Social Change and Cycling as a Form of Sustainable Transportation:
The behavior-policy interaction in a medium-sized developing city

By
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Submitted to the Department of Urban Studies and Planning and the Department of Civil and Environmental Engineering in partial fulfillment of the requirements for the degrees of

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ABSTRACT

In developing countries, growth frequently parallels increasing motorization rates, and visions of mobility are often centered on the private automobile as the most flexible form of personal transportation and a symbol of increasing wealth. The pursuit of mobility in this form has severe social, environmental, and economic consequences, some of which can be mitigated by the promotion of alternative modes of transportation. Cycling and other forms of human-powered transportation have benign environmental effects, improve physical health, and can positively affect the psychology of people who, by choosing this mode, are more active and spend time outside and engaged in their environment. Given these benefits, it is not surprising that some medium-sized, developing cities are including cycling in their transportation plans.

These cities experience significant barriers, however, in promoting cycling as a form of sustainable transportation. Much of the challenge involves effectively utilizing planning processes and tools, which are often imported and applied in a context where they were not designed to be used, to elicit more sustainable transportation behavior in the midst of rapid change. Solutions that come from these planning processes and tools (particularly infrastructure and other engineering-focused solutions) can be ineffective in promoting an alternative form of transportation.

Addressing these shortcomings to elicit a change in behavior toward cycling as a form of sustainable transportation requires a new combination of planning tools and processes that can produce effective solutions. In this thesis, I propose a three-step approach to induce behavioral change toward cycling, including: gaining an understanding of the barriers to bicycle use through attitude and perception analysis, improving the planning process through a visioning and backcasting exercise, and assessing and selecting the most appropriate modeling tools for the short-term and long-term promotion of cycling. I apply this approach using a single case study: Chihuahua, Mexico. Although I am unable to show a change in behavior in Chihuahua, initial results indicate that this adjusted approach does have promise in terms of inducing more behavior associated with sustainable transportation practices.
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Chapter 1: Introduction

Introduction
Sustainable transportation is a critical issue in developing countries. Achieving sustainable transportation in the face of rapid growth and globalization can be particularly challenging considering the phenomenon that growth is often coupled with an increase in automobile ownership (see Figure 1). Automobiles are often viewed as a symbol of improving economic and social status (Geenhuizen et al., 2002), favored by many politicians and planners as the basis of mobility in the present and for the future of a developing city. In larger cities, this focus on the automobile might be balanced with attention to mass transit as a way to move large segments of the population. Higher densities can make mass transit and walking trips more feasible. In smaller cities, however, extensive mass transit may not be viewed as a viable solution and density may seem out of place. The prioritization of automobile mobility results in social, economic, and environmental consequences that can be exacerbated by the complications of economic growth.

Figure 1: Relationship between country GDP and car ownership 1970 to 1992

There are many opinions as to how these social, economic, and environmental problems should be solved. While some are mentioned briefly in this chapter, I focus on the promotion of cycling as a non-motorized mode of transportation that is environmentally benign, affordable, healthy, and a means to improve quality of life, as understood in the
term “livability”, which is defined in the following section. In medium-sized developing

cities, which cover a smaller land area and are may have limited resources to dedicate to

transportation solutions with heavy infrastructure requirements, cycling can be an

ever extremely important and relatively equitable method of addressing the environmental,
social, and health problems resulting from the transportation sector.

In developing nations, where increasing incomes allow the investment of more money in
time-efficient, even luxurious transportation modes, cycling is often associated with
poverty. In order to establish cycling as a viable and attractive mode of transportation in
this context, the provision of appropriate infrastructure and policies must induce a shift in
perceptions towards cycling. To better promote cycling in a medium-sized city, where
the smaller distances between destinations and lower viability of extensive public transit
might be particularly amenable to the consideration of cycling as a solution to
transportation problems, the perception of cycling as a safe, flexible, respectable, and
viable form of transportation must be encouraged.

In this chapter, I first define some important terms in my argument. Then I establish the
relevance of cycling as part of the solution to the problems arising from the transportation
sector in greater detail. Next I introduce the framework for my research on the role of
policy processes and tools in promoting of cycling as a form of sustainable transportation
in a medium-sized, developing city context. Finally, I state my research question and
summarize the method I use to answer it.

Defining the Terms

Transportation is a major challenge in achieving sustainable development across the
world. Before qualifying the impact of transportation and the need to mitigate it, it is
necessary to define “sustainable development” and “sustainable transportation.”

One widely accepted definition of sustainable development from the World Commission
on Environment and Development (1987) is to meet “the needs of the present without
compromising the ability of future generations to meet their own needs” (p. 43). There
have been attempts to narrow and clarify this rather general definition. The World
Business Council for Sustainable Development (2001) offers a definition more directly
related to transportation’s role in sustainable development. It defines sustainable
transportation as “the ability to meet the needs of society to move freely, gain access,
communicate, trade, and establish relationships without sacrificing other essential human
or ecological values today or in the future” (pp. 1-2). My underlying assumption is that
sustainable transportation planning, rather than avoiding the sacrifice of human or
ecological values, should actively promote human and ecological values while enhancing
the ability to access societal resources. This can be achieved through the promotion of
transportation modes that provide access to social resources and are environmentally
friendly, avoid exacerbating existing social inequities, improve personal health, and
increase the livability of an urban area.
Sustainable transportation, by its very definition, is not an easy thing to achieve. It requires the consideration of a wide range of factors as well as the balancing of a wide range of needs. In developing cities, it may be far too easy to prioritize economic development in an unsustainable fashion. According to Black and Nijkamp (2002), existing trends, such as “increase in the number of single-parent households, more local and global leisure travel, and industrial globalization” are contributing to the unsustainability of transportation patterns (p. xi). The best approach to sustainable transportation may be the improvement of access to societal resources at a low cost, rather than increasing mobility at all costs. The rethinking of solutions to transportation problems in a more sustainable fashion requires that politicians and other decision makers are aware that there are alternative solutions, as well as technical analysis that supports this kind of approach.

A concept related to the pursuit of sustainability goals is embodied in the term “livability.” A livable city is one that prioritizes the needs of human beings by creating an environment that is pleasant to be in. It has a transportation system that emphasizes the human users of the system by providing healthy spaces that enhance access to social resources, rather than maximizing throughput by particular transportation modes. Donald Appleyard (1981), a proponent of livable streets, recognizes that streets have provided a value beyond transportation:

People have always lived on streets. They have been the places where children first learned about the world, where neighbors met, the social centers of towns and cities, the rallying points for revolts, the scenes of repression (p. 1)

Livable streets take into account this variety of activities, the range of purposes, and all of the users that might be accommodated. The values inherent in livability are a significant deviation from the prioritization of mobility and efficiency of a transportation system through high capacity infrastructure. This engineering approach tends to focus on a scale that does not appropriately incorporate the individual human experience.

**Transportation Challenges and Solutions in Medium-Sized, Developing Cities**

The value of the automobile in our transportation system cannot be ignored. According to Gatersleben and Uzzell (2002), “Cars have been a liberating force in society: they have opened up choices and opportunities with respect to where people live, work, and take their leisure” (p. 136). For those who can afford to purchase them, cars provide the most flexible and individualistic form of movement over long distances. However, as Gatersleben, Uzzell, and many others recognize, cars have also had serious environmental, economic, and social-psychological consequences. They have also allowed our societies to be built in a way that favors their use, resulting in sprawling distances between destinations that disadvantage other modes of transportation, such as public transit and non-motorized modes. These consequences, the need to promote other forms of transportation over the automobile, and the reason that cycling is a reasonable
part of the solution to some of these adverse consequences will be briefly summarized below.

The Problem
The transportation sector contributes significantly to environmental degradation and related health problems, as well as social isolation from infrastructure design and inequitable access to resources, across the world. These problems can be more acute in developing countries where rates of car ownership are rapidly increasing and environmentally friendly technology is harder to access due to availability or affordability. According to The World Bank Group (2002), while about 25% of the pollutants that contribute to global warming come from the transport sector in developed countries, in developing countries, 50% of these pollutants come from transportation. Based on data from the World Health Organization, the same World Bank (2002) report concludes that local air pollution from transport contributes to the premature deaths of 500,000 to one million people and costs up to two percent of the gross domestic product per year in developing countries. Though pollution from transportation comes from a variety of sources, including air and freight travel, the percentage from automobiles is currently the most serious concern. Figure 2 shows that light duty vehicles, which include privately owned automobiles, account for 10% of global carbon emissions (compared to 14% for all other transportation). Canada and Mexico (the location of my case study) account for seven percent of the total global emissions for light duty vehicles.

Figure 2: Global carbon emissions by sector and region for light duty vehicles

The combustion of fossil fuels by automobiles produces a range of emissions, including volatile organic compounds, nitrogen oxides, carbon monoxide, carbon dioxide, and particulate matter. These substances contribute to ground level ozone, acid rain, poor
water quality, global warming, and health problems. The Environmental Protection Agency (EPA) Office of Mobile Sources (1994) states that “in numerous cities across the U.S., the personal automobile is the single greatest polluter, as emissions from millions of vehicles on the road add up. Driving a private car is probably a typical citizen’s most ‘polluting’ daily activity” (p. 1). The relevancy of this statistic extends beyond the U.S. as the number of automobiles per 1000 people (motorization rate) grows in developing countries.

Motorization rates in developing countries are rising as automobile mobility is prioritized in development. The fact that car ownership is often viewed as a symbol of social status among growing middle classes exacerbates this problem. Figure 3 shows predicted increases in motorization rates across the world. Note that Mexico faces a large increase in its motorization rates, which the U.S. Department of Energy (U.S. DOE) (1999) predicts will more than double by 2020.

Figure 3: Motorization levels for selected countries, 1996 and projected for 2020

Source: U.S. DOE (1999, p. 14)

Prioritization of the automobile can also negatively affect the livability of a place. The growing number of cars in the developing world requires the dedication of increasing amounts of space in cities to roads. This process often occurs at the expense of other more human friendly (rather than car friendly) uses, such as parks and recreational areas. Wide, high capacity roads also can create physical and psychological boundaries dividing social networks. It has been argued that designing urban places catering to the automobile in developed countries has led to the physical and social isolation of city inhabitants (for example Kunstler, 1993).
Urban mobility based on a form of transportation as expensive as the private automobile presents equity concerns regarding access to societal resources. Private automobiles increase mobility only for those who can afford to purchase them. The infrastructure to support the use of private automobiles is very costly to construct and can contribute to a transportation system that is detrimental to access by other forms of transportation. This is easily seen in the development of large “box stores” at the peripheries of cities where there is not enough density to be well-served by public transit. Access to these areas is usually provided by highways or major roads that accommodate heavy vehicle traffic but are not navigable by cyclists and pedestrians.

This prioritization of the automobile at the expense of other modes is referred to by the World Bank (2002) as a “historic vicious policy circle that has biased urban transport policy unduly in favor of sacrificing the interests of pedestrians and cyclists to those of motor vehicle users” (p. 125). This sacrifice results in the increasing unattractiveness of non-motorized transport despite the benefit of its benign environmental impacts and provision of flexible, affordable mobility for shorter distances. Due to the disproportionate effect on poorer populations, there are even more serious ramifications to this process in the developing world, according to The World Bank Group (2002):

[The sacrifice of interests of pedestrians and cyclists to those of motor vehicle users] is unacceptable, because it stems from a failure to recognize some of the external effects of motorized transport that distort individual choice against [non-motorized transport], and hence militates particularly against the poor who do not have the means to use even motorized public transport. (p. 125)
Environmentally friendly automobile technology is often pursued as a solution to environmental problems in transport that avoids disrupting mobility trends of increasing motorization. Improved fuel technology, for example, reduces emissions and use of non-renewable resources per vehicle. It has been argued, however, that even with plausible vehicle technological advancements in the U.S., transportation will continue to have an increasingly negative impact on the environment because travel growth will offset the benefits of those advancements (Ewing et al., 2007; Heywood et al., 2003).

Achieving sustainable transportation also requires the consideration of more than the environmental impact of emissions. Although technological advances can help reduce emissions for each individual car, they do not, for example, address the equity concerns of a private automobile-based mobility system or the livability challenges presented by ever expanding, large-scale road infrastructure. Other efforts, such as promoting alternative modes, pricing, and smart growth initiatives can address a wider range of issues to do with sustainability (see Table 1). Even these efforts, however, can involve a variety of additional social and economic impacts that will have to be considered in the pursuit of solutions that address all of the above problems.

Table 1: Contribution of various solutions to sustainability goals

<table>
<thead>
<tr>
<th>Impacts</th>
<th>Efficient Vehicles and Alt. Fuels</th>
<th>Alternative Modes</th>
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<td>Energy and emissions reductions</td>
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<td>Increased safety</td>
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<td>Improved mobility for non-drivers</td>
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<td>Increased public fitness and health</td>
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<td>More efficient development</td>
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Source: Recreated from Litman (2008, p. 7)

In summary, while the automobile improves mobility, it also contributes to environmental degradation; inequity inherent in a system of mobility biased towards expensive, private vehicles; and the ‘unlivable’ urban form resulting from such a bias. The pursuit of sustainable transportation aims to solve the above problems, because it addresses the social, environmental, and economic consequences of transportation behavior. An approach to sustainable transportation would have to be comprehensive, including the promotion of a variety of alternative modes to create a healthier and more livable environment in an economically feasible way. In addition, it should be sustainable for future generations. The developing context, where motorization rates are often rapidly increasing but have not yet reached the level of developed countries, offers an interesting opportunity to explore the promotion of alternative modes before travel behavior and urban form become more permanently oriented towards motorization.
Cycling as a Solution

Cycling is only one part of a sustainable transportation solution, but I use it in my thesis as a way to think about behavioral change and the sustainable transportation problem. In particular, cycling is a relevant way of addressing transportation challenges in developing countries because of its flexibility, speed, affordability, and benefits for the environment, personal health, and livability of an urban area. According to the Federal Highway Administration (FHWA) (1993):

[Benefits of cycling range] from individual health and thrift to community-building and personal empowerment. The environmental benefits are numerous as well... Bicycling and walking conserve roadway and residential space; avert the need to build, service, and dispose of autos; and spare users of public space the noise, speed, and intimidation that often characterize motor vehicle use, particularly in urban areas. (p. 1)

While I will describe these benefits in greater detail in the three typical categories of sustainability (environmental, economic, and social/equity), it is important to emphasize that the promotion of cycling may not be an appropriate solution to transportation problems in every context. There may always be challenges to cycling that are difficult or impossible to address, such as climate and topography. Cycling is also not necessarily a feasible solution for those with physical limitations. Increased bicycle use comes with its own set of concerns. For example, particularly in a place where there is little experience in dealing with cyclists, more cycling can lead to safety issues.

These shortcomings, however, can be address through dedicated efforts. It is important to recognize that safety problems generally increase with the number of cyclists, but there are other benefits that counteract the risk (for example, see Jensen, 2008). Enforcement of traffic rules for cyclists and other road users, proper signalization, and other infrastructure can lower the number of accidents. In terms of the equity concern for the disabled, if more people cycle as a mode of transportation, infrastructure can be freed up for efficient motorized transport of those who have limited physical mobility. Finally, the barriers of climate and topography are still a subjective impression of how feasible it is to ride a bicycle, as is reflected by high cycling mode shares in places with poor climate or topography, such as Copenhagen, which is not known for its friendly climate.

Despite these shortcomings, the benefits of cycling described below make promoting bicycle use a worthwhile effort in many places that are pursuing sustainable transportation goals. Cycling can serve as an important component in a comprehensive approach to creating more sustainable transportation behavior through the improvement of a variety of alternative modes to the automobile. The following is an attempt to establish the benefits of cycling, without suggesting that it should be forced on places that have not decided to prioritize it as a form of sustainable transportation. It may be particularly difficult to promote cycling in a place where there is little foundation for cycling. The objective to increase cycling as a mode share will already likely have to exist, and then the problems associated with cycling can be addressed.
Environmental Benefits

Vehicle emissions are reduced when a choice is made to carry out a trip by a non-polluting mode such as cycling instead of by car. Cycling is a zero emission mode of transportation, avoiding the many externalities of the automobile already mentioned. Bicycle trips tend to replace shorter automobile trips, when emissions occur at a higher rate because of cold engines (Ewing et al., 2007; FHWA, 1993).

Some efforts have been made to quantify the reduction in emissions due to cycling. In an interview in the *It All Adds Up to Cleaner Air* newsletter, Patrick McCormick argued that if every other week the population of the U.S. made an average work or shopping trip by bicycle, the use of one billion gallons of gasoline and the accompanying environmental impact would be avoided (FHWA, 2004). In Canada, a study by Campbell and Wittgens (2004) estimated that a 4.8% bicycle commute mode share is equivalent to a reduction of about 1.9 million tons of CO₂, compared to the situation if there were no bicycle trips. This calculation assumes bicycle trips replace automobile trips of 3.2 kilometers, the distance of the average bicycle trip in Canada. Models estimating the impacts of cycling can get very complex, but as long as bicycle trips are being attracted from automobile trips, there are definitive environmental benefits.

Promoting cycling can have a much wider impact on environmental sustainability than emissions reductions from mode shifts. If the whole lifecycle is considered, emissions and resources that are associated with the manufacturing of bicycles should be far less than those associated with automobile manufacturing, which requires more resources per auto owner, particularly if the owner drives alone. Supporting utilitarian cycling can also go hand in hand with designing a city to offer more destinations at shorter distances, lowering vehicle kilometers traveled (VKT) by those who continue to drive a car.

Economic Benefits

Automobiles provide personal mobility over long distances, but the cost of such mobility cannot be ignored. Economic benefits of cycling have been shown to extend beyond the simple affordability of bicycles, which may allow those with limited resources to travel farther distances more quickly than on foot. For example, the Canadian study by Campbell and Wittgens above (2004) offers a conservative estimate of economic benefits of ‘active’ (cycling and walking) transportation because of reduced congestion, infrastructure construction and maintenance costs, road accidents, and user costs. According to this study, the total economic benefit of a 15.2% mode share for active transportation commuting trips (including a 4.8% bicycle mode share) amounts to Canadian $3.6 billion per year.

As an example, cycling has been shown to decrease congestion, thereby decreasing the costs associated with it (fuel consumption, lost time, etc.). Cairns et al. (2002) performed a study that showed that promoting other modes of transportation can help combat congestion by lowering the number of cars on the road. They examined over 70 case
studies where road space was reduced and given to other modes. They came to the following conclusions (p. 14):

a) Traffic congestion is usually far less serious than predicted;
b) Overall traffic levels can reduce significantly; and
c) People react to change in road conditions in more complex ways than traffic models account for.

In this study, Cairns et al. (2002) considered the idea that traffic may have simply diverted to other areas. They tried to account for this and still came to the conclusion that traffic was not simply relocated in these case studies. The third conclusion is at least a partial explanation for this phenomenon, which include both short and long-term reactions, which may include changing a journey mode, route, destination, or even the location that a person lives in relation to the desired destination. The road capacity changes are only one factor in these choices, but still relevant when considering long-term decisions regarding location and lifestyle.

Considering the potential savings and the negative externalities of automobiles, cycling can be considered a financially feasible, and even preferable, solution to cope with transportation challenges. Based on the various benefits, previous research has shown that investment in bicycle facilities can be justified on economic grounds (defined as return on capital investment), even in an area of low cycle use and where the analysis is restricted to those who currently cycle, due to the high value placed on increased safety (Hopkinson & Wardman, 1996).

Social/Equity Benefits
According to Pucher and Dijkstra (2003), cycling is an extraordinarily valuable form of cardiovascular exercise that improves both physical and mental health. The benefit of fitness is particularly relevant in a world with growing weight problems. According to the World Health Organization (WHO) (2006), in 2005, 1.6 billion adults globally were overweight and over 400 million were obese. The WHO predicts that by 2015, 2.3 billion adults will be overweight and more than 700 million will be obese. Once considered a problem of developed countries, the WHO finds that they are on the rise in developing urban areas. There are negative health impacts that can accompany increased fitness, such as inhalation of car exhaust and personal injury from accidents, but both of these are concerns for all transportation modes and policy and infrastructure changes can mitigate their effect. The benefit of cycling on mental health comes from both improved physical health and an increased engagement in the environment (if that environment is pleasant).

Promoting cycling can be a method of increasing livability in a city. Though cyclists often use the same road infrastructure as cars, the impact of which are mentioned earlier in this section, the amount of road space required for cyclists is much less than for automobiles. On that same infrastructure, drivers are isolated in their vehicles, while cyclists, by nature of being exposed to external conditions, are forced to integrate with and pay more attention to their surroundings. These characteristics are amenable to the
development of livable streets. As Appleyard (1981) argues, “there are inherent values in encouraging people and families who live in propinquity to work out their relationships without having them suppressed by the presence of passing strangers in motorized vehicles…” (p. 10).

Equity-related benefits are also part of this category. If cycling is viable, it can provide an affordable way to gain access to societal resources for lower-income people. This benefit, however, depends on a city design that does not hinder access for modes other than automobiles. If this design does enable effective cycling, it should not be viewed as an inferior form of transportation because of its affordability. Cycling enables a person to transport him/herself significant distances quickly, with the flexibility of door-to-door travel. Campbell and Wittgens (2004) found that for trips of less than 10 kilometers in downtown areas, cycling can be the fastest option. A World Bank report (2002) cites a 1995 survey of five cities in the developing world in which the majority of respondents who used bicycles preferred them as a form of transportation because of their affordability, flexibility in routing, speed, and reliability.

This is not an exhaustive list of the benefits of promoting cycling, particularly in developing cities, but it is enough to justify a more detailed look into how developing cities can incorporate cycling into their transportation planning processes and tools.

**Challenges in Eliciting Behavioral Change through Policy**

The prior section established the benefits of cycling in reducing automobile trips with the result of achieving more sustainable and livable cities. Given these benefits, it is not surprising that medium-sized, developing cities are including cycling in their transportation plans. There are significant barriers, however, in promoting cycling as a form of sustainable transportation in this context. Much of the challenge involves effectively utilizing policy processes and tools to elicit a change in transportation behavior towards more sustainable modes. In developing countries experiencing rapid change, planning processes and the accompanying tools are often imported and applied in a context that they were not designed to be used. These processes and tools, therefore, have shortcomings in accounting for the relevant factors to elicit behavioral change, including the social and cultural barriers to bicycle use.

The bias of much of the developed world towards prioritizing automobiles can be imported and applied to places with growing automobile use through the processes and tools described in more detail in Chapter 2 and Chapter 3. This bias, which becomes embedded in the processes and tools used, affects the definition of transportation problems and the perceived relevant solutions. This is a particularly unfortunate circumstance in the developing context, where the changing physical, political, and social characteristics might allow more flexibility in approaching growing mobility demand with creative transportation solutions. There has to be some impetus that originates in the developing place to pursue more sustainable transportation practices, however, before change can occur.
Even if cities decide to plan for more sustainable forms of transportation, the inadequacies of the existing tools and processes might result in ineffective implementation. Travel demand can be pushed towards more benign modes, such as cycling, through policies and investments in infrastructure that make these modes more efficient and affordable. The case justifying the investment of resources in these policies and infrastructure is difficult to make when the tools used to justify investments are designed for the consideration of traditional engineering solutions at a scale that favors motorized modes. Even if the tools are effectively implemented to consider all modes, including non-motorized modes such as cycling, solutions resulting from the use of these tools may still be insufficient to elicit the desired behavioral response, such as a large shift towards non-motorized modes.

Given these challenges, solutions that come from the use of common planning processes and tools (particularly infrastructure and other engineering-focused solutions) can prove to be ineffective in promoting an alternative form of transportation as a way to counter unsustainable trends. Button and Nijkamp (1997) call this shortcoming a “gap” between the types of solutions resulting from one approach and what is truly needed to solve certain problems: “Efforts in the past that have largely relied on engineering approaches to confront conflicts between social and environmental sustainability conflicts [sic] have failed, but nothing has yet emerged to fill the gap” (p. 217). Related to this problem is another gap between transportation modeling and political decision making, the subject of a 1998 conference in California (see Dahms et al., 1998). These gaps, which I attempt to address, make it challenging to develop trend altering solutions to comprehensive sustainability problems.

Eliciting a change in behavior toward cycling as a form of sustainable transportation will require a new combination of planning tools and processes that can produce solutions that fill this ‘gap’. This will require the reconciliation of planning tools, such as forecasting, and the application of new processes, such as participatory visioning, given the specific context of attitudes and perceptions toward cycling. I explore that reconciliation in the following chapters, making recommendations to improve both planning processes and tools to best meet the needs of promoting cycling as a form of sustainable transportation.

**Research Question and Case Study**

In this thesis, I set out to answer the following question:

> How can planning processes and forecasting tools be adapted and reconciled to most effectively elicit a change in behavior towards cycling to achieve sustainable transportation goals in a medium-sized, developing city?

My hypothesis is that the current tools and techniques employed in the medium-sized, developing city context can be modified to more effectively elicit change in behavior towards cycling as a mode of sustainable transportation, even in places where there are almost no existing cycling trips. Because of the complexity of achieving behavioral change and sustainable transportation, this modification must take place in an integrative fashion and with great attention to the details needed to more effectively promote cycling.
Although my approach could be applied to other modes, I use cycling in my thesis as a lens through which to consider sustainable transportation and behavioral change.

To test my hypothesis, I perform a literature review and utilize a case study approach. I first explore how to more effectively promote cycling as a form of sustainable transportation through the behavior-policy interaction as described by Geenhuizen et al. (2002). My research examines the effect of various policies on bicycle use, the possibilities to induce behavioral change to support sustainable transportation goals, the role of planning tools in decision making, and the application of planning tools to cycling. I then use Chihuahua, Mexico as a case study where there was already a goal to promote cycling within a larger sustainable transportation plan. I develop a methodology of adapting and integrating planning tools and processes to better achieve sustainable transportation goals. The primary contribution of my thesis is the recommendation of a three-step approach that can serve as the foundation for discovering the most appropriate steps to promote cycling (and even other modes) in medium-sized, developing cities such as Chihuahua. The three steps include the following:

1. Utilize surveys, focus groups, and interviews to analyze existing attitudes and perceptions leading to a wide range of policy and infrastructure approaches to promote cycling.
2. Augment the existing cycling planning process with visioning and goal setting workshops for stakeholders.
3. Review the wide range of the technical tools available and their ability to complement the first two steps with the end goal of promoting cycling, resulting in short-term and long-term recommendations to forecast demand with consideration of resource restrictions.

I made two trips to Chihuahua, Mexico. In the summer of 2007, I spent eight weeks working with Instituto Municipal de Planeación (IMPLAN), Chihuahua’s municipal planning agency, to assess the context and make recommendations to improve the proposed cycling plan. I also spent two weeks in January of 2008 carrying out a visioning and goal setting exercise. I performed the review of technical tools and considered their application to Chihuahua while in Cambridge, Massachusetts, using information obtained from IMPLAN during the two trips.

The single case study approach has its shortcomings, including limited applicability of the case study to a wider context. Despite this limitation, I hope that the approach I consider can be explored and replicated to some degree in other medium-sized, developing cities. The single case study approach was useful because it permitted an in-depth analysis through field work that would not have been possible if I had selected a larger number of examples. The use of field work to get a better sense for the most appropriate approach for my case study offered a valuable resource for IMPLAN.

The constricted timeframe meant that I could only begin to explore the application of my recommended approach. As a result, I only partially answer my research question. I am unable to test the effectiveness of my suggested approach in the long-term. Additional
work would have to be done to understand the outcomes of my efforts in the extent that they are applied in Chihuahua, as well as their success in being applied to other cities. In the meantime, however, this research provides a first step in the critical rethinking of the role of planning processes and tools in promoting sustainable transportation in medium-sized, developing city contexts.
Chapter 2: Literature Review/Methodology

Introduction

In this chapter, I first discuss social change related to achieving sustainable transportation and establish the criteria necessary to bring about this change. Next, I explain the behavior-policy interface described by (2002) and explore the role of planning processes and tools and their relationship to decision making. I then consider the specific challenge of eliciting behavioral change towards cycling as a form of transportation. In the last section, I outline a methodology to bring about this change through a strategic effort to more effectively utilize planning processes and tools to determine the ways to induce a shift in behavior that results in more cycling as a form of sustainable transportation. This three-part methodology includes gaining a better understanding of attitudes and perceptions towards cycling, the adjustment of the planning process to better establish and achieve sustainable transportation goals, and the strategic use of forecasting tools to address the challenges of forecasting cycling demand. I propose this methodology in recognition that the very act of using certain processes and tools can contribute to this change. Finally, better processes and tools can contribute to the evaluation of social change through predetermined indicators, though I do not explore this in great detail.

Social Change and Sustainable Transportation

It can be very difficult to achieve social change. As Ewing et al. (2007) argue, social revolutions are slower to come than technical revolutions. This slow pace is probably largely due to the fact that it is complex and difficult to actively pursue social change leading to different transportation behavior. As Glenn Lyons and John Urry (2006) explain, “To change behaviour [sic] requires an understanding of behaviour [sic] and an understanding of why we travel” (p. 2).

An understanding of behavior and why we travel can only come from consideration of a wide range of social and cultural factors beyond those generally considered relevant for technical and infrastructure solutions to transportation problems. For example, the act of transportation itself is not only a utilitarian endeavor; it also provides social functions (socializing, education, civic services) and satisfies social-psychological desires (a sense of freedom in mobility) (Geenhuizen et al., 2002). Button and Nijkamp (1997) recommend that addressing all three legs of the sustainability triangle (economics, environment, and social factors) in transport will require research that includes a “clear focus on inter alia social and cultural values, changes in industrial organization, demographic change, shifts in household patterns and behaviour [sic], and gender roles” (p. 217). Ultimately, while transportation both affects and is affected by social and cultural factors (Lyons & Urry, 2006), the outcome of changes in these factors on transportation behavior is difficult to predict.

In one direction, transportation can shape social and cultural values. Transportation supply can cause people to favor certain modes of transportation. For example, if policy
favors certain modes of transportation over others, society may become biased towards preferring that mode of transportation. While this has largely resulted in reliance on the automobile in the U.S. and other countries, an agency can also establish priorities towards a sustainable form of transportation. If transportation supply is designed to be more sustainable, social change may occur to value sustainable forms of transportation.

In the other direction, existing social and cultural factors can lead to biases in transportation solutions. Button and Nijkamp (1997) argue that “transport supply...is regulated by political interests and market pressures both of which reflect changes in social attitudes, structures and priorities” (p. 215). Once again, this interaction can be positive in terms of sustainability; if general attitudes shift towards favoring more sustainable forms of transportation, transportation supply can change to reflect those values. For example, an increased number of advocacy groups focusing on non-motorized transportation can pressure the public sector to provide for those forms of transportation.

Social and cultural factors will vary from place to place, challenging the usefulness of one-size-fits-all approaches to transportation problems. Particularly in the search for sustainable transportation, ignorance of social and cultural factors can defeat traditional solutions, such as infrastructure improvements, in terms of inducing a change in behavior. Embracing solutions that emphasize improved mobility through efficient throughput without consideration of these social and cultural issues is likely to have shortcomings in producing desired results. In order to approach this problem, it is helpful to establish guidelines that detail how to elicit this change.

Gatersleben and Uzzell (2002) provide four criteria to elicit behavioral change towards a social good like sustainable transport, which I have rephrased below:

- Clearly define the social good, including an understanding of the costs and benefits associated with achieving it.
- Ensure that people are aware of the problem (the more serious the problem the more aware they usually are).
- Encourage a sense of personal responsibility for the effects of transportation behavior, causing people to take ownership over social and environmental problems.
- Promote conditions for self-efficacy (the sense that a change in one's own behavior can affect the greater social good). This is largely dependent on a sense of trust that others will make similar choices.

Planners, as a part of the decision making process, play a critical role in eliciting a change in behavior towards a social good. According to Lyons and Urry (2006), “Governance plays a significant part in determining whether and how society aspirations and society itself evolves” (p. 11). However, planners and other decision makers are sometimes faced with conflicting goals or definitions of social good. When trying to achieve a comprehensive goal such as sustainability, which requires cooperation across multiple sectors, decision making can become very complex. Therefore, once these general
criteria are established, the next step is to examine of the ability of the existing planning processes and tools to meet these criteria.

The Behavior-Policy Interface

A planner’s influence on behavior stems from the ability to utilize appropriate planning processes and tools to yield effective policies. This realm can be thought of as the behavior-policy interface, as discussed in Geenhuizen et al. (2002). They introduce a research triangle for social change and sustainable transport (SCAST) that illustrates the connection between three major categories that are relevant in eliciting social change. They include behavior, technology, and policy; the interaction space between them is highlighted to emphasize a need for integrated efforts in order to achieve sustainable transportation.

Figure 5: Social Change and Sustainable Transport Research Triangle

The behavior-policy interface is where non-technical solutions arise to make travel demand more sustainable through the increased utilization of alternative modes and more sustainable use of modes that have negative social, environmental, and economic impacts. If technology is not enough to make our society sustainable, we must focus intently on the behavior-policy interface to realistically approach sustainable transportation practices.

Decision Making Process and Tools in the Behavior-Policy Interface

To gain insight on how policy affects behavior, this section examines the historical context of the current planning processes and supporting tools, along with concurrent transportation developments. The most widespread transportation planning approach is
grounded in the belief that decision making can be a science. Martin Wachs (1985) provides a history of planning, beginning with Woodrow Wilson’s concept that a more technically inclined group could support leaders in navigating the complexity of public policy by performing policy analysis and implementation. This concept led to the formal establishment of the rational decision making process in the 1960s in the U.S. According to Meyer and Miller (2001), in the formalized rational decision making process, "the adoption of transportation programs and projects would be determined through a sequence of choices arrived at in a rational manner with significant technical assistance from systems analysis, operations research, and computer models" (p. 52). This ‘rational manner’ included understanding the context, establishing objectives, identifying and evaluating all possible alternatives, and then selecting an alternative that maximizes benefits based on set goals (Meyer & Miller, 2001).

The emergence of rational decision making as the dominant process for transportation planning necessitated tools that provided an ‘objective’ assessment of alternatives. Wachs (1985) points out that this emergence paralleled the widespread success of the automobile, and as a result, much of the early efforts to rationalize decision making were applied to transportation policy and projects to provide infrastructure for the automobile. This era gave birth to travel demand forecasting models, which have become a tool of choice to inform decisions regarding transportation policies and infrastructure. According to a report by the Transportation Research Board (TRB) (2007), this tool fits the rational decision making process well: “Metropolitan travel forecasting models that produce reliable and broadly accepted forecasts allow elected officials to weigh the competing needs of stakeholders and make informed decisions about optimal investments of public funds” (p. 11).

Travel demand forecasting models is described by Katz (2001) as an “attempt to simulate systems by identifying a set of relationships between a limited set of variables on which the modeller [sic] has some data” (p. 2). Modelers use existing or newly gathered data to attempt to predict changes in travel demand at various scales in response to selected changes, either in infrastructure or policy, so that those proposed changes can be evaluated. As long as the models used to develop forecasts incorporate reasonable behavioral characteristics, short-term impacts can be estimated somewhat accurately. There is more debate, however, around the effectiveness of long-term forecasts because of uncertainty in the future (Bhat & Lawton, 2000; Katz, 2001). In particular, social and cultural factors become more relevant in the long-term as people adjust their behavior to cope with changes in transportation policy and infrastructure.

Although these travel demand forecasting tools are often exported from developed to developing countries, it can be difficult to apply them in the uncertain conditions of the developing world. As Genevieve Giuliano (1998) argues, “Good predictions… require a relatively stable world absent of large exogenous shocks [such as economic recessions, changing fuel prices] and without great changes in the behavioral relationships on which models are built” (p. 5). Developing nations are likely to experience just these exogenous shocks, accompanied by social and demographic changes that affect transportation
behavior, presenting a difficult environment for modeling. Harry Dimitriou (1990c) claims that one of the deficiencies in urban transport planning in developing countries is the assumption that "variables affecting travel demand do not experience unexpected changes - [which is] questionable even in medium term planning where unexpected changes and robust circumstances in the Third World can jeopardize forecasts for ten years hence..." (p. 171). Therefore, while technical tools are important for decision making, it is even more important to take into account their shortcomings in the developing world.

The Lack of Rationality in Decision Making and its Implications

Despite the reliance on rationality in planning processes and tools, decision making is often not a rational process. Instead, it can be a negotiation of tradeoffs between resource constraints, various interests, and other factors. Meyer and Miller (2001) summarize various critiques of the rational process in transportation planning by concluding that "the planning of transportation systems is as much a political process as it is a technical one" (p. 58).

A politician or other decision maker does not have to follow a technical planner's recommendations. Political will can trump well-reasoned proposals based on rigorous data analysis, making the outcomes of modeling irrelevant in certain circumstances. Lawrence Dahms (1998) explores this disassociation between analysis and policy making, and determines that there is a gap that makes it difficult to effectively incorporate modeling in the decision making process. He claims that there are three causes of this gap:

1. The limitations of models.
2. A mismatch between recommendations based on the analysis and what is politically acceptable.
3. A mismatch between the locations of decision making and analysis.

Models do not always offer a rational counterpoint to irrational processes; they themselves can be a part of the political nature of decision making. They are designed by people who have a particular approach to defining, understanding, and solving problems, a bias that is shaped by the political process. According to Wachs (1998), "Models... symbolize paradigms and as such take on some of the trappings of ritual, rite and cultural icon" (p. 3). They are just as intrinsically linked to social and cultural factors as transportation behavior.

Models, no matter what they are designed to do, can be co-opted by politicians to conform to their agenda. As Wachs (1998) has argued, decision makers often face extreme competition for funds for projects, and try to use modeling to support favored projects, regardless of the results. It can be easier to co-opt the results of models when they are calculated and communicated in a way that is obtuse. Wachs (2001) summarizes this dilemma: "Planners and policymakers know that forecasts are politically influential and that their accuracy is difficult or impossible to prove. They are also technically complex and difficult for the public and elected officials to understand" (p. 370).
Models, because they are designed and used by people, are vulnerable to being manipulated by the people who use them to produce desired results.

On the other hand, the influence of political will over solutions based on analytical results may be appealing at times, because modeling cannot tell us everything we need to know about how transportation planning should take place. Because of uncertainty in the future, faulty design, and the shortcomings of modelers, models are never entirely accurate. Despite advances in modeling, analyses show us that the accuracy of forecasting is not necessarily improving (Flyvbjerg et al., 2006). As a way to improve accuracy, agencies in the U.S. have begun to be held accountable for the quality of their modeling techniques (TRB, 2007).

Political will can also help counter the biases inherent in modeling. As will be argued further in Chapter 3, modeling as it is used today favors certain modes and is biased towards certain types of transportation solutions. These biases might encourage less creative thinking by decision makers and discourage transportation planning decisions that could improve the livability of a place and access to resources via a more balanced and equitable transportation system.

The design of current models can be particularly inadequate as a means to inform political decisions involving complex social goals, because they fall short in taking into account the full range of concerns relevant to decision makers. Wachs (1985) points out the complexity of decision making that is not well-accounted for in modeling: “Institutions and planning processes also deal with ethical questions of right and wrong, with the distribution of costs and benefits among social groups, and with the restructuring of personal and social relations” (p. 522). The outcome, as Gilbert (2002) describes, is limited contribution to environmental goals, enlarging the gap in the ability of traditional approaches to achieve sustainability goals. “Current policies and measures – many based on forecasting – have not significantly reduced the overall environmental impacts of transport, even though such reductions have been the objective of the policies” (p. 64).

Because of these vulnerabilities, modeling is not, nor should it be, the sole basis for decision making, whether the process is considered rational or not. According to Wachs (1985), it has long been judged that “adherence to the rational comprehensive model of transportation decisionmaking is formal and ritualistic” (p. 523). Thus, a well-rounded approach to justifying transportation decisions must account for the bias and errors in modeling and its vulnerability to co-option for specific interests. Modeling is a very useful tool regardless of whether the decision making process is rational, which would suggest why models are often co-opted for certain interests.

Since the results of modeling can be so easily ignored or co-opted, organizations should be critical of the outputs of models, and recognize the value laden nature of using them to define and propose solution to transportation problems. In recognition of modeling’s usefulness in exploring and supporting certain efforts to elicit behavioral change in a complex transportation system, the challenges in using modeling tools to support
planning practices for sustainable transportation, and more specifically, cycling, are laid
out in greater detail in Chapter 3, with a primary focus on forecasting. Engaging in a
critical analysis of modeling techniques enables planners in places like Chihuahua to be
more aware of shortcomings and make better use of analytical approaches.

Social Change and Cycling
Combating increasing motorization rates through the promotion of alternative forms of
transportation, such as cycling, will take more effort than the provision of infrastructure.
As a report to the FHWA (1999) states, “the decision to ride a bicycle involves a greater
conceptual leap than the decision to walk” (p. 11). This conceptual leap includes
overcoming various social and cultural barriers to cycling. For example, Pucher et al.
(1999) identify eight overall factors that affect the level of cycling in North America:
public attitude and cultural differences; public image; city size and density; cost of car
use and public transport; income; climate; danger; and cycling infrastructure. In order to
promote cycling, planners will have to think of solutions beyond the proposal of
infrastructure improvements.

The choice to cycle can be based on factors that can be viewed as subjective and
objective. According to Dill and Carr (2003), subjective factors include distance, traffic
safety, convenience, cost, valuation of time, valuation of exercise, physical condition,
family circumstances, habits, attitudes and values, and peer group acceptance. Objective
factors include climate, topography, presence of bicycle facilities and traffic conditions,
access and linkage, and transportation alternatives. Although Dill and Carr call these
factors objective, the importance of each may vary from person to person, similar to the
subjective factors. Numerous studies have explored the relevance and effect of bicycle
infrastructure as one of these ‘objective’ factors in bicycle use (Barnes et al., 2006; Dill
& Carr, 2003; Jensen, 2008; Nelson & Allen, 1997; Pucher et al., 1999; GEF, 2006). The
results of these studies are mixed.

Conclusions from these studies do seem to agree on the fact that existing bicycle users
will use new facilities when constructed, but the question is whether these facilities can
induce new users. Bike lanes and paths make cycling more attractive to those who do not
already cycle, but it is difficult to find a rigorous statistical study that suggests a direct
impact of infrastructure on cycling mode share. There is suspicion that the construction
of facilities might simply be the result of increased bicycle use drawing planners’
attention to the need for new facilities, and that use of these facilities might falsely
suggest an increase in cycling overall (Barnes et al., 2006; Pucher et al., 1999).

Some of these studies use case studies to estimate induced bicycle trips in response to
infrastructure or facility improvements in specific contexts. For example, the Global
Environmental Facility (GEF) performed before and after studies of cycle ways built in
Rio de Janeiro and Bogotá (2006). The GEF used these data to develop an estimate that
there would be 2,200 new bicycle trips per additional kilometer of bicycle lane.
However, this estimate is offered with the warning that this increase cannot be assumed
to result solely from the construction of bicycle lanes. To exemplify that the
infrastructure alone is not enough, the GEF describes the World Bank’s 1996 investment in 46 kilometers of bicycle infrastructure in Lima, Peru. This investment yielded no significant increase in cycling, which the GEF blames on the fact that “the project did not include a coherent strategy to overcome the cultural barriers inhibiting bicycle use” (2006, p. 16).

Jensen (2008) recently completed a before and after analysis in Copenhagen, Denmark to determine the safety implications of the construction of bicycle “tracks,” or two to 2.5-meter wide bicycle lanes. As a part of his analysis, Jensen looked at the change in traffic volumes and discovered that where bicycle tracks were constructed, there was a 20% increase in bicycle and moped traffic and 10% decrease in auto traffic. As a result, he recommends correcting for traffic volumes as an important part of his analysis, changing his results somewhat. This may appear to be a promising indication of a mode switch, and while Jensen agrees, he recognizes that “we do not know for sure whether these effects are a result of changes of route choice or transport mode choice or both” (2008, p. 13). In addition, this might not be a good case study for Chihuahua, since Copenhagen’s far higher bicycle commute mode share suggests that people might already be more likely to ride a bicycle.

Dill and Carr (2003) perform a statistical analysis of 33 to 35 (depending on the model) U.S. cities of 250,000 people or more to determine a relationship between bicycle infrastructure and percent of commuters that get to work by bicycle (see Table 2). Their results for Model 4, which excludes New York City, determine that each additional mile of on-street bicycle lanes per square mile is correlated with a one percent increase in commuting trips by bicycle. They recognize that it is not necessarily a cause-effect relationship, as the infrastructure could have been built in response to demand from existing cyclists. Dill and Carr’s results also show that the significance of other factors, leading them to conclude that:

...bicycle lanes and paths alone are not likely to increase bicycle commuting. Bike lanes and paths need to connect popular origins and destinations, greater efforts should be taken to educate commuters about bicycling as an option, and commuters need adequate and safe parking at work. (2003, p. 7)
Table 2: Regression analysis of factors affecting bicycle mode shares in 35 U.S. cities

<table>
<thead>
<tr>
<th>Model</th>
<th>Constant</th>
<th>Type 2 lanes per square mile</th>
<th>State spending per capita on bike/pedestrian</th>
<th>Vehicles per household</th>
<th>Days of rain</th>
<th>Adj-R²</th>
<th>F-statistic</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>1.971</td>
<td>0.892</td>
<td>0.771</td>
<td>-0.698</td>
<td>-0.005</td>
<td>0.192</td>
<td>2.964</td>
<td>34</td>
</tr>
<tr>
<td>(0.058)</td>
<td>(0.008)</td>
<td>(0.006)</td>
<td>(0.144)</td>
<td>(0.208)</td>
<td>(0.206)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 2</td>
<td>0.594</td>
<td>0.888</td>
<td>0.427</td>
<td>-0.008</td>
<td>-0.008</td>
<td>0.190</td>
<td>4.868</td>
<td>34</td>
</tr>
<tr>
<td>(0.006)</td>
<td>(0.006)</td>
<td>(0.007)</td>
<td>(0.020)</td>
<td>(0.020)</td>
<td>(0.020)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 3</td>
<td>0.761</td>
<td>0.861</td>
<td>0.328</td>
<td>-0.08</td>
<td>-0.005</td>
<td>0.178</td>
<td>8.368</td>
<td>35</td>
</tr>
<tr>
<td>(0.000)</td>
<td>(0.007)</td>
<td>(0.007)</td>
<td>(0.020)</td>
<td>(0.206)</td>
<td>(0.206)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 4</td>
<td>3.339</td>
<td>0.998</td>
<td>1.021</td>
<td>-1.520</td>
<td>-0.008</td>
<td>0.304</td>
<td>4.495</td>
<td>33</td>
</tr>
<tr>
<td>(0.005)</td>
<td>(0.002)</td>
<td>(0.047)</td>
<td>(0.020)</td>
<td>(0.020)</td>
<td>(0.020)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Dependent Variable: Percentage of workers commuting by bicycle
Beta-coefficient is shown in each cell. Level of significance is shown in parentheses.
Source: Dill & Carr (2003, p. 6)

The challenge in inducing behavioral change towards cycling as a form of sustainable transportation through infrastructure indicates that a much wider range of concerns, many of them social and cultural factors, must be taken into account in the planning processes and tools directed towards the promotion of cycling. Often, neither the objective nor subjective factors are adequately addressed in the way that planning processes and tools are currently used. This mismatch is exacerbated by the dearth of appropriate data to better analyze cycling. Komanoff et al. (1993) point out the inequity between attention to these factors in cycling versus other forms of transportation in the U.S., (though it is applicable to transportation planning in many locations, including developing contexts):

Human-powered modes of transportation - chiefly walking and bicycling - are chronically underreported and under-studied... Unlike driving, which is painstakingly measured and analyzed, or even public transit such as rail, buses, and ferries, whose ridership is diligently recorded, walking and bicycling have been ignored by most energy experts, economists, statisticians and transport planners (not to mention policy makers). (p. 9)

The purpose of my thesis is to explicitly address this lack of representation and establish a set of recommendations to adapt planning processes and tools to better serve the goal of promoting cycling as a form of sustainable transportation.

**Methodology**

In this thesis, I develop and demonstrate a methodology to fill the gap between engineering solutions and the efforts required to achieve sustainable transportation. To do so, I suggest the careful use of planning processes and tools to more effectively bring about appropriate behavioral change in the policy-behavior interaction space. This requires that the design of transportation solutions aimed at achieving sustainability goals be preceded by careful investigation into the barriers to change, which can then inform the selection of the most appropriate tools to use in a given context. After a general
analysis of processes and tools and their potential application to promoting cycling as a form of sustainable transportation, I recommend the following three-stage methodology (described in more detail below):

1. Analysis of attitudes and perceptions to determine the social and cultural barriers to cycling.
2. Visioning and goal setting leading to the determination of steps to promote cycling as a form of sustainable transportation.
3. Assessment and selection of the most appropriate forecasting tools to support this process.

**Stage 1: Attitudes and Perceptions**

As already stated, social and cultural factors are important in transportation choices (for example, see Button & Nijkamp, 1997). Particularly, in the search for sustainable transportation – that which is more environmentally friendly, economically feasible, and provides access to social resources – ignorance of these factors can undermine the ability of traditional solutions, such as infrastructure changes, to induce a change in behavior. On the individual level, social and cultural factors can be assessed in terms of the attitudes and perceptions held towards a specific mode of transportation, in this case, cycling. In fact, the FHWA (1999) considers attitudinal research most significant for cycling: “Insights from the public health and social marketing fields suggest that personal attitudes and beliefs interact strongly with environmental and policy variables to influence travel behavior and mode choice, particularly for bicycling” (section 4.2)

Attitudinal surveys provide a way to understand reactions to proposed policy and infrastructure changes. They can be used to rank preferences for various improvements and estimate the impact of those improvements in terms of induced demand (Porter et al., 1999). Attitudinal surveys, however, have shortcomings and cannot be the only method of predicting openness to cycling as a form of transportation. Preferences and attitudes expressed in surveys are not always reflected in actual behavior, as people tend to overstate their willingness to cycle (Dill & Carr, 2003; Porter et al., 1999). Surveys alone, then, can lead to incorrect estimation of demands for new facilities. Instead, a method that relies on statements to estimate behavior can be used as a precursor to other techniques including revealed preference surveys and the observation of behavioral response to policy and infrastructure. Attitudinal surveys that attempt to understand social and cultural reactions to bicycle use can give an initial impression of the perceived barriers, especially in a place where there is little bicycle use and little actual behavior related to cycling to observe.

In the Chihuahua case, I examine attitudes and perceptions through surveys, focus groups, and interviews to assess respondents’ opinions and perceptions of the challenges and benefits related to cycling as a form of transportation, of the people who for whom cycling is considered appropriate and viable, and of certain types of infrastructure. In general, I tried to understand the culturally- and socially-influenced attitudes towards cycling to determine the hindrances to promoting it. Chapter 5 describes the approach – which includes carrying out surveys of three targeted groups, two focus groups to explore
perceptions in greater depth, and interviews of policy makers and people involved in cycling work – in more detail. My analysis of these results and literature review of best practices regarding cycling led to a series of recommendations to improve IMPLAN’s cycling plan.¹

**Stage 2: Visioning and Goal Setting**

This stage addresses shortcomings in the planning process to better account for the complexity of decision making that leads to the realization of sustainable transportation goals. Planning processes can be particularly ineffective in addressing such complex goals if a clear agenda is not established transparently from the outset. The establishment of a clear agenda linked to sustainable transportation goals can help avoid the negative impact of hidden agendas, which have been argued to prevent the open consideration of a wide range of alternatives to discover the best approach to achieving those goals (Geenhuizen et al., 2002). Without an open debate of alternatives, it may be difficult to ensure that a plan to promote cycling will have the desired contribution towards sustainable transportation goals.

Even if the vague concept of sustainable transportation is established as an end goal, it is necessary to determine the details of that goal and how it can be reached. Dimitriou (1990b) explains that:

For transport planning goals not only formalize [sic] the direction(s) and purpose(s) toward which transport investments may be orientated, but also help to reveal more clearly over time (with the assistance of monitoring), the degree to which these investments are compatible with grass-root needs. (p. 79)

Without this level of critical thinking about the goals themselves, it may be difficult to determine the role of various modes in achieving them. In addition, it is difficult to perceive how sustainable transportation planning fits in with other policies. Predetermined goals help to understand the larger cooperation required to realize sustainable transportation goals.

Effective goal setting can be accomplished through the use of a visioning process. Jansen (2003) describes this process can be described in terms of backcasting, which involves:

1. Development of a long term vision followed by
2. Development of a short term approach resulting into
3. Implementation and realization of a research and development agenda.

(p. 243)

This method of establishing a cohesive vision of a desired future to determine the steps that must occur in the short-term can establish a sense of what it will realistically take in order to reach sustainability goals. Jansen (2003) describes the value of visioning and

¹ Some relevant points are summarized in Chapter 5, but the complete set of recommendations is included in a 2007 report that I submitted to the planning agency.
backcasting in producing creative solutions to complex issues, such as sustainable transportation:

The starting-point of path finding is not the present situation but a future orientation describing the situation in which the terms of reference in the fulfillment of 'a need' are met and major trends have been taken into account. This approach prevents loss of creativity resulting from being bound mentally in the possibilities of the present. (pp. 242-243)

Backcasting is recognized as an effective way to approach sustainable transportation planning because of the dramatic level of change that will be required to reach related goals. The reorientation of medium-sized, developing cities that are on a trajectory towards increasing automobile dependence will require a struggle against existing trends. Because of its ability to elicit creative solutions, backcasting is a preferable approach where such a departure from trends is required (Gilbert, 2002; Höjer & Mattsson, 2000).

Other techniques that think critically about the future can have similar results. According to Ewing et al. (2007) an analysis of various approaches demonstrates that scenario planning, for example, has led to more successful achievement of goals toward sustainable transportation. Unfortunately, the exploration of a variety of possible futures in scenario planning can require the investment of ample money and time, which may be limited in the developing context. If a full scenario planning process cannot be carried out, a simpler visioning and goal setting process can be used to backcast to suggested current steps.

Backcasting may in fact have benefits that can be distinguished from scenario planning as they have already been established in comparison to forecasting. Backcasting’s advantage over the way that scenario planning is typically carried out is that it implies calculations back to specific steps to take in the present. As Jaco Quist (2007) argues, “While most existing scenario and foresighting approaches focus on likely or possible futures, the major distinction with backcasting is its explicit normative nature, based on setting normative goals and constructing normative desirable futures” (p. 11). The newly established next steps can be compared with existing proposals that address sustainable transportation goals to determine whether adequate measures are being taken.

In Chihuahua, I carried out a simplified version of Jansen’s three steps. I focused on the first step as an experiment that would reveal the role the visioning process can play at the current stage of development of the master plan in Chihuahua. I attempted to include a wide range of stakeholders in the process to engage in a dialogue across different groups that have an interest in cycling. If time and resources do not allow for the level of depth in a backcasting or scenario planning process that might be recommended by Jansen and others, then the shorter process that I carried out is, hypothetically, useful to contribute to Gatersleben and Uzzell’s four elements of achieving social change, though I am not able to prove this through measured outcomes. This is accomplished through engaging major stakeholders in planning for cycling and raising awareness and support for cycling proposals, which could contribute to fostering positive activism towards cycling. At the
very least, it provided access for those that advocate for cycling to major government stakeholders through the participatory process.

I carried out the visioning process in the form of three workshops that included presentations with background information, justification for my work, information about Chihuahua and other case studies, and suggestions of approaches to promote cycling. These presentations were followed by brainstorming sessions to establish a vision of sustainability in Chihuahua in 2040, determine goals related to that vision, and then perform a qualitative version of backcasting to current steps that should occur to reach those goals. These workshops and the results are described in greater detail in Chapter 6.

**Stage 3: Forecasting**

The previous approach, which is oriented towards looking backwards from a desired future, can be contrasted with the approach of looking forward from the present, or forecasting. These approaches have different roles in decision making. “Policy development based on forecasting results in doing what is possible to avoid an unwanted future. Policy development based on backcasting results in doing what is necessary to achieve a wanted future” (Gilbert, 2002, p. 63). These different approaches to defining problems and shaping goals, however, can be complementary if planners utilize the strengths of both.

The strengths of backcasting have already been established, however, there are conditions for which forecasting can be a preferable technique, particularly where goal setting is controversial and incremental changes are preferred over dramatic changes. In these cases, forecasting is perceived as more grounded in reality since it is based on present conditions rather than a hypothetical future (Gilbert, 2002). Höjer and Mattsson (2000) argue that forecasting can be useful to identify when backcasting should occur. Quantitative models can help determine the impact of a variety of scenarios that can realize the established goals. Backcasting can be more effective, then, if the steps established to meet the desired future through this process are supported by forecasting to estimate the impact of those interventions based on current conditions. As Höjer and Mattson state (2000):

> If backcasting is to be more than just wishful thinking, it is important that the feasibility of the scenarios [to realize the goals established through backcasting] be analysed [sic] and that necessary measures and actions for the realisation [sic] of the scenarios be identified. During this process, models, or other tools that help quantify the consequences of different measures, are important instruments. (p. 630)

This interactive process can lead to effective goals, policies, and projects related to cycling. This is slightly different than the typical application of forecasting; rather than using forecasts to avoid an unwanted future, forecasting can be a way to predict travel demand in response to policy and infrastructure changes proposed through the backcasting process. This way, forecasting contributes to the achievement of a desired future. However, the forecasting component of this process should not be mistaken as an
objective analysis of the backcasting. While it is a useful tool, no method is entirely accurate, nor can all possible transportation outcomes be estimated for all modes. I propose using forecasting to support visioning processes to make recommendations resulting from this collaborative, future-oriented process more feasible and politically acceptable.

To better assess the type of forecasting tools appropriate for a medium-sized, developing city such as Chihuahua, I first offer a general critique of a variety of forecasting techniques and related methods in terms of their application to predicting bicycle trips in Chapter 3. I examine the four-step process in most detail due to its wide-spread use as the basis of regional travel demand forecasting models. I also compare the strengths and drawbacks of other forecasting techniques, as well as other methods that can support the forecasting process, such as determining level-of-service measures for bicycles.

In Chapter 7, I make and apply recommendations based on this review of forecasting techniques and related methods in the context of Chihuahua. While regional travel demand forecasts were created in Chihuahua from a model based on the four-step process, forecasts were not made for bicycle trips. To consider the adaptation of the existing model to incorporate bicycle trips, I evaluate the existing data and propose the gathering of new data. This is a long-term approach, however, and I make a three-phased set of recommendations that propose forecasting approaches in both the short-term and long-term. I illustrate the short-term approaches in my recommendations by applying a basic sketch planning method and a level-of-service measure. These are used as initial examples of how IMPLAN can consider carrying out the recommendations.

The assessment of modeling techniques is particularly relevant for IMPLAN at this time. Much of the sustainable urban mobility component of the master plan is based on the regional travel demand forecasting model created by consultants hired by IMPLAN. IMPLAN hopes to acquire a software package that will enable its employees to use and manipulate the model, but if it is used in a traditional sense, it may not contribute to visions of the future that include all modes (discussed in greater detail in Chapter 3). In order for the model to be a tool that contributes to the realization of effective goals established by backcasting, the way in which modeling is used in Chihuahua should be carefully analyzed. I attempt to address this need in the following chapters.

**Conclusions**

My proposed planning approach involves three steps that aim to integrate planning processes and tools based on an understanding of the context through attitude and preference analysis. I intend for this integration to be a more effective method to achieve changes in behavior at a scale necessary for social change towards using more sustainable forms of transportation.

Because this approach requires a detailed look at the variety of tools and their applicability to the cycling context, Chapter 3 contains a literature review of forecasting and other supporting methods. Chapter 4 provides details on the context of Chihuahua,
Chapters 5, 6, and 7 discuss the application of the three stages of the methodology to the Chihuahua case. The integration of these steps, lessons learned, and room for future research will be addressed in Chapter 8.
Chapter 3: The Role of Forecasting as a Tool in the Planning Process

Introduction

As already stated, regional travel demand forecasting models have become a tool of choice in rational transportation planning. They are perceived as the most advanced operational way of understanding travel needs in a complex transportation system at the regional scale. According to an article by Porter et al. (1999), "Regional travel models have the unique advantage of representing an integrated framework for predicting travel decisions, considering all trips and modal options, as well as personal and household characteristics, within the spatial structure of the surrounding area" (p. 100).

Although travel demand forecasting models are incredibly useful in this regard, and are used extensively to predict outcomes in transportation planning, their role as an objective measure of future transportation demand can be overestimated. Wachs (2001) explains that planners' faith in models' objectivity ignores the real role of models as tools that reflect our values:

> We assert that our forecasts, rather than being right because they incorporate appropriate values and goals, are appropriate and useful because they are the products of scientific or mathematical models that encapsulate empirical truths instead of our subjective ideals. (p. 369)

Models can never be entirely "right" in the sense of accurately predicting the future, because they are designed and used by individuals with biases who cannot see perfectly into the future. These biases and shortcomings become built into the models themselves. According to Beimborn et al. (1996), "All models are limited by the assumptions, factors, and alternatives that are explicitly included in the equations used by those models" (p. 3).

Therefore, the outputs of forecasting models are not purely objective; rather, they are subject to the context in which they are carried out. In this chapter, though it may often seem that I direct the critique at the models themselves, this is a critique of the way in which people design and use these tools. My underlying assumption is that models are useful and accurate tools if they are designed and used properly by people with perfect knowledge of the future. In addition, this critique is intended to help planners who import and apply models developed in other contexts to think critically about how to better adapt them to their own particular needs.

The inherent subjectivity of modeling does not necessarily diminish the value of models as tools in the planning process, as Wachs (2001) suggests. Their subjectivity can even be a strength, or if made explicit, less of a weakness. For this to be the case, models have to be transparent: the assumptions that a model is based on should be explicit and open to sensitivity analysis (Katz, 2001). If the assumptions are explicit, decision makers, if properly trained, may interpret and react to the results knowing the subjectivity inherent
in the model. In practice, however, the results of models are too easily considered objective predictions of the future.

Regional travel demand forecasting models, as they are currently designed and used, have strengths and weaknesses when used as a part of efforts to promote sustainable transportation. Regional travel demand forecasting models generally use the four-step process to assess the impact of infrastructure and policy changes on the transportation network, such as the construction of new roads, the raising or lowering of average speeds, shifts in mode shares, and other inputs. The impact of these changes is often thought of by modelers in terms of capacity problems. If solutions based on this capacity assessment reduce congestion, then they contribute to reduced emissions, because better traffic flow results in lower fuel consumption per kilometer (The World Bank Group, 2002). However, there is a risk that techniques employed solely to ease congestion and increase automobile flow can induce more automobile demand, result in more land covered in highways, and cause other behavioral changes that do not contribute to sustainability goals. In theory, this potential feedback should be accounted for in modeling, making it an appropriate tool to think about complex sustainability issues. Unfortunately, in practice, due to limitations in the models and usage of them, this often does not occur.

This shortcoming in design and usage does not exclude forecasting through models as an integral part of pursuing sustainability goals. Using modeling to assess a combination of solutions that reduces future congestion while implementing travel demand management policies to lower automobile use can contribute significantly to sustainable transportation goals. The subjective nature of modeling and the flexibility of the processes on which they are based allow for creative thinking in applying these tools to sustainable transportation planning.

There are additional challenges, however, when thinking specifically about using mainstream travel demand forecasting techniques to achieve goals related to non-motorized forms of transportation as part of sustainable transportation efforts. For example, modeling techniques are often poorly designed in terms of accounting for the social and cultural factors relevant to bicycle use. This can be largely due to our own ignorance of these factors and their importance in the entire planning process. As Wachs (1985) warned, “We know far less, however, and have made far less recent progress when it comes to explaining the social, economic and political meaning of planning and decision-making processes…” (p. 522).

Because of these challenges and the scale at which these forecasts operate, cycling trips are often not included in the models used to make decisions that affect the very infrastructure on which bicycles depend. There can be serious consequences to the omission of cycling trips in these modeling processes, such as the underestimation of cycling demand in combination with the overestimation of roadway requirements for automobiles (Beimborn et al., 1996). Due to the biases that are incorporated into modeling to particular modes of transportation, the models themselves can be self-
fulfilling, further promoting automobile use while discouraging cycling due to the dedication, or lack of dedication, of resources to each mode. Höjer and Mattsson (2000) describe this phenomenon, and how the fault lies not in the tool itself but how we use it: ... in spite of these well-known difficulties in making forecasts, a forecast in the public debate may very well be misapprehended as the truth and thus become self-fulfilling. In this way, there is a risk that forecasts have a conserving effect. They can easily strengthen a trend, and thus prevent alternative developments. However, different analytical tools can be used in different ways. It is not the tool per se, but rather, it is how a tool is used that determines how useful it will be in a particular analysis. (p. 631)

It is up to planners to design and use tools in a way that is more appropriate for sustainability, and in particular, cycling goals. There are various modeling methods that have been developed to be more directly applicable to cycling needs. They involve data specific to cycling and are applied at a smaller scale that is more appropriate for characteristics relevant to cycling trips. Unfortunately, creating new approaches to measure bicycle trips can have the result of separating debates in bicycle planning from automobile planning, even though their infrastructure can be the same, or overlapping. The different data and scales result in different outputs for cycling forecasts that might be incompatible with regional travel demand forecasting models. This disparity can introduce challenges to integrating planning for various modes, resulting in poor planning for sustainability.

Much research has been done regarding the shortcoming of modeling techniques to forecast travel demand. In this chapter I summarize the potential contribution of various forecasting techniques to the promotion of cycling as a form of sustainable transportation. First, the four-step process, which serves as a foundation for regional travel demand forecasting models, will be described generally and in terms of its application to bicycle trips. Second, a wider range of modeling techniques used to forecast transportation behavior, including those based on the four-step process, will be briefly summarized and assessed in terms of their usefulness for cycling-related planning goals. Additional techniques, including assessment of potential markets from which the demand can be forecasted and measurements of the quality and quantity of the supply of bicycle amenities and infrastructure ("level of service" tools), will be briefly discussed. These additional techniques, while not directly forecasting future cycling demand, contribute to the forecasting process. Specific recommendations on how to address the shortcoming of modeling travel forecasts in the context of promoting cycling in Chihuahua will be made in Chapter 7.

**What is Forecasting Travel Demand?**

A FHWA report authored by Moe et al. (1999) defines travel demand forecasting as a "prediction of changes in travel behavior and transportation conditions as a result of proposed transportation projects, policies, and future changes in socioeconomic and land use patterns" (1999, section 2.1). Forecasting is based on a theoretical model and
verified by empirical studies that determine how behavior changes in response to changes in relevant factors (Moe et al., 1999).

Forecasting, or modeling travel demand in the future, can serve many purposes for a transportation planner or planning agency. For example, forecasting can be used to help understand the city’s growth and how trends might affect transportation behavior. Forecasting can also be used to predict how changes in policy and infrastructure will change transportation behavior in the future. It can be used to identify important areas for infrastructure improvement, and justify or prioritize projects. This justification can be communicated to policymakers in terms of the benefits of certain proposed improvements versus the costs of that proposed change in terms of mode shifts, environmental impacts, and other measures relevant to a city or region’s goals.

Forecasting can be done at an aggregate (area wide) or disaggregate (individual) scale. Aggregate studies are usually easier to carry out and apply, but less effective at predicting behavioral change at an individual level (Moe et al., 1999). Tools to carry out forecasting tend to vary according to purpose, in the level resources required, and in the technical difficulty in modeling outcomes. Some of these variations in modeling techniques will be described later in this chapter.

Why Forecast Cycling Demand?

As already discussed in Chapter 2, the planning process often relies on the information provided by forecasting models to inform the rational decision making process regarding transportation policies and infrastructure. Unfortunately, the forecasting tools that support the decision making process are being used in a way that does not adequately accommodate bicycle trips, which tend to make up small mode shares and involve shorter trips. The end result is the omission of cycling from important conversations regarding the future of transportation systems. Although cyclists exist on the same network as automobiles, cycling trips are often excluded in the forecasting models that are used to justify changes to the very infrastructure on which bicycles depend. This is a chicken or egg question. Is the lack of serious consideration of cycling in planning tools such as forecasting a cause or an effect of the fact that it is often ignored by planners as a viable form of transportation? It is likely that the two factors are related and interactive. Therefore, the incorporation of cycling into existing forecasting techniques likely has significant benefits.

The primary benefit is increased legitimacy of cycling as a form of transportation. Forecasting models help to legitimize decisions by providing a technical analysis that supports proposals. Forecasting is used to evaluate alternative policy approaches, determine performance indicators, manage existing transportation networks, and enhance and prioritize network improvements, all of which would be beneficial to promoting cycling if the techniques can be adapted to incorporate cycling trips effectively (Katz, 2001). Requests for support for specific projects often have to be justified by numerical data “to demonstrate that all projects can reach measurable objectives” (Landis, 1996, p. 18). Decision makers are accustomed to seeing this justification in specific formats such
as regional travel demand forecasts. It can be difficult to justify cycling projects if they do not fit into this analytical process. The need to justify cycling projects in the same manner can spur the development of more sophisticated knowledge of factors that contribute to cycling, furthering a sense of legitimacy. Finally, this strategy of incorporating cycling can help planners better determine the role cycling can play in the larger transportation system.

There are valid concerns over the incorporation of cycling into mainstream forecasting techniques. As already stated, the choice to bicycle is influenced by a wide variety of factors (many of which are social and cultural) that are difficult to include in the models. The adjustment of forecasting and modeling techniques to effectively incorporate bicycle trips will require much energy and resources, and may detract from resources available to actively promote cycling through policies and infrastructure intervention. The historical prioritization of automobiles in transportation planning and the resulting environmental and social costs, many of which are outlined in Chapter 1, might alone justify the promotion of cycling and investment in cycling infrastructure without forecasting the results of these interventions. The forecasts, however, could still help determine what kinds of cycling intervention will be most effective.

There is no guarantee that the incorporation of cycling into regional travel demand forecasting models will result in increased legitimacy of bicycle projects in the planning process because of the bias inherent in the models’ design and use. As will be discussed in greater detail below, the various shortcomings of regional forecasting models in predicting cycling trips can make them seem irrelevant. Putting low use modes such as cycling next to dominant modes such as automobile use may make cycling appear insignificant in the transportation system. The scale of these models favors consideration of large infrastructure projects rather than the smaller-scale projects that would benefit bicycle use. The risk of marginalization through cycling’s incorporation into mainstream modeling techniques can be balanced by political will to promote cycling as part of sustainable transportation goals and the adaptation of models to more appropriately account for the full costs and benefits of all transportation modes. If not, cycling may continue to be under-represented in transportation discussions despite its contribution to sustainability goals in the long-term.

Taking into account the benefits and risks of incorporating cycling into mainstream forecasting methods, it makes sense to adapt a short- and long-term approach to improvements. In the short-term, cycling-related projects might be better justified based on social, health, and environmental arguments, as well as the low relative cost of providing bicycle improvements considering what has argued to be significant benefits (outlined in Chapter 1). They can also be more immediately justified as a way to help achieve a desired future within the visioning and goal setting techniques described in Chapter 2 and carried out in Chapter 6. However, establishing a process to collect appropriate data and build components of regional travel demand forecasting models to adequately predict bicycle trips as they increase will contribute to the long-term inclusion
of cycling in important discussions regarding the future of the transportation system in terms of sustainability goals.

**The Four-Step Process and its Use in Regional Travel Demand Forecasting Models**

The four-step process is the theoretical basis for models used to forecast travel demand at the scale of a city or a region. It was first developed in the 1950s as a way to predict future demand for automobile and public transit and to determine where facilities should be placed, and it is now used throughout the world (TRB, 2007).

TransCAD and other similar regional travel demand forecasting modeling programs use the four-step process to assess the impact of interventions in the transportation system, such as the construction of new roads, traffic calming to decrease average speeds, policies that might induce mode shifts, and other inputs. The output is a distribution of trips on the transportation network and can be based on both aggregate and disaggregate measures. Originally, the four-step process was primarily used to identify capacity problems for the motorized transport system (Cambridge Systematics Inc., 2000; Schwartz et al., 1999). It is now used more generally for the entire transportation system, though the nature of its origins biases it towards motorized uses.

Widespread use of the four-step process has had an impact on how planners and policymakers understand and interact with our transportation system, and its pervasiveness is the reason it is addressed first and in greater detail here. It is the most operationally advanced transportation forecasting tool upon which much modeling is based. In the U.S., the four-step process is used by most Metropolitan Planning Organizations (MPOs) (TRB, 2007). Although research interests now center on activity-based and other newer modeling techniques as the future of forecasting, the four-step process is the main forecasting technique in the near future as concerns remain over the operational effectiveness and resource intensiveness of these newer methods (TRB, 2007).

The four steps of the four-step process include:

1. **Trip Generation**: The number of trips is estimated.
2. **Trip Distribution**: Trips are assigned to origins and destinations.
3. **Mode Split**: Trips are assigned to specific modes, usually driving and public transit.
4. **Traffic Assignment**: Trips are assigned to the transportation network based on the minimized ‘cost’ to get from the origin to destination.

The method of estimating trip generation and attraction varies by the three types of trips: home-based work, home-based other or non-work, and non-home-based. Feedback loops can be created to account for the effect of the various steps on each other. For example, after traffic assignment, certain links may become very congested, influencing people to choose other routes or modes. Relevant factors can be fed back into the model in iterations to result in a final assignment that is more realistic.
There is much subjectivity in this process. For example, in the traffic assignment step, the cost to get from origin to destination can be defined differently. It is often based on perceived utility functions that take into account perceived time costs, monetary costs, and other factors that may vary over time. Social and cultural factors, discussed more fully in Chapter 2, and personal preferences might also factor heavily into these calculations.

Before beginning a review of the critiques of the four-step process, it is useful to recognize the benefits as they have been realized in regional travel demand forecasting models based on the four-step process. According to Porter et al. (1999):

[Regional travel demand forecasting] has a number of advantages over other methods, including taking into consideration how the spatial patterns of trips depend on the distribution of land uses and transportation network characteristics; how characteristics of alternative modes between specific origins and destinations influence mode choice; how travel choices vary according to trip type (work, shopping, etc.); and how policies, facility characteristics, and personal and household attributes may interact to influence travel patterns and mode choice. (p. 97)

In addition, Porter et al. (1999) point out that although it can take significant investment of resources to collect the data needed to incorporate cycling into these models based on the four-step process, once the data are gathered it is easy to carry out multiple evaluations and introduce changes to the model with minimal additional effort.

**Critique of Regional Forecast Modeling and its Application to Cycling**

The four-step process, and the regional forecasting models based on the process, will always be bounded by the computation limitations under which it was first designed. This would be the case with any tool born out of a certain context to cope with certain issues given certain capabilities. Like any other tool, there are strengths and weaknesses in the way it is adapted to other contexts.

The four-step process was designed during an era of rapid suburbanization, which depended on roads leading to the jobs in the city center. It was designed to be driven by statistical rather than behavioral information (Kitamura, 1996). Finally, it was designed to predict response to large infrastructure projects, not policies and control of existing infrastructure (McNally, 2000), though it is used for such purposes now. These characteristics are the source of many of the flaws in the application of regional forecasting models to cycling trips.

The way the four-step process is carried out in modeling programs presents various operational shortcomings. A lack of sufficient resources often limits effective use of the four-step process to estimate travel demand, though this would be the case for any complex modeling process. This might be particularly relevant in developing cities, where high rates of change of relevant characteristics (such as car ownership rates,
income, urban form characteristics, etc.) can make it challenging to gather the extensive data required as inputs in the models. Once the data are gathered, it takes additional time to estimate a model and then forecast based on that model, during which the data may have become irrelevant (McNally, 2000). Planners may employ shortcuts to overcome resource restraints, though this also can result in decreased accuracy. For example, travel demand models for smaller cities are typically based on the four-step process, but without the modal split step, and so are applied primarily to automobile use (Clark, 1997).

Even if the relevant data are acquired, planning organizations often lack the technical expertise to appropriately develop and use models. This can result in biases leading to inaccurate results. For example, there is often a bias towards optimism resulting in an overestimation of mode shifts (TRB, 2007).

There are numerous fundamental critiques of the process itself and the way it is applied. From this point forward, I will refer to regional travel demand forecasting models as regional forecasting models and assume they are based on the four-step process. The following five critiques are a summary of some of the most generally recognized weaknesses in these regional travel demand forecasting models, compiled from Bhat and Lawton (2000), Kitamura (1996), McNally (1996; 2000), Porter et al. (1999), and TRB (2007).

1. **Lack of Behavioral Basis**: One extensively discussed critique is the fact that regional forecasting models do not account well for individual behavior. According to TRB (2007), the models “are not based on a coherent theory of travel behavior and are not well suited to representing travelers’ responses to the complex range of policies typically of interest to today’s planners and politicians” (p. 2). For example, a current popular planning approach to limiting automobile use now includes transportation demand management, which can include the offering of various incentives and disincentives to using specific modes. It can be difficult to incorporate the complex behavioral responses to such efforts.

   Kitamura explains that this problem exists because the four-step process imposes an ordering to components of the decision making process. Also, regional forecasting models tend to consider cost and time as the major factors in determining transportation choices over other social and cultural factors. Finally, these models account for behavior only in an aggregated sense and at certain steps (Kitamura, 1996). Though regional forecasting models are considered good at forecasting aggregate demand, “as the problems being studied become more disaggregate and more linked to individual behavior…the four-step process yields less satisfactory results” (TRB, 2007, p. 2). Some modifications to existing modeling techniques begin to account for these shortcomings, as can be seen in the Edmonton case study described later.

2. **Lack of Dynamic Elements**: Regional forecasting models can include feedback mechanisms and take into account numerous factors, however, there might not be enough detail considered in terms of how these factors may vary. The
generalization of these factors means that they are not very good at representing the dynamic nature of the transportation system, nor the variety of responses to this dynamic transportation system based on current conditions. For example, congestion is averaged in regional forecasting models so that the models cannot express the traffic conditions at any particular point in time. Fundamentally, "these models cannot represent the conditions that would be expected or found by an individual traveler choosing how, when, and where to travel" (TRB, 2007, p. 2).

3. **Lack of Time Dimension:** People may choose to travel at specific times of the day, or may make different travel decisions at different times (TRB, 2007; Schwartz et al., 1999). Congestion is an important consideration in time, since its influence on transportation choices, fuel use, and emissions tend to occur at certain times of the day. For example, transportation choice is influenced if a person prefers walking to a local corner store during rush hour to avoid getting caught in traffic. That same person might go to a larger, cheaper, more distant grocery store on the weekend when there is less congestion and there may be less pressure on them to complete other activities. During the week, when people must work and children go to school, time pressures might be higher, limiting leisurely or unnecessary trips. These examples illustrate the importance of time in transportation decisions.

Again, some planning organizations have made adjustments in models to begin to address this issue, as seen in the Edmonton case study. However, in the Edmonton example time still exists in discrete categories rather than being fluid. Also, in general, if it is addressed, the time question is usually dealt with after the final assignment step, based on observed behavior in the peaks (McNally, 2000).

4. **Trip-Based Model Structure:** Each trip in regional forecasting models is treated independently, without the ability to consider linked or chained trips. A linked trip contains more than one individual trip, such as when someone goes from work to the grocery store and then finally to his or her home. Selecting an individual mode for each trip in a chain, which the four-step process tends to do, violates 'modal continuity,' which requires that one mode is used for the entire set of linked trips (Kitamura, 1996). Also, this shortcoming makes it difficult for models to account for foresight in planning a chain of trips. This may not be such a concern when considering major capital interventions in specific areas (Bhat & Lawton, 2000), but is certainly relevant for understanding travel behavior on a transportation network.

5. **Exclusion of Freight and Commercial Traffic:** Though I do not address this in my thesis, Porter et al (1999) note the typical exclusion of freight and commercial traffic, which prevents the consideration of the impact of these on the transportation system.
These shortcomings will result in incorrect estimates of changes in travel demand, meaning that certain policies and infrastructure may not actually elicit the reactions predicted in regional forecasting models (Kitamura, 1996). This is not likely a shortcoming specific to regional forecasting models, but all models in general. However, the above five critiques provide insight into the specific aspects of regional forecasting models influencing this inaccuracy in predictions.

**Shortcomings in Predicting Cycling Demand**

There is also a specific set of critiques related to the capabilities of regional forecasting modeling to adequately treat non-motorized travel, and specifically, cycling. Recall the historic bias of the process itself toward planning for automobile and public transit travel (Moe et al., 1999; Schwartz et al., 1999). The following list summarizes critiques that are most relevant to estimating bicycle trips.

1. **Cycling-Specific Data:** In the four-step process, the decision to cycling occurs in the mode split step. This step as it is currently modeled is usually based on household characteristics and the cost, both in monetary and temporal terms, of competing modes. However, this might not be the best way to model the decision to cycle, which is more often based on personal and environmental factors and trip characteristics, which probably also factor heavily in auto and transit use (Schwartz et al., 1999). For example, when making a decision to ride a bike a person may consider the climate, safety, the carrying capacity, and their desired appearance upon arrival. In addition, attitudinal factors (how riding a bicycle is perceived, for example) can be critical for cycling and are not easily quantified or incorporated into existing models (Katz, 2001). The relevant data for the decision to cycle often are not available.

   Even if the more subjective personal characteristics are ignored when estimating cycling demand, small-scale environmental data would still be required to provide relevant information of cycling trips. Even these data require significant effort to collect and incorporate into a network that is appropriate for modeling cycling trips (Moe et al., 1999). Again, a chick and egg problem presents itself, as it can be difficult to justify the resources required to gather cycling-relevant data because of low existing cycling mode shares (U.S. Department of Transportation Federal Highway Administration, 1996).

2. **Scale:** Regional forecasting models utilize a basic spatial unit of analysis, designed for data aggregation and computational expediency. The resulting process better represents conditions influencing longer trips – particularly for those by motorized modes (TRB, 2007; Katz, 2001; Moe et al., 1999). Data are aggregated to the Traffic Analysis Zone (TAZ), and trips between them are analyzed at a city-wide or regional scale. The spatial unit and scale of analysis can be too large to capture the number and detail of shorter cycling trips. This shortcoming could be less of a problem for longer cycling trips. However, the more micro-scale location of the origins and destinations and environmental
characteristics within a TAZ may be more relevant for bicycle users. In the end, bicycle trips tend to be removed from regional forecasting models because the small number of trips is considered irrelevant for the scale of the analysis.

3. **Types of Trips:** The four-step process arose in response to the need to accommodate the journey to work, or commute trips. As such, travel is not as well represented. Cycling, however, may be a more attractive mode for other trip types, including social, education, and recreational trips. In the U.S., for example, one-half of all bicycle trips were for recreation in 2001, based on data from the National Household Travel Survey (Liss et al., 2001). Even if cycling is not a popular way for more utilitarian trips, its popularity as a recreational activity has its own inherent benefits. Infrastructure built for recreation can also serve those who are making utilitarian trips (i.e. commuting to work, running errands, etc.), encouraging additional use.

**Coping with the Shortcomings in Regional Forecasting Models**
Theoretically, the four-step process could be applied to any transportation mode, and it often is. Increasingly comprehensive regional forecasting models can now partially address some of the above criticisms. The following list, based on review of several critiques (Moe et al., 1999; Schwartz et al., 1999; Wachs, 1985), summarizes some of the ways in which these tools can be improved to better account for cycling trips.

1. **Awareness of Limitations:** First, a careful understanding of the strengths and weaknesses of regional forecasting models in analyzing cycling helps make forecasting techniques more transparent. This transparency allows decision makers to account for the subjectivity of the tool. For this to occur, planning processes have to allow for the exploration of these strengths and weaknesses and the augmentation of forecasts with other processes (I recommend the attitudinal studies and visioning process here).

2. **Increase Data Collection on Bicycle Travel:** Porter et al. (1999) recommend the definition of data requirements in surveys and the use of technological advances, such as through information technology systems, to improve the quality of data. To address the resource requirements inherent in this recommendation, Wachs (1985) recommends research in alternative forms of data collection beyond expensive large-scale regional origin destination surveys.

3. **New Spatial Scales:** The spatial scale of regional forecasting models should be refined to account for shorter cycling trips (Schwartz et al., 1999). This would require greater computational ability, which is expanding, as well as detailed data gathering.

4. **Identify and Incorporate Environmental and Personal Factors to Better Account for Behavioral Change:** As discussed, environmental factors – such as local land use conditions and social and cultural factors, including lifestyles, and
labor-force participation rate (Wachs, 1985) – also play an important role in cycling choice. Incorporating such factors requires additional data and models capable of reflecting these characteristics in relevant choices, such as the mode and route for a trip (Schwartz et al., 1999).

Porter et al. (1999) recommend modeling behavioral change in stages. For example, bicycle ownership should be considered before the possibility of cycling, just as automobile ownership should be a prerequisite to driving. At the same time, relevant modeling components such as mode choice models need to better reflect behavioral change. This type of modeling would be specifically relevant for dynamic aspects of travel behavior incorporating time constraints and variations (Wachs, 1985).

5. Identify and Incorporate Facility Design Factors: Beyond the general environmental factors, data on the specific qualities of facilities available to cyclists are particularly relevant, and should be considered in regional forecasting models. An example that is appropriate for a bicycle includes travel time penalties resulting from major intersections (Schwartz et al., 1999). This penalty can be quantified as an actual loss in travel time and serves as a proxy for discomfort or difficulty in properly utilizing large intersections. One challenge in incorporating this kind of data is that their effect on choices to cycle can depend on the ability level and preferences of a particular cyclist.

6. Incorporate Other Policies that Affect Cycling Indirectly: Other policies important for cycling and the ways in which they can be incorporated in models should be explored (Schwartz et al., 1999). They might include, for example, the effects of parking pricing and other transportation demand management efforts.

7. Consider Alternate Models to the Four-Step Process: Some critics recommend the exploration of models that better describe, forecast, and evaluate transportation impacts at more microscopic scales (Wachs, 1985). Microsimulation involves predicting the behavior of the entire population based on a sample of households. Activity-based analysis, described in greater detail later in this chapter, is based on activity patterns instead of individual trips addressing the trip chaining problem described above (Moe et al., 1999).

8. Improve Evaluation Techniques to Better Account for Sustainability Goals: Alternative evaluation techniques can be more appropriate for evaluating the outcomes of investment in cycling infrastructure in terms of sustainability goals. Certain indicators of transportation performance and cost may be better aligned to sustainability goals. Evaluation techniques traditionally used in modeling, such as cost-benefit or cost-effectiveness analysis, need to be improved to better account for the environmental, energy, land use, and social impacts of transportation choices (Wachs, 1985).
Case Studies
Some planning agencies that prioritize the promotion of cycling and other non-motorized trips have modified their models to include cycling in their mode split step. In order to do this, agencies have had to gather and incorporate more cycling-specific data. Some examples include: Portland, Oregon; Montgomery County, Maryland; and Sacramento, CA. Other agencies have focused efforts on modeling route assignment of bicycle and pedestrian trips, including: Albany, New York; Leicestershire County, England; and Amersfoort, The Netherlands (Moe et al., 1999).

Many of these efforts involved the use of new transportation modeling programs or modules that assisted in incorporating bicycle use into regional forecasting models. For example, according to the FHWA (2008), planners in Leicester used TRIPS software, which contains a bicycle model as part of the software package. This software, along with a mode choice model called START, was developed by a British consulting firm called MVA to include non-motorized travel. QUOVARDIS – BICYCLE is a bicycle network model developed in The Netherlands by DHV Environment and Infrastructure. It is similar to the traditional four-step based models except that the only mode it considers is bicycle trips (Katz, 2001).

The following two case studies highlight attempts to include cycling into the mode split choice using different levels of resource investment. The case study of two small Oregon towns is relevant for my analysis of Chihuahua, Mexico due to the extremely low existing bicycle mode share and the planners’ motivation to increase cycling mode share. Edmonton, Canada is a relevant case study due to its comparable population to Chihuahua, low cycling levels, and motivation to measure the ability of various scenarios to achieve sustainability goals.

A Short-Term, Resource-Light Solution: Bend and Pendleton, Oregon
Planning agencies in small cities often discard the mode split step in their regional forecasting models in favor of modeling only automobile behavior. As noted by TRB (2007), "In smaller metropolitan areas, there may be little or no public transit, and the mode of travel step may be omitted, resulting in a three-step process" (p. 1). This case study of two small towns illustrates planners’ attempts to reintroduce this mode split step for low-use modes with limited resources. This could be particularly relevant for places where there may be a desire to increase bicycle mode share from very few existing bicycle trips, such as in Chihuahua.

The information for the two small towns of Bend, Oregon (population 35,000) and Pendleton, Oregon (population 18,000), is drawn from a paper by David Clark (1997). To explore whether promoting alternative modes of transportation could be beneficial to sustainability goals in these small towns, planners applied adjustment factors to the mode split step in their forecasting model to estimate bicycle trips.

Instead of creating a complicated modal choice model, planners in these two cities engaged in a two-step process for the mode split step. First they developed bicycle trip
length and time matrices for all trips to determine how many trips might reasonably be made by bicycle. This step could be simple, based on existing attributes of the road network, or more complex, incorporating cycling-relevant factors and introducing time penalties for certain characteristics of facilities, such as the penalty for large intersections described earlier. Planners in these towns pursued a more complex methodology, creating different trip lengths and time for nine possible trip types related to non-motorized forms of transportation. In the second step, they multiplied the possible trips by a percentage mode share that city officials believed reasonable, given certain policy recommendations. These trips were then mapped to the network, and the results were used to guide the development of corridors (Clark, 1997).

According to Clark (1997), the towns used estimated adjustment factors, based on best guesses of the effects of the proposed improvements in bicycle and pedestrian corridors, to determine the reduction in vehicle trips that would feed into their regional forecasting models. For example, Bend, Oregon estimated the following reductions for all trip purposes: a 10% reduction in vehicle trips less than .5 miles due to induced pedestrian trips, a five percent reduction in vehicle trips less than two miles due to induced recreational bike trips, and a two percent reduction in vehicle trips less than five miles due to induced “serious bicycle trips.” This amounted to a 4.6% estimated reduction of total vehicle trips. Pendleton used different adjustment factors to estimate a total reduction of 3.8% after a $4.8 million investment on 64 bicycle and pedestrian projects.

In this approach, the impact of various policies was assessed based on the intuitions and opinions of policy-makers rather than surveys and extensive data gathering. This approach can be very relevant for a place that does not have the resources to develop a complex model. Despite its simplicity, this approach can still be applied to assess sustainability goals.

A Long-Term, Resource-Intensive Solution: Edmonton, Canada

The Edmonton, Canada Transport Analysis Model is an example of a regional travel demand model that incorporates bicycle trips into the four-step process. In this case, the analysis of cycling trips occurs in the typical scale of the regional forecasting model. Most of the following information comes from Hunt (2003), which describes the 1997 version of the Edmonton Transportation Analysis (ETA) Model in terms of how it assessed the achievement of Kyoto Protocol guidelines.

In 1996, the Edmonton metropolitan area had a population of 860,000, which is comparable in size to the population of Chihuahua, Mexico. The 1999 Edmonton Master Transportation Plan reported its bicycle share within a category called “other,” which was only two percent of the total trips made, indicating a very low bicycle share, another similarity to Chihuahua (see Figure 6). Planners included bicycle trips in the ETA model despite a very small mode share because of political interest in increasing non-motorized modes of transportation, a third compatibility with my own case study.

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\(^2\) It is unclear what is meant by “serious” in this context.
Figure 6: 1999 mode shares for weekly daily person trips, Edmonton, Canada

The ETA model was designed to consider all modes, including cycling and walking trips. Transportation networks were built for each mode. The temporal issue was taken into account for automobile and public transit trips through the creation of additional networks for each of three time periods (the AM and PM peak and off-peak). The entire modeling system consists of a nested logit model, including the choices of number of trips, destination, mode, and time of travel.

Hunt (2003) presents a subset of five scenarios: an existing trends scenario, in which transit service and pricing remains unchanged and roads are improved and expanded; a balanced scenario, in which both transit and roadway infrastructure improves; a maintained level of service scenario, which includes more, better roads and no change in transit service; a traffic demand management scenario; and an extreme traffic demand management scenario, which involve different levels of policies to reduce automobile use. The impact of individual policies that would factor into scenarios was explored before the construction of scenarios. The scenarios themselves were based on population and employment forecasts, as well as predicted changes in other socio-economic and demographic variables for 2020. These scenarios were assessed for their ability to achieve Kyoto targets for emissions reductions as well as changes in ‘traveler consumer surplus.’ The change in surplus was calculated using utility measures derived from the nested logit to assess benefits to the traveler as designed in the model. Emissions were estimated based on link-by-link performance and vehicle characteristics.

Due to the small cycling mode share, there were challenges in collecting enough relevant data to calculate appropriate utilities. Additional resources had to be expended to acquire sufficient data. According to Hunt (2003), “A special supplementary survey of bicycle use was conducted, with stated preference choice experiments included to obtain additional observations for estimating certain coefficients in the bicycle utility functions” (p. 51).

The results of this modeling and scenario analysis showed that goals for Kyoto Protocol requirements could only be reached with the help of direct policies intervening in automobile use. Improved technology for automobiles helped, but was insufficient
without additional policies. Their most ‘successful’ scenario in terms of Kyoto Protocol
goals resulted in a dramatic loss in traveler consumer surplus (3.6 million Canadian 1994
dollars) because of suppression of travel due to high prices.

This definition of surplus illustrates an interesting bias in how transportation benefits are
viewed. In this case the benefits are thought of in terms of ‘mobility,’ the actual act of
traveling. The most aggressive measures, because they reduce emissions through a
reduction in automobile use, are assessed as reducing mobility. Hunt (2003) points out,
though, that at least the loss is primarily for the main adult population, so it does not
disproportionately affect, for example, the elderly or very young. Rather than stopping at
a negative conclusion of the impact of the most aggressive scenario, the loss in consumer
surplus could be taken to justify additional, stronger policies not included in the scenarios
that promote other modes as viable methods of travel to increase consumer surplus again.

There were only very modest changes in bicycle and walking trips in all of the scenarios,
so either the goal of increasing these modes was not achieved through the policies
proposed or the model was not well calibrated to predict changes in these modes. Given
the description of the scenarios, the former is certainly likely. As for the latter, the model
may not account for behavioral shifts that might occur in response to lost automobile
mobility. Long-term behavioral adjustment, for example, could include housing
relocation to take advantage of other travel modes.

Other Travel Demand Forecasting Approaches
Regional forecasting models are not the only tools available to predict cycling trips.
Planners use other methods more easily adapted to cycling. In addition, planners have
developed methods that are primarily designed to forecast cycling trips. There are
benefits and drawbacks to different techniques.

The FHWA published a guidebook (Moe et al., 1999) that provides a significant amount
derail detail on 11 types of methods of forecasting travel demand organized around four
major purposes: demand estimation, relative demand potential, supply quality analysis,
and supporting tools. I focus my analysis on the first purpose, demand estimation,
supplementing their summary with relative demand potential (latent demand) and supply
quality analysis (level-of-service and environment measures) from other sources.

According to Moe et al. (1999), demand estimation techniques also include comparison
studies, aggregate behavior studies, sketch plan methods, and discrete choice models.
These are not entirely separate methods; for example, discrete choice models are used to
inform the mode split step of regional forecasting models. This is, however, a useful
separation to make to assess various techniques.

Aggregate level methods for forecasting include comparison studies, aggregate behavior
studies, and sketch planning methods. They can all be used alone as simpler forecasting
techniques and/or provide inputs for the four-step process. They all include the definition
of a population served by a facility or network; identification and use of existing data or
gathering of simple additional data; and the application of various assumptions of change in mode share based on trip lengths, purpose, and characteristics about the traveler. These techniques (like most other models), all require many assumptions. However, they provide quick and relatively easy forecasts that are often limited in accuracy because of shortcuts due to resource limitations.

At a disaggregate level, discrete choice methods are more complicated and focus individual choices. Discrete choice models are determined from stated preference (when introducing new services) or revealed preference surveys (based on existing choices) that provide information on choice-making. Discrete choice studies can be used to estimate elasticities of travel behavior responses to infrastructure changes (for example, see Noland & Kunreuther, 1995) and, typically, feed into the mode split step of regional forecasting models. They can provide detailed information at a greater level of accuracy than the aggregate measures, but require greater resources. They are limited by the fact that they often rely on self-reporting of behavior (Schwartz et al., 1999).

Table 3 provides more detail on these four additional approaches as they can be applied to forecasting bicycle trips and the challenges associated with such applications. It is important to remember that these are generalizations, and attention can be given to any method to improve accuracy in forecasting bicycle trips.
The Moe et al. report (1993) offers a rating system that the authors developed to more easily compare these methods with regional forecasting models (see Figure 7). The aggregate level techniques tend to rank the lowest in difficulty of use and data requirements, but they also rank low in accuracy and sensitivity to design factors. The more difficult and resource intensive discrete choice and regional travel models provide greater accuracy and sensitivity to design factors. Sketch planning is the most widely used technique, and has relatively high accuracy levels for an aggregate level technique.
Finally, Table 4 offers more detail on the ranking for each of these methods in terms of the five categories of ease of use, data requirements, accuracy, and sensitivity to design factors. The summary also offers some examples of where each method is used.

The Moe et al. (1999) report did not cover some additional methods that represent a new direction in modeling travel demand. One modeling approach, an activity-based approach that is still in development but considered very promising by many researchers, is thought to address many of the shortcomings already described with the four-step process. Three of the four proposals to improve existing modeling techniques submitted to the FHWA’s Travel Model Improvement Program (TMIP) involved the use of activity-based approaches (McNally, 1996). The problem of the TMIP, however, is that the resources dedicated through this program are not necessarily enough to keep up with the increasingly complex demand put on models (TRB, 2007).
Table 4: Summary of ratings of demand estimation techniques from FHWA

<table>
<thead>
<tr>
<th>Method</th>
<th>Ease of Use</th>
<th>Data Requirements</th>
<th>Accuracy</th>
<th>Sensitivity to Design Factors</th>
<th>Where Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparison Studies</td>
<td>Simple to understand and relatively easy to apply</td>
<td>Requires facility user counts; data on surrounding population and land uses are optional</td>
<td>May provide rough estimates of demand if truly comparable case studies can be found. Accuracy has not been formally tested.</td>
<td>Relatively low; requires identification of comparable facilities within a comparable environment</td>
<td>Massachusetts; Netherlands; Germany; Australia</td>
</tr>
<tr>
<td>Aggregate Behavior Studies</td>
<td>Requires simple statistical analysis skills</td>
<td>Varies; can use existing sources such as census and local land use data bases</td>
<td>Models have generally had low explanatory power and have not been transferable.</td>
<td>Low, since detailed information on facilities has generally not been collected</td>
<td>UK; Berkeley, CA</td>
</tr>
<tr>
<td>Sketch Plan Methods</td>
<td>Methods are relatively simple to apply</td>
<td>Varies; can use existing sources such as census and local land use data bases</td>
<td>Varies by method; some methods may give reasonable estimates others have not been formally tested</td>
<td>Low; rely on general assumptions</td>
<td>Seattle, WA (bicycle); New York City, NY; Plattsburgh, NY; Milwaukee, WI; Toronto and Montreal, Canada (pedestrian)</td>
</tr>
<tr>
<td>Discrete Choice Models</td>
<td>Knowledge of statistical analysis and specialized survey and modeling techniques is required</td>
<td>Usually requires survey data collection specific to situation being analyzed</td>
<td>Can be relatively accurate in predicting impacts of specific actions</td>
<td>High, although only limited number of factors can be considered at once</td>
<td>Wisconsin; California, Chicago, IL; Raleigh, NC</td>
</tr>
<tr>
<td>Regional Travel Models</td>
<td>Requires established capabilities for travel demand modeling</td>
<td>May require additional data collection on bicycle and pedestrian travel patterns and/or facility characteristics</td>
<td>Including bikes/peds has improved performance of some models at predicting auto and transit trips</td>
<td>Potentially high; limited by data availability and tradeoff information</td>
<td>Portland, OR; Montgomery County, MD; Sacramento and San Francisco, CA; Edmonton, Canada; Leicester, UK; Netherlands</td>
</tr>
</tbody>
</table>

Source: Moe et al. (1999, Table 3.2)
Activity-Based Approaches

Activity-based microsimulation travel demand forecasting overcomes the trip focus shortcoming of the four-step model, the lack of behavioral basis, and common time issues. The approach focuses on modeling the reasons people engage in activities and how they carry them out (Bowman & Ben-Akiva, 2000). This approach “…views travel as a derived demand; derived from the need to pursue activities distributed over space and time” (Bhat & Lawton, 2000, p. 2). It is called a microsimulation because the approach models a sample of people or households that represents the population. Based on those results, travel behavior can then be modeled for any population characteristic from the sample population (U.S. Department of Transportation Federal Highway Administration, 2000). Some programs that apply the activity-based approach include TRANSIMS (TRansportation ANalysis SIMulation System) and STARCHILD.

The activity-based approach replaces the generation and distribution steps of the four-step process (McNally, 1996). This can be problematic for cycling in that in the end there may still be difficulties with the mode choice step. It is still also important to have proper data on the factors that might be most relevant for cycling, requiring purpose-specific data gathering.

Non Forecasting Methods: Relative Demand Potential and Supply Quality Analysis

Other types of methods, while not directly predicting future bicycle trips, can be used to contribute to the above methods’ predictions. The first set of methods aims to estimate potential demand to which mode splits can be applied. This was part of the process used in the Oregon case studies mentioned above, carried out using measures of trip lengths and times to which certain criteria were ascribed according to types of trip. One well-known method to predict potential demand is Bruce Landis’ Latent Demand Score (LDS). Other approaches are maximal share studies and market analysis.

Another type of method that contributes to the prediction of future bicycle trips is the use of level-of-service (LOS) measures. These measures rely on information regarding the quality of cycling infrastructure. A well-known example of an LOS measure is the Bicycle Compatibility Index (BCI) developed by the FHWA.

Measures of Potential Demand

While measures of potential demand are not full forecasts of future trips, according to Porter et al. (1999), “they are frequently used to prioritize projects based on potential usage or to place an ‘upper bound’ on the number of trips that might be expected” (p. 95). The LDS, for example, measures potential demand at the facility level based on trip generators near proposed bicycle facilities (Schwartz et al., 1999). It is a probabilistic gravity model that, according to Landis (1996), serves as “a measure of the relative amount of bicycle travel that would occur on a road segment if there were no bicycle travel inhibitions caused by motor vehicle traffic” (p. 18). The LDS estimates the probability of bicycle travel based on relevant generators and attractors of bicycle trips. The steps of this process include:
1. Establish tripmaking ‘thresholds’ (markets, indicators, parks, public schools).
2. Geocode/map trip attractors and tabulate and sum the number for each segment, stratified by proximity.
3. Compute tripmaking probability for each network segment using an LDS equation and trip probability vs. distance curves for each trip purpose share.

(Landis, 1996, p. 25)

Additional steps of normalization leading up to the calculation of the actual score (FHWA, 1996) will not be outlined in detail here. The LDS is useful because it is based on readily available data and simple techniques. Planners often use LDS to determine where additional bike infrastructure should be placed to take advantage of existing latent demand.

Another example of a method of calculating potential demand is a Maximal Share Study (MSS). An MSS identifies impediments to cycling based on household interview surveys and classifies them roughly according to how easy they are to overcome. Examples of impediments include a lack of information, poor perception of bicycle use, and lack of infrastructure. This method can be useful in understanding the major perceived constraints on bicycle use and determining methods to overcome them. Some problems with this approach include that it is hard to classify impediments and reliance on interviews means the results are subjective (Katz, 2001).

Finally, potential demand can be determined from a market analysis done before the four-step process to break the population into market segments according to their likeliness to cycle (Katz, 2001). Like all of these measures, these can be fed into other modeling techniques as the basis from which mode splits are determined.

**Level-of-Service Measures**

An LOS measure for bicycles quantifies the quality of the current network and can be used to provide information to the public about routes, to prioritize improvements, and to evaluate proposed projects (Harkey et al., 1999). If thorough enough, it could be used to inform the mode share and assignment stages of the four-step process.

The FHWA’s Bicycle Compatibility Index (BCI) is a common method used by a range of planners, engineers, and advocates for the various reasons described above, with the end goal of improving the LOS (Harkey et al., 1999). The BCI has been made very accessible via an Excel workbook that requires inputs from observed characteristics and the ratings bicyclists have given to roadways based on their comfort level.

According Harkey et al. (1999), problems with the BCI include the subjectivity of the rating of road links by various cyclists. Different cyclists will have different comfort levels. Statistical analysis can be done on survey results to rate characteristics more...
rigorously, but it is difficult to obtain consistent measures because of peoples' varying experiences of and comfort with riding a bicycle.

Conclusions
Models that forecast travel demand are standard tools in transportation planning. While they can be helpful in justifying and calibrating proposals, the way they are applied still provides a subjective look into travel behavior. For example, they are grounded in the context in which they were designed. They also are based on an understanding of existing trends or a subjective prediction of how trends might change. Modeling might be based on even less certain assumptions in the developing context where so much socio-cultural and economic change is likely to occur. To be most useful, forecasting results will have to be assessed in a logical fashion that considers the variety of possible effects of interacting policies and cultural shifts.

Ideally, the modeling of bicycle trips should be integrated with traditional regional forecasting models to include cycling in the same negotiations over investment of resources as other modes. This inclusion should not, however, assume that models should or can provide the primary justification for investment in cycling infrastructure and implementation of policies that affect cycling, at least in the short-term. So, while it is important to consider how cycling can be incorporated into mainstream forecasting techniques, it is also important to think about a wide range of approaches to promote cycling. Planners and decision makers should keep in mind the inherent subjectivity in modeling and the various shortcomings of models as they are designed and used when using them to inform decision making. Awareness of these shortcomings should allow for the pragmatic use of models to support planning processes that rely on a variety of quantitative and qualitative techniques and tools to inform decision making.

High quality, context-specific, and mode-specific data are critical to increasing accuracy in predicting bicycle trips. Despite the resource requirements for gathering such data, a planning agency should strive to collect a wide range of high quality data if models are to be useful in decision making. The type of data required to accurately predict bicycle trips, as well as the type of data that allow for reasonable evaluation based on preset sustainability goals, should be established up front to allow for a streamlined assessment of the impact of policies and infrastructure improvements.

My analysis of a variety of approaches and their advantages and shortcomings suggest a potential short- and long-term approach to forecasting in the medium-sized, developing city context based on resource availability. For example, simpler aggregate approaches can be pursued in the short-term, especially for modes that do not yet have a significant mode share. However, as time passes, and hopefully as targeted modes increase due to policies designed to promote their use, it is useful to have already determined the kind of data and expertise that will be necessary to construct more complex modeling techniques that incorporate modes such as cycling into transportation forecasts. With this already established, appropriate data can be gathered as resources are available.
Chapter 4: Context: Chihuahua, Mexico

Introduction

A United Nations (UN) (2007) report predicted that the majority of the world population would live in urban areas in 2008. While the mega-cities of the world like Mexico City, Mumbai, and Beijing have received much attention in terms of urban issues and sustainability goals, medium-sized cities, those of about 500,000, will experience the most growth and major challenges. To exacerbate the problem, smaller cities may be less equipped to deal with such challenges. According to the report:

Although mega-cities have received most of the attention, conditions in smaller urban areas call for even greater consideration. Contrary to general belief, the bulk of urban population growth is likely to be in smaller cities and towns, whose capabilities for planning and implementation can be exceedingly weak. (p. 3)

The challenges that these small- and medium-sized cities will face will apply to many aspects of development, including the pursuit of sustainable transportation. For example, in denser, larger cities, extensive public transit can be a more feasible solution to transportation and environmental problems. The scale of these projects, and subsequent concentration of resources, often diverts attention to these larger cities while the smaller cities, those experiencing the most growth, can be largely ignored. Despite the fact that smaller cities may require less resource investment to change the trajectory of transportation trends, many are developing in a way that prioritizes automobile use. As Dimitriou (1990a) argues:

The severity of the [urban transportation] problems encountered [in the developing world] is in part explained by the rise in the number of automobiles which has outstripped the growth in urban population. In the coming decades, these problems are expected to become even more serious – particularly in fast-growing cities currently hovering just below the one million mark. (p. 17)

By focusing on medium-sized cities, problems that affect more of the world’s population can be addressed. According to the UN (2007) report, while mega-cities of 10 million inhabitants or more constitute nine percent of the world’s urban population, cities with a population less than 500,000 comprise more than half. Cities of 500,000 to one million inhabitants have approximately 10% of the world’s urban population (about the same as the mega-cities) and those of one to five million have about one-quarter (see Figure 8).
Chihuahua, Mexico illustrates many of the challenges inherent in planning for sustainable transportation in a developing context. It emerged in my research as the logical place to test my methodology outlined in Chapter 2 for a variety of reasons, including its:

1. size;
2. transitional, developing state;
3. growing car-oriented culture; and
4. planning agency with a mission of sustainable development, which has collected extensive data to develop a sustainable mobility plan.

Although I will touch on each of these factors throughout this chapter, my initial motivation in considering Chihuahua was its size, so I will review this factor first, and in greater detail. Chihuahua was once in the city size category in which half of the world’s urban population resides. It has grown to just over 700,000, putting it in a category of urban size that contains the same percentage of world urban population as mega-cities. Chihuahua is projected to grow to one million people by 2015 based on IMPLAN’s predictions using a Consejo Nacional de Población (CONAPO) model incorporating 2005 data (see Figure 9). This growth would place Chihuahua in the category of cities that contains about one-quarter of the world’s urban population. It has faced and is still facing the social, economic, and environmental challenges that the UN predicts the majority of the world’s urban population will encounter. It is also in a state of significant transition, and it could provide insight into considering the role of cycling as a form of sustainable transportation in a wide range of differently sized, developing cities in the world.
This chapter describes the context of Chihuahua, Mexico and my case study’s applicability to the larger challenge of promoting cycling as a form of sustainable transportation in the developing world. To do so I outline general characteristics of Chihuahua; briefly describe the political context for transportation planning in the city; depict transportation characteristics and trends using statistics and other information; introduce the planning agency I worked with; summarize the sustainable mobility plan, specifically as it includes cycling; and analyze the existing context for cycling and characteristics for cycling trips in Chihuahua.3

Chihuahua, Mexico

General Characteristics

Chihuahua is the capital of the state of Chihuahua in Mexico (see Figure 10). Its proximity to the U.S. border (about 150 miles to the nearest point) may contribute to the fact that it sometimes physically appears more like a Texan city than a Latin American one, especially along the newly constructed highway lined with box stores, malls, fast food and other American restaurants, and cinemas. Also contributing to the similarity is the moderate density and high amount of road area in the city (see Table 5).

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3 Unless otherwise noted, the individual and household travel data used in this thesis come from the 2006 Chihuahua Household Travel Survey (IMPLAN, 2006b) provided to the author by IMPLAN. Additional information provided by IMPLAN which is used in this thesis are a series of shape files including: 0801902.shp and 0801904.shp (files containing data for census blocks); ZonasTransitoFin.shp (a file defining Traffic Analysis Zones); RedChihuahua_EMME2_Base.shp (the road network file containing traffic counts and other relevant data); pendientes.shp (a file containing slopes); and centros_communitarios (a file containing the location of community centers).
The climate in Chihuahua is hot and dry. According to historical weather data from MSN (2008), average temperatures range from average monthly lows range of 37°F in December and January to an average high of 92°F in June. The average precipitation ranges from .11 inches in March to 1.77 inches in July. The rainy season, illustrated by high relative average rainfall, is from July through September. Otherwise, the highest average rainfall is about half an inch.

The air quality in Chihuahua can be considered acceptable, according to the Indice Metropolitano de Calidad del Aire (IMECA), an index created in Mexico to measure pollution. A value of 100 represents what is considered standard air quality for Mexico. A website by the Centro de Investigación en Materiales Avanzados (CIMAV) (2008) shows the air quality in terms of this index for up to four months in the past for five pollutants: carbon monoxide (CO), sulfur dioxide (SO2), nitrogen dioxide (NO2), ozone (O3), and particle matter of 10 micrometers or less (PM10). Figure 13 shows that the only the PM10 concentration measured in the “bad” category (above an IMECA value of 100) in the first four months of 2008. Otherwise, PM10 stays in the second best category, “moderate.” O3 and CO also enter the moderate range, though usually just barely and not for all the months.
A recent thesis by Judith Parra Berumen (2007) examined the emissions data in greater detail. She concluded that while SO₂ and CO levels do not currently represent a problem in the city, the PM₁₀ concentration is a possible threat to health. Rather than explain these pollutants and their effects in detail, I conclude from these data and her analysis that Chihuahua currently does not have what Mexico would consider a serious air pollution problem. There are, however, certain risks to which automobiles with internal combustion engines contribute, a problem can always become more serious if the related pollutants are not studied and controlled.

Chihuahua’s 20,000 urbanized hectares form an L-shape, constrained somewhat by the surrounding topography. The topography in Figure 12 shows that in most of the city, the slopes are less than 3°. This might lead to the conclusion that the city is flat. However, my personal experience revealed that some of the inclines under 3° are noticeable when attempting to traverse the city using a non-motorized mode. Ortúzar et al. (2000) face a similar challenge in Santiago, Chile: “…even a 3% slope over a considerable distance is hard to negotiate for many of us, particularly when using very basic (the cheapest possible) bicycles” (p. 354). The gradients do become more differentiated along the west side of the city, as well as in a band of hilliness in the southeast.
Chihuahua is somewhat isolated as a denser locale in the middle of a large area of low density in Mexico (see Figure 13). Still, Chihuahua is not a very dense Latin American city. Its 37.5 person per hectare density is similar to moderately dense European examples (see Figure 14). The city’s density has been decreasing since the 1980s, though the rate of its decrease is declining (see Figure 15). The data show a change in the trend with a slight increase in population density in 2005. This statistic is not perceived by IMPLAN as a turnaround in the trend of decreasing density given development plans on the fringe of the city as well as interest in highway growth allowing development even further outside of the city.
Figure 13: Population density in Central America

Chihuahua, Mexico

Legend:
Population Density (people per km²)
- 0
- 1 - 5
- 5 - 10
- 10 - 25
- 25 - 50
- 50 - 100
- 100 - 250
- 250 - 500
- 500 - 1000
- 1000 - 2500
- 2500 - 5000
- 5000 - 10000
- 10000 - 25000
- 25000 - 50000
- Countries

Source: UNESCO (2008)

Figure 14: Densities for various U.S., European, and Latin American cities

Legend
- U.S. Cities
- Latin American Cities
- Mexican Cities
- European Cities
- Chihuahua

Source: Adapted from IMPLAN (2007d)
There is variation in population concentrations within the city (see Figure 16). More people live in the southeast and northwest of the city (shown as absolute numbers reflected in the size of the pie charts). High-income residents tend to live in a less populated area in the western central part of the city, where there are more gated communities, larger homes, a golf course, and quick access to the new highway lined with high end malls, upscale restaurants, and box stores. Some higher-income people also live to the north of the city, where there are new gated communities that offer nice housing, but which are distant from the historical center of the city. Many medium- and high-income people also live in the southern periphery and north of the large concentration of wealthy residents in the western central area.

Gated communities in Chihuahua represent a phenomenon growing in popularity for both the middle and upper classes. New lower-income neighborhoods are being constructed in ways that imitate the self-contained, homogenous style of gated communities without the formal security present in the higher-income gated communities (see Figure 17).
Figure 16: Income distribution in Chihuahua, Mexico

Higher concentrations of high-income residents

Source: Data provided by IMPLAN
Political Characteristics

The country of Mexico is divided into 300 districts, each of which has a representative. The city of Chihuahua lies in two districts, and therefore has two representatives. The state of Chihuahua, like every other state in Mexico, is represented by three senators.

Mexico has eight political parties, the most relevant for Chihuahua being Partido Revolucionario Institucional/Institutional Revolutionary Party (PRI) and Partido Acción Nacional/National Action Party (PAN). PRI is a left leaning party with links to socialist groups, and PAN is a conservative Christian party. In Mexico, PAN now has a majority of the representatives and senators. In the summer of 2007, PRI had control of the state government and the city. Mayoral elections take place every three years, and in 2007 the city of Chihuahua elected a new mayor, Carlos Borruel Baquera (PAN).

I spoke to Representative Emilio Flores Domínguez (PAN) (personal communication, July 9, 2007) to get a sense of the issues that are important to politicians campaigning in the Chihuahua area. Representative Flores defined employment and the cost of goods (particularly energy and gasoline) as the primary problems. PAN’s platform, and therefore Representative Flores’ platform, relies on education as the primary solution to most social problems. Representative Flores also prioritized the lowering the cost of electricity, the elimination of a car tax, and the creation of a National Forest Service.
This is a very simple description of the political context of Chihuahua within the larger political context of the country. In addition, as a way to gain a better understanding of the politics in Chihuahua, I explored the political challenges related to the implementation of a sustainable development plan. According to Luis Martínez Saenz (personal communication, May 8, 2008), the Director of IMPLAN, there is a significant gap in Chihuahua between technical analysis and planning objectives. Usually, he explained, politicians establish agendas and then seek justification through technical analysis. He also stated that the gap between technical and sustainability issues, specifically the social aspects of sustainability, is not well recognized in Mexico among decision makers.

Another challenge for implementing long-term plans designed to address sustainability issues comprehensively is the three-year mayoral term. According to Martínez (personal communication, May 8, 2008), mayors only have about one and a half years of effective time in office to implement policy. The mayor usually spends the first half-year of his or her setting up the office with his or her own staff. The mayor must start campaigning to get reelected in the last year of his or her term. Not surprisingly, the short term in office and desire to be reelected leads mayors to pursue projects that have an immediate impact. This importance placed on immediate gratification and the gap between technical analysis and decision making make Chihuahua an interesting political climate in which to study the pursuit of sustainable planning objectives.

**Politics of Transportation Planning**

Chihuahua’s politicians, similar to politicians in other developing (and developed) places, have been guilty of “ribbon-cutting,” or a focus on large-scale, highly visible infrastructure projects. This can be particularly relevant to transportation planning, in which Dimitriou (1990b) argues that political will often usurps recommendations by planning professionals. According to Dimitriou (1990b):

> Associated with the [ribbon-cutting] phenomena is the strong preference of many politicians for projects which present an image of ‘modern development’ through the construction of sophisticated transport systems, such as elevated high capacity urban freeways (as in Lagos and Delhi) and urban rapid transit systems (as proposed for Bangkok and Calcutta). (p. 72)

The most recent example of this phenomenon in Chihuahua is Mayor Borruel’s proposal upon entering office in 2007 to construct a partially elevated ring road, budgeted to cost about $300 million (see Figure 18). Mayor Borruel’s proposal was not based on existing predictions of travel demand that had occurred under the previous mayor. Mayor Borruel is now seeking technical data to support his current proposal. It remains to be seen whether the mayor’s proposal will be supported by new projections, and whether he will move ahead with the proposal despite a lack of analytical support.
General Travel Characteristics and Behavior

Planning in Chihuahua has historically promoted automobile use to the detriment of other modes of transportation, making it an automobile oriented city. The layout of Chihuahua (partially constrained by natural barriers) makes effective public transportation feasible in theory, and there is an extensive, although inefficient, bus network run by a variety of private operators. There is also a history of a large number of walking trips, though much of the infrastructure for pedestrians, such as sidewalks, is in disrepair.

IMPLAN (2006b) carried out an origin destination survey in 2006 for the 24 hours of a typical work day, using households as the sample unit, to better understand the travel behavior in the city and to provide information for a forecasting model to inform their sustainable mobility plan. The survey included 4,332 households and 13,147 people, resulting in a final number of 34,036 trips for a variety of purposes over a 24-hour period on a workday.

Based on the origin destination survey, Chihuahua’s 2006 motorization rate was approximately 429 cars per 1,000 people. Although high for Central and South America, this number is only about half of the U.S. motorization rate. The U.S. DOE (2007) calculates that the 2005 motorization rate for Central and South America as 121 vehicles per 1000 people, and for the U.S. as 804 vehicles per 1000 people (see Figure 19).
Figure 19: U.S. motorization rates compared to other countries in 1994 and 2005

Inset:

X = Approximate location of Chihuahua based on 2006 motorization rates

Source: U.S. DOE (2007) and IMPLAN (2006b)
Chihuahua’s relatively high motorization rate, influenced by the import of cheap, used cars from the U.S., contributes to the mode choice for trips in the city. Of course, factors other than automobile ownership also play a role. There is an extensive public transit system, but it is chaotically run by various private entities without integrated route planning or fare systems. Pedestrian conditions are worsening as sidewalks deteriorate and more space is devoted to highways and other roads. There is almost no infrastructure dedicated to cycling. All of this has contributed to the fact that the majority of trips in Chihuahua are currently made by automobile. Based on the results of the 2006 origin destination survey, automobile trips (either as driver or passenger) accounted for 62% of trips; pedestrians, 21%; and bus, 15% (see Figure 20).

Figure 20: Share of trips made by different modes in Chihuahua, Mexico

![Pie chart showing the percentage of trips made by different modes.](image)

Source: IMPLAN (2006b)

Excluding return trips home, trip purposes in the origin destination survey were primarily commuting to work or school, making up 52% of the purposes (see Figure 21). A large percentage of trips were listed as “other,” so we cannot be sure of the purpose. While many trips were also made for shopping and social visits, relatively few trips were made for recreation.

Figure 21: Trip purposes in Chihuahua, Mexico

![Pie chart showing the percentage of trips by purpose.](image)

Source: IMPLAN (2006b)
The average trip length in Chihuahua, as estimated by IMPLAN based on the 2006 origin destination survey, is about ten kilometers. I used the origin destination survey, a road network as represented in IMPLAN’s regional forecasting model, and other files provided by IMPLAN to make some more detailed estimates of trip lengths. I calculated the shortest distance on the road network from the geographic center of each Traffic Analysis Zone (TAZ) to every other TAZ and applied them to trips in the origin destination survey.4 Not surprisingly, average trip lengths are generally longer when they originate from or end at outlying TAZs (see Figure 22 and Figure 23). Interestingly, there are more TAZs that have an average originating trip of less than 4.5 kilometers (the distance IMPLAN targets for bicycle trips, represented in orange) than TAZs with an average destination trip of less than 4.5 kilometers, though I am not sure what phenomenon causes this variation. Perhaps it indicates that there is a concentration of shorter trips originating from the center of the city, while the destination TAZs of those trips are more dispersed.

Figure 22: Average trip distances originating from each TAZ

![Average trip distances originating from each TAZ](image)

Source: Trip distances calculated based on IMPLAN(2006b)

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4 This process is described in more detail in Chapter 7.
Because travel behavior is associated with socio-demographic characteristics, I also analyze the relationship between income and mode choice. Figure 24 illustrates the variation in mode shares for income segments in the population. Not surprisingly, as income level increases, the number of trips made by car increase. There are also no trips made by public transit in the highest income group in the origin destination survey.
People with higher household incomes tend to also make more trips overall. I divided the total number of trips within each income category by the total number of trip makers in the income category to come up with the number of trips made per capita by income level (see Figure 25).

This same income effect on trip making manifests itself in a display of total trip distances originating at TAZs (rather than the averages represented in Figure 22 and Figure 23). As Figure 26 and Figure 27 show, the sum of trip distances is much greater in the wealthier areas of Chihuahua, which were identified in Figure 16. This indicates that the trips made from areas where more wealthy people reside are longer, in addition to the wealthy making more trips by automobile. This can lead to the conclusion that Chihuahua, as an increasingly automobile dependent city, has favored the higher-income residents when affordable, non-motorized modes such as cycling are de-prioritized in

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5 I converted these amounts from pesos in the origin destination survey that correspond to income divisions (low, medium, medium-high, and high), using the June 1, 2008 exchange rate for U.S. dollars.
favor of automobile growth. This is a trajectory that many developing cities are likely following, with potential consequences that were discussed in Chapter 1.

Figure 26: Total trip distances originating from each TAZ

Source: Trip distances calculated based on IMPLAN (2006b)
Statistics in Chihuahua also suggest that safety concerns are increasing with motorization rates. According to the data from the State Department of Transportation (2005), the city of Chihuahua recorded a 16% increase in accidents involving motor vehicles between 2004 and 2005. Out of the total accidents, 52% were caused by speeding, a problem probably exacerbated by road designs encouraging speeds higher than posted.

Source: Chihuahua State Department of Transportation (2005)
Not surprisingly, as accidents increase, injuries and deaths also increase, as illustrated in Figure 29 and Figure 30. It is possible that part of the increase in accidents, injuries, and deaths is due to increasingly accurate gathering of traffic data. However, the data provided by the State Department of Transportation (2005) is the best information at hand to quantitatively understand the transportation safety conditions in the area.

Figure 29: Number of injuries per year as a result of traffic accidents

![Figure 29](image)

Figure 30: Number of deaths per year as a result of traffic accidents

![Figure 30](image)

Source Figure 29 and Figure 30: Chihuahua State Department of Transportation (2005)

Finally, increasing motorization rates could eventually contribute to congestion problems. The volume over capacity ratio on the representative road network provided by IMPLAN shows the congestion levels in Chihuahua. I calculated the volume-to-capacity ratio as the sum of the total auto, taxi, bus, truck, and motorcycle flow in the AM peak over the hourly capacity per lane times the number of lanes for each direction. Figure 31, which illustrates the volume to capacity ratio in both directions as a scaled symbol, does show that there are a number of roads that have a 75% to 100% volume to capacity ratio in the AM peak. These links have a potential problem as they approach capacity. There were a few road links that are utilized at over 100% of the capacity, indicating congestion. However, the percentage of links over capacity remains in the minority.

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6 I weighted trucks and buses as two times the volume of cars, and motorcycles as half to be more conservative (even though some buses and trucks in Chihuahua are not that large).
Because of the existing and potential consequences of increased motorization, it is important to consider transportation planning for a wide variety of modes to provide access to resources for all income levels, rather than for a single motorized mode. Chihuahua’s mode share and other transportation characteristics indicate that it is becoming an automobile oriented city. IMPLAN has taken up the task of addressing these consequences and changing the trajectory of the city.

**IMPLAN**

In Mexico, municipal planning agencies (IMPLANs) are given the task of overseeing regional planning. According to Salvador Herrera Montes (personal communication, May 31, 2007), the first director of Chihuahua’s IMPLAN, Mexico’s first IMPLAN was established in León, inspired by work done in Curitiba, Brazil. In 2007, there were 26
IMPLANs in Mexico, all organized under a single organization called the Mexican Association of IMPLANs (AMIMP).

IMPLAN Chihuahua’s mission is to be a technical consulting arm of the city of Chihuahua on issues related to design, development, implementation, and evaluation of the Sustainable Urban Development plans and programs. As a part of this role, IMPLAN sets the methods and policies for the evaluation, carries out the necessary research to ensure the quality of the planning projects, and obtains public participation in each case (translated from IMPLAN, 2008a). IMPLAN views itself as a link between the government and society in Chihuahua (2007c).

IMPLAN functions quasi-independently, however, the appointment of the new mayor in 2007 resulted in turnover in much of the staff. According to Herrera (personal communication, May 31, 2007), IMPLAN assists with one administrative procedure for the city, which is to review land use modifications proposed by developers. The influence that IMPLAN can leverage through its role in reviewing land uses could help implement their sustainable transportation goals, though it is limited by the fact that IMPLAN is only allowed one month to review the proposal.

In the summer of 2007, Chihuahua’s IMPLAN had 15 employees, 11 of whom were technical staff. IMPLAN also employs a number of consultants, one of whom, the former director under the previous mayor, is in charge of implementing the sustainable mobility plan.

**Plan Sectorial de Movilidad Urbana Sustentable (PSMUS)**

In Chihuahua, IMPLAN has established a sustainable transportation plan (PSMUS) as a part of their larger plan for sustainable development. The overall sustainable development plan has six guiding principals (IMPLAN, 2007c, slide 7):

- Good and plentiful jobs close to home
- Mised [sic] use corridors accessible to all
- Five-minute walking distances
- Access to natural areas and parks
- Lighter, greener, cheaper, smarter infrastructure
- Different housing types

The PSMUS addresses a wide range of topics, including construction of new roads, parking pricing and infrastructure, a bus rapid transit system, and the improvement of infrastructure of non-motorized modes of transportation (IMPLAN, 2007b). The plan is based on extensive technical analysis, with the following objectives (IMPLAN, 2007c, slide 17):

- To develop solutions to traffic problems through an optimum use of the existing network and through its improvement.
- To strengthen [sic] institutional capacity to manage the system for sustainable urban mobility.
- To establish investments with socio economical profitability.
- To diminish pollution.
- To attract more users to public transportation services by improving quality in service and the efficiency of operation.
- To encourage profitability of public transportation services.
- To develop public space and a network for non-motorized transportation.
- To implement the system in the short term, at least in its first stage.

One of the pillars of the PSMUS is the creation of the bus rapid transit (BRT) system, starting with one main trunk running the length of the city and expanding as resources allow. The BRT lines would be supported by feeder routes in the far north and southeast of the city, as well as conventional routes in the middle of the city (see Figure 32).

Figure 32: PSMUS public transit system proposal

Based on the political challenges already discussed, it will be very difficult to implement this sustainable mobility plan. According to Martínez (personal communication, May 8, 2008), IMPLAN’s current priority is to obtain cooperation from the existing public transportation providers and later create the legislative framework within which the BRT project can be implemented. In addition, they are trying to partially build the first phase of the bicycle infrastructure described below. Unfortunately, these objectives do not align well with the mayor’s proposed ring road project. The bottom leg of the ring road is expected to traverse a canal in the middle of the city, creating a more formidable
boundary between the northwestern part of the city and the downtown area. As a consulting organ to the city, IMPLAN may or may not be able to use its technical analysis or other tactics to create better alignment between the mayor’s agenda and IMPLAN’s sustainability objectives.

**Cycling in the PSMUS**
IMPLAN (2007b) proposes to construct a system of permanent bicycle routes that connect with the public transit system, green areas, and existing and proposed pedestrian zones (see Figure 33 for a visual representation of this strategy). This proposal envisions cycling principally as a form of recreation, but also offers the possibility for cycling as an alternative form of transportation. IMPLAN’s idea is to start small by focusing on areas where links can be created between public transit and amenities, where slopes are less challenging, where sidewalks are adequate for intervention, and where the existing pavement quality is adequate for bicycle use. It targets trips of 4.5 kilometers or less, which is supported by the assertion by the Centro de Transporte Sustentable in Mexico City (2007) that bicycle trips should be promoted in Mexico as the fastest way to get from door to door for trips under five kilometers.

![Figure 33: Representation of immediate-term BRT/bicycle path proposal](image)

Figure 33: Representation of immediate-term BRT/bicycle path proposal

This overall concept serves as the basis for a four-phase bicycle plan (see Figure 34). The first, or immediate-term phase, involves the construction of 31 kilometers of bicycle lanes by 2008. The second, or short-term phase, involves an additional 43 kilometers by 2011. The medium-term and long-term phases include the construction of an additional 78 and
127 kilometers by 2016 and 2026, respectively. This plan results in a total of 279 kilometers of bicycle infrastructure in 2026. While IMPLAN’s end goal is a connected bicycle network, the initial success the proposed infrastructure depends on the construction of the BRT trunk route to encourage use.

Figure 34: IMPLAN’s proposed phasing of the cycling network from 2007 to 2026


Medium-Term Phase (2011-2016)  Long-Term Phase (2016-2026)

Source: Data provided by IMPLAN

Due to the perceived danger of riding on roads and the goal to introduce paths appropriate for recreation, IMPLAN (2007b) proposes the construction of bicycle lanes primarily separated from traffic. The favored bicycle lane design utilizes a landscaped median that also offers a pedestrian walkway (see Figure 35).
The bicycle plan within the PSMUS includes consideration of other transportation modes through connections to the bus rapid transit line and designs for incorporating bicycle lanes in streetscapes. Other components of the PSMUS, however, were not necessarily consistent with the proposals in the bicycle plan. In the version that existed in the summer of 2007, the PSMUS included designs for the expansion and improvements of roads without provisions for bicycles. In addition, there were conflicting goals within the mobility plan. For example, several of the new proposed roads could open up new areas for development. This strategy could promote sprawl and less optimal use of public transit and the bicycle network. There was a need to perform an overall integration of all of the components of IMPLAN’s master plan for the city based on overarching goals of sustainable development. There have already been some efforts in this direction, but the progress made by January 2008 was uncertain.

**Existing Cycling Conditions and Bicycle Trips**

There are many environmental and livability challenges in Chihuahua that affect bicycle use. With 42% of the city covered by roads (IMPLAN, 2007a), there are ample streets for cyclists to use, but no provisions have explicitly been made for bicycles in the existing infrastructure. Figure 36 through Figure 39 illustrate various challenges for bicycle use in Chihuahua. Because of traffic safety concerns, there have been recent attempts to reduce speeds through traffic calming techniques that are unfriendly to cyclists, such as the introduction of speed bumps that can be difficult for cyclists to navigate safely (see Figure 38). Drunk driving is considered a serious problem in Chihuahua, which affects perceptions of safety (for more information see Chapter 5). There are a number of visibly deserted store fronts in the downtown area, which could serve as a popular and accessible destination for pedestrians, cyclists, and users of public transit alike. Business has probably been lost to the new, massive, peripherally-located malls designed primarily for private car access. As already discussed, in general, density has been decreasing as the city has grown, contributing to longer travel distances.
The road safety data from the State Department of Transportation (2005) do not allow for good conclusions about bicycle accidents. Based on the categories provided and consultation with IMPLAN’s staff, I estimated that three percent of accidents and eight percent of injuries may have involved a pedestrian or cyclist.7 Recently, there was a high profile case in which a professional cyclist, training with a team followed by a protecting car with signage indicating that cyclists were in front, was killed on a highway by a drunk driver (Gabriel Cano Olivas, personal communication, July 19, 2008).

IMPLAN’s origin destination survey (2006b) included 108 bicycle trips, or .3% of the total trips in the survey. To better understand the bicycle trips made in the city, I used my calculated trip distances and applied them to the 108 bicycle trips in the 2006 origin destination survey. I was only able to assign distances to 102 of the 108 bicycle trips.

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7 I guessed that two categories of accidents were likely to have included a cyclist or pedestrian. I included the accident in my calculation if the type of accident was recorded as “ATROPELLO,” or if the cause of the accident was recorded as “CRUZAR SIN OBSERVAR.”
indicating an average trip of 4.3 kilometers (the same average as the overall trips), a median of 3.5 kilometers, and a mode of .3 kilometers. There were some interesting results regarding the distribution of the trip lengths (see Figure 40). Trip lengths by bicycle were often longer than 4.5 kilometers, suggesting that it might be reasonable for IMPLAN to target longer trips. Nine percent of the 102 bicycle trips are even longer than 10 kilometers, although the majority (68%) of them are still five kilometers or less. It is possible the longer trips are due to a lack of alternative transportation options.

**Figure 40: Histogram of trip distances for cycling trips in Chihuahua, Mexico**

![Histogram of trip distances for cycling trips in Chihuahua, Mexico](image)

Source: Trip distances calculated based on IMPLAN (2006b)

I expected cycling trips between one and 10 kilometers to be the most common, but there are a surprising number of trips (28% of the total) of one kilometer or less. It is difficult to imagine this being an efficient mode for such a short trip, because bicycles have to be locked or protected from theft. Of course, the number of short trips might be exaggerated by the way I calculated intra-TAZ distances as half of the radius of the TAZ. All of these intra-TAZ distances were under one kilometer.

IMPLAN (2007b) shows the desire lines for bicycle trips, or the general paths that cyclists use in the origin destination survey (see Figure 41). The strongest desire lines run from the northeast to the southwest, representing a long distance to traverse that is not necessarily aided by the proposed short connectors the BRT trunk.
Out of the total bicycle trips, almost half (46%), were return trips, or trips made with the purpose of arriving home. This percentage indicates that the survey recorded very little trip chaining in bicycle trips. Among the non-return trips, destinations were primarily work and school (see Figure 42). Recreational trips accounted for only about four percent of this sample of trips. This distribution of purposes suggests that it would be appropriate to provide infrastructure appropriate for commuting, not just recreation.

A cyclist in Chihuahua is mostly likely male (71%). Almost three-quarters of existing cyclists (73%) have no driver’s license, which suggests why there is a perception that cyclists are often workers with limited options for transportation (discussed more in Chapter 6). The ages of cyclist are distributed between one and 71 (see Figure 43). The
average age of the people making trips by bicycle is 31 years old, the median is 30, and the mode is 18. Most cyclists in the sample (89%) had no physical limitations, though small percentages were hearing or sight impaired, or had a chronic illness (see Figure 44). Cyclists tended to have low education levels, with 40% completing only preschool or primary school, and another 32% completing secondary school. 26% had higher degrees from technical to university degrees (see Figure 45). Finally, cyclists in the origin destination survey are mostly low-income (see Figure 46).

Figure 43: Histogram showing frequency of ages for cyclists

![Histogram showing frequency of ages for cyclists](source: IMPLAN (2006b))

Figure 44: Limitations for those making bicycle trips

![Limitations for those making bicycle trips](source: IMPLAN (2006b))
Conclusions: Applicability of the Case Study

Chihuahua, Mexico is a city that meets the conditions in which I hoped to test my methodology. It is a medium-sized city experiencing growth. Its infrastructure development and other characteristics favor automobiles as the primary mode of transportation. There are implications for this trajectory in transportation planning in terms of social, environment, and economic concerns. Chihuahua also faces political, physical, and social challenges to promoting cycling as a potential solution to some of these concerns that could exist in any other medium-sized, developing cities. In the midst of these challenges, using Chihuahua as a case study also presented the opportunity to work with a cooperative planning agency that had embraced sustainability goals, employs a skilled technical staff, and had data relevant for my analysis.

These factors offer a favorable context in which to examine the possibilities of adjusting planning processes and tools to elicit behavioral change towards cycling as a form of
sustainable transportation. Chihuahua is a case where there is a gap between engineering solutions, which have been proposed in the PSMUS, and what will likely be required to achieve the social change required to realize sustainable transportation goals. It also represents the gap between technical analysis carried out by IMPLAN and political will towards projects that do not contribute to the sustainable efforts followed by IMPLAN.

The following chapters illustrate the application of my proposed approach, described in Chapter 2, in Chihuahua, Mexico.
Chapter 5: Attitudes and Perceptions of Cycling in Chihuahua, Mexico

Introduction
Chapter 4 lays out the context for cycling in Chihuahua, including an analysis of the road culture and existing cycling trips that indicates that Chihuahua is not necessarily a friendly place for cyclists. Chihuahua has little existing cycling culture, which would include a history of cycling as well as organizations, advocacy groups, and social networks organized around cycling. As presented in Chapter 2, I propose a three-step approach to better promote cycling as a form of sustainable transportation through planning process and tools. This chapter details the first step of that approach – assessing the local attitudes and perceptions towards cycling – as applied in Chihuahua. The knowledge gained from this assessment provides insight into the social and cultural barriers to cycling as a form of sustainable transportation.

Part of my work in the summer of 2007 was to better understand the specific context of Chihuahua and the challenges posed for IMPLAN’s cycling plan. I carried out field work to understand the attitudes and perceptions towards cycling, explored the existing conditions for cycling (discussed more in Chapter 7), and performed a literature review of best practices in promoting cycling. Based on this research, I developed a list of recommendations to improve IMPLAN’s cycling plan within the PSMUS. As discussed in Chapter 4, the plan takes a traditional infrastructure-based approach to shifting travel behavior, focusing primarily on the creation of a network of bicycle lanes.

To better understand the attitudes and perceptions of people in Chihuahua towards cycling as a form of sustainable transportation, I performed two types of field work: surveys and focus groups. I also interviewed people involved in cycling work in the city, politicians, and other key figures to provide insight into the policy structure within which the promotion of cycling takes place.

The attitudes and perceptions of residents reveal a low likelihood that the proposed bicycle infrastructure will contribute to sustainability in the city without additional policies to promote their use. However, the potential for use exists.

The recommendations that resulted from this work were focused on the structure and phasing of the network proposed by IMPLAN, as well as additional steps necessary to promote the use of the network through a social and cultural change that favors bicycle use. They can be summarized in the following eight categories (Teich, 2007):

1. Infrastructure
2. Integration

8 Details can be found in Teich (2007).
9 The information gained from interviews is incorporated in Chapter 4 and Chapter 8, and additional summary, which is not entirely relevant to the thesis, is in Appendix G.
Surveys

My initial intention was to complete a survey that could be generalized to the population of Chihuahua. Unfortunately, time and resources necessary for such a survey were not available, especially considering I could not identify a way to create and reach a random sample for the city. Instead, surveys were targeted at specific groups and carried out in person on site at homes, in community centers, and at a location with a concentration of cyclists.

Three groups were targeted to better understand attitudes and perceptions towards cycling: students, community center users, and cyclists (see Table 6). I targeted students because the attitudes and perceptions of young people will eventually comprise the attitudes of adults in the population. I selected community center users because they tended to be low- to middle-income and female. I estimated that the affordability of cycling might be appealing to this group. Women tend to ride bicycles less than men in Chihuahua, so I thought the survey of this group might also reveal a stronger sense of the challenges that exist. Finally, many of the women could provide a parent’s perspective. The last target group was existing cyclists, whom I believed were likely initial users of bicycle facilities. I also expected them to provide different perspectives based on their cycling experience and knowledge of existing conditions. Finally, by engaging cyclists I hoped to get a sense of whether there is an existing cycling culture (and related advocacy activities).

<table>
<thead>
<tr>
<th>Group</th>
<th># of Surveys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students (using a list provided by consultants)</td>
<td>35</td>
</tr>
<tr>
<td>Community center users (at 3 centers)</td>
<td>15</td>
</tr>
<tr>
<td>Cyclists (Chihuahua residents only, approached at a race in Aldama, Mexico)</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>65</strong></td>
</tr>
</tbody>
</table>

In addition to these three surveys, I conducted an additional survey of park users at Pistolas Meneses (described in greater detail below) to gain a better sense of attitudes of recreational cyclists and other park users. This survey was more open-ended, and
included onsite discussions with a variety of individuals and groups of park users regarding attitudes towards cycling and reactions to various types of infrastructure.  

**Students**

All but one of the student surveys were completed in person at students’ homes by a Spanish speaking consultant. This consultant conducted the survey and recorded answers while I listened and asked for clarification when needed. We asked for the closest intersection to both the students’ homes and schools to gain a sense of the geographic dispersion of the respondents. Figure 47 shows the locatable results on the road network, grouped by the survey ID to give a sense of the distances that people travel from home to work. Interestingly, the majority of the respondents live and work in similar parts of the city.

![Figure 47: Identified locations of student respondents’ home and school addresses](source: Data provided by IMPLAN)

**Community Centers**

I elected to survey three community centers corresponding to three commonly identified parts of the city: the north, center, and southeast. Resources did not allow for additional surveys. To select these centers, I first divided a list of community centers in the city into three groups based on their geographic location. I then selected two centers in each region randomly. Finally, to make the exercise more practical, I asked the consultant

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Appendices A and B contain the Spanish versions of the surveys, with one given to students and community center users, and the other given to cyclists. Appendix C contains the guide for the survey of park users, and Appendix D contains the photos used to obtain reactions from the survey takers.

Mario Sila de la Garza Alvarez
assisting me\textsuperscript{12} to select the more feasible of the two centers in each area. Figure 48 shows the location of the three final community centers related to an income measure, demonstrating that the three centers are located in areas with different income characteristics.

![Three community centers surveyed and percentage of high income earners](image)

\textbf{Source: Data provided by IMPLAN}

This consultant assisted with the organization of trips to the community centers, and along with a few others on his team, helped organize and carry out the focus groups. At the community centers, different survey methods were used depending on the context. If it was possible, either the consultant or I conducted the surveys verbally and recorded answers to ensure that each question was understood correctly. When presented with larger groups of individuals that were asked to complete the surveys at the same time, the community center users completed the forms themselves. There was greater inconsistency and more interpretive errors in the responses when the users filled out the surveys themselves.

\textbf{Cyclists}

The same consultant who conducted the student surveys also helped conduct the surveys of cyclists participating in a race in nearby Aldama, Mexico. We approached cyclists both before and after the race to ask them the questions using a different survey than the one for the students and community centers (see Appendix B). There were multiple

\textsuperscript{12} Jorge Garcia Perez
ability levels and age groups amongst the cyclists, and the respondents loosely
represented a variety within the group of cyclists. I was again able to locate the homes
and work or school of many of the cyclist respondents based on questions asked in the
survey. Figure 49 shows that they are more centrally located than the students, so much
so that they overlap each other and it is difficult to make out many of the respondents’
locations. This creates even shorter trip distances for them to travel for their basic
commute trips.

Figure 49: Identified locations of cyclist respondents’ home and school addresses

Source: Data provided by IMPLAN

Pistolas Meneses Park Survey
With the help of the same IMPLAN consultant\textsuperscript{13} working with me on the student and
cyclist surveys, I carried out a more open-ended survey in a public park called Pistolas
Meneses, which is used heavily for exercise and socializing by a wide range of age
groups. This park is located in the northern part of the city, between census blocks that
have high and low concentrations of high income earners (see Figure 50). The park
contains various sports facilities, including a 450-meter loop that had three separate lanes
for walkers and joggers, for inline skaters, and for cyclists (see Figure 51).

\textsuperscript{13} Mario Sila
With the help of some questions to guide the conversation, the consultant asked respondents their thoughts about the environment and cycling in Chihuahua. After this warm-up, respondents were shown some pictures of bicycle infrastructure and asked their opinions on which examples were most important for Chihuahua.

**Survey Results**

**Students/Community Center Users and Cyclists**

I separately compiled and analyzed the student and community center user surveys from the cyclist surveys for several reasons. The surveys contained a few different questions to take into account the different levels of experience with cycling. I also discovered that the cyclist respondents were more frequently male and higher-income than the students and community center users. The question regarding monthly income was inconsistently answered in the surveys of all groups, so the results should not be relied on as accurately representing the respondents’ income levels. However, they did indicate that the cyclists’ incomes were generally much higher than the other groups’. Finally, the cyclists’ identifiable home, work, and school locations, shown in Figure 49, are more central than the students’ locations and the location of the community centers where surveys were carried out. Table 7 demonstrates some of the differences (and similarities) between the two groups in a variety of categories that can be used to characterize the groups.
Not surprisingly, cyclists used their bicycles more often, with the majority of cyclists using their bicycles daily for training (see Figure 52). Of course, this result is biased because we surveyed cyclists at a race, where there would be more competitive athletes. These were not necessarily utilitarian cyclists (people who use their bicycles to get to work, shop, or run other errands). Regarding frequency of use, the largest group of students and community center cyclists used a bicycle once per month, mostly for recreational purposes (described in more detail later in Figure 53).

Figure 52: Frequency of bicycle use of students/community center users
Respondents were asked to indicate the most important problems for cycling. Their choices were:

1. cars are aggressive, fast, and not respectful;
2. streets are in poor condition;
3. someone will steal their bicycle;
4. there is not infrastructure for bicycles;
5. there are not enough routes for training (cyclists only);
6. there are not facilities to change clothes at destinations like work and school;
7. the climate is not agreeable;
8. hills are too difficult; and
9. other.

Respondents were asked to rank their responses, but since respondents did not rank them consistently, the results were tabulated on the frequency of the selection of a specific problem (see Table 8). Both the students and community center user group and the cyclist group respondents selected the problems of drivers’ aggressiveness and lack of respect, the lack of infrastructure, and the poor conditions of streets most frequently. There was a slightly different ranking of these problems between the two groups, but for both they were the top three. The lack of appropriate routes for training also tied for second place for cyclists, though the survey for students and community center users did not contain this option. Climate was not in the top three selected problems for cycling in the survey for either group, but the weather is hot in the summer in Chihuahua.\textsuperscript{14}

Informal conversations and focus groups revealed that some perceive it to be too extreme for riding a bicycle. Unfortunately, climate is not something that can be changed via urban planning policies except in the very long-term sense of global warming. However, the effect of the heat can be mitigated or worsened by the amount of green space and asphalt in the city, and shade can provide respite from the heat. These situations can be improved through planning endeavors.

There were slight differences in the infrastructure that each group thought was most important for cycling (see Table 8). Both groups selected bicycle lanes in streets and in parks and gardens as the two most important types of infrastructure. This was surprising, because in focus groups, conversations, and other venues, people expressed the concern that bicycle lanes in the streets were not safe and would not be respected by drivers. The third choice for infrastructure for students and community center users was bicycle stations, described in the survey as places where bikes could be rented, parked, and repaired for small fees. Cyclists preferred bicycle lanes on sidewalks, which was again surprising, considering the potentially slower speeds and conflict with pedestrians that more experienced cyclists might be more eager to avoid.

\textsuperscript{14} Refer to Chapter 4.
The survey also asked questions to explore reactions to the provision of infrastructure. By far the majority of both groups said they would consider riding a bicycle if bicycle lanes and routes existed. Of those that do not ride in the streets, 78% of the students and community center users and 93% of the cyclists responded that they would consider cycling as a form of transportation if there were bicycle routes or lanes. 77% of students and community center users and 73% of cyclists said they would use a bicycle more frequently if streets were smaller and cars moved at slower speeds. Some people responded negatively to the idea of riding in smaller, rather than wider streets. Cyclists were asked if they would use parks with bicycle routes along the Rio Sacramento or other natural places. 87% responded that they would use such an amenity, and 13% responded maybe. No respondent answered that they would not use such an amenity.

Almost all of the respondents in both groups were in favor of using more ecologically friendly forms of transportation, walking and riding bicycles to have a cleaner city, and using bicycles as a mode of transportation. Despite this, most do not use a bicycle as a form of transportation (see Figure 53), and many do not use one at all. In this question, people were able to choose all of the types of trips that they used a bicycle for, so the total amounts in Figure 53 do not necessarily add up to 100%. Of the 18 students and community center users who responded to a question regarding the types of trips made by bicycles, 83% use them for recreational trips and none use them as a way to commute to work or school. A small percentage did use their bicycles for shopping or other trips besides recreational use. Only 13% of the cyclist group uses a bicycle for commuting trips. Cyclists, however, were more likely than the other respondents to use a bicycle for more utilitarian trips, though many denied the viability of cycling as a form of transportation due to the various challenges of riding a bicycle in Chihuahua.
Figure 53: Types of trips made by bicycle for respondents who ride a bicycle

* Multiple selections could be made, so the percentages only apply to respondents for the particular category over all respondents and do not add to 100%.

The survey also contained some questions regarding family members’ bicycle use. It was most common for children of the family to ride a bicycle and for those trips to primarily be made for recreation purposes (Figure 54 and Figure 55).

Figure 54: Family members who ride a bicycle

* Multiple selections could be made, so the percentages only apply to respondents for the particular category over all respondents and do not add to 100%.
Out of the students and community center users who do not use a bicycle, the top three reasons were safety (32%), the lack of a bicycle and lack of intention to buy one (29%), and length of distances and trips (22%). This last issue of distance was raised a number of times in conversations with survey respondents and in focus groups, even though my distance calculations in Chapter 7 determine that 63% of the trips in the origin destination survey could be suitable for IMPLAN's target bicycle trip of less than 4.5 kilometers. IMPLAN's proposal to integrate the first bicycle routes with the new bus rapid transit line is an attempt to address the perception that trips are often too long to complete solely with a bicycle.

Cyclists were asked whether they rode in the streets, and students and community center users were asked where they or their families rode a bicycle. 87% of cyclists claimed to ride in the streets, but anecdotal information suggested that this was mainly on highways while training. Cyclists tended to express discomfort with using bicycles on urban streets. The large majority of students and community center users claimed to use bicycles in parks, although about one-third also responded that they cycled on the streets and sidewalks (see Figure 56).
Both groups were asked who they thought rode bicycles. In the student and community center group, the most popular answer was children. A smaller number thought typical cyclists were athletes. Other suggestions were young people, people with low-incomes, and people without cars. Among cyclists, the most common responses were athletes and people without cars.

The survey also asked for whom it was appropriate to ride a bicycle. This question was designed to determine who respondents thought could be potential cyclists. The largest number of students, community center users, and cyclists suggested that cycling was viable for everyone. The next most popular group for whom cycling was considered viable was young people, which corresponds with the perception that these are the people riding bicycles currently. Both groups suggested that cycling was least viable for those with health problems.

Finally, both groups were questioned regarding the motivations for both themselves and other people to ride bicycles (see Figure 57 and Figure 58). Respondents most often claimed that their own motivation to cycle involved health interests, while the motivation for others had more to do with affordability of cycling as a mode of transportation. Respondents of both groups considered environmental concerns a motivation more often for themselves than others.
These results reveal a level of stated willingness to ride a bicycle, and a value in the health and ecological reasons for riding a bicycle, but this is not yet reflected in behavior. Respondents tended to believe that others are more likely to ride a bicycle for financial reasons. The construction of additional infrastructure can improve this situation, as a significant number of people stated that they were willing to consider cycling if there were better facilities, however, literature review on cycling suggests that more effort will be required to influence a significant mode shift.

**Pistolas Meneses Park Users**

It seemed likely that there would be more people who occasionally rode bicycles for recreation in the park. In our fieldwork in Pistolas Meneses Park, we did see many
cyclists, though not all of the respondents of this survey rode bicycles. The more informal conversational structure of the survey provided more anecdotal information on perceptions towards cycling.

The main purpose of the survey of Pistolas Meneses Park users was to determine which types of cycling infrastructure were most appealing to these respondents, and why this was the case. We showed pictures of bicycle lanes in streets, on sidewalks, in parks, and on medians. We also showed pictures of other bicycle facilities, including bicycle parking, bicycle stations such as the one in Millennium Park in Chicago, and signaling systems specially designed for cyclists. As was expected, many felt that bicycle lanes in the street were not safe. The most popular proposed infrastructure was IMPLAN’s bicycle lane design on medians (see Figure 35). However, a small number of the respondents recognized the potential conflicts at intersections inherent in this design. To some, the signaling system seemed attractive.

This more open-ended process did support earlier indications that there would be a challenge to turn recreational users into regular on-street cyclists. These surveys also supported the conclusion that the road culture was perceived as dangerous for cyclists and would be a barrier to eliciting additional bicycle trips.

**Focus Groups**

The goal of the focus groups was to further explore the attitudes and perceptions of targeted groups towards cycling as a form of transportation, and to better determine the challenges to promoting cycling as a form of sustainable transportation in Chihuahua. I conducted two focus groups with the help of the team described earlier: one in a community center (see Figure 59) and one at IMPLAN with a small group of four cyclists. I intended to complete three focus groups, with the third one including students, each with a minimum of eight participants. Unfortunately, only one of the eight confirmed students came to the focus group meeting. An employee from IMPLAN called to confirm the attendance of more than eight cyclists for another focus group, but only four attended. This lack of response might indicate unwillingness, even on the part of cyclists, to spend time talking about cycling issues. The attendance of the workshops described in Chapter 6 may counteract this theory, though the targeted attendees were somewhat different. The low attendance may also reflect problems with the times we selected to hold the focus groups.

The focus group team consisted of a moderator, sound and video recorder, note taker, and two observers. All members of the team, excluding me, were native Spanish speakers.

Appendix E and F contain the scripts for the focus groups that served as a guide to the moderator.

Arturo Tovar
The cyclist focus group attendees were drawn from those who participated in the survey. To try to contact a wider group of cyclists, I searched for, but did not find organizations that keep lists of cyclists. Part of the problem was that there was an apparent lack of organized groups of cyclists, or groups that kept track of or advocated for cycling-related issues. Future work should include better tracking of cyclists in order to include those who might be interested in the planning process for cycling infrastructure.

Results

**Community Center Focus Group**

We completed the community center focus group at CDC Karike, the northernmost community center in Figure 48. There were originally ten participants, all of whom were women ranging in age from adolescent to the elderly. Later, two more participants joined the group, one of whom was male. The participants in this focus group did not receive a prior invitation; they were at the community center at the time to attend classes or to pick up or drop off their children.

The group was dominated by the most aggressive speakers and the moderator did not actively encourage others in the group to contribute, so the dynamic of the group did not include much disagreement or debate. The concern with this type of group dynamic is that a few people might have overly influenced the answers of the other participants.

The participants were asked a variety of questions about their perceptions of the city, the environment, health problems, transportation, and cycling. The major health concerns identified by the participants (asthma and allergies) were connected to air quality. While there was some debate in the group over whether the city was clean or contaminated, the debate ended with the expression of the opinion that although there was air pollution, the levels were not serious when compared to other cities in Mexico, such as Juarez.

Participants first cited transportation as a cause for the pollution, perhaps skewed by the initial explanation of the purpose of the focus group. Participants singled out public transportation over private automobiles as the primary cause of the pollution within the transportation sector. This is not surprising, as the poor conditions of the buses in Chihuahua and use of diesel fuel results in noxious, visible exhaust. Participants also suggested that factories are another cause of pollution. Finally, participants noted that people do not have a habit of cleaning the streets.
The moderator asked participants how individuals could help fix the problem of pollution in the city. Initial suggestions included not littering, cleaning up the fronts of houses, and other cosmetic improvements. Other members of the group later suggested ‘no driving days,’ using fertilizers with less environmental impact, and removing trash.

The moderator shifted to the topic of bicycles by first asking participants who they thought typically rode them. This group thought of cyclists as people who are healthy, who cannot afford a car, and the elderly. The last of these three categories was surprising since at other times participants stated that it was difficult for the elderly to commute by bicycle.

Participants expressed the concern that some cyclists are imprudent (around cars) or that cyclists are trying to use a space that was not designed for them. The conclusion that arose from discussion of these comments was that there should be separate routes or that cyclists be limited to riding in the periphery of the city. Due to the danger inherent in cycling, it was viewed as a way to exercise but not as a viable form of transportation. One person suggested that it should be used as a form of transportation to reduce traffic, to which others responded that riding to work would not be viable due to distances.

There was a consensus in the group that education and awareness are necessary for both cyclists and drivers. When asked what infrastructure was needed for cyclists, the conversation focused on safety equipment and security for cyclists. All agreed that parking for bicycles is important, including at work, where a company could ensure the bicycle’s security. Participants also suggested the use of helmets and vests to make cyclists visible to drivers. One participant thought collapsible bicycles were practical, and another suggested that companies provide incentives for riding to work through bonuses.

Finally, I showed participants several types of infrastructure, including bicycle lanes in the street, sidewalk, and in parks; signaling systems; and bicycle parking, similar to the pictures that we showed the Pistolas Meneses Park users. These participants expressed some interest in the bicycle signals to cross traffic, and generally rejected bicycle lanes in sidewalks due to a fear that there would be no sidewalk space left for pedestrians.

This focus group highlighted a conflicting sentiment that while cycling is good for the environment and for personal health, it is not safe. The safety issues were attributed to the behavior of both cyclists and drivers. While there is a positive attitude towards cyclists who choose to ride a bicycle, it is often also seen as a sign of poverty.

Cyclist Focus Group
The benefit of having such a small number of cyclists for this focus group was that everyone contributed significantly to the conversation. Only one participant, an Argentinean who had lived in Chihuahua for six years and appeared significantly older
than the others, makes most or all of his trips on a bicycle. The rest, including a student and two middle aged men, all of whom were Mexican, ride a bicycle primarily for sport.

This group perceived a more critical environmental situation in Chihuahua, including accelerating deterioration of air quality, lack of green space, noise pollution, and potentially uncontrolled growth. They agreed that these problems were both the fault of the government and individual behavior. They proposed various solutions to these problems, including more green space, better automobile maintenance, and recycling.

In general, this group felt that that the transportation system was dominated by cars, and that car ownership is higher than necessary in Chihuahua. They partially attributed the current high automobile ownership to the fact that factory workers used to ride bicycles but can now afford cars. They also recognized various faults in the public transportation system, including buses in poor condition, poor scheduling, and minimal competition.

This group had much to say about cycling. First, most of the group felt that it is impractical or impossible to ride in the city. They also commented on poor driving, including driving under the influence of drugs and alcohol, and suggested that it is too easy to get a driver’s license. They talked about the danger of cycling, and the fact that there is no cycling culture. They agreed that the people in Mexico, or Latin America in general, are not very interested in exercise and therefore do not seek the health benefits of cycling. Also, they considered bicycle theft a serious problem.

In a discussion about bicycle infrastructure and how it might be applied in Chihuahua, one cyclist commented on the bicycle lanes that had been painted on streets in nearby Delicias, but are already difficult to see (see Figure 60). Unfortunately, drivers are not respecting the bicycle lanes by driving and parking in them.

Figure 60: Bicycle lanes in Delicias, Mexico

One participant suggested that if bicycle lanes or routes were to be created in Chihuahua, there should be incentives to use them. He explained how he provides an incentive for cycling: he offers a 20% discount to people who ride their bicycle to his café. Another suggested that infrastructure be provided with careful consideration of use. For example, a route that goes to major attractions could be used by tourists, and one that goes through a beautiful natural area could be used for recreation.
This focus group highlighted a number of perceived challenges to cycling that prevent even experienced cyclists from considering it a viable form of transportation. These include physical safety, built environment challenges, and social and cultural issues. This focus group might also have represented a tendency towards more environmental awareness in higher-income, physically active groups in Chihuahua.

**Conclusions**

Although little cycling history or culture exists in Chihuahua, there is generally a positive response to the proposal of promoting cycling as a form of sustainable creation to create positive change in the city. Respondents in these surveys and focus groups suggested that more cycling could help abate pollution, natural resource consumption, cost of transportation, and health problems. However, the less than one percent commute mode share for cycling suggests that some major barriers remain to cycling as a viable form of transportation. According to the respondents and participants of the surveys and focus groups, barriers include, but are not limited to the following issues related to the perceptions and attitudes towards cycling:

1. The road system is designed for use of automobiles, whose drivers are irresponsible. The existence of a variety of users, including cyclists, may only exacerbate the problem.
2. There is no cycling culture and minimal organizing around cycling issues, which results in little advocacy around cycling. While some politicians express support for the promotion of cycling, it was not clear that there were many avenues to effectively promote it as a form of transportation.
3. Current road conditions are far from satisfactory for cycling, even if bicycle lanes are added to existing roads. Though separated cycle lanes may help, they may also cause problems at intersections and conflicts with pedestrians.
4. There is a social perception that automobiles represent higher status, and that riding a bicycle, unless done for recreation or sports, represents an inability to afford an automobile.
5. Automobiles are not necessarily considered one of the most critical sources of environmental problems in Chihuahua.
6. Trip distances are perceived as too long for bicycles due to a variety of challenges, including the climate, topography, and physical limitations.

These barriers point largely toward a need to improve infrastructure for bicycle use, a need to change the road culture (attitudes and resulting behavior on the road) to be safer for more users, as well as a need to increased education and awareness of environmental problems and the benefits of cycling. These recommendations are summarized in some greater detail in Chapter 8, and in the original report (Teich, 2007).

Once again, these conclusions can only be linked to perceptions of the people surveyed and in the focus groups. This is the limit of doing a targeted, instead of a random sample.

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17 See Appendix G.
survey. Focus groups also provide limited results that cannot be generalized to the population, for a variety of reasons that are well-known (the influence of certain focus group participants on other participants, the fact that many people in the focus group likely know each other, etc.), some of which have already been discussed. The surveys and focus groups complement each other, and can also be supported through additional anecdotal information. The general impression I had after living in the city for ten weeks during the summer was that these feelings exist in force in the city, at least for those who think about cycling. These results should, of course, still be treated with skepticism. I was concerned that the enthusiasm and openness towards cycling was exaggerated by the fact that respondents tended to know that the primary focus of the surveys and focus groups was cycling. However, the analysis of the visioning process in the following chapter contributes to the sense that the enthusiasm does exist, at least within certain groups.

One of the resulting recommendations from this analysis, discussed in greater detail in Chapter 8 and Teich (2007), is to improve the planning process to better promote cycling as a form of transportation. This helped me formulate part of my approach to answering my research question. Chapter 6 explores the application of this part of my approach to address the recalibration of planning tools and processes to more directly affect behavioral change given the specific social and cultural barriers to promoting bicycle use.
Chapter 6: Visioning and Goal Setting in Chihuahua, Mexico

Introduction

As previously mentioned in Chapter 2, Jansen (2003) describes the process of backcasting as containing three major elements, two of which are the creation of a long-term vision that leads to a short-term approach. In January of 2008, I held three workshops at IMPLAN in Chihuahua as a way to accomplish these two elements, with the goal of assisting in the third, which is the implementation of the established short-term approach. After this point I will refer to the visioning and goal setting process as a separate entity than the specific action of backcasting. In this sense, backcasting is the act of using the results of the visioning process to calculate how to achieve those goals from actions in the present. I was not able to carry out quantitative backcasting, but instead used the third workshop to ask participants to qualitatively determine the steps that would have to occur today to achieve goals established during the first two workshops. The end of this chapter includes a recommendation for a more intensive visioning process followed by quantitative backcasting that can lead to a different understanding of the steps that need to occur today to achieve those goals.

I had four main goals for engaging in the process, which I established prior to the workshops:

1. Engage major stakeholders in planning for cycling, raising awareness and support for the cycling proposal.
2. Foster activism towards cycling and access for cycling advocates to major government stakeholders through their inclusion in the process.
3. Contribute to the four components of creating social change towards sustainable transportation, summarized from Gatersleben and Uzzell (2002).
4. Calibrate this thesis so that the results are more relevant and useful for IMPLAN in achieving their sustainable transportation plan.

These goals were accomplished through the three workshops in the following ways. By engaging government officials, cyclists, planners, and other relevant stakeholders in creative conversations that highlighted the importance of cycling as a form of sustainable transportation, the workshops not only raised awareness and support but also offered an opportunity for networking between stakeholders interested in promoting cycling. Following the four elements of creating social change defined by Gatersleben and Uzzell (2002), the workshops included the presentation of the environmental, economic, and social challenges in Chihuahua; the provision of information on the existing barriers to cycling; the engagement of participants to more clearly define the social good through visions of the future; the encouragement of participants to consider the role that they and others could play in creating change; and the offering of an opportunity to participate in the planning process, an avenue for affecting change. Finally, I was able to obtain more information and a different perspective of the planning process and participants’
perceptions of cycling as a form of sustainable transportation, which helped recalibrate some of my conclusions and recommendations from previous work.

This was a truncated version of what could have been a much longer, more detailed planning process including the exploration of well-designed scenarios of the future. However, an approach this detailed was not feasible given my timeframe and resources. If IMPLAN or a similar planning agency were to carry out a visioning process such as this in the future, or a more intensive scenario planning process, it should be done at an earlier stage in the planning process.

**Description of Workshops**

The workshops involved several steps to establish goals and determine how they might be achieved. In the first two workshops, which had the same structure but different participants, participants were asked to discuss their **visions** of a sustainable future in Chihuahua, particularly in terms of transportation characteristics. They were then asked to narrow their visions to determine the appropriate sustainable transportation goals, and specifically, the role of cycling in those goals. In a third workshop, which was attended by participants from both of the first two groups, participants performed qualitative **backcasting**. They brainstormed the appropriate steps to take in order to realize those goals using case studies of cities with various bicycling mode shares as examples or guides. The resulting recommendations for the current steps that should be taken to realize these goals can be compared to the cycling plan in the PSMUS, which focuses mostly on infrastructure improvements.

**Workshops 1 and 2**

The first two workshops were held on the same day, and had the same agenda but with two different groups of participants. The first workshop included employees of IMPLAN and various government departments at both the municipal and state levels. The second workshop included employees that worked more directly on cycling issues, as well at least three cyclists. 18

The two-hour workshop began with a 15-minute presentation in Spanish, including an introduction to my work; a quick definition of sustainable transportation; some characteristics of Chihuahua relevant to sustainable transportation, including social, environmental, and economic challenges; and an introduction to visioning and goals setting. This last section included an argument for the importance of the process, definitions of relevant terms, examples of relevant goals, and some guidelines to establishing goals.

The discussion was moderated by the consultant responsible for implementing the PSMUS and former director of IMPLAN. 19 The discussion had the following objectives:

1. Establish a vision of the city with sustainable transportation in 2040.

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18 For more information on workshop participants, see Appendix H.
19 Salvador Herrera Montes
2. Detail the role that cycling plays within this vision.
3. Set goals for cycling that will realize this role.

We had also planned to discuss and establish indicators for realizing those goals, but we ran out of time. To fill in this gap, I estimated some indicators associated with the established goals after the meeting (see Table 12 in the results section).

**Workshop 3**

Participants in the third workshop included two IMPLAN employees, seven participants from the first workshop, and one from the second. These were all government employees, including representatives from the state-level Department of Transportation, Office of Communication and Public Works, and Department for Sports and Physical Culture, along with the municipal-level Office of Public Works, Planning Department, Office of Economic Development, and Urban Development and Ecology Department.

I compiled and sent a summary of case studies to workshop participants in advance. I summarized various United States, Canadian, and European cities in the categories of general characteristics (population, size, terrain, climate), bicycle infrastructure, cycling-related education, intermodality, cycling advocacy, and information. The southern U.S. examples of Phoenix, Arizona and Albuquerque, New Mexico were the closest to the Chihuahua case in respect to general characteristics and low bicycle mode share. IMPLAN requested that I include them as case studies due to the perceived similarity to Chihuahua.

The hour-long workshop began with a ten-minute presentation in Spanish in which I first summarized the goals established in the first two workshops in a table. I then proposed a target mode share of bicycle use (25%) based on feedback in the prior workshops (see Figure 61). I provided an estimate of the potential impact of the bicycle infrastructure proposed in the PSMUS based on case studies and research, followed by the conclusion that the desired mode shift was not likely to occur without additional interventions (described in greater detail below). I ended the presentation with a summary of the recommendations from the Teich (2007) report to stimulate consideration of the wide variety of ways to promote cycling.

I offered two different estimates of the impact of infrastructure on cycling mode share to the participants of the workshop (see Table 9). First, I estimated that there would be a three to five percent mode share of cycling after the construction of the 279 kilometers of bicycle infrastructure described in the PSMUS (IMPLAN, 2007d). I based this first estimate on consideration of the Chihuahua context and comparison to other case studies. My second estimate was a 30% new bicycle mode share based on the GEF (2006) prediction of 2,200 new trips per kilometers of constructed bicycle lanes, described in greater detail in Chapter 2.

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20 See Appendix I for the Spanish version of the table of case studies.
Recall that the GEF (2006) results were from a before and after study in Rio de Janeiro and Bogotá, and that this very same report recognized that infrastructure alone is not enough to promote bicycle use. In addition, I pointed out that according to some studies, bicycle lanes that have a positive impact on cycling trips are often built in areas that already have cycling trips (Barnes et al., 2006; Dill & Carr, 2003), which would not apply well to the Chihuahua case.

The case studies that I gave to the participants also indicated a difficulty in drawing a direct relationship between infrastructure and bicycle mode shares (see Table 10). Specifically, the highest and lowest mode shares in this group of case studies do not correspond to the highest and lowest gross amount of bicycle infrastructure. In fact, Albuquerque and Phoenix have many more kilometers of bicycle lanes than Copenhagen, and yet the percent of work trips made by bicycle is only approximately one percent. This presentation may have been deceptive in that perhaps a more valuable way to think about the relationship of bicycle infrastructure and mode shares is the density of infrastructure, or kilometers of bicycle lane per area or kilometer of road. Other studies, such as Dill and Carr (2003), suggested that it was also difficult to find patterns of mode share associated with density of bicycle infrastructure. Nevertheless, I did not normalize bicycle infrastructure by area or road miles in the case studies, which may produce different results.

### Table 9: Estimates of possible mode shifts presented in Workshop 3

<table>
<thead>
<tr>
<th>Km Bicycle Lanes</th>
<th>Guess of Bicycle Mode Share Based on Case Studies</th>
<th># New Bicycle Trips According to GEF*</th>
<th>Bicycle Mode Share Estimated from Applying those to Total Trips*</th>
</tr>
</thead>
<tbody>
<tr>
<td>279</td>
<td>2-5%</td>
<td>613,800</td>
<td>30%</td>
</tr>
</tbody>
</table>


**Based on: 2,012,772 total trips, described on page 143
### Table 10: Summary of characteristics of case studies in visioning workshops

<table>
<thead>
<tr>
<th>City</th>
<th>% Bicycle Trips for Work Commutes</th>
<th>Km Bicycle Lanes</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copenhagen, Denmark</td>
<td>36.0%</td>
<td>300</td>
<td>1,825,814</td>
</tr>
<tr>
<td>Berlin, Germany</td>
<td>10.0%</td>
<td>1140</td>
<td>3,410,000</td>
</tr>
<tr>
<td>Victoria, Canada</td>
<td>4.8%</td>
<td>377</td>
<td>330,088</td>
</tr>
<tr>
<td>Vancouver, Canada</td>
<td>1.9%</td>
<td>133</td>
<td>2,116,581</td>
</tr>
<tr>
<td>Albuquerque, New Mexico</td>
<td>1.2%</td>
<td>480</td>
<td>448,607</td>
</tr>
<tr>
<td>Phoenix, Arizona</td>
<td>0.9%</td>
<td>725</td>
<td>1,321,045</td>
</tr>
<tr>
<td>Toronto, Canada</td>
<td>0.8%</td>
<td>252</td>
<td>5,113,149</td>
</tr>
<tr>
<td>Chihuahua</td>
<td>?</td>
<td>(279*)</td>
<td>713,000**</td>
</tr>
</tbody>
</table>

* Amount of infrastructure proposed by IMPLAN in the PSMUS.

** Rounded off from the 2005 population.

Source: Various. Refer to Appendix I.

The Dill and Carr (2003) study involved a regression analysis of bicycle mode shares and on-street bicycle lanes normalized by area for 35 U.S. cities. Despite their difficulty in finding patterns, Dill and Carr’s analysis suggested that each additional mile of on-street bicycle lanes would lead to a one percent point increase in bicycle commutes. Assuming IMPLAN’s proposed 279 kilometers of bicycle lanes are all on-street (which they are not) and an urban area 20,000 hectares, IMPLAN’s proposal would result in 2.25 on-street bicycle lanes per square mile, higher than any city in the Dill and Carr study. Applying Dill and Carr’s findings and adding in the existing .3% bicycle mode share results in approximately a 2.5% bicycle mode share.

While I also offered the more optimistic 30% estimated increase in bicycle trips based on the GEF (2006) findings, I also emphasized that the prior assessment of attitudes and perceptions, literature review summarized in Chapter 2, and case study review indicated that infrastructure would not be enough to elicit this estimated change. I presented the theory that social and cultural factors are more relevant in the choice to ride a bicycle, leading to the summary of my recommendations of other policies that will have to be implemented to promote cycling in Chihuahua. I encouraged the participants to consider a wide variety of ways to meet the target bicycle mode share of 25%.

After the presentation, the participants spent approximately 50 minutes brainstorming how to achieve a 25% bicycle mode share in 2040 given the specific challenges faced by Chihuahua, keeping in mind the various goals established in the earlier workshops. Participants were asked to determine next steps in each of the categories included in the case studies, including city characteristics, infrastructure, education, intermodality, advocacy, and information.
Results
Results from Workshops 1 and 2
The results from the first two workshops included a variety of potential visions of Chihuahua (see Table 11). The visions were not always complementary and sometimes were merely projections of trends rather than characteristics of a hypothetical sustainable city, so it was difficult to include only the comments that appropriately addressed the task at hand. We did not have time to come to a consensus on a unified vision of a sustainable Chihuahua. However, I selected one scenario of a future bicycle mode share from these workshops to guide the qualitative backcasting in the third workshop.
<table>
<thead>
<tr>
<th>Category</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population/growth</td>
<td>- The city’s population will not grow much due to the limits of natural resources.</td>
</tr>
<tr>
<td></td>
<td>- The city will grow from 730,000 to three to four million inhabitants with higher quality of life.</td>
</tr>
<tr>
<td></td>
<td>- Growth will be vertical.</td>
</tr>
<tr>
<td></td>
<td>- The city will become denser, more compact, with more use of public transit.</td>
</tr>
<tr>
<td></td>
<td>- There will be more integration of natural features/resources, including rivers, streams, and hills as part of urban development.</td>
</tr>
<tr>
<td>Social characteristics</td>
<td>- Society will be more diverse.</td>
</tr>
<tr>
<td></td>
<td>- The population will be super educated, which will include the following characteristics:</td>
</tr>
<tr>
<td></td>
<td>o A more conscientious public regarding global warming and the effect of vehicles, which will include making choices that consider the natural environment.</td>
</tr>
<tr>
<td></td>
<td>o Increasing mentality of caring for their bodies/physical health.</td>
</tr>
<tr>
<td></td>
<td>o Existence of education for bicycle use and culture</td>
</tr>
<tr>
<td>Economy</td>
<td>- The economy will be more conservative (unclear what conservative means in this context).</td>
</tr>
<tr>
<td></td>
<td>- The economy will revolve more around technology and knowledge.</td>
</tr>
<tr>
<td></td>
<td>- There will be more employment in the center of the city, so that jobs can be accessed by bicycle.</td>
</tr>
<tr>
<td></td>
<td>- Companies will be more conscientious, with fiscal incentives to use bicycles.</td>
</tr>
<tr>
<td>Modes</td>
<td>- Balance between cars, public transit, and non-motorized transportation</td>
</tr>
<tr>
<td></td>
<td>- Less use of cars</td>
</tr>
<tr>
<td></td>
<td>- Mass transit system, part free and part paid</td>
</tr>
<tr>
<td></td>
<td>- Higher cost of gasoline</td>
</tr>
<tr>
<td></td>
<td>- A culture permeated with bicycle use without elitism of bicycle use.</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>- Better infrastructure for all uses.</td>
</tr>
<tr>
<td></td>
<td>- Inaugurate a new type of street infrastructure.</td>
</tr>
<tr>
<td>Technology</td>
<td>- Bicycles and infrastructure for bicycles of the future – wind free bicycle corridors, chain free bicycles, etc.</td>
</tr>
<tr>
<td></td>
<td>- Hybrid and electric vehicles</td>
</tr>
<tr>
<td>Policy</td>
<td>- Employ public policies to promote and discourage different modes of transportation. Some considerations include car free city centers and care free days.</td>
</tr>
<tr>
<td></td>
<td>- Recreovías (areas where streets have been closed to car traffic for recreational non-motorized transportation use) in the north and south of the city, or all over the city.</td>
</tr>
<tr>
<td></td>
<td>- Use resources on publicity to foment cycling</td>
</tr>
</tbody>
</table>

21 The results are translated from notes from the meeting and a table that was created by Mario Sila during the session on a projector.
Some participants envisioned the future as growing dramatically while being constrained geographically, causing increasing density and compactness. Some imagined a sustainable future with limited or no growth in the city. Participants identified diversity and education as important qualities in a sustainable future, because they would lead to a heightened sense of environmental and health issues. Visions of the economy varied, but most participants did predict a change in the types and locations of employment that dominate in the city.

The visions of sustainability included different ideas of future mode shares, all of which involved more cycling, transit use, and walking, along with a reduction in private automobile use. There seemed to be a general consensus in the workshop that although car ownership and usage is increasing, they will have to be curbed to achieve a sustainable Chihuahua in the future. Figure 61 summarizes three scenarios for new shares of transportation trips in 2040 based on the workshops compared to the current mode share.

**Figure 61: Scenarios of alternative mode shares in Chihuahua, 2040**

![Graph showing mode shares in Chihuahua 2040](image)

Table 12 includes a summary of the goals established by participants in the workshop after creating the outline of the vision for a sustainable future. I divided these goals by the three typical components of sustainability: environmental, economic, and social. The contents of the goals themselves came entirely from the participants. The environment was interpreted as both ecological and physical, and this category contains goals such as lowering emissions and appropriate urban design. Economic goals focused on private company incentives and economic development through cycling. Social goals were related to health, legal concerns, and the development of a cycling culture. Other goals that did not fit as well in these three categories included infrastructure improvements and intermodality.

After the workshop I incorporated an initial proposal of ways to think about and measure indicators that might be useful for measuring the achievement of these goals since there
was not time in the workshops to debate them. I did not determine precise indicators, because these would be better established by IMPLAN, which has for more intimate knowledge of the context and data gathering capabilities. The supplementation of the workshop results with my proposed indicators offer IMPLAN an initial exploration of both creating and measuring goals surrounding cycling in the PSMUS. This, however, is a very brief, vague initial attempt and should be expanded on in a more rigorous fashion.

Table 12: Cycling goals to realize a sustainable vision of Chihuahua, 2040

<table>
<thead>
<tr>
<th>GOAL</th>
<th>POTENTIAL MEASUREMENTS RELEVANT FOR INDICATORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td></td>
</tr>
</tbody>
</table>
| Contribute to urban design and appropriate environment | 1. Kilometers of bicycle lanes in linear parks  
2. Amount of urban furniture  
3. Number of trees |
| Lower pollution: Recommended reduction in pollution of 5% by 2015 and 25% by 2030 | 1. Estimate the reduction of pollution based on number of trips switched to bicycle |
| Economic |  |
| Companies providing fiscal and other incentives for cycling | 1. Number of companies with bicycle facilities (parking, showers, etc)  
2. Money spent per employee on bicycle related incentives  
3. Savings in health insurance due to more active lifestyles |
| Increase spending on cycling | 1. Monitor the budget: suggested 10% of resources dedicated to non-motorized transportation |
| Lower the cost of living | 1. Measure the cost of transportation within the average cost of living.  
2. Measure savings in gasoline, insurance, and other expenses related to using non-motorized transportation. |
| Increase the number of events that promote or involve cycling as a way to also increase economic activity. | 1. Number of events  
2. Money spent on services and companies participating in the event  
3. Number of users of the Recreovia |
| Businesses involving bicycles or cycling (such as messenger services, bicycle tours for tourists, bicycle shops, etc.) | 1. Measure the contribution of these businesses to the economy |
| Social |  |
| Reduce the number of illnesses related to sedentary lifestyles. Recommended improvement of making people 50% healthier | 1. Measure changing overall health compared to changes in mode shares in non-motorized transportation.  
2. Compare health of those who commute by bicycle compared to those who commute by car or public transit |
| Establish appropriate laws to protect cyclists | 1. Number of new laws with restrictions protecting cyclists  
2. Number of accidents involving cyclists  
3. Number of prosecutions of drivers involved in accidents with cyclists |
| Increase the number of young people who ride bicycles | 1. Number of young people who own and ride bicycles  
2. Number of programs in schools promoting cycling and cycling safety  
3. Bicycle infrastructure in schools and universities  
4. Number of parents who claim to teach their children how to use a bicycle safely |
| Organize more bicycle events to raise consciousness of issues related to cycling | 1. Number of events  
2. Number of users of the Recreovia  
3. Surveys at events to understand whether they have succeeded in bringing about a change in consciousness. |
| Other |  |
| Promote intermodality, primarily between public transit and bicycles | 1. Number of parking spots for bicycles at transit stops  
2. A count of users of public transit who arrive by bicycle, as well as a survey to determine level of service  
3. Number of buses with bike racks |
| A connected cycling network | 1. The ability to access all of the city via bicycle infrastructure  
2. Number of breaks in the bicycle infrastructure network |
| Include bicycle lanes in all road projects | 1. Existence of a law to require the incorporation of bicycle lanes in all road projects  
2. Number of new projects (new roads or repaving of old roads) with infrastructure for bicycles |
Table 11 and Table 12 include the combined results of both of the first two workshops. The participants of the two workshops comprised groups with different characteristics, but have surprisingly compatible visions and goals. Both groups, for example, recognized the importance of incentives and policies to promote cycling, but also stated the importance of better automobile technology. Both groups prioritized a focus on children to promote more bicycle use. The greatest difference involved the growth of the city. To illustrate the extremes, a participant in the first group suggested that the population and size of the city should not grow. In contrast, a participant in the second group suggested a vision of Chihuahua as a city of three or four million people in 2040. Another difference was that the second group, which included more cyclists, thought more about technology for bicycles. However, there was also some variation within the groups, so the differences between them should not be emphasized too heavily.

Results from Workshop 3
Participants in the third workshop engaged in a qualitative backcasting exercise, estimating the steps that would lead to the goals summarized in Table 12. These goals were made more concrete through the use of the equality scenario, which had the highest bicycle mode share of 25%, established from the first two workshops (see Figure 61). I selected this scenario as the goal for the backcasting workshop because it was aggressive, but still included car use, unlike the Car Free scenario. Since visioning exercises are useful to achieve creative solutions to transportation problems (Jansen, 2003), this was not the appropriate time to select the most conservative approach, which is useful in other parts of the analysis.

To reach the proposed 25% cycling mode share, workshop participants suggested a variety of approaches within the categories that were represented in the case studies provided before the meeting. In terms of city characteristics, participants emphasized the need to create sub-centers, increase densification, and provide a mix of land uses. Densification in particular represents a departure from the existing trends in the city. Many of the participants suggested ways to reach the targeted mode share through additional infrastructure improvements or refining the infrastructure proposal from IMPLAN, illustrating that the participants still found it easy to fall back on discussion of infrastructure-based solutions. Education and advocacy recommendations centered on the idea of changing the road culture, described in Chapter 4. Participants also considered policies that might have an indirect effect on cycling, such as parking availability and pricing to create a disincentive to driving.

Many of these recommended next steps (described in more detail in Table 13) are similar to the recommendations made in the Teich (2007) report. This was within the expected outcomes of the workshop, because prior work was based on research, reports, and case studies. Instead, the combination of suggestions was specific to the context in Chihuahua, and might serve as a guide for this type of city to achieve dramatic change towards encouraging greater bicycle use.
Table 13: Next steps to achieve a 25% cycling mode share in Chihuahua, 2040

| City Characteristics | - Create city sub-centers to have various concentrated areas of activity.  
|                      | - Intensify and mix land uses.  
|                      | - Provide incentives for densification, to be achieved through interesting, innovative projects.  
|                      | - Make public space more attractive, with more consideration of users, including cyclists.  
| Infrastructure       | - Create intelligent bicycle routes that:  
|                      |   • are focused on practicality rather than recreation.  
|                      |   • connect commercial centers, neighborhoods and schools, people with the bus routes, and the rest of the city to the center.  
|                      | - Locate bicycle routes along rivers.  
|                      | - Realize a gradual process of inclusion of bicycle routes through starting with lanes in secondary road versus primary roads.  
|                      | - Perform adequate maintenance on bicycle routes.  
|                      | - Design subprojects and developments in accordance with bicycle needs.  
|                      | - Provide safe bicycle parking (ciclopuertos).  
|                      | - Provide bathrooms in work places to allow cyclists to tidy up.  
|                      | - Create more bicycle shops to fix bicycles.  
| Education            | - Teach respect between drivers and cyclists to improve cyclist safety.  
|                      | - Make driver and cycling tests more difficult.  
|                      | - Teach material on sustainability in schools so that young people will be more conscientious regarding bicycle use in the future. This should contribute to the need to create cultural change in the mentality of people in Chihuahua.  
|                      | - Provide scholarly grants for transportation.  
| Intermodality        | - Integrate a system of mass transportation with bicycle use.  
| Promotion/Advocacy   | - Reduce vehicle speeds.  
|                      | - Create adequate legislation regarding the use of bicycles.  
|                      | - Make bicycle parking in commercial developments and schools obligatory to have a space to publicize cycling.  
|                      | - Carry out a public campaign showing families how much they save via the use of a bicycle.  
|                      | - Set appropriate parking regulations that impact the entire system of mobility and transportation in the city.  
|                      | - Encourage the start-up of socially responsible companies fomenting bicycle use through promotions and products (for example, a bike messenger service, a bicycle tourist service, etc).  
|                      | - Demand that developers include bicycle routes in developments  
|                      | - Create cycling groups, including:  
|                      |   • a committee to promote cycling as a sport.  
|                      |   • a cycling association that includes businessmen, bicycle users, and people who defend the interest of cyclists to fortify, protect, and promote cycling beyond regular efforts.  
|                      | - Provide bicycles for rent.  
| Information          | - Research and carry out studies of bicycle routes.  
|                      | - Provide signage in accordance with the use of bicycles.  

Conclusions

In general, attendance and participation in these workshops reflected a greater enthusiasm for cycling as a form of sustainable transportation than I registered in the interviews in the summer of 2007. While it is possible that times are changing in Chihuahua resulting in increased recognition of the relevancy of cycling as a form of sustainable transportation, it is more likely that during my second visit, the direct assistance of the consultant and former director of IMPLAN led to more efficient identification and attraction of people that cared about cycling issues in Chihuahua.

The motivation for using this approach is to increase awareness of and the perception of the legitimacy of bicycle planning when dealing with sustainability goals. In addition, the workshops were intended to raise awareness of the interconnectedness of cycling with
other urban issues, better equipping IMPLAN to argue the relevancy of other policies and efforts to ensure increased bicycle use. Finally, these workshops offered an opportunity for stakeholders to cooperate to increase the chances of effective implementation of cycling projects in the future. It is too early to tell whether the workshops had these desired effects.

I did not carry out a quantitative backcasting approach here. Instead, I asked the participants of the workshop to qualitatively determine the steps that would be required today to achieve the goals they had established. In a general sense, this process fits within the second step of Jansen's definition of backcasting, where a short-term approach is determined based on a previously established long-term vision. For future work, it would be useful to carry out a more intensive visioning process accompanied by more quantitative backcasting based on the goals set out in the visioning process. For example, if we calculate necessary reduction in emissions to lower pollution by 25% in 2030 (see Table 12), we can then determine a realistic role that cycling can play based on an estimated contribution to emissions reductions. This role can be compared to the estimated effect of the proposed 25% bicycle mode share. Beyond a more rigorous form of backcasting, Chihuahua may benefit from a scenario planning process that considers the role of all the modes of transportation in the desired future of the city.

I did provide some very simple forecasting estimates of the ability of the 279 kilometers of infrastructure to induce a change in mode share, and supplemented this with additional research on the effect of infrastructure on bicycle trips. By performing very simple forecasting, I illustrated its value in the visioning process, leading to the recommendations for more complex forecasting techniques explored in Chapter 7. Using a more sophisticated forecasting technique, many of the steps established from backcasting could be evaluated based on their contribution to achieving the target bicycle mode share.
Chapter 7: The Role of Forecasting in Chihuahua, Mexico

Introduction

As established in discussion of the context of Chihuahua in Chapter 4 and through surveys and focus groups in Chapter 5, there are significant barriers to bicycle use in Chihuahua. Understanding those barriers was the first step to promoting cycling as a form of sustainable transportation in Chihuahua. The second step, in Chapter 6, illustrated the usefulness of visioning and goal setting in the planning process to establish the steps necessary to instigate social change towards cycling as a form of sustainable transportation. In the third and final step, explored in this chapter, I make recommendations on the application of forecasting techniques to cycling trips in Chihuahua in a way that benefits and is benefited by the first two steps. Together, this well-rounded approach to thinking about the processes and tools can contribute to the promotion of cycling in this medium-sized, developing city context.

Based on the assessment of forecasting tools and techniques summarized in Chapter 3, I recommend tools that would be useful for Chihuahua in three phases, allowing for the consideration of a range of improvements to the forecasting process requiring different levels of resource investment. The recommendations range from the short-term use of simpler methods and improvement of data quality to the long-term development of more complex, integrated forecasting techniques. I will explore the application of the first two more immediate phases in Chihuahua using existing data and data that I gathered in 2007. This chapter ends with some persistent concerns and conclusions regarding the role of forecasting in promoting cycling in Chihuahua.

Challenges and Opportunities of Applying Forecasting Approaches in Chihuahua

Table 3 summarized different approaches to travel demand forecasting and challenges associated with each in terms of prediction of cycling trips. Table 14 considers the same set of approaches but describes the challenges and opportunities of applying them in Chihuahua.

It seems clear in this assessment that each method has advantages in Chihuahua. However, within the aggregate approaches, sketch planning provides more promising opportunities than the comparison and aggregate behavior studies in predicting the response to specific facility level interventions. Discrete choice models, which are often a part of regional forecasting models, offer the greatest opportunity out of these options for more complex forecasts of trips based on more detailed data. These are general conclusions based on the FHWA assessment (Moe et al., 1999). Any of the methods can be improved and qualities of all the approaches can be utilized. However, when using any of these methods, special attention should be given to their shortcomings in
forecasting cycling trips, particularly in the case of Chihuahua where there are few existing cycling trips from which to gather empirical data.
Table 14: Comparison of modeling approaches*

<table>
<thead>
<tr>
<th>Type of Travel Demand Forecasting</th>
<th>Description as Applied to Cycling</th>
<th>Application to Chihuahua Context</th>
<th>Opportunities in Application to Chihuahua Context</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Comparison Studies</strong></td>
<td>Predict cycling travel on a facility by comparing it to usage, surrounding population and land use characteristics of other similar facilities. These studies are typically before and after analyses.</td>
<td>Comparisons would have to be made with another city that has almost no cycling infrastructure or bicycle trips. This method is risk considering so many of the social and cultural factors that are relevant for bicycle use are difficult to measure.</td>
<td>Though the scale this is applied at is at the area/regional level according to FHWA, in application it is generally focused on response to a facility. This study could be extended to particular policies as a rough estimation of the effect of those policies. It may help to try to find a case study with similar potential demand.</td>
</tr>
<tr>
<td><strong>Aggregate Behavior Studies</strong></td>
<td>Predict cycling travel based on relation of cycling trips to local population, land use, and other characteristics, usually through regression analysis. Because it is an aggregate measure, it is applied at the area or regional scale.</td>
<td>It is difficult to gather empirical information in a place like Chihuahua where little cycling already exists. It is possible that even if the studies are carried out, there is not enough existing cycling to provide useful information.</td>
<td>The FHWA states that quantitative relationships between some factors that affect non-motorized travel and modal split have been developed, which might be applied to trip generation and modal split steps in regional travel models in Chihuahua. However, due to lower forecasting accuracy and inability to incorporate aviation and attitudinal factors, this may not be the best approach for Chihuahua.</td>
</tr>
<tr>
<td><strong>Sketch Plan Methods</strong></td>
<td>Predict cycling travel on a facility or in an area (though FHWA states that it is generally applied at the facility level) through calculations about trip lengths, mode shares, and other aspects of travel behavior.</td>
<td>This method, because of its wide range of possibilities and application to various contexts, may be a good first start for Chihuahua, which may later be replaced with discrete choice models, incorporating cycling into regional travel models.</td>
<td>This method is still simple and easy, therefore is easy to communicate, but it also has the potential to be reasonably accurate in forecasting demand according to the FHWA. This method could be used at first to justify specific bicycle projects. It could be calibrated by the data on attitudes and perceptions, and can be compared to case studies to estimate how realistic results are and calibrate the outputs.</td>
</tr>
<tr>
<td><strong>Discrete Choice Models</strong></td>
<td>Predict individual travel decisions based on the characteristics of alternatives available to travelers. Information is gathered from surveys designed to obtain revealed or stated preferences to create discrete choice models. This measure can be applied at either the facility level or area/regional level.</td>
<td>This method again depends on an assessment of existing bicycle users and the choices they would make. It could be applied to whether or not people make the choice to cycle, however, because there are limited bicycle trips, these models would at first have to be built from stated preference surveys.</td>
<td>This method begins to address the individual choices made, which is probably more critical for bicycle use, and can be applied well to policy changes in addition to facility change. The results could be a component of their existing regional forecasting models.</td>
</tr>
<tr>
<td><strong>Regional Travel Models (Four-Step Travel Demand Models)</strong></td>
<td>Predict total trips by purpose, mode, and OD and distribute them across a network of transportation facilities using land use and transportation network characteristics. It is based on the four-step process and can be applied at facility or area/regional level according to FHWA, although it makes most sense to use them at the area or regional scale.</td>
<td>This is the method used in Chihuahua to predict automobile and transit trips, and has the corresponding weaknesses for estimating cycling trips unless various recommendations are followed for improving characteristics of the model.</td>
<td>In order to incorporate bicycle planning into mainstream transportation planning, bicycle forecasting can be done that include cycling in this format alongside the other modes. This will require much work and adjustment, however. At the same time, the results can be checked and examined at a more micro scale using alternative methods.</td>
</tr>
</tbody>
</table>

*Most of the information in the first description column of this table was obtained from an FHWA report (Moe et al., 1999). The last two columns contain my interpretation of the methods' application to the Chihuahua context.
Recommendations

Based on the analysis of travel demand forecasting and supporting methods in the context of the specific challenges in Chihuahua, I recommend an approach to improving forecasting methods for predicting bicycle trips in three overlapping phases:

**Phase 1:** Develop a sketch plan method that is reasonable in the short-term, given limited resources, to derive bicycle demand in response to the construction of facilities or infrastructure at a city-wide scale.

**Phase 2:** Improve available data and gather new data that have their own value but also can better equip the regional forecasting model to predict cycling trips. There are two parts to this phase:

- a. Gather data through level-of-service measures that can eventually result in the construction of a bicycle network to be used in the regional forecasting model
- b. Predict responses to bicycle policies and infrastructure as they are introduced through a stated preference survey, leading to the development of discrete choice model for the regional forecasting model’s mode split step.

**Phase 3:** As bicycle trips increase, design and implement a revealed preference survey to create a new discrete choice model to further incorporate cycling into the regional forecasting model, supplemented by results of the methods carried out in Phases 1 and 2.

The first two phases can be carried out in the immediate term, and then be improved after facilities are built and there are more bicycle users. The third step should occur after there are enough bicycle users to make a reasonably sized sample for a revealed preference survey and IMPLAN has the technical capability to manipulate the regional forecasting model. These three phases can also utilize qualities from other approaches. For example, the sketch plan method can be complemented by before and after studies on facilities used to calibrate elasticities (estimated mode switches due to specific infrastructure and policies). Below I summarize these three phases in slightly greater detail, and then I explore the application of the first two phases in Chihuahua.

**Phase 1**

Sketch plans, as a first step to predict bicycle demand in response to new facilities, can help assess IMPLAN’s infrastructure plan in more detail and justify specific bicycle projects. Sketch plans, or a similar aggregate method, can provide sufficient initial technical detail as the attempt is made to elicit more cycling trips in the city. A sketch plan for Chihuahua could be structured in the following way:

1. **Define the area of interest:** In IMPLAN’s case, the most useful approach might be to consider buffers around proposed facilities, such as a bicycle lane network.
in a new neighborhood or a linear park bicycle lane along the Sacramento River. The sketch plan can also be carried out at the scale of the entire city to consider the ability of proposed infrastructure to achieve overall cycling mode shares.

2. **Determine the potential bicycle trips:** The 2006 origin destination survey can be used to determine the number of trips of an appropriate trip length for bicycles that enter, exit, or pass through the area of interest. Recall that IMPLAN is targeting trips of 4.5 kilometers or less to reach the bus rapid transit trunk. This target could be adjusted depending on the facility and as perceptions of realistic bicycle trip lengths change.

3. **Assess factors that affect the choice to cycle:** The socio-demographic characteristics – such as age, income, and gender – of people making existing trips by bicycle can be compared to the characteristics of the area of interest to determine the propensity to cycle. The relevant characteristics can be estimated from an analysis of attitudes and perceptions and characteristics of existing cyclists. The percentages of bicycle users with these qualities can be compared with the percentage of people in the area of interest to adjust the estimation of potential bicycle trips. When there are more bicycle trips, regression analyses can be performed on stated or revealed preference survey results to determine the impact of these factors on choices to cycle. In the meantime, the impact of each factor can be weighted according to a best guess.

4. **Estimate the percentage of trips that switch to bicycle:** City officials, residents, and cyclists can take part in workshops to create ‘best guesses’ of trip makers’ behavioral responses to policies and infrastructure to determine a probable cycling mode shift, as described in the Oregon case studies. This estimated mode shift can be applied to the potential bicycle trips determined in Step 2. Adjustment factors, informed by estimations of the propensity to cycle from the third step, can also be applied to the possible bicycle trips determined in the second step to predict new bicycle trips. Initially this will be a rough guess based on an analysis of these factors and comparison to similar case studies. However, as more data are gathered on who cycles and why, this can become a more informed estimate.

5. **Estimate the percentage of bicycle trips that came from automobile trips:** The final step in the sketch plan is to estimate the percentage of new bicycle trips that come from automobile trips to determine the contribution of the proposed facility to emissions reductions. The average length of a bicycle trip, or a random sample of the trip lengths of possible bicycle trips, multiplied by the number the trips that shift to bicycle equals the reduced VKT. This VKT should then be multiplied by the emissions reduction per kilometer according to car types in Chihuahua. Emissions reductions are a simple first step in considering the impact of bicycle use on environmental goals, though many other indicators can be used.
These calculations can be carried out with relative ease using Excel spreadsheets, eliminating the need for the extensive technical capabilities required to maintain and run a regional forecasting model. The spreadsheet format and low processing requirements also make it relatively easy to run various scenarios based on different estimates of possible bicycle trips, mode shift, and so on.

Exercises like the visioning and goal setting workshops described in Chapter 6 can be better designed to establish weights of various factors that affect the choice to cycle. In addition, an understanding of the attitudes and perceptions towards cycling can help calibrate these weights to the specific context of Chihuahua. This will impact the final estimation of the percentage mode shift within the possible trips.

**Phase 2**

The next phase of improving forecasting capabilities in Chihuahua for bicycle trips should overlap with the first and involve improving the data available for estimating cycling trips. There are two main types of data that should be improved: the existing infrastructure’s level of service related to bicycle use and measured behavioral responses to changes in policy and infrastructure.

**Level-of-Service Measures**

A context-appropriate LOS measure can help prioritize and justify infrastructure improvements. The FHWA’s BCI, introduced in Chapter 3, offers a detailed guide on creating an LOS measure. BCI categories include the presence and width of a bicycle lane or paved shoulder, the curb lane width, the volume of traffic in the curb lane, the volume of other lanes, the speed of traffic, the presence and occupancy of a parking lane, and existence of residential roadside development. Adjustment factors address truck volumes, parking turnover, and right turn volumes. IMPLAN can directly adopt the FHWA approach or establish a different set of relevant factors, depending on the resources available for this step.

Once improvements are made, measurements of changes in LOS measures can feed into established indicators for sustainability. These indicators, however, would have to be established in advance, and can help inform how the LOS measures are chosen and defined.

**Stated Preference Surveys**

Stated preference surveys can be used to quantify behavioral reactions and predict responses to new facilities. An assessment of attitudes and perceptions can help determine the factors to be analyzed in stated preference surveys. Ortúzar et al. (2000) carry out focus groups and stated preference surveys in Santiago, Chile, to provide information on potential bicycle users. They use the results of the stated preference survey, given to those who would consider using a bicycle, to estimate a mode choice model and forecast future bicycle demand under different infrastructure and transport system development scenarios. IMPLAN can adopt a similar approach. If resources allow, IMPLAN can carry out a more sophisticated adaptive stated preference survey,
which allows the surveyor to control the choices the respondent has based on prior responses.

The selection and rating of factors in LOS measures can be improved by regression analysis of results from stated preference surveys. This connection can create more standardized rating of road segments based on cyclists’ and non-cyclists’ reactions to LOS factors. It also contributes to determining the relevant data to collect for the LOS.

**Linking LOS and Stated Preference Surveys to Wider Modeling Efforts**

Both LOS measures and stated preference surveys can be used to enhance forecasting methods. IMPLAN can use the LOS measure, in the form that it takes in Chihuahua, to create characteristics of a transportation network for bicycles. This network can inform the time and distance impedance matrices for bicycle trips in the regional forecasting model. Stated preference surveys enable a more complex mode choice model than I suggested in the sketch planning method, and can also be incorporated into the regional forecasting model in the mode split, and even the route choice step, which I have not addressed here.

Both of these approaches have shortcomings, which will have to be addressed in the long-term. For example, LOS measures are usually incorporated in bicycle specific networks in terms of the suitability of specific links for cycling. They are not usually aggregated into an overall route measure, which is more appropriate for the choice to make an entire trip by bicycle (Schwartz et al., 1999). The accuracy of stated preference surveys may be severely limited by inconsistencies between stated preferences and actual behavioral response, a problem with many surveys, as discussed in Chapter 2.

**Phase 3**

The third phase, which should occur as bicycle trips increase and there is more of an empirical basis to analyze cycling, involves the development and application of revealed preference surveys. Revealed preference surveys rely on observed, rather than reported behavior. They can be combined with results of stated preference surveys to estimate more informed mode split and route choice models. They perform a similar function in model estimations, but avoid the problems associated with stated preference surveys by using actual behavior. These surveys can and perhaps should be done for all mode choices given sufficient resources to better inform the mode choice step in the regional forecasting model used by IMPLAN.

Revealed preference survey results can be compared to and combined with stated preference survey results. Such a comparison offers a way to measure the difference between attitudes and actual behavior. If a revealed preference survey is carried out some time after a stated preference survey, the behavior that is inconsistent with the initial assessment of attitudes and perceptions towards cycling might reflect some change in those social and cultural factors. However, used alone, revealed preference surveys have their own shortcomings: while they may be more accurate in terms of predicting
behavior, they do not provide much insight into what led up to the final decision to act (Tilahun et al., 2007).

Mode choice and route choice models can be recalibrated based on results from revealed preference surveys to feed into the regional forecasting model used by IMPLAN, supported by additional improvements, such as the incorporation of a bicycle specific network. This incorporation should be improved over time to become more sophisticated and better adapted to predicting bicycle trips.

Beyond Phase 3: Future Considerations

While Chihuahua may not be a likely place to test out the newer and less operational activity-based modeling, it would be useful to track the advancement of such models. It may be more feasible to consider a calibration of the regional forecasting model based on microsimulation. This method is not covered in detail here because it might be more appropriate as a much longer-term goal than the improvements to the regional forecasting model. Because activity-based modeling is meant to address many of the shortcomings of regional forecasting models and is applied at a scale that may be more appropriate for cycling, IMPLAN should consider adopting it as a modeling technique once it has been operationalized and tested in a variety of other settings.

Applying the Recommendations to the Chihuahua Context

This section illustrates how the first two phases of the forecasting recommendations for Chihuahua can be carried out with relative simplicity using few resources. To elaborate on the first phase of the recommendation, I perform a simple sketch plan based on the available data. To elaborate on the second phase, I develop initial LOS measures for cycling in Chihuahua based on both existing and easily gathered data. The measures I develop here, though they are only initial exploration, can also serve as inputs to more complex forecasting methods. Shortcomings of the application of my approach are discussed at the end of the section for each phase.

Phase 1: An Initial Sketch Plan at the City-wide Scale

A sketch plan, carried out at the city scale, can be used to estimate the mode shift in response to the construction of 279 kilometers of bicycle infrastructure in Chihuahua by 2026. My initial analysis uses many assumptions, some of which can be replaced with more rigorous analysis as IMPLAN acquires and devotes more resources to gathering data on cycling in Chihuahua. This approach is similar to the Oregon case studies described in Chapter 3 in that I estimate possible bicycle trips and then apply a reasonable best guess of a mode shift informed by research and knowledge of the context. This analysis is more simplistic, however, than the Oregon cases; it does not, for example, consider multiple trip types.

Step 1: Define the Area of Interest

Rather than selecting a buffer around a hypothetical facility to assess its impact, I roughly carry out a sketch plan for the entire city region. I did this to consider the effect that the 279 kilometers of proposed bicycle infrastructure in IMPLAN's PSMUS might have on
overall cycling mode share effect. This analysis could just as easily be applied at the facility level to assess, for example, the impact of the construction of a linear park on Sacramento or a neighborhood-level bicycle network in a new development.

**Step 2: Determine the Potential Bicycle Trips**
I estimate the number of potential bicycle trips based on trip lengths and the age of trip makers. I perform my own calculations of length in TransCAD based on the road network provided by IMPLAN. Data on characteristics of trip makers are from IMPLAN (2006b).

As mentioned in Chapter 4, I estimated trip lengths as the shortest possible route on the road network from the centroid (geographic center) from each TAZ to every other TAZ. I calculated distances for trips that begin and end within the same Traffic Analysis Zone as half the radius of the TAZ. 22

\[
\text{Intra-TAZ Distance} = \frac{1}{2} \sqrt{\frac{A}{\pi}}
\]

I was only able to estimate distances for 33,281 of the 34,036 trips in the origin destination due to the fact that there were 315 TAZs in the origin destination survey and only 213 in the IMPLAN files representing the transportation network. The fact that the missing TAZs are on the outskirts of Chihuahua and could involve longer trips may have resulted in an underestimation of trip distances, except that intra-TAZ trips or trips between adjacent TAZs, even on the outskirts of the city, still might be relatively short.

Histograms of trip distance offer a sense of how trip lengths are distributed (see Figure 62 and Figure 63). The majority of the trip lengths I calculated (63%) are less than 4.5 kilometers. The average trip is 4.3 kilometers (the same as bicycle trips), the median is 3.3 kilometers, and the mode is .29 kilometers. The number of targeted bicycle trips could be even larger by considering the trips within five, or eight, or even ten kilometers.

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22 I selected this calculation based on other methodology I had seen in the past. It occurred to me, after noting that all of these distances resulted in trip length of less than one kilometer, that it might have made more sense to use the full radius, though there is no way to determine how trips within the TAZ were geographically distributed.
Starting with all trips under 4.5 kilometers as the possible bicycle trips, I considered eliminating trips under one kilometer as being too inconvenient for riding a bicycle. However, the histogram of bicycle trips, shown in Figure 40, shows that over one-quarter of them are less than or equal to one kilometer (28%). One-third of the potential trips I estimated were less than one kilometer, which was a reasonably close percentage to the existing bicycle trips. Therefore, I left the shorter trips as possible bicycle trips.

I also considered eliminating trips made by people with physical limitations from the estimate of possible trips. “Limitations” in the origin destination survey fell into the categories of sight, hearing, immobility of a part of the body, communication, and chronic diseases. However, information from existing bicycle trips suggests that these limitations do not necessarily prevent bicycle use. 11% of trips by bicycle in the origin destination survey were made by people with one of these limitations, compared to only seven percent in the potential bicycle trips, so I did not remove them from the estimate of potential cyclists.

Age finally provided a way to narrow down the potential bicycle trips. The age of existing trip makers by bicycle ranged from one to 71, suggesting (along with common sense) that it was unlikely that someone over 70 years old would ride a bicycle. I also eliminated trip makers in the potential group who were younger than 10 because I assumed these trips would require adult supervision, and the refore would require the adult to switch to cycling as well. I also eliminated the existing bicycle trips, with the assumption that these trips would remain bicycle trips from the estimated potential trips. There were only 52 bicycle trips in this sample, so this removal did not have a large impact on the percentage of possible trips.
After these adjustments, the number of potential bicycle trips was 19,600, or 59% of the trips for which I was able to calculate distances. This represents great potential for inducing bicycle trips in Chihuahua.

Step 3: Assess Factors that Affect the Choice to Cycle
I used the estimate of potential bicycle trips in Step 2 as an upper bound. Adjusting the number of trips to account for the overrepresentation of females and those with a driver’s license provides a lower bound on which to perform the mode shift in Step 4.

57% of the possibly bicycle trips were made by a female, compared to 28% of existing bicycle trips in the origin destination survey that were made females. If females are less likely to ride a bicycle in Chihuahua, it would make sense to reduce the number of possible bicycle trips to reflect this bias. 42% of the potential bicycle trip makers had no license to drive, which might make them more likely to consider a bicycle due to limited options. This percentage is low compared to the 73% within the existing bicycle trips without a driver’s license. Table 15 illustrates these differences, and compares them with the percentages of all of the trips in the origin destination survey.

Table 15: Analysis of relevant factors for bicycle trips in Chihuahua, Mexico

<table>
<thead>
<tr>
<th>Category</th>
<th>% of Possible Cycle Trips (19,600)</th>
<th>% of Actual Bicycle Trips (102)</th>
<th>% of All Trips (34,036)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>57%</td>
<td>28%</td>
<td>53%</td>
</tr>
<tr>
<td>Male</td>
<td>43%</td>
<td>72%</td>
<td>46%</td>
</tr>
<tr>
<td>No License</td>
<td>42%</td>
<td>73%</td>
<td>42%</td>
</tr>
<tr>
<td>License</td>
<td>58%</td>
<td>27%</td>
<td>58%</td>
</tr>
</tbody>
</table>

Source: IMPLAN (2006b)

To determine a lower bound, I multiplied the percentage of male and female bicycle trip makers to the potential male and female bicycle trips calculated in Step 2. This resulted in new total of possible trips of 9,229 (see Table 16). I also multiplied the percentage of trip makers with and without a driver’s license to those categories in the potential trips, resulting in another new number of total possible trips of 9,124. In a sense this process could be viewed as applying a mode shift to the possible trips, and 9,124 could be the estimated number of new bicycle trips. However, this would represent a 27% bicycle mode share, which is optimistic based on literature review of the effect of infrastructure. To make my estimation more conservative, I use 9,124 as my lower bound in the mode shift calculation performed in Step 4.

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23 These two numbers do not add up to 100% due to missing information in the origin destination survey.
Step 4: Estimate the percentage of trips that switch to bicycle

Due to limited information and the lack of elasticities from a similar context, I used the ‘best guess’ approach to determine mode shift, similar to the Oregon case studies. In the visioning and goal setting workshops outlined in Chapter 6, I presented my own best guess of a three percent to five percent bicycle mode share after the implementation of 279 kilometers of infrastructure based on case studies and knowledge of the Chihuahua context. This seems reasonable when compared to the Ortúzar et al. (2000) results from a model estimated from stated preference surveys. They predict a 5.8% bicycle mode share in 2005 (a 4.2 percentage point increase from the 1991 mode share) in response to the construction of a network of 3.2 kilometers of cycle path per square kilometer in Santiago. IMPLAN’s proposal is roughly equivalent to 1.4 kilometers of cycle path per square kilometer of urbanized area, suggesting that the mode shift in Chihuahua will be less.

These single digit percent estimations contrast with the GEF-based (2006) elasticity leading to an estimate of a 30% bicycle mode share in response to the proposed infrastructure. This estimate might be worth considering since 59% of the total trips are possible bicycle trips in this analysis. However, the 30% mode share is still higher than my lower bound of possible trips (27% of total trips) and the elasticity was calculated in a different context. Therefore, I do not believe it accounts for the specific challenges to promoting cycling in Chihuahua, and I decided the best guess approach, supported by the Ortúzar et al. (2000) results, was more realistic.

I applied this best guess as a mode shift (rather than a final mode share) to the upper and lower bounds I established in Steps 2 and 3. Based on the literature review, I believe this is a reasonably conservative approach. I used five percent as the mode shift, the upper edge of the range, because I am applying it to a subset of trips. I compared this to a U.K. study by Mackett (2001) on the policies that attract drivers to other modes for shorter trips. Through surveys this study found that seven percent of people would use a bicycle as an alternative to the automobile for shorter trips if they were not able to use their automobiles. Because I am not assuming a limitation on automobile use, and because there are more cultural and social barriers (including such a small cycling mode share) to switching to bicycle use in Chihuahua, the five percent shift seems a reasonably conservative guess. I applied this percentage to the upper and lower bounds of possible trips and added in the existing cycling mode share, resulting in a 1.7 to 3.3% bicycle mode share.

### Table 16: Calculation of lower bound

<table>
<thead>
<tr>
<th>General Category</th>
<th>Specific Category</th>
<th>Number of Possible Trips</th>
<th>% of Actual Bicycle Trips</th>
<th>% Actual Bicycle Trips / # Possible Trips</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Female</td>
<td>11,098</td>
<td>28%</td>
<td>3,107</td>
<td>9,229</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>8,502</td>
<td>72%</td>
<td>6,121</td>
<td></td>
</tr>
<tr>
<td>Driver's License</td>
<td>No License</td>
<td>8,302</td>
<td>73%</td>
<td>6,023</td>
<td>9,124</td>
</tr>
<tr>
<td></td>
<td>License</td>
<td>11,298</td>
<td>27%</td>
<td>3,101</td>
<td></td>
</tr>
</tbody>
</table>

Source: IMPLAN (2006b)
mode share in Chihuahua after the construction of 279 kilometers of bicycle lanes and paths (see Table 17). This result also seems feasible considering that some U.S. cities have up to a three percent bicycle mode share with a lower density of bicycle lanes (Dill & Carr, 2003).

Table 17: Upper and lower bounds of new bicycle mode shares

<table>
<thead>
<tr>
<th>Mode Shift</th>
<th>Possible Bicycle Trips</th>
<th>Mode Shift</th>
<th>New Bicycle Trips</th>
<th>% of Total Trips Used In OD Survey (33,281)</th>
<th>With Current Bicycle Mode Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Bound</td>
<td>19,600</td>
<td>5%</td>
<td>980</td>
<td>2.9%</td>
<td>3.3%</td>
</tr>
<tr>
<td>Lower Bound</td>
<td>9,124</td>
<td>5%</td>
<td>456</td>
<td>1.4%</td>
<td>1.7%</td>
</tr>
</tbody>
</table>

The final method to determine the probable mode shift should be debated by planners and officials in Chihuahua, as well as potential bicycle trip makers, to obtain their opinions regarding likely responses to bicycle interventions.

**Step 5: Estimate the percentage of bicycle trips that came from automobile trips**

There are also many ways to estimate the potential impact of the predicted mode shift on sustainability goals. As a part of this effort, calculating the number of bicycle trips that come from automobile trips helps measure the achievement of environmental goals through emissions reductions. The Victoria Transport Policy Institute (VTPI) (2007), for example, estimates that 20% to 50% of new cycling and walking trips tend to come from automobile trips. The FHWA (1993) estimates that 38% to 56% of bicycle miles traveled replace automobile miles.

I use a somewhat conservative guess attributing 30% of the bicycle trips to former automobile trips (less than FHWA and within the lower half of the range given by VTPI) because Chihuahua still has a large percentage of walking trips compared to Canada and U.S. cities. Using this number, there would be a .5 to one percent reduction in total automobile trips based on the lower and upper bounds of my analysis, respectively.

In order to estimate the total drop in VKT and resulting emissions reductions, it is necessary to apply this percentage to the number of total trips in the Chihuahua area. The diagnostic report (Informe de Diagnóstico) of the PSMUS offers several estimates of total trips based on expansion factors (IMPLAN, 2006c). One set of expansion factors based on the number of people in a household gives an estimate of 2,012,772 total trips. I used the 1.9-kilometer average trip distance of the possible bicycle trips from calculations described in Chapter 4 to come up with a total reduction of VKT of 19,569 to 37,813 kilometers.

The amount of emissions per VKT is based on many factors, such as type of vehicle, length of trip, maintenance of vehicle, and so on. For simplicity in this analysis, I used an average 0.175 kg/km of CO₂ emissions reductions used in a Green Calculator developed by TANDBERG (2007). These estimated VKT reductions from bicycle trips
would then lead to 3,425 to 6,617 kg reduction in CO₂ emissions for a 24-hour work day (see Table 18).

**Table 18: Total reduced VKT based on new estimates of bicycle mode share**

<table>
<thead>
<tr>
<th>Mode Shift</th>
<th>With Current Bicycle Mode Share</th>
<th># Trips Based on Total Trips (2,012,772')</th>
<th>% of Trips From Automobile Trips</th>
<th># Trips From Automobile Trips</th>
<th>Reduced VKT (Avg Trip Dist = 1.9km)</th>
<th>Kg Reduced CO₂ Emissions (Based on 0.175 kg/km average)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Bound</td>
<td>3.3%</td>
<td>65,655</td>
<td>30%</td>
<td>19,697</td>
<td>37,813</td>
<td>6,617</td>
</tr>
<tr>
<td>Lower Bound</td>
<td>1.7%</td>
<td>33,978</td>
<td>30%</td>
<td>10,193</td>
<td>19,569</td>
<td>3,425</td>
</tr>
</tbody>
</table>

* Source: IMPLAN (2006c)
** Source: TANDBERG (2007)

**Assessing the Results**

The results of this analysis do not predict a dramatic new bicycle mode share, and fall far short of the 25% bicycle mode share proposed in the visioning process. This analysis, however, does not incorporate the possible changes in attitudes towards cycling due to additional policies. These policies could include requiring installation of shower facilities at offices, increases in the cost of parking, individual fiscal incentives to cycle, increased education programs, and improved road safety. The changes in attitudes and perceptions in response to additional policies should be monitored.

Performing sensitivity analysis suggests that the effects of additional policies should not be overestimated. For example, if policies increasingly target women as cyclists, the lower bound of possible cycling trips in my analysis increases (see Figure 64). However, this only increases the percentage of possible bicycle trips out of total trips from 28% to 29%. This improvement would not have a noticeable effect on the final mode share.
Figure 64: Sensitivity analysis based on percentage of women who cycle

Source: Elaboration based on IMPLAN (2006b)

Shortcomings
There are a number of shortcomings in this methodology, including the method of calculating the distance matrix and the subjective nature of my ‘best guess.’ Recall from Chapter 4 that the distance matrix calculates the shortest distance between geographic centers of TAZs on the road network. Each centroid is connected to the road network by a link that has no distance. The size of a TAZ can vary, and the larger it is, the less accurate the distance is likely to be. Accuracy could be improved through knowledge of the exact location of the trips' origins and destinations. In future origin destination surveys, the trip distances should be measured at this level of detail and, if needed, they can be aggregated up to the TAZ level. To further increase accuracy, trip distances could be calculated on a bicycle-specific network with relevant characteristics.

My distance matrix does not correspond with the trip distances calculated by consultants working for IMPLAN regarding the average trip distance. IMPLAN reports the average trip distance in Chihuahua as 10 kilometers, but my method of estimating trips distances puts the average trip at 4.3 kilometers, making the average Chihuahua trip suitable for cycling. The reason for this disparity could involve the omission of the trips that originated or ended at TAZs outside the network I used, or the fact that I do not use expansion factors for the origin destination survey.

Finally, my estimate of the mode shift to bicycles, while being my best guess, is very rough. Elasticities from other contexts can be used instead, but they might not be relevant in Chihuahua. By implementing a before and after study in Chihuahua, IMPLAN could obtain data on responses to new infrastructure that could be used to develop a more accurate estimate of mode shift. However, the value of this effort is limited by the fact that the elasticity might change as other policies and increased usage induce changes in the social and cultural factors relevant to bicycle use.
I considered the possibility that my results were biased because I took the potential trips from those that are shorter distances. To assess this possibility, I compared the mode share in the possible bicycle trips to overall mode shares. The mode shares were similar, though there were slightly more drivers, less passengers, more pedestrians, and less public transit users in the possible bicycle trips. This seems reasonable in that it is likely that trips on foot would be shorter and trips by transit are likely not convenient at such short distances. This may make it slightly more likely that converted trips would come more from automobile and walking trips than public transit trips.

Figure 65: Mode share comparison between possible bicycle trips and total trips

![Mode Share Comparison Graph](image)

Source: IMPLAN (2006b)

**Phase 2: Level of Service in Chihuahua**

To demonstrate the application of a LOS measure in Chihuahua, I select my own factors based on an assessment of relevant factors for cycling in Chihuahua and the data I was able to gather given limited resources. I used ten factors, five of which were based on existing data and five of which were created based on new data. I applied ratings to each road segment for each factor, on a scale of one to five from the most to least optimal conditions for a cyclist, respectively.

The five factors based on existing data included the volume-to-capacity ratio\(^\text{24}\) of motorized traffic, the posted speed for the street, the pavement quality, the percent of buses and other heavy vehicles compared to the total volume, and the presence of cyclists (see Table 19).

\[^{24}\text{Based on the same volume to capacity calculation used in Figure 31 in Chapter 4, but for only one direction.}\]
A noticeable number of road segments had an average rating of one or two, which would be friendlier to cycling (see Figure 66). There are a few segments that could indicate areas that are very unfriendly to cyclists. The average could not be calculated for all road segments in the network due to missing information. This calculation was incomplete and only for one direction, but it provided an initial sense of areas that might have better conditions for cycling.
To collect data for the additional five factors, I performed a physical survey of a small sample of roads, selected based on convenience and the desire to map out routes that I considered relevant given the existing desire lines. I also selected streets near a northern industrial area that I examined in more detail during the summer of 2007.25

The five factors included: the quality and amount of shoulder available to indicate space for cyclists between traffic and the curb; the quality of pavement markings to offer a sense for how easily conflicts might occur on the road; presence of obstacles such as dirt, trash, and potholes; amount of shade providing relief from the hot sun; and then an overall rating of the riding experience. The rating system is described in more detail in Table 20. It was difficult to standardize these ratings. For example, sometimes a wide shoulder might not necessarily be a benefit to the cyclist if it has rubble or debris in it. The overall rating of the experience is an attempt to systematically include an overall subjective sense of the road as a riding route.

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25 I physically rode my bicycle on the links for which I recorded data, ranking the factors and taking pictures of the conditions.
Table 20: Rating guide for inputted data relevant for cycling use

<table>
<thead>
<tr>
<th>Category</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality/Amount of Shoulder</td>
<td>Wide shoulder of good quality</td>
<td>Wide Shoulder, but of poorer quality; or lack of shoulder but plenty of room for space between cars and parked cars</td>
<td>Narrow Shoulder, usable, or existence of a median that could be converted, or no shoulder but just enough space in between cars and edge or parked cars to feel okay.</td>
<td>Narrow unpaved shoulder or paved shoulder with significant debris and obstacles; almost no room between cars and edge of road.</td>
<td>No shoulder, cars must move out of their lane to get around a cyclist.</td>
</tr>
<tr>
<td>Quality of Pavement Markings</td>
<td>Lanes are clearly delineated, it is always clear where cars need to go</td>
<td>Lanes are delineated, but there are conflict points at intersections, etc., or the pain that delineates the lanes is there but faint.</td>
<td>Lanes are not always clearly delineated, and there are often conflict points</td>
<td>Lanes are rarely delineated, cars are constantly shifting because of the lack of clarity and numerous conflict points</td>
<td>Lanes are not delineated</td>
</tr>
<tr>
<td>Presence of Obstacles</td>
<td>No obstacles, clean road surface</td>
<td>Clean road surface but occasional obstacles such as speed bumps unfriendly to cyclists</td>
<td>Occasional sand, trash, unfriendly grates and speed bumps</td>
<td>Frequent sand, trash, unfriendly grates and speed bumps</td>
<td>Extremely unfriendly to bicycle use, to the point that any sane cyclist would avoid this road</td>
</tr>
<tr>
<td>Shade/Exposure</td>
<td>Fully shaded edge of the road</td>
<td>Frequent trees offering regular respite from heat</td>
<td>Occasional tree, offering occasional respite.</td>
<td>Almost no trees or respite from heat and sun</td>
<td>No shade</td>
</tr>
<tr>
<td>Riding Experience</td>
<td>Lots of space, easy to ride, few stops along the road, a pleasant ride.</td>
<td>Easy to ride, lots of space, but more frequent stops and enough traffic to cause some safety concerns.</td>
<td>Moderate traffic, but enough space to feel okay to ride with the traffic. A tolerable ride but could use additional infrastructure.</td>
<td>Major road with high speeds and not too much room, could be good to ride but needs significant change in infrastructure, currently uncomfortable to ride.</td>
<td>Extremely undesirable ride. High speed, highway feel, no space, seemingly aggressive cars, etc.</td>
</tr>
</tbody>
</table>

Although I spent several days gathering these data, I ended up with ratings for few roads on the network. This was at least partly because it tended to be easy to ride on smaller side streets, which are not included in the network, reflecting a shortcoming in the existing road network in predicting bicycle trips. Once again, to determine a LOS measure based on the data I gathered, I averaged the five categories (see Figure 67).

Figure 67: Average rating of cycling friendliness based on new data

![Figure 67](image)

Source: Elaboration on data provided by IMPLAN

One of the streets, Nogales, received a ranking higher than 2, because it has an off-road, paved path that runs the length of a canal. There are obstructions that occasionally interrupted its use as a bike path (see Figure 68). However, it still provides some of the best riding conditions in the city if safety and separation from traffic is a priority (which might be most important for inexperienced cyclists). This street does not link popular destinations but runs along one of the densest developments in Chihuahua and is a part of IMPLAN’s proposed bicycle network.
There are also validity concerns in that I selected the factors based on what I estimated would be important to cyclists in Chihuahua. Other factors could be created using additional existing data, such as inclines, and entirely different new data. This methodology would be more rigorous if it incorporated a stated or revealed preference survey to determine local cyclists’ response to conditions. This may be a long-term approach as there are currently so few people cycling as a form of transportation.

The LOS factors were also not ranked in the most rigorous fashion. I attempted to measure conditions in the physical survey as consistently as possible, improving reliability, but personal subjectivity was unavoidable. The methodology could be made more rigorous by the design of a field survey instrument and the training of a crew of surveyors to cover the entire city. Chihuahua is small enough to be covered relatively quickly, perhaps by student volunteers to limit the resources invested in this process. Validity and reliability concerns would still have to be checked.

Finally, the factors I established do not necessarily have the same importance for all cyclists, creating additional reliability concerns. I merely averaged the measures for each road segment, whereas different factors might have been weighted as more or less relevant for cyclists. For example, the utilization ratio might have been less important to a cyclist if the roads are small and in good condition and other cyclists are present. This information can also be gained from surveys to determined cyclists’ preferences.

**Persistent Concerns**

Some concerns persist despite my attempt to create a package of recommendations to address the shortcomings of the various approaches. First, there is still a heavy
infrastructure focus in these methods. The outputs are generally suitable to inform infrastructure changes, which is only one part of the promotion of cycling. Modeling in this sense should not be relied on as the primary tool for promoting bicycle use, but rather an aid in a larger planning process that is designed to achieve sustainability goals. These techniques can be particularly useful in justifying the funds required for specific projects, but intensive use of resources to improve modeling techniques may result in a continued bias towards relying on the results of the models over other analyses and processes. It may be more useful to engage in an open or inclusive debate with other stakeholders regarding the relevant factors to include in modeling to further engage people in the issue of increasing cycling.

Second, the resources invested in forecasting cycling demand can quickly become irrelevant in the face of political will. As has already been discussed in the case of the ring road in Chihuahua, politicians can decide to advance projects without the support of forecasts and other technical tools. The diversion of excessive resources for the enhancement of technical tools could detract from other efforts to gain political support for projects that aim to make transportation practices in Chihuahua more sustainable. Because of this dilemma, resources should be devoted to both technical and political strategies.

Conclusions

This chapter presented a variety of techniques to forecast cycling demand. They include the development of short-term approaches that simultaneously enhance the longer-term ability to incorporate cycling into the existing regional forecast model. This strategy assumes that the integration would be beneficial to promote cycling as a form of transportation. It is important to note that I do not recommend that IMPLAN immediately attempt to use the regional forecasting model to predict cycling trips.

Many of the challenges to considering cycling trips alongside automobile and public transit trips have already been outlined in Chapter 3. It is difficult to address these challenges through acquisition of more reliable data because of the low bicycle mode share. Until there are significant travel patterns that include cycling, any attempt to force the model to include cycling trips will not be well-informed by empirical evidence (Katz, 2001). In the meantime, justification for projects to promote cycling can be supported by other modeling approaches. In order to instigate dramatic change in transportation behavior in Chihuahua, a wide range of tactics should be considered.

One point that has not been covered here, but should be seriously considered by IMPLAN, is the development of methods that are useful for both pedestrian and cyclist forecasting. Pedestrians represent a 21% mode share in Chihuahua, which may offer a stronger justification for projects that favor both pedestrians and cyclists. When pedestrian and cyclist interests are compatible, projects can more easily be justified based on a wider range of benefits.
Chapter 8: Conclusions

Introduction

In this thesis, I set out to answer how planning processes and tools can be adjusted to better promote cycling as a form of sustainable transportation in a medium-sized, developing city. I propose a three-step approach to achieve this goal. I explore the application of the approach through a case study methodology, though I was not able to measure the resulting effect on behavior. I conclude that in the context of my case study, traditional infrastructure solutions alone are not likely to induce the amount of change necessary to combat trends of automobile dependence. Instead, context-appropriate planning process and supporting tools must be carefully analyzed, chosen, and applied in an integrated fashion that can most likely induce the desired change.

In this chapter, I will first summarize some of the recommendations from my prior report (Teich, 2007) that are most relevant to this thesis and have been enhanced by the completion of the rest of the analysis. I will then state my general conclusions based on the application of the recommended approach, discuss challenges related to the more complete implementation of the approach, and finally, suggest future efforts to enhance this work.

Recommendations for the Cycling Plan

Using the understanding of the barriers (both perceived and real) to bicycle use in Chihuahua from Step 1 of the approach, I made recommendations to improve the existing cycling plan in the PSMUS in Chihuahua. The recommendations, initially described in Chapter 5, are summarized in greater detail here:

1. Augment the proposed bicycle network with routes that incorporate both recreational and utilitarian use on the same infrastructure, primarily by providing longer, more continuous, attractive routes for cyclists.
2. Adopt a more widely integrative approach. In addition to the proposed integration with public transit, this includes integration of bicycle policy within the master plan and integration of cyclists with other road users to elicit a change in the road culture.
3. Use social marketing and other promotional efforts to more effectively elicit a change in behavior towards cycling.
4. Promote grassroots cycling advocacy through the engagement of citizens and groups in the planning process.
5. Provide education and information so that potential cyclists are well-informed and, if they start cycling, safe.
6. Provide incentives for developers to promote cycling behavior through the incorporation of cyclists’ needs in new development.
7. Utilize indirectly related policies to improve cycling conditions or promote additional cycling trips.
8. Adjust the planning process to better promote cycling, incorporating a visioning process that establishes cycling goals in terms of sustainable development goals. These recommendations are based on a wide range of literature review, and are therefore likely applicable in many contexts. Details can be found in the Teich (2007) report, but I highlight relevant points in this section. Because the role of infrastructure improvements is important to this thesis, I summarize my recommendations for creating more viable, mixed-purpose bicycle infrastructure. The integration of cycling with public transit and the integration of cycling in the master plan have already been adequately addressed in Chapter 4 and the 2007 report. I address the integration of bicycle users into the road network, which is relevant to the infrastructure argument. Social marking, education, the role of developers, and indirectly related policies are covered sufficiently in the 2007 report. I was able to complement the advocacy consideration with additional input from interviews and perceptions from these surveys and focus groups, which I summarize here. Finally, I developed the recommendation to change the planning process after the initial release of the 2007 report. This was the main motivation leading to second step of my approach, and thus is also be summarized.

Infrastructure
Research has shown that creating opportunity for both utilitarian and recreational cycling can contribute to changing the perception of the role of bicycles in the transportation system. As Cruz et al. (2007) stated in an MIT report on bicycle sharing programs, “The first step is to show that bicycles are part of leisure, and then to extend the user’s notion of what bicycles can do by diminishing the perceived risks…” (p. 39). IMPLAN is partially adopting a strategy of mixed-use infrastructure by proposing a bicycle network connecting social resources, such as parks and other recreational areas, with BRT stops (see Figure 35).

While IMPLAN’s proposal has the possibility of expanding the perceived utility of bicycles (assuming that the BRT trunk is constructed), there are shortcomings to this strategy. Figure 41 illustrates the desire lines for bicycle trips in Chihuahua, indicating relatively high demand from the northeast to the southwest of the city, which is not well accommodated in Chihuahua’s existing road network. The short paths in the BRT-related strategy may have a limited utility for cyclists given the existing demand and the orientation of the BRT line from the northwest to the southeast. Also, the Porter et al. (1999) assertion that bicycle trips are often, if not primarily, stand alone trips, suggests that resources should be invested in infrastructure that connects cyclists more directly to destinations.

Based on these concerns, it may be useful to offer infrastructure in the short-term that accommodates extended recreation as well as longer commutes. The Sacramento River is an optimal location for an attractive route covering a significant northwest-southeast distance (see Figure 69). While this route does not exactly follow the desire line mentioned above, there are many benefits to such a strategy. This river is one of the more attractive areas in Chihuahua with excellent views of the surrounding hills. On
either side there are medium- and low-income neighborhoods, which, because of the design of the highway along the river, have little or no direct access to each other or the river area. The highway was built with wide, exposed sidewalks, and with space between the road and the river. The sidewalk can be redesigned to be a mixed-use path for pedestrians and cyclists. Landscaping using indigenous, low maintenance plants and trees on the banks of the river could provide shade. Finally, this route could connect to a path constructed along the Chuviscar Canal, another potential amenity to the city, providing access to the downtown and the west side of Chihuahua.

Figure 69: Location of Sacramento and Canal as site for linear bicycle park.

If there is not enough funding or interest to create a linear park, IMPLAN could focus on improving road conditions for cyclists along the most important desire lines. However, the linear park would also create an amenity for the general public and improve the livability of the city. This project might be more effectively justified in terms of the benefits it bring to pedestrians, which compose 21% of the mode share in Chihuahua. It would also address many of the concerns regarding barriers to bicycle use in Chihuahua, for example, by offering a safe route that is shaded from the heat.

Integration
There are three types of integration considered the Teich (2007) report. I only highlight the integration of cyclists into the road system through on-street infrastructure. This strategy can contribute to a change in the existing road culture to create safer conditions for all users in the long-term. IMPLAN’s proposed bicycle lane design, shown in Figure
35, follows the strategy of creating separated space for bicycles and pedestrians, with the goal providing protection from motorized vehicles. While the surveys and focus groups indicate that a sense of security might increase the likelihood of cycling, the separation of modes of transportation in this manner may further contribute to a growing car culture and increasingly unsafe road conditions. Roads can have a variety of users, but in IMPLAN’s proposal they continue to be reserved for motorized forms. Similar to the isolation of cycling in forecasting methods described in Chapter 3, this physical isolation of cyclists from road infrastructure may support the omission of cycling from transportation planning debates.

An alternative to separation of transportation modes is the forced integration of cyclists and other road users in “living streets.” As defined in Chapter 1, the concept of “living streets” includes the reclamation of streets as more diversely used space. Fiddies and Markström (2006) explain that the technique of removing all markings to create a living street in Drachten, Holland caused a change in behavior, including decreased driving speeds and increased use of non-motorized modes. The results were lower accident rates and decreased congestion.

While this approach may have positive results in Holland, caution should be used in importing techniques to change transportation behavior that are successful in parts of the world with different physical, social, and cultural characteristics. While I would not recommend removing all signage and traffic rules in Chihuahua, encouraging a more diverse use of streets could force drivers to be more aware and share the road. This approach could combat the monopoly that cars currently have on the roads, which creates a dangerous environment for pedestrians and cyclists.

Because drivers are in the majority in Chihuahua and the roads are perceived as a place primarily for cars and other motorized forms, it is likely that there would be resistance to reclaiming road space for other users. One objection might be that removing capacity increases congestion. Although congestion was sometimes cited as a problem in the surveys and focus groups I conducted, described in Chapter 5, the congestion assessment in Chapter 4 suggests that while it is a potential problem in parts of Chihuahua, it is not yet a widespread, serious concern. Chapter 1 also includes the argument that reclaiming street space for cycling can decrease congestion, and improve the livability of a place.

**Advocacy**

I asked Herrera (personal communication, January 9, 2008), the former director of IMPLAN, to speculate on the reason for the lack of advocacy for cycling in Chihuahua. He pointed out that in addition to the absence of cycling groups, there are no active environmental groups in Chihuahua even though they exist in other Mexican cities. He speculated that the dearth of advocacy is related to the social characteristics of people in Chihuahua. He perceived a more individualistic attitude in Chihuahua, related to the fact that social circles are more limited to the family and there are few good public social spaces where people might informally organize around social issues.
Some interviewees and survey and focus group participants expressed the concern that people are not willing to advocate for environmental and health-related issues until they have a comfortable income level. The applicability of this argument to Chihuahua is questionable. Many of the cyclists at the Aldama race were higher-income earners, and yet they do not organize around cycling issues. I only witnessed this tendency in one cyclist, Jesus Grajeda Uribe, who founded a company with the mission of promoting cycling through a for-profit messenger service, tourist bike service, and other bicycle-related endeavors. The messenger service started in the winter of 2007-2008. This may contribute to creating a more extensive bicycle culture in Chihuahua.

Whether or not these perceptions of the barriers to advocacy are accurate, these conversations emphasized a need to explore the social and cultural roots of advocacy behavior. It is difficult to force advocacy to occur, but increasing the amount of attractive public space, raising awareness of societal issues, and creating a sense of efficacy (as suggested by Gatersleben and Uzzell (2002)) may help encourage advocacy behavior. One way I attempted to create a sense of efficacy was through the engagement of cyclists or cyclist groups in the visioning workshops, work that IMPLAN can continue. However, one challenge to this work is the lack of an umbrella list through which to easily contact cyclists. However, the workshops can help create a communication network between people working on cycling issues.

Planning Process
In the summer of 2007, it became clear that the planning process for the cycling portion of the PSMUS did not establish goals related to cycling’s role in achieving sustainable transportation. The cycling plan primarily relies on infrastructure provision without critically assessing the real impact that this infrastructure might have on inducing new bicycle trips. Provision of bicycle infrastructure does provide a benefit for cyclists, and is even progressive for a Mexican city of this size. However, if IMPLAN is serious about promoting cycling as an alternative form of transportation, the planning process will have to be reformed to more directly address the cultural and social barriers to bicycle use.

The planning process, including the tools that are used in the process to perform analyses, is part of the behavior-policy interface (Geenhuizen et al., 2002) and can have a direct impact on behavior. The planning process for cycling in the PSMUS can engage citizens and cycling groups and make a major contribution to the four requirements for social change outlined by Gatersleben and Uzzell (2002). The way that the planning process is carried out, as well as a recalibration of the tools used to support the process, can contribute to a paradigm shift amongst planners and policy makers leading to the devotion of more resources to promoting cycling.

General Conclusions
There is no simple way to fill the gap described by Button and Nijkamp (1997) resulting from the inadequate application of engineering solutions to achieve social and

26 See http://www.velo-e.com/ for more information.
environmental sustainability goals. Engineering solutions are helpful, but not sufficient to induce the change in behavior required to fully realize a goal as complex and comprehensive as sustainability. The comprehensiveness inherent in the concept of sustainability requires a similarly comprehensive look into the planning processes, the tools that support the processes, and the way they can be integrated to effectively bring about change. This is not the first time that the value of integrating analytical techniques and planning process has been realized. Katz (2001), for example, recommends using sketch planning techniques informed by discrete choice models along with visioning exercises.

Based on my analysis and the Teich (2007) recommendations, I determine that a three-step approach would be more effective in eliciting social change towards sustainable transportation. Figure 70 is a simplified diagram of this approach, showing the three steps, how they interact, and how they might occur over time. The diagram accounts for the feedback that will occur after the plan is established and behavior begins to change. This feedback suggests that the processes, tools, and the plan itself should be recalibrated as time passes and conditions change.

Figure 70: Diagram of recommended approach
I partially demonstrated the approach through simplified applications of the three steps in Chihuahua, Mexico. While I cannot measure the outcomes of the application, I was able to determine barriers to bicycle use in Chihuahua, recommend a more comprehensive approach to promoting bicycle use in the PSMUS, assist in the development of a clearer vision of a sustainable future for Chihuahua and cycling's role in that future, and suggest short- and long-term improvements in IMPLAN's modeling techniques. The approach contributed to Gatersleben and Uzzell's (2002) four criteria for achieving social change, because the visioning process engaged stakeholders in defining the social good in terms of cycling's contribution to sustainability goals; the surveys, focus groups, and visioning process raised awareness of sustainability problems related to transportation and individuals' roles in creating them; and these processes carried out with the cooperation of a local planning agency showed that efforts are being made to remedy transportation problems in a participatory fashion. The recommended modeling techniques serve as support for these efforts, however, the open debate about the role of modeling in sustainability efforts also increases awareness of problems related to sustainability and potential solutions.

The recommended steps in my approach complement each other. For example, the surveys, focus groups, and interviews indicate that the respondents are often supportive of and open to the idea of cycling as a form of transportation. However, the 2006 origin destination survey results show that despite this proclaimed support, people are not riding bicycles. In addition to the inconsistency between stated attitudes and behavior, the planning process for the cycling component of the PSMUS did little to contribute to behavioral change in the immediate-term. The visioning and goal setting process helped make the role cycling can play in achieving sustainable transportation more concrete to participants. This process does not, however, necessarily support the justification of cycling projects through quantitative measures. I hypothesize that cycling projects can be further legitimized with the use of forecasting tools to predict their impact. I have not proved this in my thesis, though the literature review suggests that this is the case, and the initial application in Chihuahua seems promising.

**Implementation**

I have recommended an approach that is applicable to Chihuahua; however, it should be grounded in the political reality of the context. In particular, I have discussed the perceived gap between technical analysis and decision making, and the assertion that agendas are often decided before technical analysis is sought for justification of projects. The success of the proposed approach in Chihuahua depends on the existence of an organization like IMPLAN pursuing a long-term strategy of sustainable development regardless of the mayor in office. In the meantime, the understanding of social and cultural barriers to cycling and determination of next steps through backcasting should lead to short-term projects that can be pursued in a single mayor's term. IMPLAN has to pursue other longer-term projects, such as the implementation of the BRT line, diligently through multiple mayoral terms.
This approach would become irrelevant if the resulting bicycle plan were overruled by a mayor who is not concerned with cycling or sustainability issues. There are several ways that IMPLAN can reduce the likelihood of this occurring. For example, new legislation that gives IMPLAN the power to implement the PSMUS can provide an ongoing framework of support regardless of political leadership. Improved technical tools can give IMPLAN a base of data analysis providing continual justification for sustainability objectives. Even if a mayor prioritizes a conflicting agenda, such as the ring road project, and seeks technical support from IMPLAN, he or she will first have to counter results from existing data analysis.

Chihuahua, Mexico provided an interesting case study, but in another context it would be more useful to apply this methodology before the master plan is so advanced. Both the attitude and perception analysis as well as the visioning and backcasting exercise should have occurred in the early stages of the planning process. They should be paralleled by the assessment of modeling tools. After these processes have been carried out and the preferred tools have been selected and used to create initial forecasts of the effects of various policy and infrastructure interventions, a comprehensive cycling plan can be created. This process can be applied to any mode of transportation with the aim of achieving sustainability goals.

**Shortcomings and Future Work**

My desire to apply all of the steps in the recommendations to the Chihuahua case led to a broad analysis that lacks detail and depth in certain areas. Some of the shortcomings for each step, which can be corrected in future work, include the following:

**Attitudes and Perceptions:** The survey and focus group methodology has its shortcomings, and I only performed basic statistical analysis of the results. The results cannot be generalized to the population because of my sampling approach. My survey instrument was also not sophisticated enough to be used to determine a mode choice model that could feed into the four-step process. A larger, random sample would provide more generalizable data that could be incorporated into other planning tools. More sophisticated attitudinal and preference surveys can produce results that can later be incorporated into a four-step model that includes bicycle trips.

**Visioning and Goal Setting:** I was able to carry out a basic visioning process and qualitative backcasting approach, but more rigorous backcasting calculations from the established goals might have provided more beneficial comparison to IMPLAN’s proposed infrastructure changes. The backcasting could either be based on the results from the workshops that already occurred, or a new process that establishes goals in more detail. In addition to more rigorous backcasting, the visioning could have been expanded into a much more detailed scenario planning process. This would require more time and resources, but could be done in a way that incorporates all modes of transportation and other aspects of sustainability.
**Forecasting Techniques**: While I critiqued the four-step process, I did not actually attempt to adapt it for the Chihuahua case, except for a few early experiments that are not included here. As more data are gathered that are relevant to cycling, it would be useful to explore the adjustment of the regional forecasting model in Chihuahua to be more applicable to cycling.

I worked closely with IMPLAN during this analysis with the intention that these recommendations be useful to the agency. If IMPLAN elects to invest additional resources in carrying out the proposed approach in a more complete fashion, incorporating the recommendations into standard planning processes in the future, Chihuahua will provide an interesting case study to measure the success of these efforts in promoting a sustainable and primarily unused form of transportation in a medium-sized, developing city. To improve upon this approach and measure its success, IMPLAN can establish a set of process and product indicators, which could be used as this approach is applied in other cases. These indicators would also give IMPLAN a way to assess the validity of my recommendations.
Bibliography


---. (2004). Ask the "Experts": Interview with Patrick McCormick. It all adds up to cleaner air, Fall, from http://www.italladdsup.gov/newsletter/fall04/experts.html


Appendices

Appendix A: Survey Instrument for Community Center Users and Students

1.- Nombre: ________________________________

2.- Sexo: □ masculino, □ femenino.

3.- Edad: ____________________

4.- Cuánto gana mensualmente:
   □ Menos de 5,000 pesos.
   □ Entre 5,001 y 10,000 pesos.
   □ Entre 10,001 y 20,000 pesos.
   □ Más que 20,000 pesos.

5.- ¿Cuál es el crucero vial más cercano a su casa?

6.- ¿Cuál es el crucero vial más cercano a su trabajo/escuela?

7.- ¿Cuál es su función en la familia?
   □ Jefe/a de la casa (gana más dinero).
   □ Esposo/esposa del jefe/a.
   □ Hijo/hija del jefe/a.
   □ Otro familiar del jefe/a.
   □ Padre/madre/suegra/suegro del jefe/a.
   □ Otro ________________________________

8.- ¿Cuántas personas viven en su casa (familiares directos)? ____________

9.- ¿Tiene usted licencia de manejo?
   □ Sí □ No

10.- ¿Cuántas bicicletas hay en su casa? _______ ¿Cuántos carros? _______

11.- ¿Tiene usted su propia bicicleta?
   □ Sí □ No

12.- ¿Cuánto tiempo tiene con su bicicleta? _______ años.

   Si no tiene una bicicleta, pase a la pregunta 17.

13.- ¿Cuándo usa su bicicleta? (Elija uno)
   □ Nunca.
   □ Una vez cada mes (máximo).
   □ Unas veces cada mes.
   □ Una vez cada semana.
   □ Más que una vez cada semana, menos que todos los días.
   □ Cotidianamente.

14.- ¿Para qué tipo de viajes utiliza su bicicleta? (Puede marcar más de uno).
   □ Recreativo.
   □ Ir al escuela/trabajo.
   □ Ir a comprar cosas.
   □ Otro: ________________________________

15.- ¿Qué distancia recorre en su bicicleta o cuántos minutos la utiliza?
   ______ km. ______ min.

16.- ¿Utiliza un casco cuando la usa?
17.- ¿Quién en su familia anda en bicicleta?
- Niño.
- Niña.
- Esposo.
- Esposa.
- Hermano.
- Hermana.
- Otro: _____________________________

18.- ¿Para qué otras actividades utilizan la bicicleta en su casa?
- Recreativo.
- Ir al escuela/trabajo.
- Ir a comprar cosas.
- Otro: _____________________________

19.- ¿En dónde utiliza más la bicicleta (usted o su familia)? (Puede marcar más de uno).
- En parques.
- Por ciclo rutas.
- Por banqueta.
- Por la calle.
- Otro: _____________________________

20.- ¿Por qué no utiliza la bicicleta? (Puede marcar más de uno).
- No tengo una bicicleta y no voy a comprar.
- Es demasiado fácil robarla.
- No es seguro andar.
- No me gusta andar en bicicleta. Explicar: _____________________________
- No puedo utilizarla. Problemas físicos.
- Mi trabajo/escuela están demasiado lejos.
- Otro: _____________________________

21.- Si no utiliza su bicicleta en la calle por que no es seguro, consideraría utilizarla si existieran ciclo rutas?
- Sí
- Quizás
- No

22.- ¿Cuales problemas considera usted que son los más comunes para no utilizar la bicicleta en Chihuahua?
(Enumeré 1 para lo más importante, 2 al poco importante y 3 al menos importante)

____ Los carros son agresivos, rápidos, no respetan al peatón, etc.
____ Las calles están en malas condiciones.
____ Tiene miedo de que le roben su bicicleta.
____ No hay infraestructura para bicicletas, como ciclo rutas.
____ No hay facilidad para cambiar de ropa en su destino (trabajo/escuela).
____ El clima de Chihuahua no es agradable.
____ Las pendientes son demasiado difíciles.
____ Otro: _____________________________
23.- ¿Qué tipo de infraestructura necesita Chihuahua para que se utilicen las bicicletas?
(Enumeré 1 para lo más importante, 2 al poco importante y 3 al menos importante)
   ___ Ciclo rutas en las calles.
   ___ Ciclo rutas en la banquetas.
   ___ Ciclo rutas especiales por parques y jardines.
   ___ Estaciones de bicicletas: lugares para estacionar, arreglar, rentar.
   ___ Duchas cerca de su trabajo para cambiar la ropa.
   ___ Otro: ___________________________________________
   ___ Nada   Explique: ____________________________________

24.- ¿Si las calles fueran más pequeñas y los vehículos fueran más despacio, utilizaría su bicicleta más frecuentemente?
   □ Sí    □ No   Explique: ______________________________

25.- ¿Si hubiera rutas más convenientes o seguras, las utilizaría para llegar a su destino más rápido?
   □ Sí    □ No   Explique: ______________________________

26.- ¿Por qué andaría usted en bicicleta, y por qué cree que andarían otras personas en bicicleta?
Usted:   Otras Personas:
   □ Es más barato que el carro.        □ Es más barato que los carros.
   □ Es más saludable.                 □ Es más saludable.
   □ Es más conveniente.               □ Es más conveniente.
   □ Es más ecológico.                 □ Es más ecológico.
   □ Para que otra persona pueda usar el carro.
   □ Otro ___________________________                  □ Otro ___________________________

27.- ¿Sabe de alguien que no sea familiar que utilice su bicicleta?
   □ Sí    □ No   ¿Quién? ______________________________

28.- ¿En general quién utiliza su bicicleta en Chihuahua? ¿Qué tipo de persona?

29.- ¿Para quién es viable utilizar o no su bicicletas?

30.- ¿Estaría a favor del uso de formas de transporte más ecológicas a las que usted usa comúnmente?
   □ Sí    □ Quizás    □ No

31.- ¿Estaría dispuesto a caminar o usar la bicicleta más seguido para tener una ciudad más limpia?
   □ Sí    □ Quizás    □ No

32.- Por favor, escriba comentarios sobre bicicletas, ciclistas, y sus experiencias acerca de utilizar bicicletas como un modo de transporte en Chihuahua.

__________________________________________________________

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Appendix B: Survey Instrument for Cyclists

1.- Fecha: ________________

2.- Sexo: □ masculino, □ femenino.

3.- Edad: ________________

4.- ¿Cuánto gana mensualmente (toda su familia):
   □ Menos de 5,000 pesos.
   □ Entre 5,001 y 10,000 pesos.
   □ Entre 10,001 y 20,000 pesos.
   □ Más que 20,000 pesos.

5.- ¿Cuál es el crucero vial más cercano a su casa?
   Calle 1: _____________________________
   Calle 2: _____________________________
   Barrio: _____________________________ Ciudad _________________ Estado:

6.- ¿Cuál es el crucero vial más cercano a su trabajo/escuela (por favor rodea uno)?
   Calle 1: _____________________________
   Calle 2: _____________________________
   Barrio: _____________________________ Ciudad _________________ Estado:

7.- ¿Cuál es su función en la familia?
   □ Jefe/a de la casa (gana más dinero).
   □ Esposo/esposa del jefe/a.
   □ Hijo/hija del jefe/a.
   □ Otro familiar del jefe/a.
   □ Padre/madre/suegra/suegro del jefe/a.
   □ Otro _____________________________

8.- ¿Cuántas personas viven en su casa (familiares directos)? ________________

9.- ¿Tiene usted licencia de manejo?
   □ Sí  □ No

10.- ¿Cuántas bicicletas hay en su casa? ____________ ¿Cuántos carros? ____________

11.- ¿Cuánto tiempo tiene andando bicicleta? ________ años.

12.- ¿Cuándo usa su bicicleta? (Elige uno)
   □ Nunca.
   □ Una vez cada mes (máximo).
   □ Unas veces cada mes.
   □ Una vez cada semana.
   □ Más que una vez cada semana, menos que todos los días.
   □ Cotidianamente.

13.- ¿Para qué tipo de viajes utiliza su bicicleta? (Puede marcar más de uno)
   □ Deportes.
   □ Recreativo.
   □ Ir al escuela/trabajo.
   □ Ir a comprar cosas.
   □ Otro: ________________________________________________

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14.- ¿Usa usted su bicicleta en la calle?  
- Sí □  No □  ¿Por qué? ______________________________________________________________________________

15.- ¿Utiliza un casco cuando la usa?  
- En la calle: Sí □  No □  
- Para deportes: Sí □  No □  
¿Si no, por qué? ______________________________________________________________________________

16.- ¿Quién más en su familia anda en bicicleta?  
- Niño. □  
- Niña. □  
- Esposo. □  
- Esposa. □  
- Hermano. □  
- Hermana. □  
- Otro: ______________________________________________________________________________

17.- ¿Para que otras actividades utilizan su familia la bicicleta?  
- Recreativo. □  
- Ir al escuela/trabajo. □  
- Ir a comprar cosas. □  
- Otro: ______________________________________________________________________________

18.- ¿Cuáles problemas considera usted que son los más comunes para no utilizar la bicicleta en Chihuahua?  
(Enumeré 1 para lo más importante, 2 al poco importante y 3 al menos importante)  
- Los carros son agresivos, rápidos, no respetan al peatón, etc.  
- Las calles están en malas condiciones.  
- No hay bastante rutas para entrena.  
- No hay infraestructura para bicicletas, como ciclo rutas.  
- Tiene miedo de que le roben su bicicleta.  
- No hay facilidad para cambiar de ropa en su destino (trabajo/escuela).  
- El clima de Chihuahua no es agradable para andar bicicletas.  
- Las pendientes son difíciles.  
- Otro: ______________________________________________________________________________

19.- ¿Qué tipo de infraestructura necesita Chihuahua para que se utilicen las bicicletas?  
(Enumeré 1 para lo más importante, 2 al poco importante y 3 al menos importante)  
- Ciclo rutas en las calles.  
- Ciclo rutas en la banquetas.  
- Ciclo rutas especiales por parques y jardines.  
- Estaciones de bicicletas: lugares para estacionar, arreglar, rentar.  
- Duchas cerca de su trabajo para cambiar la ropa.  
- Otro: ______________________________________________________________________________

20.- ¿Si no utiliza su bicicleta en la calle, consideraría utilizarla en la calle como una moda de transporte si existieran ciclo rutas?  
- Sí □  Quizás □  No □  
Explique: ______________________________________________________________________________
21.- ¿Si las calles fueran más pequeñas y los vehículos fueran más despacio en las calles transitas, utilizaría su bicicleta en la calle más frecuentemente?

☐ Sí  ☐ Quizás  ☐ No

Explique: __________________________________________

22.- ¿Si hubiera parques muy largos con ciclorutas y paseos peatonales, al lado de Río Sacramento o otra lugar bonito y natural, utilizaría para andar?

☐ Sí  ☐ Quizás  ☐ No

Explique: __________________________________________

23.- ¿Por qué andaría usted en bicicleta, y por qué cree que andarían otras personas en bicicleta? (Puedes marcar más que uno)

Usted:  Otras Personas:

☐ Es más barato que el carro.  ☐ Es más barato que los carros.
☐ Es más saludable.  ☐ Es más saludable.
☐ Es más conveniente.  ☐ Es más conveniente.
☐ Es más ecológico.  ☐ Es más ecológico.
☐ Para que otra persona pueda usar el carro.  ☐ Para que otra persona pueda usar el carro.
☐ Otro ______________________________  ☐ Otro ______________________________

24.- ¿En general quién utiliza su bicicleta en Chihuahua? ¿Qué tipas de personas?

25.- ¿Para quién es viable/bueno utilizar o no su bicicleta?

Viable: ______________________________

No es viable: ______________________________

26.- ¿Estaría al favor del uso de formas de transporte más ecológicas a las que usted usa comúnmente?

☐ Sí  ☐ Quizás  ☐ No  ¿Por qué? ______________________________

27.- ¿Estaría dispuesto a caminar o usar la bicicleta más seguido para tener una ciudad más limpia?

☐ Sí  ☐ Quizás  ☐ No  ¿Por qué? ______________________________

28.- ¿Piensa usted que sería bueno utilizar bicicletas como un modo de transporte en Chihuahua?

☐ Sí  ☐ Quizás  ☐ No  ¿Por qué? ______________________________

29.- Por favor, escriba comentarios sobre la cultura de bicicletas, los problemas, y como se puede arreglar estos problemas.

________________________________________________________________________

________________________________________________________________________

30.- ¿Puede usted participar en un grupo focal esta semana para hablar sobre estas ideas? IMPLAN esta trabajando en instalando ciclorutas en la ciudad de Chihuahua, y necesitamos tus pensamientos. Es muy importante incluir las ideas de las ciclistas, por eso las ciclorutas son útiles para ustedes.

Miércoles: Entre ☐ 10 – 12am, ☐ 2 – 4pm, ☐ 4 – 6pm

Jueves: Entre ☐ 10 – 12am, ☐ 2 – 4pm, ☐ 4 – 6pm
Appendix C: Survey Script for Pistolas Meneses Park Users

Medio Ambiente:
1A.- ¿Qué piensas sobre el medio ambiente en Chihuahua?
2A.- ¿Cuáles son los problemas mayores?
3A.- ¿Qué debían hacer la gente de Chihuahua para mejorar el medio ambiente?
4A.- ¿Qué haces tú en tu vida para ayudar el medio ambiente?

Bicicletas:
1B.- ¿Andas bicicleta? ¿Si sí, te gusta? ¿Por qué? ¿Sino, por qué?
2B.- ¿Piensas que es bueno para muchas personas tener bicicletas en Chihuahua?
3B.- ¿Hay algunas personas para quién andar bicicleta sea mejor que para otras personas?
4B.- ¿Cuáles son las razones para andar bicicletas?

Mostrar fotos de tipos de ciclorutas
1C.- ¿Si hubiera ciclorutas como en el plan, andarías bicicleta para más que deportes?
2C.- ¿Cuáles diseños prefieres?
3C.- ¿Cuáles son los problemas con el plan o estilo de ciclorutas?
Appendix D: Infrastructure Photos for Pistolas Meneses Surveys
Diseños de cicloviás y otro infraestructura

Cicloviás en banquetas/camellones
1: Planta de corredor Dostoievsky – Cervantes

Fuente: IMPLAN

Cicloviás especiales por parques
1: Cicloviás en parques lineares para recreativa y para ir al trabajo.


Cicloviás en las calles
1: Cicloviás al lado de las calles, separadas

Fuente: http://www.streetsblog.org/2006/11/06/cyclists-and-pedestrians-fighting-over-the-scrapes/

2: Cicloviás al lado de las calles, no separadas, pavimento diferente

Fuente: http://www.streetsblog.org/2006/11/06/cyclists-and-pedestrians-fighting-over-the-scrapes/
3: Ciclovías al lado de las calles, no separadas, pintadas

4: Ciclovías al lado de las calles, no separadas, en carillas especiales para camiones.

Otras Cosas: Infraestructura
1: Estacionamiento para bicicletas, con sombra

2: Semáforos especiales para bicicletas

3: Estaciones de bicicletas (estacionamiento, duchas, talleres, etc.)
Appendix E: Community Center Focus Group Script

Estos grupos focales deben ser 90 minutos a 2 horas, con una encuesta escrita muy corta.

I. Introductions/Warm-Up (5-10 minutes)
   A. **Moderador Introducción:** Me llamo ____, soy el moderador de este grupo focal.
      Estoy trabajando hoy con IMPLAN, Instituto Municipal de Planeación, y una
      estudiante de Massachusetts Institute of Technology. Este grupo focal está
      patrocinado por IMPLAN...
   B. **La intención del grupo focal:** Para discutir las actitudes y retos sobre usando
      bicicletas como un medio del transporte en Chihuahua.
   C. **Reglas de procedimiento:**
      1. Sea completamente honesto; no hay respuestas incorrectas; todas las ideas
         y respuestas abiertas y honestas son útiles.
      2. Todos los participantes deben contribuir en una manera equilibrada. Es
         aceptable no estar de acuerdo.
   D. Estamos grabando y tomando notas (los observadores), pero no son para uso
      comercial. Por favor, hable uno por uno.

II. Presentaciones/Introducciones (cada participante, 10 minutos total):
   3. Nombre
   4. ¿Vives con su familia, otra?
   5. ¿Hobby favorito? ¿Cuál deportes?
   6. ¿Usualmente, como te mueves en Chihuahua, para llegar al trabajo, comprar
      cosas, divertirte? *(respuesta corta sobre el medio principal de transporte para
      cada cosa)*

III. Actitudes Generales (30 minutos)
   1. ¿Piensas que estás sana? ¿Piensas que esta ciudad es sano para vivir? ¿Cómo
      quedas sana? ¿Que debe hacer aquí para que la gente pueda ser mas sano en el
      futuro?
   2. ¿Qué piensas sobre el medio ambiente en Chihuahua?
      *(Pregunta abierta primera, y después, pregunta la siguiente)*
      a. Calidad del aire
      b. Agua (Contaminación, falta, etc)
      c. Cantidad, calidad de espacios verdes públicos
   3. ¿Qué son las procedencias/causas de contaminación en Chihuahua?
      *(Pregunta abierta primera y después, sugiere la siguiente)*
      a. ¿Fábricas? ¿Hogares/Personas? ¿Transporte?
   4. ¿Hay grupos/lugares en la ciudad para quién/qué este peor?
   5. ¿Qué deberían hacer la gente de Chihuahua para mejorar el medio ambiente?
      ¿Qué haces tú en tu vida para ayuda el medio ambiente?
   6. ¿Qué es la relación entre carros y el medio ambiente en Chihuahua?
   7. ¿Transporte/átráfico es un problema ahora? ¿Cómo se debe arreglar?
   8. ¿Cómo maneja la gente de Chihuahua? ¿Si es mal, como podemos arreglarlo?
9. ¿Es mejor tener calles rápidas y grandes para viajar rápidamente o un centro concentrado y calles vivas para peatonales, etc.?

IV. Bicicletas (45-60 minutos)
A. General
1. ¿Cuántas personas tienen bicicletas en el grupo focal? Si no tienes, piensa que es bueno para ti y otras personas cuando andando bicicletas.

B. Viajes
1. ¿Qué tipos de viajes son buenos para andar en bicicleta?
   (respuestas posibles, ideas)
   a. comprar cosas
   b. ir al trabajo
   c. ir a la escuela
   d. diversión/pasatiempo
   e. media semana, fin de semana
   f. a que hora
   g. verano/invierno
2. ¿Cuántos kilómetros es apta/demasiado para un viaje por bicicleta?
3. ¿A dónde es bueno para llegar en bicicleta? ¿A dónde es malo?
   (respuestas posibles, ideas)
   a. trabajo
   b. divertido/recreación
   c. escuela
   d. comprar cosas
   e. el centro u otro parte de la ciudad
4. ¿Cómo es tu barrio para andar bicicleta?

C. Sentimientos sobre bicicletas
1. ¿Quién le gusta andar bicicleta? ¿Por qué? ¿Hay otras razones para andar?
2. ¿Quién en la ciudad anda bicicletas? ¿Son diferentes de ustedes? ¿Por qué andaría alguien una bicicleta?
   (Pregunta abierta primera, y después, sugiere la siguiente)
   a. Es mas barato que carros
   b. Es más saludable
   c. Es más fácil
   d. Otra persona puede usar el carro
   e. Otro
3. ¿Qué piensas sobre ciclistas en las calles? ¿Qué piensan otra personas, como conductores, vecinos, etc.? ¿Ellos están (in the way?) Deben ser en las calles?
   ¿Piensas que ellos están haciendo algo bueno o malo?
4. ¿Hay una cultura de ciclismo aquí? ¿Qué tipo es? ¿Cómo debería cambiar?
   ¿Cómo se puede cambiar? ¿Debía ser una?

D. Problemas para bicicletas
1. ¿Cuáles son los problemas más peores para andar bicicleta en Chihuahua?
   (Pregunta abierta primera, y después, sugiere la siguiente)
   a. Tráfico/carros
b. Las condiciones de las calles: pavimento, ancho (de la calle carriles), velocidad, tráfico (carros, autobuses), de sentido único, etc.
c. Seguridad – de su bicicleta, de su en la calle (accidentes)
d. La clima de Chihuahua no es agradable
e. Las pendientes son demasiado difíciles
f. No hay infraestructura de bicicletas, como ciclorutas
g. No hay facilidades para estacionar y arreglar su bicicleta, para cambiar su ropa en su destinación
h. Perros

2. ¿Cual infraestructura es importante para bicicletas y porque? *(Pregunta abierta primera, y después, sugiere la siguiente)*
   a. Ciclorutas en la calle (carriles, separado con obstrucciones)
   b. Ciclorutas en las banquetas
   c. Ciclorutas especial por parques, etc.
   d. Estaciones de bicicletas: lugares para estacionar, arreglar, alquiler bicicletas
   e. Solamente estacionamiento para bicicletas
   f. Duchas cerca de su trabajo para cambiar la ropa
   g. Nada

3. ¿Para andas bicicleta, que más necesitas? ¿Nunca vas a andar o quieres andar?

4. ¿Para quién es apta o no es apta andar bicicletas? ¿Hay personas que no debían andar porque no es apropiado? ¿Que piensa sobre profesionales en una bicicleta? ¿Niños (es seguro)? ¿Mujeres?

E. Muestra el plan/dibujos de ciclorutas:
   1. ¿Si hubiera ciclorutas como en el plan, andarias bicicleta? Explique. ¿Cuáles son los problemas con el plan o estilo de ciclorutas?
   2. ¿Si hubiera otras políticas, haciendo las calles tránsitos más pequeños, las velocidades más despacio, etc… sería bueno o mal para la ciudad? ¿Por qué?
      a. *(Si ellos piensan que es una cosa mala)* ¿Si lo que estamos hablando sobre mejorara la vitalidad de la ciudad, para hacer la ciudad más ambientalmente amigable, pensarías que es una buena idea?
   3. ¿Si no quieres andar bicicletas en la calle, o si no quieres andar bicicleta, usarías un parque linear, muy largo al lado del Río Sacramento, o prefieres un parque cuadro y concentrado como La Deportiva?
Appendix F: Cyclist Focus Group Script

Estos grupos focales deben ser 90 minutos a 2 horas, con una encuesta escrita muy corta.

I. Introductions/Warm-Up (5-10 minutes)
   A. Moderador Introducción: Me llamo _, soy el moderador de este grupo focal.
      Estoy trabajando hoy con IMPLAN, Instituto Municipal de Planeación, y una
      estudiante de Massachusetts Institute of Technology. Este grupo focal está
      patrocinado por IMPLAN...
   B. La intención del grupo focal: Para discutir las actitudes y retos sobre usando
      bicicletas como un medio del transporte en Chihuahua.
   C. Reglas de procedimiento:
      1. Sea completamente honesto; no hay respuestas incorrectas; todas las ideas
         y respuestas abiertas y honestas son útiles.
      2. Todos los participantes deben contribuir en una manera equilibrada. Es
         acceptable no estar de acuerdo.
   D. Estamos grabando y tomando notas (los observadores), pero no son para uso
      comercial. Por favor, hable uno por uno.

II. Presentaciones/Introducciones (cada participante, 10 minutos total):
   1. Nombre
   2. ¿Vives con su familia, otra?
   3. ¿Hobby favorito? ¿Cuál deportes?
   4. ¿Usualmente, como te mueves en Chihuahua, para llegar al trabajo, comprar
      cosas, divertirse? (respuesta corta sobre el medio principal de transporte para
      cada cosa)

III. Actitudes Generales (30 minutos)
   1. Salud: ¿Piensas que esta ciudad es sano para vivir? ¿Piensas que las personas
      en esta ciudad son sanas? ¿Que debe hacer aquí para que la gente pueda ser
      mas sano en el futuro?
   2. ¿Qué piensas sobre el medio ambiente en Chihuahua?
      (Pregunta abierta primera, y después, pregunta la siguiente)
      a. Calidad del aire
      b. Agua (Contaminación, falta, etc)
      c. Cuantidad, calidad de espacios verdes públicos
   3. ¿Qué son las procedencias/causas de contaminación en Chihuahua?
      (Pregunta abierta primera y después, sugiere la siguiente)
      a. ¿Fábricas? ¿Hogares/Personas? ¿Transporte?
   4. ¿Hay grupos/lugares en la ciudad para quién/qué este peor?
   5. ¿Qué debían hacer la gente de Chihuahua para mejorar el medio ambiente?
      ¿Qué haces tú en tu vida para ayuda el medio ambiente?
   6. ¿Qué es la relación entre carros y el medio ambiente en Chihuahua?
   7. ¿Transporte/trafico es un problema ahora? ¿Como se debe arreglar?
   8. ¿Como maneja la gente de Chihuahua? ¿Si es mal, como podemos arreglarlo?
9. ¿Es mejor tener calles rápidas y grandes para transportar rápidamente o un centro concentrado y calles vivas para peatonales, etc.?

IV. *Bicicletas* (45-60 minutos)

A. General
1. ¿Piensas que es bueno para muchas personas tienen bicicletas?

B. Viajes
1. ¿Qué tipos de viajes son buenos para andar en bicicleta?
   *(respuestas posibles, ideas)*
   a. comprar cosas
   b. ir al trabajo
   c. ir a la escuela
   d. diversión/pasatiempo
   e. media semana, fin de semana
   f. a que hora
   g. verano/invierno
2. ¿Cuántos kilómetros es apta/demasiado para un viaje por bicicleta por la persona promedio?
3. ¿A dónde es bueno para llegar en bicicleta? ¿A dónde es malo? ¿Por qué?
   *(respuestas posibles, ideas)*
   a. trabajo
   b. divertido/recreación
   c. escuela
   d. comprar cosas
   e. el centro u otro parte de la ciudad
4. ¿Cómo es tu barrio para andar bicicleta?

C. Sentimientos sobre bicicletas
1. ¿Cuáles son las razones para andar bicicletas?
2. ¿Por qué andaría alguien una bicicleta?
   *(Pregunta abierta primera, y después, sugiere la siguiente)*
   a. Es más barato que carros
   b. Es más saludable
   c. Es más fácil
   d. Otra persona puede usar el carro
   e. Otro
3. ¿Quién en la ciudad andar bicicletas? ¿Son diferentes de ustedes?
4. ¿Para quién es apta o no es apta andar bicicletas? ¿Hay personas que no debían andar porque no es apropiado? ¿Qué piensa sobre profesionales en una bicicleta? ¿Niños (es seguro)? ¿Mujeres?
5. ¿Qué piensas sobre ciclistas en las calles? ¿Qué piensan otras personas, como conductores, vecinos, etc.? ¿Ellos están (in the way)? ¿Deben ser en las calles? ¿Piensas que ellos están haciendo algo bueno o malo? ¿Para quién son las calles?
6. En las encuestas, muchas personas dicen que no hay cultura de ciclismo aquí. ¿Dónde hay una cultura de ciclismo mejor? ¿Qué tipo es? ¿Cómo debía
cambiar la cultura? ¿Cómo se puede cambiar la cultura en Chihuahua?
¿Cuáles son las ventajas de tener una cultura de ciclismo?

D. Problemas para bicicletas
1. ¿Cuáles son los problemas más peores para andar bicicleta en Chihuahua?
(Pregunta abierta primera, y después, sugiere la siguiente)
   a. Tráfico/carros
   b. Las condiciones de las calles: pavimento, ancho (de la calle carriles), velocidad, tráfico (carros, autobuses), de sentido único, etc.
   c. Seguridad – de su bicicleta, de su en la calle (accidentes)
   d. La clima de Chihuahua no es agradable
   e. Las pendientes son demasiado difíciles
   f. No hay infraestructura de bicicletas, como ciclorutas
   g. No hay facilidades para estacionar y arreglar su bicicleta, para cambiar su ropa en su destinación
   h. Perros

E. ¿Cual infraestructura es importante para bicicletas y porque?
(Pregunta abierta primera, y después, sugiere la siguiente)
   a. Ciclorutas en la calle (carriles, separado con obstrucciones)
   b. Ciclorutas en las banquetas
   c. Ciclorutas especial por parques, etc.
   d. Estaciones de bicicletas: lugares para estacionar, arreglar, alquiler bicicletas
   e. Solamente estacionamiento para bicicletas
   f. Duchas cerca de su trabajo para cambiar la ropa
   g. Nada

F. ¿Para usar bicicleta como una moda de transporte, que más necesitas?

G. Muestra el plan/dibujos de ciclorutas:
1. ¿Si hubiera ciclorutas como en el plan, andarías bicicleta para más que deportes? ¿Para ir al trabajo? Otro? Explique. ¿Cuáles son los problemas con el plan o estilo de ciclorutas?
2. Mostrar fotos de tipos de ciclorutas ¿Si no quieres andar bicicletas en la calle, o si no quieres andar bicicleta, usarías un parque linear, muy larga al lado del Río Sacramento, o prefieres un parque cuadro y concentrado como La Deportiva?
3. ¿Si hubiera otras políticas, haciendo las calles tránsitos más pequeños, las velocidades más despacio, etc… sería bueno o mal para la ciudad? ¿Por qué?
¿Qué son incentivos buenos para andar bicicletas?
Appendix G: Interview Results, Summer, 2007

Four interviews were conducted with people of different levels of involvement in cycling and the government, including:

- Ing. Jesús Munoz: an employee of the State Sports Department
- Gabriel Cano Olivas: owner of a bicycle shop and the technical director for the annual international bicycle race in Chihuahua (Vuelta Chihuahua Internacional)
- Diputado Federal Emilio Flores Domínguez, an elected federal level representative from the PAN party
- Virgilio Cepeda Cisneros, the director of Urban Development for the city

These interviews helped me to identify three major cycling related groups, members of which attended the workshops described in Chapter 6:

- Asociación Estatal de Ciclismo: state level association for cycling
- Instituto Chihuahua de la Deporte y Cultura Física: focuses on promoting cycling to young people
- Comisión Estatal de Bicicletas: meets almost once a week except for in July

The difference between the function of the first and third groups is not yet clear. The Comisión Estatal de Bicicletas (state commission on bicycles), meets frequently, but its only current agenda item is the race organized by Gabriel Cano Olivas.

Results

Interviewees spoke of concern for cycling issues and cooperation between interested parties, but the reality of how cycling is dealt with was difficult to discern from these interviews. It seems that IMPLAN is the main group actively attempting to impact policy in order to promote cycling and that there are few, if any, existing independent groups organized around this mission.

Most of the interviews involved general discussion of the political context (summarized in Chapter 4) and expressions of support for cycling efforts. At least one interviewee, Representative Cepeda, explicitly expressed his support of the prioritization of bicycle and pedestrian projects in the PSMUS (personal communication, June 20, 2007).

Representative Cepeda had some opinions about the challenges to promoting bicycling in Chihuahua, which included hills, summer temperatures, and the poor permeability of pavement. He also noted that car ownership was increasing due to a perception of cars as a symbol of social status and the importation of cheap used cars from the U.S. Only the interview with Gabriel Cano Olivas contained extensive discussion of cycling related issues, and is described in greater detail below.

Gabriel Cano

Gabriel Cano owns a bicycle shop, is a university-level cycling coach, and is the technical director for Vuelta Chihuahua Internacional, the annual international bicycle race in Chihuahua. This race is the most public event organized around cycling, and I felt that it was the existing event with the highest potential of promoting cycling as a form of sustainable transportation, although the event is more focused on cycling as a competitive
sport. Cano mentioned his interest in eliciting cultural change through a cyclist movement, though it did not seem that he or others had seriously considered cycling promotion through other festivals or educational efforts.

Cano’s brother was killed by a drunk driver while cycling about one year previous to our interview. He explained that immediately after the death, the Comisión Estatal de Ciclismo’s agenda became more focused on promoting cycling awareness and safety. However, this impetus faded as time passed. Now the Commission’s sole agenda item is the organization of Vuelta Chihuahua Internacional. This tragic event could have been an opportunity to launch a cycling initiative, but it appears that the impetus has now faded.

Cano is another professional cyclist who does not ride his bicycle as a form of transportation because of his safety concerns on urban streets. He said that some people in Chihuahua use cycling as a form of transportation because it interests them. However, Mexico generally lacks the culture of alternative transportation that exists even in the automobile dominated United States. He noted a lack of leadership around cycling advocacy, even in the groups that are designated to work on cycling issues, such as the Comisión Estatal de Ciclismo.
Appendix H: Visioning Participants, Workshops 1 and 2

Workshop 1
On the municipal level, there were employees from:
- Dirección de Planeación Municipio (Municipal Planning Department)
- Dirección de Fomento Económico Municipal (Municipal Economic Development Department)
- Dirección de Desarrollo Urbano y Ecología (Department of Urban Development and Ecology)
- Dirección de Obras Publicas (Office of Public Works)

From the state, there were employees of the following departments:
- Secretaría de Comunicaciones y Obras Públicas (Office of Communication and Public Works)
- Dirección de Transporte (Department of Transportation)

One participant represented the Centro de Investigación en Materiales Avanzadas (Center for Research in Advanced Materials). Also, the coordinator of public relations for the city, an advocate of cycling, was present.

Workshop 2
There were 15 participants, this time including five employees of the Recreovia, a member of the Asociación Estatal de Ciclismo, an employee of the Instituto Chihuahuense del Deporte y Cultura Física (State Department for Sports and Physical Culture), the city subdirector of sports of the Dirección de Atención Ciudadana y Desarrollo Social (Department of Citizen Attention and Social Development), and at least three cyclists. One of the cyclists was the previously mentioned entrepreneur who, in January of 2008, started Chihuahua's first bike messenger company. Three employees of Brasa Desarrollos, a private Mexican real estate firm, arrived late and listened from a back row, although I did not directly invite them.
### Appendix I: U.S., Canadian, and European Case Studies for Workshop 3

<table>
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<tr>
<th>Ciudad</th>
<th>Población</th>
<th>Área de la ciudad</th>
<th>Población aumentada</th>
<th>Población disminuida</th>
<th>Promedio extremo (julio)</th>
<th>Promedio punto bajo (enero)</th>
<th>Precipitación mínima y máxima</th>
<th>Infraestructura para bicicletas</th>
<th>Educación de la población sobre bicicletas</th>
<th>Intermodalidad</th>
<th>Promoción y uso de la bicicleta</th>
<th>Información</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Toronto, Canadá</strong></td>
<td>5,1 millones en 2001</td>
<td>5,903 km²</td>
<td>8%</td>
<td>2001</td>
<td>27°C</td>
<td>10°C</td>
<td>Invierne extrema: ciclismo disminuye 53%</td>
<td>220 km ciclovías</td>
<td>154 km ciclovías</td>
<td>53%</td>
<td>Hay un mapa gratis de la red de ciclovías, mostrando conexiones con transporte público y otras cosas interesantes para ciclistas.</td>
<td>Hay un mapa gratis de la red de ciclovías, mostrando conexiones con transporte público y otras cosas interesantes para ciclistas.</td>
</tr>
<tr>
<td><strong>Phoenix, Arizona, EEUU</strong></td>
<td>1,3 millones en 2000</td>
<td>12,300 km²</td>
<td>0,9%</td>
<td>2001</td>
<td>40°C</td>
<td>6°C</td>
<td>La precipitación media mínima y máxima: 23 - 234 km</td>
<td>325 km ciclovías</td>
<td>350 km ciclovías</td>
<td>93%</td>
<td>Hay un programa de seis meses, se llama &quot;Bicicleta en Autobús&quot;, para mostrar cómo se puede llevar bicicletas en transporte público.</td>
<td>Hay un programa de seis meses, se llama &quot;Bicicleta en Autobús&quot;, para mostrar cómo se puede llevar bicicletas en transporte público.</td>
</tr>
</tbody>
</table>

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2 Fuentes de todo la información sobre el tiempo y precipitación: http://weather.uk.mer.com

3 Fuentes de toda la información sobre el tiempo y precipitación: http://weather.uk.mer.com


6 Fuentes de toda la información sobre el tiempo y precipitación: http://weather.uk.mer.com

7 http://www.bicycleinfo.org/bikasafe/case_study_east Case Study #8


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### Estudios de Caso por Número de Viajes por Bicicletas, 31 Enero, 2008

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<th>Ciudad</th>
<th>Viages por año</th>
<th>Características de la ciudad</th>
<th>Infraestructura</th>
<th>Educación</th>
<th>Intermodalidad</th>
<th>Promoción/Defensa</th>
<th>Información</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albuquerque, Nuevo México, EEUU</td>
<td>1.18% 448,000/2000</td>
<td>- Población: 448,000 en 2000&lt;br&gt; - El área de la ciudad: 468 km²&lt;br&gt; - Densidad: 969 pp/km²&lt;br&gt; - Promedio temporal (julio): 34°C&lt;br&gt; - Promedio punto bajo (enero): -6°C&lt;br&gt; - La precipitación media y máxima: 1.12 - 4.39 mm&lt;br&gt; - La mayoría de viajes a trabajo son 5 a 8 km, una distancia perfecta para ciclismo.&lt;br&gt; - Hay la percepción que bicicletas son para usos recreativos.†</td>
<td>- Uno de los sistemas más extensivos en los Estados Unidos, 480 km de ciclovías, 160 km pavimentada separada de vialidad.†&lt;br&gt; - Según una encuesta, ciclistas usan ciclovías en las calles 60% del tiempo y ciclovías pavimentada separada de vialidad 25% del tiempo.&lt;br&gt; - Hay Pendientes</td>
<td>- &quot;Bike Node&quot; clases para enseñar a los niños. Las clases son gratis y están proporcionadas de la ciudad.&lt;br&gt; - Educación de seguridad para Bicicletas.&lt;br&gt; - Hay un parágrafo sobre ciclistas en el manual de manejar.</td>
<td>- Hay &quot;racks&quot; en todos los autobuses.</td>
<td>- Bike Albuquerque. <a href="http://www.bikealbq.org">http://www.bikealbq.org</a>, con eventos, clases (510). Información, estadísticas sobre llevando un casco, etc. Se puede encontrar alguien con quien andar bicicleta al trabajo.</td>
<td>- Mapas gratis. Un mapa interactivo en GIS.</td>
</tr>
<tr>
<td>Vancouver, Canadá</td>
<td>1.9% 2001</td>
<td>- Población: 2.1 mil en 2000&lt;br&gt; - El área de la ciudad: 2.87 km²&lt;br&gt; - Densidad: 736 pp/km²&lt;br&gt; - Promedio temporal (julio/agosto): 24°C&lt;br&gt; - Promedio punto bajo (feb): 3°C&lt;br&gt; - La precipitación media y máxima: 4.19 - 21.4 mm&lt;br&gt; - Partes pendientes, desarrollo restricto.</td>
<td>- 93 km ciclovías&lt;br&gt; - Hay semáforos activados por ciclistas.&lt;br&gt; - Hay &quot;traffic calming&quot; (trafico calmado) barrios</td>
<td>- &quot;CAN-BIKE&quot; organizer en 2003 por el departamento de los pares, parkades y la recreación, enseñado de empleos de la ciudad. Es educación para adultos.&lt;br&gt; - El manual de manejar tiene información sobre ciclistas.</td>
<td>- Hay &quot;racks&quot; en autobuses. Se puede llevar las bicicletas en todo transporte público, excepto el metro durante las horas pico.</td>
<td>- Un mapa gratis financiado por Translink (la autoridad regional de transporte).</td>
<td>- Un mapa actualizado anualmente y una guía que llama &quot;bike Sense.&quot;</td>
</tr>
<tr>
<td>Victoria, Canadá</td>
<td>4.8% 2001</td>
<td>- Población: 350,088 en 2006&lt;br&gt; - El área de la ciudad: 659 km²&lt;br&gt; - Densidad: 475 pp/km²&lt;br&gt; - Promedio temporal (julio): 24°C&lt;br&gt; - Promedio punto bajo (enero): 3°C&lt;br&gt; - La precipitación media y máxima: 84.5 - 56.8 mm&lt;br&gt; - Pendiente, compuesto. Primero nivel de salud físico en Canadá.</td>
<td>- 37 km de ciclovías. 67 km pavimentada separada de vialidad y 103 km sobre amicro vehicular.&lt;br&gt; - Hay un plan de aumentar la red de ciclovías a 550 km.</td>
<td>- &quot;CAN-BIKE&quot; para adultos. &quot;Bike Smarts&quot; para los niños&lt;br&gt; - El manual de manejo tiene una sección, &quot;Comparte la Calle&quot;</td>
<td>- &quot;Bike to Work Week&quot; Los fondos son del gobierno provincial y donantes del sector privado.&lt;br&gt; - 3 grupos: Greater Victoria Bike to Work Society, Capital Bike Walk, y Greater Victoria Cycling Coalition. Ofrecen educación, arreglan facilidades de ciclismo, organistán datos para ciclismo, y presionan los gobiernos sobre ciclismo.</td>
<td>- Greater Victoria Cycling Coalition ofrece un mapa actualizado anualmente y una guía que llama &quot;Bike Sense.&quot;</td>
<td>- Un mapa interactivo en GIS.</td>
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</tbody>
</table>

† Bicycle Commuting and Facilities in Major U.S. Cities If You Build Them, Commuters Will Use Them – Another Look; Jennifer Dill and Theresia Cern, Portland State University


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<tr>
<th>Ciudad</th>
<th>Viajes por bicicleta</th>
<th>Características de la ciudad</th>
<th>Infraestructura</th>
<th>Educación</th>
<th>Intermodalidad</th>
<th>Promoción/Difusión</th>
<th>Información</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berlin, Alemania</td>
<td>10% 1998</td>
<td>- 1144 km ciclovías en 2004: 80 km pavimentación separada de vialidad, 50 km en banquetas, 100 km de uso mixto separada de vialidad, 70 km en banquetes.</td>
<td>- 45% de los viajes son menos de 3 km.</td>
<td>- Niños, entre el tercero y cuarto nivel de la escuela, necesitan tomar una clase de ciclismo y pasar un examen con una policía.</td>
<td>- Se pueden llevar su bicicleta en el tren todo el día, pero no es gratis.</td>
<td>- En 2003 el primer consejo de ciclismo estaba fundado. Estaba hecho de expertos, y ellos trabajan en el plan de ciclismo.</td>
<td>- Hay una página web muy completa para planear una ruta por bicicleta.</td>
</tr>
<tr>
<td>Copenhagen, Dinamarca</td>
<td>30% 2004</td>
<td>- Una red de ciclovías de 300 km+; hay 35 km de ciclovías &quot;verdes&quot; para recreación e ir a trabajar. Los ciclovías son amplias.</td>
<td>- Una red de ciclovías de 300 km+; hay 35 km de ciclovías &quot;verdes&quot; para recreación e ir a trabajar.</td>
<td>- Clases para inmigrantes.</td>
<td>- Las estaciones del tren tienen mucho estacionamiento para bicicletas.</td>
<td>- &quot;Park and Pedal&quot;. Se puede comprar un sitio de estacionar y por $20 mas, una bicicleta también para quedar allí.</td>
<td>- Hay alejamiento y mucho ciclismo.</td>
</tr>
</tbody>
</table>

25 El primero de los ciclovías "verdes" fue el "Danish Cycle Foundation" en 1995. En 2000, las empresas recibieron bicicletas gratis para uso de los empleados de viajes en la ciudad (la campaña para empresas). |
Por favor, considera cómo se puede iterar y cambiar los datos de Chihuahua.

<table>
<thead>
<tr>
<th>Ciudad</th>
<th>Viajes por bic</th>
<th>Características de la ciudad</th>
<th>Infraestructura</th>
<th>Educación</th>
<th>Intermodalidad</th>
<th>Promoción/Defensa</th>
<th>Información</th>
</tr>
</thead>
</table>
| Chihuahua, México<sup>23</sup> | <1% | - Población: 730,000 en 2005  
- El área de la ciudad: 200km²  
- Densidad: 3,750 pp/km²  
- Promedio extremo (julio): 34°C  
- Promedio punto bajo (enero): 3°C  
- La precipitación medida mínima y máxima: 28 - 4.5cm  
- La superficie verde: 1.4% | - La superficie vial: 42%  
- Propuesta: 276 km ciclovías, la mayoría en camellones. | - En el plan: Poner estacionamiento en las estaciones del troncal del autobús nuevo. | - La Recreovía, los domingos | - |

<sup>23</sup> Fuente: IMPLAN

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