III. Demand for and Benefits of Walking and Bicycling in Connecticut

This chapter provides an overview of benefits of and the demand for bicycling and walking in Connecticut.

The Value of Walking and Bicycling

Walking and bicycling provide a great value to the quality of life and travel in Connecticut. Though not all people may ride a bicycle on a daily basis, the interest in bicycling as one method to reduce travel costs and energy consumption has grown continuously over the past ten years. Nearly every person walks for at least a portion of their travel each day, whether it is from a parking lot to an office building or store, a means to exercise, or a way to reach another travel mode such as a train station or bus stop.

Some of the valuable characteristics of walking and bicycling include:

- **Health** – Walking and bicycling promote good health. The U.S. Department of Health and Human Services recommends 10,000 steps per day to achieve better health and fitness. Bicycling is a low-impact exercise that improves overall balance and coordination. Both activities increase the health of the heart and cardiovascular systems and can improve resistance to obesity related health problems such as strokes, diabetes, and cancer.

- **Environment** – Walking and bicycling are good for the environment. These means of travel are energy efficient and non-polluting because they do not require the use of fossil fuels. About 40% of Connecticut's greenhouse gas emissions come from transportation according to the 2006 *Connecticut Greenhouse Gas Inventory: 1990 - 2001* published by CTDEP. Programs that increases transit use and walking and biking, while decreasing single occupancy vehicles rates can significantly reduce Connecticut's greenhouse gas emissions.

- **Cost** – The cost of walking and bicycling are much less than the cost of driving a motor vehicle, which includes purchasing, insuring, fueling, and maintaining the vehicle. They are also lower than the cost of regular transit use. For walking, one only needs a comfortable pair of walking shoes. For bicycling, one needs a bicycle, lock, and helmet. In addition, the cost of building sidewalks and bicycle travel facilities is significantly less than building roads and parking facilities to accommodate motor vehicles and buses or rail lines to accommodate trains.

- **Independence** – Walking and bicycling provide freedom of travel and independence to those who choose to or cannot drive because of age, disability, or income. Convenient and safe options for biking and walking can also provide connections to employment locations for those without automobile access.

- **Community** – Pedestrians and bicyclists add to the sense of community in villages, towns, and cities around the world. Pedestrians move at a slow speed and must have face-to-face interaction with and maneuver around other pedestrians.

Bicyclists also must communicate with other travelers with eye contact, verbal signals, and hand signals.

Demand Analysis

A variety of demand models were used to quantify usage of existing bicycle and pedestrian facilities as well as to estimate potential usage of new facilities. All models produce a range of accuracy that can vary based on assumptions and available data. The models used for this study incorporate information from existing publications as well as data from the U.S. Census. All data assumptions and sources are noted in the tables following each section of the analysis.

U.S. Census data provides a useful baseline for quantifying demand. In the 1990 Census, Connecticut's combined bicycle/pedestrian mode share was 3.8 percent, with 62,942 people walking or bicycling to work. In the year 2000, the mode share of bike/walk commuters had decreased to 2.8 percent, a 25 percent reduction from the 1990 numbers. The 1990 – 2000 US Census trend data is shown in Table 5.

An additional source of bicycle and walking statistics is the America Community Survey (ACS). Information from the ACS is collected on an annual basis and shows separate data for walking and bicycling. The 2006 ACS shows that approximately 52,221 Connecticut residents walked to work and upwards of 23,633 people (listed as "other modes") biked to work. It is important to note that the Census and ACS data only counts trips to work, and do not capture Connecticut's significant amount of travel to schools, other utilitarian travel, or recreation trips.

Table 5: Selected Characteristics by Place of Work, Connecticut (1990 & 2000)

Selected Characteristics	1990		2000		Change 1990 to 2000	
	Number	%	Number	%	Number	%
Number of workers 16 years or over	**1,668,645**	**100**	**1,642,090**	**100**	**-26,555**	**-1.6**
Sex						
Male	891,978	53.5	857,000	52.2	-34,978	-3.9
Female	776,667	46.5	785,085	47.8	8,418	1.1
Mode of travel to work						
Drove alone	1,313,826	78.7	1,331,260	81.1	17,434	1.3
2-person carpool	153,279	9.2	125,745	7.7	-27,534	-18.0
3-or-more-person carpool	38,571	2.3	31,735	1.9	-6,836	-17.7
Bus or trolley bus	38,785	2.3	36,240	2.2	-2,545	-6.6
All other transit[1]	4,670	0.3	8,400	0.5	3,730	79.9
Bicycle or walked	62,942	3.8	47,020	2.9	-15,922	-25.3
Taxicab, motorcycle, or other mode	11,452	0.7	10,275	0.6	-1,177	-10.3
Worked at home	45,120	2.7	51,420	3.1	6,300	14.0

Source: Census Transportation Planning Package (CTPP) 2000.

To further understand the potential demand in Connecticut, a spreadsheet model was developed to capture potential bicycling and walking trips. This model is an attempt to fully identify modal trips, beyond those identified in either Census numbers or the ACS survey, which focus on work commute related travel. The model described in the following section uses Census data as a baseline, along with documented sources to incorporate the full range of bicycle and walking mobility in Connecticut.

Existing Walking Demand

The Connecticut Walking Demand Model consists of several variables including commuting patterns of working adults, and predicted travel behaviors of area college students and school children. For modeling purposes, the study area included all residents of Connecticut in 2006. The information was ultimately aggregated to estimate the total existing demand for pedestrian facilities in the state. Table 6 identifies the variables used in the model. Data regarding the existing labor force (including number of workers and percentage of walking commuters) was obtained from the 2006 ACS. In addition to people walking to the workplace, the model also incorporated a portion of commuters traveling by public transit since almost all of those trips involve a pedestrian component. Based on the 2006 ACS, it was assumed that about three-quarters of transit riders access the transportation by foot. The 2006 ACS was also used to estimate the number of children in Connecticut. This figure was combined with data from National Safe Routes to School (SRTS) surveys to estimate the proportion of children riding bicycles to and from school. College students constituted a third variable in the model due to the presence of numerous higher education institutions and the likelihood of those students to walk or bike to classes. Data from the Federal Highway Administration's National Biking and Walking Study was used to estimate the number of students walking to and from campus. Finally, data regarding non-commute trips was obtained from the 2001 National Household Transportation Survey to estimate bicycle trips not associated with traveling to and from school or work.

Table 6 summarizes estimated existing daily walking trips in Connecticut. The table indicates that over 2,465,000 trips are made on a daily basis, with most trips made by college students. The model also shows that utilitarian trips comprise the vast majority of existing walking demand.

Existing Bicycling Demand

The Connecticut Bicycle Demand Model utilizes many of the same variables as the walking demand model and information was aggregated to estimate the total existing demand for bicycle facilities. Table 7 identifies the variables used in the model. Data regarding the existing labor force (including number of workers and percentage of bicycle commuters) was obtained from the 2006 ACS. In addition to people commuting to the workplace via bicycle, the model also incorporated a portion of the labor force working from home. Specifically, it was assumed that about half of those working from home would make at least one bicycling or walking trip during the workday.

Table 7 summarizes estimated existing daily bicycle trips in Connecticut. The table indicates that over 680,000 trips are made on a daily basis, and like the walking demand model, non-commuting trips, other utilitarian and recreational, comprise the vast majority of existing bicycle demand.

Table 6: Aggregate Estimate of Existing Daily Walking Activity in Connecticut

Variable	Figure	Calculations
Employed Adults, 16 Years and Older		
a. Study Area Population [1]	3,504,809	
b. Employed Persons [2]	1,764,288	
c. Walk to Work Commute Percentage [2]	3.0%	
d. Walk to Work Commuters	52,929	(b*c)
e. Transit-to-Work Percentage [2]	4.0%	
f. Transit Pedestrian Commuters [3]	52,929	[(b*e)*0.75]
School Children		
g. Population, ages 4-14 [4]	684,000	
h. Estimated School Walking Commute Share [5]	11.0%	
i. School Bicycle Commuters	75,240	(g*h)
College Students		
j. Full-Time College Students [6]	249,000	
k. Walking Commute Percentage [7]	60.0%	
l. College Walking Commuters	149,400	(j*k)
Work and School Commute Trips Sub-Total		
m. Daily Commuters Sub-Total	330,498	(d+f+i+l)
n. Daily Commute Trips Sub-Total	660,996	(m*2)
Other Utilitarian and Discretionary Trips		
o. Ratio of “Other” Trips in Relation to Commute Trips [8]	2.73	ratio
p. Estimated Non-Commute Trips	1,804,519	(n*o)
Total Estimated Walking Trips	**2,465,515**	(n+p)

Notes: Census data collected from 2006 American Community Survey for the State of Connecticut.

(1) 2006 American Community Survey.

(2) 2006 American Community Survey.

(3) Assumes 75% of transit riders access transit by foot.

(4) 2006 American Community Survey.

(5) Estimated share of school children who walk to school, as of 2000 (source: National Safe Routes to School Surveys, 2003).

(6) 2006 American Community Survey.

(7) Review of walking commute share in 7 university communities (source: National Bicycling & Walking Study, FHWA, Case Study #1, 1995).

(8) 27% of all trips are commute trips (source: National Household Transportation Survey, 2001).

Table 7: Aggregate Estimate of Existing Daily Bicycling Activity in Connecticut

Variable	Figure	Calculations
Employed Adults, 16 Years and Older		
a. Study Area Population [1]	3,504,809	
b. Employed Persons [2]	1,764,288	
c. Bicycle Commute Percentage [2]	1.3%	
d. Bicycle Commuters	23,641	(b*c)
e. Work-at-Home Percentage [2]	3.4%	
f. Work-at-Home Bicycle Commuters [3]	29,993	[(b*e)/2]
School Children		
g. Population, ages 6-14 [4]	684,000	
h. Estimated School Bicycle Commute Share [5]	2%	
i. School Bicycle Commuters	13,680	(g*h)
College Students		
j. Full-Time College Students [6]	249,000	
k. Bicycle Commute Percentage [7]	10%	
l. College Bicycle Commuters	24,900	(j*k)
Work and School Commute Trips Sub-Total		
m. Daily Commuters Sub-Total	92,214	(d+f+i+l)
n. Daily Commute Trips Sub-Total	184,428	(m*2)
Other Utilitarian and Discretionary Trips		
o. Ratio of "Other" Trips in Relation to Commute Trips [8]	2.73	ratio
p. Estimated Non-Commute Trips	503,488	(n*o)
Total Estimated Bicycle Trips	**687,916**	(n+p)

Notes: Census data collected from 2006 American Community Survey for the State of Connecticut.

(1) 2006 American Community Survey.

(2) 2006 American Community Survey.

(3) Assumes 50% of population working at home makes at least 1 daily bicycle trip.

(4) 2006 American Community Survey.

(5) Estimated share of school children who commute by bicycle, as of 2000 (source: National Safe Routes to School Surveys, 2003).

(6) 2006 American Community Survey.

(7) Review of bicycle commute share in 7 university communities (source: National Bicycling & Walking Study, FHWA, Case Study #1, 1995).

(8) 27% of all trips are commute trips (source: National Household Transportation Survey, 2001).

Benefits Analysis

A variety of models were used to quantify the benefits of bicycle and pedestrian facilities. The models estimated the positive air quality, public health, transportation, and recreation benefits associated with existing and future bicycle travel in Connecticut.

Air Quality Benefits

Non-motorized travel directly and indirectly (through access to transit) reduces vehicle trips, vehicle miles traveled and auto emissions. The variables used as model inputs include population, employed persons, and commute mode share were used for this analysis. In terms of daily bicycle and walking trips, assumptions regarding the proportion of persons working at home and traveling by transit reflect those used in the demand model. Other inputs included data regarding college student and school children commuting patterns.

Additional assumptions were used to estimate the number of reduced vehicle trips and vehicle miles traveled, as well as vehicle emissions reductions. These assumptions are derived from previous applications of this model over the past five years and have included diverse communities across the country from California to New York. In terms of reducing vehicle trips, it was assumed that roughly 73 percent of walking or bicycle trips would directly replace vehicle trips for adults and college students. For school children, the reduction was assumed to be about 53 percent. To estimate the reduction of existing and future vehicle miles traveled, a bicycle roundtrip distance of eight miles was used for adults and college students, and one mile was used for school children. These distance assumptions are used in various non-motorized benefits models and are derived from the National Bicycle and Walking Study. The vehicle emissions reduction estimates also incorporate calculations commonly used in other models, and are identified in the footnotes of Tables 8 and 9.

Estimating future benefits required additional assumptions regarding Connecticut's population and anticipated commuting patterns. According to the ACS data, approximately 1,764,288 people were employed in Connecticut in 2006. The most recent Census data indicates a loss of workforce population between 1990 and 2000, which corresponds to 1.6 percent decrease. The future workforce population of 1,736,059 was used to reflect current overall population growth trends and the number of school age children and college students was kept constant. In terms of commuting patterns, the bicycling and walking mode shares were increased by approximately 0.2 percent to address anticipated higher use generated by the addition of new non-motorized facilities and enhancements to the existing system. The estimated proportions of residents working from home and taking transit were also increased by 0.2 percent.

Tables 8 and 9 summarize existing (2006) and potential future air quality improvements associated with walking and biking in Connecticut. Bicycling and walking currently remove over 312,000 weekday vehicle trips, thus eliminating nearly 750,000 vehicle miles traveled. The combined modes also prevent nearly 435,000 tons of vehicle emissions from entering the ambient air each weekday. Walkway and bikeway network enhancements are expected to generate more bicycling in the future. This growth is expected to improve air quality by further reducing the number of vehicle trips, vehicle miles traveled, and associated vehicle emissions.

How quickly these air quality improvements are achieved depends upon a number of factors, including the cost of gasoline, economic indices and how quickly the recommendations of this Plan are implemented. Some communities in the U.S. have achieved their projected air quality benefits within a year of implementing a Plan. However, based on the pace of typical project implementation in the northeast, five years is a reasonable timeframe to achieve the projected future air quality benefits.

Table 8: Existing and Potential Future Air Quality Benefits from Increased Walking

Vehicle Travel Reductions	Existing	Future
Reduced Vehicle Trips per Weekday (1)	248,110	252,681
Reduced Vehicle Trips per Year (2)	64,756,665	65,949,728
Reduced VMT per Weekday (3)	269,818	274,796
Reduced VMT per Year (2)	70,422,434	71,721,644
Vehicle Emissions Reductions	**Existing**	**Future**
Reduced PM_{10} (tons per weekday) (4)	4,965	5,056
Reduced NO_x (tons per weekday) (5)	134,585	137,068
Reduced ROG (tons per weekday) (6)	19,589	19,950
Reduced CO_2 (tons per weekday) (8)	115	117
Reduced PM_{10} (tons per year) (7)	1,295,773	1,319,678
Reduced NO_x (tons per year) (7)	35,126,710	35,774,756
Reduced ROG (tons per year) (7)	5,112,669	5,206,991
Reduced CO_2 (tons per year)) (8)	29,930	30,482

Table 9: Existing and Potential Future Air Quality Benefits from Increased Biking

Vehicle Travel Reductions	Existing	Future
Reduced Vehicle Trips per Weekday (1)	64,580	67,704
Reduced Vehicle Trips per Year (2)	16,855,505	17,670,739
Reduced VMT per Weekday (3)	465,891	485,804
Reduced VMT per Year (2)	121,597,560	126,794,781
Vehicle Emissions Reductions	**Existing**	**Future**
Reduced PM_{10} (tons per weekday) (4)	8,572	8,939
Reduced NO_x (tons per weekday) (5)	232,386	242,319
Reduced ROG (tons per weekday) (6)	33,824	35,269
Reduced CO_2 (tons per weekday) (8)	198	206
Reduced PM_{10} (tons per year) (7)	2,237,395	2,333,024
Reduced NO_x (tons per year) (7)	60,652,863	63,245,237
Reduced ROG (tons per year) (7)	8,827,983	9,205,301
Reduced CO_2 (tons per year)) (8)	51,679	53,888

Note: VMT means Vehicle Miles Traveled

(1) Assumes 73% of bicycle trips replace vehicle trips for adults/college students; 53% reduction for school children.

(2) Weekday trip reduction multiplied by 261 weekdays per year.

(3) Assumes average round trip of 8 miles for adults/college students; 1 mile for school children.

(4) PM_{10} reduction of 0.0184 tons per mile.

(5) NO_x reduction of 0.4988 tons per mile.

(6) ROG reduction of 0.0726 tons per mile.

(7) Weekday emission reduction multiplied by 261 weekdays per year.

(8) CO_2 reduction of 0.000425 tons per mile

It should be noted that this model only addresses commute-related trips. This model does not account for air quality improvements associated with recreational non-motorized travel. Quantifying the benefits of recreational travel could further improve the air quality benefits of bicycling.

Other Benefits

Walking and bicycling generate benefits beyond air quality improvements. Non-motorized transportation can also serve recreational purposes, enhance mobility, and improve health. The "*BikeCost*" model, made available by the National Pedestrian and Bicycle Information Center, quantifies these benefits and provides a starting point for identifying the potential cost savings of improving Connecticut's bikeway network.

Several modeling assumptions should be discussed. First, the *BikeCost* model is project-specific, requiring specific information regarding project type, facility length and year of construction. Because the *BikeCost* model focuses on specific urban areas, Hartford, Connecticut was selected as the trial city. The model is based on a 100-mile network of on-street bike lanes, with an expected 2017 "mid year" of construction. The model also requires other inputs obtainable from the 2000 U.S. Census, including bicycle commute mode share, average population density and average household size.

Based on the variables described above, the *BikeCost* model estimates annual recreational, mobility and health benefits. The benefits were quantified based on a combination of research from previous studies as well as other factors (identified in the footnotes of Table 7).

Table 10 summarizes the estimated benefits of an enhanced bikeway system in Hartford. Except for mobility benefits, the model outputs are represented on an aggregate basis. Potential annual recreational benefits range from a low estimate of about $212,000 to a high estimate of almost $4 million. Annual health benefits range from about $10,000 to almost $90,000. Mobility benefits were estimated on a per-trip, daily and annual basis. The roughly $3 per-trip benefit of an expanded network could translate to an annual benefit of close to $75,000. Decreased auto usage could also generate monetary benefits. As Connecticut is generally urban in character, it is important to remember that these numbers are based on a single city and the overall benefits to the state would be expected to be much higher.

Table 10: Estimated Aggregate Annual Benefits of an Enhanced Bikeway Network-Hartford

Recreational Benefits (1)	Low Estimate	Mid Estimate	High Estimate
	$212,512	$2,464,022	$3,713,370
Mobility Benefits (2)	**Per-Trip**	**Daily**	**Annually**
	$3.60	$319	$74,972
Health Benefits (3)	**Low Estimate**	**Mid Estimate**	**High Estimate**
	$10,002	$88,959	$88,959

Source: Benefit-Cost Analysis of Bicycle Facilities ("*BikeCost*") Model, Pedestrian and Bicycle Information Center.

(1) Recreational benefit estimated at $10 per hour (based on previous studies). Assumes one hour of recreation per adult. $10 value multiplied by the number of new cyclists minus the number of new commuters. This value multiplied by 365 days to estimate annual benefit.

(2) Assumes an hourly time value of $12. This value multiplied by 20.38 minutes (the amount of extra time bicycle commuters are willing to travel on an off-street path). Per-trip benefit then multiplied by the daily number of existing and induced commuters. This value then doubled to account for roundtrips, to reach daily mobility benefit. Daily benefit then multiplied by 50 weeks per year and 5 days per week.

(3) Annual per-capita cost savings from physical activity of $128 based on previous studies. This value then multiplied by total number of new cyclists.