. Do not widen the road. Except for a few locations, space for cyclists on Prince Avenue can be provided by reducing on-street parking and removal of turn lanes. Of course, for this to happen the need for turn lanes has to be reduced. As described above, reducing the number of entrances and exits can reduce the need for turn lanes. Likewise, reducing the need for automobiles, through more cycling, mass transit, and walking, can reduce the need for on-street parking. The angled parking in Normaltown is well used and would be difficult to eliminate, but if the existing rear parking lots were made available to all business users then the angled spaces could be removed or oriented parallel to the curb. The parallel curbside parking between Milledge Avenue and Hill Street is sporadically used and could be gradually eliminated. As a first step, week-day parking could be prohibited, while still allowing parking on weekends for church services. Figure 6.22 depicts the current division of roadway space and Figure 6.23 depicts the roadway with the removal of turn lanes (or on street parking), buried utilities, and no additional widening.

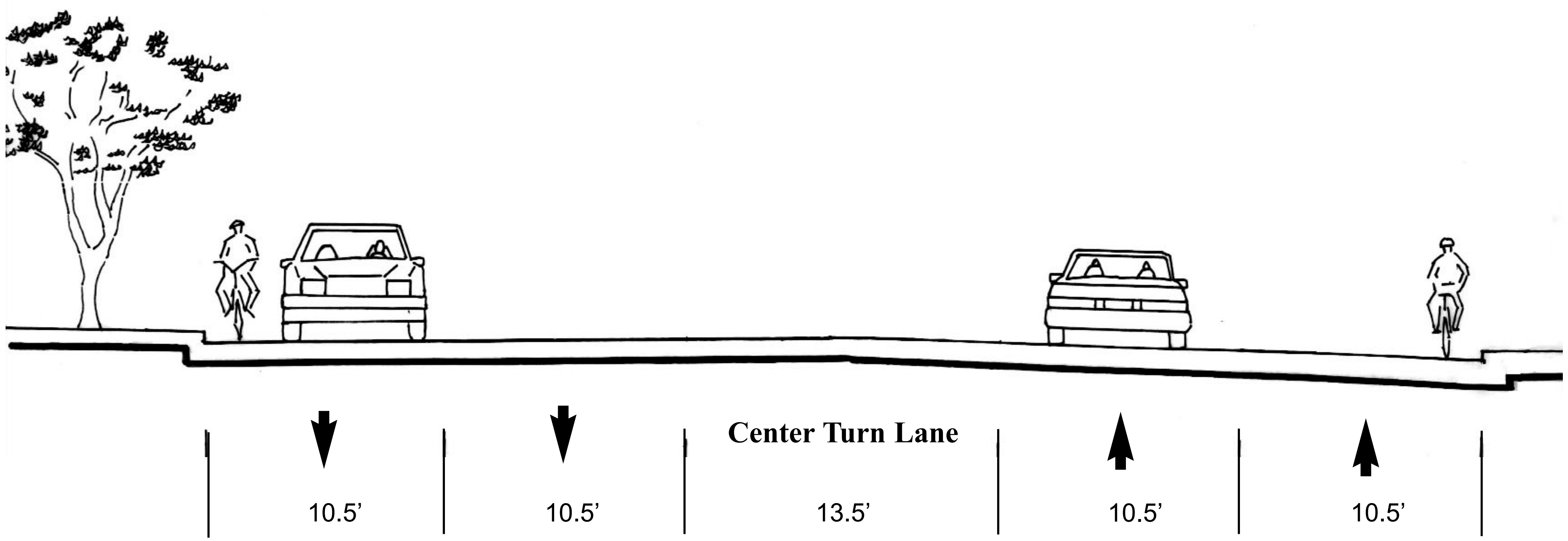


Figure 6.22: Current division of roadway space.

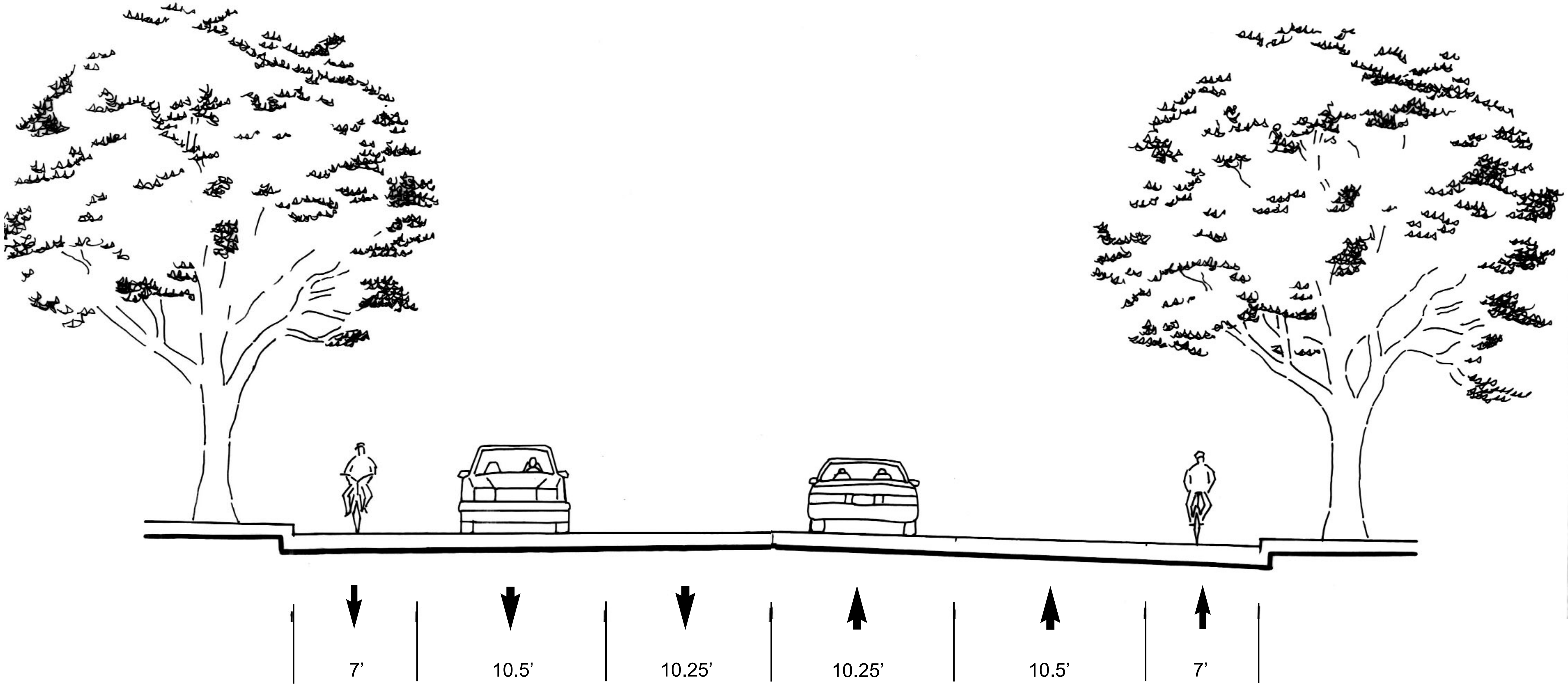


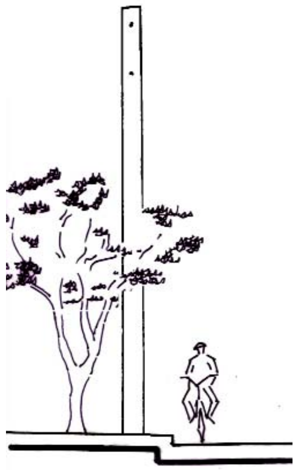
Figure 6.23: Roadway potential without center turn lane.

5. Bury the utility lines. This is needed to reduce visual clutter and provide the opportunity to plant larger street trees. Figure 6.24 demonstrates the effect of power lines on small and large street trees and shows healthy tree growth in the absence of power lines.

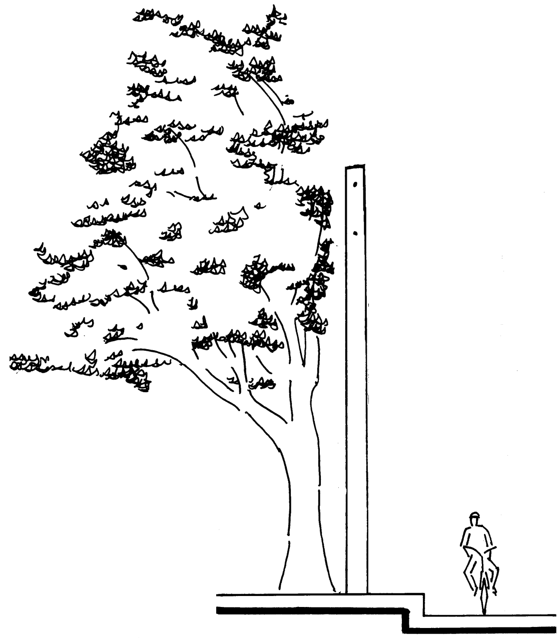
6. Plant large street trees. The existing dogwoods are irregularly spaced and provide little canopy coverage over the street. Street trees can provide unity and rhythm, reduce wind, decrease summer temperatures, and calm traffic, but only when they are consistently spaced and in appropriate scale with the street. Although a single species is usually preferred, a pattern that alternates smaller dogwoods with a larger canopy tree is an option that would keep dogwood trees on Prince Avenue and provide a healthier environment for them to grow.[7] Street trees also provide cyclists with a sense of motion which is desperately lacking on Prince due to the variable setbacks. Finally, street trees can help reduce the effect of the disjointed architectural styles if they are planted on the entire length of the street. Figure 6.25 shows the sense of rhythm and enclosure that is provided by larger street trees.

7. Improve the architectural unity along Prince Avenue. Due to the mixture of historic homes and zero lot line urban construction there will never be complete harmony or balance between the buildings, but improvements are possible. If the demand for parking can be reduced, then infill development can occur in street-front parking lots and can help develop greater density. New buildings should complement the street in terms of size, scale, setback, and orientation. Buildings without sidewalk level windows are discouraged.

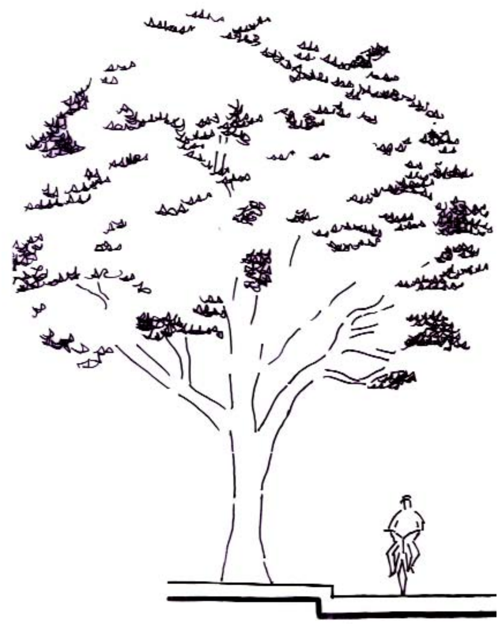
8. Create a visually stimulating street environment. Trees and architecture are prime components of a visually stimulating environment, but appropriately scaled signage, lighting, art, and sculpture can also add visual intrigue. Already, numerous businesses utilize unique lighting to attract customers. This should be encouraged and could become an identifying characteristic



A) Little Shade or Canopy



B) Little Shade or Canopy



C) Shade and Canopy

Figure 6.24: Effect of power lines on street conditions

Figure 6.25: Rhythm and enclosure from street trees.

of the street for nighttime use. Oversized signage obstructs and detracts from the visual coherence of the street and should be avoided. Large display windows provide visual intrigue and reflections in the glass create a sense of motion and speed (Figure 6.26).

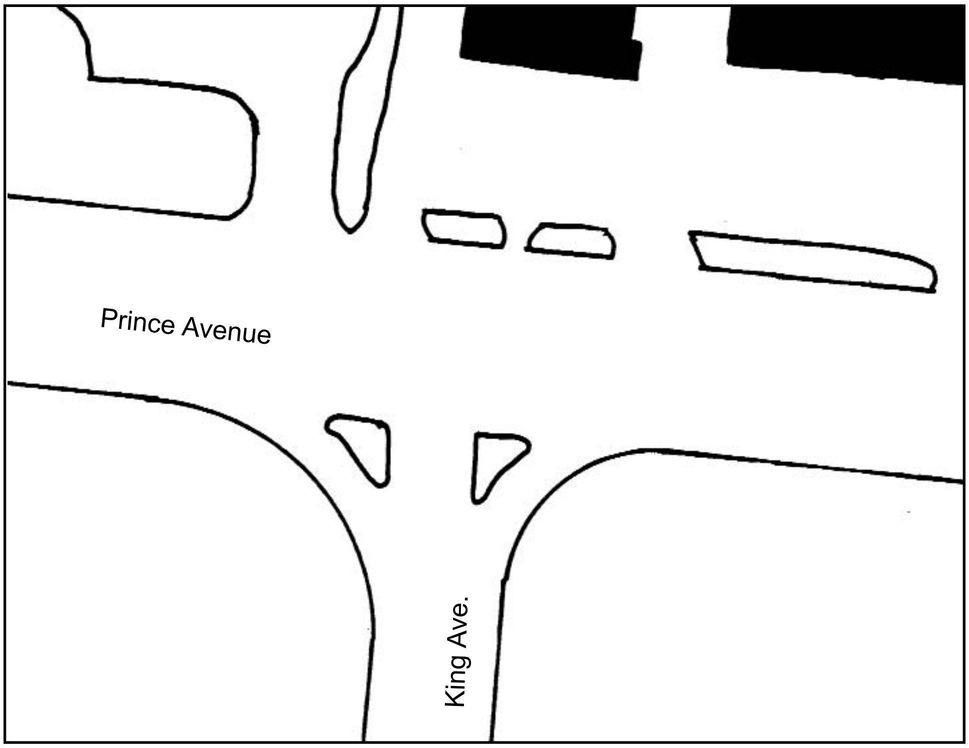
9. Improve conditions for pedestrians and transit users. Sidewalks need to be extended down the entire length of Prince Avenue. Additional mid-block crossings are needed where traffic signals are infrequent. Likewise, more benches and covered bus stops would improve conditions for all street users. Reducing the number of parking lot entrances and exits provides longer sections of continuous sidewalks. Finally, reducing street widths at intersections decreases pedestrians exposure to vehicles. Figure 6.27 shows how the intersection of Prince and King Avenues could be simplified to become more pedestrian friendly.

10. Encourage cycling through education, training, and promotion. Cycling needs to be promoted in order to attract individuals to cycling. Programs promoting cycling to work or to the university could improve cycling. Since billboards already exist along Prince Avenue, these could be used as part of a marketing/promotion campaign aimed at motorists. Cycling education could be incorporated into the local school in the same manner that driver's education is now.

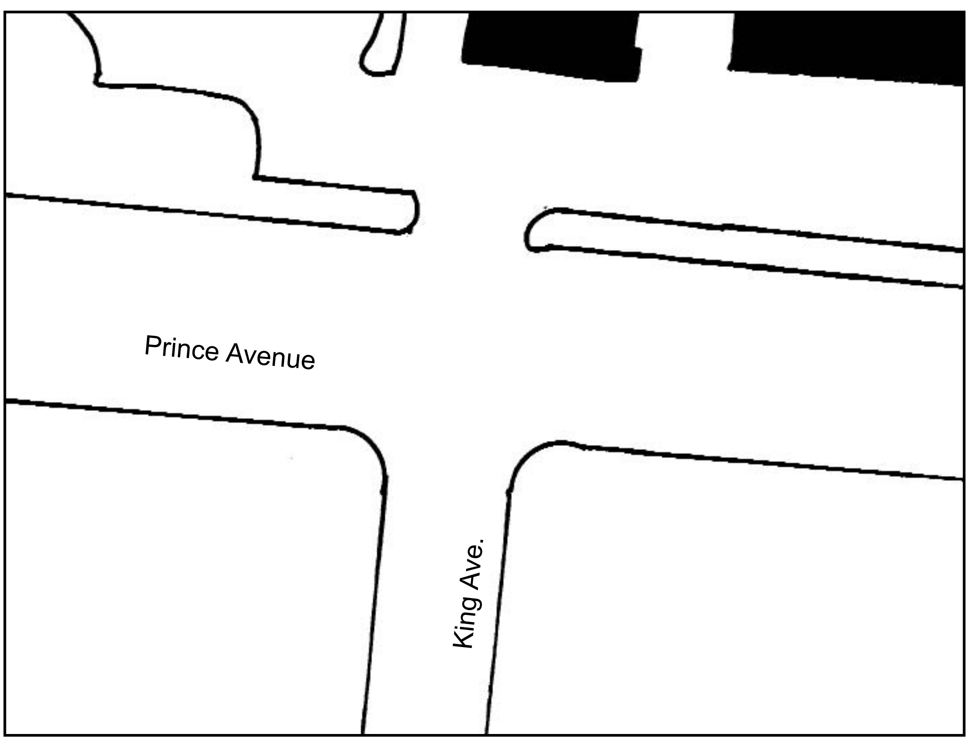
11. Improve cycling facilities. Restriping the roadway to accommodate wider outside curb lanes and narrower center lanes would improve cycling. Restriping the road from four lanes to three lanes between Pulaski Street and just beyond Barber Street would allow for space on this section of the road without the need to widen it. The addition of bicycle racks outside more businesses is also needed and should be a priority.

12. Encourage Density. Density keeps trip distances short, and provides a larger customer base for local merchants. This, in turn, provides a greater number of services within easy access to local residents. As can be seen from the building density on Figure 6.8, the residences are

Figure 6.26: A visualy stimulating building facade.



Existing intersection conditions



Pedestrian friendly intersection improvements

Figure 6.27: Pedestrian improvements.

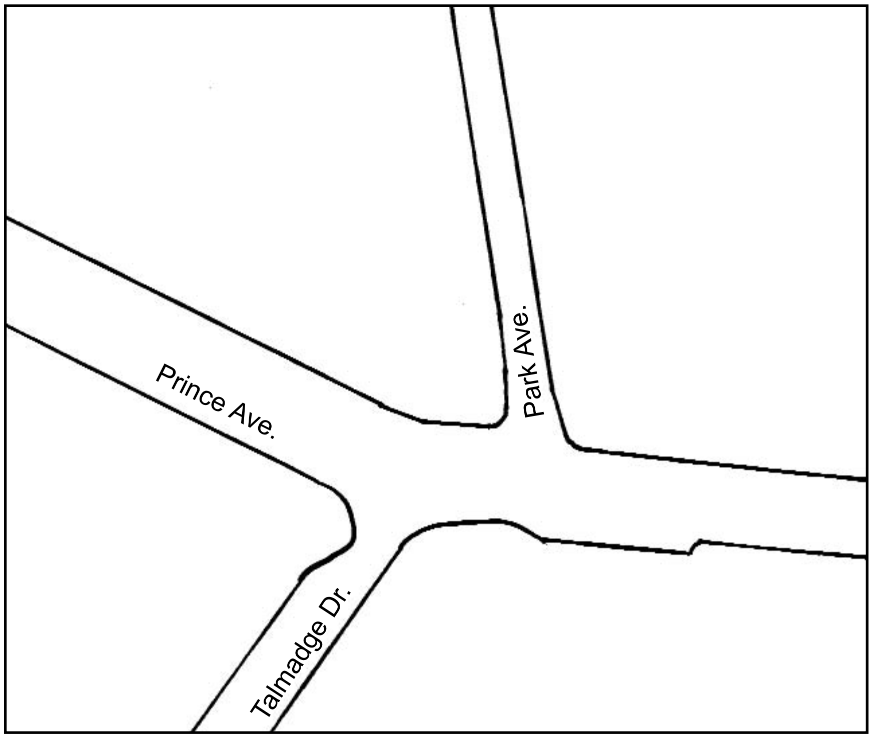
relatively closely spaced, but the buildings on Prince Avenue have large gaps between them that are currently used for parking lots. Reducing the need for parking would allow infill development in these locations.

13. Simplify intersections and improve traffic signals. Intersections should be as simple as possible in terms of traffic signals and roadway alignment. Traffic signals should be adjusted to recognize the presence of bicycles. Additionally, Figure 6.28 shows the possibility for realigning Park Avenue to meet Talmadge Drive. The existing offset requires separate green light phases for both Park Avenue and Talmadge Drive, and causes an unnecessary delay on Prince Avenue.

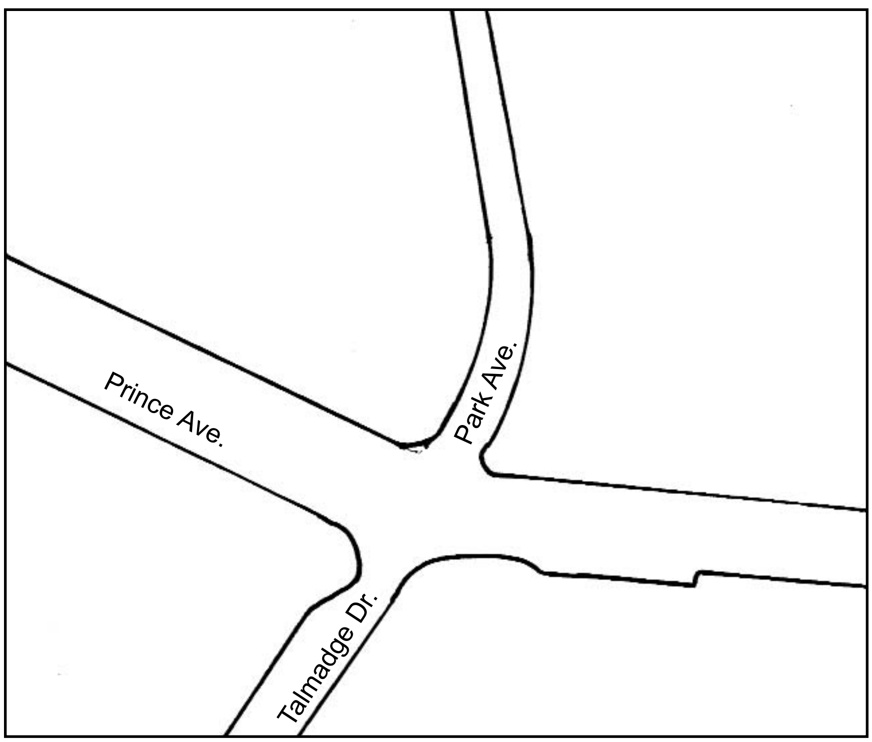
14. Convert unneeded automobile spaces to places for people. Cities need to realize the space saving benefits of cycling. Figure 6.29 and Figure 6.30 depict how a small reduction in parking can transform small segments of the road into pleasant environments for community use.

6.4 SUMMARY

This chapter demonstrates the challenges and opportunities for cycling in the Prince Avenue area. The nature of the street and the number of adaptations for the automobile suggest that transforming Prince Avenue into an environment where people enjoy cycling will be a challenge. Despite this challenge, Prince Avenue presents great opportunities for increased cycling, and there appears to be a significant population that could benefit from improved cycling conditions. Finally, the inventory, analysis, and design phases of this chapter show the need for cycling design to look beyond the confines of the road and consider a broader range of design solutions.



Existing intersection alignment



Proposed intersection realignment

Figure 6.28: Intersection realignment.

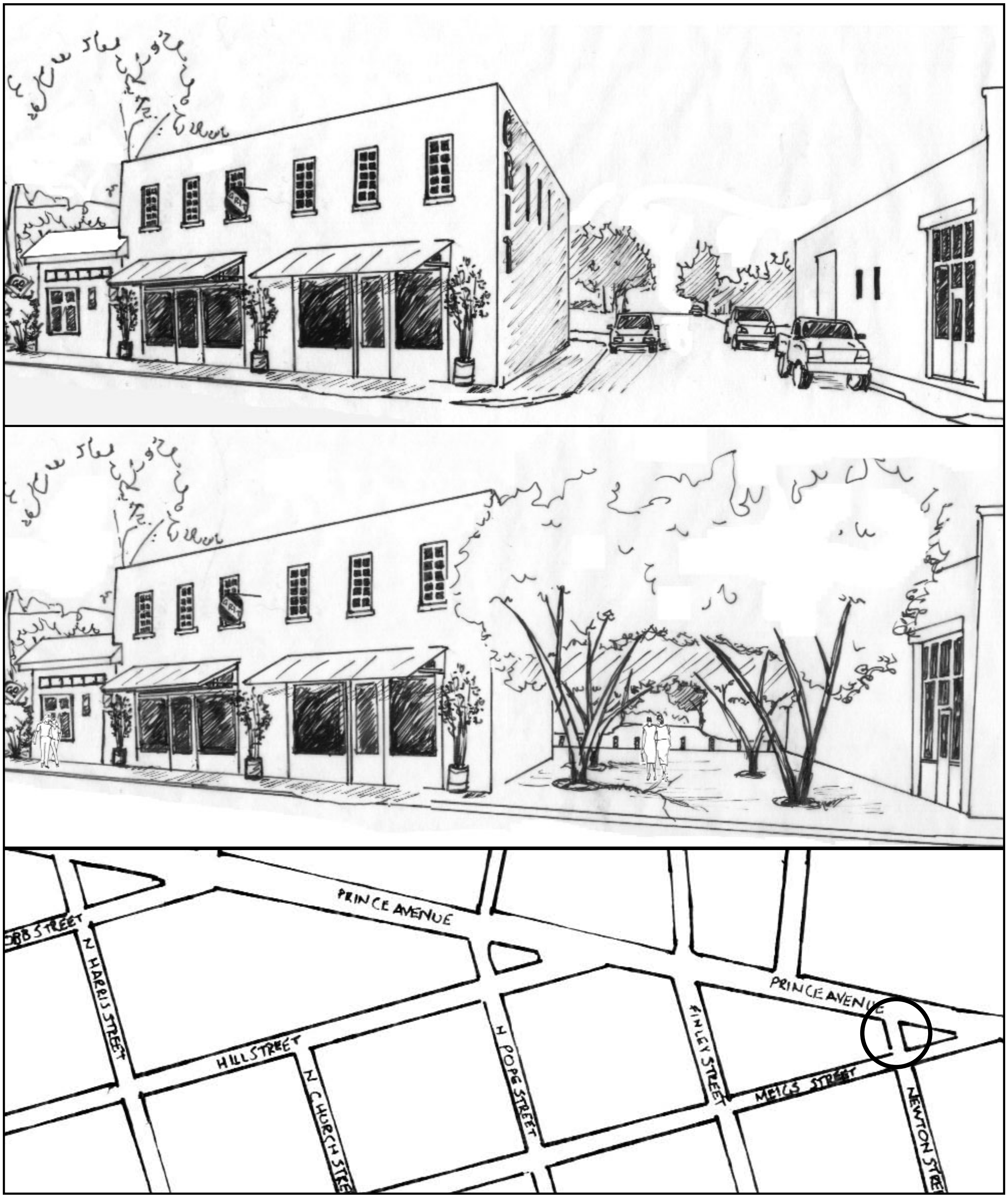


Figure 6.29: Reclaiming space for people.

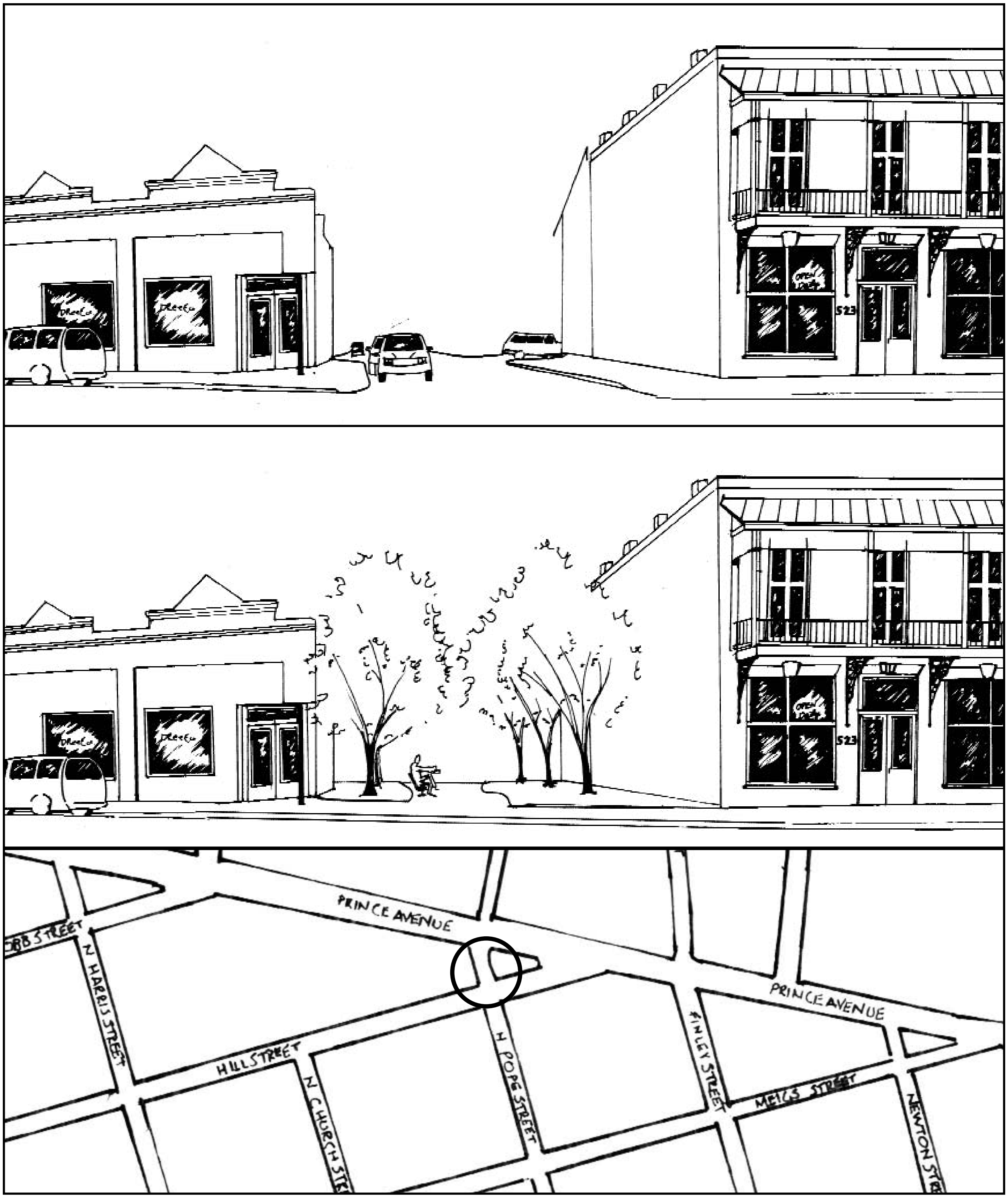


Figure 6.30: Converted street use for people.

Chapter 6: Notes

[1] Athens Clarke County Planning Office <http://www. athensclakecounty.com/about.htm>.
[2] The University of Georgia <http://www.uga.edu/profile/facts.html>.
[3] The University of Georgia <http://www.uga.edu/profile/facts.html>.
[4] Athens Clarke County Planning, , e-mail to the author , 14 Mar. 2005.
[5] Lee Shearer, "Athens Air Quality on Upswing," Athens Banner Herald 27 Sept. 2004.
[6] Lee Shearer, "Athens Air Quality on Upswing," Athens Banner Herald 27 Sept. 2004.
[7] Henry Arnold, Trees in Urban Design. (New York: Van Nostrand Reinhold, 1993) 156.

CHAPTER 7

CONCLUSIONS

The role that urban cycling plays in U.S. cities can be greatly improved, and the urban design - urban cycling relationship provides an alternative framework for viewing cycling design. This relationship suggests that cycling design must extend beyond the confines of the road in order to address the needs of cyclists, and to attract more cyclists. As described in Chapter 3, the street environment is fundamentally different for cyclists when compared to drivers of motor vehicles. Sensory elements and urban design features have impacts on cycling that cannot be resolved with the simple addition of signage or bicycle lanes. Due to these differences, a more substantial approach to cycling design is needed. The approach needs to include the recognition of streets as places for people, and to recognize the consequences of larger planning issues. The approach must also recognize that, in an age where people may choose their mode of transportation, designs that do not recognize the difference between environments designed for automobiles and those designed for people will fail to attract and retain cyclists. If these considerations are not included in cycling design, then cycling levels in this country will likely remain low until the environment through which individuals cycle improves, or until driving becomes so expensive that individuals cannot afford to drive.

The challenge for cycling design based upon the urban design - urban cycling relationship lies within the current approach to urban planning. Under this approach, cities evolve through many small scale incremental decisions, but these incremental decisions have long-lasting, large-scale implications. Planning for transportation, economic development, zoning, housing, water quality, air quality, and a range of other civic functions are often undertaken as individual isolated tasks. A transportation planner who adds bicycle lanes to a street has fulfilled the requirements for his position. Despite the addition of bicycle lanes the streets may remain a miserable place for cyclists, but this is not the responsibility of the transportation planner because he has done all he can. Additionally, it is not seen as failure of planning if cyclists do not utilize the lanes, but instead it is seen as a lack of interest in cycling. The problem is that everyone can individually perform the tasks assigned to them (and do them well), but the collective result can be a poorly planned city. Recognizing the relationship between urban design decisions is essential in order for the incremental decisions to produce a positive collective result. Producing positive change is possible, but it will require a more collaborative approach that combines the skills of different disciplines and assigns responsibility for the desired outcome. Cycling advocates may need to be the driving force that pulls together different design disciplines in order to create environments where cycling is a pleasant experience rather than a stressful one. At the local government level, the addition of a bicycle/pedestrian coordinator may also be needed to pull together city planning and transportation planning professionals.

In The Experience of Place, Tony Hiss writes, "I had the good fortune of learning at an early age that experiences of places can be a valuable part of life, but it took me years to learn the next lesson: that these experiences are under our control; they are a rainbow well within our grasp."[1] Urban design can create valuable life experiences, but it must be done in such a way that incremental decisions contribute to urban living and do not detract from it. The urban design - urban cycling relationship shows how cities and cycling affects urban experiences, and as Hiss points out, these experiences are under our control. In this context, the bicycle is a design element that is capable of improving urban living to a great extent. Achieving the benefits of cycling will be a challenge for many cities, but the case studies show that with proper planning, long term vision, and incremental steps, change is possible.

Chapter 7: Notes

[1]Tony Hiss, The Experience of Place. (New York: Vintage Books, 1990) 99.

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