CONSERVE BY BICYCLING AND WALKING

PHASE II REPORT

State of Florida Department of Transportation

Prepared by:

Sprinkle Consulting
Planners+Engineers+Landscape Architects

Kittelson & Associates, Inc.
Transportation Engineering/Planning

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TABLE OF CONTENTS

APPENDICES (available as a separate document)

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

Background

This Florida Department of Transportation (FDOT) Conserve by Bicycling and Walking report represents the second phase of the original Conserve by Bicycle Program Study. The first phase, which was completed in 2007, evaluated the energy and health-related benefits of providing bicycle facilities and bicycle-related programs. There are two primary purposes for this new phase of the study: 1) to fulfill many of the recommended areas for further research that were identified during Phase I, and 2) to expand the scope of the research to include the pedestrian mode. The original Conserve by Bicycle Program purposes and the corresponding Conserve by Bicycle Program Study goals are replicated below; please note that the Phase I report also provides a more extensive discussion of the benefits of bicycling and related existing conditions and trends.

Conserve by Bicycle Program Objectives[1]

- Save energy by increasing the number of miles ridden on bicycles, thereby reducing the usage of petroleum-based fuels.
- Increase efficiency of cycling as a transportation mode by improving interconnectivity of roadways, transit and bicycle facilities.
- Reduce traffic congestion on existing roads.
- Provide recreational opportunities for Florida's residents and visitors.
- Provide healthy transportation and recreation alternatives to help reduce the trend toward obesity and reduce long-term health costs.
- Provide safe ways for children to travel from their homes to their schools by supporting the Safe Paths to Schools Program.

Conserve By Bicycle Program Study Goals

- Where energy conservation and savings can be realized when more and safer bicycle facilities, such as bicycle paths, bicycle lanes, and other safe locations for bicycle use, are created which reduce the use of motor vehicles in a given area.

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[1] As outlined in Section 335.067, F.S., Conserve by Bicycle Program, created by the Florida Legislature in 2005.

- Where the use of education and marketing programs can help convert motor vehicle trips into bicycle trips.
- How, and under what circumstances, the construction of bicycling facilities can provide more opportunities for recreation and how exercise can lead to a reduction of health risks associated with a sedentary lifestyle.
- How the Safe Paths to Schools Program and other similar programs can reduce school-related commuter traffic, which will result in energy and roadway savings as well as improve the health of children throughout the state.
- How partnerships can be created among interested parties in the fields of transportation, law enforcement, education, public health, environmental restoration and conservation, parks and recreation, and energy conservation to achieve a better possibility of success for the program. The above stakeholder groups for instance, may be brought into new or existing groups such as the Bicycle and Pedestrian Advisory Committee operated by FDOT.[2]

The Conserve by Bicycle Program Study accomplished these goals to a large degree and, in the process, identified numerous areas for additional research that would assist in advancing the achievement of the Program's purposes. These research needs were prioritized by the FDOT Safety Office, and several of them were selected as tasks to be performed during Phase II. The selected tasks and corresponding task summaries are identified in the following section.

Conserve by Bicycling and Walking (Phase II) Tasks

1. Steering Committee Coordination

The Conserve by Bicycle Program Study benefited greatly from input provided by its project Steering Committee. This Committee consisted of members from FDOT, other state agencies, metropolitan planning organizations, and universities. This Steering Committee was maintained and supplemented to assist the research team during the development of Phase II. Many members of the original Committee were retained, and others were added because of their ability to guide work on the specific Phase II tasks. Among the new members were the ongoing

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[2] FDOT's Bicycle and Pedestrian Advisory Committee no longer exists.

Conserve by Transit[3] FDOT project manager and researchers. The Steering Committee met with the research team multiple times and provided extensive comments regarding draft report materials. A complete list of Committee members is shown in Appendix A.

2. Collect Additional Corridor Data and Refine Models

Among the most anticipated components of the Conserve by Bicycle Program Study was the development of predictive models for mode choice and induced recreational bicycle travel based on characteristics of a study roadway corridor and its surrounding area. These models were developed, based in part on companion research performed for FDOT District Seven, and have already been applied as part of FDOT projects. However, the researchers believed that additional data would likely improve the performance of these models. While originally envisioned to consist in part of "after" data from many of the corridors studied during Phase I, several new corridors were ultimately selected instead because of their relatively high bicycle and pedestrian usage, a characteristic uncommon to many of the corridors in the prior dataset. The additional data formed the basis for refinement of both existing models and the creation of a new induced recreational pedestrian travel model.

3. Develop Energy and Health Benefits Calculator and User Guide

The models described above are relatively complex and require a significant number of inputs in order to predict corridor-level bicycling and walking use. As such, this task involved the creation of a Microsoft Excel computational engine, which was designed to be both user-friendly and visually appealing. The computational engine also serves as a Benefits Calculator by converting the predicted trips into corresponding energy, health, and (at the request of Steering Committee members) air quality benefits. A companion User Guide was developed that provides information on the model development and potential applications, as well as variable definitions and guidelines for data collection and entry. The Benefits Calculator is available separately from FDOT; the User Guide is included as Appendix B of this report.

[3] This report is scheduled for adoption in November 2009.

4. Determine Long-Term Effects of Bicycle and Pedestrian Facilities

This task serves to identify the long-term impact of providing bicycling and walking facilities on individuals' travel and fitness habits. Specifically, the researchers examined whether a correlation exists between the provision of such facilities and bicycling and walking behaviors throughout later stages of their users' lives. In-person interviews were conducted at locations around the state to gather data on participants' lifelong bicycling and walking behaviors and the availability of associated facilities during various stages of their lives.

5. Determine the Effects of Incentives for Automobile and Bicycle Use on Levels of Bicycling

Financial incentives for bicycling are generally believed to be associated with increased bicycling activity, while financial incentives for driving are correspondingly believed to be associated with lower levels of bicycling activity. As part of this task, a literature search was performed to identify research results related to this hypothesis. Ultimately, little research on this topic was found and the review of literature was expanded to include the impacts of providing bicycling infrastructure. Both direct and indirect effects have been examined, and recommendations for additional research were identified.

6. Evaluate the Effectiveness of Florida-Based Safe Routes to School Programs

Safe Routes to School (SRTS) programs have now been operational in Florida for several years. However, little research has been performed within the State of Florida to evaluate whether these programs (and their various components) lead to increased numbers of children walking and bicycling to and from school. This task involved the collection of all available data from existing programs to determine whether conclusions can be drawn at this time. True before and after data, while unavailable for the majority of existing sources, was available for some programs and these data were analyzed for potential conclusions.

Report Format

The nature of the Phase II tasks is such that, while they all share a common theme of evaluating and/or measuring bicycling and walking activity, they are also largely independent of one another. Accordingly, the subsequent chapters of this report, all of which correspond to Tasks 2-6 as outlined above, should be treated by the reader as stand-alone documents.

CHAPTER 2 HEALTH AND ENERGY BENEFITS

Introduction

As part of the Conserve by Bicycle Program Study, completed in 2007 for FDOT, two models were developed that predict the number of bicyclists along a roadway corridor based on the characteristics of the roadway and its surrounding area.

One of these models is an induced recreational bicycle travel model, which predicts the number of recreational (leisure or exercise) bicycle trips. This model is important in achieving the Study goal of determining "How, and under what circumstances, the construction of bicycling facilities can provide more opportunities for recreation and how exercise can lead to a reduction of health risks associated with a sedentary lifestyle." By comparing the number of recreational bicyclists along a corridor with no bicycle facilities with the number of recreational bicyclists along the same corridor with a bicycle facility, it is possible to convert the difference (i.e., the number of recreational trips *induced* by the presence of the facility) into a quantifiable health benefit. As part of this second phase of the Study, a separate but similar induced recreational walking model has also been developed.

The other previously developed model is a mode choice model that predicts the number of utilitarian (non-recreational) trips along a roadway corridor for each of four modes of travel: automobile, transit, bicycle, and pedestrian. This model is important in achieving the Study goal of determining "Where energy conservation and savings can be realized when more and safer bicycle facilities, such as bicycle paths, bicycle lanes, and other safe locations for bicycle use, are created which reduce the use of motor vehicles in a given area." For every trip that the model predicts will be shifted from the automobile mode to the bicycle or pedestrian mode, fuel is saved and energy conservation results. Each trip that shifts to a non-motorized mode also leads to health benefits in the same way that induced recreational trips do.

At the conclusion of Phase I, the researchers recommended that the dataset be expanded from the 17 corridors that were included at that time. The dataset now includes 28 corridors as a result of data collected specifically for Phase II and as part of a parallel and related FDOT District Seven research project. The Phase II study corridors were selected based on input from the Steering

Committee, which targeted locations with moderately high existing bicycle and pedestrian use with the intent of adding robustness to the dataset. The combined list of corridors, which includes other characteristics, is shown in Table 2-1. Location maps of the corridors can be seen in Appendix C.

TABLE 2-1 Study Corridors

ID	Name	From	To	Location	Facility Type[1]	Sidewalks[3]	Length of Facility (mi)	Width of Facility (ft)
1	16th St S	Pinellas Point Dr	62nd Ave S	St. Petersburg	Bike lane (E)	One side	1.7	4
2	31st St N	Central Ave	5th Ave N	St. Petersburg	Bike lane (P)	Both sides	5.2	4
3	Bruce B. Downs Blvd	Amberly Dr	Hunter's Green Dr	Tampa	Shared use path adjacent to roadway (P)	One side	4.3	10
4	Bruce B. Downs Blvd (S.R. 581)	Hillsborough Co. line	S.R. 54	Wesley Chapel	Shared use path adjacent to roadway (P)	None	6.9	10
5	C.R. 550	Shoal Line Blvd	US.. 19	Weeki Wachee	Paved shoulders (P)	None	3.4	5
6	Elgin Blvd	Deltona Blvd	Mariner Blvd	Spring Hill	Paved shoulders (P)	None	5.4	5
7	Lutz-Lake Fern Rd	Gunn Hwy	Dale Mabry Hwy	Lutz	Shared use path adjacent to roadway (P)	None	6.9	Unknown
8	Nebraska Ave (U.S. 41)	Kennedy Blvd	Bearss Ave	Tampa	Bike lane (P)	Both sides	9.4	4
9	S.R. 60	Kings Ave	Kingsway Rd	Brandon	Bike lane (P)	Both sides	21.5	5
10	Pinellas Trail	Union St	Orange St	Dunedin	Independent alignment (E)	Both sides	34	10

ID	Name	From	To	Location	Facility Type[1]	Sidewalks[3]	Length of Facility (mi)	Width of Facility (ft)
11	20th St	Adamo Dr	Causeway Blvd	Tampa	Shared use path adjacent to roadway (E)[1]	None	1.9	12
12	M-Path	SW 67th Ave	SW 7th St	Miami	Shared use path adjacent to roadway (E)	One side	8.3	8
13	Sunrise Blvd	Hiatus Rd	Pine Island Rd	Plantation	Bike lane (P)	Both sides	1.8	5
14	Spring to Spring Trail	Gemini Springs Park	DeBary Hall	DeBary	Shared use path - independent alignment (E-P)[2]	Both sides	1.3	10
15	St. Marks Trail	Riverside Dr	Capital Circle	Wakulla and Leon Counties	Shared use path - independent alignment (E)	None	27	10
16	Upper Tampa Bay Trail	Memorial Hwy	North of Ehrlich Rd	Tampa	Shared use path - independent alignment (E)	Both sides	7.3	10
17	West Orange Trail	Oakland	North of Apopka	Orange County	Shared use path - independent alignment (E)	One side	19	10
18	Starkey Blvd	Town Ave	River Crossing Blvd	New Port Richey	Shared use path adjacent to roadway (E)	One side	2.7	12
19	Lithia-Pinecrest Rd	S.R. 60	Polk Co. line	Brandon	Bike lane/paved shoulder (E)	Both sides[4]	17	4
20	East Lake Rd	Brooker Creek Way	South of Keystone Rd	Palm Harbor	Shared use path adjacent to roadway (E)	Both sides	4.2	12
21	Ehrlich Rd	Turner Rd	Sheldon Rd	Tampa	Bike lane (E)	Both sides	2.3	4

ID	Name	From	To	Location	Facility Type[1]	Sidewalks[3]	Length of Facility (mi)	Width of Facility (ft)
22	31st St N	Central Ave	5th Ave N	St. Petersburg	Bike lane (E)	Both sides	5.2	4
23	Nebraska Ave (U.S. 41)	Fowler Ave	Fletcher Ave	Tampa	Bike lane (E)	Both sides	0.8	3
24	S.R. 60	Kings Ave	Kingsway Rd	Brandon	Paved shoulder (E)	Both sides	1.7	4
25	16th St	West Ave	Washington Ave	Miami Beach	Bike lane (E)	Both sides	0.7	5.5
26	C.R. A1A	U.S. 1	Indiantown Rd	Jupiter	Bike lane (E)	Both sides	5.2	5.5
27	Minutemen Cswy	Cocoa Beach H.S.	Brevard Ave	Cocoa Beach	Shared use path adjacent to roadway (E)	One side	1.3	8
28	Livingston St	Magnolia Ave	Festival Way	Orlando	Bike lane (E)	Both sides	1.9	4

[1] P = Programmed facility, E = existing facility
[2] An extension from Lake Beresford Park to C.R. 4142 (French Avenue) is programmed for the Spring to Spring Trail
[3] Including shared use path adjacent to the roadway, if present

The remainder of this chapter contains two sections: 1) Recreation and Exercise, and 2) Energy Conservation and Savings. The two recreational travel models are discussed in detail as part of the former, and the mode choice model is discussed in detail as part of the latter.

Recreation and Exercise

According to the U.S. Centers for Disease Control and Prevention (CDC), in 2005, about 46 percent of Floridians engaged in the level of physical activity recommended by the CDC.[4, 5] The

[4] http://apps.nccd.cdc.gov/PASurveillance/StateSumV.asp

[5] The Centers for Disease Control defines “recommended physical activity” as

> Reported moderate-intensity activities in a usual week (i.e., brisk walking, bicycling, vacuuming, gardening, or anything else that causes small increases in breathing or heart rate) for at least 30 minutes per day, at least 5 days per week; or vigorous-intensity activities in a usual week (i.e., running, aerobics, heavy yard work, or anything else that causes large increases in breathing or heart rate) for at least 20 minutes per

remaining 54 percent had insufficient physical activity. This statistic is significant in that the lack of physical activity increases the instances of chronic diseases, such as heart disease, stroke, colon cancer, diabetes, and osteoporosis. Children who become obese as a result of poor diet and lack of exercise are particularly at risk of contracting Type 2 diabetes. In addition to health impacts on individuals, future increases in the rates of these conditions will lead to an ever-increasing burden on Florida's health care costs. This section details some of these health risks and describes how increases in physical activity can help address them.

In 1996, the U.S. Department of Health and Human Services issued a Report of the Surgeon General entitled "Physical Activity and Health," which linked a variety of health issues to lack of physical activity. The report summarized a wide array of research and concluded that regular physical activity can "greatly reduce the risk of coronary heart disease, the leading cause of death in the United States."[6] Regular physical activity also "reduces the risk of developing diabetes, hypertension, and colon cancer; enhances mental health, fosters healthy muscles, bones and joints; and helps maintain function and preserve independence in older adults."[7]

In light of the broad benefits associated with regular physical activity, the CDC also issued a recommendation that "Every U.S. adult should accumulate 30 minutes or more of moderate-intensity physical activity on most, preferably all days of the week." This recommendation focused on the benefits derived by presently inactive people beginning and maintaining activity of moderate intensity. The recommendation cited evidence that "low- to moderate- intensity physical activity levels are more likely to be continued than high-intensity activities." The recommendation cited numerous impediments to physical activity, including environmental

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day, at least 3 days per week or both. This can be accomplished through lifestyle activities (i.e., household, transportation, or leisure-time activities).

[6] U.S. Department of Health and Human Services. *Physical Activity and Health: A Report of the Surgeon General*. Atlanta GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 1996, p. iii.

[7] U.S. Department of Health and Human Services. *Physical Activity and Health: A Report of the Surgeon General*. Atlanta GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 1996, p. iii.

factors such as "a lack of bicycle trails and walking paths away from traffic, inclement weather and unsafe neighborhoods." The recommendations specifically identified cycling as one kind of moderate-intensity activity that will help people realize the numerous benefits of becoming active. The recommendation also identified specific levels of bicycling that are equivalent to the recommended daily "dose" of physical activity: Moderate bicycling (5 miles in 30 minutes) has a benefit equivalent to a shorter period of more vigorous bicycling (4 miles in 15 minutes).

This recommendation from the CDC provides a standardized unit of activity that is accepted to yield a complex but accepted health benefit. Some studies have taken this measure as a unit of benefit for changes in the built environment, either with regard to meeting the recommended dose, or extrapolating further to calculate the difference in health care costs incurred between those people who meet the CDC's recommended level of activity and those who do not. For example, in 2003, James Sallis and others summarized research linking urban form to walking and biking activity and estimated a mean difference in activity levels between people who live in "walkable neighborhoods" and those who do not; the mean difference they found translates into 15-30 minutes of walking per week, or, an entire day's dose of physical activity being accounted for in the difference.[8]

To give another example of how the benefits of improving the built environment can be calculated, if a study can predict how much time will be spent cycling or walking, or how many miles will be ridden or walked, as a result of some facility construction, then that new activity can be estimated as a percentage of meeting the activity threshold. The Federal Highway Administration (FHWA) study *Characteristics of Emerging Road and Trail Users and Their Safety*, published in 2004, found that the average bicycle rider on a shared use path is riding at a speed of about 10 miles per hour[9], which is equal to the 5 miles in 30 minutes recommended by the CDC (the same study also discovered an average walking speed of about 4 miles per hour on

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[8] Sallis, James F., L.D. Frank, B.E. Saelens, and M.K. Kraft. Active Transportation and Physical Activity: Opportunities for Collaboration and Public Health Research. *Transportation Research Part A*, 2004.

[9] Landis, Bruce W., Theodore A. Petritsch, and Herman F. Huang. *Characteristics of Emerging Road and Trail Users and Their Safety.* Federal Highway Administration, McLean, VA, 2004, p. 75.

shared use paths). Therefore, on average, every 5 miles ridden on a shared use path is equal to one person meeting his or her recommended daily dose of physical activity.

Researchers have also made efforts to further quantify benefits of meeting the recommended levels of physical activity. Efforts have been made to also estimate the health care costs associated with lack of physical activity, and thereby quantify some savings to be gained by helping more people meet the recommended levels of physical activity. Report 552 from the National Cooperative Highway Research Program, *Guidelines for Analysis of Investments in Bicycle Facilities*, summarizes various studies that have compared health care expenditures for people who are active to those for people who are inactive. These studies found a range of per-capita annual health savings, ranging from $19 in the State of Washington to $1,175 in Michigan; with a median value of $128 across ten studies.[10] In a similar effort, the Robert Wood Johnson Foundation funded the development of an online physical inactivity calculator that estimates the costs associated with physically inactive people in specific situations.[11]

Statewide Estimates of Health Benefits

The health benefits of cycling and walking activity in Florida can be estimated based upon the number of bicycling and walking trips taken in each year as shown in Table 2-2 (see the Phase I Report for more detail).[12] To calculate the overall health benefits of cycling and walking, each bike and walk trip was taken to represent approximately 30 minutes of exercise and each 30 minutes of exercise represents approximately $0.49 of health benefit.[13] These values yielded a combined benefit of $2.6 billion in Florida in 2002.

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[10] Krizek, K., *et al*. *Guidelines for Analysis of Investments in Bicycle Facilities*. National Cooperative Highway Research Program Report 552. Transportation Research Board, Washington, DC, 2006, p. E-2.

[11] Chenoweth, Dr. David H., Department of Health Education and Promotion, East Carolina University, chenowethd@ecu.edu.

[12] Center for Urban Transportation Research. *Bicycle and Pedestrian Travel: Exploration of Collision Exposure in Florida*. University of South Florida, Tampa, FL, 2002.

[13] As mentioned above, Krizek *et al.* found that the median health benefit of being physically active is $128 per person per year. Physically active is defined as participating in physical activity 5 times per week (for 30 minutes each time), which translates into 260 times per year. Dividing $128 per year by 260 times per year yields approximately $0.49 of health benefit per time (or bike trip).

TABLE 2-2 Estimated Levels of Bicycling and Walking in Florida MSAs

Year	Annual Bicycle Trips	Annual Bicycle Miles Traveled	Annual Pedestrian Trips	Annual Pedestrian Miles Traveled
1998	611 million	3.1 billion	4.6 billion	N/A[1]
2002	961 million	4.4 billion	6.1 billion	7.1 billion

[1] The average pedestrian trip length was not calculated in 1998.

Literature Search

As part of a literature search performed during Phase I, the researchers first reviewed numerous studies of the impacts of bicycle facilities on bicycle ridership. A few studies included counts of bicyclists using facilities. However, nothing was available to allow the researchers to predict how many bicyclists are likely to use a bicycle facility improvement, or what health benefits would result. Therefore, preliminary methods for predicting the number of bicyclists and the accompanying health benefits were to be developed as part of Phase I of this study.

Measurable Criteria

To measure the health benefits of providing bicycle (and now pedestrian) facilities, the number of people who will use these facilities if they are provided must be known. Thus, measurable criteria for evaluating the energy conservation and savings associated with providing bicycle and pedestrian facilities are before-and-after bicycle/pedestrian counts and replaced activity. These are discussed below.

Before-and-After Bicycle Counts

Few people will engage in recreational bicycling in a shared lane with motor vehicle traffic because few people perceive that to be safe or comfortable. The same is true for walking in the absence of sidewalks. The provision of bicycle lanes, sidewalks, and shared use paths will increase perceived safety and comfort on the part of the bicyclists and pedestrians, who will then be more likely to engage in recreational travel on those facilities. Before-and-after bicycle and pedestrian counts provide information on how many additional non-motorized trips are being made as a result of a facility being provided.

Replaced Activity

The presence of a bicycle or pedestrian facility may motivate some individuals to opt for using the facility instead of pursuing another activity. Individuals can choose from among many options for leisure. These include walking or riding a bicycle on a trail, driving to the park, and staying at home to watch rented movies, to name just a few. Replaced activity may or may not result in health benefits. If a person rides a bicycle from his/her home to a trail and then back home, instead of driving to the park, then health benefits will result because the bicycle trip replaces the driving trip. On the other hand, if a person rides or walks on a trail instead of swimming at the community pool, then health benefits may not result because one physical activity (walking) has replaced another (swimming).

The literature search described above found no information related to replaced activity. While the impact on improved public health is likely minimal, a specific study would be needed to confirm this.

Research Plan

To address the Study goals, the extent of mode shift and induced recreational travel that result from the construction of bicycle and pedestrian facilities needs to be determined. That is, how many users will be mode-shifted from the motor vehicle mode to the bicycle or pedestrian mode? How many users will be induced to bicycle or walk for recreational purposes? After determining the number of users that will be using the facility, the energy savings and health benefits for that facility can be calculated.

To answer these questions, the researchers have collected "before" and "after" data on 28 corridors (Table 2-1). The corridors were nominated by FDOT staff and by members of the Steering Committee. Some corridors were chosen because they currently have bicycle and/or pedestrian facilities (bicycle lane, sidewalk, and/or shared use path). These were used as surrogate "after" data points. Other corridors were chosen because they are scheduled to receive a facility in the near future. These were used as "before" data points.

Induced Recreational Trips

To identify the specific factors that should be evaluated, the researchers consulted several groups: members of the Steering Committee, participants in the National ProWalk/ProBike Conference, and a variety of other transportation professionals from around the United States. They identified that the following characteristics of bicycle facilities influence their decisions to make recreational bicycle trips:

- Facility length;
- Intersections/interruptions;
- Amenities/points of interest;
- Number of other trail users;
- Crime;
- Scenery/aesthetics;
- Density-weighted population; and
- Bicycle and pedestrian level of service (LOS).

These were previously described in detail in the Phase I Final Report.

Data Collection

Data collection consisted of three components: intercept surveys, in-office data (Census data and map reviews), and field data (windshield surveys and detailed multi-modal LOS data). The intercept surveys were conducted along each corridor and included questions about the specific trip being taken (trip length, trip purpose) and respondent demographics. Census data and map reviews were used to obtain data on population and employment. Field data collection resulted in the level of service and network friendliness information.

Induced Recreational Trips Model Development

Statistical Package for the Social Sciences (SPSS) software was used to model the number of recreational trips as a function of the characteristics mentioned above. The Phase II dataset consisted of the previously analyzed FDOT District Seven corridors and the Phase I Conserve by Bicycle corridors, as well as four new study corridors. These new corridors were selected with input from the Steering Committee. They were chosen based on the fact that they all have moderate to high current levels of bicycling and walking activity (by Florida standards), a characteristic not common among the prior study corridors. Their inclusion was intended to increase the sample size of bicyclists and pedestrians who would complete intercept surveys. The supplemental corridors analyzed during Phase I, taken from the FDOT District One study on "Sidepath Facility Selection and Design,"[14] have been supplanted by these new study corridors.

Final Induced Recreational Bicycle Travel Model

For each study mode (bicycling and walking), numerous combinations of independent variables and independent variable transformations were tested during Phase II. The final bicycle model, which has an R^2 value of 0.775, and its terms are shown below:

$$RecEstBk = -16.856 + (2.779 \times 10^{-4})*Pop\_10 + 2.443*AESxINT + 11.396*sig\_len - 2.321*lnBLOS$$

where

RecEstBk	= Estimated number of recreational bicycle trips from 3 PM to 6 PM
Pop_10	= Distance-weighted population
AESxINT	= Aesthetics multiplied by points of interest
sig_len	= Sigmoid of the facility length
lnBLOS	= Natural log of the bicycle LOS

More detailed descriptions of the variables in the model follow.

RecEstBk (Estimated number of recreational bicycle trips from 3 PM to 6 PM) The researchers obtained three-hour bicycle counts for each corridor, generally from 3 PM to 6 PM on a Tuesday, Wednesday, or Thursday. Based upon consensus with the project management team from a previous project, the researchers' knowledge of the corridors, and trip purposes stated on returned surveys, they then estimated the number of recreational bicyclists as 10, 40, or 90 percent of the total number of bicyclists counted. For example, an estimated 90 percent of the

[14] Landis, Bruce, *et al. Sidepath Facility Selection and Design.* Florida Department of Transportation, 2005.

bicyclists on the Pinellas Trail are recreational. On the other hand, based on the researchers' knowledge of the area, most bicyclists on Nebraska Avenue are making utilitarian trips, so the amount of recreational trips was estimated to be 10 percent. The estimated number of recreational bicyclists on some corridors was negligible. Some potential variable transformations (such as logarithmic) are not applicable when the variable has a value of zero, consequently a value of 0.01 was substituted for zero values in those cases. Hence, the estimated number of recreational trips is always a positive number.

AESxINT (Aesthetics multiplied by points of interest) This variable includes amenities/points of interest and scenery/aesthetics. It is also believed to function as a surrogate for crime in that areas perceived as having more criminal activity often have little in the way of aesthetics. Each corridor received a score of 1 (lowest), 2, 3, 4, or 5 (highest) for aesthetics. While this value is inherently subjective, it should represent the collective viewpoint of Floridians and be graded more highly based on characteristics such as the presence of trees, location adjacent to bodies of water, and absence of industrial and high-density commercial land uses (see Figure 2-1).

FIGURE 2-1 Examples of scores for qualitative "Aesthetics" variable

Each corridor also received a score of 1 (lowest), 2, or 3 (highest) for points of interest. Points of interest should include (at a minimum) state and regional parks, beaches, regional tourist attractions, colleges/universities, and multi-use trails.[15] While some degree of subjectivity should be allowed in the determination of what other attractions constitute individual points of interest, the corridor should generally be assigned one of the following values:

- "3" if there are two or more adjacent designated points of interest;
- "2" if there is one adjacent designated point of interest; or
- "1" if there are no adjacent designated points of interest.

It was expected that this variable combining aesthetics and points of interest would have a positive coefficient because bicyclists prefer riding in visually appealing environments with points of interest.

Pop_10 (Distance-weighted population) Pop_10 is calculated by

1. Identifying all Census tracts whose centroids were within 10 miles of the actual or hypothetical survey location;
2. Dividing the population of each Census tract by the square of the distance between that Census tract and the survey location (individuals living near a bicycle facility are more likely to use it than those living farther away from the facility); and
3. Summing the "Pop_10" values across all Census tracts.

Mathematically, the equation is written as:

$$Pop\_10 = \sum_{i=1}^{n} \frac{pop_i}{d_i^2}$$

where

pop_i = Population of the i-th Census tract

d_i^2 = Distance (in miles) of the i-th Census tract from the survey location, squared

n = Total number of Census tracts whose centroids are within a specified distance (in this case, 10 miles) of the survey location

[15] Because shared use paths fall into this last group, any shared use path corridor is considered a point of interest itself, and should have a minimum value of "2" assigned to it.

Figure 2-2 shows a cut line (represented by a black circle) surrounded by numerous Census tracts that are within 10 miles. Census Tracts 1, 2, and 3 are highlighted in blue. These tracts are located at distance d_1, d_2, and d_3 from the cut line. The population of Tract 1 is divided by the square of its distance from the cut line to obtain a distance-weighted population for Tract 1. The process is repeated for Tracts 2, 3, etc., until distance-weighted populations have been obtained for all of the tracts. The distance-weighted populations are then added together to obtain the distance-weighted population within 10 miles.

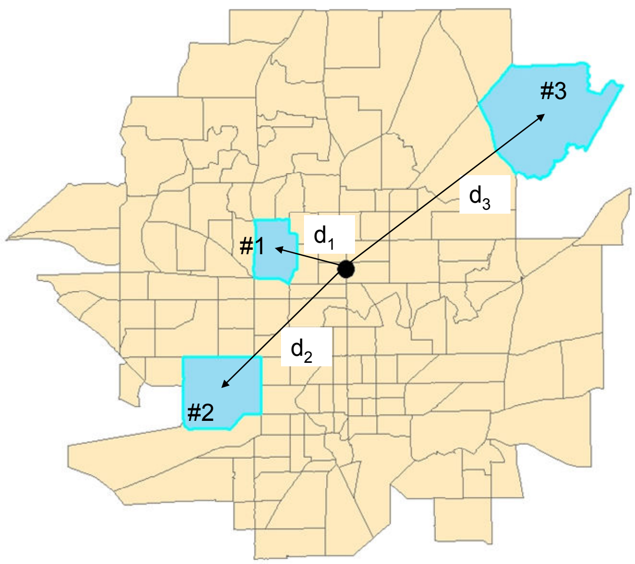

FIGURE 2-2 Distance from cut line to Census tracts

The researchers calculated distance-weighted populations for distances of 5, 10, 15, 20, 25, 30, 35, and 40 miles (Pop_5, Pop_10, Pop_15, etc.). Pop_10 was more nearly statistically significant than Pop_5. There were virtually no changes in the levels of significance with Pop_15 and greater distances, so the final model contains the population proximity within 10 miles, Pop_10.

Sig_len (sigmoid of the facility length) This variable incorporates facility length. Figure 2-3 shows that the expected relationship between the number of recreational bicyclists and the length of the facility follows a sigmoid (S-shaped) curve. The sigmoid of the facility length is calculated as follows:

$$P(L) = \frac{1}{1 + e^{-(L-9)}}$$

where

P(L) = Sigmoid of the length

L = Facility length, in miles

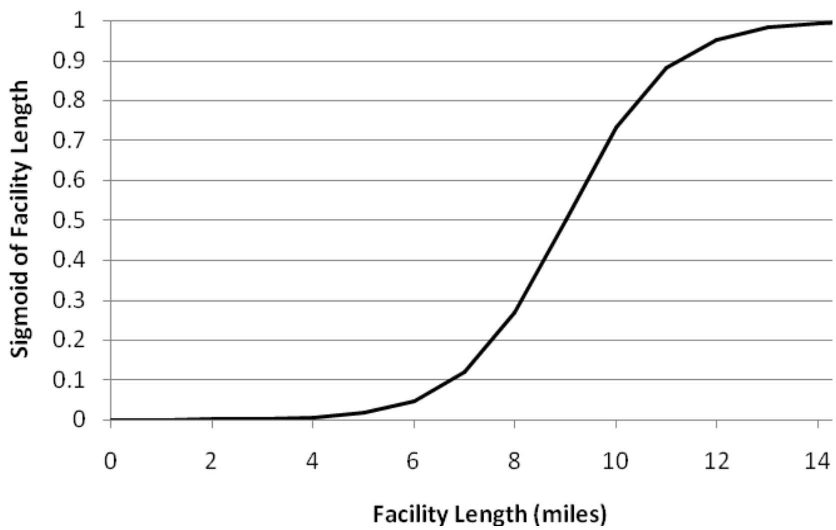

FIGURE 2-3 Sigmoid curve

lnBLOS (Natural log of the positive effective bicycle LOS) The positive effective bicycle LOS can take on one of three values:

1. The calculated segment bicycle LOS +2.00 for the roadway corridor (if no shared use path is present)
2. 0.01 for a shared use path (independent alignment)
3. The calculated sidepath LOS for a shared use path adjacent to the roadway

This third value is based on ongoing research being conducted for the FDOT Central Office, which has produced a user-based statistically validated LOS model for sidepaths. The model form is as follows:

SPLOS = 3.309 – 0.919*lnSeparation

where

SPLOS = Sidepath Level of Service

lnSeparation = natural log of the distance from the sidepath facility to the edge of the adjacent roadway (feet)

The researchers took the natural log of the positive effective bicycle LOS because an improvement in the bicycle LOS has more effect on the number of riders when the existing bicycle LOS is already very good (for example, an improvement from 2 to 1) than when the existing bicycle LOS is poor (for example, an improvement from 6 to 5). The expected relationship is shown graphically in Figure 2-4.

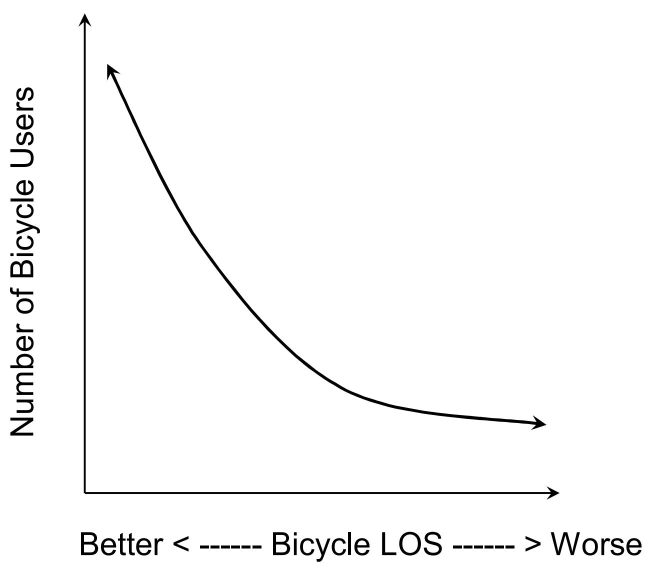

FIGURE 2-4 Number of bicycle users by bicycle LOS

The researchers expected that lnBLOS would have a negative coefficient because the number of recreational bicyclists is thought to increase with better bicycle LOS, which translates into a lower bicycle LOS value.

Induced Recreational Bicycle Travel Model Summary

A summary of the coefficients (B), t statistics (t), and p-values (Sig.) appears in Table 2-3. Table 2-4 shows the values of the variables in each corridor.

TABLE 2-3 Induced recreational bicycle travel model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta	B	Std. Error
1	(Constant)	-16.856	4-990		-3.378	.003
	AESxINT	2.443	.685	.393	3.565	.002
	POP_10	$2.779*10^{-4}$	.000	.775	7.576	.000
	lnBLOS	-2.321	1.185	-.220	-1.958	.062
	Sig_len	11.396	5.808	.201	1.962	.062

TABLE 2-4 Values of variables in each corridor

ID	CORRIDOR	AESxINT	POP_10	Bicycle LOS	lnBLOS	Facility Length	Sig_len
1	16th St S (St. Petersburg)	3	21261	0.99	-0.01	1.7	0.01
2	31st St N (before)	2	78998	1.68	0.52	5.2	0.31
3	Bruce B. Downs @ Commerce Palms	2	13442	0.96	-0.04	4-3	0.15
4	Bruce B. Downs @ S.R. 56	2	6946	5.44	1.69	6.9	0.71
5	C.R. 550	3	10628	5.64	1.73	3.4	0.07
6	Elgin Blvd	2	10849	4.33	1.47	5.4	0.35
7	Lutz-Lake Fern Rd	3	15799	4.82	1.57	6.9	0.71
8	Nebraska Ave @ Linebaugh	1	79663	4.85	1.58	9.4	0.97
9	S.R. 60 @ Parsons	1	43858	5.8	1.76	21.5	1.00
10	Pinellas Trail (U.S. Alt. 19)	9	76177	0.01	-4.61	34.0	1.00
11	20th St	1	36925	2.38	0.87	1.9	0.02
12	M-Path (U.S. 1)	3	129804	0.20	-1.61	8.2	0.90
13	Sunrise Blvd	2	96245	5.17	1.64	1.8	0.01
14	Spring to Spring Trail (U.S. 17/92)	4	17631	0.01	-4.61	1.3	0.01
15	St. Marks Trail (Woodville Hwy)	8	407	0.01	-4.61	27.0	1.00
16	Upper Tampa Bay Trail (Sheldon Rd)	8	37368	0.01	-4.61	8.0	0.88
17	West Orange Trail (Clarcona Rd)	8	16121	0.01	-4.61	19.0	1.00

ID	CORRIDOR	AESxINT	POP_10	Bicycle LOS	lnBLOS	Facility Length	Sig_len
18	Starkey Blvd	4	29152	1.18	0.17	2.7	0.04
19	Lithia-Pinecrest Rd	2	50314	3.18	1.16	16.6	1.00
20	East Lake Rd	6	22295	0.43	-0.84	4.2	0.14
21	Ehrlich Rd	2	53083	3.59	1.28	2.3	0.02
22	31st St (after)	2	78998	1.68	0.52	5.2	0.31
23	Nebraska Ave @ 131st	1	109181	4.11	1.41	0.8	0.01
24	S.R. 60 @ Hilltop	1	43242	3.38	1.22	1.7	0.01
25	16th St (Miami Beach)	6	340155	1.25	0.22	0.7	0.00
26	C.R. A1A	15	35668	2.59	0.95	5.2	0.31
27	Minutemen Cswy	15	6821	1.27	0.24	1.3	0.01
28	Livingston St	3	146121	2.29	0.83	1.9	0.02

Final Induced Recreational Pedestrian Travel Model

The final pedestrian model, which has an R2 value of 0.544, and its terms are shown below:

RecEstPd = -21.549 + .007*Pop_05 + 13.181*PLOSinv + 3.429*AESTHET

where

RecEstPd	= Estimated number of recreational pedestrian trips from 3 PM to 6 PM
Pop_05	= Population within a half-mile of the facility
PLOSinv	= Inverse of the positive effective pedestrian LOS
AESTHET	= Aesthetics of the study corridor

More detailed descriptions of the variables in the model follow.

RecEstPd (Estimated number of recreational bicycle trips from 3 PM to 6 PM) – The researchers obtained three-hour pedestrian counts for each corridor, generally from 3 PM to 6 PM on a Tuesday, Wednesday, or Thursday. According to the researchers' knowledge of the corridors and trip purposes stated on returned surveys, they then estimated the number of recreational pedestrians as 10, 40, or 90 percent of the total number of pedestrians counted. For example, an estimated 90 percent of the pedestrians on the Pinellas Trail are recreational. On the other hand, based on the researchers' knowledge of the area, most pedestrians on Nebraska Avenue are making utilitarian trips, so the amount of recreational trips was estimated to be 10 percent. The estimated number of recreational pedestrians on some corridors was negligible. Some potential variable transformations (such as logarithmic) are not applicable when the variable has a value of zero, consequently a value of 0.01 was substituted for zero values in those cases. Hence, the estimated number of recreational trips is always a positive number.

Pop_05 (Population within a half-mile of the midpoint of the facility) Pop_05 is calculated through the following steps:

1. Identifying all Census tracts that are partially or entirely located within a half-mile of the midpoint of the facility
2. Identifying the population of the Census tracts
3. Calculating the proportions of the Census tracts that are within a half-mile of the midpoint of the study corridor
4. Reducing the Census tract populations by multiplying the populations by those proportions
5. Summing the resulting values for all Census tracts

Figure 2-5 shows a graphical example (Livingston Street) of this variable, including the half-mile area around the midpoint of the corridor and the Census tracts that intersect that area.

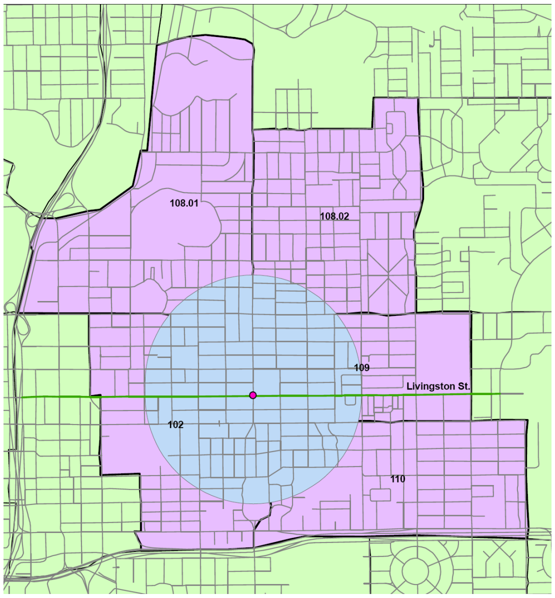

FIGURE 2-5 Calculating surrounding population (pedestrian mode)

The researchers calculated distance-weighted populations for distances of 0.25, 0.5, and 0.75 miles. Pop_05 was more statistically significant than the other possibilities.

PLOSinv (inverse of the positive effective pedestrian LOS) - The positive effective pedestrian LOS can take on one of two values:

1. The calculated segment pedestrian LOS for the roadway corridor, if no shared use path (independent alignment) is present; if a shared use path adjacent to the roadway (sidepath) is present, it is treated as a wise sidewalk in the pedestrian LOS calculation
2. 0.5 for a shared use path (independent alignment)

As with the use of the natural log for the bicycle LOS, the researchers took the inverse of the positive effective pedestrian LOS because an improvement in the pedestrian LOS has more effect on the number of pedestrians when the existing pedestrian LOS is already very good (for example, an improvement from 2 to 1) than when the existing pedestrian LOS is poor (for example, an improvement from 6 to 5).

AESTHET (Aesthetics of the study corridor) This variable represents the scenery/aesthetics of the corridor. It is also believed to function as a surrogate for crime in that areas perceived as having more criminal activity often have little in the way of aesthetics. Each corridor received a score of 1 (lowest), 2, 3, 4, or 5 (highest) for aesthetics. It was expected that this variable would have a positive coefficient because pedestrians prefer walking in visually appealing environments with points of interest.

Induced Recreational Pedestrian Travel Model Summary

A summary of the coefficients (B), t statistics (t), and p-values (Sig.) appears in Table 2-5. Table 2-6 shows the values of the variables in each corridor.

TABLE 2-5 Induced recreational pedestrian travel model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta	B	Std. Error
1	(Constant)	-21.549	9.879		-2.181	.040
	Pop05	.007	.002	.670	4-554	.000
	PLOSinv	13.181	6.008	.366	2.194	.039
	AESTHET	3.429	3.379	.169	1.015	.321

TABLE 2-6 Values of variables in each corridor

ID	Corridor	Pop_05	Pedestrian LOS	PLOSinv	AESTHET
1	16th St S (St. Petersburg)	4848	2.75	0.36	3
2	31st St N (before)	3081	2.80	0.36	2
3	Bruce B. Downs @ Commerce Palms	640	4.96	0.20	2
4	Bruce B. Downs @ S.R. 56	389	5.47	0.18	2
5	C.R. 550	365	4.76	0.21	3
6	Elgin Blvd	849	4.36	0.23	2
7	Lutz-Lake Fern Rd	708	4.39	0.23	3
8	Nebraska Ave @ Linebaugh	3975	4.07	0.25	1
9	S.R. 60 @ Parsons	2409	4.96	0.20	1
10	Pinellas Trail (U.S. Alt. 19)	2656	0.50	2.00	3
11	20th St	498	2.66	0.38	1
12	M-Path (U.S. 1)	7117	5.24	0.19	3
13	Sunrise Blvd	3841	4.18	0.24	2

ID	Corridor	Pop_05	Pedestrian LOS	PLOSinv	AESTHET
14	Spring-to-Spring Trail (U.S. 17/92)	655	0.50	2.00	4
15	St. Marks Trail (Woodville Hwy)	39	0.50	2.00	4
16	Upper Tampa Bay Trail (Sheldon Rd)	1450	0.50	2.00	4
17	West Orange Trail (Clarcona Rd)	1205	0.50	2.00	4
18	Starkey Blvd	753	3.65	0.27	4
19	Lithia-Pinecrest Rd	1983	5.05	0.20	2
20	East Lake Rd	995	4.92	0.20	3
21	Ehrlich Rd	2401	4.28	0.23	2
22	31st St (after)	3801	2.80	0.36	2
23	Nebraska Ave @ 131st	4584	3.87	0.26	1
24	S.R. 60 @ Hilltop	2244	4.69	0.21	1
25	16th St (Miami Beach)	11910	2.11	0.47	3
26	C.R. A1A	1503	3.29	0.30	5
27	Minutemen Cswy	1392	2.61	0.38	5
28	Livingston St	3767	1.82	0.55	3

Variables Not Included in the Final Models

Other variables were theoretically important but were not included in the Study's Phase I induced recreational trips model for various reasons, including the following:

Intersections and interruptions The researchers tested various measures of intersections and interruptions (including signals per mile; unsignalized intersections per mile; driveways per mile; and unsignalized intersections per mile plus driveways per mile). There were only weak Pearson correlations[16] between these variables and the dependent variable (number of recreational trips).

Number of other trail users The number of other trail users is theoretically important but it is not possible to confirm the importance of this variable on induced demand without a specific

[16] The Pearson correlation, r, is a measure of the linear relationship between two variables. The value ranges from -1 (perfect negative correlation) to +1 (perfect positive correlation). A value of 0 means that there is no linear relationship between the two variables.

study targeting this variable. The number of users observed on the corridors was not high enough for this to be a factor.

Example Induced Recreation Calculation

To estimate the health benefits of providing bicycle and pedestrian facilities, it is necessary to estimate the number of bicyclists and pedestrians that result when a facility is provided. Some bicyclists and pedestrians will have switched modes from the automobile (see the later section on mode choice). Other facility users will be induced recreational bicyclists and pedestrians; an example calculation follows.

This example calculation uses the recommended model on Corridor 8, Nebraska Avenue in Tampa. Nebraska Avenue is a four-lane urban arterial. The cross-section is a mix of four-lane divided and four-lane undivided. The surrounding land uses are a mix of commercial and residential at fairly moderate to high densities in terms of Florida metropolitan areas. The input variable values are shown in Table 2-7.

TABLE 2-7 Input variable values, Nebraska Avenue, Tampa

Variable	Common Values
Aesthetics	1
Points of Interest	1
Facility Length	9.4
Distance-Weighted Population	79,663
Population within 0.5 mile	3,975

Type of Bicycle Facility	Baseline – Shared Use Lane	Bicycle Lane or Paved Shoulder	Shared Use Path Adjacent to Roadway	Shared Use Path (Independent Alignment)
Effective Bicycle LOS	7.08	5.04	1.27[1]	0.01

Type of Pedestrian Facility	Baseline – No Sidewalk	Sidewalk	Shared Use Path Adjacent to Roadway	Shared Use Path (Independent Alignment)
Effective Pedestrian LOS	5.49	3.95	3.61	0.50

[1] This bicycle LOS calculation is based on the shared use path being separated from the roadway by 10 feet.

The recommended model for induced recreational bicycle trips is repeated here for convenience:

RecEstBk = -16.856 + (2.779 x 10^{-4})*Pop_10 + 2.443*AESxINT + 11.396*sig_len – 2.321*lnBLOS

where

RecEstPos	= Estimated positive number of recreational trips from 3 PM to 6 PM
AESxINT	= Aesthetics multiplied by points of interest
sig_len	= Sigmoid of the facility length
lnBLOS	= Natural log of the bicycle LOS
Pop_10	= Distance-weighted population

Substituting the values from the baseline column into the model results in:
RecEstPos = -16.856 + (2.779 x 10^{-4})*79,663 + 2.443*1*1 + 11.396*0.599 – 2.321*1.957

By applying the LOS values for each of the four facility types (no facility, bicycle lane/paved shoulder, shared use path adjacent to roadway, and shared use path (independent alignment)), the final term of the equation is calculated. The resulting predicted number of recreational bicycle trips for 3 PM to 6 PM is shown in Table 2-8. The 3 PM to 6 PM time period accounts for 25 percent of daily bicycle trips.[17] The corresponding daily bicycle trips are shown in the bottom row of the table.

[17] Jones, Michael and Lauren Buckland. National Bicycle & Pedestrian Documentation Project. Presented at the Transportation Research Board Annual Meeting, 2006.

TABLE 2-8 Predicted number of recreational bicycle trips by facility type, Nebraska Avenue corridor, Tampa

	Baseline –Shared Use Lane	Bicycle Lane or Paved Shoulder	Shared Use Path Adjacent to Roadway	Shared Use Path (Independent Alignment)
Trips (3 PM to 6 PM)	14[1]	15	18	29
Trips (daily)	57	60	73	118

[1] The numbers shown in this table have been rounded to the nearest whole number

Applying the same process for the pedestrian mode leads to a prediction of recreational pedestrian users for four facility scenarios (baseline (no sidewalk), sidewalk, shared use path adjacent to the roadway, and shared use path (independent alignment)). The user estimates for these scenarios are shown in Table 2-9.

TABLE 2-9 Predicted number of recreational pedestrian trips by facility type, Nebraska Avenue corridor, Tampa

	Baseline – No Sidewalk	Sidewalk	Shared Use Path Adjacent to Roadway	Shared Use Path (Independent Alignment)
Trips (3 PM to 6 PM)	12	13	13	36
Trips (daily)	36	39	40	109

Energy Conservation and Savings

In 2007, Floridians consumed about 8.4 billion gallons of motor gasoline, or about 450 gallons per person.[18] At $3.00 per gallon, this translates to $25.2 billion for all Floridians, or $1,350 per person in 2007. Individuals can reduce their energy consumption and transportation-related expenditures by driving less; provision of bicycle and pedestrian facilities is one way the State of Florida can accomplish this.

[18] McDonald, James S. and Amy B. Albanese. *2007 Florida Motor Gasoline and Diesel Fuel Report*. Florida Department of Environmental Protection, Tallahassee, FL, 2008.

Literature Search

A Phase I literature search was conducted, which highlights case studies of successful programs which have achieved some or all of the Conserve by Bicycle Program Study goals. The search includes evaluations of existing Florida-based programs that relate to the Study goals, as well as out-of-state statewide research and national studies/programs.

As part of the literature search, the researchers reviewed numerous studies of the impact of bicycle and pedestrian facilities on the rates of bicycling and walking. A few studies included counts of bicyclists on facilities. However, nothing was available to allow the researchers to predict how many bicyclists and/or pedestrians are likely to use a non-motorized facility improvement, nor what the energy conservation and health benefits would result. Therefore, methods for predicting the number of bicyclists and pedestrians and the accompanying energy conservation and health benefits were developed as part of this project.

Measurable Criteria

To measure the energy conservation of providing bicycle (and now pedestrian) facilities, the number of people who will use these facilities if they are provided, must be known. Thus, measurable criteria for evaluating the energy conservation and savings resulting from the provision of bicycle and pedestrian facilities are *mode shift* and *replaced activity*.

Mode Shift

A mode shift occurs when an individual changes his/her mode of travel, for example, from car to bicycle, car to walk, or car to transit. The provision of a bicycle or pedestrian facility results in energy savings if the provision of that facility results in an individual who would otherwise have driven a car to his or her destination choosing to ride a bicycle or walk instead.

Replaced Activity

The presence of a bicycle or pedestrian facility may motivate some individuals to opt for bicycling or walking on the facility instead of pursuing another activity. Individuals can choose from among many options for leisure. These include riding a bicycle on a trail, driving to the park, and staying at home and watching rented movies, to name just a few. Replacing an activity with bicycling or walking may or may not result in energy savings. If a person rides a bicycle from his/her home to a trail and then back home, instead of driving to the park, then energy savings will result because the bicycle trip replaces the driving trip. On the other hand, if a person drives to a trail head, rides a bicycle on a trail, and then drives back home, then energy savings may or may not result. Indeed, if the alternate choice was to stay at home and watch movies, then the trail has created a new driving trip.

The literature search described previously found no information related to replaced activity. While the impact on energy savings is likely minimal, a specific study would be needed to confirm this.

Research Plan

To address the Study goals, the extent of mode shift that results from the construction of bicycle and pedestrian facilities needs to be determined. That is, how many users will be mode-shifted from the motor vehicle mode to the bicycle or pedestrian mode? After determining the number of users that will be using the facility, the energy savings for that facility can be calculated. To answer this question, the research plan included a study evaluating different bicycle and pedestrian facility types in different built environments to determine the mode shift resulting from those facilities. Based upon data collected on these facilities, which are the same as those shown in Table 2-1, the researchers developed a method for predicting the mode shift resulting from the provision of these facilities. The researchers also identified values associated with energy savings resulting from a mode shift to bicycling or walking. Using these values, the energy savings resulting from providing specific bicycle and pedestrian facilities could be predicted.

Mode Shift The first step was to determine which factors were important for predicting the mode shift. Only after doing this could the necessary data needs be determined.

When planning a utilitarian trip (e.g., to work, to school, or to a doctor's appointment), people have a choice among modes (such as car, transit, bicycle, walk). Each mode has a "utility," defined as a level of attractiveness or satisfaction, associated with it. Infrastructure investments or changes in operational and demographic characteristics may increase the utility of one mode relative to the others, or in other words, make one mode more attractive relative to the others. For example, the construction of a bicycle lane on a roadway that currently has a shared use lane would make the bicycle mode more attractive because individuals would perceive the bicycle lane as being more accommodating of bicycling. As another example, the pedestrian mode is more attractive for a shorter trip (e.g., one mile) than it is for a longer trip (e.g., 10 miles). As the attractiveness (i.e., utility) of bicycling and walking increases, more individuals are expected to choose these non-motorized modes.

To identify the specific factors that should be evaluated, the researchers consulted several groups: members of the Steering Committee, participants in the national ProWalk/ProBike Conference, and a variety of other transportation professionals and bicyclists from around the United States. They identified that the following characteristics of bicycle and pedestrian facilities influence their decisions to make utilitarian bicycle and pedestrian trips:

- Congestion on the roadway;
- Quality of the bicycle facility;
- Transit quality of service;
- Bicycle network friendliness;
- Pedestrian network friendliness;
- Trip length;
- Density of population and employment; and
- Income.

These characteristics and their potential influences on mode shift were described in detail in the Conserve by Bicycle Phase I Report.

Energy Conservation and Savings: Reducing the Usage of Petroleum-based Fuels

For the purposes of this Study, the metric for energy conservation and savings is the Florida average at-the-pump cost of regular unleaded gasoline. This is a conservative metric (approximately $2.50 per gallon at the time of this writing) which does not include the full societal cost of the usage of petroleum-based fuels. There are a host of references that estimate the full societal cost (a recent example being the National Cooperative Highway Safety Program

Report 552) which include factors such as federal subsidies for oil and gas exploration, source development and protection, refinement and distribution. Externalities of petroleum-based fuel costs for domestic personal surface transportation also include the incremental cost (with respect to the bicycle) of construction and maintenance of transportation infrastructure (e.g. pavement lanes, parking, etc.).

The calculation of energy conservation and savings requires several key pieces of information, including fuel costs, recreational and utilitarian bicycle trip lengths, and fuel economy. The researchers obtained this information from various sources, as discussed in the following paragraphs.

The fuel cost at the pump, $2.50 per gallon for regular gasoline, is a directly observable value, easily obtained from several sources. Because it represents the cost for regular gasoline, and since medium and premium grade gasoline is typically 10 to 20 cents more expensive per gallon, it underestimates the actual average costs being paid by motorists for gasoline around the state.

An average recreational bicycle trip length of five miles and an average utilitarian bicycle trip (shopping, commuting to school or work, running errands, etc.) length of three miles were used. The corresponding average pedestrian trip length is one mile for each trip type. These trip lengths were obtained from a 2002 phone survey of Florida residents within four Metropolitan Statistical Areas.[19] These values are also considered conservative. An internet survey conducted as part of this Study found much higher bicycle trip lengths for both recreational and utilitarian trips. This internet survey also found the length of the trips depended on the perceived quality of the facility provided, with longer utilitarian trips occurring on shared use paths. The survey was advertised through bicycling clubs and advocacy organizations, and by word of mouth. Consequently, those responding to the survey were likely to be more avid cyclists than those responding to the 2002 phone survey. Nonetheless, it provides an indication that actual average

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[19] Center for Urban Transportation Research. *Bicycle and Pedestrian Travel: Exploration of Collision Exposure in Florida*. University of South Florida, Tampa, FL, 2002.

utilitarian trip lengths are significantly higher than those used for calculating energy savings in this report.

The average fuel economy used for the energy conservation estimates is 20 miles per gallon (mpg).[20] This takes into account the average fuel economy of passenger cars (22.9 mpg) and two-axle, four-tire trucks (16.8 mpg). The 20 mpg value is considered conservative for this study because of the trip lengths associated with bicycle and pedestrian travel. Trips made by bicycling and walking are typically shorter than the average trip length along a corridor. The potential occurrence of motor vehicle trips being replaced by bicycling and walking trips is therefore more common among trips with short lengths. Replacing these shorter trips (particularly those involving cold starts) will represent greater fuel savings than that represented by the average car/light truck fuel economy.

The calculated energy conservation and savings in this section are conservative because utilitarian bicycle trip lengths will likely increase above three miles as more Floridians start bicycling.

Preliminary Evaluation Results

The "before" data collected on these corridors were used to develop the models that measure corridor-level mode shift as a result of investing in various types of bicycle and pedestrian facilities. The model development process, specific utility equations, and model terms are discussed in the following sections.[21]

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[20] Davis, S., and S. Diegel, Oak Ridge National Laboratory. *Transportation Energy Data Book: Edition 26.* Office of Planning, Budget Formulation and Analysis, Energy Efficiency and Renewable Energy, U.S. Department of Energy, 2007.

[21] The researchers would like to acknowledge the efforts and budgetary contribution of FDOT District Seven in the development of both this model and the induced recreational travel models. The preliminary model forms and models were developed during the District Seven project *Predicting Non-motorized Trips at the Corridor/Facility Level: The Bicycle & Pedestrian Mode Shift and Induced Travel Models* (Phases 1, 2, and 3).

Mode Shift Model Development

The researchers used the NLOGIT 3.0 software package to model mode shift. The data set consisted of the combined survey responses from the 28 corridors listed previously in Table 2-1. Responses which stated a trip purpose (Question 5 on the survey) of "Recreation" were used in the development of the previously described induced recreational/exercise travel model but not in the mode shift model, because the mode shift model pertains to utilitarian trips. The utilitarian data set included responses from:

- 1,936 motorists;
- 43 transit riders;
- 71 bicyclists; and
- 52 pedestrians.

Model Form

The proposed mode shift model provides users the ability to predict the number of existing motorized trips that will be shifted to non-motorized modes due to the enhancement, construction, or provision of bicycle and pedestrian facilities along a corridor.

The mode shift model may take the form of either a traditional multinomial logit or a nested logit model. The traditional multinomial logit model of mode choice takes the following form:

$$P(i) = \frac{e^{\beta' x}}{\sum_{i=1}^{m} e^{\beta' x}}$$

where	P(i)	=	probability that mode i is chosen for a trip within the corridor (in other words, the mode share)
	e	=	base of natural logarithms, approximately 2.718
	β	=	vector of model coefficients
	x	=	matrix of explanatory variables including socio-economic variables, trip characteristics, and level of service variables
	m	=	number of modes
	β'x	=	utility equation for any given mode

This is the classic multinomial logit model that is used as standard practice for estimating modal split. The model predicts changes in the probability that a trip will be undertaken on a certain mode in response to changes in explanatory factors or variables (depicted by matrix x).

Nested logit models, which have hierarchical structures and are designed to capture similar alternatives in the choice set, were also developed and estimated. An example of a nested structure appears in Figure 2-6. The example shows that the user first makes a choice between motorized and non-motorized modes. If the user chooses motorized, then he/she chooses between the car and bus modes. If the user chooses non-motorized, then he/she chooses between the bike and walk modes.

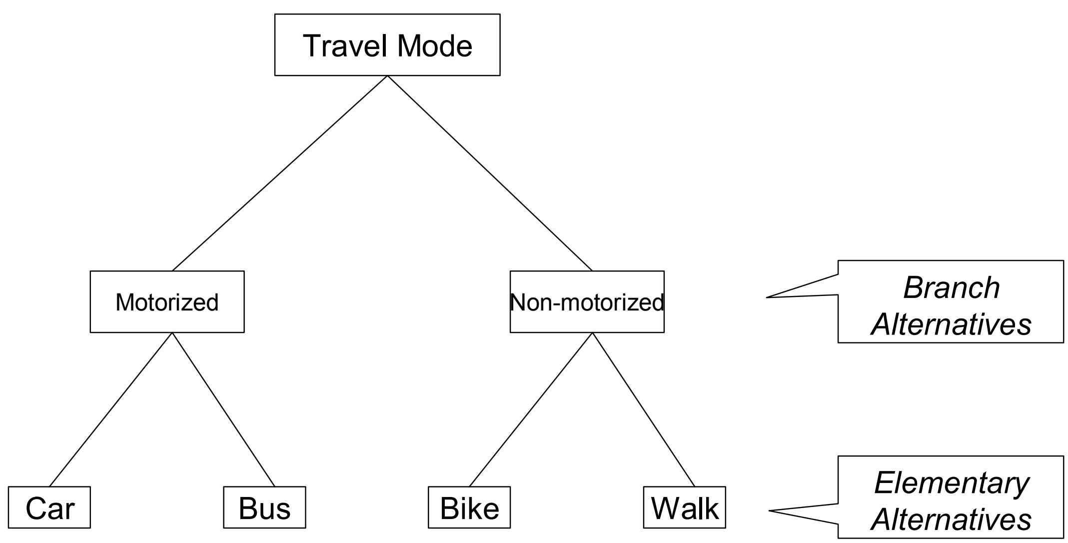

FIGURE 2-6 Example of a nested logit model structure

Initial models were developed using both the multinomial and nested logit forms. Examination of the outputs revealed that the nested logit model form would collapse to the multinomial logit form without significantly reducing the predictive capabilities of the model. Therefore, the multinomial logit form was chosen for further model development.

Theoretical Utility Equations

The variables described in the preceding section are incorporated into the theoretical utility equations for the motor vehicle (MV), transit (T), bicycle (B), and pedestrian (P) modes as follows:

U_{MV} = f(Trip Length, Income, Population Density, Employment Density, Motor Vehicle LOS, Network Friendliness, Bicycle Friendly Community)

U_T = f(Trip Length, Income, Population Density, Employment Density, Transit LOS, Motor Vehicle LOS, Network Friendliness, Bicycle Friendly Community)

U_B = f(Trip Length, Income, Population Density, Employment Density, Bicycle LOS, Network Friendliness, Transit QOS, Bicycle Friendly Community)

U_P = f(Trip Length, Income, Population Density, Employment Density, Pedestrian LOS, Network Friendliness, Transit QOS, Bicycle Friendly Community)

Mode share =

$$p(K) = \frac{e^{U_k}}{\sum_x e^{U_x}}$$

Mode Shift Model

Dozens of combinations of variables and variable transformations were tested. The utility equations in the recommended model consist of the following constants and variables.

CAR	TRANSIT	BIKE	WALK
Acar	Abus		
MVLOS	MVLOS	BikeConInv	PedConInv
	BusLOS	BikeLOS	PedLOSInv
	Trip_Len	Trip_Len	Trip_Len
	InvIncome	Pop_Emp	Pop_Emp
			InvIncome

where

MVLOS	= Motor vehicle LOS for the corridor
BusLOS	= Transit LOS for the corridor
Trip_Len	= Trip length for each individual
InvIncome	= Median household income (inverse)
BikeConInv	= Network friendliness for the bike mode (inverse)
BikeLOS	= Bicycle LOS for the corridor
Pop_Emp	= Product of the population and employment densities and the influence area
PedConInv	= Network friendliness for the walk mode (inverse)
PedLOSInv	= Pedestrian LOS for the corridor (inverse)
Acar, Abus	= Mode-specific constants for the car and bus modes, respectively

Most variables pertained to specific corridors. The exception is trip length, which pertained to individual respondents. The variables in the utility equations are discussed below.

Motor Vehicle LOS (MVLOS) The motor vehicle LOS for each corridor was obtained from the generalized tables in FDOT's *Quality/Level of Service Handbook*. It was expected that this variable would have a negative coefficient, as higher numerical values correspond to a worse motor vehicle LOS and would reduce utility. For the transit mode, the motor vehicle LOS was set to "A" for the U.S. 1 corridor in Miami (#12 in Table 2-1) because that corridor is serviced by Metrorail, a rapid transit line operating in its own right-of-way. As such, the utility of the transit mode on the U.S. 1 corridor would not be adversely affected by degradations in the motor vehicle LOS on U.S. 1.

Transit Level of Service (BusLOS) - The transit level of service for each corridor was assigned a value of A, B, C, D, E, or F according to service headways, as defined in FDOT's *Quality/Level of Service Handbook*. It was expected that this variable would have a negative coefficient, as higher numerical values correspond to a worse transit quality of service and would reduce utility.

The *Transit Capacity and Quality of Service Manual* (*TCQSM*) contains six transit service measures:

- Service frequency;
- Hours of service;
- Areas served by transit;
- Passenger loading;
- Reliability; and
- Travel time relative to the automobile.

FDOT's *Quality/Level of Service Handbook* simplifies the Transit LOS so that it can be calculated from the frequency of transit service and several adjustment factors related to pedestrian access to transit stops. This simplified application of the Transit LOS was used in the mode shift model.

Trip Length (Trip_Len) Trip lengths were calculated using the origins and destinations provided by the survey respondents. Many of the respondents did not provide sufficient information for trip lengths to be calculated. It was expected that trip length would have a negative coefficients for the bike and walk modes.

Median Household Income (InvIncome) The median household income (in thousands of dollars) in the analysis zone is obtained from the median household income for each TAZ (or Census tract) that intersects the analysis zone. To account for the fact that some TAZs and tracts constitute a large portion of the analysis zone while others barely coincide with it, these values are then weighted by the proportional area of each TAZ or tract to the entire area of the analysis zone. The sum of these weighted values is the median household income for the analysis zone. It was hypothesized that the influence of income on the potential for choosing pedestrian trips would have a decreasing effect as income rose; consequently it was decided to test the inverse of the median income for modeling. It was expected that this variable would have a negative coefficient, as income increases, the likelihood of choosing walking for utilitarian trips decreases.

Network Friendliness (BikeConInv, PedConInv) The network friendliness for each corridor was calculated according to the procedure in Appendix D of this Phase II Report. It was expected that the inverse of the network friendliness (which was used because it produces stronger results than the untransformed variable) would have a negative coefficient for both the bicycle and walk modes, as lower values indicate greater friendliness and would increase utility of bicycling and walking. Table 2-10 presents the raw network friendliness values for each corridor.

TABLE 2-10 Network friendliness values

ID	Name	From	To	Bicycle	Pedestrian
1	16th St S	Pinellas Point Dr	62nd Ave S	0.64	0.64
2	31st St N	Central Ave	5th Ave N	0.71	0.73
3	Bruce B. Downs Blvd	Amberly Dr	Hunter's Green Dr	0.32	0.29
4	Bruce B. Downs Blvd (S.R. 581)	Hillsborough Co. line	S.R. 54	0.24	0.24
5	C.R. 550	Shoal Line Blvd	U.S. 19	0.27	0.26
6	Elgin Blvd	Deltona Blvd	Mariner Blvd	0.46	0.46
7	Lutz-Lake Fern Rd	Gunn Hwy	Dale Mabry Hwy	0.21	0.21
8	Nebraska Ave (U.S. 41)	Kennedy Blvd	Bearss Ave	0.40	0.41
9	S.R. 60	Kings Ave	Kingsway Rd	0.24	0.24
10	Pinellas Trail	Union St	Orange St	0.24	0.25
11	20th St	Adamo Dr	Causeway Blvd	0.23	0.24
12	M-Path	SW 67th Ave	SW 7th St	0.31	0.32
13	Sunrise Blvd	Hiatus Rd	Pine Island Rd	0.51	0.52
14	Spring to Spring Trail	Gemini Springs Park	DeBary Hall	0.42	0.42
15	St. Marks Trail	Riverside Dr	Capital Circle	0.31	0.28
16	Upper Tampa Bay Trail	Memorial Hwy	North of Ehrlich Rd	0.43	0.43
17	West Orange Trail	Oakland	North of Apopka	0.27	0.27
18	Starkey Blvd	Town Ave	River Crossing Blvd	0.22	0.22
19	Lithia-Pinecrest Rd	S.R. 60	Polk Co. line	0.34	0.34
20	East Lake Rd	Cove Dr	Keystone Rd	0.24	0.24
21	Ehrlich Rd	Turner Rd	Sheldon Rd	0.38	0.37

ID	Name	From	To	Bicycle	Pedestrian
22	31st St N	Central Ave	5th Ave N	0.71	0.73
23	Nebraska Ave (U.S. 41)	Fowler Ave	Fletcher Ave	0.44	0.45
24	S.R. 60	Kings Ave	Kingsway Rd	0.40	0.40
25	16th St	West Ave	Washington Ave	0.68	0.73
26	C.R. A1A	U.S. 1	Indiantown Rd	0.77	0.77
27	Minutemen Cswy	Cocoa Beach H.S.	Brevard Ave	0.76	0.77
28	Livingston St	Magnolia Ave	Festival Way	0.58	0.61

Bicycle LOS (BikeLOS) The effective bicycle LOS can take on one of these three values:

1. 0.01 for an existing independent alignment
2. The calculated sidepath LOS for a shared use path adjacent to roadway, depending on the distance from the roadway
3. calculated segment bicycle LOS + 2.00 for the roadway corridor (if no shared use path is present)

This variable was expected to have a negative coefficient, as higher numerical values indicate a worse bicycle LOS and would reduce the utility of the bike mode.

Population and Employment Density (Pop_Emp) For each corridor, the population density within the network analysis zone was first multiplied by the employment density within the network analysis zone. Next, the result was multiplied by the area (in square miles) of the network analysis zone. This result was then divided by 1,000 for scaling purposes. It was expected that this variable would have a positive coefficient, as higher population and employment densities translate into higher utilities of bicycling and walking.

Pedestrian LOS (PedLOSInv) The effective pedestrian LOS can take on one of two values:

1. 0.50 for a shared use path (independent alignment)
2. The calculated segment pedestrian LOS for the roadway corridor, if no shared use path (independent alignment) is present

The inverse of pedestrian LOS was used in the model. This variable was expected to have a positive coefficient, as higher numerical values for the inverse of the LOS indicate a better pedestrian LOS and would reduce the utility of the pedestrian mode.

Mode Shift Model Summary

A summary of the coefficients, t-statistics (b/St.Er.) and p-values (P[Z>z]) for the recommended model appears in Table 2-11. The sign of the coefficient indicates whether the correlation between the variable and the number of predicted modal users is positive or negative. The t-statistics indicate the explanatory power of the variable (higher absolute values indicate greater significance) while the p-value represents one minus the confidence level of the variable's significance.

TABLE 2-11 Mode shift model variable statistics

Variable	Coefficient	t-statistic	p-value
Acar	3.05	4-369	0.000
MVLOS1	-0.0743	-0.597	0.550
Abus	3.02	3.393	0.007
MVLOS2	-0.431	-2.207	0.027
BusLOS2	-0.523	-2.70	0.007
IncomeInv2	5.747	.302	0.763
Trip_Len2	-0.0162	-0.744	0.457
BikeConInv3	-0.291	-1.191	0.233
BikeLOS3	-0.462	-.315	0.753
Trip_Len3	-0.198	3.248	0.001
Pop_Emp3	$2.08*10^{-5}$	5.222	0.000
IncomeInv4	52.18	2.260	0.024
InvPedLOS4	0.367	1.769	0.077
PedConInv4	-0.186	-0.931	0.316
Trip_Len4	-0.581	-4-582	0.000
Pop_Emp4	$8.05*10^{-6}$	1.961	0.050

where

Acar	= Mode-specific constant for the car mode
MVLOS2	= Coefficient for motor vehicle LOS for the car mode
Abus	= Mode-specific constant for the transit mode
MVLOS2	= Coefficient for motor vehicle LOS for the bus mode
BusLOS2	= Coefficient for transit quality of service
IncomeInv2	= Coefficient for the inverse median income for the transit mode
Trip_Len2	= Coefficient for trip length for the transit mode
BikeConInv3	= Coefficient for network friendliness for the bike mode
BikeLOS3	= Coefficient for bicycle level of service
Trip_Len3	= Coefficient for trip length for the bike mode
Pop_Emp3	= Coefficient for population and employment density for the bike mode
IncomeInv4	= Coefficient for the inverse median income for the walk mode
InvPedLOS4	= Coefficient for the inverse of the pedestrian level of service
PedConInv4	= Coefficient for network friendliness for the walk mode
Trip_Len4	= Coefficient for trip length for the pedestrian mode
Pop_Emp4	= Coefficient for population and employment density for the walk mode

By substituting the coefficients from above, the utility equations in the recommended model may be written as follows:

U (car) = exp (-0.0743 * motor vehicle LOS)

U (transit) = exp (-0.065 – 0.431 * motor vehicle LOS – 0.532 * transit QOS + 5.747 * inverse of median income - 0.0162 * trip length)

U (bike) = exp (-6.714 – 0.291 * inverse of bike network friendliness – 0.462 * bicycle LOS – 0.198 * trip length + 2.08×10^{-5} * population/employment density)

U (walk) = exp (-6.396 + 52.18 * inverse of median income - 0.367 * inverse of pedestrian LOS – 0.186 * inverse of pedestrian network friendliness – 0.581 * trip length + 8.05×10^{-6} * population/employment density)

Constants in the provided equations have been adjusted to account for the difference in the observed mode splits on the study roadways and the splits in the survey responses received.

Update from Previous Model Versions

There have been three changes to the list of included variables established in the previous version of the mode shift model. First, the motor vehicle LOS was added as a variable in the car utility model. This is because as congestion increases, the car's utility is somewhat reduced when compared to the other modes. Secondly, the inverse of the median household income was added as a variable for the transit and pedestrian modes. During the testing of variable transformations, it was discovered that using the inverse of the network bicycle connectivity measure provided significantly better explanatory power than the untransformed variable. The same was also true for the pedestrian network connectivity measure, so both of those transformations have been included. Overall, the individual Z-values are improved as a result of this model update. In terms of measures of fit, the rho-squared value is virtually unchanged, while the log likelihood function has improved.

Variables Not Included in Model

The utility equations for the other modes express their utilities relative to the car mode, consequently the constants were adjusted to represent the car mode as the baseline. No model forms built with NLOGIT 3.0 were specified to include all of the variables for the other travel modes. One proposed variable that was not included is location within a designated Bicycle Friendly Community, due to weak correlations and a limited sample size.

Example Mode Shift Model Calculation

To estimate the health benefits of providing bicycle facilities, it is necessary to estimate the number of bicyclists and pedestrians resulting from a particular facility. Some users will be induced recreational bicyclists and pedestrians; an example calculation for these trips is provided earlier in this chapter. Other non-motorized users will have switched modes from the automobile; an example calculation of the estimated mode shift calculation is provided in this section.

This example calculation uses the recommended model on a hypothetical corridor, using the default input values shown in Table 2-12.

TABLE 2-12 Mode shift model input variable values

Variable	Common Values
Motor Vehicle LOS	E
Transit LOS	C
Average Corridor Trip Length	4.0 miles
Median Household Income	$60,000
Bicycle Connectivity Factor	0.80
Population per Square Mile	8,000
Employment per Square Mile	4,000
Pedestrian Connectivity Factor	0.80

Type of Bicycle Facility	Baseline – Shared Use Lane	Bicycle Lane or Paved Shoulder	Shared Use Path Adjacent to Roadway	Shared Use Path (Independent Alignment)
Effective Bicycle LOS	6.29	5.39	1.27[1]	0.01

Type of Pedestrian Facility	Baseline – No Sidewalk	Sidewalk	Shared Use Path Adjacent to Roadway	Shared Use Path (Independent Alignment)
Effective Pedestrian LOS	7.16	4.69	4.29	0.50

[1] This bicycle LOS calculation is based on the shared use path being separated from the roadway by ten feet.

The recommended multinomial logit model for induced bicycle and pedestrian trips is shown in Table 2-11. Substituting the values for the common values into the utility functions for each mode gives:

U (car) = exp [-0.0743 * 5.00]

U (transit) = exp [-0.065 – 0.431 * 5.00 – 0.532 * 3.00 + 5.747 * (1/$60,000) - 0.0162 * 4.0]

U (bike) = exp [-6.714 – 0.291 * (1/0.80) – 0.462 * (1/BikeLOS) – 0.198 * 4.0 + $2.08*10^{-5}$ * (8,000*4,000)]

U (walk) $= \exp [-6.396 + 52.18 * (1/\$60{,}000) - 0.367 * (1/PedLOS) - 0.186 * (1/0.80) - 0.581 * 4.0 + 8.05 \times 10^{-6} * (8{,}000*4{,}000)]$

By applying the respective pedestrian and bicycle LOS values for each of the four facility types (no facility, bicycle lane/paved shoulder, shared use path adjacent to roadway, and shared use path-independent alignment), the utilities of each mode may be calculated under each scenario. These utilities are used to determine the corresponding mode splits for each scenario using the logit model form. For instance, under the shared-lane, no sidewalk scenario, the mode split calculation are:

U (car) = exp (-0.372)

U (transit) = exp (-3.789)

U (bike) = exp (-7.494)

U (walk) = exp (-7.755)

Thus, the probability of walking is equal to:

P (walk) = exp (-7.755)/[exp (-0.372)+ exp (-3.789)+ exp (-7.494)+ exp (-7.755)]

= 0.06%

Completing the calculations for each mode and facility type results in the number of peak-hour utilitarian bicycle and pedestrian trips shown in Tables 2-13 and 2-14. The peak-hour time period is estimated to account for approximately eight percent of daily bicycle trips and five percent of daily pedestrian trips. The corresponding daily bicycle and pedestrian trips are shown in the bottom rows of the tables.

TABLE 2-13 Predicted number of utilitarian bicycle trips by facility type

Bicycle Trips	Baseline –Shared Use Lane	Bicycle Lane or Paved Shoulder	Shared Use Path Adjacent to Roadway	Shared Use Path (Independent Alignment)
Trips (hourly)	11	11	14	15
Trips (daily)	138	143	173	184

[1] The reader is advised that the numbers shown in the table have been rounded to the nearest whole number.

TABLE 2-14 Predicted number of utilitarian pedestrian trips by facility type

Pedestrian Trips	Baseline – No Sidewalk	Sidewalk	Shared Use Path Adjacent to Roadway	Shared Use Path (Independent Alignment)
Trips (hourly)	25	27	28	49
Trips (daily)	509	543	562	986

Recommended Additional Data Collection and Model Refinement

The models in this Conserve by Bicycling and Walking Phase II Report are superior to those from earlier modeling efforts. However, as with any model, additional refinements could be performed. For the mode choice models, additional data from densely populated downtown areas would allow for better refinement of the interplay among facility quality and population density. Also, more areas with higher volumes of pedestrians would be valuable to ensure the robustness of the model for all area types.

CHAPTER 3 BENEFITS CALCULATOR

Introduction

As part of Phase I of the Conserve by Bicycle Program Study, an Energy Savings and Health Benefits spreadsheet was developed. The worksheet shows the predicted number of recreational and utilitarian bicycle and pedestrian trips for a roadway corridor. The predicted number of trips leads in turn to calculations of energy savings and health benefits. During this Phase II Conserve by Bicycling and Walking effort, the spreadsheet was revised to:

- create a more user friendly Benefits Calculator;
- incorporate the latest recreational and utilitarian models as described in Chapter 2;
- incorporate calculations for CO_2 emissions reductions;
- create a “report” page; and
- create a companion User Guide for the Calculator.

The User Guide, which provides background information, variable definitions, and guidelines for data entry and collection, is included in this report as Appendix B. The Benefits Calculator itself is available separately from FDOT.

Creation of the Benefits Calculator

The Phase I Energy Savings and Health Benefits spreadsheet was essentially a computational engine developed to perform sensitivity testing for the mode choice and recreational travel demand models. It was not intended for general use by anyone other than the researchers. Updating the computational engine to become a user friendly Benefits Calculator required several significant changes to the format. These updates are described below.

The general “look” of the spreadsheet did not change much. The initial data entry screen has unprotected fields into which analysts can enter data. A “hotlink” button provides access to a separate spreadsheet into which the detailed data on roadways within the facility’s analysis zone are entered. A summary of results is included at the bottom of the screen. See Figure 3-1 for a view of the initial data entry page.

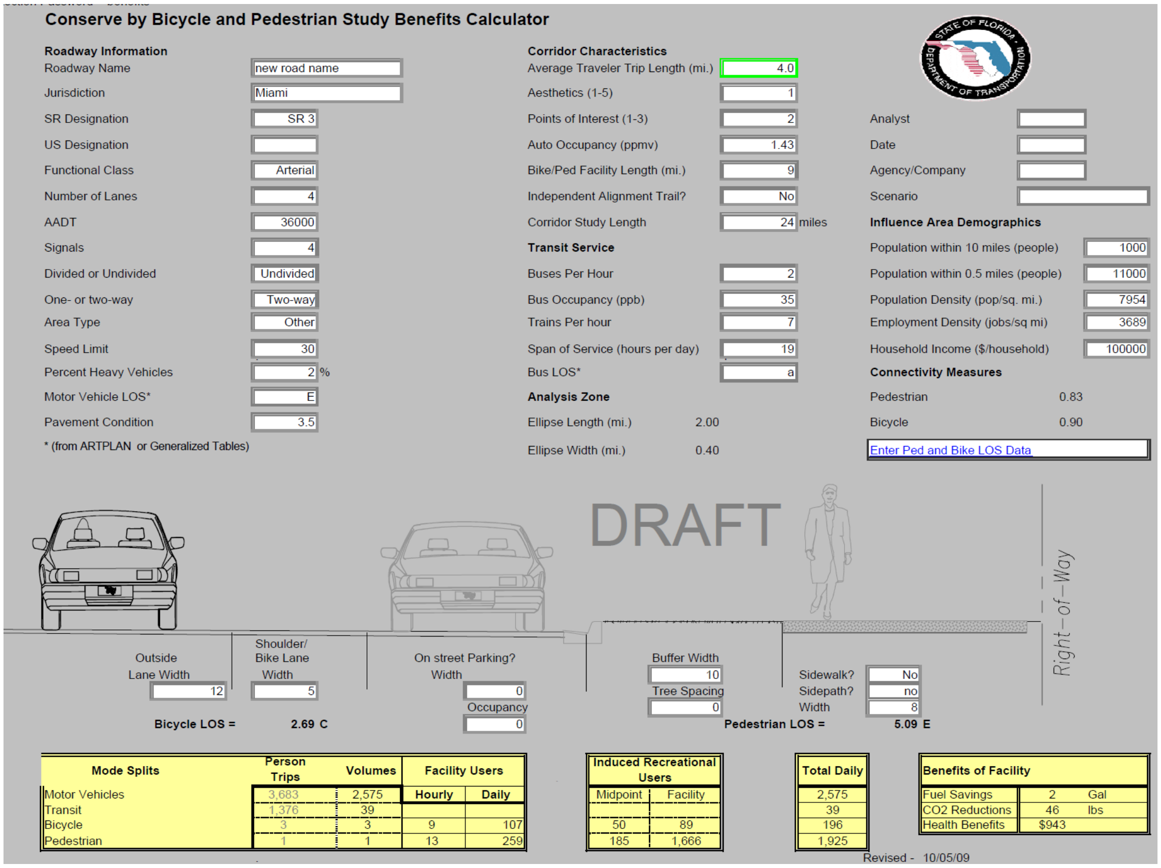

FIGURE 3-1 Initial Data Entry Page

To provide guidance on what data are required, drop down data entry fields were included to prevent improper data entry from creating errors in the calculations fields. Additionally, *help boxes* were created for many of the input fields. Each *help box* includes similar text to the User Guide information concerning the input values and, if appropriate, how they are to be calculated. A sample of such a *help box* is provided in Figure 3-2.

The pedestrian and bicycle LOS data entry spreadsheet allows users to enter LOS data for each roadway segment within the analysis zone. It provides some default values for various roadway types so that the model can be run to estimate potential use even if full segment data collection is not completed.

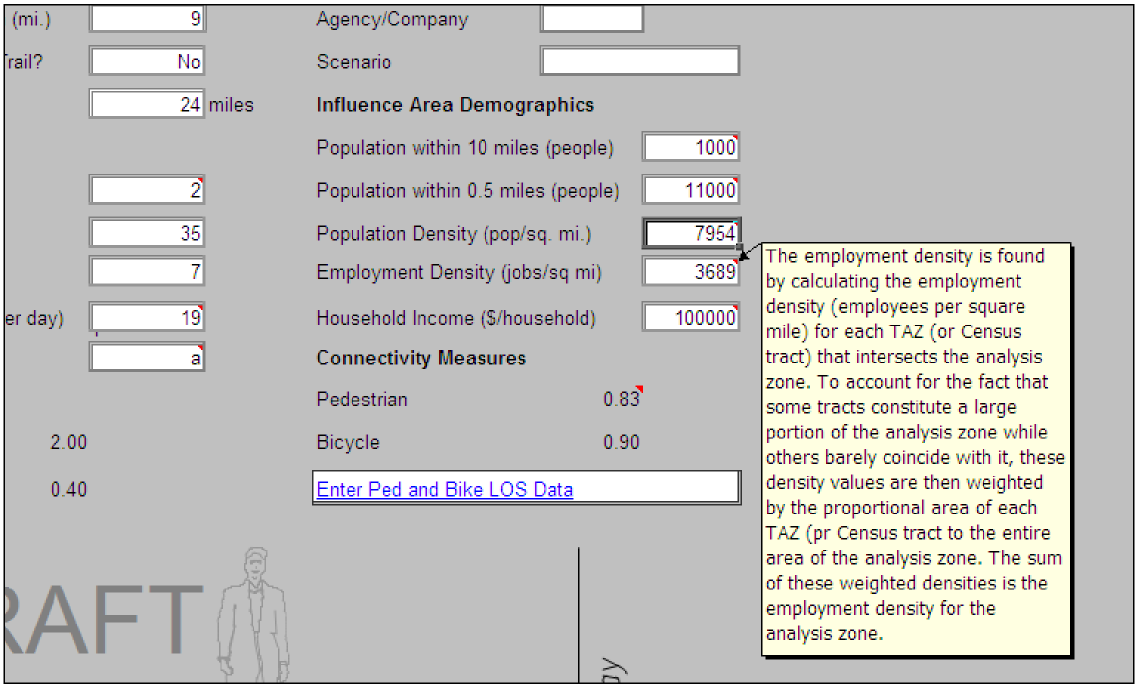

FIGURE 3-2 Sample drop down Help Box

Separate worksheet tabs - one for estimating recreational users, the other for utilitarian users - are included in the Benefits Calculator. Within each of these worksheet tabs, there are several fields which represent general assumptions required for calculations. While these fields have been filled in and the values need not be changed, if analysts have better data for these fields, the values can be changed to represent these data. These default fields include the k factors[22] for various modes (for the utilitarian models), three hour volume to daily volume adjustment factors (for the recreational trip models), and weekday to weekly volume adjustments.

Another separate worksheet tab is included for the calculation of benefits. Again, several fields include assumptions used in the calculations. On the benefits worksheet, these include average fleet mileage; assumed CO_2 emissions per gallon of gas consumed; assumptions for CO_2 for a one mile and a three mile trip length; and the monetary value associated with the health benefit of one day's recommended allotment of exercise. Values are provided in the spreadsheet for these fields; however the analyst may override these default values if better local data are available.

---

[22] The k factor is the percentage of daily trips that occurs in the peak hour.

Finally, an output report page was added. This page is formatted to be printed on a single sheet of letter-sized paper. An example printout is provided in Figure 3-3.

Health and Energy Benefits Calculator
Mode Choice and Induced Recreational Travel Estimation/Prediction

Roadway Information			**Analyst**		
Roadway Name	new road name		**Date**		
Jurisdiction	Miami		**Agency/Company**		
SR Designation	SR 3		**Scenario**		
US Designation	0				
Functional Class	Arterial		**Corridor Characteristics**		
Number of Lanes	4		**Average Traveler Trip Length**	4	miles
AADT	36000		**Aesthetics (1-5)**	1	
Signals	4		**Points of Interest (1-3)**	2	
Divided or Undivided	Undivided		**Auto Occupancy (ppmv)**	1.43	
One- or two-way	Two-way		**Bike/Ped Facility Length**	9	miles
Area Type	Other		**Independent Alignment Trail?**	No	
Speed Limit	30		**Corridor Study Length**	24	miles
% Heavy Vehicles	2				
Motor Vehicle LOS*	E		**Influence Area Demographics**		
Pavement Condition	**3.5**		**Population within 10 miles**	1000	people
			Population within 0.75 miles	11000	people
Transit Service			**Population Density (pop/sq. mi.)**	7954	
Buses Per Hour	2		**Employment Density (jobs/sq mi)**	3689	
Bus Occupancy (ppb)	35				
Trains Per hour	7		**Analysis Zone**		
Span of Service	19		**Ellipse Length**	2.00	miles
Bus LOS*	a		**Ellipse Width**	0.40	miles
Cross Section			**Connectivity Measures**		
Outside lane width	12	feet	**Pedestrian**	0.83	
Shoulder/bike lane width	5	feet	**Bicycle**	0.90	
Parking Width	0	feet			
Parking Occupancy	0	percent	**Bike LOS**	C	
Buffer Width	10	feet	**Ped LOS**	E	
Tree Sapcing	0	feet			
Sidwalk?	No				
Sidepath?	No				
SW/SP Width	8	feet			

Mode Splits	**Person Trips**	**Volumes**	**Facility Users**	**Induced Recreational Users**		**Total Daily**
Motor Vehicles	3,683	2,575	Daily	Midpoint	Facility	
Transit	1,376	39	0	0	0	39
Bicycle	3	3	107	50	89	196
Pedestrian	1	1	259	185	1666	1,925

Benefits	Daily	Annually
Fuel Savings	2 gallons	730 gallons
CO2 Emmissions Savings	46 pounds	7 tons
Health Costs Savings	$943	$55,822

Revised - 10/05/09

FIGURE 3-3 Sample report page

CHAPTER 4 LONG-TERM EFFECTS OF PROVIDING BICYCLE AND PEDESTRIAN FACILITIES

Background

While performing the Conserve by Bicycle Program Study, the project team – FDOT Project Manager, Steering Committee, and researchers – identified several areas for Phase II investigation. Among these was to attempt to document the long-term effects of providing bicycle and pedestrian facilities. It was postulated that in the long term, recreational bicyclists may become utilitarian bicyclists, utilitarian bicyclists may become commuter bicyclists, and occasional bicyclists may become frequent bicyclists. Likewise those who walk for one purpose may go on to walk for other purposes. It was hoped a correlation could be shown between some initial access to bicycle and pedestrian facilities and sustained bicycling and walking. This research could provide valuable insight to the progression of bicyclists and pedestrians from recreational users to utilitarian users, and from occasional participants to frequent participants.

This task of the Conserve by Bicycle and Walking Program Phase II Study was to try and determine if the presence of bicycling or pedestrian facilities at a point in a person's life would result in an increased propensity for bicycling and walking in later periods. The following sections provide information on the research plan, its implementation, the data collected, and the results of data analysis. This effort failed to find overwhelming support for the hypothesis that providing facilities leads to long-term increases in bicycling and walking.

A secondary objective of this task was to determine if recreational bicycling and walking are "gateway" activities to utilitarian bicycling and walking. That is, do people who walk or bicycle for recreational purposes go on to walk or bicycle for utilitarian purposes? While the analyses suggest that frequent recreational walking is correlated with concurrent utilitarian walking, the long-term impacts are inconclusive.

Survey Development

To determine the effects of bicycling and walking facilities on long term biking and walking habits, it was necessary to determine levels of biking and walking activity over the span of a person's life. Specific information desired for this investigation included:

- current levels of bicycling or walking;
- reasons for bicycling and walking;
- types of walking or bicycling facilities used;
- previous levels of bicycling and walking;
- reasons for these previous walking and bicycling levels; and
- facilities used during these previous periods.

It was initially thought that a written survey filled out by respondents would be the most effective way of obtaining this information. However, a written (or computer-based) format for the survey proved problematic. In particular, open-ended questions concerning the reasons for (or for not) walking and bicycling were not completely filled out during pilot testing. Multiple choice answers with an "other" category tended to "steer" respondents to a particular set of answers.

After several pilot tests and format changes, it was determined that an intercept interview would likely provide the best data for this effort. A draft interview form was distributed to the Project Steering Committee for review and comment; their comments were incorporated into the interview form. A copy of both the final bicycling and the final walking interview forms are included as Appendix E and Appendix F of this report, respectively.

Interview Implementation

It was originally intended that the interviews would be conducted at recreational facilities. However, this approach would have biased the identification of trends to those individuals who are currently active. A more varied population of interview participants was necessary. Numerous locations/events were considered for conducting the intercept interviews, including the following:

- retail establishments (such as department stores or grocery stores);
- baseball games;
- "Saturday Markets";
- government offices (Department of Highway Safety and Motor Vehicles was specifically investigated);
- tourist attractions; and

- general high urban pedestrian locations during lunch hours.

At many of these locations, there were policies restricting our ability to implement the intercept interviews. These final locations were finally selected for implementing the intercept interviews:

- The Pier in St. Petersburg – a mixed retail and dining establishment;
- Tallahassee Downtown Market;
- Lake Ella (Tallahassee) Wednesday Farmers Market;
- Land O' Lakes Branch Library; and
- Regency Park Branch Library (New Port Richey).

Potential interviewees were asked if they would be willing to participate in an FDOT-sponsored survey about bicycling or walking habits. If pressed for a further explanation concerning the purpose of the interviews, participants were told it was to obtain information on lifetime walking and bicycling habits. That the purpose was also to obtain information concerning the influence of facilities on long term bicycling and walking habits was not revealed to the participants. The interviewees did not get to choose, or know prior to beginning the interview, if they would be participating in the walking or bicycling interview.

A total of 129 interviews were conducted, 52 bicycling interviews and 77 walking interviews. The distribution of the surveys given out at the various locations is provided in Figure 4-1; the two Tallahassee locations were grouped together as there were no notations as to which survey was conducted at which location on the forms.

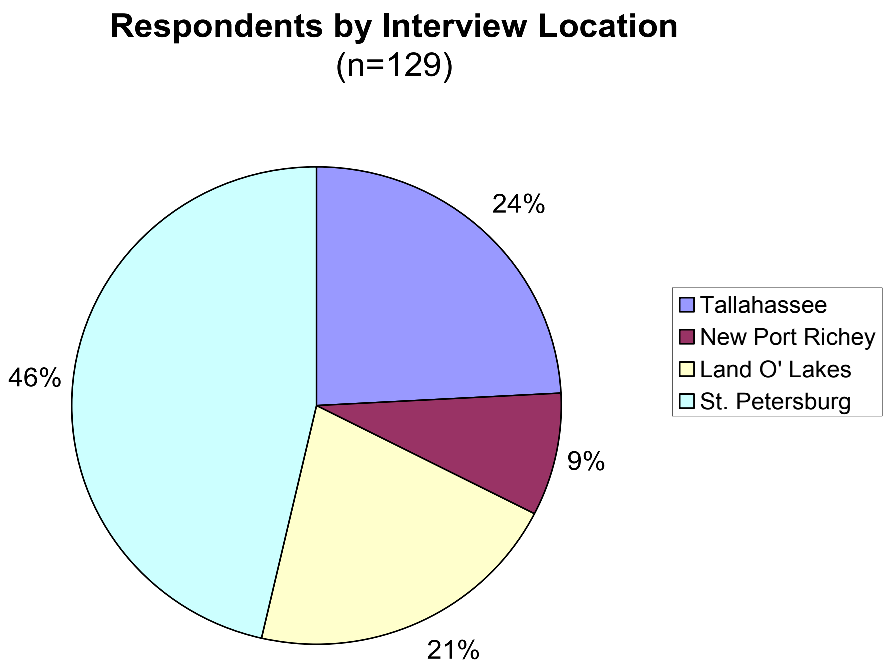

FIGURE 4-1 Percent of responses by interview location

Survey Responses (Combined Dataset)

The general purpose of this Conserve by Bicycling and Walking Phase II task was to determine if there is a correlation between the bicycling and walking levels of individuals and the presence of bicycling and walking facilities. Specifically it was to determine if a presence of facilities at one point in an individual's life correlates to a sustained participation in walking and bicycling. However, the researchers have provided an overview of the individuals participating in the research to provide insight into the scope of the types of individuals who participated.

The gender distribution of the respondents was fairly even, with 57 males and 68 females participating in the interview (Figure 4-2).

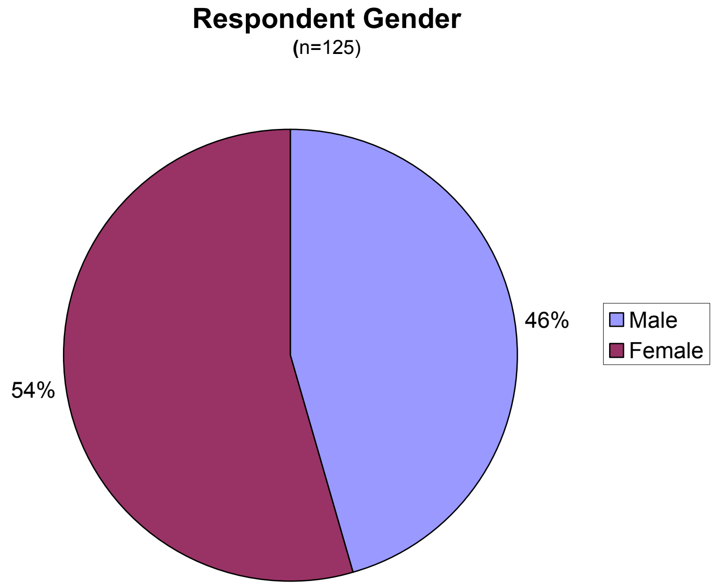

FIGURE 4-2 Percent responses by gender

The age distribution of the respondents was as shown in Figure 4-3.

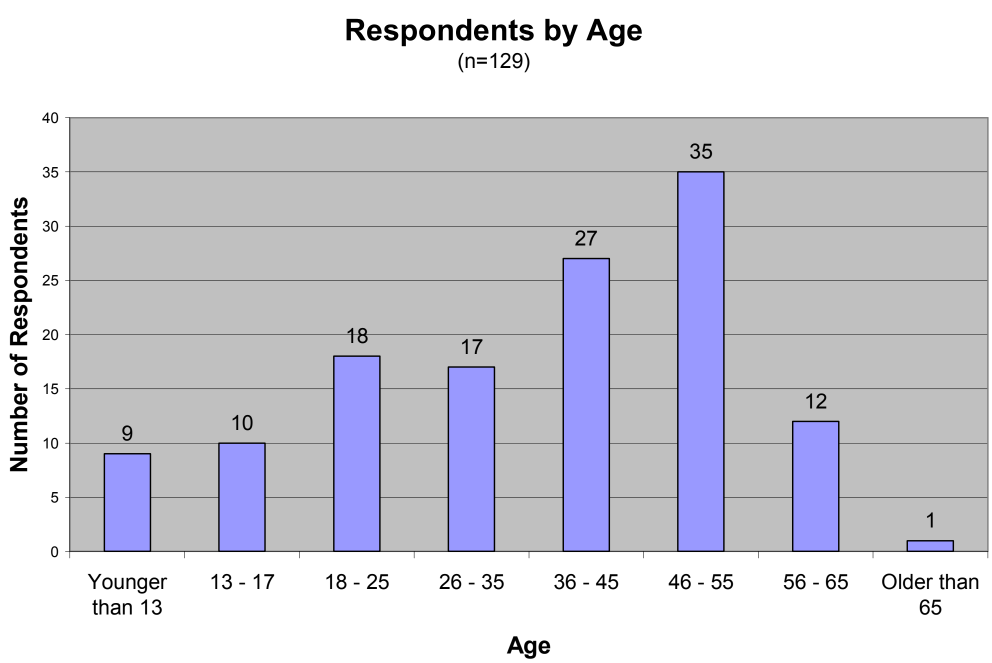

FIGURE 4-3 Number of respondents by age

Respondents were asked where they currently live. Naturally, the responses were clustered around the locations the interviews were conducted. However, numerous locations around Florida and several other states were represented. Table 4-1 provides the reported Florida residence distribution.

TABLE 4-1 Location of residence (Florida)

City/Town/Place	Number of Responses (n=108)
Tallahassee	21
Tampa	20
Land O' Lakes	18
St. Petersburg	17
Lutz	4
Gainesville	3
Odessa	3
Wesley Chapel	3
Clearwater	2
Lakeland	2
Orlando	2
Calvary	1
Chapel	1
Crawfordville	1
Daytona Beach	1
Havana	1
Holiday	1
Lake Mary	1
Plant City	1
Riverview	1
Safety Harbor	1
Seminole	1
Sebring	1
Temple Terrace	1

Out of state respondents were distributed as shown in Table 4-2.

TABLE 4-2 City of residence (outside Florida)

City/Town/Place	State	No. of Respondents (n= 13)
Galesburg	IL	2
Harrow	AK	1
San Diego	CA	1
Denver	CO	1
Golden	CO	1
Hamilton	GA	1
Lagrange	GA	1
Lawrenceville	GA	1
Dayton	IN	1
Bay City	MI	1
Knoxville	TN	1
Green Bay	WI	1

Do you consider bicycling (or walking) to be a regular activity in your life? When asked "Do you consider bicycling (or walking) to be a regular activity in your life?" 77 percent of the respondents stated that they do (Figure 4-4).

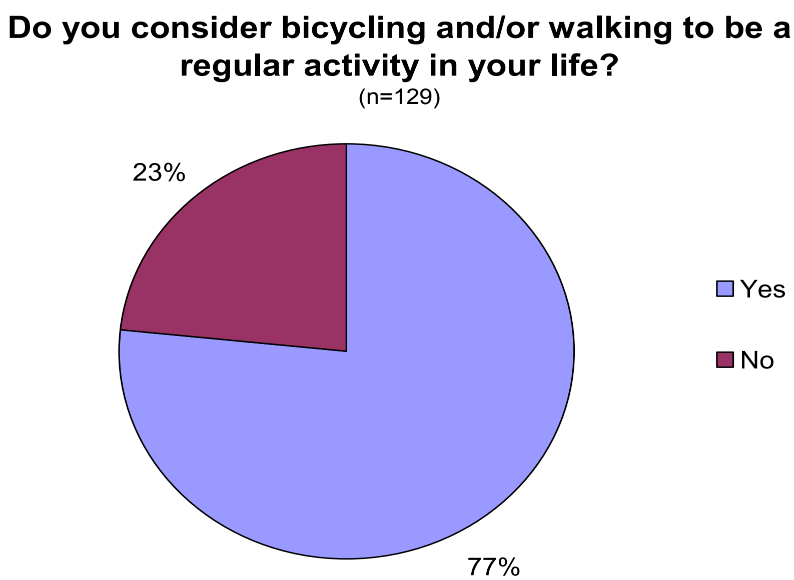

FIGURE 4-4 Percent who felt bicycling and walking represented a regular activity in their lives

Those participants responding that they do **not** consider bicycling (or walking) to be a regular activity in their lives were asked why they did not bicycle (or walk). The answers they gave are enumerated in Table 4-3.

TABLE 4-3 Reasons given for not bicycling or walking

Reason for not bicycling or walking	**Number of responses (n=10*)**
Work	2
Lazy	2
Exercise (unclear, however "exercise" was reported as a response)	1
School	1
Age	1
Sight (vision impairment)	1
Prefer walking to driving	1
Hate cars	1

*participants were allowed to provide up to three responses

Those participants responding that they **do** consider bicycling (or walking) to be a regular activity in their lives were asked what factors prompted them to bicycle or walk regularly. Recreation and exercise were the most common answers, representing 49% of the answers provided. The presence of facilities (sidewalks or trails) represented only 2.5% of the responses (but 5% of the respondents). A complete list of the answers the respondents gave is enumerated in Table 4-4.

TABLE 4-4 Reasons given for bicycling or walking

Reason for beginning to bike or walk regularly	Number of responses (n=203*)
Exercise	65
Recreation	35
Family activity	15
Other work	13
Convenience	11
Commute	10
Errands	9
Social	8
No car	5
Dog to walk	5
Transportation	5
School	4
Independence	4
Good trails system	3
Sidewalks	2
Other	2
Have time	2
Don't like driving	1
Close to destinations	1
Neighborhood walking group	1
Environmentally safe	1
Require outside time	1

*participants were allowed to provide up to three responses

Bicycling Survey Results and Analysis

Current Bicycling Habits

Participants were asked about their current bicycling habits. They were first asked if they consider bicycling to be a regular activity in their lives. 52% reported that they did (Figure 4-5).

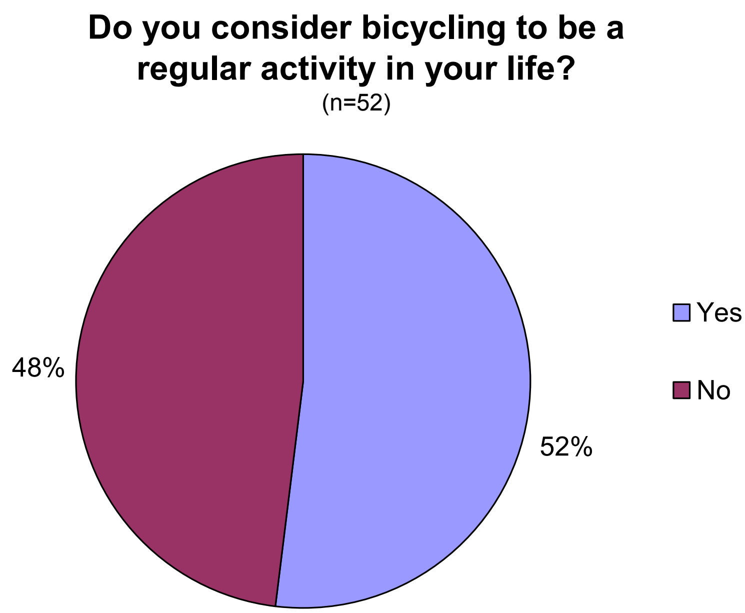

FIGURE 4-5 Percent who felt bicycling represented a regular activity in their lives

Participants were asked how frequently they rode a bicycle for a variety of trip types: commuting, errands/appointments, and recreation. Response distributions are provided in Figure 4-6.

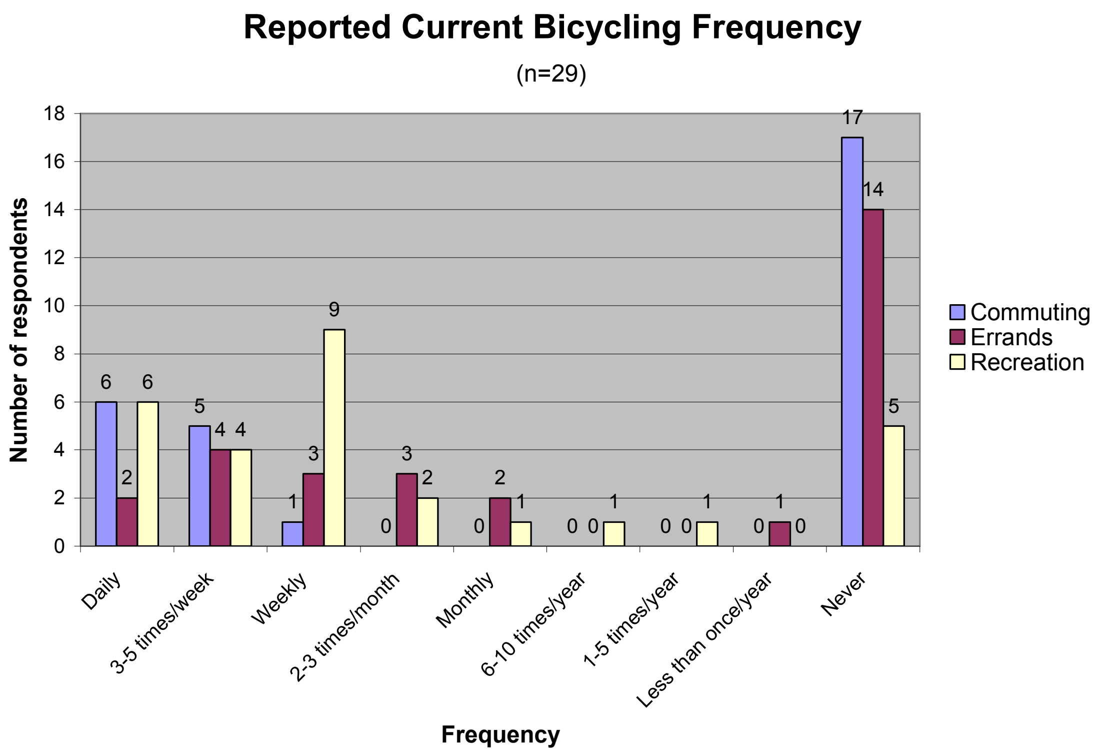

FIGURE 4-6 Frequency of riding bicycles

In addition, the overall average bicycling trip length was reported as 3.4 miles. The longest individual average bicycling trip length reported was 15 miles.

Facilities Used

Participants were also asked about the facilities they ride bicycles upon. They were asked to identify the primary facility type as well as secondary facility types. Their responses for commuting are provided in Figure 4-7.

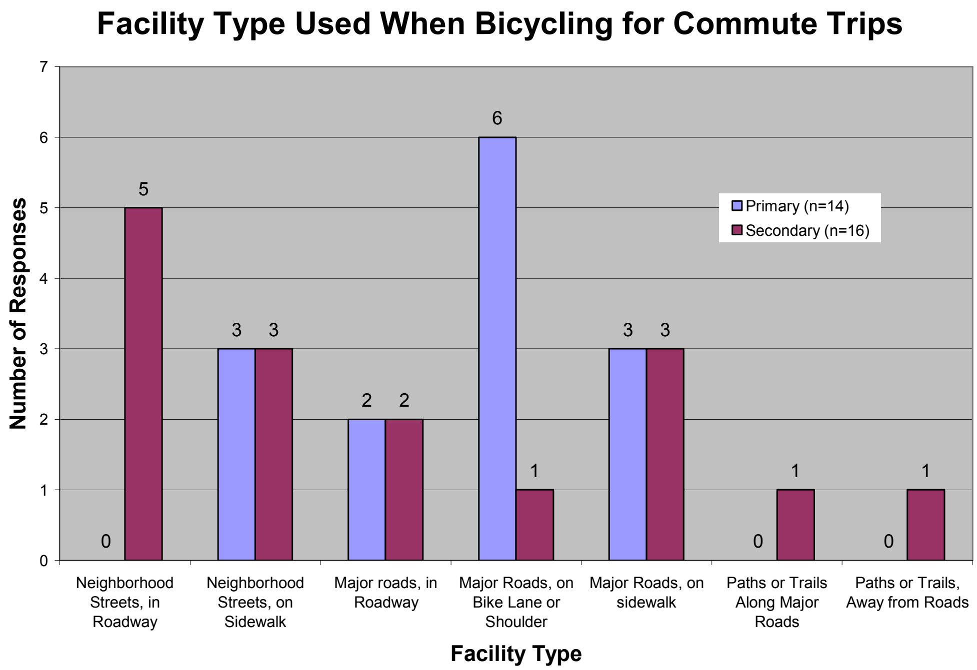

FIGURE 4-7 Reported bicycle facility type usage for commute trips

The results for errand or appointment trips are provided in the Figure 4-8.

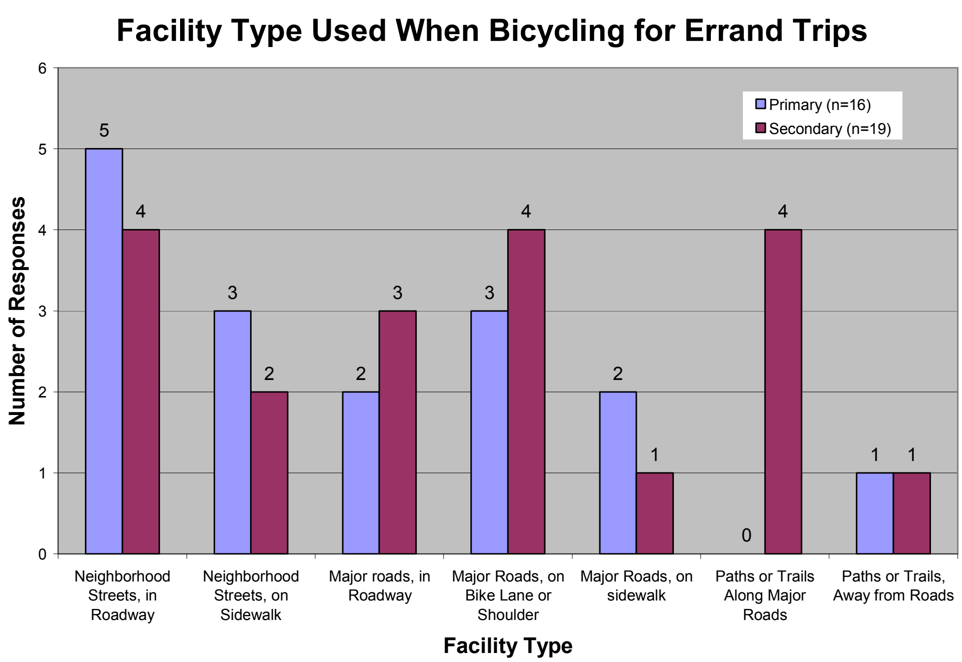

FIGURE 4-8 Reported bicycle facility type usage for errand trips

The results for recreational trips are provided in Figure 4-9.

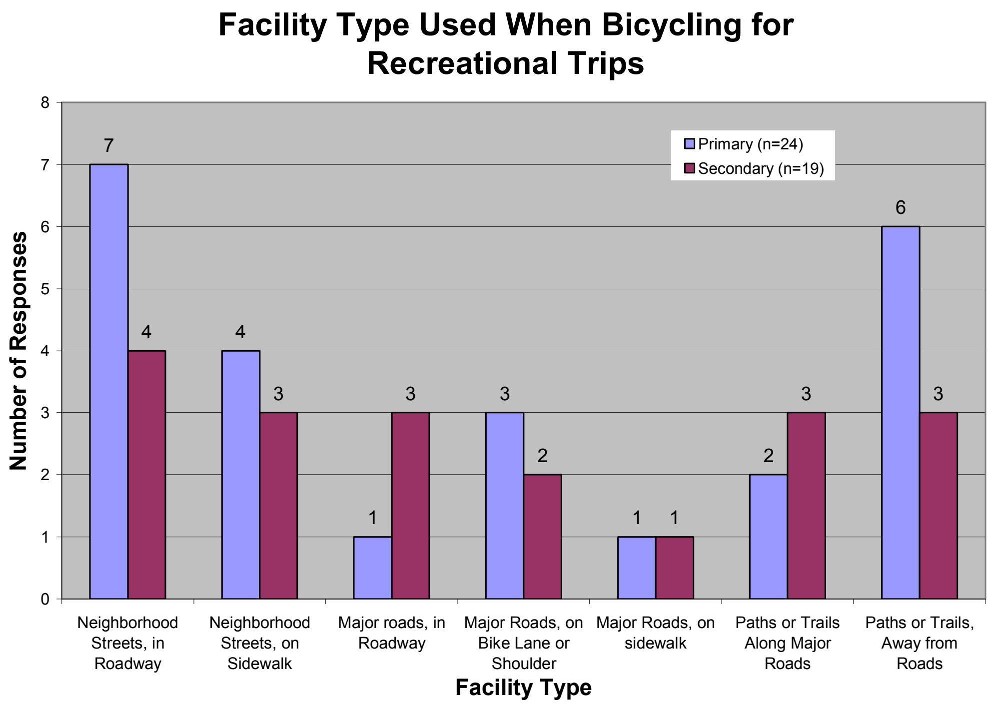

FIGURE 4-9 Reported bicycle facility type usage for recreational trips

Bicycling Patterns by Age Group

Participants were asked about their bicycling habits and the facilities they used for bicycling at previous periods during their lives. The interviewers also asked the reasons participants did or did not ride a bicycle, the facilities available, and the amount the participant used each facility type.

The interviewers asked participants how often they rode a bicycle and the primary facility types they rode a bicycle upon during each age group. Responses are divided into each age group and shown in Figures 4-10 through 4-22.

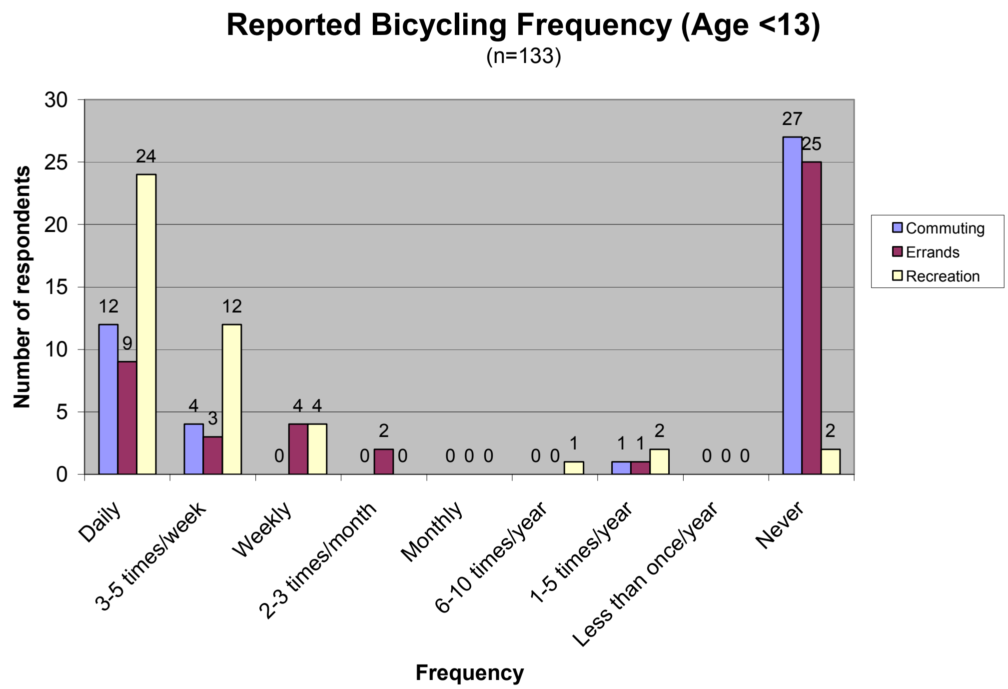

FIGURE 4-10 Frequency of riding, less than 13 years old

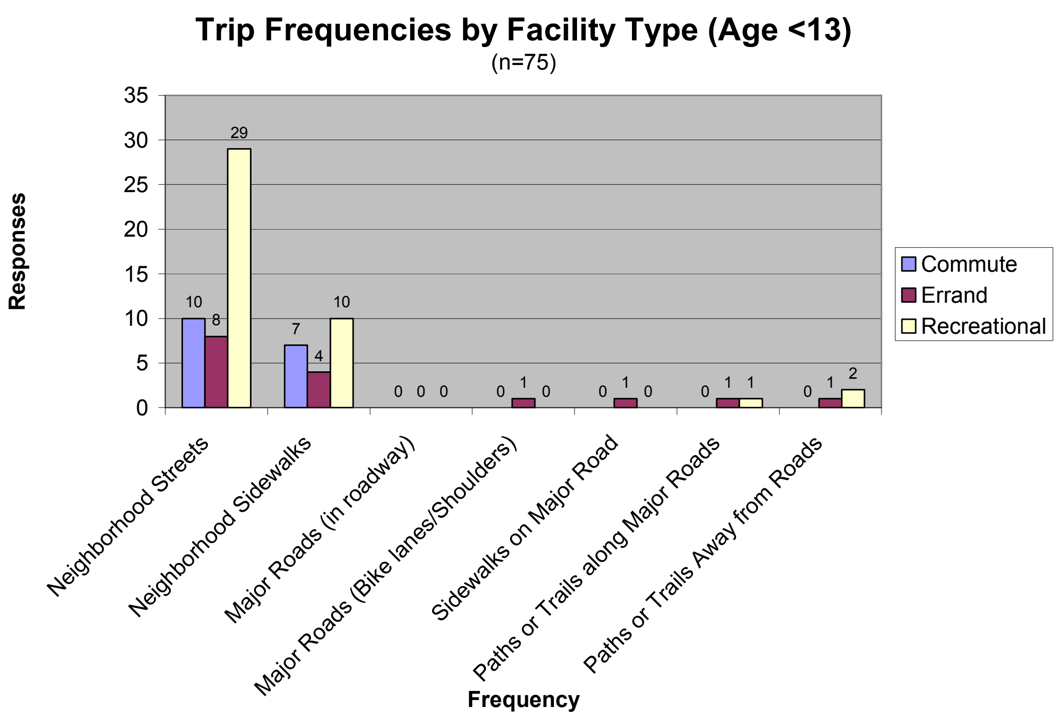

FIGURE 4-11 Frequency of riding by facility type, less than 13 years old

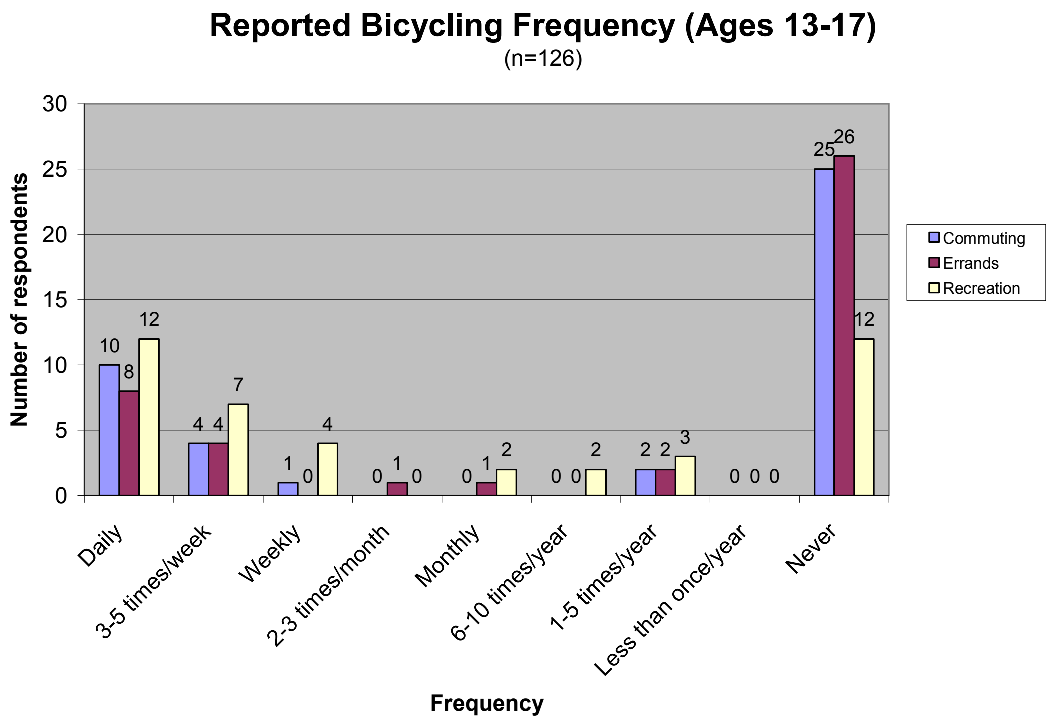

FIGURE 4-12 Frequency of riding, 13-17 years old

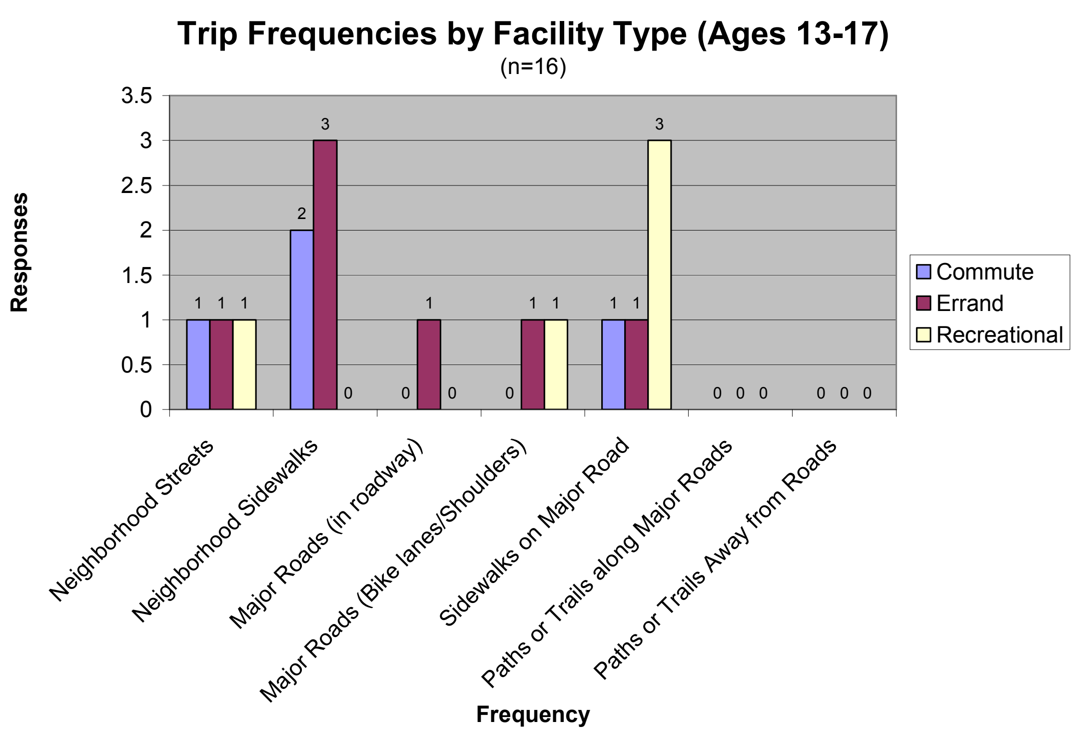

FIGURE 4-13 Frequency of riding by facility type, 13-17 years old

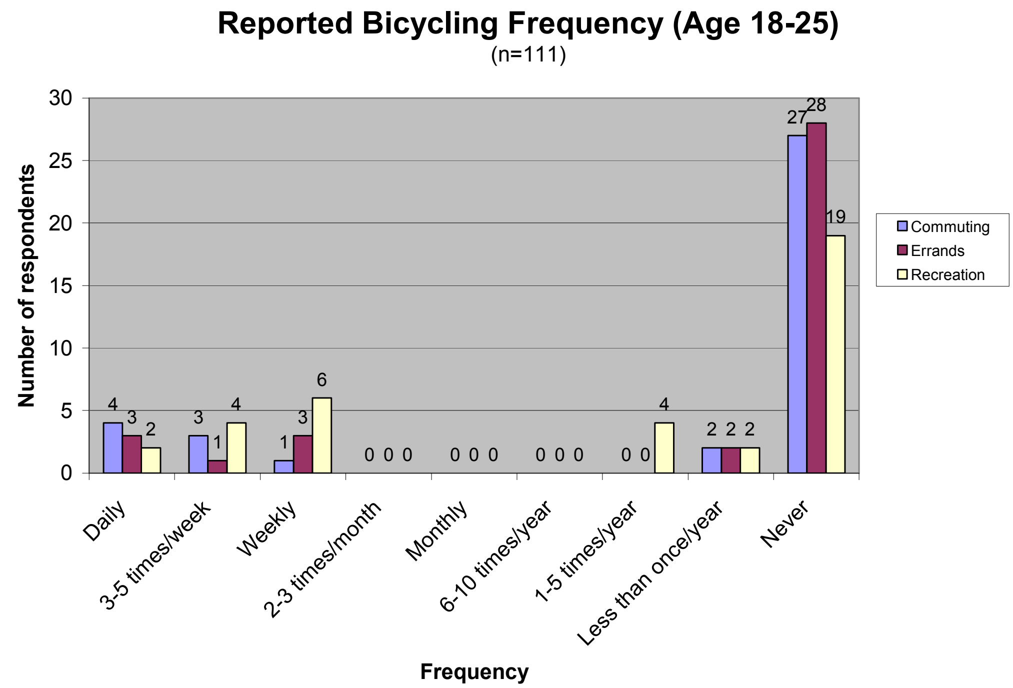

FIGURE 4-14 Frequency of riding, 18-25 years old

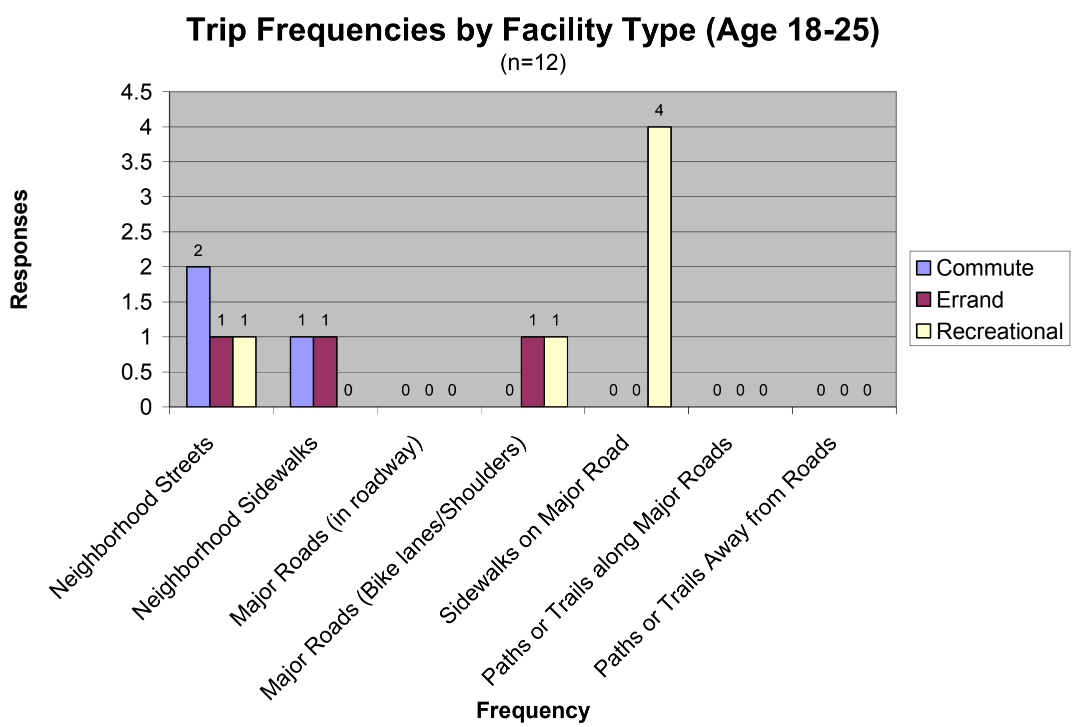

FIGURE 4-15 Frequency of riding by facility type, 18-25 years old

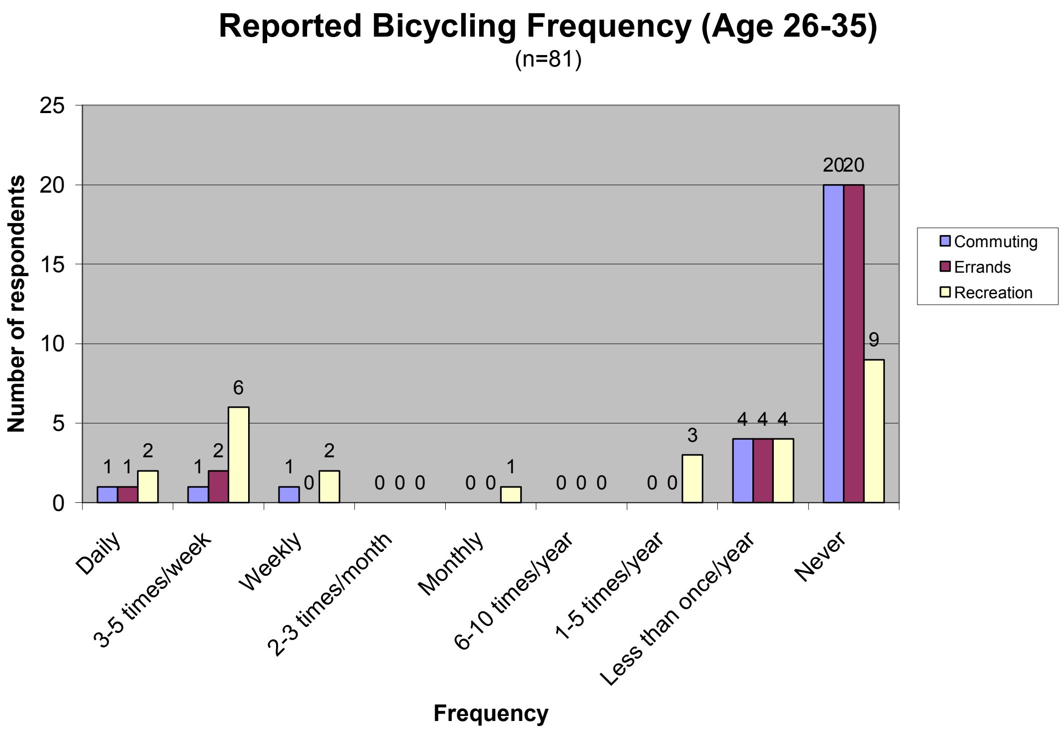

FIGURE 4-16 Frequency of riding, 26-35 years old

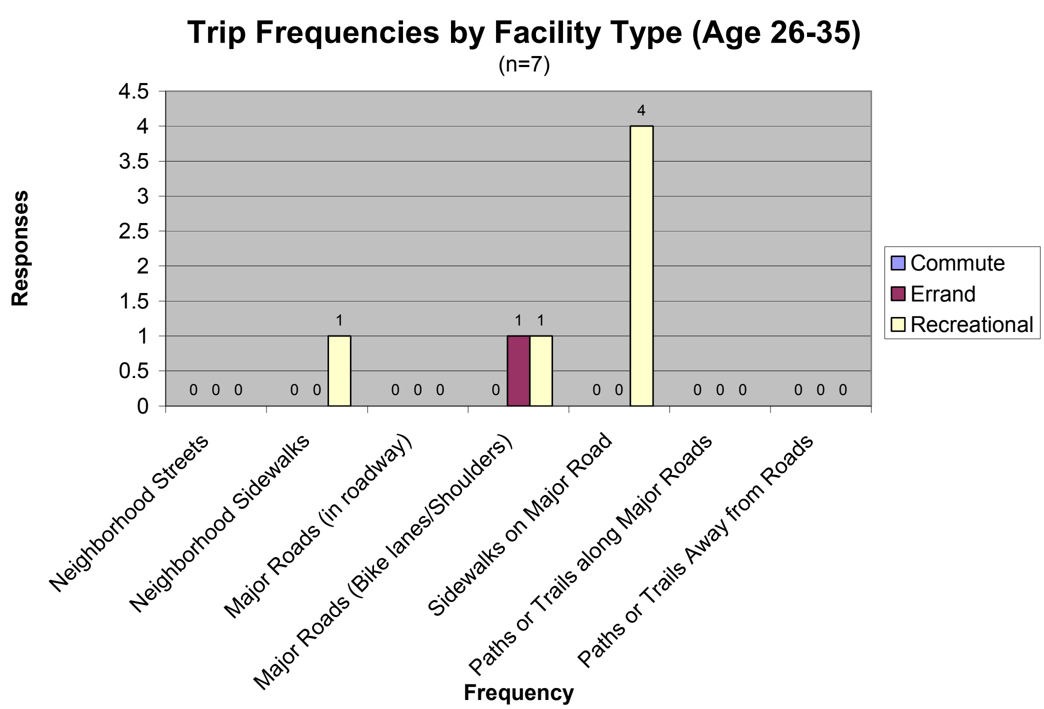

FIGURE 4-17 Frequency of riding by facility type, 26-35 years old

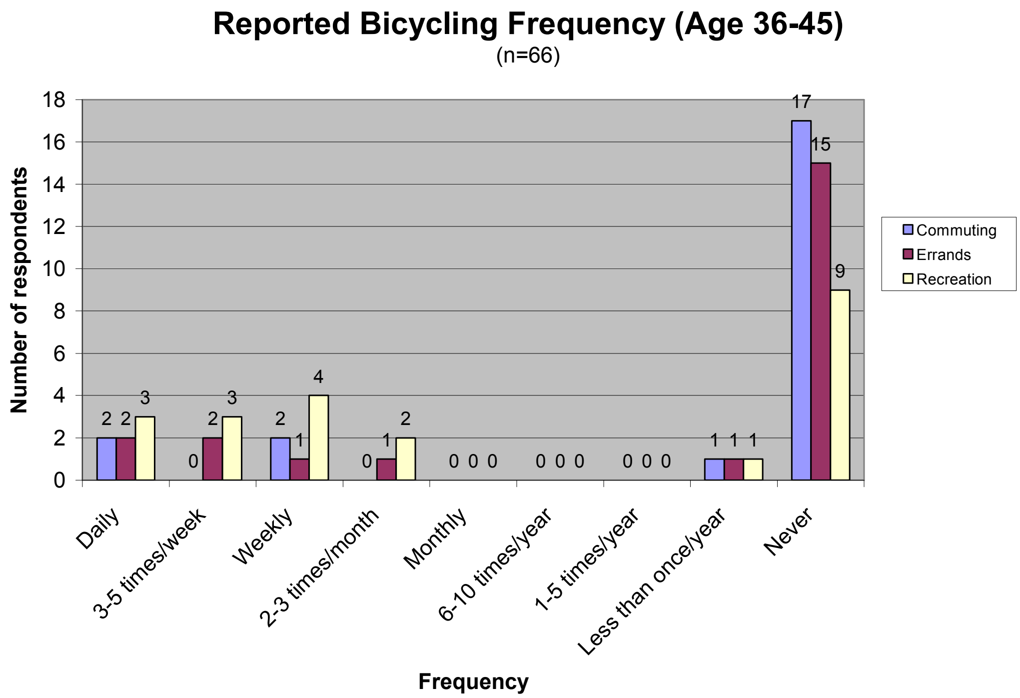

FIGURE 4-18 Frequency of riding, 36-45 years old

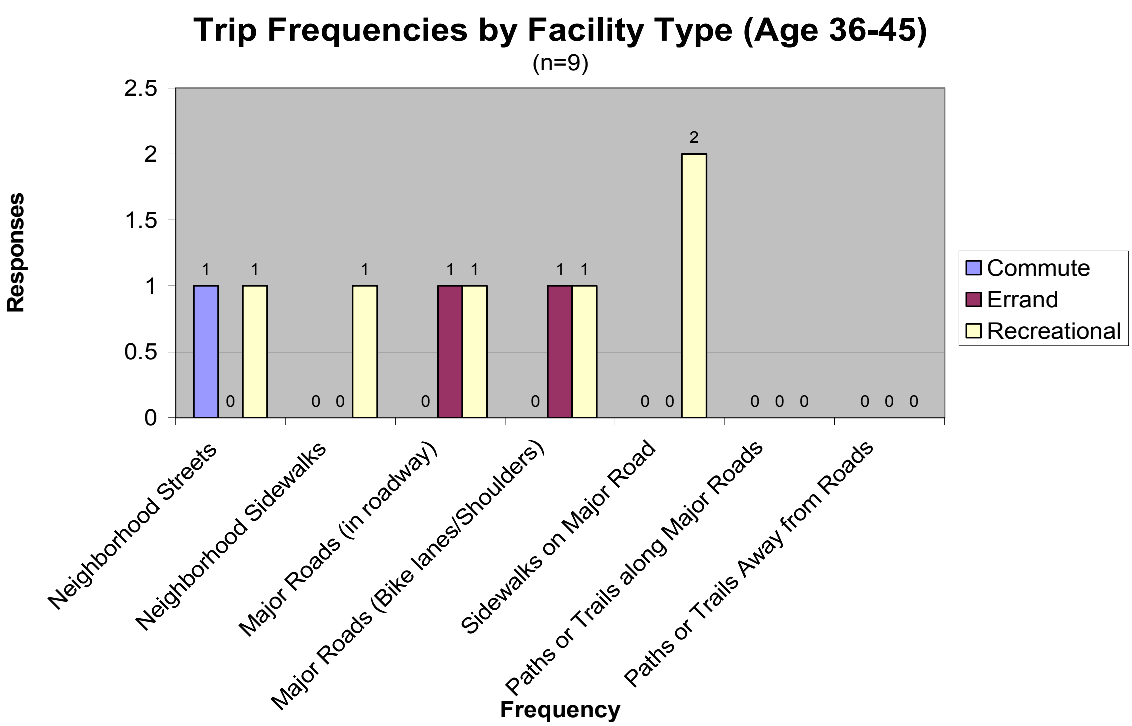

FIGURE 4-19 Frequency of riding by facility type, 36-45 years old

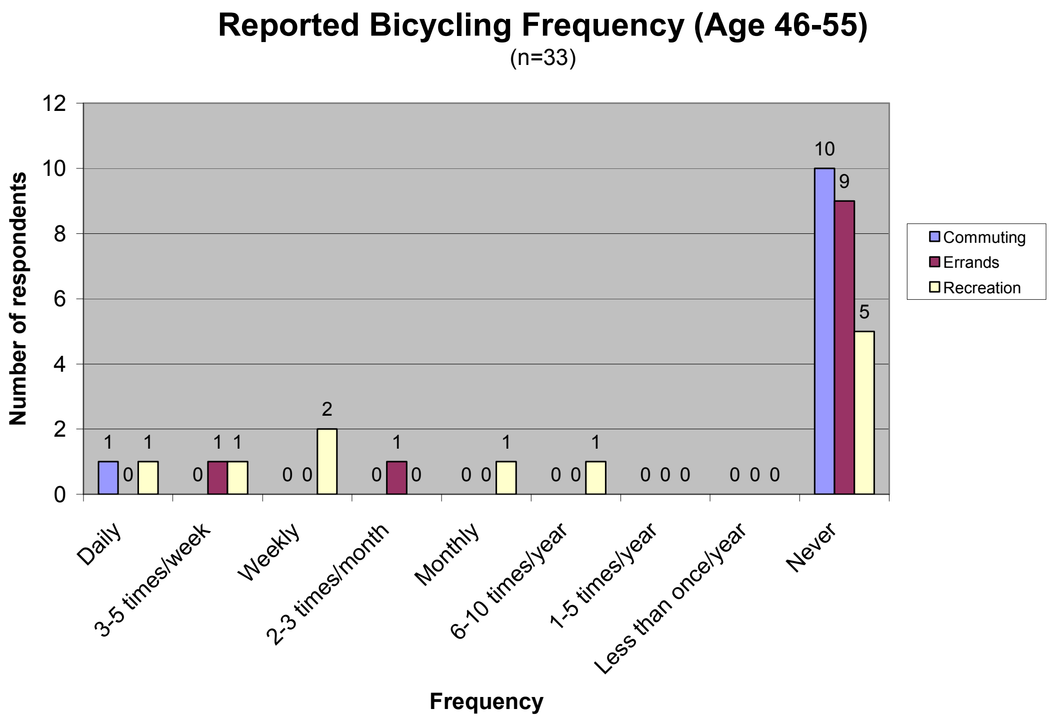

FIGURE 4-20 Frequency of riding, 46-55 years old

Only one participant reported the facility type, neighborhood sidewalk facility, for bicycling between the ages of 46-55.

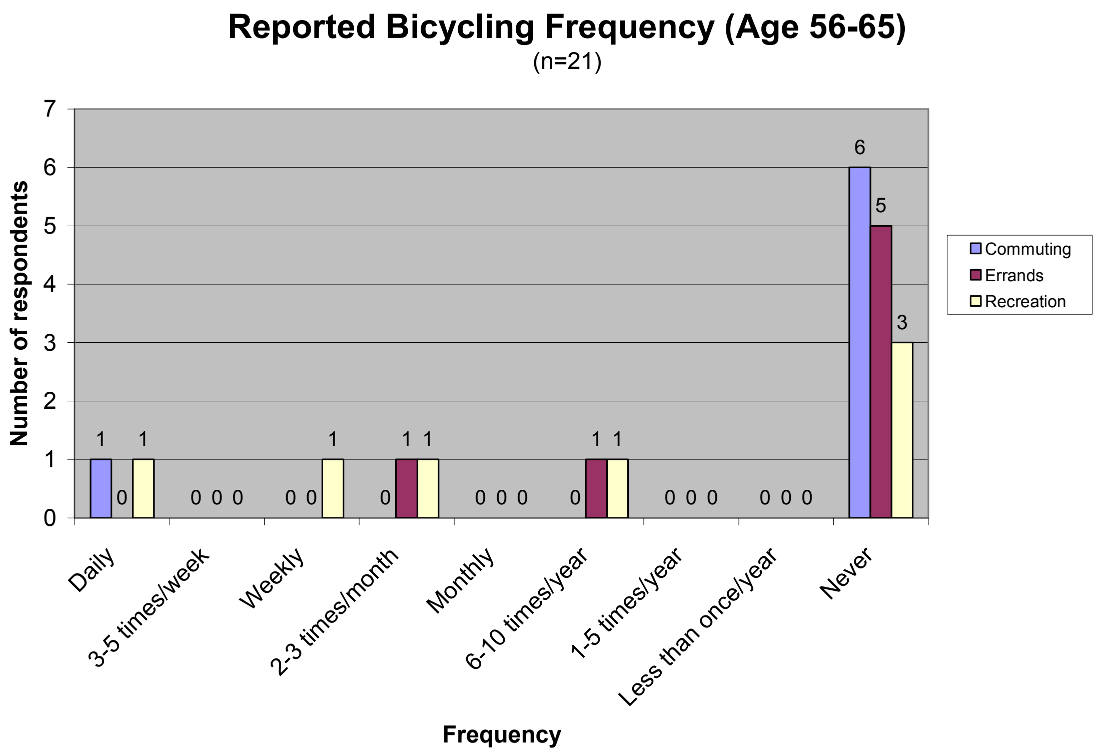

FIGURE 4-21 Frequency of riding, 56-65 years old

Only one participant reported the facility type, major road sidewalk facility, for bicycling between the ages of 56-65.

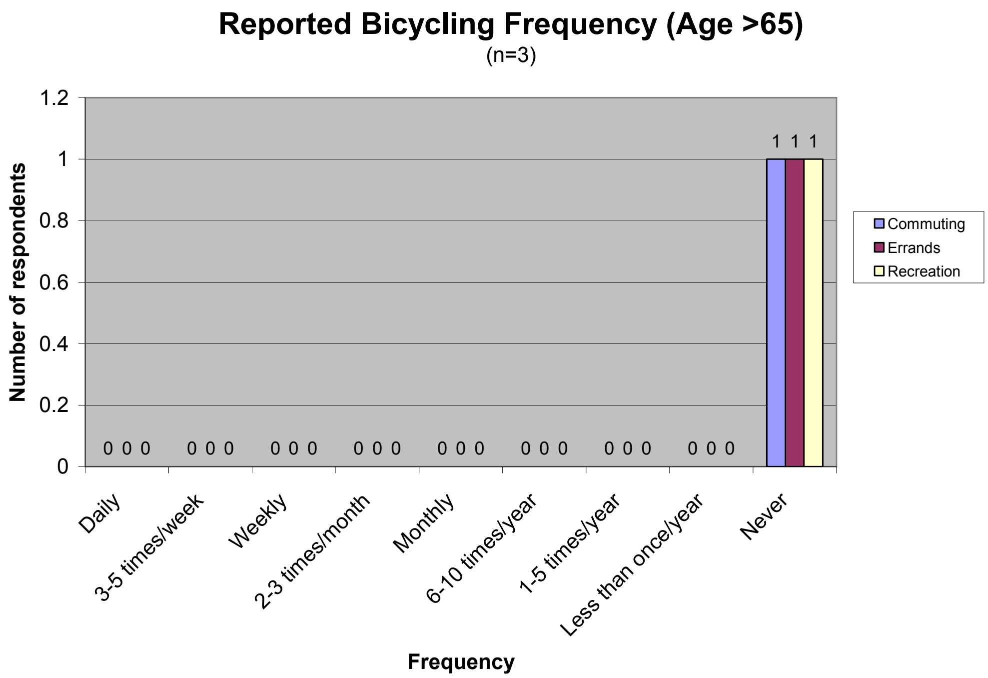

FIGURE 4-22 Frequency of riding, more than 65 years old

No bicycle facility type was reported for this age group.

Analysis

Two tests were run to compare participants' current bicycling habits with their corresponding habits for each age group. The first test was to determine if current bicycling frequencies were greater for those who reported having greater bicycling frequencies in each age category. A two-tailed t-test was performed. The mean of the calculated yearly bicycling frequencies was determined, as was the standard deviation. Then, those participants whose reported bicycling frequencies exceeded one standard deviation above the mean were identified. Their current reported bicycling frequencies were compared to the balance of the participants' reported bicycling frequencies. The correlations for significance at the 95 and 90 percent levels are summarized in Table 4-5. An "S" depicts significance whereas an "NS" depicts non-significance. A finding of significance suggests there is a correlation between frequent bicycling in each corresponding age group and frequent bicycling later in life. [23]

TABLE 4-5 Correlation of current (last 2 years) riding with previous riding

Age Group	T-test	95%	90%	no subsequent riding in the last 2 years (n)	subsequent riding in the last 2 years (n)
Pre-teen	0.979	NS	NS	45	8
13-17	0.812	NS	NS	42	8
18-25	0.494	NS	NS	37	3
26-35	0.079	NS	S	27	3
36-45	0.000	S	S	22	3
46-55	0.022	S	S	11	2
56-65	0.925	NS	NS	7	2
Over 65	NA	NS	NS	1	1

A more detailed review of lifetime riding habits as they relate to trip types will be discussed later.

[23] Statistical tests do not "prove" or "disprove" a correlation. The findings of "significance" at the 90 percent level means that we can be 90 percent sure that there is a real correlation between frequent bicycling as a pre-teen and frequent bicycling as an adult. However, we cannot be 95 percent sure, because results at the 95 percent level were not found to be significant.

Another test was performed to determine if those having bike lanes and paths for each age group reported higher current bicycling frequencies. Participants reporting having bike lanes and paths in each age group were identified. Their current bicycling frequencies were then compared to the balance of the participants. Results are shown in Table 4-6.

TABLE 4-6 Correlation of current (last 2 years) riding on bike lanes or paths with previous riding

Age Group	T-test	95%	90%	no subsequent riding in the last 2 years (n)	subsequent riding in the last 2 years (n)
Pre-teen	0.828	NS	NS	44	5
13-17	0.223	NS	NS	33	7
18-25	0.277	NS	NS	19	6
26-35	0.882	NS	NS	15	8
36-45	0.821	NS	NS	11	4
46-55	NA	NS	NS	6	1
56-65	NA	NS	NS	5	1
Over 65	NA	NS	NS	0	0

Reasons for Bicycling Regularly

The participants were asked their reasons for bicycling and were allowed to give up to three responses. The responses for each age group are summarized in Table 4-7.

TABLE 4-7 Reasons given for bicycling regularly

Reason for bicycling regularly	Number of responses Age <13 (n=31*)	Number of responses Ages 13-17 (n=25*)	Number of responses Ages 18-25 (n=22*)	Number of responses Ages 26-35 (n=13*)	Number of responses Ages 36-45 (n=8*)	Number of responses Ages 46-55 (n=7*)	Number of responses Ages 56-65 (n=2*)	Number of responses Ages >65 (n=0*)
Bike paths	-	-	-	1	-	-	-	-
Bought bike	-	-	1	1	-	1	-	-
Close to destina-tions	-	-	-	-	-	-	1	-
Commute	1	1	4	3	-	-	-	-
Conven-ience	1	1	2	-	-	-	-	-
Dog to walk	-	1	-	1	-	-	-	-
Errands	-	1	2	-	-	-	-	-
Exercise	1	1	5	1	2	2	1	-
Family activity	-	-	1	1	1	1	-	-
Good facilities	3	1	-	-	-	-	-	-
Good trails system	-	-	-	1	-	-	-	-
Have time	1	1	-	1	-	-	-	-
Indepen-dence	-	2	-	-	1	-	-	-
Lack of parking	-	-	1	-	-	-	-	-
Lived in city	-	-	1	-	-	-	-	-
Neighbor-hood biking buddies	1	-	-	-	-	-	-	-
No car	3	3	-	1	2	1	-	-
Other work	1	1	-	-	-	1	-	-
Recreation	10	4	1	1	2	-	-	-
Require outside time	1	1	-	-	-	-	-	-
School	-	2	3	1	-	1	-	-
Social	2	-	-	-	-	-	-	-
Transporta-tion	6	5	1	-	-	-	-	-

*participants were allowed to provide up to three responses

Reasons for Not Bicycling Regularly

The participants were asked for their reasons of not bicycling and were allowed to give up to three responses. The responses for each age group are summarized in Table 4-8:

TABLE 4-8 Reasons given for not bicycling regularly

Reason for not bicycling regularly	Number of responses Age <13	Number of responses Ages 13-17	Number of responses Ages 18-25	Number of responses Ages 26-35	Number of responses Ages 36-45	Number of responses Ages 46-55	Number of responses Ages 56-65	Number of responses Ages >65
	(n=3*)	(n=14*)	(n=10*)	(n=10*)	(n=7*)	(n=2*)	(n=2*)	(n=1*)
Bicycling scary	-	-	-	1	1	-	-	-
Family	-	-	1	-	-	-	-	-
Just did not	-	-	-	-	-	-	1	1
Lack of facilities	2	3	1	2	1	-	-	-
Lazy	-	-	1	-	-	1	-	-
Owned car	-	10	6	4	2	-	-	-
Prefer walking	1	-	-	2	2	1	-	-
Too far for errands	-	-	-	-	1	-	-	-
Work	-	1	1	1	-	-	1	-

*participants were allowed to provide up to three responses

Review of Bicycling Survey Results

The analyses described above, when considered collectively, does not provide clear evidence that bicycling during a particular stage of life leads to a greater likelihood of bicycling later in life. This is not to say that exercise and healthy lifestyles as a whole do not lead to a continuation throughout life, but rather that the activity of bicycling itself is not significantly (statistically) tied to riding habits developed at earlier ages.

Close review of the data reveals that higher level bike facilities (bike lanes and trails) were not reported as being used by most cyclists when they were children. This is likely because most communities have only recently (within the last 20 to 25 years) begun to construct bike lanes and trails. Consequently, the potential for showing long term carryover effects of using such facilities as a child is limited. It is possible that if the same survey were conducted in an area that has been constructing bike facilities for many years the results would have shown a positive correlation between facilities and long term bicycling habits.

Walking Survey Results and Analysis

Current Walking Habits

Participants were asked about their current walking habits. They were first asked if they consider walking to be a regular activity in their lives. 94 percent reported that they do (Figure 23).

FIGURE 4-23 Percent who felt walking represented a regular activity in their lives

Participants were asked how frequently they walked for a variety of trip types: commuting, errands/appointments, and recreation. Response distributions are in Figure 4-24.

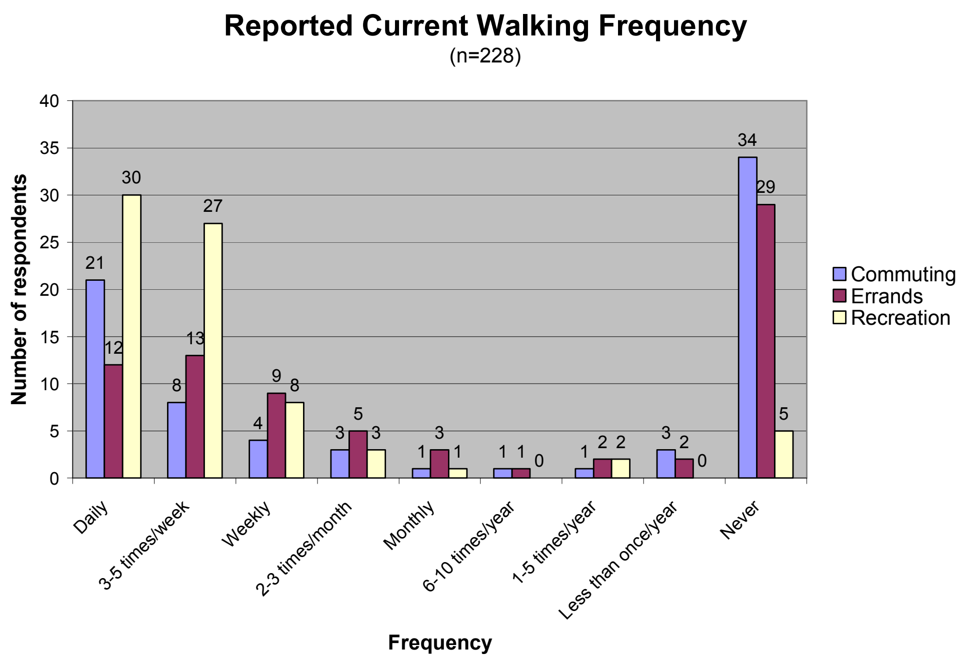

FIGURE 4-24 Frequency of walking

In addition, the overall average walking trip length was reported as 2.4 miles. The longest individual average walking trip length reported was 12 miles. A cumulative percent distribution is shown in Figure 4-25.

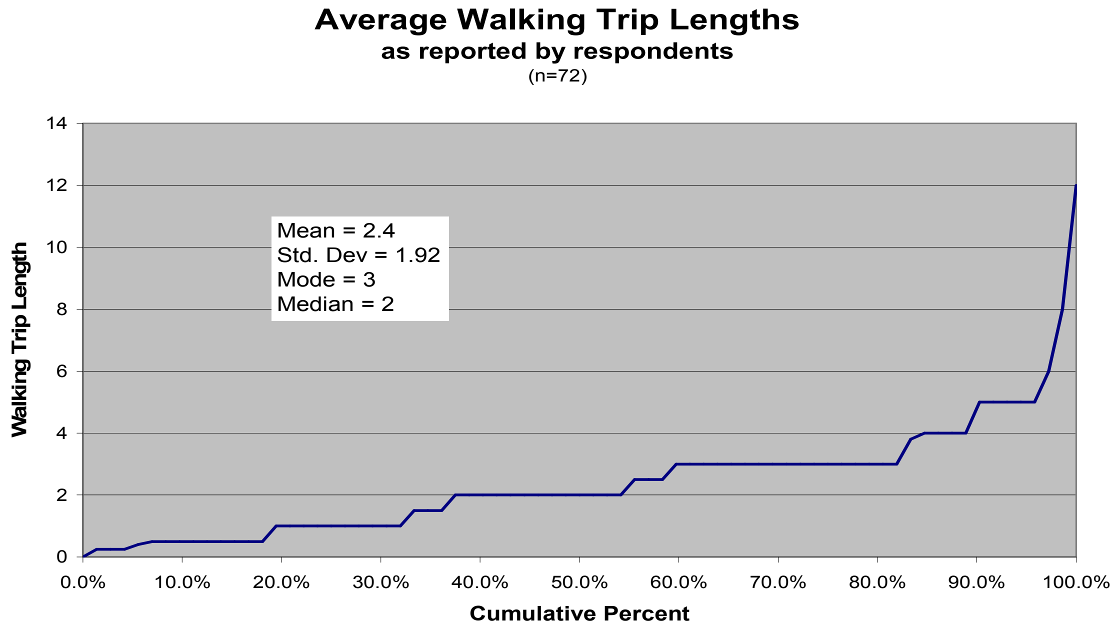

FIGURE 4-25 Reported walking trip length

Facilities Used

Participants were also asked about the facilities they walk upon. They were asked to identify the primary facility type as well as secondary facility types. Their responses for commuting are provided in Figure 4-26.

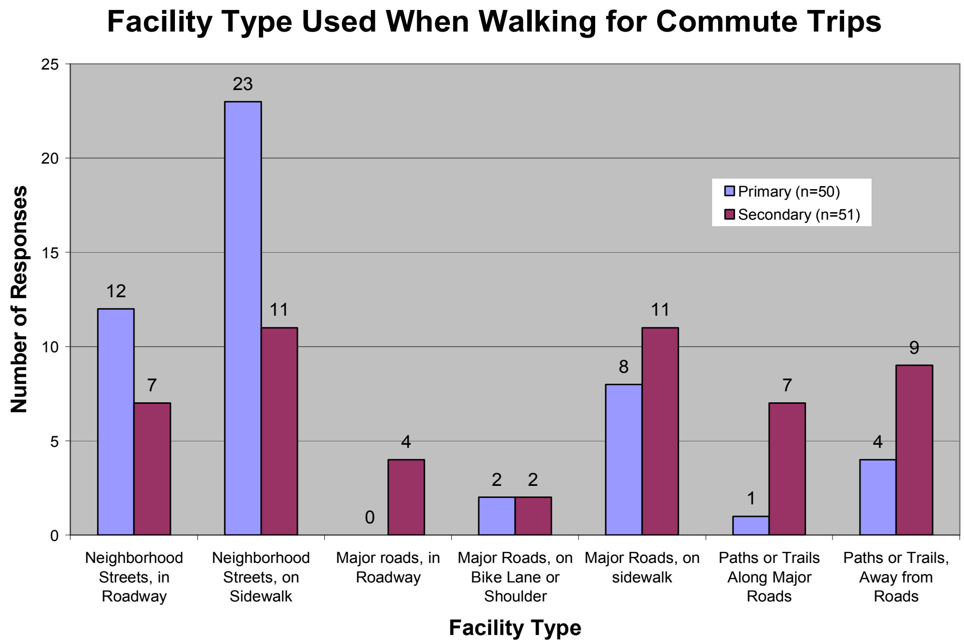

FIGURE 4-26 Reported pedestrian facility type usage for commute trips

The results for errand or appointment trips are provided in Figure 4-27.

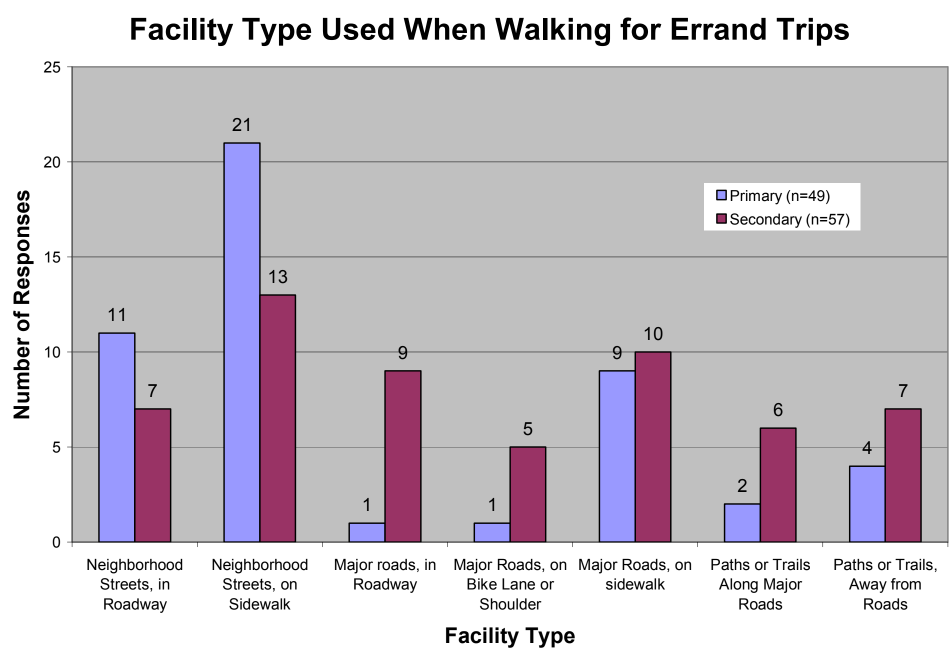

FIGURE 4-27 Reported pedestrian facility type usage for errand trips

The results for recreational trips are provided in Figure 4-28.

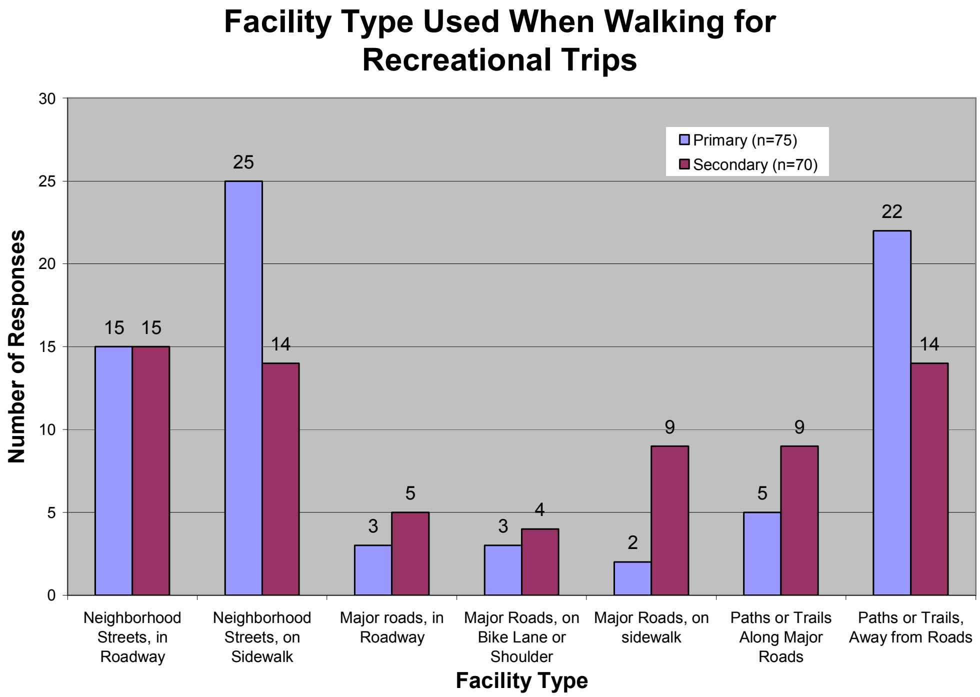

FIGURE 4-28 Reported pedestrian facility type usage for recreational trips

Walking Patterns by Age Group

Participants were asked about their walking habits and the facilities they used for walking at previous periods during their lives. The interviewers also asked the reasons participants did or did not walk, the facilities available, and the amount the participant used each facility type.

The interviewers asked participants how often they walked and the primary facility types they walked upon in their pre-teen years. Responses are divided into each age group and shown in Figures 4-29 through 4-44.

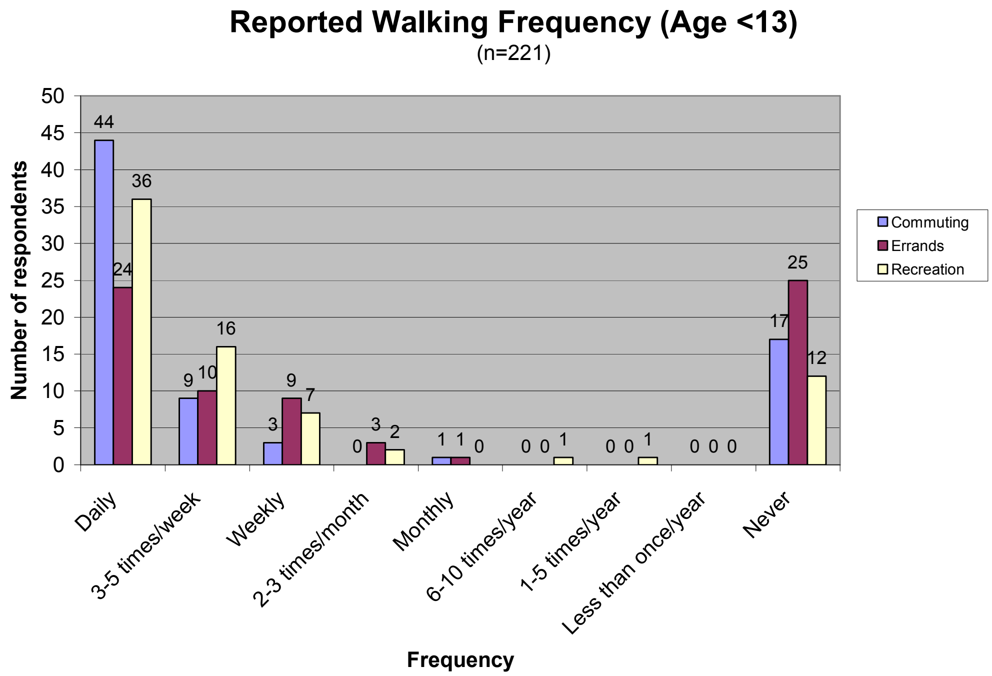

FIGURE 4-29 Frequency of walking, less than 13 years old

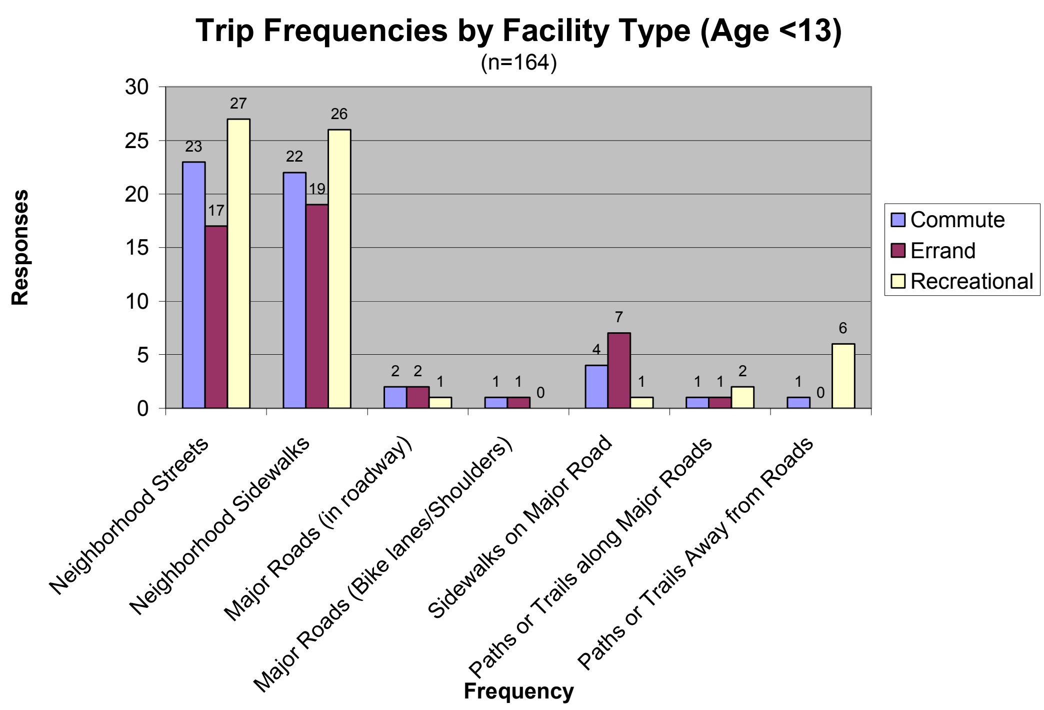

FIGURE 4-30 Frequency of walking by facility type, less than 13 years old

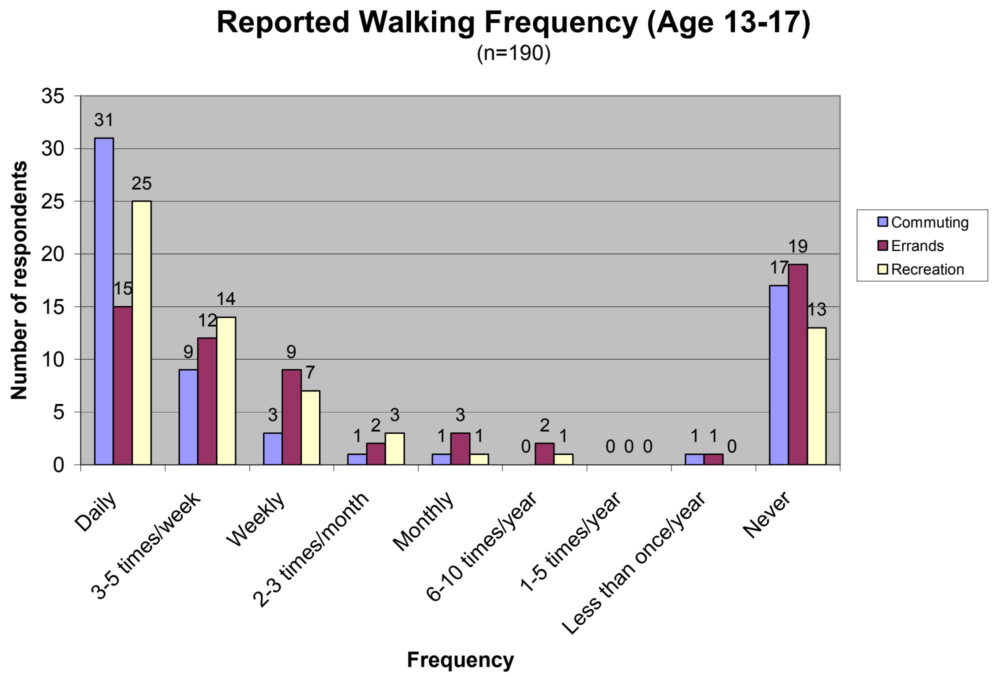

FIGURE 4-31 Frequency of walking, 13–17 years old

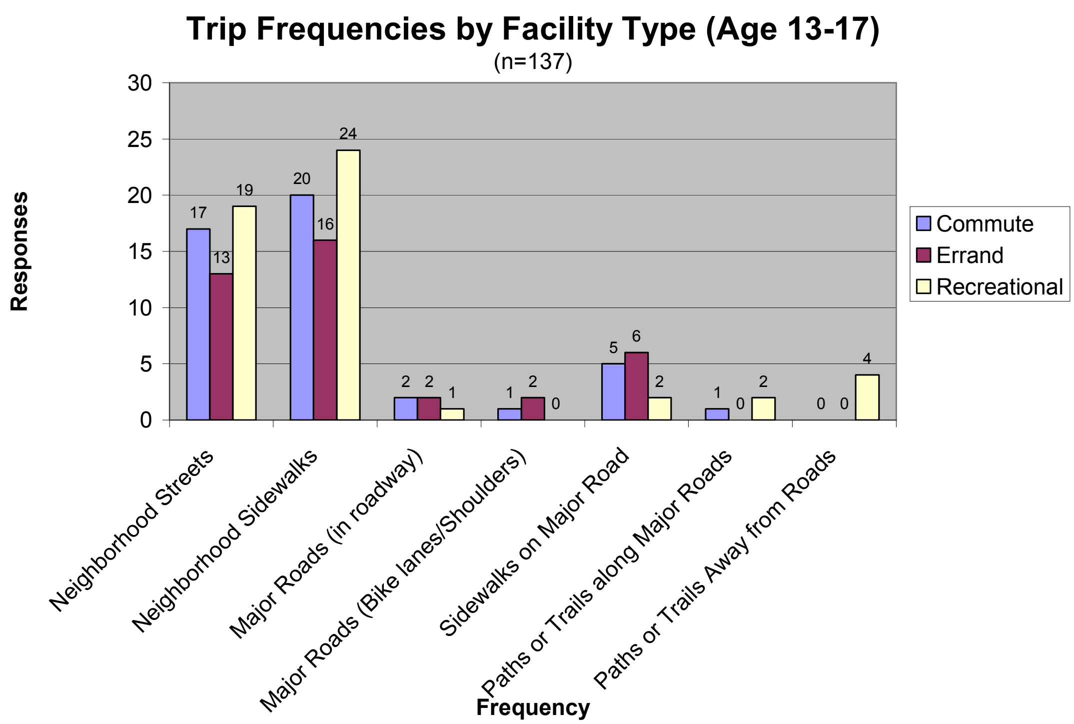

FIGURE 4-32 Frequency of walking by facility type, 13–17 years old

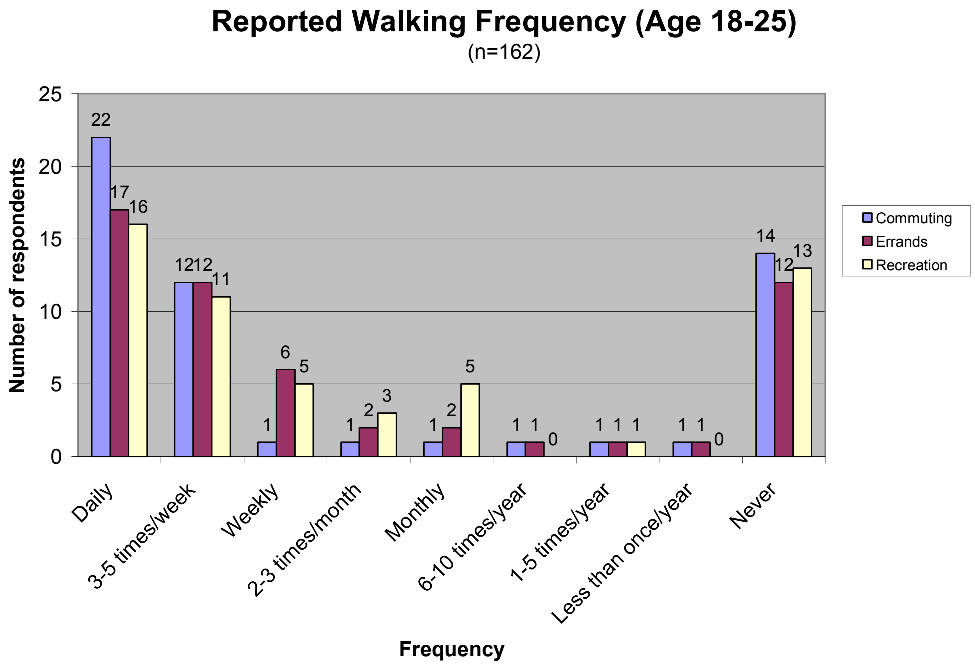

FIGURE 4-33 Frequency of walking, 18-25 years old

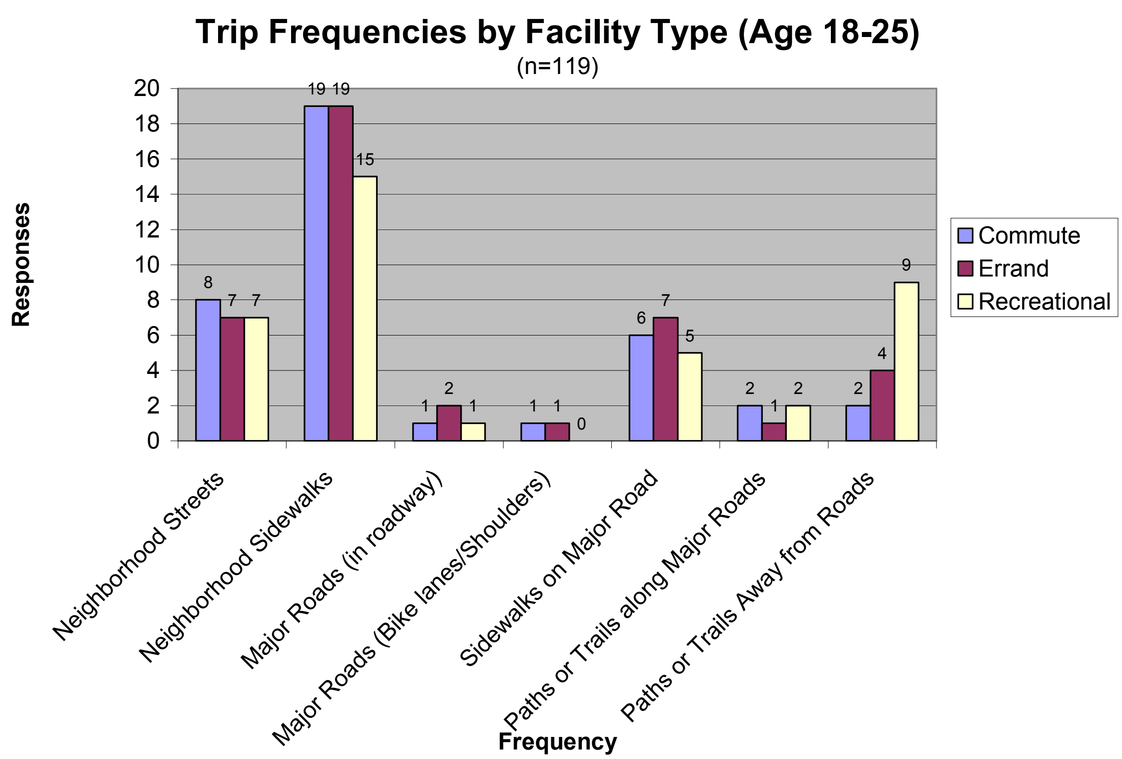

FIGURE 4-34 Frequency of walking by facility type, 18-25 years old

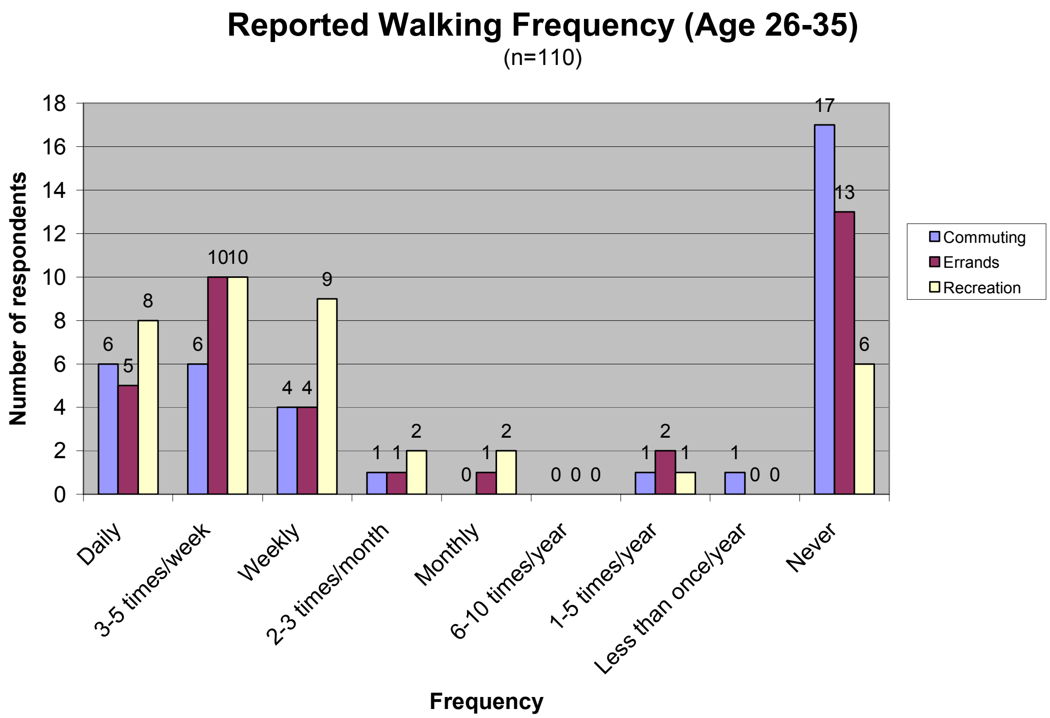

FIGURE 4-35 Frequency of walking, 26-35 years old

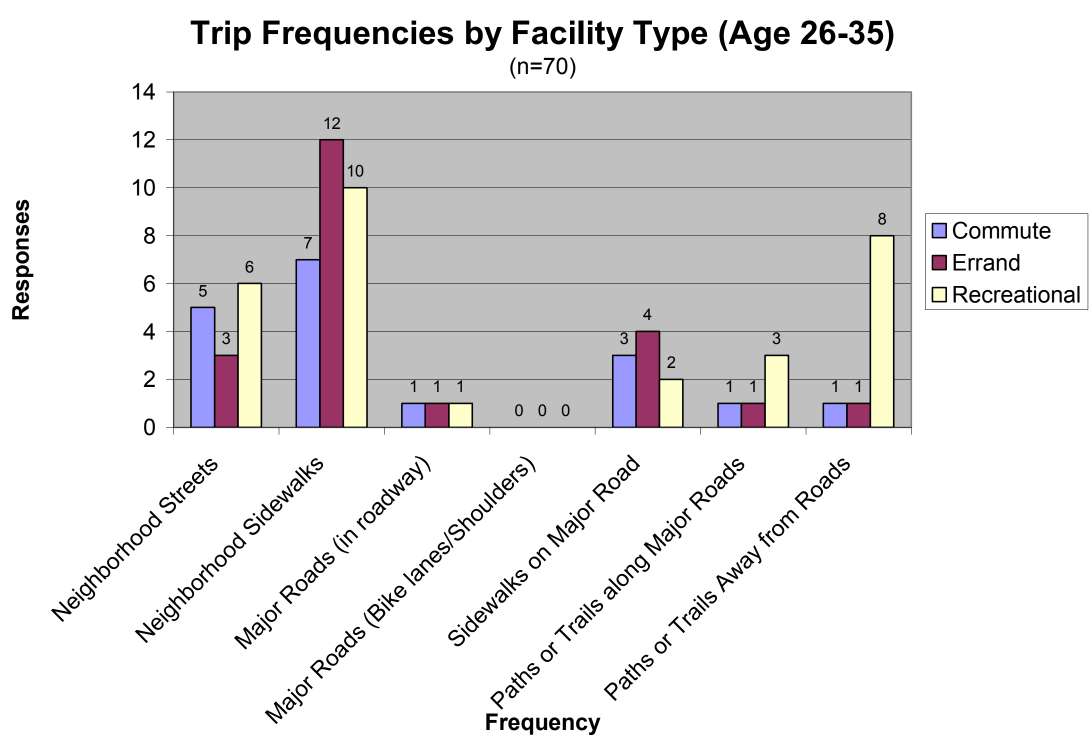

FIGURE 4-36 Frequency of walking by facility type, 26-35 years old

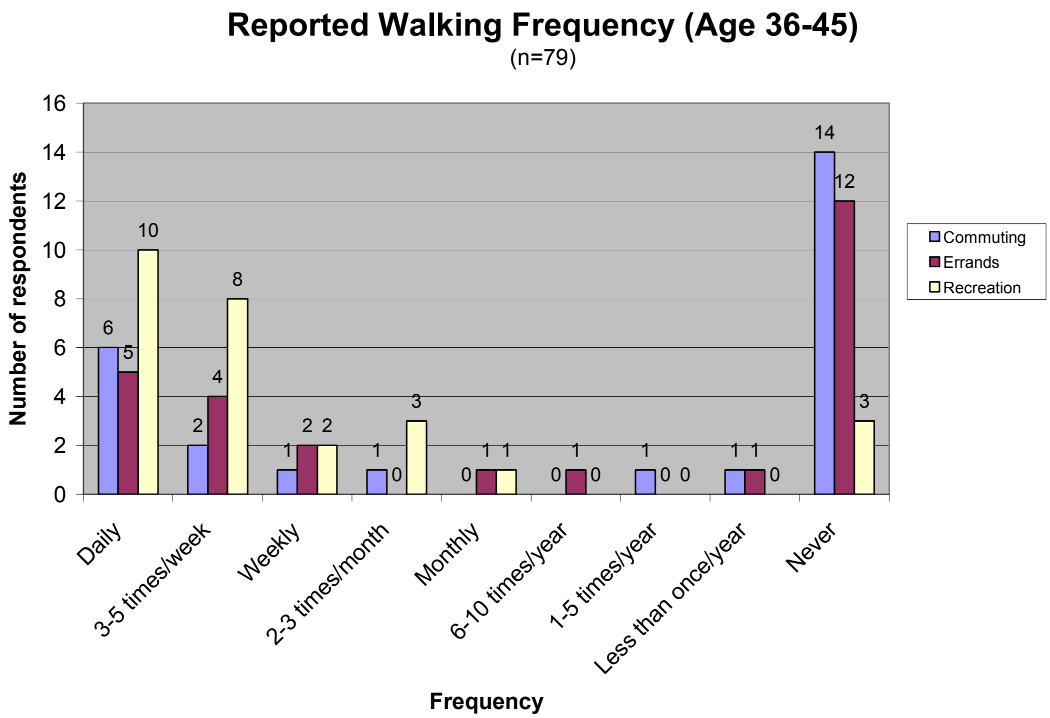

FIGURE 4-37 Frequency of walking, 36-45 years old

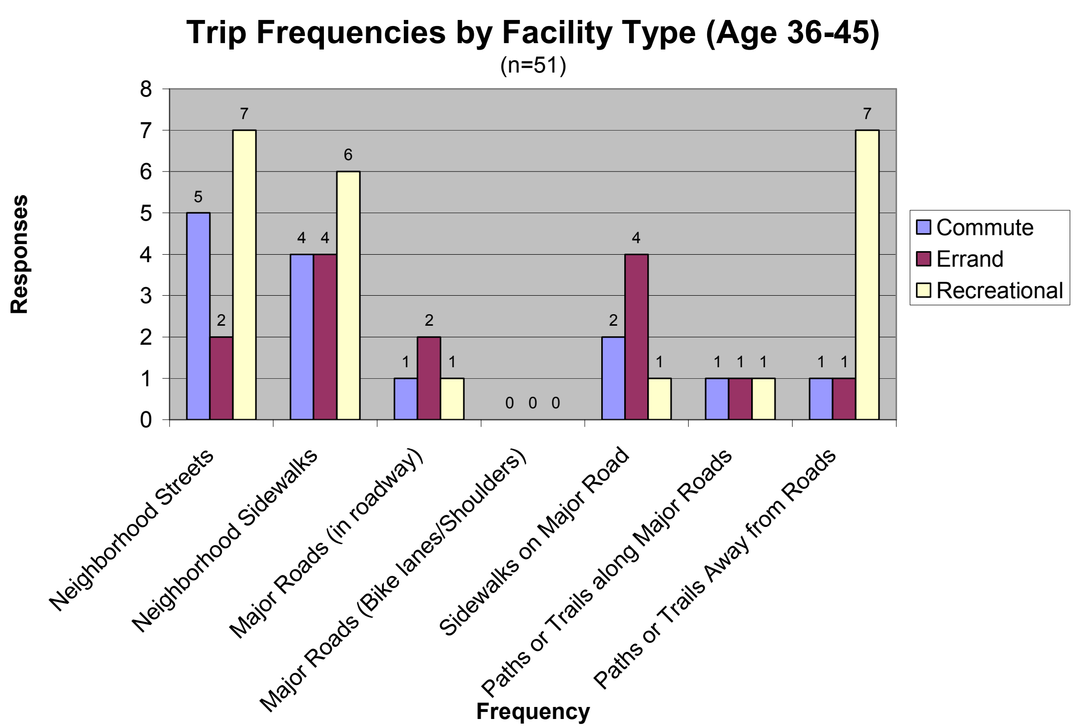

FIGURE 4-38 Frequency of walking by facility type, 36-45 years old

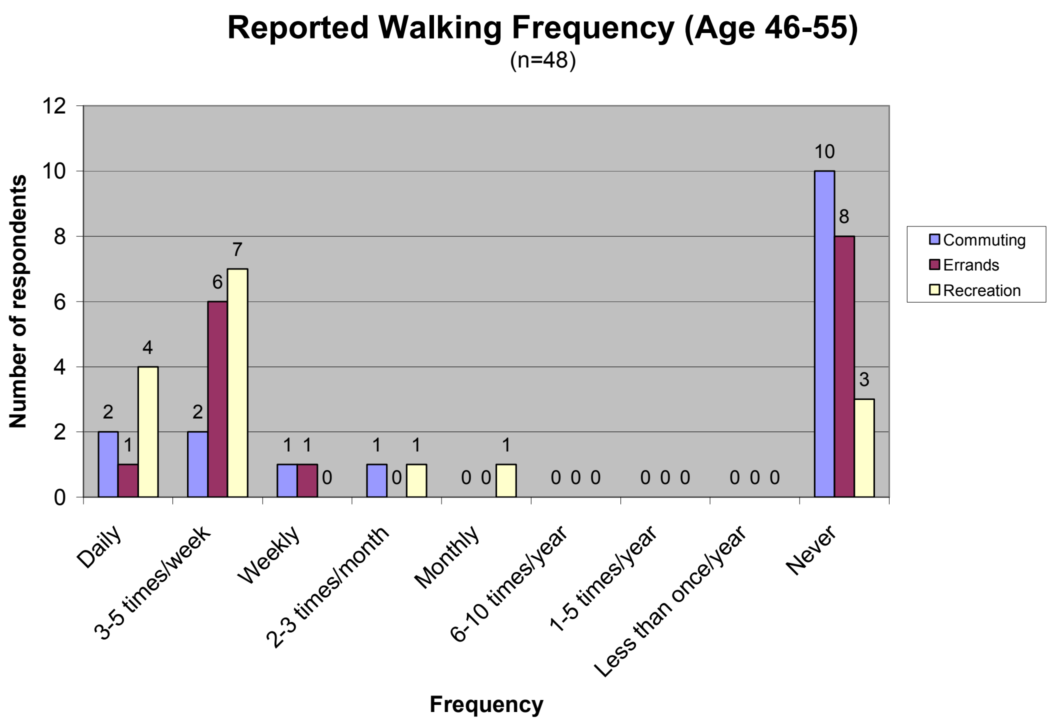

FIGURE 4-39 Frequency of walking, 46-55 years old

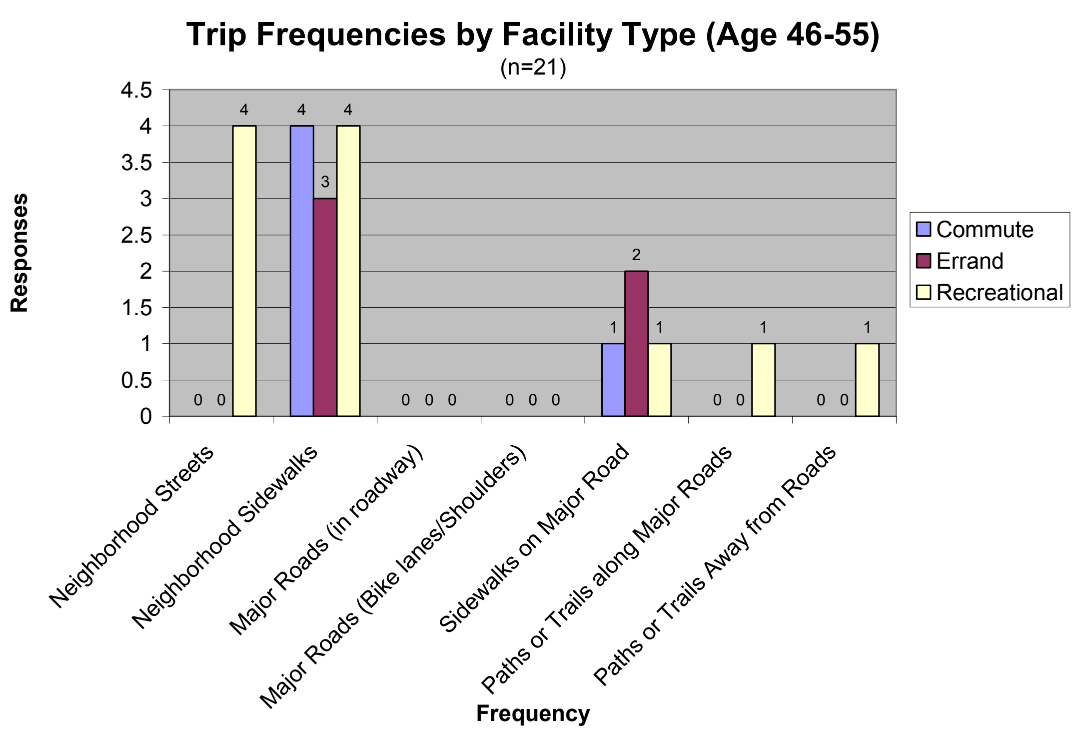

FIGURE 4-40 Frequency of walking by facility type, 46-55 years old

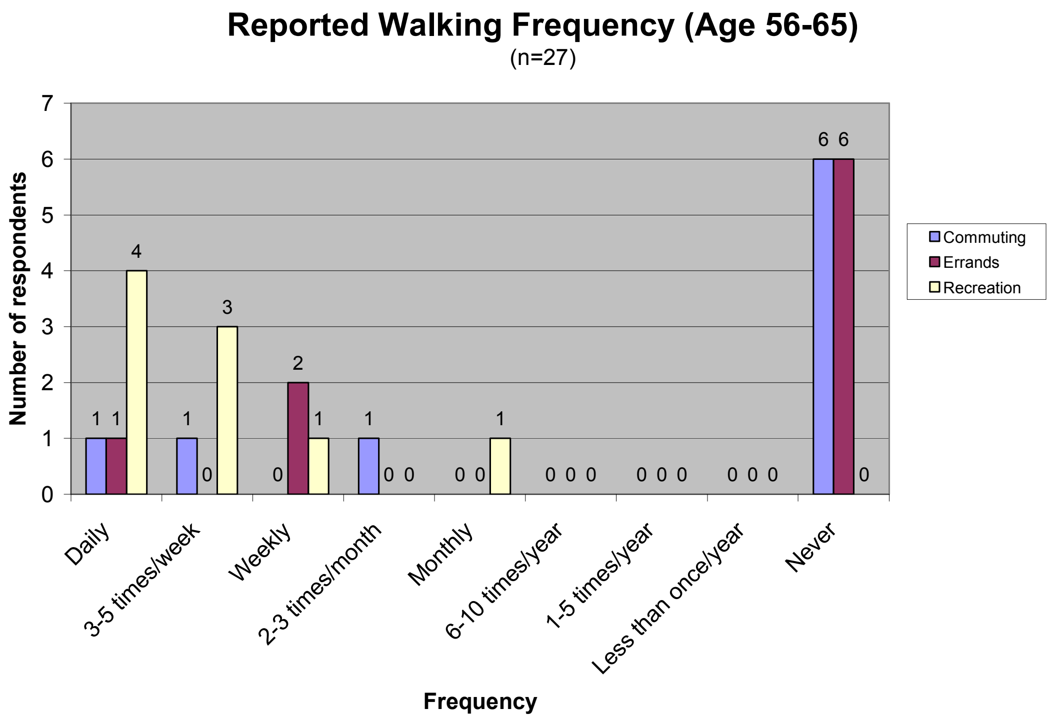

FIGURE 4-41 Frequency of walking, 56-65 years old

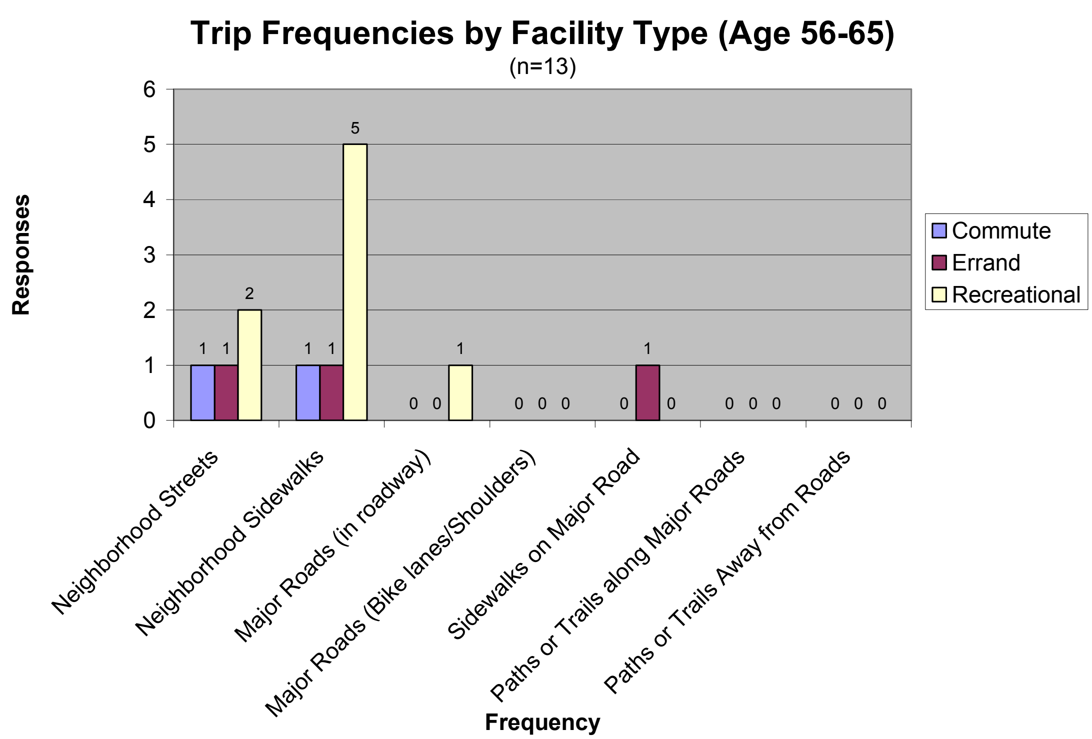

FIGURE 4-42 Frequency of walking by facility type, 56-65 years old

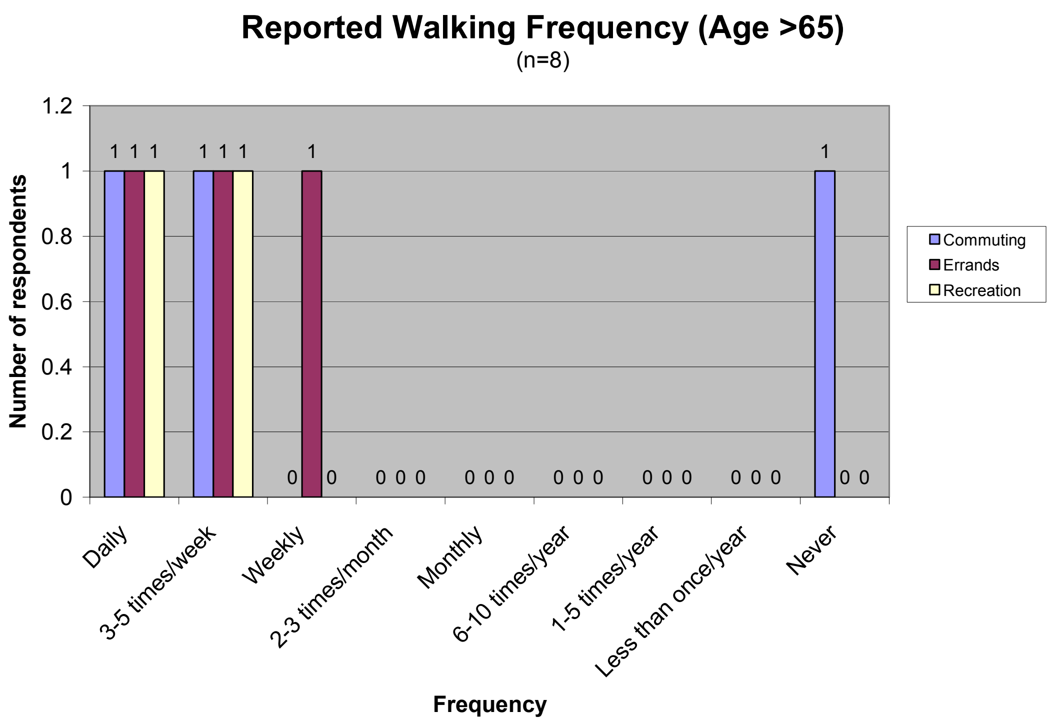

FIGURE 4-43 Frequency of walking, more than 65 years old

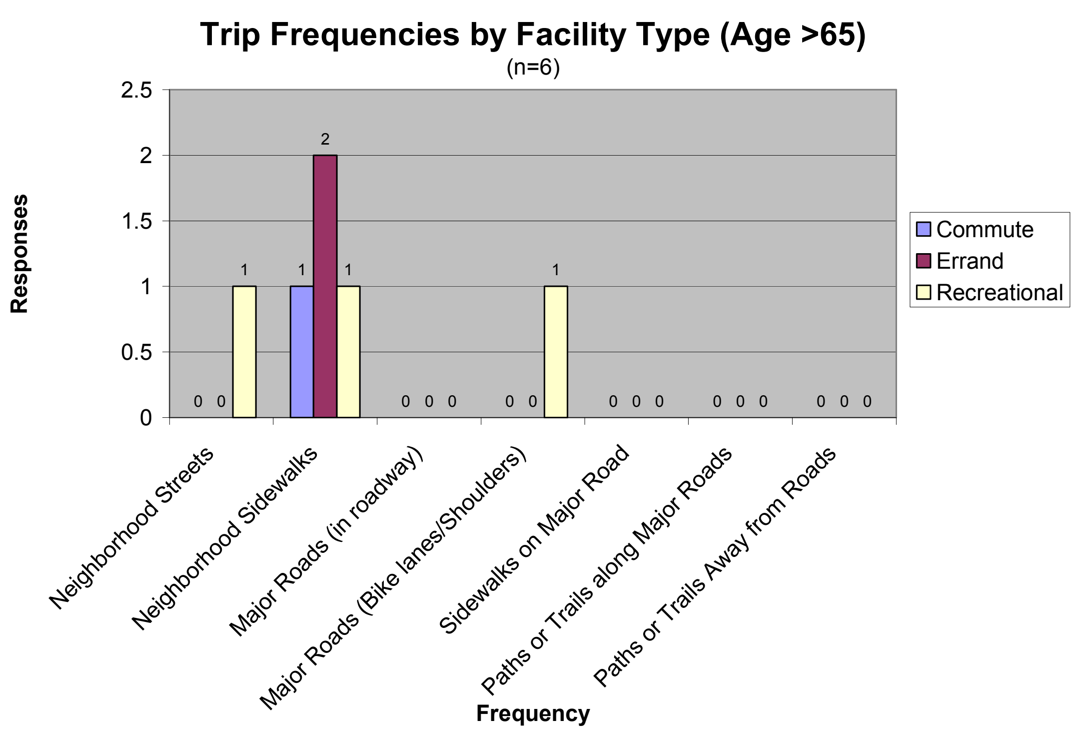

FIGURE 4-44 Frequency of walking by facility type, more than 65 years old

Analysis

Two tests were run to compare participants' current walking habits with their corresponding habits for each age group. The first test was to determine if current walking frequencies were greater for those who reported having greater walking frequencies in each age category. A two-tailed t-test was performed. The mean of the calculated yearly walking frequencies was determined, as was the standard deviation. Then, those participants whose reported walking frequencies exceeded one standard deviation above the mean were identified. Their current reported walking frequencies were compared to the balance of the participants' reported walking frequencies. The correlations for significance at the 95 and 90 percent levels are summarized in Table 4-9. An "S" depicts significance whereas a "NS" depicts non-significance. A finding of significance suggests there is a correlation between frequent walking in each corresponding age group and frequent walking later in life.[24]

TABLE 4-9 Correlation of current (last 2 years) walking with previous walking

Age Group	T-test	95%	90%	no subsequent walking in the last 2 years (n)	subsequent walking in the last 2 years (n)
Pre-teen	0.920	NS	NS	76	14
13-17	0.080	NS	S	66	15
18-25	0.000	S	S	55	19
26-35	0.165	NS	NS	40	13
36-45	0.129	NS	NS	28	8
46-55	0.427	NS	NS	16	8
56-65	0.947	NS	NS	9	7
Over 65	0.727	NS	NS	3	3

Another test was performed to determine if those in each age group having sidewalks and paths reported higher current walking frequencies. Participants reporting having sidewalks and paths in

[24] Statistical tests do not "prove" or "disprove" a correlation. The findings of "significance" at the 90 percent level means that we can be 90 percent sure that there is a real correlation between frequent walking as a pre-teen and frequent walking as an adult. However, we cannot be 95 percent sure, because results at the 95 percent level were not found to be significant.

each age group were identified. Their current walking frequencies were then compared to the balance of the participants. Results are shown in Table 4-10.

TABLE 4-10 Correlation of current (last 2 years) walking on sidewalks or paths with previous walking

Age Group	T-test	95%	90%	no subsequent walking in the last 2 years (n)	subsequent walking in the last 2 years (n)
Pre-teen	0.704	NS	NS	76	44
13-17	0.846	NS	NS	66	39
18-25	0.489	NS	NS	55	43
26-35	0.068	NS	S	40	28
36-45	0.390	NS	NS	28	19
46-55	0.427	NS	NS	16	10
56-65	0.262	NS	NS	9	7
Over 65	0.517	NS	NS	3	2

Reasons for Walking Regularly

The participants were asked for their reasons of walking and were allowed to give up to three responses. The responses for each age group are summarized in Table 4-11.

TABLE 4-11 Reasons given for walking regularly

Reason for walking regularly	Number of responses Age <13	Number of responses Ages 13-17	Number of responses Ages 18-25	Number of responses Ages 26-35	Number of responses Ages 36-45	Number of responses Ages 46-55	Number of responses Ages 56-65	Number of responses Ages >65
	(n=100*)	(n=59*)	(n=54*)	(n=29*)	(n=26*)	(n=11*)	(n=11*)	(n=3*)
Close to destina-tions	4	1	1	3	-	-	-	-
Commute	3	1	2	2	1	1	-	-
Conven-ience	17	7	6	2	3	1	1	-
Couldn't drive	2	-	-	-	-	-	-	-
Dog to walk	1	-	-	-	1	2	1	1
Don't like driving	-	1	-	-	-	-	-	-
Errands	9	1	4	1	1	1	1	-
Exercise	3	1	4	3	8	1	3	-
Family activity	5	1	2	5	3	-	1	-
Good trails system	-	-	1	2	-	-	-	-
Hate cars	-	-	1	1	-	-	-	-
Live in city	1	-	-	1	-	-	-	-
Neighbor-hood walking buddies	-	-	-	-	1	-	-	1
No car	15	15	10	-	-	-	-	-
No need for a car	-	-	2	1	-	-	-	-
Other work	4	3	2	2	-	-	-	-
Prefer walking	1	1	1	-	-	-	-	-
Recrea-tion	9	5	4	3	6	2	4	-
School	14	14	9	-	-	1	-	-
Sidewalks	1	1	2	2	2	2	-	-
Social	10	6	2	1	-	-	-	-
Transpor-tation	1	1	-	-	-	-	-	-
Spouse	-	-	1	-	-	-	-	1

*participants were allowed to provide up to three responses

Reasons for Not Walking Regularly

The participants were asked their reasons for not walking and were allowed to give up to three responses. The responses for each age group are summarized in Table 4-12.

TABLE 4-12 Reasons given for not walking regularly

Reason for not walking regularly	Number of responses Age <13	Number of responses Ages 13-17	Number of responses Ages 18-25	Number of responses Ages 26-35	Number of responses Ages 36-45	Number of responses Ages 46-55	Number of responses Ages 56-65	Number of responses Ages >65
	(n=6*)	(n=11*)	(n=14*)	(n=11*)	(n=4*)	(n=5*)	(n=1*)	(n=0*)
Walking scary	1	-	-	-	-	-	-	-
Buses scary	1	-	-	-	-	-	-	-
Family	-	-	1	1	-	-	-	-
Lack of facilities	1	-	-	-	1	-	1	-
Lazy	2	1	-	1	-	-	-	-
Owned car	-	2	6	2	1	-	-	-
Too far for errands	1	5	-	1	1	2	-	-
Work	-	3	7	6	1	3	-	-

*participants were allowed to provide up to three responses

Review of Walking Survey Results

As with the bicycle mode, the analyses described above, when considered collectively, suggest that walking during a particular stage of life does not lead to a greater likelihood of walking later in life. This is not to say that exercise and healthy lifestyles as a whole do not lead to a continuation throughout life, but rather that the activity of walking itself is not significantly (statistically) tied to walking habits developed at earlier ages.

Recreational Bicycling/Walking Leading to Long Term Utilitarian Bicycling/Walking

A separate goal of this task is to determine whether bicycling/walking recreationally leads to people making utilitarian bike/walk trips. For each age range for which respondents provided data (beginning with “under 13”), each respondent who indicated that he or she bicycled/walked regularly (at least once a week) for recreational purposes was examined. Specifically, the subsequent utilitarian travel behavior (age 13-18, 19-25, etc.) was reviewed for those who bicycled/walked regularly during their pre-teen years. Among utilitarian trips, commuting trips and errand trips were analyzed separately. In addition, separate analyses were conducted for respondents who indicated that they rode for recreational purposes at least once a week, at least three times per week, and daily.

A series of t-tests was carried out for each of these time-based interactions to determine statistical significance. This approach allowed the researchers to verify if there are long-term carryover effects of bicycling at different stages of life. Matrices of the results for each mode are shown in Table 4-13 and Table 4-14.

To interpret the matrices, consider the upper right box in Table 4-13A. Table 4-13A represents correlations of recreational bicycling to utilitarian bicycling for those individuals who reported riding recreationally at least once a week when they were within a given age group. The upper right box of Table 4-13A represents the age group of 19 to 25 years old. Those individuals who reported bicycling for recreational purposes at least once per week during the period when they were 19 to 25 years old were correlated (at the 90% confidence level) with those who report higher levels of commute bicycling trips over the last two years. Those individuals who reported bicycling for recreational purposes at least once per week during the period when they were 19 to 25 years old were correlated (at the 95% confidence level) with those who report higher levels of errand bicycling trips over the last two years. Interestingly, these individuals did not also report increased bicycling levels for recreational purposes over the last two years (at least not to the 90% confidence level). The next two rows within the upper right box, representing age groups up to and including 18 years old, are not included in this analysis because backward (temporally) correlations would be meaningless. The next row represents bicycling activities reported for the age group of 19 to 25 years old. Recreational bicycling at this age was significantly correlated (at the 95% level of confidence) with higher levels of commute and errand bicycling trips. The next row shows that those who bicycled at least once per week in the age group of 19 to 25 had increased frequencies of bicycling for all purposes when they were in the 26 to 35 age group. No correlations were found (at least not to the 90% confidence level) for increased recreational bicycling trips for the 19 to 25 age group to the 36 to 45 age group. Reported commute bicycling trip frequencies for individuals 46 to 55 were found to be significantly higher for those who bicycled at least once per week for recreational purposes when they were in the 19 to 25 age period.

Table 4-13A evaluates correlations with bicycling frequencies of at least once per week. Table 4-13B evaluates correlations with bicycling frequencies of at least three times per week. Table 4-13C evaluates correlations with bicycling daily.

The tables on the subsequent page (4-14A, 4-14B, and 4-14C) are in the same format but relate to walking habits.

TABLE 4-13 Correlations of bicycle riding habits over time

Reported biking for New Rec Purposes at least once per week
Correlations of Recreational Riding with Subsequent Riding
Recreational riding at age

	<13 years old			13 - 18 years old			19 - 25 years old		
	Commute	Errand	Recreation	Commute	Errand	Recreation	Commute	Errand	Recreation
Last Two Years	NS	NS	NS	NS	NS	NS	NS*	S	NS
< 13 years old	NS	NS*	--	--	--	--	--	--	--
13 - 18 years old	NS	NS	S	NS	NS*	--	--	--	--
19 - 25 years old	NS	NS	NS	NS	NS*	S	S	S	--
26 - 35 years old	NS	NS	NS	NS*	NS	NS	S	S	S
36 - 45 years old	NS	NS	NS	NS	NS	NS	NS	NS	NS
46 - 55 years old	x	x	x	NS	NS	NS	S	NS	NS
56 - 65 years old	x	x	x	NS	S	NS	x	x	x
> 65 years old	x	x	x	x	x	x	x	x	x
	26 - 35 years old			**36 - 45 years old**			**46 - 55 years old**		
	Commute	Errand	Recreation	Commute	Errand	Recreation	Commute	Errand	Recreation
Last Two Years	NS*	NS	NS	NS	NS	NS	NS	NS	NS
< 13 years old	--	--	--	--	--	--	--	--	--
13 - 18 years old	--	--	--	--	--	-	--	--	-
19 - 25 years old	--	--	--	--	--	--	--	--	-
26 - 35 years old	S	S	--	--	--	--	--	--	-
36 - 45 years old	S	S	S	S	S	--	--	--	-
46 - 55 years old	NS	S	NS	NS	NS	NS	--	--	-
56 - 65 years old	x	x	x	x	NS	NS	x	NS	S
> 65 years old	x	x	x	x	x	x	x	x	x

TABLE 4-13A

Reported biking for New Rec Purposes at least three times a week

	<13 years old			13 - 18 years old			19 - 25 years old		
	Commute	Errand	Recreation	Commute	Errand	Recreation	Commute	Errand	Recreation
Last Two Years	NS	NS	NS	NS	NS	NS	NS	NS	NS
< 13 years old	NS	NS	--	--	--	--	--	--	--
13 - 18 years old	NS	NS	NS	S	S	--	--	--	--
19 - 25 years old	NS	NS	NS	NS	NS	NS	S	S	--
26 - 35 years old	NS	NS	NS	NS	S	S	S	S	S
36 - 45 years old	NS	NS	NS	NS	NS	NS	NS	NS	NS
46 - 55 years old	x	x	x	NS	NS	NS	x	x	x
56 - 65 years old	x	x	x	NS	NS*	NS	x	x	x
> 65 years old	x	x	x	x	x	x	x	x	x
	26 - 35 years old			**36 - 45 years old**			**46 - 55 years old**		
	Commute	Errand	Recreation	Commute	Errand	Recreation	Commute	Errand	Recreation
Last Two Years	NS	NS	NS	NS	NS	NS	NS	NS	NS
< 13 years old	--	--	--	--	--	--	--	--	--
13 - 18 years old	--	--	--	--	--	-	--	--	-
19 - 25 years old	--	--	--	--	--	--	--	--	-
26 - 35 years old	S	S	--	--	--	--	--	--	-
36 - 45 years old	S	S	S	NS*	S	--	--	--	-
46 - 55 years old	NS	S	NS	NS	NS	NS	S	NS	-
56 - 65 years old	x	x	x	x	NS	NS	x	x	x
> 65 years old	x	x	x	x	x	x	x	x	x

TABLE 4-13B

Reported biking for New Rec Purposes daily

	<13 years old			13 - 18 years old			19 - 25 years old		
	Commute	Errand	Recreation	Commute	Errand	Recreation	Commute	Errand	Recreation
Last Two Years	NS	NS	NS*	NS	NS	NS	NS	NS	NS
< 13 years old	NS	S	--	--	--	--	--	--	--
13 - 18 years old	NS	NS	NS	S	S	--	--	--	--
19 - 25 years old	NS	NS	NS*	NS	NS	NS	S	S	--
26 - 35 years old	NS	NS	NS	S	S	NS	S	NS*	NS
36 - 45 years old	NS	NS	NS	NS	NS	S	NS	NS	NS
46 - 55 years old	NS	NS	NS	NS	NS	NS	x	x	x
56 - 65 years old	NS	NS*	NS	NS	NS*	NS	x	x	x
> 65 years old	x	x	x	x	x	x	x	x	x
	26 - 35 years old			**36 - 45 years old**			**46 - 55 years old**		
	Commute	Errand	Recreation	Commute	Errand	Recreation	Commute	Errand	Recreation
Last Two Years	NS	NS	NS	NS	NS	NS	x	x	x
< 13 years old	--	--	--	--	--	--	--	--	--
13 - 18 years old	--	--	--	--	--	-	--	--	-
19 - 25 years old	--	--	--	--	--	--	--	--	--
26 - 35 years old	S	NS*	--	--	--	--	--	--	--
36 - 45 years old	S	S	S	S	S	--	--	--	--
46 - 55 years old	x	x	x	x	x	x	x	x	--
56 - 65 years old	x	x	x	x	x	x	x	x	x
> 65 years old	x	x	x	x	x	x	x	x	x

TABLE 4-13C

S - Significant at the 95% level
NS - Not Significant at the 95% level
* - Significant at the 90% level
x - Insufficient volume of data to calculate

TABLE 4-14 Correlations of walking habits over time

TABLE 4-14A

Reported walking for New Rec Purposes at least once per week
Correlations of Recreational Walking with Subsequent Walking
Recreational riding at age

	<13 years old			13 - 17 years old			18 - 25 years old		
	Commute	Errand	Recreation	Commute	Errand	Recreation	Commute	Errand	Recreation
Last Two Years	NS	NS	NS	NS	NS	NS	S	NS	NS*
< 13 years old	NS	NS*	--	--	--	--	--	--	--
13 - 17 years old	NS*	S	S	S	S	--	--	--	--
18 - 25 years old	NS	NS	NS	NS	NS	NS	S	S	--
26 -35 years old	NS	S	NS	NS	NS	NS	NS	NS	NS
36 - 45 years old	NS	S	NS	NS	S	NS	S	S	NS
46 - 55 years old	NS	NS*	NS	NS*	S	NS	S	NS	NS
56 - 65 years old	x	x	x	x	x	x	NS	NS	NS
> 65 years old	x	x	x	x	x	x	x	x	x
	26 -35 years old			36 - 45 years old			46 - 55 years old		
	Commute	Errand	Recreation	Commute	Errand	Recreation	Commute	Errand	Recreation
Last Two Years	NS	NS	NS	NS	NS	NS	NS	NS	NS
< 13 years old	--	--	--	--	--	--	--	--	--
36 - 45 years old	--	--	--	--	--	--	--	--	--
46 - 55 years old	--	--	--	--	--	--	--	--	--
0	S	NS	--	--	--	--	--	--	--
0	S	S	NS	NS	NS	--	--	--	--
46 - 55 years old	NS	S	NS	NS	NS	S	NS	NS	--
56 - 65 years old	NS	NS	NS	NS	NS	NS	NS	NS	NS
> 65 years old	x	x	x	x	x	x	x	x	x

TABLE 4-14B

Reported walking for New Rec Purposes at least three times a week

	<13 years old			13 - 17 years old			18 - 25 years old		
	Commute	Errand	Recreation	Commute	Errand	Recreation	Commute	Errand	Recreation
Last Two Years	NS	NS	NS	NS	NS	NS	S	NS	NS
< 13 years old	NS	NS	--	--	--	--	--	--	--
13 - 17 years old	NS	NS	S	NS	NS*	--	--	--	--
18 - 25 years old	NS	NS	NS	NS	NS	NS	S	S	--
26 -35 years old	NS	NS	NS	NS	NS	NS	NS*	NS	NS
36 - 45 years old	NS	NS	NS	NS	NS	S	S	S	NS
46 - 55 years old	NS	NS	NS	NS*	S	NS	S	S	NS
56 - 65 years old	NS	NS	NS	NS	NS	NS	S	NS	NS
> 65 years old	x	x	x	x	x	x	x	x	x
	26 -35 years old			36 - 45 years old			46 - 55 years old		
	Commute	Errand	Recreation	Commute	Errand	Recreation	Commute	Errand	Recreation
Last Two Years	NS	NS	NS	NS*	S	NS	NS	NS	NS
< 13 years old	--	--	--	--	--	--	--	--	--
13 - 17 years old	--	--	--	--	--	--	--	--	--
18 - 25 years old	--	--	--	--	--	--	--	--	--
26 -35 years old	NS	NS	--	--	--	--	--	--	--
36 - 45 years old	NS*	NS	NS	NS	NS	--	--	--	--
46 - 55 years old	NS	S	NS	NS	NS	NS*	NS	NS	--
56 - 65 years old	NS	NS	NS	NS	NS	NS	NS	NS	NS
> 65 years old	x	x	x	x	x	x	x	x	x

TABLE 4-14C

Reported walking for New Rec Purposes daily

	<13 years old			13 - 17 years old			18 - 25 years old		
	Commute	Errand	Recreation	Commute	Errand	Recreation	Commute	Errand	Recreation
Last Two Years	NS	NS	NS	S	NS	NS	NS	NS	NS
< 13 years old	S	NS	--	--	--	--	--	--	--
13 - 17 years old	S	S	S	S	S	--	--	--	--
18 - 25 years old	NS	NS	NS	NS	NS	NS*	S	S	--
26 -35 years old	NS	NS	NS	NS	NS	NS	NS	NS	NS
36 - 45 years old	NS*	NS	S	S	S	S	S	S	NS
46 - 55 years old	NS	NS	NS	S	NS*	NS	S	NS*	NS
56 - 65 years old	NS	NS	NS	NS	NS	NS	NS	NS	NS
> 65 years old	x	x	x	x	x	x	x	x	x
	26 -35 years old			36 - 45 years old			46 - 55 years old		
	Commute	Errand	Recreation	Commute	Errand	Recreation	Commute	Errand	Recreation
Last Two Years	NS	NS	NS	NS	NS	NS	NS	NS	NS
< 13 years old	--	--	--	--	--	--	--	--	--
13 - 17 years old	--	--	--	--	--	--	--	--	--
18 - 25 years old	--	--	--	--	--	--	--	--	--
26 -35 years old	NS	NS	--	--	--	--	--	--	--
36 - 45 years old	NS	NS	NS	NS	NS	--	--	--	--
46 - 55 years old	NS	NS*	S	NS	NS	S	NS	NS	--
56 - 65 years old	NS	NS	NS	NS	NS	NS	NS	NS	NS*
> 65 years old	x	x	x	x	x	x	x	x	x

S - Significant at the 95% level
NS - Not Significant at the 95% level
* - Significant at the 90% level
x - Insufficient volume of data to calculate

Discussion and Conclusions

Bicycling

The majority of the individual tests indicate that *sustained* increases in utilitarian bicycling as a result of earlier recreational bicycling are not statistically significant. However, instances of significant increases can be found throughout the data and there appears to be a trend toward recreational bicycling and utilitarian bicycling being coincident. This may indicate that as people take up recreational riding they also begin to ride for utilitarian purposes.

Walking

Interestingly, the results for recreational walking suggest that recreational walking may be linked to more frequent use of walking for commuting or running errands. This appears to be the case even when previous recreational walking is not significantly correlated with current recreational walking.

General Data Comments

There is still a wealth of information that may be distilled from the data collected through the intercept surveys. Much of this is likely to be related to why people do or do not participate in bicycling or walking. While beyond the scope of this task, this data will be reviewed and any further observations passed onto FDOT and other interested agencies.

CHAPTER 5 EFFECTS OF INCENTIVES FOR AUTOMOBILE AND BICYCLE USE ON BICYCLING

Summary

This review was undertaken to identify research results relating changes in financial incentives for cycling or driving to changes in the amount of bicycling, so that these results could be synthesized into a set of recommendations for practices to promote bicycle use. Unfortunately, very little research has been done to measure the effects of changes in financial incentives on bicycle use. The review summarizes this literature, plus literature on how the provision of bicycling infrastructure, which is itself a form of nonfinancial incentive, affects cycling. In addition, the review considers ways in which incentives that promote driving also create conditions that act as disincentives to bicycle use.

The review draws several conclusions, the most important of which are:

1. Connectivity of the infrastructure for bicycling is important. Building a path for cycling is unlikely to have much effect on the amount of cycling unless it connects would-be cyclists with where they want to go, or unless it connects them with an existing network that enables them to reach where they want to go.

2. The bicycling market consists of different market segments. Most notably, there is a relatively small proportion of the general population that is willing to use cycling infrastructure on streets that have high volumes of motor-vehicle traffic. And there is a relatively large proportion that is interested in cycling, but is unwilling to ride on facilities with high volumes of fast motor-vehicle traffic. The latter segment is looking for different kinds of cycling facilities (separation from traffic, quiet residential streets) than the former. In some places, such as Portland, Oregon, planning and provision of cycling facilities has focused on the former (Mapes, 2009, p.166; City of Portland 2007). Development of financial incentives, and of nonmonetary incentives such as cycling infrastructure and route planning services for cyclists, needs to consider the different needs of these different market segments if it is to attract would-be cyclists from the larger segment. For example, a strategy to encourage short bicycle trips within neighborhoods, out to bus routes on arterial streets, with a transfer from bicycle to bus for

the remainder of the trip, might lead to more cycling among the larger segment, even though a traveler might cover more of the distance by bus than by bike. Whether such a strategy would yield a larger increase in cycling than one focused on improving bicycling facilities along arterial streets, or whether it would be more cost-effective, are questions for further research.

Introduction

The objective of this review was to determine the effects that incentives for automobile use, and disincentives for bicycle use, have on bicycle use, with a goal of synthesizing the results of the review to develop a quantitative model of these effects. So, for example, if one were to start charging for automobile parking, what effect would this have on the use of bicycles? Many factors complicate the ability to answer this question, but two stand out.

- One is the need to account for existing cycling infrastructure. For example, if one reduces an incentive for automobile use in an area with good cycling infrastructure, the effects on cycling are likely to be greater than if the same action is taken in an area where cycling is difficult, inconvenient, or unsafe.

- The second is the extent to which incentives for automobile use are accompanied by other kinds of incentives that, while directed at other goals, reinforce the effects of incentives for automobile use. For example, if federal tax policy reduces the cost of developing suburban housing, and makes more-distant housing attractive, this would in turn increase the amount of driving, even in the absence of other policies that tend to subsidize automobile use. Sorting this out is beyond the scope of the resources available for this review, and the review ignores this problem of whether an incentive that has the effect of encouraging automobile use was adopted for that purpose, or whether it is a side effect of some other purpose.

Disappointingly little literature specifically addresses the question “What effects do financial incentives for automobile use have on bicycle use?” There are somewhat more, but still limited, analyses that address the question “What effects do financial incentives for bicycle use have on bicycle use?” A later section of this chapter (on public attitude and image of cycling) touches on a likely reason that so little work has been done on these questions. In response to the lack of research on these questions, an approach was developed to back out useful information from other studies, essentially to look at indirect and non-financial incentives and their effects on cycling. Most of this review thus focuses on non-financial incentives. But there is still too little quantitative information in the literature to support development of a model to predict how a change in incentives for driving or bicycling will affect cycling. A review of largely European efforts to promote walking and cycling found slightly more quantitative information, but the authors of that review expressed similar frustration (Ogilvie et al, 2004).

Direct Effects of Incentives for Automobile Use on Bicycle Use

The three most obvious incentives for automobile use are the provision of parking at a price (usually zero) below the cost of providing it; the use of property tax, sales tax, or other general revenue, in addition to revenues collected just from motor vehicle users, to provide infrastructure and services (such as traffic law enforcement) for automobiles and driving; and allowing the use of infrastructure at prices (again, usually zero) below the cost of using it. All of these tend to increase the use of automobiles relative to other modes, such as cycling.[25]

Parking

Shoup (1997) examined eight employers in the Los Angeles, California area who implemented varying forms of parking cash-out, in which employees were offered a commuting payment equal to any parking subsidy they received. For the eight firms, the percentage of commute trips made by driving alone dropped from 73% to 66%; the percentage made by carpooling increased from 14% to 23%; the percentage by transit increased from 6% to 9%; the percentage by walking, from 2% to 3%; and by bicycling, from 0.8% to 0.9%. The results are less clear than desired, because many of the employers also implemented, increased, or maintained existing incentives for the use of alternative modes at the same time they offered employees the parking

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[25] Bicycle use also receives subsidies, in that bicyclists also do not pay for parking or the use of most infrastructure, and in that they use roads and services paid for in part by people who neither drive nor bicycle. However, the cost of providing bicycle parking is lower per bike the per-car cost of providing parking for cars. Also, most cyclists in the U.S. also drive cars and pay for at least some of their road use through their car use. The review did not identify any studies attempting to sort this out.

cash-out. This appears to be the definitive study on this topic. It is widely cited and does not seem to have been repeated in other settings or extended by other researchers.

Other studies have modeled (rather than measured) the effects of charging for parking but, to keep the modeling manageable, have focused only on driving alone, carpooling, and transit. For example, Hess (2001) analyzed detailed travel diary data for people working in downtown Portland, Oregon, and estimated that charging $6 for employee parking there would reduce the drive-alone rate from 62% to 46%, reduce the percent of carpool trips from 16% to 4%, and increase transit's share from 22% to 50%, for employees who now pay nothing for parking. Given the well-developed cycling infrastructure in Portland, it is likely that some of the trips estimated to shift to transit would actually shift to cycling. The model is based on real differences in mode use between employees who work at sites with free parking and those who work at sites without, but the research does not actually report those differences.

Other Subsidies

Estimates of subsidies for automobile use vary widely, depending on what is considered to be a subsidy. DeLucchi and Murphy (2008) distinguish between a broad definition and a narrower one. Their broad definition includes

> anything that favors a particular industry, or that causes an industry's prices to fall below an efficient, "fair" or full-cost price. These price distortions can be the result of government policies and programs *(such as outlays for infrastructure or services), preferential tax treatment*, government-funded research and development, regulatory policies, military expenditures to defend oil interests, the presence of externalities (such as pollution, climate change, or highway congestion), or other market imperfections and government intervention. [italics added]

Their narrow definition considers only direct cash assistance beyond direct payments by users, and preferential tax treatment; in other words, the items listed in italics above. DeLucchi and Murphy acknowledge that that practices included in the broader definition do affect prices and create an advantage for driving, but that economists do not consider them to be "subsidies." They also note that reports which use the broader definition of subsidies tend to be published by government agencies and advocacy groups, rather than in scholarly literature.

DeLucchi (2007), applying the narrow definition to national data, has estimated that automobile use receives an average subsidy equivalent to between $0.20 and $0.70 per gallon of gasoline. The range reflects different assumptions about what to count as a subsidy, even within the narrow definition. DeLucchi notes that broadening the definition to include climate change, disruptions of oil supplies, and the cost of preparing for or insuring against such disruptions and their effects, these would increase the amount of the subsidy even further, by on the order of $1.00 per gallon. He notes that even the smaller of these amounts is large enough to affect vehicle use. Hanson (1992) used state and local data, and a different range of revenue and expenditure categories, to estimate subsidies for automobiles in Madison, Wisconsin. He reported a total subsidy of $1.27 per gallon for 1983, in 1987 dollars ($2.32 per gallon in 2007 dollars).

DeLucchi (2004) has also estimated the full social cost of motor vehicle use in the U.S. Much of this cost is paid by the users, but some is not. For example, his estimated costs for just the externalities, (congestion delay imposed on others, environmental impacts), which are not paid by users, range from $111.1 billion to $833.8 billion in 1991 dollars. In 2009 dollars, the approximate range of the externality costs would be between $1.60 and $12.02 per gallon.[26] These values would be in addition to the subsidies he estimated in later work using the narrow definition.

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[26] Externality costs from Tables 1-8 and 1-9 in DeLucchi, (2004), divided by 2.250 trillion VMT in 1992 from http://www.fhwa.dot.gov/ohim/tvtw/archive/arch92r.htm, an online data series from the Federal Highway Administration that begins in 1992, multiplied by 20.4 miles per gallon from Federal Highway Administration's 2007 Highway Statistics (the most recent year available) at http://www.fhwa.dot.gov/policyinformation/statistics/2007/vm1.cfm, multiplied by 1.59 to convert from 1991 to 2009 dollars (http://www.bls.gov/data/inflation_calculator.htm). Note that changes in conditions since 1991, such as more stringent vehicle tailpipe emission standards, and improved understanding of the risks of climate change and the health effects of lower exposure to air pollutants such as ozone, would change DeLucchi's results and the calculations based on them here. Without redoing his analysis, it is not possible to say whether the resulting costs would be higher or lower.

Because the estimates from the narrow definition of subsidies are within the range of the increase in gasoline prices that occurred in 2008, it is reasonable to examine responses to that increase as a guide to what eliminating the subsidy would do. Available data document a reduction of 3-5% in vehicle-miles traveled in 2008 relative to 2007 (Federal Highway Administration, 2008), and increases in transit use during the same period (American Public Transportation Association, 2008). Abundant anecdotal information describes various responses to the higher gasoline prices, and several organizations have surveyed their members and documented changes that are consistent with a shift from driving to other modes. These include the large increases in public transit ridership reported by the American Public Transportation Association (2008), and increases in bicycle sales reported by a survey of bicycle shop owners and managers (Bikes Belong, 2008). However, it is too early yet to have solid, quantifiable information on how people have responded - how much of the reduction in vehicle miles traveled (VMT) was the result of foregoing trips entirely; how much was the result of more efficient planning and chaining of trips, changing to closer destinations, and similar strategies; how much was from shifting to other modes; and how much of any overall mode shift went to which alternative modes, such as transit, cycling or walking. The brief duration of the increase in gasoline prices reduces the chance that we will have much solid analysis of how people responded to it.

There is, in addition, a subsidy of local government expenditures from federal programs. Persky and Kurban (2003) note that federal programs for building highway, transit, and other infrastructure (including bicycling, although they do not mention it) have the effect of subsidizing local governments, implying that some of these expenditures would not occur if they had to be paid for entirely from local resources, even if the federal expenditures are derived from infrastructure users. This kind of subsidy leads to more investment in infrastructure for automobiles and transit than would have occurred if it had to be paid for directly from local taxes. (Following the passage of ISTEA and TEA-21 legislation in the 1990s, this has also become true of infrastructure for cycling and walking.) The net effect, over decades, has been that the overinvestment has been greater for automobile and transit infrastructure than for cycling and walking. State programs that fund infrastructure at local levels have similar effects.

Rajamani et al (2003) analyzed non-work trips reported in an activity survey from Portland, Oregon, and were able to estimate cross-elasticities between costs of driving and cycling of (0.0151); of shared ride and cycling (0.0080); and of transit and cycling (0.0022). The study treated the cost of cycling and walking as zero to the user, and thus did not report self-elasticities for cycling costs. They also reported a very high self-elasticity of travel time for cycling (-0.3396), although less than half the values of the elasticities for transit and walking, and a high elasticity between cycling and a measure of accessibility. It is important to note that the survey respondents did not report travel cost, travel time, and accessibility measures; the researchers calculated these measures from data provided by the Portland Metropolitan Planning Organization (MPO). Thus, the elasticities are indicative rather than actual.

Pucher and Buehler (2006) attribute an unspecified portion of the difference in levels of cycling between the United States and Canada to an estimated 27% higher cost of car ownership and use in Canada than in the U.S., and to the higher proportion these costs would be of average income (29.1% in Canada, vs. 18.6% in the U.S.). They also suggest that part of the difference arises from more limited and more expensive parking available for cars in Canada than in the U.S. In a subsequent analysis (Pucher and Buehler, 2008), they make similar arguments when comparing the low cycling rates in the U.S. and the United Kingdom relative to the Netherlands, Denmark, and Germany.

Road Use

Several recent studies have examined the effect that time-of-use pricing of roadways (also known as congestion pricing or value pricing) would have on the use of transportation.

> By undercharging vehicles for using the nation's roadways, policymakers have also reduced the per-mile cost of commuting (including out-of-pocket and travel time costs) for most motorists and distorted the development of metropolitan areas by inducing households to live in more distant, lower-density locations, thereby contributing to urban sprawl (Langer and Winston, 2008).

Langer and Winston estimate that proper pricing of roadways would raise roughly $180 billion annually, or about $0.17 per vehicle-mile traveled if applied equally to all 3 trillion VMT in the

U.S. (FHWA, 2008); this would be the equivalent of an additional $3.18 per gallon of gasoline. However, the charge would be much greater on peak-period commuting travel in urban areas, and much less - as little as zero - on other travel.

The context for most studies of roadway pricing in the U.S. has been in testing congestion pricing for one or more lanes of a limited-access highway, and bicycling would not be a reasonable alternative for most of these trips. Two other studies have simulated charging for travel in a broader context, and found that automobile use does decline. Jakobssn, Fujii and Gärling (2002) found that a uniform charge of approximately $0.20 per mile in Göteberg, Sweden had a greater effect on shopping trips and off-peak travel than travel during peak periods, but the effect may have been a result more of getting households to think about and plan their travel than of responding to pricing. The reductions were greater in the frequency of trips than in the distance traveled. The study does not report sufficient information to calculate a price elasticity for driving. Also, although the authors of the study discuss changes in driving, they do not discuss changes in the use of substitute modes, such as bicycling. The Puget Sound Travel Choices Study (PSRC, 2008) simulated congestion charging on all major freeways in the Seattle, Washington metropolitan area, and found an average reduction of 12% in vehicle-miles traveled. Again, the study reports changes in driving but not changes in the use of substitute modes. Both of these studies simulated congestion pricing by offering participants a sum of money, from which the researchers deduct amounts based on observed travel behavior, and allowing the participants to keep any balance left over at the end of the study. Motorists might perceive actual congestion pricing systems differently from the simulated ones and reduce their driving by amounts different from those in the simulations.

This literature review did not examine the effects of European projects to increase the cost of driving, such as London’s congestion charge or Oslo’s tolling system, to see whether they have measured effects on the use of alternative modes. The decision not to examine these projects reflects a belief by the researchers that the context of the European projects is too different from that in Florida to be relevant.

Direct Effects of Incentives for Bicycle Use on Bicycle Use

The most obvious incentives for bicycle use are the provision of a financial incentive for a bicycle (perhaps a discount on a good or service at the destination, a tax reduction of some sort for cycling expenses, or a direct payment by an employer based on the number of commute trips made by bicycle); provision of bicycle parking, storage, showers for cyclists, or similar amenities valued by cyclists; and infrastructure on which to cycle. All of these have been found to increase cycling, but again, there is little good data to answer the question "How much does cycling change if these incentives change?"

Direct Financial Incentives

Although some employers do offer financial incentives for employees who bicycle instead of drive to work, the review identified only one study that examined the effects of changing the incentive on cycling behavior. Roche, Kolodinsky and Aultman-Hall (2009) examined changes in an established gift-card incentive program in Burlington, Vermont. Prior to these changes, employees received $10 gift cards if they biked or walked at least two days a week for four weeks. The changes required employees to walk or bike at least three days a week for eight weeks to receive a $15 gift card, and they received nothing if they failed to meet the new threshold for the period. The researchers examined 53 weeks' worth of data for a panel of 160 commuters and found that the incentive had very little effect on the probability of walking/biking, or of meeting the threshold in any particular week, for those participating in the program. The authors suggest that people participating in the program were already committed to biking or walking and might well do so without the incentive. However, they did not examine commuting by employees who chose not to participate in the incentive program, or those who dropped out after the incentive changed, or the rate of enrollment in the program before and after the change in requirements.

In addition, it is possible that employers who provide incentives for bicycling do so in response to requests from employees who already cycle to work, perhaps to provide a degree of equitable treatment when they also offer financial incentives for carpooling or riding transit (Dill and Wardell, 1994). This is a parallel situation to studies of the correlation between bicycle facilities and bicycling (discussed later in this chapter), where the facilities could be built in response to political efforts by cyclists, rather than simply leading to an increase in cycling after they have been built. Data are available from the Washington State Commute Trip Reduction program, which could in principle be used to evaluate the effects of employee incentives on cycling, and clarify the relationship between payments and cycling mode share. However, analyzing the Washington data was beyond the scope of the present literature review.

Employer-based commuter-assistance or demand-management programs, such as the ones in Washington state and Florida, often ask employees to choose from a list of changes that would encourage them to use alternative modes. These lists sometimes include the provision of financial incentives, or the provision of bicycle parking, lockers, and showers, but they often fail to distinguish cycling from other modes, and they generally do not indicate a specific amount when asking whether employees would prefer or respond to a subsidy. Published results from these surveys do not often report separate tabulations for users and non-users of alternative modes. Changing these surveys, to make them more useful as a source of information about potential responses to incentives, would also make them longer and more complex. In the researchers' experience, such changes also would reduce the willingness of employers to administer this type of survey.

Wardman, Tight, and Page (2007) analyzed a stated-preference survey of non-cyclists in the United Kingdom, and found that a £2 daily payment for cycling to work would almost double the level of cycle commuting, whereas the unrealistic scenario of universal provision of cycling-only trails would increase the level only a quarter as much. Showers and indoor parking were predicted to increase cycling by only about 22%. The authors examined combining the incentive, workplace facilities, and improvements to enable half of bike travel to occur on roads with safe cycling facilities instead of roads without; they estimated that this would increase cycling threefold. Although their survey and analysis did not include reimbursement of costs of cycling to work, the authors imply in their conclusions that a direct payment such as they modeled probably would be more effective.

Cycling Facilities as Incentives

With this in mind, the primary incentive for bicycle use is the provision of infrastructure for cycling. Following the analysis of Persky and Kerban (2003) cited earlier, to the extent that these facilities receive funding from state or federal revenues, the local governments that provide these facilities receive some subsidy to provide them, which becomes an additional subsidy (incentive) to the persons who use them.

Dill and Wardell (1994) developed a model predicting mode share for walking and cycling (combined share) for employers participating in Portland, Oregon's ECO program, which requires large employers to reduce driving to their worksites. They found that employers who provide lockers, showers, and/or a financial incentive for bicycling, had a combined bicycling and walking share that was 1.9 percentage points higher than sites that provided none of these. Dill and Wardell did not report results for the financial incentive alone, and it is possible that it would not have been statistically significant. The authors note that the relationship is not necessarily causal, and that the employers might have provided the incentive or facilities in response to interest by people already cycling or walking to work. Street connectivity near the employer also was significant, although worksites within ¼ mile of the light rail system had lower rates of cycling and walking than did sites farther away; the authors were uncertain whether this was because employees who had the option to use light rail did so instead of cycling or walking, or whether it was because in some areas the light rail line itself is a barrier that cyclists and pedestrians can cross only at stations. The ECO program has collected additional data since Dill and Wardell completed their study, and these data probably could be used to examine changes in on-site facilities, incentives, and cycling and walking, over time. The University of South Florida Center for Urban Transportation Research (CUTR) is in the process of acquiring the ECO data for another project, but its analysis falls outside the scope of this literature review.

Several studies have examined relationships between the provision of infrastructure for cycling and the amount of cycling. Most of these have built statistical models to estimate relationships between these incentives and the amount of bicycling, using metropolitan areas as observations.

Dill and Carr (2003) reviewed several of these in preparation for developing a model of their own. Dill and Carr considered the previous evidence linking the availability of bicycling infrastructure and bicycle use to be "limited," and likely to be unduly influenced or weighted by small metropolitan areas that were university towns. Their own analysis showed that, for U.S. urban areas with populations of at least 250,000, each additional mile of Class II bike lane per square mile was associated with an increase of 1 percentage point in the share of workers commuting by bicycle. When they included Class I facilities as well as Class II, and smaller urban areas, the model they estimated did not predict as well, and it did not show as strong a relationship as the more limited model. Like other researchers, Dill and Carr caution that their approach is correlational, not causal. They note that increasing bicycle facilities is not necessarily a cause of increased cycling, and that investments in bicycle facilities may reflect active support by cyclists instead. But they conclude that additional bicycle facilities are likely to be used. The available data limited their analysis to commuting, and they note that the way the data on cycling's mode share were collected may systematically underestimate the amount of commuting by bicycle.

Cleaveland and Douma (2008) reviewed changes in commuting by bicycle in six cities where investments in cycling infrastructure had been made during the 1990s, including Orlando, Florida, and found that adding facilities was not always associated with an increase in bicycle commuting. Their analysis used sub-county data, with a geographic information system to overlay Census block groups with distance buffers around new bicycle facilities. The analysis found larger increases in bicycle commuting where new facilities were added along usable commuting routes, where the new facilities tied into an existing network of facilities, and where local interests had put greater effort into publicizing and promoting use of the facilities. Nelson and Allen (1997) and Birk and Geller (2006) also noted the importance of connectivity in the network of bicycling infrastructure, and of connecting appropriate origins and destinations in enabling utilitarian trips by bicycle[27]. Cleaveland and Douma note that facilities, such as those in

[27] The introduction to this review noted that little attention has been paid to the question of how the underlying network of bicycling facilities would affect any response to changes in incentives. As noted by Cleaveland and Douma, and by other work reviewed here, the effect of adding bicycle facilities depends to some extent on how the connectivity and usefulness of the network to which the new facilities are added. It is logical to expect that changes in financial incentives, aimed at reducing driving or increasing cycling, would have a greater effect on bicycle use if made in an area with extensive, good, well-connected cycling facilities than in an area with limited facilities that do

Orlando, which do not converge on a major commuting destination and therefore showed little increase in commuting around them, still have value for recreation. However, their reliance on Census data limited the analysis to commuting.

Barnes, Krizek, and Thompson (2005) performed a study similar to Cleaveland and Douma's, using Traffic Analysis Zones in the Minnesota Twin Cities. They reached similar conclusions, noting also that the facilities they considered were in areas that already had bicycle commute mode shares above the regional and national averages, that commuting by bicycle in the region declined between 1990 and 2000 except in the areas where new facilities were added, and that the increase in bicycle commuting near new facilities (1.7% to 2.0% between 1990 and 2000) was much less than the difference in 2000 between areas within 1 mile of the new facilities (or within 1.5 miles of their endpoints), where the bicycle commuting rate was 2.0% and those farther away, where it was only 0.2%.

Burbidge and Goulias (2009) used a tailored panel survey to measure the effect of a new one-mile trail on cycling activity among a sample of residents living within a mile of the trail before and after the trail was completed in early 2007 (eight months before, one month after, and five months after); in addition, Burbidge and Goulias surveyed all new residents who moved into the area after the trail was completed. They found that walking decreased while transit and bicycle mode shares remained nearly the same, and also that the new trail did not seem to have played a role in attracting the new residents to the neighborhood. A survey of trail users found that only 16% of them were cyclists, and that 87% of users had been walking, cycling, or running on neighborhood streets and sidewalks before the trail was completed, and had simply shifted some of their route to the trail for convenience. Although the authors mention convenience, they do not discuss whether safety was a consideration. 23% of users said the trail was too short, and 10% noted its lack of connectivity to other destinations. Other than to note that the bicyclists who used the trail lived an average of 1.75 miles from it, the authors did not report results separately for bicyclists. Other studies (e.g., Krizek and Johnson, 2006) have reported that people who live within .25 mile of on-street bicycle facilities are significantly more likely to ride than those

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not connect would-be riders with where they want to go. But the literature search turned up no research on this broader context for connectivity.

living farther away. These distance thresholds are for local utilitarian and recreational use. Betz, Bergstrom and Bowker (2003) found evidence that trails that target a tourist market can draw users from as far as 200 miles away. Krizek, El-Geneidy, and Thompson (2007) found that the distance threshold is sensitive to the length of the trip the cyclist expects to make on a trail. Cyclists were willing to travel farther in order to include the trail on their route when they expect to use the trail for longer distances than for shorter ones.

Several studies (e.g., Abraham et al., 2002; Tilahun, Levinson, and Krizek, 2007; Garrard, Rose, and Lo, 2007) have tried to estimate the relative preferences that cyclists have for different types of facilities, using stated preference or similar methodologies. These studies have found, for example, that cyclists tend to have strong preferences for off-street facilities (true of both men and women, but stronger for women), and are willing to incur extra travel time in order to use such facilities over more direct routes using on-street facilities. In principle, the results of these studies could be used to estimate a value of time and a willingness of cyclists to pay for improved facilities, and thus a value of the subsidy embedded in the facility. However, these studies have not done so, and their methodologies do not lend themselves to estimating the effect that additional bicycling facilities might have on the amount of cycling in an area (other than possible additional mileage by existing cyclists diverting their routes to use the new facilities).

Hunt and Abraham (2007) used a stated-preference survey to examine not just lanes, trails, and paths, but also lockers and showers, both for commuting and for social gathering. In common with the studies mentioned earlier, they found preferences for bike paths over bike lanes and for both over mixed traffic. However, Hunt and Abraham also found that the provision of secure parking at the destination had a large and significant effect on the attractiveness of cycling. The effect of parking was much greater than that of showers. Again, the stated-preference methodology of their approach did not lend itself to estimating the effect that additional facilities would have on the amount of cycling in an area. Stinson and Bhat (2004) analyzed a sample of cyclists and also found that bicycle racks and lockers were a more important influence on cycling than were shower facilities at work.

Bikes on/to Buses/Rail as Incentives

A number of studies have examined the effects of measures to integrate bicycles with transit, such as enabling bicyclists to take their bikes with them on the bus or train, or providing safe parking for bikes at transit stops so that cyclists can ride to where they board transit. These studies have tended to emphasize the effect of the practice on transit ridership rather than on bicycle use. For example, Schneider (2005) reviewed steps that transit agencies have been taking to facilitate use of their systems by bicyclists. Schneider summarized reports of increased use of bikes-on-buses over time. However, he did not report studies of the effect of offering these services on cycling behavior. Hagelin (2005) surveyed users of bikes-on-bus service in Florida, and found that three-quarters of those who had used transit previously used it more frequently after starting to use the bikes-on-bus service, and that roughly 20% of service users were new to transit and began using it because of the bikes-on-bus service. It seems likely that many of the joint bike-bus trips involved new use of bicycles for commute trips, but the survey did not ask for information about previous use of bicycles. Thus, it is not clear what share of bikes-on-bus users were riding bicycles previously; what share have substituted use of the bus for part of the distance previously made by bicycle; and what share began cycling for transportation as a result of being able to access the bus by cycling. Lasky (2005) surveyed users of bikes on light-rail in Portland, and found that they tended to be frequent riders for other purposes as well. He also found that the respondents who used bike-on-rail most frequently were the least likely to be doing so to avoid roads that lacked bicycle lanes, and that a subset of respondents did so to avoid hills on their rides. Lasky's survey did not ask about cycling use prior to beginning to cycle to the light-rail service, but these responses suggest that some of the users were cycling prior to introduction of the service.

The question of prior use is important in evaluating bike-bus strategies as incentives for bicycling (instead of just for riding transit).

Further complicating analysis of the effects of bike-bus strategies on commuting is the practice of standard data sources, such as the Census and many demand management or commuter assistance programs, to ask people to report their primary means of transportation for commuting. It is likely that many joint bike-bus trips would be reported as transit trips rather than as bike trips.

Indirect Effects of Incentives for Automobile Use on Bicycle Use

The approach in this section has been developed to examine how incentives for automobile use affect factors that have been identified as barriers to cycling. Some barriers, such as weather, are not affected by incentives for automobile use. However, others are. These include safety, public attitude and image, density and trip lengths, and the artificially low cost of high-speed, convenient car use.

Safety

Surveys of public willingness to cycle identify people's fear for their safety while cycling as a major barrier (e.g., Ozarks Transportation Organization, no date; Hillsborough County MPO, 2008; District of Columbia, 2005). High volumes of motor vehicles, high vehicle speeds, and aggressive driving have all been mentioned as contributing to a fear for safety that keeps many people from cycling along or across roadways with high volumes of motorized traffic. It should be noted that many of these surveys tend to be targeted toward persons interested in transportation or in cycling, and the general population may place different emphasis on safety. Incentives, subsidies, or failure to charge for externalities arising from automobile use contribute to the conditions (higher traffic volumes, higher speeds, roads to accommodate the demand for these) that make many people fearful of cycling.

Portland, Oregon has done an analysis dividing the general population of Portland into four groups (Geller, no date). The report notes that the sizes of the groups are estimates, but seem consistent with other sources of information.

- One group, consisting of well under 0.5% of the population, consists of "hard core," "fearless" cyclists who will ride regardless of conditions.
- A second group, consisting of about 7% of the population, is "enthused and confident." While comfortable with traffic, people in this group prefer cycling in facilities designed for cycling, and they have responded to the increase in facilities and to policies to

increase density and shorten trip lengths. This second group accounts for most of the increase in cycling that has occurred in response to Portland's efforts to actively encourage cycling. The report suggests that about 60% of this group in the Portland area cycles regularly for part or all of their trips.

- A third group, with 60% of the population, is "interested but concerned." People in this group would like to ride more but are afraid to ride on arterials with traffic, which is where the city has developed most of its bicycling infrastructure. People in this group would bicycle if cars were slower and less frequent, or they would bicycle on quiet streets with few cars, or on paths without any cars.
- The fourth group - the remaining third or so of the population - would not ride under any conditions, because of topography, health, or lack of interest.

If the relative proportions of the four groups in other urban areas are similar to those in Portland, then this typology has several implications for increasing the use of bicycles. In places where the infrastructure for cycling is much less developed, connected, and complete than in Portland, improvements in on-road infrastructure (e.g., bicycle lanes and shoulders) can open up opportunities for the "enthused and confident" group. And because the proportion of trips made by cycling is very small, this could lead to large relative increases in cycling. An aggressive and well-publicized program of such investments might induce migration of some "enthused and confident" cyclists into an area, as may have occurred in Portland. However, large absolute increases in cycling probably will have to draw on the "interested but concerned" group. This group seems much less likely to respond to additional facilities on arterial roads than to facilities physically separated from motor vehicle traffic. Given their safety concerns, inducing the "interested but concerned" group to bicycle to transit may be a more cost-effective way to increase cycling than inducing them to use bicycles for complete trips. However, as noted in an earlier section, additional research is needed to determine the effectiveness of such measures as an incentive for bicycling. A study by Akar and Clifton (2009) of transportation choices and attitudes toward cycling, by persons working or studying at the University of Maryland, found results broadly consistent with the Portland findings. Of respondents who lived within five miles of campus and had bicycles, but did not use them to get to campus, 64% said they did not feel safe about vehicular traffic, and 37% said the lack of bike lanes/paths/trails kept them from cycling (in the study survey, respondents were allowed to select more than one reason for not cycling). The corresponding percentages for respondents who lived within five miles of campus, had bicycles, and used them for at least some of their mobility needs were 45% and 41%, and for those who lived within five miles of campus but did not have bicycles the percentages were 48% and 26%. Akar and Clifton also found that 44% of all respondents did not feel safe bicycling *on campus* after dark (for walking, the percentage was 64%). This implies that seasonal changes in the hours of darkness would affect use of bicycling facilities.

Pucher et al. (1999) note that there is a general public perception that cycling is intrinsically unsafe, which tends to further marginalize the status of cycling and discourage new cyclists; however, operating a motor vehicle is not considered inherently unsafe despite the large number of automobile accidents. The authors offer no explanation for the difference in beliefs. However, by increasing traffic volumes and speeds, incentives for automobile use would contribute to the perception that cycling is unsafe, and thus depress bicycle use. Lower rates of cycling, in turn, reduce safety for bicyclists, which contribute to the perception that cycling is unsafe. Jacobsen (2003) found that it is not just perceived but actual safety for cyclists (and pedestrians) which declines when cyclists (and pedestrians) are rare in an area. Conversely, the likelihood of a cyclist being struck by a motorist decreases as the amount of cycling in an area increases.

Public Attitude and Image

Pucher et al. (1999) note that bicyclists continue to be seen as being “outside the mainstream” in the U.S., particularly for utilitarian cycling, and that this discourages additional people from cycling. Automobile use is considered the norm, and cyclists are viewed either as rebelling or as too poor to use a car. Incentives for automobile use both reflect and reinforce these attitudes. Pucher et al. note that attitudes and image are different in Europe, where cycling is considered normal and more people do it, which makes it easier for people to begin (or return to) cycling.

A related issue is that automobile use is so much the norm that goods and services are developed to support it, while other travel modes, such as cycling, are used so little that they attract little effort from providers of services, which in turn reinforces their having low visibility and being outside the mainstream. Two instances of this bear mention. One involves the collection of data. The second involves the availability of online trip planning services.

Data There are very little data available about the amount of cycling activity in the U.S., whether at the national, state, or local scale. The U.S. Census collects and reports information about cycling to work, but it uses an approach to collection that probably understates the proportion of commute trips made by bicycle (Dill and Carr, 2003). In addition, the shift from the decennial Census Long Form, which collected data from one of every six households every ten years, to more frequent but smaller sample sizes of the American Community Survey (ACS), probably makes commuting by bicycle even harder to track for small areas within cities. In addition, although the ACS collects data on commuting by bicycle, some of the default summary tables of ACS data include cycling with other modes, and it takes some expertise and persistence to retrieve cycling data from the main data files. In contrast, data on driving are reported as a matter of course. The National Household Transportation Survey, conducted every five to eight years, provides more detail on bicycle use at the national level and for multi-state regions, but not at the state level or below. Even Portland, the leading large U.S. city for bicycling, relies on counts of bicycles passing 80-90 locations for several hours each year to measure annual changes in bicycling (FHWA 2005), and many cities do not even gather this much data more than once every several years.

Because cycling is a small share of transportation use, it can be difficult and expensive to collect good data on infrequent, spatially diffuse behavior. The result is that many states and cities have very limited information about the extent of cycling, and the quality of the bicycling data is not as good as that for automobile use. This has implications for cycling. For example, it is difficult to compare the relative safety of bicycling with driving, because there is such limited data on the frequency of cycling and length of cycling trips compared to driving trips (Mapes, 2009). It is also more difficult and expensive to identify representative samples of bicyclists to study their behavior and responses to policies, incentives, or services outside the context of specific facilities. The very small proportion of trips made by bicycle, relative even to trips by transit or other alternatives to driving alone, has probably contributed to the dearth of research on how incentives affect bicycling, as opposed to alternatives in general, or major alternatives such as public transportation.

Trip Planning During the past five to seven years, much of the U.S. public has become accustomed to going onto the Internet, typing in an address to start a trip and an address to go to, and having Mapquest, Yahoo, Google, or similar services provide detailed directions and a map to use in making the trip. However, these services are all oriented toward driving. About 110 public transportation agencies in the U.S., and another 300 or so in other countries, have provided data for Google to use in giving similar directions for trips by transit (Google, 2009), and there have been rumors that Google may be planning to provide a similar service for bicycling. However, Google has not officially announced any plans for a similar cycling service.

Bicycle trip planning services, with functionality similar to Google Maps, are beginning to appear in an increasing number of cities and metropolitan areas (e.g., Broward MPO, 2009). However, these services are not yet common or well publicized; they are not part of high-volume Internet sites visited each day by large numbers of people in each city; and they all use different user interfaces and different conventions for storing, using, and presenting bicycle routes. In addition, most seem to be targeted at the small share of the general population who are willing to bicycle on facilities along streets that have high volumes of motor vehicle traffic, rather than at the much larger share of the population that is willing to cycle only if it can avoid cycling along such streets.

The relative ease of obtaining good information, in a standard format, for planning trips by car, and the relative difficulty of obtaining comparable information for planning trips by bicycle, probably acts as an incentive for driving and a disincentive for bicycling. The bicycle trip planning services have emerged too recently for there to have been much research on their effects on bicycle use, or on whether any such effects vary with the degree of comfort that service users have with cycling on different types of facilities.

Density and Trip Length

Density and trip length affect the time and effort required to cycle. A cyclist in a low-density environment has fewer opportunities for utilitarian trips within a cycling distance of, say, three miles, than does one in an environment with higher density of shops, residences, and employers. Cervero (1996) found that residential density was an important predictor of commute mode choice, except for walking and cycling, where it was the mix of uses and activities within easy walking and cycling distance, rather than simply the density of residential development *per se*, that better predicted choices of cycling and walking. Goldsmith (1992) noted that trip length is particularly important for active cyclists considering whether or not to commute by bicycle, because of the need when commuting to traverse a fixed distance under time constraints and work requirements, under road conditions that are less than ideal. Stinson and Bhat (2004) also found that distance to work had a very strong influence on the propensity to bicycle. Pucher and Buehler (2006) attribute an unspecified portion of the higher commuter bicycling rate in Canada, relative to the U.S., to higher density and the greater opportunity for shorter trip lengths in Canada. They make a similar argument when comparing the low cycling rates in the U.S. and United Kingdom relative to the Netherlands, Denmark, and Germany (Pucher and Buehler, 2008).

Incentives for automobile use have tended to reduce density of new development (Persky and Kurban, 2003) and, all else being equal, to require longer trips. In addition, Pucher et al. (1999) note that traffic volumes and speeds tend to be lower in small dense urban settings than in larger areas with lower density (see previous discussion of safety). Limited infrastructure for bicycle riding in many U.S. cities also limits the number of opportunities for bicycle use. In addition, limited infrastructure for storing bicycles used for only part of a trip (such as to reach public transit) discourages cycling by leaving the would-be cyclist wondering what will happen to his/her bicycle (Pedestrian and Bicycling Information Center, no date). Shannon et al. (2006) concluded from an analysis of commuting to a Western Australian university that improving cycling travel time, by improving facilities for cycling, would be more effective than promoting the benefits of cycling.

Relative Advantage of Car Travel

In most parts of the U.S., the low perceived cost, the speed, and the convenience of automobile travel discourage use of other modes. The various economic incentives for automobile use (discussed in an earlier section of this chapter), including failure to charge for the costs that driving imposes on others, contribute to the relative advantage of car travel compared to other transportation modes. Reducing or eliminating those incentives would make car travel less advantageous for some trips.

Conclusions and Recommendations

Unfortunately, there has been too little research on the relationship between financial incentives and bicycling to enable development of a model that can predict how large a change in bicycling would result from a change in financial incentives for bicycling or for driving. Some data exist that probably could support development of such a model, but they have yet to be analyzed. However, the literature does support some qualitative conclusions:

1. Availability of bicycle parking and storage is more important than availability of showers as an incentive for employees to bicycle to work.

2. Connectivity of the infrastructure for bicycling is important. Building a path for cycling is unlikely to have much effect on the amount of cycling unless it connects would-be cyclists with where they want to go, or unless it connects them with an existing network that enables them to reach where they want to go.

3. Over time, incentives for driving have helped to create conditions that make cycling less attractive. These conditions include low density development patterns, long distances between destinations of utilitarian trips, high volumes of high-speed motor vehicle traffic, and perceptions that bicycling is unsafe and abnormal simply because it is not driving.

4. The bicycling market consists of different market segments. Most notably, there is a relatively small proportion of the general population that is willing to use cycling infrastructure on streets that have high volumes of motor vehicle traffic. And there is a relatively large proportion that is interested in cycling but is unwilling to ride on facilities with high volumes of fast motor vehicle traffic. The latter segment is looking for different kinds of cycling facilities (separation from traffic, quiet residential streets) than the former. In some places, such as Portland, planning and provision of cycling facilities has focused on the former (Mapes, 2009; City of Portland, 2007). Development of financial incentives, and of nonmonetary incentives such as cycling infrastructure and route planning services for cyclists, should consider the different needs of these different market segments if it is to attract would-be cyclist from the larger segment. For example, a strategy to encourage short bicycle trips within neighborhoods, out to bus routes on

arterial streets, with a transfer from bicycle to bus for the remainder of the trip, might lead to more cycling among the larger segment, even though a traveler might cover more of the distance by bus than by bike. Whether such a strategy would yield a larger increase in cycling than one focused on improving bicycling facilities along arterial streets, or whether it would be more cost-effective, are questions for further research.

This review has also identified needs for additional research.

1. More study is needed of bike-transit integration to better understand how users of these services were traveling prior to beginning to use the service. These services clearly are beneficial to transit agencies by increasing transit ridership. What is much less clear is the extent to which they induce non-cyclists to cycle, as opposed to increasing cycling among people who were already cycling, or substituting transit for portions of trips previously made entirely by bike. Research on this topic should also evaluate the cost of such programs as tools for inducing non-cyclists to begin cycling.

2. Although (in the researchers' experience) the quality of data from employer-based demand management is not as good as one would like, some analysis of this, focused on bicycling, might yield useful information on how employees respond to changes in subsidies and cycling infrastructure. The commuting information in these programs needs to be disaggregated so that responses can be analyzed in the context of the cycling infrastructure available in the area.

3. Research is needed to develop a simple standard way to identify which of the four groups from the Portland typology a person belongs to. This would increase the usefulness of the Portland typology as a planning tool by making it easier to estimate the sizes of the groups in local populations. And it would assist in guiding individuals who seek cycling services toward those that they are most likely to be willing to use.

4. As web-based bicycle trip-planning services become more common, more information is needed about who uses them (frequent, infrequent, or non-users), what they are seeking (routes for recreation or for utilitarian riding), and how this varies with the quality of

cycling infrastructure in an area and with the user's degree of comfort with different types of cycling infrastructure.

References

Abraham, J.E., et al. Investigation of Cycling Sensitivities. Presented at the Annual Meeting of the Transportation Research Board, Washington, D.C., 2002.

Akar, G., and K.J. Clifton. The Influences of Individual Perceptions and Bicycle Infrastructure on the Decision to Bike. Presented at the Annual Meeting of the Transportation Research Board, Washington, D.C., 2009.

American Public Transportation Association, 2008. Public Transit Ridership Surges in 2nd Quarter. Washington, D.C., press release, September 9, 2008. http://www.apta.com/media/releases/080909_ridership_report.cfm

Barnes, G., K. Krizek, and K. Thompson. *Longitudinal Approaches to Examining the Effects of Bicycle Facilities on Mode Share*, Appendix C, in Barnes, G., and K. Krizek, *Tools for Predicting Usage and Benefits of Urban Bicycle Network Improvements*. Report MN/RC-2005-50. Minnesota Department of Transportation, 2005.

Betz, C., J.C. Bergstrom, and J.M. Bowker. A Contingent Trip Model for Estimating Rail-Trail Demand. *Journal of Environmental Planning and Management*, Vol. 46, 2003, pp. 79–96.

Bikes Belong, 2008. Survey Says: High Gas Prices are Fueling Bike Sales, http://www.bikesbelong.org/node/1033254

Birk, M. and R. Geller. Bridging the Gaps: How the Quality and Quantity of a Connected Bikeway Network Correlates with Increasing Bicycle Use. Presented at the Annual Meeting of the Transportation Research Board, 2006.

Broward Metropolitan Planning Organization, 2009. BiKE Broward, http://arcservdev.fiu.edu/mpobike/index.html, accessed August 17, 2009.

Burbidge, S. K., and K. G. Goulias. Evaluating the Impact of Neighborhood Trail Development on Active Travel Behavior and Overall Physical Activity Among Suburban Residents. Presented at the Annual Meeting of the Transportation Research Board, 2009. Also published in *Transportation Research Record*.

Cervero, R. Mixed Land-Uses and Commuting: Evidence from the American Housing Survey. *Transportation Research, Part A*, Vol. 30 (5), 1996, pp. 361–377.

City of Portland Department of Transportation, no date. Portland’s Approach in Updating its Bicycle Master Plan. http://www.portlandonline.com/transportation/index.cfm?&a=249100&c=44674. Accessed September 30, 2009.

City of Portland, 2007. Existing Conditions for Bicycling – (2) Bicycle Use. http://www.portlandonline.com/transportation/index.cfm?c=50736&a=260032. Accessed September 30, 2009.

Cleaveland, F., and F. Douma. The Impact of Bicycling Facilities on Commute Mode Share. Report MN/RC 2008-33. Minnesota Department of Transportation, 2008.

DeLucchi, M.A., 2004 The Annualized Social Cost of Motor-Vehicle Use in the U.S., 1990-1991: Summary of Theory, Data, Methods, and Results, Report No. 1, Davis, CA: University of California—Davis Institute for Transportation Studies, report UCD-ITS-RR-96-3 (1) rev. 1 http://www.its.ucdavis.edu/publications/2004/UCD-ITS-RR-96-03(01)_rev1.pdf .

DeLucchi, M. A. Do Motor-Vehicle Users in the U.S. Pay Their Way? *Transportation Research Part A*, Vol. 41, 2007, pp. 982-1003.

DeLucchi, M.A., and Murphy, J. J., 2007. How large are tax subsidies to motor-vehicle users in the US? *Transport Policy*, Vol. 15, 2007, pp. 196-208.

Dill, J., and T. Carr. Bicycle Commuting and Facilities in Major U.S. Cities: If You Build Them, Commuters Will Use Them. *Transportation Research Record 1828,* 2003, pp. 116–123.

Dill, J., and E. Wardell. Factors Affecting Worksite Mode Choice: Findings from Portland, Oregon. *Transportation Research Record 1994*, 2007, pp. 51–57.

District of Columbia Department of Transportation, 2005. District of Columbia Bicycle Master Plan.
http://ddot.dc.gov/ddot/cwp/view,a,1245,q,634448,ddotNav_GID,1761,ddotNav,|34416|.asp

Federal Highway Administration, 2008. Traffic Volume Trends, September 2008.
http://www.fhwa.dot.gov/ohim/tvtw/tvtpage.cfm

Federal Highway Administration, 2009. Pedestrian and Bicycle Data Collection in United States Communities, January, 2005. http://atfiles.org/files/pdf/PBICDataCollection.pdf

Garrard, J., G. Rose, and S.K. Lo. Promoting Transportation Cycling for Women: The Role of Bicycle Infrastructure, *Preventive Medicine*, Vol. 46, 2007, pp. 55–59.

Geller, R, no date. Four Types of Cyclists. City of Portland Office of Transportation.
http://www.portlandonline.com/transportation/index.cfm?&a=237507&c=44597. Accessed September 24, 2009.

Goldsmith, S.A. Case Study No. 1: Reasons Why Bicycling and Walking are Not Being Used More Extensively as Travel Modes. *National Bicycling and Walking Study*. Report FHWA-PD-92-041. Federal Highway Administration, 1992.

Google, 2009. *Google Transit*. http://www.google.com/intl/en/landing/transit/text.html#mdy. Accessed August 17, 2009.

Hagelin, C.A. *A Return on Investment Analysis of Bikes-on-Bus Programs.* Report NCTR 576-05. University of South Florida Center for Urban Transportation Research, 2005.

Hanson, M. E. Automobile Subsidies and Land Use: Estimates and Policy Responses. *APA Journal.* 1992, pp. 60–71.

Hess, D. B. The Effects of Free Parking on Commuter Mode Choice: Evidence from Travel Diary Data. Working Paper No. 34. UCLA School of Public Policy and Social Research, 2001.

Hillsborough County Metropolitan Planning Organization, 2008. Hillsborough County 2008 comprehensive bicycle plan update. Tampa, FL. http://www.hillsboroughmpo.org/pubmaps/pubmaps_folders/draft-publications/DRAFT%202008%20Bicycle%20Plan%20Update%20for%20WEB.pdf

Hunt, J.D. and J.E. Abraham. Influences on Bicycle Use, *Transportation,* Vol. 34, 2007, pp. 453–470.

Jacobsen, P.L. Safety in Numbers: More Walkers and Bicyclists, Safer Walking and Bicycling. *Injury Prevention*, Vol. 9, 2003, pp. 205–209.

Jakobsson, C., S. Fujii, and T. Gärling. Effects of Economic Disincentives on Private Car Use. *Transportation*, Vol. 29, 2002, pp. 349–370.

Krizek, K. J., A. El-Geneidy, and K. Thompson. A Detailed Analysis of How an Urban Trail System Affects Cyclists' Travel. *Transportation*, Vol. 34, 2007, pp. 611–624.

Krizek, K., and P.J. Johnson. Proximity to Trails and Retail: Effects on Cycling and Walking. *Journal of the American Planning Association*, Vol. 72, 2006, pp. 33–42.

Langer, A., and C. Winston. Toward a Comprehensive Assessment of Road Pricing Accounting for Land Use. *Brookings-Wharton Papers on Urban Affairs*, 2008, pp. 127–176.

Lasky, M., 2005. Understanding the Link Between Bicyclists and Light Rail, Field Paper, Urban and Regional Planning, Portland State University. http://web.pdx.edu/~jdill/Lasky_FAP_Link%20_Bicyclists%20_Light_Rail.pdf

Mapes, J. *Pedaling Revolution*. Oregon State University Press, Corvallis, OR, 2009.

Nelson, A.C., and D. Allen. If You Build Them, Commuters Will Use Them. *Transportation Research Record 1578*, 1997, pp. 79–83.

Ogilvie, D., M. Egan, V. Hamilton, and M. Petticrew. Promoting Walking and Cycling as an Alternative to Using Cars: Systematic Review. *BMJ*, doi:10.1136/bmj.38216.714560.55, 2004.

Regional Bicycle Plan Inventory of Bicycle Usage (Demand). Ozarks Transportation Organization, Springfield, MO, no date.

Persky, J., and H. Kurban. Do Federal Spending and Tax Policies Build Cities or Promote Sprawl? *Regional Science and Urban Economics*, Vol. 33, 2003, pp. 361–378.

Pedestrian and Bicycling Information Center, no date. "Bikestation Long Beach", http://www.bicyclinginfo.org/library/details.cfm?id=3969.

Puget Sound Regional Council. *Travel Choices Study—Summary Report.* PSRG, 2008.

Pucher, J., and R. Buehler. Why Canadians Bicycle More than Americans: a Comparative Analysis of Bicycling Trends and Policies. *Transport Policy*, Vol. 13, 2006, pp. 265–279.

Pucher, J., and R. Buehler. Making Cycling Irresistible: Lessons from the Netherlands, Denmark, and Germany. *Transport Reviews*, Vol. 28, 2008, pp. 495–528.

Pucher, J., C. Komanoff, and P. Schimek. Bicycling Renaissance in North America? Recent Trends and Alternative Policies to Promote Bicycling. *Transportation Research Part A*, Vol. 33, 1999, pp. 625–654.

Rajamani, J., et al.. Assessing Impact of Urban Form Measures on Nonwork Trip Mode Choice After Controlling for Demographic and Level-of-Service Effects. *Transportation Research Record 1831*, 2003, pp. 158–165.

Roche, E., J. M. Kolodinsky, and L. Aultman-Hall. Inelasticity of Incentive Demand for Non-Motorized Commuting. Presented at the Annual Meeting of the Transportation Research Board, 2009.

Schneider, R. *Integration of Bicycles and Transit: A Synthesis of Transit Practice*. TCRP Synthesis 62. Transportation Research Board, 2005.

Shannon, T., et al. Active Commuting in a University Setting: Assessing Commuting Habits and Potential for Modal Change. *Transport Policy*, Vol. 13, 2006, pp. 240–253.

Shoup, D. Evaluating the Effects of Cashing Out Employer-Paid Parking: Eight Case Studies. *Transport Policy*, Vol. 4, (4), 1997, pp. 201–216.

Stinson, M. A., and C.R. Bhat. Frequency of Bicycle Commuting: Internet-Based Survey Analysis. *Transportation Research Record 1878*, 2004, pp. 122–130.

Tilahun, N. Y., D. M. Levinson, and K. J. Krizek. Trails, Lanes or Traffic: Valuing Bicycle Facilities with an Adaptive Stated Preference Survey. *Transportation Research Part A*, Vol. 41, 2007, pp. 287–301.

Wardman, M., M. Tight, and J. Page. Factors Influencing the Propensity to Cycle to Work. *Transportation Research Part A*, Vol. 41, 2007, pp. 339–350.

CHAPTER 6 EFFECTIVENESS OF SAFE ROUTES TO SCHOOL PROGRAMS IN PROMOTING BICYCLING AND WALKING IN FLORIDA

Introduction

Safe Routes to School (SRTS) programs have now been operational in Florida for several years. However, little research has been performed within the State to evaluate whether these programs (and their various components) lead to increased numbers of children walking and bicycling to and from school. The researchers postulated that data collected as part of the statewide Safe Routes to School Program efforts could be used to evaluate the various promotional activities associated with the Program.

This document summarizes an evaluation conducted to assess the ability of the existing data to answer questions related to program effectiveness. Overall, the analysis found that the available data was too limited to provide conclusive evidence regarding the impacts of the Safe Routes to School Program. Details of the evaluation are provided below.

Research Plan

The National Center for Safe Routes to School serves as a repository for Safe Routes to School data from the school districts participating in the program. Their website states:

> The National Center provides resources to help make collecting and summarizing data as easy and straightforward as possible for communities and states. These resources help those involved in local programs collect, enter, and analyze their data. Hundreds of local programs and thousands of schools are using these resources to gather information about their local SRTS programs.
> http://www.saferoutesinfo.org/data/

The National Center provides uniform data collection forms for collecting and reporting data. There are several forms provided on the website; the names of the forms, their descriptions and intended use follow:

- **In-Class Student Tally Form** - one-page form used to collect information about student travel to and from school at the classroom-level.

- **Parent Survey** - two-page form used to collect information about student travel, important issues, and parental attitudes.
- **Background Information Cover Sheet** - two sheets that provide an overview of the Safe Routes to School components implemented across a program.
- **School Information Page** - single sheet that provides information on the school where the data was collected and the time period (before/during/after) implementation of a Safe Routes to School project or program; the sheet does not provide information on the components implemented at the individual school.

As was realized during this Safe Routes to School results documentation effort, the data for these programs is severely limited. Moreover, without school-specific data concerning what programmatic elements are implemented, conclusive results will continue to be difficult to obtain.

Florida Safe Routes to School Evaluation Data

Austin Brown from the National Center for Safe Routes to School sent the researchers a file with all of the Safe Routes to School survey and tally responses received from programs in Florida through June 9, 2009. He also provided an explanation of the dataset, which included results collected by teachers or others in the classroom and/or by surveys distributed to parents of students at the schools.

The researchers then spoke with Lauren Marchetti at the National Center to see what analysis had been done on the data to date. She explained that there was limited potential for analysis of the data as: (1) there was no requirement that programs send in before-and-after data, and (2) the reporting forms do not list the programs and activities that actually took place at individual schools. As a result of the lack of requirement for before-and-after data, Mr. Brown stated that 80-90 percent of the data received by the National Center is limited to a single set of data points (i.e., either before data or after data, but not both).

Ms. Marchetti noted that she has sent recommended changes in the next transportation bill to Congressman Oberstar's office to address these issues and improve the data collection process.

However, Ms. Marchetti also expressed a concern that analysis using the currently available data may find that the programs have no benefit due to use of inadequate information.

In total, the dataset includes information from 25 programs throughout Florida that were planned for implementation in the 2008-09 school year. The size of individual programs ranged from a single school to as many as 43 schools covered under a single program. In total, the dataset provided by the National Center includes at least some information on 124 schools. The various programs and number of schools that participated in each program are summarized in Table 6-1.

TABLE 6-1 SRTS programs and number of participating schools

Programs	Location	Number of Schools
WalkSafe program	Miami-Dade County	43
Volusia County School	Volusia County	19
Miami-Dade County	Miami-Dade County	18
Community Safety Coalition	Jackson County	7
Center for Urban Transportation Research	Hillsborough County	5
School Board Broward County	Broward County	5
Manatee County	Manatee County	4
Highlands County School Board	Highlands County	3
Health Masters Club	Orange County	3
Skyline Elementary School	Lee County	2
Trafalgar Elementary School	Lee County	2
City of Mt. Dora	Lake County	1
Collier County	Collier County	1
Dale R. Fair Babson Park Elementary School	Polk County	1
DeSoto County	DeSoto County	1
Dommerich Elementary School	Orange County	1
Golden Gate Elementary School	Collier County	1
Gulf Elementary/Middle School	Lee County	1
Harns Marsh Elementary School	Lee County	1
Lake Alfred Elementary School	Polk County	1
Lee Middle School	Lee County	1
Sarasota County	Sarasota County	1
Scott Lake Elementary School	Polk County	1
Sunshine Elementary School	Lee County	1

Data for the vast majority of schools in the files sent from the National Center included only one data point (before or after), making it impossible to measure any change. Most schools conducted a pre-implementation survey, where the teachers or the program coordinators gathered information from students regarding their trips to and from the school. However, some schools that provided pre-implementation survey results apparently did not receive funding, and so did not implement their programs or collect post-implementation surveys. The Volusia County program was implemented but collected only post-implementation surveys and not pre-implementation surveys.

Due to the issues described above, the data from the National Center was not analyzed further, with two exceptions:

- One program with sufficient data to analyze was the WalkSafe program, managed by the University of Miami and Miami-Dade County. For the 2008-09 school year the dataset contained student tally data from 23 schools, four of which had the data collected by WalkSafe staff in order to ensure accuracy. The WalkSafe program also collected parental surveys, but they were not delivered to the National Center until after the initial dataset was provided to the researchers.

- Two Orlando elementary schools participated in a Safe Routes to School program that included a further evaluation.

Finally, pre- and post-implementation data for the Hillsborough County program managed by the Center for Urban Transportation Research (CUTR) was also analyzed, though it was not included in the data initially provided by the National Center. Rather, CUTR provided this data directly to the researchers in August 2009 after they had completed the data entry and some initial analysis. Brief summaries of the WalkSafe, Orlando, and CUTR-Hillsborough programs are provided in the following sections.

WalkSafe

The WalkSafe program was introduced by the University of Miami Miller School of Medicine, with assistance from multiple agencies, to address high numbers of child pedestrian injuries in Miami-Dade County. The program's stated main objectives are to:

- increase pediatric pedestrian safety;
- increase physical activity levels by encouraging students to walk to and from school; and,
- improve the walkability in and around elementary schools.

The WalkSafe program is based on a 5-E model that includes education, engineering, enforcement, evaluation, and encouragement components. Each component is described below.

Education A three-day curriculum was taught to students in grades K through 5. The course highlighted the benefits of walking/biking, maintaining a healthy lifestyle, preserving the environment and sustainable transportation. Pedestrian safety videos complemented with teacher-led discussions are shown to children on the first day. An outside simulation on the second day provides modeling and training by a physical education or classroom teacher. This enables the children to be active, while reiterating traffic safety skills through a hands-on experience. The final day involves having each child participate in a poster contest, thus providing a creative way for children to demonstrate what they have learned.

Engineering This phase included identifying potential engineering modifications at sites where pediatric crashes have occurred in the past. Various organizations such as the Department of Public Works and the Metropolitan Planning Organization play a key role in both identifying and implementing the changes. This step also helps the Miami-Dade School Board to prioritize larger engineering projects for which applications for SRTS funding can be submitted. The Miami-Dade school construction policy was modified to improve site design, select better locations, etc.

Enforcement Police departments and community organizations help ensure that the school environment is safe for healthy, active living.

Evaluation Various tools and surveys were used to evaluate the increase in safety after the implementation of the WalkSafe program, including crash data, parent and teacher surveys, and behavioral research. From 2001 to the present, there has been a 41% decrease in the total amount of pedestrian injuries for children aged 0-14 in Miami Dade County, and crash rates continue to decline at a faster rate than in neighboring counties.

Encouragement The WalkSafe program encouraged people in the communities near the schools to maintain an active and healthy environment. A "Walk to School Day" or a similar event was introduced in the schools to encourage walking/biking. Technology based activities such as a website, Facebook group, Twitter feed, and email list were also available to encourage more participation. These media provide information about news, upcoming events, and recent awards to interested parties.

For 23 in the 2008-09 year a classroom count of the number of students walking and bicycling to school was conducted before and after the safety education program. In many cases, a third survey was conducted about six months after the educational curriculum to evaluate the long term effects of the program.

Anamarie Garces de Marcilla at the University of Miami spoke to the research team about the data available from these schools. She emphasized that the WalkSafe curriculum for 2008-09 focused almost entirely upon improving the safety of walking and not on encouraging more active transportation to school. While she noted that the data from the 2008-09 school year showed no significant difference between the before, after, and six-months-after tallies, she emphasized that the program resulted in a significant reduction in pedestrian injuries at the schools where the program was implemented, which was the program's goal.

For the upcoming school year (2009-10) WalkSafe is adding new elements to their program to promote walking and bicycling to school, along with two separate projects that are being implemented to specifically increase bicycling (among elementary and middle school students and among middle-aged men). Data evaluating the success of these programs should provide a better indication of the effectiveness of Safe Routes to School programs in increasing bicycling activity.

Orlando

The Orlando Safe Routes to School programs at Wheatley Elementary School and Ivey Lane Elementary School (each with about 400 students) were the result of a partnership between the non-profit Health Masters Club staff, the Orange County Health Department, and Florida Department of Transportation. Led by Dr. Toni Moody, the founder of the Health Masters Club team, the program established a "Healthy School Team" for each school using a $50,000 non-infrastructure grant from FDOT. The program provided educational programs, encouragement activities, and helmet promotions. Helmets were donated by the Central Florida Epilepsy Foundation. Teacher-members of the Healthy School Team received mini-grants to become certified in Florida Elementary Traffic Safety Education. All teachers were encouraged to include pedestrian and bicycle safety tips into their respective academic areas (e.g. bicycle-specific art projects).

In-class surveys conducted by teachers in the fall of 2007 and then again at the end of the school year suggest the program had positive results. Wheatley Elementary School had an 18 percent increase in students walking to school and Ivey Lane Elementary had a 37 percent increase in walking to school.

CUTR – Hillsborough County

The Center for Urban Transportation Research, part of the University of South Florida, implemented a variety of strategies in five schools in Hillsborough County, focused on increasing bicycling and walking. A preliminary review of the results, shown in Table 6-2, found that at three of the schools there was little bicycling by students before the program and there was no clear increase or reduction in bicycling after the program. However, in the two schools (Hunter's Green Elementary and Lawton Chiles Elementary) where at least five percent of the students were bicycling in the before survey, the percentage of students bicycling after the program went up for most grade levels. Hunter's Green experienced a school-wide increase in cycling of approximately 7%, while Lawton Chiles experienced an increase of over 25%.

Jason Jackman, who managed the program at CUTR, stated that the results were more minor than he had hoped, for a variety of factors. In particular, he cited the need for a more prolonged effort to shift attitudes and behaviors and the fact that many parents have security concerns that are not easily addressed through Safe Routes to School programs. He also noted that socioeconomic factors play a large part in the likelihood of students bicycling and walking to school, making behavior difficult to change.

TABLE 6-2 CUTR Hillsborough County student tally results for bicycling

School Name	Grade	Before			After			% Change
		# Surveyed[1]	# Cycling	% Bike	# Surveyed[1]	# Cycling	% Bike	
Hunter's Green Elementary	K	228	0	0.0%	125	4	3.2%	N/A
	1	190	0	0.0%	87	0	0.0%	0.0%
	2	253	15	5.9%	631	41	6.5%	9.6%
	3	219	14	6.4%	693	51	7.4%	15.1%
	4	309	41	13.3%	180	21	11.7%	-12.1%
	5	208	34	16.3%	160	32	20.0%	22.4%
	(blank)				62	4	6.5%	
	Total	*1,407*	*104*	*7.4%*	*1,938*	*153*	*7.9%*	*6.8%*
Lawton Chiles Elementary	K	64	8	12.5%	86	2	2.3%	-81.4%
	1	162	22	13.6%	205	16	7.8%	-42.5%
	2	186	20	10.8%	233	12	5.2%	-52.1%
	3	95	4	4.2%	164	44	26.8%	537.2%
	4	410	65	15.9%	652	132	20.2%	27.7%
	5	237	33	13.9%	358	80	22.3%	60.5%
	(blank)				25	0	0.0%	
	Total	*1,154*	*152*	*13.2%*	*1,723*	*286*	*16.6%*	*26.0%*
Lewis Elementary	K	322	4	1.2%	391	7	1.8%	44.1%
	1				644	9	1.4%	
	2				520	6	1.2%	
	3	285	2	0.7%	477	10	2.1%	198.7%
	4	295	10	3.4%	592	4	0.7%	-80.1%
	5	144	4	2.8%	356	0	0.0%	-100.0%
	(blank)				81	0	0.0%	
	Total	*1,046*	*20*	*1.9%*	*3,061*	*36*	*1.2%*	*-38.5%*

School Name	Grade	Before			After			% Change
		# Surveyed[1]	# Cycling	% Bike	# Surveyed[1]	# Cycling	% Bike	
Maniscalco Elementary	P				84	0	0.0%	
	K	216	0	0.0%	234	0	0.0%	0.0%
	1	379	0	0.0%	394	0	0.0%	0.0%
	2	545	2	0.4%	394	4	1.0%	176.6%
	3	298	0	0.0%	402	0	0.0%	0.0%
	4	317	0	0.0%	410	0	0.0%	0.0%
	5	258	0	0.0%	547	2	0.4%	N/A
	(blank)				128	0	0.0%	
	Total	*2,013*	*2*	*0.1%*	*2,593*	*6*	*0.2%*	*132.9%*
Shaw Elementary	K	330	0	0.0%	107	0	0.0%	0.0%
	1	265	0	0.0%	267	2	0.7%	N/A
	2	122	0	0.0%	92	0	0.0%	0.0%
	3	15	0	0.0%	200	0	0.0%	0.0%
	4	79	0	0.0%				
	5	210	0	0.0%	118	0	0.0%	0.0%
	Total	*1,021*	*0*	*0.0%*	*784*	*2*	*0.3%*	N/A
Grand Total		***6,641***	***278***	***4.2%***	***10,099***	***483***	***4-8%***	***14.3%***

[1] Number of surveys may differ in before and after cases, as not all students in each school were surveyed

Conclusions

The data from Florida's Safe Routes to School Program are limited and, at this point, are not able to show a strong increase in bicycling or walking as a direct result of Safe Routes to School programs. In part, this is due to the need for programs and infrastructure projects to become established over a longer period of time. However, the available data is also insufficient to comprehensively evaluate existing programs. If data collection remains the same in the future, the lack of program-specific data for individual schools will continue to make component-specific analysis of the Safe Routes to School programs difficult.

Despite the general lack of data, the preliminary results from the CUTR and Health Masters Club programs show the potential for more clear findings when before and after data are collected, and when the program has a focus on increasing bicycling and walking to school. The results of the WalkSafe program's expanded efforts to increase active transportation to schools in the 2009-10 school year should provide a more thorough evaluation of the influence of encouragement programs to increase bicycling and walking.

Recent changes to data collection requirements such as Florida's requirement that grant recipients collect before-and-after data, as well as the National Center's suggested revisions to Safe Routes to School requirements in the federal transportation bill, indicate that improved effectiveness data will be available in the future. These changes are welcome, as information on the benefits of Safe Routes to School programs will be critical to future decisions about how to both encourage more children to walk and bike to school and make it safer for them to do so. As many school districts face budget cuts and the prospect of reduced busing, finding cost-effective methods to improve school transportation will become even more important.