

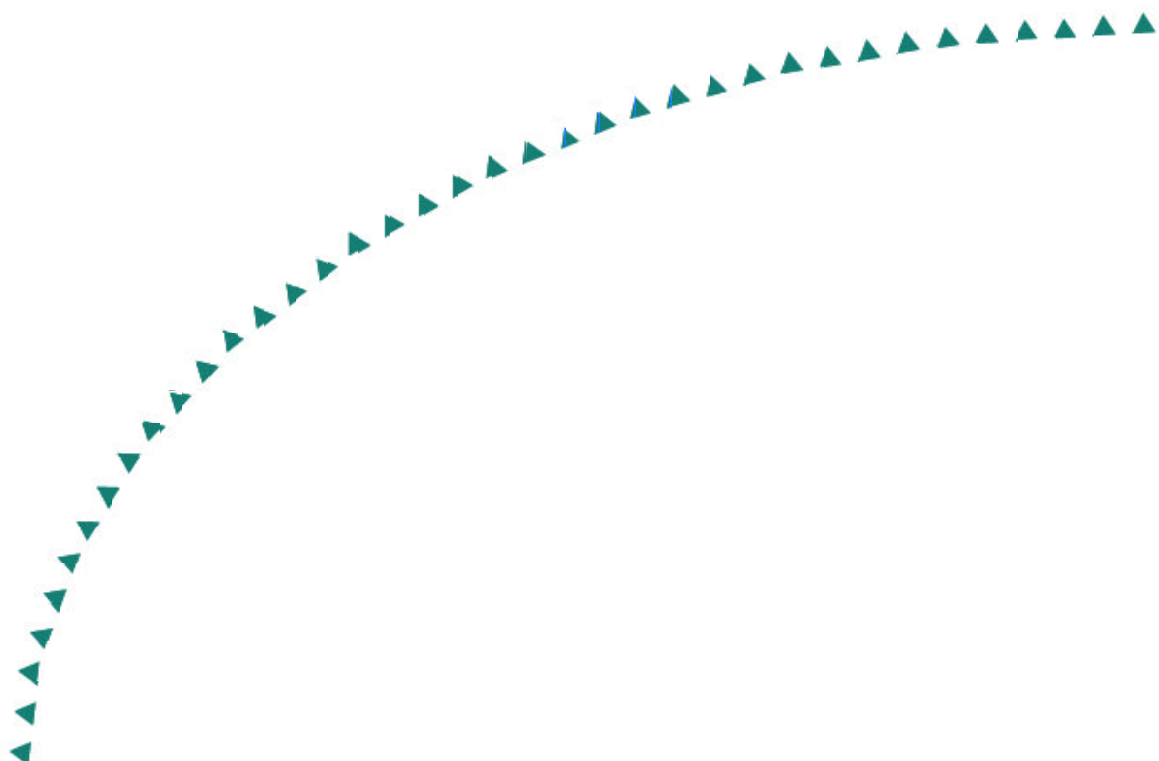
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The Benefits Of Bicycling In Minnesota



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<p>This report establishes basic facts about bicycling in Minnesota, and estimates the sizes of the various types of benefits that bicycling creates. There are three main parts to the report. The first uses surveys and data analysis to estimate the amount of bicycling that takes place in Minnesota, and to describe its characteristics. The second part is the development of a theoretical and accounting framework for categorizing and measuring benefits. The third part calculates estimates of the total general benefits of bicycling in Minnesota.</p> <p>Probably about half of adults bicycle at least once in a typical summer. The benefits that result from this riding are large relative to expenditures on bicycle facilities; by our conservative assumptions, total benefits in Minnesota are in excess of \$300 million per year. The size of these benefits is particularly notable when one considers that they are derived from relatively limited bicycling by most of the population. We find that the benefits to cyclists themselves are much larger than the benefits to society that bicycling creates, and that recreational riding, due to its much larger volume, creates more total benefits than does utilitarian riding.</p>			
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Final Report

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Executive Summary

This report represents a first step in trying to ascertain what is known about bicycling in Minnesota, and an initial effort to estimate the sizes of the various types of benefits that bicycling creates. The primary objective is to form a clear, well-documented case, based on conservative assumptions, to establish that bicycling is an activity that generates substantial benefits far in excess of current expenditure levels, and that should be willingly accommodated and supported by targeted investments.

This objective is achieved through three main steps. The first uses surveys and other measurements, both from Minnesota specifically and from the U.S. as a whole, to develop estimates of the amount of bicycling that takes place in Minnesota, and to describe various characteristics of it. This serves to establish a baseline that could be used for discussions about appropriate overall expenditure levels as well as providing some information about users and facilities. These overall bicycling estimates are also used as inputs to the estimates of total benefits that are developed in the last part of the report.

The second step is the development of a theoretical and accounting framework that practitioners can use to organize their analyses and discussions, and that can possibly organize and motivate further research. This framework is based on a distinction between 1) benefits that result directly from investments in specific facilities (such as improved safety in a high-traffic area) and 2) benefits that result from bicycling more generally, regardless of the facility (such as improved health). The first of these will be useful for planners in determining how to prioritize possible investments given budget limitations. The second should be useful for policy makers in justifying levels of expenditures on bicycling more generally.

Finally, the third step uses this framework, the estimates of the amount of bicycling, and various insights from the literature as well as our own work, to calculate estimates of the total general benefits of bicycling in Minnesota. These estimates, which we have developed using conservative assumptions, indicate that the total benefits of bicycling far exceed current annual expenditures. Given the relatively low level of bicycling currently, it seems likely that these benefits could become extremely large given appropriate investments in facilities that will make riding more attractive.

There are not a lot of bicyclists on any given day, on average about 1.5% of adults and 5% of children. But a large fraction of the population does participate at least occasionally; probably about half of adults will ride at least once in the course of a summer. The benefits that result from this riding are large relative to expenditures on bicycle facilities; by conservative assumptions, total benefits are in excess of \$300 million per year. The size of these benefits is particularly notable when one considers that they are derived from relatively limited use by most of the population. The potential benefits are much higher than this. Perhaps only 10% of adults ride more than six times a year. It is entirely realistic to suppose that much more riding could be taking place, and indeed surveys indicate that people would like to ride more than they do.

Much of the discussion of the benefits of bicycling in recent years has focused on bicycling as transportation, with an implicit judgment that utilitarian trips are more valuable in some sense than those rides that are purely for recreation. This discussion also seems to have often been based on a belief that cycling must provide benefits to others besides the cyclist to be worthwhile. These underlying assumptions have led to a focus on the benefits of bicycling as being defined by comparison to cars, rather than thinking about bicycling as a unique activity with its own objectives and benefits.

By contrast, we find that the “personal” benefits to cyclists themselves are much larger than the benefits to society that bicycling creates, and that recreational riding, due to its much larger volume, creates more benefits than does utilitarian riding. And we see nothing wrong with this. For automobile travel, the idea that the trip should be accommodated is taken as given; no one asks drivers to justify their trip or prove that it generates benefits for someone besides themselves. A substantial amount of driving is ultimately recreational in its intent; the only difference with bikes is that the recreation typically comes from the travel itself rather than from activities at the destination.

There is reason to believe that the benefits that bicyclists receive are strongly dependent on the nature of the facilities that they use. This derives from common sense; the personal enjoyment value is the major benefit of bicycling, and some types of facilities are more enjoyable to ride on than are others. It also derives from counts of actual bicyclists, in which off-road facilities are overall much more intensively used than other riding options on streets and roads. Finally, it is reflected in surveys that invariably show a strong preference for off-road facilities, and for on-road facilities with certain characteristics.

If good facilities provide a superior riding experience, this should provide greater benefits to those that use them, by comparison to where they may have been riding previously. By making the experience more appealing, it should also induce additional people to ride, and for current riders to ride more often. The benefits that are created by a specific facility will depend on the degree to which it induces new riding, and to which it attracts existing riding off of inferior options such as busy streets.

However, although these shifts and increases in riding are central to evaluating facility-level benefits, there is little existing information that can be used to understand what specific facility characteristics will have the greatest impacts on riding patterns. While it seems clear that the overall benefits of bicycling are very large relative to expenditures, and that investment in additional facilities has real potential to substantially increase the size of these overall benefits, the exact form that those investments should take is hard to specify given the current state of knowledge. More research is needed to better understand the details of bicycling patterns and how facilities influence them.

Chapter 1 Introduction

The state and local governments of Minnesota have been generous in recent years in supporting expenditures on bicycle facilities, and recently, bicycling research. However, further efforts in these areas, especially in the context of serious general budget constraints, would benefit from information that can be used to better evaluate the overall value of bicycling as well as the benefits to be gained from specific investments. This report represents a first step in defining what such information might consist of, and an initial effort to estimate the sizes of the various types of benefits that bicycling creates. The primary objective is to form a clear, well-documented case, based on conservative assumptions, to establish that bicycling is an activity that generates substantial benefits far in excess of current expenditure levels, and that should be willingly accommodated and supported by targeted investments.

This objective is achieved through three main steps. The first uses surveys and other measurements, both from Minnesota specifically and from the U.S. as a whole, to develop estimates of the amount of bicycling that takes place in Minnesota, and to describe various characteristics of it. This serves to establish a baseline that could be used for discussions about appropriate overall expenditure levels as well as providing some information about users and facilities. These overall bicycling estimates are also used as inputs to the estimates of total benefits that are developed in the last part of the report.

The second step is the development of a theoretical and accounting framework that practitioners can use to organize their analyses and discussions, and that can possibly organize and motivate further research. This framework is based on a distinction between 1) benefits that result directly from investments in specific facilities (such as improved safety in a high-traffic area) and 2) benefits that result from bicycling more generally, regardless of the facility (such as improved health). The first of these will be useful for planners in determining how to prioritize possible investments given budget limitations. The second should be useful for policy makers in justifying levels of expenditures on bicycling more generally.

Finally, the third step uses this framework, the estimates of the amount of bicycling, and various insights from the literature as well as our own work, to calculate estimates of the total general benefits of bicycling in Minnesota. These estimates, which we have developed using conservative assumptions, indicate that the total benefits of bicycling far exceed current annual expenditures. Given the relatively low level of bicycling currently, it seems likely that these benefits could become extremely large given appropriate investments in facilities that will make riding more attractive.

This is not an advocacy paper. A case could be made that much that has been written about bicycling in the last decade or so has exaggerated many of the potential benefits, seemingly because a desire to advocate has led to what might be called a selective interpretation of the facts. In contrast, the objective here is simply to try to present a well-documented, defensible evaluation of the benefits of bicycling that can be used by all

sides as a basis for further discussion. This leads us to downplay many of the benefits that advocates emphasize, such as those based on auto substitution, and to emphasize others that have been less discussed.

Overall, the benefits discussed here may seem both limited in number and small in size by comparison with some other studies. This is in fact probably the case. We take the approach that the best way to convince non-advocates of the importance of bicycling is to present a short list of easily understandable and (hopefully) undeniable benefits, and to estimate them using assumptions that non-advocates will not dispute. This, we hope, can make it possible for everyone to focus on the nature and sizes of the benefits and their implications for policy, rather than arguing about the methods used to derive them. Even our limited and conservative benefits are still large and important enough, and the cost of accommodating bicycles small enough, that including bicycles as a standard element of the transportation system is probably a good proposition from a benefit-cost standpoint.

Chapter 2 Basic Facts About Bicycling in Minnesota

The following is a summary of characteristics of Minnesota bicyclists and the trips they make. The values are estimated using information drawn from a variety of sources. Different surveys and data sources seem to show considerable variation. The methodology employed here was to find information from all the sources that address a particular question, then to try to reconcile differences and apply judgment to arrive at a best estimate. All of the sources individually have weak points; however, it turns out that they in fact usually give roughly the same answers, given that they are often reporting slightly different things. So it is possible to feel a fair amount of confidence in most of the numbers, except where noted.

Some of the differences arise from questions being asked in different ways, or in ambiguous ways, so that it is sometimes not clear what a given number means or how to compare it to others. Some differences come from different purposes or methodologies. General travel behavior surveys and diary-based data are reliable in that they ask very specific questions about specific time frames. However, their focus on destination-oriented trips makes it unclear whether they capture all of the purely recreational trips that are made by bike. Bicycle-specific surveys, by contrast, give much more detail about bike riding without the possible bias toward utilitarian trips, but the explicit focus on cycling could inadvertently give respondents an incentive to exaggerate the amount or frequency of their riding. These are the sorts of issues that need to be considered when reconciling numbers.

Timing also matters; surveys that are done at a specific time of year may give results that are hard to compare to a survey done at a different time of year. All estimates below refer to warm-weather months (April-October), except where noted. And children are much more likely to ride bikes than are adults, as will be discussed below. However, most surveys are of adult riding. It is thus necessary to be careful about whether children are included when discussing bicyclist numbers. The numbers below generally refer to adults (18 years and older) except where specifically noted.

Sources of information

Primary sources. These are used to calculate a variety of different statistics and to supplement information drawn from other sources. In the subsequent text, these are referred to either by the author's name when this is an individual, or by an organizational or survey abbreviation shown in parentheses.

- 2001 Twin Cities Travel Behavior Inventory (TBI): Sample of 6,219 households, 14,671 people; from 7-county metro and a small number from counties bordering the 7-county metro. It is a one-day diary of travel by all modes, including bicycle. Care was taken in asking about bicycle trips, so these data seem fairly reliable. It

is not clear to what extent bike trips that were not for transportation purposes were included; that is, simply going for a ride without stopping at some destination may not be counted here. The survey was only done on weekdays. It includes both adults and children. (1)

- 2001 National Household Transportation Survey (NHTS). This is a one-day diary survey, similar to the TBI but for the entire country. The entire sample is over 60,000 people, including over 1,300 from Minnesota. It includes adults and children. (2)
- Gary Davis's 2000 estimate for the Minnesota Department of Transportation (Mn/DOT) of bicycle miles of travel in a 3-county region (Hennepin, Ramsey, Dakota); done using camera counts of random segments of a variety of streets and bike facilities, summed up using statistical methods. This includes all bike travel but is purely an estimate of quantity, with no information about people or purpose. (3)
- US Bureau of Transportation Statistics, 2002 National Survey of Pedestrian and Bicyclist Attitudes and Behaviors, Summary Report. (BTS) This is a sample from the whole country and provides basic information on trip purpose, length, etc. It includes only adults. (4)
- National Bicycling and Walking Study Report #1 (1995). (NBWS) This summarizes findings from a number of other sources not listed here, primarily surveys. (5)
- Rodale/Harris (1995 and 1992). Two national surveys asking the same set of questions of about 1,000 respondents each. Very clear questions about frequency, purposes, and facilities. Includes only adults. (6)

Secondary sources. Used only for one or two statistics, or to supplement other sources.

- Moritz (1996) and Twin Cities Bicycling Club (TCBC). Moritz reports on a survey of the League of American Bicyclists, attempting to duplicate a survey done in the 1970s. This gives information about riders and facility use. A primary point of interest is that it is a survey of "serious" active riders; as such it provides some ability to compare this group to the general public. The TCBC (2003) also reports on a survey of their members, who are similarly serious riders. (7, 8)
- Statistical Abstract/National Sporting Goods Association (NSGA). The NSGA survey is reported in the Statistical Abstract of the United States, reporting on the number of people who bicycle at least six times per year, broken down by sex, age, and income. (9)
- US Census 2000 information on commuting. Information on the trip to work. (10)
- Mn/DOT 2003 Omnibus Survey. Mostly information about preferences. (11)

Amount and types of bicycle riding

Measuring the amount of bicycle riding requires defining a unit of measurement. For auto travel this is easy; a car trip almost always begins in one place and ends in another, so there is a natural interpretation of the notion of a "trip," and it is easy to estimate the total number of vehicle miles that are driven between the origin and destination. For bicycling,

the problem is much harder. Because a high proportion of bicycle rides are recreational, they start and end in the same place, and may involve short breaks in the middle. This makes the notion of a “trip” less obvious, and it is impossible to estimate the total distance of a ride that ends where it began. If one knows how long the ride took, distance can be estimated by assuming an average speed, but if the rider took a break during the ride, this time may or may not be subtracted out, depending on the rules of the particular survey.

Ultimately we use the very simple criteria of “did the person ride a bike during a given day” (a person-day) as our preferred unit of measurement. This has three major advantages over measures such as trips, miles, or minutes. First, it is unambiguous to define, unlike trips. Second, it does not rely on the memory or judgment of the individual to the same extent that miles or minutes do. It is much easier to remember if you took a bike ride than to remember exactly how long it was, especially given that part of the point of riding a bike is not keeping track of time. Third, it is comparable with other surveys, of which almost none ask about distance or number of rides, but only about if the person rode or not.

While we do address the total mileage and duration of bike riding, we see these numbers as both less reliable and less valuable from a political standpoint. Political support for bike facilities seems more likely to be influenced by a large number of riders than by a large number of miles ridden.

Number of bicyclists

This is the basic question, and it immediately introduces the difficulty of reconciling information sources collected for different reasons. The primary problem is that different people cycle from one day to the next, so that the number of people who claim to ride a bike will depend on the length of the time frame being considered. For example, the number of people who ride at least once in a month will be considerably larger than the number who ride on a given day in that month.

The Twin Cities TBI shows that roughly 2.2% of people ride a bike on the day that they kept their diary. This breaks down into 1.4% of adults and 5.5% of children. This was done during spring and summer. The NHTS has a much smaller sample, but generally supports these numbers: 1.6% of adults and 5.4% of children, for an overall average of 2.7%. This is for the entire state and was done over the entire year. This compares with the national average from this survey of 0.9% of adults and 4.9% of children for an overall average of 1.9%.

For the entire state, this would imply that on an average day about 110,000 – 130,000 people ride a bike in Minnesota. This is a minimum estimate, if these surveys are not capturing purely recreational trips, the number could be somewhat higher than this.

Although the Twin Cities are not specifically identified in the NHTS, the ridership numbers from the TBI would rank them 5th out of 19 major metropolitan areas in that survey, while the state of Minnesota ranks 3rd out of 34 identified states.

The NHTS also asks about whether the individual has made bike trips during the last week. Here 7.1% of Minnesota adults and 17% of children claim to have made at least one bike trip, compared to national averages of 6.7% and 13%. This gives an average for the state of about 9% of people riding a bike at least once in a given week, or 450,000 people.

Over a month, Rodale indicates about 18% ride a bike in the U.S. (They find that 32% rode in the last “good weather” month, but leave it to the respondent to define this, thus biasing the results upward.) BTS reports that 27.3% of adults rode during the summer of 2002. The Harris and Rodale surveys find 46% and 37% rode in the last year. Mn/DOT finds 50% claim to bicycle, but this does not ask about frequency. The Twin Cities and greater Minnesota seem about the same both from the Mn/DOT survey and the TBI/NHTS comparison. The NSGA survey shows (for 2002) 37.8% of children (7-17) and 10.7% of adults riding a bike at least 6 times in the year.

A summary of the findings of all these sources is shown in Table 2.1.

TABLE 2.1 Measures of Adult Bicycling Frequencies

Source and Area	Measure	Average	Range
TBI, Twin Cities MSA	% per day	1.4%	-
NHTS, U.S. Total		0.9%	-
NHTS, US MSAs		-	0.2% - 2.4%
NHTS, US States		-	0.0% - 2.2%
NHTS, U.S. Total	% per week	6.7%	-
NHTS, US MSAs		-	4.5% - 12.7%
NHTS, US States		-	3.5% - 12.4%
Rodale	% per month	-	16.6% - 21.2%
BTS	% per summer	27%	
Rodale	% per year		37% - 46%
NSGA	% 6 times per year	10.7%	-
Mn/DOT	% that ever ride	50%	-

If roughly 20% of 4 million adults ride in a month, and (estimating proportionally) 50% of 1 million children, that would be 1.3 million people in Minnesota that ride a bike during a given month. The same kind of reasoning would give an estimate of perhaps 2-3 million in a given year, depending on what estimates are used.

Some people ride almost every day; others may only ride once a year. The longer the time frame being considered, the more people will have ridden at least once. It is interesting to consider how the population can be divided into different frequencies of

riding in a way that is consistent with the number of people who ride in a given time frame. Table 2.2 shows an example, based on simple trial and error, of what such a breakdown might look like.

TABLE 2.2 Possible Population Distribution of Bicycling Frequencies

Frequency of cycling	% of adults
3 of every 4 days	0.1%
1 of every 2 days	0.2%
1 of every 4 days	0.5%
1 of every 10 days	1.2%
1 of every 20 days	3%
1 of every 50 days	10%
1 of every 100 days	15%
1 of every 200 days	20%
Never	50%

These riding probabilities and population frequencies are mathematically consistent with about 1% of adults riding in a given day, 5.3% in a week, 16% in a month, 29% in a summer, and 40% in a year, and with 50% “sometimes” riding, although not necessarily in a given year. Mathematically consistent here means that the fraction of each population frequency group who will ride during a given time span can be calculated using a simple probability formula, and the groups summed to arrive at a population total.

The numbers deriving from the population frequencies do not exactly correspond to the national averages over the medium time frames. This is probably because the national averages may be slightly overestimated in these cases. The questions “did you ride a bike today” and “did you ride a bike this summer” or “this year” have fairly clear answers. But intermediate time frames such as “this week” or “the last month” contain some room for fudging; a person who rode ten days ago might consider that to be close enough to count as part of the last week. Evidence that this is happening can be seen in the fact that the fraction of adults in the NHTS who report riding in the last week is more than seven times the number that rode on their survey day. Given that survey days covered all days of the week, and that every day will not be a completely new set of people, this result should be logically impossible.

If this frequency table is roughly right, there are some interesting implications. The top three lines are the people who ride at least once a week. They are 2% of the adult population, or 5% of the people who cycle in a given year. But they constitute 47% of the riders on any given day. That is, the 5% most active cyclists generate about half the riding days, the other 95% generate the other half. The implication is that the 5% most active produce about 17 times as many riding days per person as the 95% less active. Clearly there are two different categories of cyclists here, although there is somewhat of a continuum between them.

In terms of policy, this raises interesting questions in terms of whose preferences should have the greatest influence. The infrequent riders constitute the vast majority of people who ride, but the small group of frequent riders generates a disproportionate amount of the actual riding (and probably of the activists). To the extent that their preferences differ in terms of facilities and policies there could be hard choices to be made.

Miles and minutes of bicycling

In the TBI the average duration of an individual bike trip is about 15 minutes. The average person who rides makes about 2.5 trips, giving a total daily duration of 38.8 minutes. Assuming that not all of this time is spent moving (time was supposed to be recorded “door to door”), the “average” person who rides, goes for about perhaps 30 minutes; at 12 mph that would be 6 miles. (However, there is a great deal of variation, as will be discussed later.) The average daily duration is slightly longer for adults, at 45.3 minutes compared to 30.8 minutes for children. There is no information on distance recorded in the TBI.

In the NHTS both time and distance are reported and somewhat different results emerge. In this survey the average trip duration nationwide is about 22 minutes, with a total daily duration of about 42 minutes. Although individual trips are longer, the average rider makes fewer trips in this survey, so total daily duration is about the same. The average reported trip distances nationwide are 3.1 miles for adults and 1.0 miles for children. However, the distances reported here seem extremely unreliable; many people report outcomes such as 60 minutes spent covering one mile (one person reports 240 minutes for 4 miles), while on the other hand one family reported bicycling 52 miles in 30 minutes. Thus we do not attempt to derive any further information from these numbers.

One possibility for the discrepancy in trip times is that the TBI survey was more careful to identify intermediate stops and to count time spent there as non-travel time. If this were the case, one would expect to see the average trip taking less time (as is in fact observed), both because some trips would be broken into two or more shorter ones, and because some amount of time spent stopped at intermediate destinations would be subtracted from the total duration. The total duration seems somewhat more consistent between the surveys. Table 2.3 shows the distribution of total daily duration among adults; it is quite consistent across the two surveys.

TABLE 2.3 Distribution of Total Daily Bicycling Duration, Adults

Total Daily Duration	TBI count	TBI % of total	NHTS count	NHTS % of total
0 - 14 min.	31	17.9	75	18.9
15-29 min.	32	18.5	92	23.2
30-44 min.	35	20.2	76	19.2
45-59 min.	19	11.0	47	11.9
60-89 min.	38	22.0	51	12.9
90 + min.	18	10.4	55	13.9

In the BTS survey the average reported length is 3.9 miles, longer for recreational and shorter for utilitarian. This is longer than either the TBI or the NHTS. One possible reason is that the BTS is reporting the last day that a person rode; thus frequent and infrequent riders are weighted the same. If the infrequent riders tend to make longer recreational trips, this would have the effect of making the unweighted average give trip lengths that are too long.

At six miles average per day of bicycling, the three county area (Hennepin, Ramsey, Dakota) where Davis did bike counts would generate about 260,000 total bike miles of travel per day, based on the trip counts in the TBI. This estimate is probably too low, since it assumes an average speed for a “typical” rider. In fact, most of the mileage is being ridden by the roughly one third of bicyclists who are riding for more than 60 minutes in a day; they are almost certainly averaging more than 12 miles per hour.

Table 2.4 shows the results of a plausible set of assumptions about average speed for different bicyclist categories; these assumptions give an average daily duration (as is observed in the data) of 45 minutes, and an average daily distance of 9.5 miles. This is because the long distance cyclists are assumed to go faster than the average, and they (the bottom two rows) account for two thirds of total mileage.

TABLE 2.4 Speed and Distance by Total Daily Duration

Average Daily Duration	Percent of total bicyclists	Assumed average speed	Total daily mileage
5 min.	18	8	0.7
20 min.	18	10	3.3
35 min.	20	10	5.8
50 min.	11	12	10.0
70 min.	22	14	16.3
120 min.	10	14	28.0

Table 2.4 describes adult cyclists; children are more heavily weighted toward shorter durations, and assuming a lower average speed at each duration gives an estimated 5.1 miles average per child cyclist. Since overall cyclists are about evenly split between adults and children, the overall average daily mileage is probably about 7.3, which would give a three-county total mileage of about 316,000 miles per day. This is still somewhat lower than Davis’s estimate for those counties of 383,000 miles. The reasons for the discrepancy are unclear. The timing or design of the Davis work may have created a bias toward counting on good weather days when more people cycle. If this were the case, then the higher number could be interpreted to describe the total miles of bicycling on a good day, while the lower number represents an “average” day.

Those three counties are 40% of the state population, but the average person is considerably more likely to bicycle in those counties (especially Hennepin). So the rest of the state probably generates a similar total amount of cycling with its larger population, for a total daily bicycle mileage in the state of around 630,000 to 760,000.

Trip purposes

The NBWS makes this point quite succinctly: “By and large, the data provide unambiguous evidence that bicycling is overwhelmingly considered a recreational pursuit” (5, p. 17). They cite seven different polls, in which recreation is the primary purpose of 55%-95% of bicyclists. Other “utilitarian” trip purposes, such as riding to work, school, or shopping, are in the range of 5%-20%. The Rodale poll, done in two different years (1992 and 1995) shows remarkable consistency in this area: in both years 82% of cyclists rode for recreation, 65% for fitness, about 16% for shopping, and about 8% to commute to work. (These are percentages derived from the roughly 28% who rode a bike in the last mild weather month.) Since respondents were obviously allowed to choose multiple trip purposes, these percentages can be taken as upper bounds on the number using bikes for various activities. Even some of the “utilitarian” trips might be motivated more by recreation or fitness considerations, given that many bike commuters are older and higher earning (as discussed later), and presumably do not need to ride to work to save money.

In the TBI about 1.1% of trips to work were made by bike. This is about the same number as report that bike is their “typical” mode to get to work. This is considerably higher than the 0.4% share from the 2000 census. Part of the answer is probably that the Twin Cities share is somewhat higher than the state average; it is especially high in the city of Minneapolis, about 2%. Similarly, in the NHTS the percent of people who commuted to work by bike on their survey day was about the same as the number who reported “usually” getting to work by bike. In this national study the number was about 0.4%, which corresponds exactly with the national average from the census.

Although there is some belief that the census systematically underestimates the number of bicycle commuters because it asks only about the primary commute mode (which will miss those who might ride once a week), other evidence indicates that this is not a major source of bias. The evidence from the TBI and NHTS described above is fairly compelling. The Rodale survey indicates that of the 1.5% of the population that reported commuting by bike in a given month, that 30% of those commuted almost every day. This subset (0.46% of the general population, matching almost exactly with census bike mode share) makes 65-70% of the total bike to work trips. The other 70% who commute occasionally by bike adds the other 30-35%.

Thus if one assumes that the frequent commuter cyclists sometimes use other modes (as evidenced in the TBI and NHTS), then the infrequent riders probably add about enough trips to keep the overall average bike mode share, across all days, in the range of 0.4% - 0.5% nationwide, perhaps about 1% in the Twin Cities. Certainly the number may be

well above this on a particularly nice day, but over a long term average the census numbers are probably about right.

Similarly, only about 0.5% of children report biking as their typical way to get to school. However, this includes children of all ages. Bike use increases with age (through high school), so the rate is higher among older students. Also, the total rate of bike use among children is much higher than this, as noted above. About 3% of college students report getting to school by bike. While this may seem low, it may reflect the fact that many students live on campus and probably just walk to classes.

Among destination activities, the types that were most likely to be accessed by bike were school and school-related activities, visiting friends and family, and entertainment/recreation/fitness. However, none of these were more than a 4% mode share, compared to about a 1% average for bikes for all trip purposes.

Statewide there are at least 30 major organized rides per year, drawing total participation of about 25,000 people. There are also several bike clubs that hold regular training and recreational rides; during the summer the Twin Cities Bicycle Club sponsors several rides per day all around the metro region.

Characteristics of bicycle riders

There are two significant demographic characteristics of people who ride bicycles: they are disproportionately male, and children. There may be interesting policy implications to this fact.

In the TBI about 61% of the bike riders are male, 39% female. This is true for both adults and children. This corresponds exactly with the BTS findings nationally, of people who rode at least once during the summer. In the NHTS, 67% of those who reported riding on their diary day were male, as were about 61% of those who reported riding in the last week. Again, this is consistent across both adults and children. The NSGA respondents who rode at least six times in the last year are 56% male. NBWS cites several other studies, almost all of which are somewhere in this range. For commuting the difference is even greater; in Minnesota men are three times as likely to commute by bike as women are.

NBWS goes on to state that “the cause of this disparity is unknown.” One possible reason is that males are more inclined to risky behavior; to the extent that biking is perceived as somewhat dangerous, this could discourage females from riding. This intuitively seems less likely to explain the differential among children, who in general don’t seem particularly averse to risk-taking. Girls are 2-4 times as likely to bike as adult women, but they are still much less likely to bike than are boys. Social norms might have some impact; girls may just get drawn into other types of activities at an early age. Males may, for some genetic reason, simply enjoy the sensation of cycling more than females do. In any case, there could be significant policy implications in understanding if the difference

arises because females like cycling less than males (which is not necessarily objectionable), or because they feel discouraged from doing it for some reason (which may be objectionable).

In the TBI about half of the people who ride bikes in a given day are children (<18 years old). Children are 4 times as likely to ride in a given day than are adults (5.5% to 1.4%). Since they are about 20% of the total population, they generate about the same number of daily cyclists as the much larger adult population. Very similar percentages arise from the Minnesota sample in the NHTS, and nationally the numbers are about 5.0% of children and 0.9% of adults.

In terms of riding in the last week, the numbers for Minnesota from NHTS are 7.1% of adults and 17% of children, and nationally 6.7% of adults and 13% of children. The gap between adults and children seems to narrow when a longer time span is considered, although these numbers are somewhat suspect since this variable was not reported for a large majority of the children in the sample. The statistical abstract reports that 37.8% of children rode at least six times in the last year, compared with 10.7% of adults. This number is not exactly comparable because they do not count children under 7 years old, which the other numbers above do; however the difference would still be considerable if younger children were included.

This significant amount of cycling by children could have important policy implications. Much policy and investment seems aimed at accommodating or encouraging bike commuting, which is not a particularly major component either of commuting or of bicycling. As with the frequent/occasional cyclist dichotomy described earlier, it seems again that there is a fundamentally different class of cyclist here, with significantly different needs than the typical bike commuter. It also seems likely that many of the “occasional” adult cyclists probably share more in common with children, in terms of their skills, preferences, and needs, than they do with the frequent adult riders.

Among adults, in the TBI about 2.5% of people aged 18-44 ride bikes in a day, then the rate drops steadily to near zero for 65 and above. In the NSGA a similar pattern emerges, as shown in Table 2.5.

TABLE 2.5 Bicycling Frequency by Age

Age	% who cycle (day) (TBI)	% who cycle (6x/year) (NSGA)
7-11	4.6	48.1
12-17	6.0	30.5
18-24	2.9	10.4
25-34	2.5	14.7
35-44	2.4	15.3
45-54	1.6	9.0
55-64	1.3	7.2
65+	0.3	4.7

NBWS cites three other studies that show similar although not identical patterns. The two salient features of all studies of biking and age are the precipitous decline starting in the teen years and continuing into the 20s, possible due to a combination of less discretionary time and the new availability of other forms of recreation. The rate then seems to level out, perhaps due in part to people riding with their children. Then starting at age 45 there is another large and steady decline.

As with differences by sex, the reduction in cycling as people age may be due to innocent factors unrelated to the attractiveness of biking per se. However, there could also be a significant element of social norms discouraging biking among various age groups. More to the point, there may not be enough easily accessible places where less skilled adults, and especially older people, enjoy riding or feel safe doing so. Again, really understanding the reasons for this decline could have important policy implications.

An interesting comparison is that the cyclists in the Moritz study are substantially older than cyclists in the general public, with an average age of 48. The members of the TCBC have a similar age distribution, unusually weighted toward older riders. In both cases these are “serious” cyclists who ride hundreds or even thousands of miles a year, indicating that age need not be a barrier if skills and fitness hold up. If people quit cycling as they get older because their physical condition is too poor, this could be a strong argument for why cycling should be more encouraged.

In the TBI, 62% of households report that they have bicycles available for use. This is supported by the NHTS, in which the Minnesota sample has a 66% bike ownership rate. The national average from NHTS is only 47%, so Minnesota is substantially higher, although it is not clear that this translates into a correspondingly greater amount of riding. The BTS reports that nationally 26% of people cite lack of access to a bike as their primary reason for not riding, but this does not exclude the possibility that others who cite different primary reasons may also not own a bike. The households that do own bikes tend to own several; the average is 2.6 per household in the TBI and about 2.2 in Minnesota and 2.0 nationally in the NHTS. Overall, the number of bikes reported in the TBI implies that there are about 3.5 million bikes in Minnesota.

About 10% of households that don't own a motorized vehicle make bike trips in a given day, compared to 4% of vehicle-owning households. However, non-car owning households are often older people, who are generally much less likely to bike. Among households with at least one person under 45 years of age, 22% of non-car owners made bike trips. While such households are only a little over 1% of the total, these benefits of basic mobility can be of considerable significance to them.

Otherwise, the likelihood of making bike trips is only slightly correlated with income, it is slightly higher for low-income households, but not dramatically so. In both NHTS and NSGA, the rate of biking actually gets higher as income rises. In NSGA it is a steady rise, while in NHTS it is very high at the lowest income level, then drops and holds steady though much of the range, then rises significantly at the highest income levels. NBWS reports on a study of bike commuting in which the highest rates occurred at the lowest

incomes, then the rate steadily declined until spiking up again at the highest income category.

Among adults, college-educated people are about twice as likely to ride a bike on a given day as those with high-school educations, according to the TBI. This is consistent with findings of the Mn/DOT omnibus survey, which found that higher income, degreed individuals were more likely to bike for health purposes. In the NHTS the difference is slightly less significant but still large; about 9% of college-educated adults in the U.S. ride in a week compared to about 5.5% with high school or less. This factor may explain much of the spike in riding at the higher income levels described in the previous paragraph.

In terms of the geographic location of riding, it seems clear that it is not just an urban phenomenon. Although the rate of bicycle commuting is much higher in the Twin Cities, and especially in the city of Minneapolis, than in the rest of the state, the overall rate of cycling in general shows no such bias. The Mn/DOT survey shows that the fraction of people who bike for health reasons was 55% in the Twin Cities and 45% in the rest of the state.

More significantly, in the NHTS, the fraction of adults who bike in a given week is 7.6% in the state's small metro areas, 7.1% in the Twin Cities metro, and 7.6% for those who do not live in a metropolitan area. While the precise numbers need to be taken with caution because the sample is so small, the general point that there is no urban bias seems clear enough. The higher rate of bike commuting in the Twin Cities does not carry over into a higher rate of riding in general because commuting is such a small share of the total. And it could be that the types of conditions that make bike commuting attractive do not have the same impact on recreational riding.

In the U.S. as a whole there is also no relationship between the degree of urbanization and the probability of riding a bike. In non-metro areas the rate is 5.5%, and in the five sizes of metro, the rate ranges from 6.5% to 7.5%, with no correlation between the rate of riding and the size of the city.

Bicycling Facilities

According to the BTS, about 60% of adult riding is on paved roads, 13% on sidewalks, 5% bike lanes, 13% trails, and 7% unpaved/other.

The more experienced cyclists in the Moritz survey show generally similar patterns. Minor streets with no facilities are used 45% of the time (compared to 44% and 58% in two other studies that he references), major streets with no facilities are 32% (26% and 35% in the other studies). Signed bike routes, on-street lanes, and off-road paved trails are 6-7% each; off road unpaved trails are 4% and sidewalks 0.5%. Multiuse trails are used for 17% of total riding in a study from Washington State that he cites. The much lower use of sidewalks by experienced cyclists is a point of interest here.

Rodale/Harris does not break down cycling by facility, but asks respondents whether they “usually” use certain types of facilities. People could answer “yes” to more than one type. This way of asking the question showed that 85% of people ride often on streets and sidewalks, about 40% on mixed-use paths, and about 35% on dedicated cycling paths.

An issue with all of these studies is that the degree to which people use different facility types probably depends on the degree to which those facilities are available. Off-road paths do not get a huge share of total riding, but there are also not that many miles of them, compared to the number of miles of streets and roads. To understand relative intensity of usage, one needs to know the amount of facilities of different types that people have access to.

Davis does counts broken down by both facility type and degree of urbanization. This makes it possible to get at the total amount by facility type, and the intensity of use by facility type, as well as the impact of urbanization. In this study the total use by type is 25% off road path, 4% on road lane, 37% minor street (<5000 ADT), 34% major street. The counts in the latter two categories include people riding on adjacent sidewalks. These numbers are broadly consistent with the two studies cited above, except for the very high usage of off-road paths, probably due to the very high density of such facilities in the Twin Cities area.

Average daily counts by facility type and location type, shown in Table 2.6, give an idea of the intensity of use. Because of the small sample in each cell, the specific numbers should be taken with caution; still, interesting patterns can be observed.

TABLE 2.6 Bicycle Counts by Facility Type, Urbanization (from Davis)

	Off-road	On-road	Low traffic	High traffic
University	410	570	153	362
Other Urban	334	130	31	178
Suburban	58	16	14	23
Exurban/Rural	137	8	3	15
Total	187	94	38	78

Note the very high use of off road paths, and the surprisingly high use of high-traffic streets. Low-traffic streets are a large fraction of total riding because there are a lot of them, but they are not very intensively used compared with other facilities. Low-volume streets may be unattractive for all but very short recreational trips because eventually one need to cross high-volume streets, and this is much easier to do when the cyclist is also on a high-volume street and can utilize traffic signals. Also, for longer trips, high-volume streets tend to go on for long distances, including freeway, river, and railroad crossings, while low-volume streets very often dead-end at these obstacles.

Geographic analysis shows that for the households in the TBI who are in the 7-county metro and whose home location is geocoded, that the average distance to a bike facility (an on-road marked bike lane or an off-road path) is about 600 yards. These households have on average about 1.25 miles of bike facilities within a half-mile of their homes, and about 5.5 miles of facilities within a mile of their homes. About three quarters of these facilities are off-road on average.

Chapter 3 A Framework for Evaluating Benefits

The purpose of a framework for organizing and categorizing benefits is simply to provide a clear means of keeping track of exactly what benefit is being discussed at any given time, and how it relates to others. This is important because different types of benefits, even if they appear similar, may be of very different magnitudes, or arise out of different policy decisions or facility investments.

The benefits of bicycling are generally going to be a function of the amount of cycling that is done, and will possibly also depend on finer details such as the location, purpose, person cycling, or characteristics of the facility being used. Being able to talk in a useful way about the size of the benefits requires at the very least a reasonable estimate of how big they are in one's own local area, and ideally a way of understanding how this size might change as facilities are improved, programs implemented, or the cycling environment in general changed in various ways. Information on the size of benefits will be useful in justifying expenditures on cycling in general; while understanding how they might change over time will help in evaluating and prioritizing specific investments.

The primary structure that we propose for organizing benefits is to divide them into "facility-specific" benefits that arise primarily from the improved conditions created by specific facilities or programs, and "general" benefits that accrue because of people riding bikes in general, independent of where they are doing it. An example of the first type would be a situation where striping a bike lane on a busy street makes it easier for bikes to stay out of the traffic lanes, thus reducing accidents, improving traffic flow, and creating a more enjoyable environment for the cyclist on that street. An example of the second type would be the health and fitness benefits that people get from riding bikes; these are not dependent on any specific facility, except in the indirect sense that better facilities might lead to more riding.

Both of these broad categories of benefits can be further subdivided based on the nature of the impact and the recipient of the benefit. The two sections that follow discuss these categories, their subdivisions, and examples of the types of situations and specific benefits to which they could apply. Many of the different types of benefits that we discuss are taken from Sharples (12, 13), who provides a fairly comprehensive list. She proposes a different organizational framework based primarily on the recipient of the benefit. While we do include a division into benefits to cyclists and non-cyclists as secondary criteria in our framework, we feel that a primary division into facility-specific benefits versus general bicycling benefits is more useful for the types of analyses that planners might need to do.

In distinguishing these two types of benefits, facility-specific and general, the intent is to clarify the idea that policies and investments that impact the bicycling environment have two different effects. One is to improve some specific situation; thus reducing the degree of an existing problem, or improving upon previously marginal conditions for existing

cyclists. The degree to which policy or investments will create these types of benefits will be dependent on the nature of the existing situation.

The second type of impact that policies and investments can have is to increase the number of people who ride bikes, or the frequency with which they ride, or the amount of time they spend riding. Some of the most significant benefits of bicycling accrue to cyclists themselves, in the form of better health and fitness, and general recreational enjoyment. Improvements to the cycling environment, by making cycling more attractive to more people, will increase the size of these types of benefits. This can be a side effect of facilities that are created to solve existing problems, but can also occur more broadly from more discretionary facilities, or from policies and programs related to cycling in general rather than specific facilities or places. It is important, when analyzing the benefits of investments, to recognize these indirect impacts.

In the discussion that follows we use the word “facilities” as shorthand for any bicycle-related program or investment, direct or indirect; in other words, anything that impacts cycling conditions, whether intentional or not. This would obviously include the normal facilities such as off-road paths or on-road bike lanes. It can also include smaller direct physical investments such as bike lockers or racks on buses. It could include physical investments that might be made for other reasons, but which impact bikes, such as paved shoulders, pavement quality improvements, intersection redesign, and so on. Finally, it could include both direct bicycle-related policies and programs, such as education and ride-to-school programs, and indirect policies that affect bikes, such as speed limits, traffic calming, and law enforcement.

Facility-Specific Benefits

Facility-specific benefits can be subdivided into four broad types. User benefits are the value that cyclists themselves derive from the facility, such as improved safety or the possibility of using a more pleasant off-road option. Societal benefits accrue to non-cyclists; these could include situations where, for example, a bike lane makes it easier for bikes to stay out of traffic and improves flow and speeds. These societal benefits could also include quality of life or option value benefits, where the presence of a safe and pleasant biking environment creates ongoing value for nearby residents because they have access to these good quality recreational options. A third type of facility-specific benefit is the increase in economic activity that can occur in an area due to increased tourism or recreational activity. Finally, demand-related benefits are created by the possibility that improved facilities will increase the level of bicycling, thus increasing the size of the general (non-facility-specific) benefits discussed in the next section.

Facility User Benefits

Benefits that accrue to cyclists from new or improved facilities could include any of a number of possibilities; the specific benefits will depend on the nature of the facility. Here we are concerned with benefits to existing cyclists; the fact that some new people

may be induced to cycle is addressed later as a “demand-related” benefit. Some examples of facility user benefits include:

- Reduced accident risk (improving conditions at known high-accident locations)
- Time or distance savings (for example when a new bike lane makes it possible to use a more direct or faster route which was too dangerous before; or an off-road path, even if longer in distance, may save time by avoiding stops at intersections)
- More convenient access (when new facilities improve route or mode options, such as bike racks on buses, or lockers at bus stops)
- Better security for person or bicycle (e.g., lighting, bike lockers, etc.)
- More enjoyable riding conditions
 - Perceived safety from accidents with cars
 - Reduced conflicts with other bikes, pedestrians, etc.
 - Smooth pavement
 - Better scenery
 - Clean air, quiet surroundings

To some extent these types of benefits are more measurable than others; since they accrue to users of a specific facility or cyclists within a general geographic area, it is possible at least in principle to count the number of people who will be affected by a given improvement. Knowing how much these users actually value the improvement is somewhat more difficult, but there are precedents for at least some of these benefits. There are standard values used in transportation for valuing accident reduction and time savings, and there are at least a few studies that have attempted to place values on some of the more bicycling-specific issues, such as how much people value a continuous off-road path compared to an ordinary city street (14, 15).

While safety costs can be significant, they also can be influenced in a positive way by better facilities, and probably by programs to help people learn improved riding skills and safer behavior. Experienced riders crash relatively infrequently compared with the broader public, and many of the accidents for experienced riders likely involve that subset that enjoys riding fast and aggressively. While the natural thought is of bike-car accidents, these are actually in the minority. Most bike accidents involve simple falls, or hitting a stationary object (7). Some researchers have used these findings to argue that trying to reduce bike accidents through facilities (at least in the absence of a specific problematic situation) will probably be less effective than training programs, since most accidents are due to the rider’s own mistake or lack of skill (16).

Facility Non-user Benefits

Non-user benefits from bicycling facilities are, like user benefits, generally dependent on the specific characteristics of the facility. That is, since these benefits are defined to be those that arise from a facility creating a direct improvement of some existing situation, the types as well as the size of the benefits will depend on the prior situation. Some types of improvements that bike facilities could create for non-cyclists would generally have to do with reducing conflicts between cyclists and others. For example, a striped bike lane might in some cases make it easier for cyclists to stay out of traffic, thus improving

traffic flow and reducing accidents. It could induce some cyclists who had been riding on sidewalks to use the street instead, reducing conflicts with pedestrians. The lane, by providing a buffer between the traffic lanes and the edge of the road, could improve visibility for turning traffic, reducing crashes between cars. Yet another example would be a new off-road path diverting cyclists to a different route entirely, thus reducing problems on the old routes.

A different type of benefit that can arise from bicycling facilities accrues to residents of the area in general, in the form of what can be called a quality of life or option value benefit. The idea here is that a bicycling facility can create recreational and even transportation options for residents that were not previously available; having these options available has value to people even when they are not using them. The possibility of a bicycle ride is one valuable option, and bicycle facilities can also be used for other activities such as walking, running, and skating.

Another type of option value could occur when a facility is among the first in an area. In this case it may be too small and isolated to be used much, but it may represent the first step in a system that will eventually be much larger. That is, because everything can't be done at once, some facilities that may appear underused at the beginning could be serving a valuable purpose as a backbone for a more comprehensive future system.

These types of benefits can be particularly hard to value, but are no less significant for that. A case could be made that many of the things that people spend money on cannot be justified by how much they are actually used; people pay a premium for these things because they want to have them available when they want to use them. For many people memberships at health clubs may be in this category. Bicycle facilities should not be evaluated solely on the basis of how much they are used.

In principle quality of life benefits of bicycle facilities might be reflected to some extent in housing prices; people should be willing to pay slightly more to live close to nice facilities. However, it can be hard to discern any such premium out of the plethora of factors that affect housing prices.

A final important point is that the value of these benefits depends on the attractiveness of the facility. A facility that few people want to use, for example because it is poorly maintained and is in an unattractive setting, probably does not create much option value for the nearby residents; an option only has value if there is some chance it will actually be exercised. Similarly, a small, isolated facility in an area where it is unlikely to ever be expanded may not have much value as a future system backbone.

Facility Economic Benefits

A third type of benefit that can arise from bicycling facilities accrues to residents of the area, and perhaps more broadly, in the form of increased economic activity. The most extreme forms of this occur in non-metro places with very large attractive bicycle facilities, where visitors will come to bicycle on the facility and then spend the night in

local lodging, eat dinner, and perhaps shop at local stores. This is not that common, but occurs for example in situations like the Root River Trail at Lanesboro, Minn., and the network of mountain biking trails in the Chequamegon National Forest around Cable and Hayward, Wisc. (17)

Typically this type of impact occurs when there are other interesting features in the area to occupy visitors when they are not bicycling. Most rural trails have not had the kind of impact that the Root River Trail has had on Lanesboro; indeed, even that trail has not had anything like the same impact on other towns that it passes through. Nonetheless, these places as well as many others around the U.S. do provide evidence that well-placed, attractive bicycle facilities with the right supporting environment can have a very substantial impact on local economies (18, 19).

Less direct impacts are more common but can still be significant. Many areas whose primary draw is some other form of recreation still see value in maintaining some bicycle facilities. Although the bicycle facilities may not be a major attraction in their own right, they can serve to increase the range of options available to visitors to an area (20). This can have marginal but important effects like inducing people to stay an extra day, to lodge locally rather than in a less expensive but more distant location, or even to choose that area rather than another one that may be similar in other respects. In other words, people may not come specifically to use the bike facility, but it may influence their decision on how long to stay or which location to visit, with potentially major economic impacts.

Finally, smaller impacts can come from local visitors or day-trippers purchasing food or drinks along the trail, or perhaps eating a meal. These are probably not the sort of impacts that are going to lead to new businesses or jobs, but they can make existing businesses more profitable.

Given the broad definition of facility that we are using, another different example of a facility impact would be events and large group rides. Like physical facilities, these are situations where a specific decision and investment leads to specific impacts. Broader policy and infrastructure decisions can play a role in the feasibility of these types of events.

Facility Demand-Related Benefits

Bicycling facilities can also create indirect benefits. By improving conditions, either in general or by reducing a location-specific problem, they can induce additional people to cycle, or encourage current cyclists to ride more often or longer. Thus in evaluating the benefits of a particular facility, it is necessary to consider the extent to which the total amount of cycling will be increased, and the value that is created by this. The question of the size of the benefits that are created by a given level of bicycling, or by a change in the current level, is discussed in the next section of this report.

The question of how facilities contribute to the total amount of bicycling is a complex one, and is not well understood at this time. Simple and reliable tools for estimating and predicting the amount of bicycling in a given area, and how this amount depends on bicycle facilities and other conditions, would be useful for a variety of investment and policy decisions. However, while the desirability of such tools is generally recognized, and although there have been a number of efforts to model demand either for specific situations or more generally, no modeling technique or set of parameter values or even rule of thumb has emerged as definitive.

A good first step in thinking about how to model bicycling demand is to understand the types of questions that the model might be used to answer. Porter, Suhrbier, and Schwartz (21) list three major questions, paraphrased here:

1. How many people will use a new facility?
2. How much will total demand increase given an improved facility or network?
3. How does bicycling affect public objectives such as congestion and air quality?

To this list could be added: What are the total benefits that bicycling creates, including the benefits to cyclists themselves, such as improved health and recreational opportunities? The answer to this and the previous question could be useful politically, in justifying public spending on bicycle-related projects. The answers to the first two questions are likely to be more useful for technical analyses, in prioritizing projects given limited resources.

Another way of approaching the problem is to note that there are three different demand prediction objectives:

1. predicting the total amount of bicycling in an area or on a facility,
2. predicting the marginal amount that total demand will change given a change in facilities or policy, and
3. identifying areas where inadequate facilities appear to be holding the level of bicycling below its potential, as in the “Latent Demand” approach (22).

In principle, a model that explains the total amount of bicycling as a function of basic potentially influencing factors such as demographic, policy, and facility variables, would answer all of these questions at the same time. Most past work has taken this kind of approach. Federal Highway Administration (23) and Texas Transportation Institute (24) completed major surveys of non-motorized modeling techniques in the late 1990s; the majority of the efforts they describe focused on predicting either commute shares or total bicycle travel by reference to characteristics of the population and land use of the area being considered, and typically to some measure of the bicycling environment. More recent efforts such as Dill and Carr (25) have also used this methodology.

Results of these efforts have been mixed. While certain demographic and geographic variables routinely emerge as important, evidence linking bicycle facilities and policies to levels of cycling has proven hard to come by. Dill and Carr note that there is somewhat of

a consensus that such evidence has not been established; and that even the positive relationship that they observe could arise from high levels of cycling creating a demand for bike facilities, rather than the facilities inducing the cycling. In general it has been hard to find strong relationships because the differences in levels of bicycling across different areas can be very large in relative terms, much larger than can reasonably be explained by differences in the bicycling environments. Unmeasured factors, perhaps cultural or historical, appear to play an extremely large role in determining the level of cycling in an area.

A second, less common type of demand prediction method uses census commute-to-work shares, often combined with other data, to provide an area-specific baseline of bicycle usage; this can help to neutralize or perhaps proxy for some of the unmeasured factors that can have such a large impact on demand. Epperson (26) in Miami used census data combined with demographic factors for estimating bicycling demand generally. Goldsmith (27) in Seattle used census data combined with local information to predict likely changes in bicycle commuting due to facility improvements.

We are generally of the opinion that the second approach will probably be more useful from a practitioner's perspective. That is, if the objective is to produce predictions that will have practical value, then all available sources of information should be utilized, as long as they contribute something useful. Estimating the impact that a given facility will have on total riding in an area is likely to be more accurately accomplished by starting from an accurate estimate of how much riding is being done currently, and assuming a small percentage increase from this level. For situations where the facility is intended to draw bicycle traffic from less desirable routes, again this can be best determined by starting from a good estimate of how much riding is currently taking place, rather than trying to derive a number from scratch based on characteristics of the area.

The current level in an area can be estimated with some degree of accuracy by using existing surveys such as the census commute to work data, the National Household Transportation Survey, and local travel behavior surveys such as the Travel Behavior Inventory in the Twin Cities area. These sources could be used to derive a range of possible cycling levels both over an entire area and for specific locations within it. Such estimates could then be supplemented by using counts of bicycles on a sample of facilities and roads of various types around the area in question. A methodology for doing this is beyond the scope of the present report, but an example of using counts to estimate total bicycle miles of travel is outlined in Davis's 2001 report for Mn/DOT (3).

General Benefits from Bicycling

A second, distinct category of benefits that can be related to bicycling are those benefits that accrue to cyclists or the broader public because of the act of bicycling and the presence of a bicycle-friendly environment in a more general sense; as opposed to those benefits that can be directly traced to a specific facility or program. For example, people who bicycle derive health benefits from doing so, but these benefits have to do with the

act of bicycling in a general sense; they are independent from the specific facility on which the cycling takes place.

While these kinds of benefits may not enter directly into a benefit-cost analysis for a particular project, they are still of considerable indirect importance. Bicycling creates a level of benefits as a baseline; this level, and the possibility of increasing it, can be used to justify general levels of expenditure on facilities and programs. In addition, a major potential impact of new facilities is to improve the cycling environment in general; by making cycling more attractive they may eventually increase the number of participants and increase the level of these baseline benefits, albeit in an indirect way. These are the demand-related facility benefits that were discussed in the previous section.

General User Benefits

Possibly the largest single benefit of bicycling in general is the value of recreation. People bicycle because they enjoy it; this has real value even if it is not reflected in any monetary or market transaction. This value is reflected indirectly in the fact that people spend several hundred dollars typically to purchase a bike in the first place; this indicates that they place a high value on having the option available to go for a ride, and that they expect the eventual benefits of the riding that they will do to generate total benefits in excess of the up-front costs. An improved bicycling environment will make riding more enjoyable when it is done, and will likely increase the frequency with which it is done, making the total excess benefits even larger.

While recreation may seem like a so-called soft benefit (that is, difficult to quantify and perhaps somewhat optional in nature), it is actually of very considerable importance. In general, a very large part of the typical household's spending has more to do recreation or entertainment than with necessity. Looking at transportation specifically, a case could be made that a not insignificant fraction of government and personal expenditures have a primary or secondary purpose to provide access to recreational opportunities. The only difference with bicycling and bicycle facilities is that the travel itself is the recreation, rather than the travel being a means to access recreation that is located elsewhere. The transportation system provides a service to people who wish to use it to improve their lives through access to practical opportunities or to recreation. Both of these are valid uses; they are even hard to distinguish at times.

Another major general benefit to users, or bicyclists, has to do with improved health, including cardiovascular fitness and decreased susceptibility to common serious ailments such as heart disease, problems associated with excess weight, and emotional disorders such as depression. In principle, of course, any form of aerobic exercise can have these positive effects. Bicycling, however, has the advantage of being an activity that a large fraction of people find enjoyable, and staying with an exercise program long enough to reap benefits is more likely when the activity is enjoyable in its own right. In this sense expenditures focused on increasing the rate of bicycling could have more impact on improving health than other types of programs.

Our concern here is specifically with non-monetary health benefits; that is, simply the greater sense of well-being that comes from being healthy rather than sick. There are also monetary benefits of better health such as reduced medical costs and less missed work. However, we include these later as societal benefits, since in most cases they will accrue to society more broadly rather than directly to the individual. Most people do not pay their own medical or insurance costs, and if they do, those costs generally are not dependent on the health of the particular individual. While in some cases the healthier individual may see monetary benefits, it is simpler conceptually to just count all of these types of benefits as societal.

Against these positive health benefits must be set the negative benefit, or cost, of bicycle accidents. While these costs can be significant in the aggregate, they are, as discussed in the previous section, amenable to reduction through appropriate programs or facility investments. They should, however, still be tracked in order to have a complete picture of the benefits of bicycling in general.

Bicycling can also provide an inexpensive form of basic mobility for those who are not able to afford an automobile, or who have no compelling need to own one, and for whom transit may not be sufficiently fast or flexible for all the trips that they want to make. This can be a very considerable benefit to those individuals, although in Minnesota at least they are relatively small in number, at least among adults. For children bicycling could be a very substantial factor in providing basic mobility. However, the extent to which it is used for this purpose seems to be declining over time. It is not clear to what extent this is due to concerns about crime, or an unsafe bicycling environment, or just general attitudinal changes.

A final important general benefit to users is the possibility of lower costs for utilitarian trips such as commuting to work, for those adults for whom other modes are available. This can be a sizable benefit for those who work in areas with high parking costs, although it may not be that significant in most other cases, and could even be more expensive when time costs are considered. Indeed, if it were in fact cheaper in some clear cut way, one would expect to see much more of it being done, given most people's apparent concern with finding the best deal on the goods and services they consume.

General Societal Benefits

Probably the most significant general societal benefits are reduced health insurance costs and improved productivity. While the individual is made healthier by biking, and benefits from this at a personal level, the monetary benefits will accrue more to society at large, because health insurance costs are spread over the population rather than being determined at an individual level. Similarly, taking fewer sick days will affect overall company and social productivity, regardless of whether this is directly reflected in the worker's wages.

Bicycle activist literature often makes much of a set of benefits that bicycling is thought to provide to society in the form of reduced congestion, pollution, infrastructure costs and

so on; these can be conceptually grouped together as auto substitution benefits. These benefits are based on a presumption that a substantial fraction of bike trips are replacing car trips; this in turn arises out of the common focus in the advocate literature on utilitarian rather than recreational trips. The latter are almost certainly not replacing car trips, and may even be adding to them if people drive to a facility some distance from their home in order to go for a bike ride.

However, at least some bike trips do replace car trips, and will reduce various auto-related problems by varying amounts depending on circumstances. Perhaps the most significant is reduction in vehicle emissions; these can be relatively large because short car trips produce disproportionate amounts of pollution. It is also worth noting that bike trips by children might in many cases be replacing car trips if the child would have been driven to the destination otherwise. However, there is no data on which to evaluate this question.

General Economic Benefits

The final category of baseline benefits is those impacts on local and regional economies that occur due to bicycling in general, as opposed to those that are attributable to a specific facility. The primary example of this is sales and repairs of bikes and supplies. Bike shops, and all the jobs they create, are directly dependent on the amount of bicycling in general. More basic bicycle-related employment, such as manufacturers and distributors of bicycles and supplies can also be significant, although their business may be more dependent on a broader national or even world market rather than the amount of local bicycling. Finally, many tourists bicycle during their trips, either as a primary or secondary activity. To the extent that the opportunity for bicycling was a factor in deciding their trip destination or the length of their stay, some of their expenditures can be considered to be due to bicycling. These can be very significant at the local level.

Chapter 4 Estimates of the Benefits of Bicycling in Minnesota

This chapter outlines some estimates of the likely sizes of bicycling benefits in Minnesota. The objective here is not to give precise numbers; in most cases the underlying data and methods are not sufficient to allow much precision. The point here is to understand which benefits are big and which are small, and roughly how big they are for purposes of further discussion.

We focus here on the general benefits as described in the last chapter. While facility-specific benefits can be significant, the fact that they are dependent on the nature of the facility makes them hard to evaluate in a general way. Our objective here is to outline the benefits of bicycling more broadly, to make the point that investments do have payoffs in a sense that goes beyond a specific facility.

We estimate benefits in reference to bicycling in general by combining our own judgment and basic facts about bicycling in Minnesota with insights and estimates from the bicycling literature and other sources. We rely primarily on relatively easily available information. Because we take a very broad view of benefits rather than targeting a specific type of benefit for detailed study, our resources did not permit a major effort at primary data collection. Our original effort here is more theoretical; that is, to estimate the approximate sizes of a variety of benefits using a conservative and economically rigorous methodology. Such work is in limited supply in the literature because so much of the work in this field is motivated, directly or not, by advocacy.

Our primary focus here is on the benefits that are large, relatively certain, relatively widespread, and easy to understand. Fortunately those that are large also have the other qualities. There are three of these: non-monetary recreational and health benefits to bicyclists, reduced medical and productivity costs to society due to improved health of cyclists, and economic impacts and job creation. While other types of benefits, such as congestion and pollution reduction and reduced transportation costs are often cited in the bicycle advocacy community, we find that these benefits are quite small and relatively uncertain compared with the first three. We briefly discuss these benefits as well, both to show that they are small relative to the others, and to outline in more detail our arguments for why we believe the typical advocate reasoning is inappropriate.

In general the size of the benefits depends on the amount of cycling that takes place; we assume the amount that is described in the chapter on basic facts about bicycling. For purposes of calculating total benefits, we need information on total person-days of bicycling and the total number of bicycle miles traveled. The population of Minnesota includes about 4 million adults and 1 million children. About 1.6% of the adults and 5.5% of the children ride a bike in a given day; this gives roughly 65,000 adults and 55,000 children biking on an average day. Supposing that the cycling season is about 200 days, this gives a total number of bike-days of 24 million, of which 13 million is by adults and 11 million is by children. Multiplied by an average daily distance of about 6 miles, this

gives 144 million bike miles traveled each year; of this 78 million is by adults and 66 million is by children.

User Benefits: Health and Recreation

In general people bicycle because they enjoy the activity and the improved sense of well-being and health that comes from it. There is value in this, although it is not reflected in any monetary transaction. An improved bicycling environment will make riding more enjoyable when it is done, and will likely increase the frequency with which it is done; both factors will increase the overall size of this benefit.

Our concern here is with the non-monetary benefits derived from user enjoyment of bicycling and its effects, including health. By this we mean simply the greater sense of well-being that comes from being healthy rather than sick. There are also monetary benefits of better health such as reduced medical costs and less missed work; these are discussed later as societal benefits.

It is hard to place a value on recreation and on improved health separately. One approach to dealing with both these issues is to treat them jointly. This approach would assume that the individual who chooses to ride a bike derives some personal non-financial benefits from doing so, in terms of better health and general enjoyment, but does not try to disentangle this bundle of benefits into its components, instead simply comparing the overall size of the bundle to the costs of participating in the activity. For any person who participates in the activity, the bundle of benefits must exceed the time, money, or other costs of participation. Estimates of non-monetary value then reflect this entire bundle rather than any individual component of it.

While there is a monetary cost to owning and maintaining a bike, the apparent cost of any given ride is generally very low. The larger cost of riding is the value of the time that it takes. If one supposes, as is common in transportation work, that the average person values time at about \$10/hr, then the typical hour bike ride, including some preparation and cleanup time, must be generating at least \$10 in non-monetary benefits to justify the time taken. Since the total benefits must *exceed* the total costs to justify the activity, the total benefits are certainly higher than this.

Three methods for estimating the value of recreational activities and facilities have been informally sanctioned by the federal government in the form of guidelines for their application. All tend to yield similar results. Perhaps the most relevant for this situation is the “travel cost” approach. Very briefly, the idea of this is to measure and value the time spent accessing the activity, and to value the *net* benefits of the activity as being at least this value. That is, the total benefits of participation, minus the costs incurred by participating, must be greater than the cost of accessing the activity in the first place. A person who makes a two hour round trip to get to a bike trail, at \$10 per hour, must place a net value on the bike ride itself of at least \$20.

A wide variety of studies of outdoor recreational activities (non-bicycling) generated typical values of about \$40 per day in 2004 dollars (28). If a typical day of recreation is about 4 hours, this would be about \$10/hour. Note that this is an estimate of the *net* benefits, above and beyond the value of the time taken by the activity itself. This estimate is also in line with a recent study of urban trails in Indianapolis, which used the travel cost method to find typical implied values per trip of about \$7 – \$20 (29).

Applying a value of \$10 per bike-day (since the “typical” day involves about an hour of total bicycling activity) to 24 million bike-days per year in Minnesota gives a total annual non-monetary recreational/health benefit of \$240 million. This is a very significant benefit, and it has important policy implications in that off-road trails are the preferred riding environment, especially for recreational riding. This is confirmed by measurement (3) in which these trails are much more heavily utilized than other riding options in the Twin Cities area, and by survey (11, 30) in which trails are by far the preferred riding environment for most people. The presence of trails very likely induces more people to ride, and gives them a more pleasant (and benefit-generating) experience when they ride.

General Societal Benefits: Reduced health costs

The significant societal benefits of bicycling are monetary, in the form of reduced health insurance costs and improved productivity. While the individual is made healthier by biking, and benefits from this at a personal level, the monetary benefits will accrue more to society at large, because health insurance costs are spread over the population rather than being determined at an individual level. Similarly, taking fewer sick days will affect overall company and social productivity, regardless of whether this is directly reflected in the worker’s wages. Even if these things do sometimes ultimately pay back to the individual, it is simpler conceptually to just count them all here.

The benefits of physical activity in enhancing overall health are well established (31, 32). The task of attaching monetary amounts to levels of physical activity is a more challenging endeavor. Estimating the effect of physical inactivity on direct medical costs is a strategy often employed. A few examples of this exist in the literature. One class of studies comes from state governments (33, 34) estimating the annual increase in health care expenditures for the state as a whole due to physical inactivity in the population. These generate a very wide variety of results, in part because they include different costs, and in part because of differing methodologies regarding the impact of exercise on medical costs.

Teasing out the specific impact of exercise is the difficult part of this problem. All agree that people with bad health habits incur much higher medical costs than those with good habits. However, bad and good habits tend to come in clusters: people who don’t exercise also are more likely to smoke, eat too much and the wrong kinds of foods, and participate in other unhealthy behaviors. People who do exercise tend to do many of the other things right as well. So it can be difficult to ascertain how much of the reduced medical costs are due to exercise versus these other factors.

Disaggregate studies, typically done by academics; attempt to address this problem by estimating costs for specific individuals as a function of their exercise level and other variables (35, 36). These studies, too, are difficult to compare because they include different conditions, outpatient and pharmacy costs, and actual paid amounts rather than charges. Nonetheless, existing literature provides adequate, though developing, methodologies for estimating the public health impact of bicycle facilities in terms of economic impacts.

Annual per capita cost savings as reported in these studies vary considerably: between \$19 and \$1,175. However, the extreme values come from state-sponsored aggregate studies, which are somewhat less rigorous and may not even be considering the same factors. The more rigorous disaggregate studies give values of \$57, \$172, \$176, and \$330.

As a very simple approach to deriving a value for a bike ride, consider the following. The number of days of exercise per week that is considered to meet the standard of “physically active” in these studies ranges from three to five. About 3 ½ days a week would be about 175 days a year. This corresponds to the middle range of the annual cost savings from the disaggregate studies. So approximately, one day of physical activity (for 30 – 40 minutes, the duration of a typical bike ride) gives one dollar in reduced health care costs. This would give about \$24 million per year in reduced health care costs in Minnesota.

Productivity gains are another issue. There is less in the literature on this. A state-sponsored study in Michigan (37) was the only one to try to capture these types of costs. They estimated lost productivity costs due to inactivity to be 30 times larger than direct medical costs; this was more than \$1,000 per person or about \$2,000 per worker. This is quite a surprising result given that these costs have drawn so little attention in the literature relative to direct medical costs. Their results do seem to rely to some extent on what might be considered by some to be generous assumptions regarding the amount of work lost each year due to inactivity-related illness and injury, including a substantial amount of time in which the employee is at work but not functioning at full capacity.

However, even more conservative assumptions support the notion that this is a significant and perhaps understudied cost. Assume for simplicity that the average income is \$50,000, or \$200/day (not that far off for the average bicyclist). Total productivity is higher than this since overhead and profit must be covered as well. So assume total production per person is \$300/day on average. Then suppose hypothetically that every 100 days of bicycling means one less sick day, i.e. that someone who is physically active will take 2 – 3 fewer sick days per year than someone who is not. This does not seem inherently implausible, especially looking over the long term and considering the eventual potential impact of serious chronic illnesses such as heart disease, diabetes, etc. By this math, each day of cycling generates \$3 in avoided productivity losses due to missed work.

Even with more conservative assumptions, that total productivity is only \$200/day and that it takes 200 days of exercise to eliminate one sick day, the productivity benefit of a day of exercise is still \$1. Given that this benefit is seemingly at least as large, and possibly many times larger, than direct medical expenses, it would be a worthwhile endeavor for a future research project to examine it in more detail.

Suppose that about 8 million of the 13 million annual adult bike-days in Minnesota are by people who work. Then the above numbers would give an annual range of \$8 million to \$24 million in increased productivity due to bicycling.

General Economic Benefits

The final category of major benefits is those impacts on local and regional economies that occur due to bicycling. A few studies have been done on this issue. We start from their findings and extrapolate from them based on what we know about how Minnesota differs, and in some cases by making more conservative assumptions.

A major study from Colorado (30) measures the total economic impact of bicycling, including tourism and other special activities, the bicycle industry, and retail sales of bicycles and supplies. Studies from North Carolina and Maine (20, 38) focus specifically on tourism, the former in the case of a limited area and the latter for the state as a whole.

Colorado breaks economic impacts of bicycling into four categories: manufacturing, retail, tourism, and other. They arrived at their estimates through large scale surveys of residents, bicycling-related companies, retailers of bicycles and supplies including shops primarily focusing on other products, and ski areas, which are a major bike tourist destination in Colorado. They also measured the impact of tours, races, and other formal activities. Because of the very broad scope and thoroughness of their study, they form a good basis for deriving and cross-checking equivalent numbers for Minnesota.

Colorado bicycle manufacturing is estimated to generate total revenue of \$763 million, with \$18 million of this going to employee salaries for 513 jobs. The remainder pays for parts and materials, building and other capital costs, and company profit. These numbers seem low in regard to the amount of total revenue that goes to wages, as manufacturing is typically a fairly labor-intensive activity. We were not able to find the source of these numbers to understand why they are so low.

Interpreting “manufacturing” to mean any activity short of retail, there are two major firms in Minnesota. Quality Bicycle Products in Bloomington “is the largest parts and accessories distributor in the cycling industry. [They] answer more than 25,000 calls a month, employ more than 200 people and operate from a newly expanded, 105,000 square foot facility.” Park Tool in St. Paul “has been manufacturing bicycle specific tools since 1963 and is currently the world’s largest bicycle tool manufacturer ... the first choice of professional and home bicycle mechanics around the world.” These two companies combined with a few smaller firms, generate perhaps \$100 million in annual

revenue, and employ roughly 250 people. Compared to Colorado, Minnesota manufacturers employ far more people relative to the amount of revenue they generate.

In Colorado, a survey of specialty bike shops produced an estimate that they made about \$80 million of sales of bikes and accessories. This category includes general sporting goods retailers and a few large catalog operations. There are about 150 of these shops in Colorado. There are about 185 specialty bike shops in Minnesota, a number commensurate with our slightly larger population. While we were not able to get exact revenue information for the largest shops, as this information is proprietary, we did have data on the number of shops with various levels of sales. From this we estimated the total revenue from these shops to be in excess of \$70 million. Assuming revenue per shop the same as in Colorado would give total revenue of about \$95 million, which is not implausible given that we made conservative assumptions about the revenues of the biggest Minnesota shops.

The Colorado study stated that total sales of bicycles and accessories were \$200 million. However, this number was derived from a household survey, which also indicated that 80% of these expenditures were at specialty bike shops. These numbers contradict those from the bike shops themselves, as they reported total sales only half of what consumers reported spending. Assuming that the shops are probably right, total sales in Colorado might have been more like \$100 million, or 25% above the specialty shop total. (Other sources of sales include department and discount stores.)

If a similar proportion of sales between bike shops and other sources hold in Minnesota, total sales of bike products would be about \$90 million to \$120 million, using the more conservative assumptions based on the Colorado study. Given the Colorado ratio of wages to total sales, this would give about \$11 million to \$15 million in wages earned due to the sale of bike products in Minnesota. This equates to about 450 to 600 employees, or full-time equivalents.

Bicycle-related tourism is the most difficult of these benefits to quantify. The essential problem is that many tourists bicycle while vacationing or taking shorter trips, but relatively few of them bicycle exclusively or even as their primary activity. When a tourist participates in a variety of different activities, one of which is bicycling, how much of their total expenditure should be considered bicycle-related? This is especially an issue in Minnesota, which unlike Colorado does not have unique bicycling opportunities; bicycling by tourists here is likely to be part of a broader-based vacation involving many different activities.

The Colorado and North Carolina studies could be criticized for making excessively optimistic assumptions about the number of tourists for whom bicycling was a major factor in their decision to visit, and for considering all of the expenditures by those tourists to be attributable to bicycling, even when the tourists may have only bicycled a few hours or even less. The Colorado study estimates \$250 million in annual spending by bicycle tourists in two categories, summer mountain biking at ski resorts and Colorado residents vacationing in-state. The North Carolina study estimates as a midrange about

\$60 million in spending by bicycle tourists in one small area on the coast. This number in particular seems far too high given the relatively small amount of cycling, both reported and measured. It also relies on extremely generous assumptions about the average expenditures of bicycle tourists.

The Maine study seems somewhat more conservative in its assumptions, both about the number of bicyclists and the average expenditure level. They conclude that bicycle tourism generates about \$36 million in the state per year. Maine has about 50 million annual tourists, of which 2 million ride a bicycle at some point. About 98% of the cyclists are “day trip” cyclists, a category that includes people on one-day trips and people on multiple day trips who cycle for one day. The high proportion of day trip cyclists explains the relatively low average expenditure level of \$18. However, this number is in line with estimates for day trip cycling expenditures in other places.

Minnesota has only about half as many tourists because of its distance from other major population centers, but each tourist spends twice as much on average, so there is about the same amount of total tourist spending (39). Thus we conclude that it is reasonable to assume a similar level of bicycle tourist expenditure, or about \$35 million. This is supported by a trail user survey by the Department of Natural Resources, which estimated that users of seven long and significant trails spend about \$5 million annually (40). Extrapolating to include all other trails as well as riding on roads and streets, it seems likely that the total for the state would be a small multiple of this.

A final category in the Colorado study is organized tours, races, charity rides, and other formal bicycling events of this type. While these events can be significant revenue generators and can have substantial economic benefits to the towns where they are held or through which they pass, as a group they are fairly small compared to the other major categories. In Colorado these events brought in about \$6 million in revenue. Minnesota probably generates a similar amount.

While this total is relatively small compared to other economic benefits, these events can have a very significant impact on the localities where they are held. Unlike other impacts, which tend to be more spread out, events tend to be focused around specific places. As an example, the Headwaters 100 in September attracts about 800-900 riders from the upper Midwest and Canada to the Park Rapids area generally for that purpose only. Most stay in local motels or resorts for 1-2 nights and eat out and shop. Some stay for a week and do other things. Assuming \$200 per person for travel, lodging, meals, registration, shopping generates \$160,000 in spending, which is substantial for a single weekend in a town of 3,000 people.

Minor Benefits

This section discusses three categories of benefits that we believe to be small: lower transportation costs for bicyclists, reduced governmental and infrastructure costs, and reducing problems associated with automobile use. Although our work leads us to conclude that these benefits are relatively small in Minnesota, and probably in most other places, we treat them at some length here because they are generally considered to be of great importance in the bicycle advocacy literature. Because of this we felt that it was important to explain in some depth our reasons for considering these benefits to be of only minor significance.

The arguments for these benefits, and calculations of their sizes, are summarized in the work of Litman (41); his discussion is generally representative of other work in this area. All of these benefits ultimately rely on some assumption of bicycle travel substituting for car travel, with correspondingly reduced costs of some type. There are two broad issues that impact the potential size of benefits from this source.

The first is that the fraction of total bicycling that is actually replacing a driving trip is probably very small. All sources agree that more than half of all riding is recreational or fitness-oriented; these rides almost certainly are not substituting for a driving trip, and may even be creating extra driving if people drive their bikes somewhere else to ride. Even of those trips that are utilitarian in nature, it could be that the trip would have been made by transit, walking, as a car passenger, or not at all if not made by bike. Evidence from the NPTS and the census suggests that those people who usually commute to work by bike are about evenly split between transit, walking, and driving on the days that they do not bike.

The second reason that biking probably does not have much impact on broader transportation problems is that there is so little of it relative to the amount of driving. Total daily miles of travel by bike in the Twin Cities are perhaps 0.25% of daily vehicle miles of travel by cars. This will certainly have no impact on overall infrastructure needs, and it is hard to imagine that it could have much impact on congestion except possibly in a few isolated situations. Considering that the transit strike of 2004 affected probably ten times as many commuters as typically use bikes, with no significant impact on congestion as a result, a few more bike commuters more or less seems even less likely to be noticeable.

Lower transportation costs for bicyclists

The notion that bicycling reduces transportation costs tends to rely on some combination of three assumptions, each of which is questionable. The first is that a bicycle does not cost very much to operate compared with a car. The second is that the extra time (not to mention inconvenience) that is needed to make trips by bike rather than car is not really a cost. The third is that a great deal of bike travel is being done in place of auto travel. We address each of these in turn below.

Litman states (without evidence) that the variable costs of bicycling are one cent per mile. These seem low by perhaps a factor of 10 or 20. Parts wear out, or are damaged in crashes. The chain needs to be cleaned and lubricated; the tires need to be inflated. It is impossible to use a bike for 5,000 miles without doing any maintenance on it, as is routinely done with cars. Even if the rider does this work, the time costs of doing it should be counted as a cost of riding. If one rides any significant amount, or uses the bike for utilitarian purposes, then specialized clothing and other equipment will typically also be purchased.

A pair of mid-priced tires, as an example, might cost about \$50, and might last about 5,000 miles. This is one cent per mile, about the per-mile cost of car tires. Spending three minutes every 100 miles or so to inflate the tires is 50 cents worth of time, or 0.5 cents per mile. The chain should be cleaned every 500 miles at least, at a time cost of about \$5, or 1 cent per mile. The occasional tube puncture imposes a monetary and time cost. As with cars, more expensive repairs and tune-ups are sometimes necessary. Expensive bike-specific clothing, a near necessity if one rides very much, wears out after a few hundred miles (and must be laundered in the interim). We are not aware that anyone has really tried to systematically determine these costs, but the author's personal experience does not lead him to believe that he saves money when he rides a bike rather than driving.

Even in terms of fuel, consider that a mile of biking might burn perhaps 50 calories. A dollar would buy roughly somewhere between 100 and 1000 calories worth of replacement food, depending on the type of food. At 500 calories per dollar, the replacement food is costing 10 cents per mile, a cost that is not really any cheaper than the gas needed to drive a car the same distance. To the possible objection that people enjoy eating but not putting gas in their car, we respond yes, but that benefit is already counted as part of the non-monetary recreational benefits above. Here we are talking about monetary costs, and whether it is possible to save money by riding a bike.

The overall variable costs of operating a car (the costs that actually go up as the car is driven more) are about 15 - 20 cents per mile depending on the degree of stop and go traffic conditions (42). These costs include fuel, tires, maintenance and repairs, and depreciation. Of these, depreciation is probably the only area where a bike is cheaper. Overall a bike seems likely to be more expensive for off-peak travel (when cars are cheaper to operate), and even for peak travel the difference seems unlikely to be more than three cents per mile, and likely zero if clothing is included as part of the cost, as we believe that it should be. This is substantially less than Litman's estimated savings of 11 to 17 cents per mile.

A second point concerns the time costs of biking versus driving. While there may be isolated situations of extreme congestion where biking is faster, in general there will be a time penalty to riding a bike rather than driving. While Litman argues that since this time penalty is incurred voluntarily it should not be counted as a cost, we contend that this falls into the same category as food. Litman's point is that if someone enjoys riding then the extra time it takes is not really a cost to that person. But again, we are counting this

enjoyment value as part of the non-monetary recreational benefits above. The fact that there is a compensating benefit does not mean that there is not a cost as well.

The final issue is the amount of riding that is actually substituting for driving. As discussed above, suppose generously that a quarter of total biking is substituting for driving, or about 36 million miles a year. Half of this is probably off-peak, when there is no savings. Suppose also that the additional time needed to make a trip by bike is ignored. Then the remaining 18 million miles, at three cents savings per mile, gives about half a million dollars a year in total user savings.

Another possible source of user savings is parking, for those commuters who work in areas where parking must be paid for. This may be a bigger issue in other places than in Minnesota, where there are only a handful of places where parking is not free, at least given a short walk. Again, of the bike commuters to these areas, some fractions are probably not substituting for driving anyway. Supposing that there are a few thousand bicycle commuters, who save perhaps a few hundred dollars a year, there would be an additional user savings of another few hundred thousand dollars; again not much compared to the larger benefits discussed earlier.

These results are a small fraction of the level that Litman asserts. We believe that the true value is closer to zero, as we are ignoring the extra time costs usually associated with bicycling, and probably underestimating the monetary costs.

Reduced governmental and infrastructure costs

Litman and some advocates argue that bicycling saves costs of roads, parking, and other transportation infrastructure and maintenance. These arguments, however, rely on a confusion of fixed and variable costs. Most roads are more or less fully funded through fuel taxes and other fees, so that any additional costs created by driving are paid for by taxes on driving. In this sense driving does not create a financial burden on government in general. The one exception is local streets and roads, which are often paid for by property taxes and hence could be considered to be “subsidized.”

However, philosophically, local streets are paid for by property taxes because their primary purpose is considered to be providing access to property, not transportation (43). A person who rides a bike and never drives still needs streets. In any case, the primary cost of streets in most developed areas is for cleaning, snow plowing, and routine maintenance. None of these things will need to be done with any less frequency if bikes are used instead of cars; indeed, they might be even more important for bikes. The need for maintenance arises primarily from weather, the passage of time, and heavy trucks and other equipment, not from cars. The fact that a certain amount of money is spent each year, and a certain number of miles are driven in cars, does not mean that the amount of money would decrease if the number of miles driven did. That is, these costs are largely fixed; riding a bike will not save the government money.

Similarly for parking (the governmental or private costs of providing it, not the costs to the user, which were discussed above), almost all the cost is the fixed cost of creating the facility in the first place; shifting a trip from car to bike will not change this. In cases where parking is in very short supply, the fact that bicyclists are not taking up spaces may create some convenience for others who are able to park in areas that would otherwise have been full, but the value of this seems unlikely to be large or the occurrence very frequent, at least in Minnesota.

One possible exception to this argument would be those cases where costs are incurred to expand streets to alleviate heavy traffic conditions. In this case less traffic could mean eliminating or at least delaying these expenditures. However, as a practical matter, as discussed above, the amount of bike-car replacement is so small that it cannot possibly influence these decisions, even in terms of timing, compared to more important factors such as funding availability, environmental impact issues, and even more significant alternative modes such as transit.

Reducing problems associated with automobile use

A final set of minor benefits are those that have to do with reducing problems associated with automobile use, primarily congestion and air pollution. Other related benefits such as reductions in noise, uncompensated crash costs, and other environmental concerns, are worth much less than one million dollars a year in Minnesota even by optimistic assumptions so we do not address them here. The issue here is whether reductions in congestion and air pollution are major or minor benefits. We argue the latter.

Litman claims, citing a Minnesota study (44), that urban congestion costs range from 5 to 30 cents per vehicle mile. However, this study was examining primarily the Twin Cities freeway and major arterial network, in the context of understanding how congestion pricing could reduce these costs in part by shifting trips to less congested (but slower) alternate routes. Most of the value of the congestion reduction comes from shifting traffic off of freeways and on to other routes. Once this takes place, the congestion costs are already greatly reduced; further reductions due to shifting from car to bike are limited. The average congestion costs on the non-freeway streets that bikes can use is more in the range of zero to 5 cents a vehicle mile; the high end is achieved only in a few especially problematic places.

If the average congestion savings is two cents a mile, and about 18 million miles a year are peak period bike-car substitution miles as derived above, then the total annual benefit would be about \$360,000.

With regard to air pollution, Litman cites sources indicating that average costs of air pollution caused by automobiles are about 5 cents per mile for urban driving and 1 cent per mile for rural (rural emissions cause fewer costs because there are fewer people around to be affected by them). Using the high end of this range since most riding is in cities and towns, 36 million miles per year of bike-car substitution would give about \$1.8

million in benefits. While this is not entirely insignificant, it is at least a factor of ten lower than even the smallest of the major benefits discussed earlier.

Summary of Benefits

Table 4.1 summarizes the benefits discussed in this chapter.

TABLE 4.1: Estimates of Total Annual Benefits of Bicycling in Minnesota

	Total benefits	Adults	Children
User non-monetary	\$240 million	\$130 m.	\$110 m.
Reduced medical costs	\$24 million	\$13 m.	\$11 m.
Productivity gains	\$8 – 24 million	\$8 – 24 m.	\$0
Economic impacts	Approx. 900 jobs, \$30 million payroll		
Minor benefits	Approx. \$3 m.	\$2.5 m.	\$0.5 m.

Chapter 5 Conclusions

The primary objective of this research was to develop an argument that bicycling is an activity that generates substantial benefits both to participants and to society more broadly, and that it should be routinely accommodated as part of the transportation system as well as through specific facilities. There were two major findings in support of this conclusion. The first was a set of measurements of the amount of bicycling that takes place in Minnesota. These measurements were used to develop the second finding, which was estimates of the various benefits that bicycling creates.

There are not a lot of bicyclists on any given day – on average about 1.5% of adults and 5% of children. But a large fraction of the population does participate at least occasionally; probably about half of adults will ride at least once in the course of a summer. The benefits that result from this riding are large relative to expenditures on bicycle facilities; total benefits are in excess of \$300 million per year. The size of these benefits is particularly impressive when one considers that they are derived from relatively limited use by most of the population. The potential benefits are much higher than this. Perhaps only 10% of adults ride more than six times a year. It is entirely realistic to suppose that much more riding could be taking place.

Bicycles appear with a surprising frequency in advertising of other products, as a symbol intended to increase the appeal of the product being advertised. It is perhaps ironic that bicycles are used so often in advertisements for autos and trucks; the value of the vehicle is apparently enhanced by the fact that it can facilitate biking. Bicycles also appear regularly in brochures and advertisements for vacation spots as well as new housing developments, as a symbol of a good quality of life. These observations are not trivial. They indicate that the appeal of cycling is much more extensive than can be seen by simply observing how much actually takes place.

Much of the discussion of the benefits of bicycling in recent years has focused on bicycling as transportation, with an implicit judgment that utilitarian trips are more valuable in some sense than those rides that are purely for recreation. This discussion also seems to have often been based on a belief that cycling must provide benefits to others besides the cyclist to be worthwhile. These underlying assumptions have led to a focus on the benefits of bicycling as being defined by comparison to cars, rather than thinking about bicycling as a unique activity with its own objectives and benefits.

By contrast, we find that the “personal” benefits to cyclists themselves are much larger than the benefits to society that bicycling creates, and that recreational riding, due to its much larger volume, creates more benefits than does utilitarian riding. And, we see nothing wrong with this. For automobile travel, the idea that the trip should be accommodated is taken as given; no one asks drivers to justify their trip or prove that it generates benefits for someone besides themselves. A substantial amount of driving is ultimately recreational in its intent; the only difference with bikes is that the recreation typically comes from the travel itself rather than from activities at the destination.

In the end, the issue is not about autos versus bikes; it is about people who want to do things from which they derive value, and whether some sources of value have to be justified when others are not. Bicycles are not a general substitute for cars. This does not mean that they do not have a legitimate place as users of the transportation system. Perhaps the best analogy, oddly enough, is with large commercial trucks. These trucks, like bikes, use the transportation infrastructure for different purposes than cars use it. People do not use trucks to commute to work or go to the grocery store, yet they are considered to be valid users of the transportation system; they simply create different kinds of benefits. Similarly, if bicycling generates benefits in excess of the costs of accommodating it, then it should not matter what those benefits are or who receives them.

And in any case, there is no reason inherently to think that the needs of bicycles necessarily must compete for funds with the needs of automobiles. For example, wider shoulders on streets and highways create room for bicycles, but also have proven safety benefits for automobiles; providing better visibility for entering and turning traffic, forgiveness for accidental lane departures, and room for emergency stopping. And the apparent conflict between autos and bikes seems less serious when one considers that almost all adult bicyclists also drive cars, and probably half of drivers ride bikes sometimes. The machines are different, but the people using them are the same.

There is reason to believe that the benefits that bicyclists receive are strongly dependent on the nature of the facilities that they use. This derives from common sense; the personal enjoyment value is the major benefit of bicycling, and some types of facilities are more enjoyable to ride on than are others. It also derives from counts of actual bicyclists, in which off-road facilities are overall much more intensively used than other riding options on streets and roads. Finally, it is reflected in surveys that invariably show a strong preference for off-road facilities, and for on-road facilities with certain characteristics.

The significant amount of cycling by children could have important policy implications in this respect. As with the distinction between frequent and occasional adult cyclists, there may be a large and fundamentally different class of cyclist here, with significantly different needs and preferences than the typical bike commuter. While the frequent cyclists may do a disproportionate amount of the riding, children and occasional adult cyclists are most of the people who ride, and represent most of the potential for increased riding. This perhaps should influence the types of facilities that policy and investment should focus on.

If good facilities provide a superior riding experience, this should provide greater benefits to those that use them, by comparison to where they may have been riding previously. By making the experience more appealing, it should also induce additional people to ride, and for current riders to ride more often. The benefits that are created by a specific facility will depend on the degree to which it induces new riding, and to which it attracts existing riders away from inferior options such as busy streets.

However, although these shifts and increases in riding are central to evaluating facility-level benefits, there is little existing information that can be used to understand what specific facility characteristics will have the greatest impacts on riding patterns. While it seems clear that the overall benefits of bicycling are very large relative to expenditures, and that investment in additional facilities has real potential to substantially increase the size of these overall benefits, the exact form that those investments should take is hard to specify given the current state of knowledge. More research is needed to better understand the details of bicycling patterns and how facilities influence them.

This research could take a variety of forms, each of which could potentially fill in a piece of the puzzle. The major constraint on efforts to understand bicycling behaviors at this level of detail is lack of data; little exists currently, and it is very expensive to collect enough to develop statistically significant results because bicycling is relatively rare compared to driving. Thus the challenge of understanding bicycling behavior lies in making the best use of data that already exists, while supplementing this in the most strategic ways with original data collection.

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