Performance Measures for Bicycling: Trips and Miles Traveled in Minnesota

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ABSTRACT

Transportation managers are grappling with the challenge of implementing performance management systems for all modes of transportation, including bicycling. Comprehensive measures of the magnitude of bicycling for states, regions, or municipalities do not exist. Development of performance measures for bicycling is especially challenging because bicycle traffic historically has not been monitored and, except for the journey-to-work question asked by the U.S. Bureau of the Census, surveys about bicycling have not been administered consistently over time. This paper presents two sketch plan methods for estimating the number of bicycle trips and miles traveled in the state of Minnesota. One approach involves use of results from a decennial travel behavior inventory administered by the Metropolitan Council to adjust and extrapolate estimates from the Census journey-to-work question statewide. This approach indicates Minnesotans take between 85 and 96 million bicycle trips annually. This estimate is likely low because it does not include all recreational trips taken on weekends. The miles traveled measure estimated with this approach (between 165 and 198 million miles) also is believed to be low. The second approach involves extrapolation from a randomized population survey administered annually by the Minnesota Department of Transportation. This approach indicates Minnesotans take approximately 75.2 million bicycle trips annually. The miles traveled estimate based on this approach is 139 million miles. Both approaches have limitations but can be replicated over time to provide information about trends. Additional research and experimentation is needed to develop valid, reliable measures of the magnitude of bicycling, especially at the state level.

Keywords: *bicycling, performance measures, travel inventory, survey, bicycle miles traveled*

INTRODUCTION

How many people bicycle? How often do they ride? How far do they ride? The inability of analysts to answer these basic questions has limited the ability of policy-makers to establish substantive policies, set meaningful targets, plan effectively, and invest efficiently in bicycling infrastructure and programs. Bicycle commuter mode share, the most widely cited statistic used to compare rates of bicycling across states and municipalities, is based on the U.S. Bureau of the Census journey-to-work question, summarizes only the relative proportion of all commuters who primarily use a bicycle, and provides no information about the actual number or characteristics of bicycling trips made for commuting or other purposes. Previous research has shown that the ACS measure underestimates bicycling mode share by a factor of 1.75 to 3.33 (*1*). Policy-makers, transportation officials, and advocates continue to use the journey-to-work measure because it is available, not because it summarizes the most important information needed to plan and develop efficient, safe bicycling infrastructure. New performance measures for bicycling are needed.

This paper presents sketch plan methods for two bicycling performance measures that may be useful additions to the toolkits of analysts who want more complete measures of bicycling but must work with the limited data available to most state and regional agencies. The two measures, number of bicycle trips (NBT) and bicycle miles traveled (BMT), are estimates of actual quantities of bicycling, not simply shares of trips made for a single purpose, and they correspond better to analogs for motorized vehicles (e.g., vehicle miles traveled) commonly used to inform transportation policy-making and planning. Both approaches generate statewide estimates by applying simple factors derived from periodic regional and statewide transportation-related surveys similar to those administered in many states by regional and state agencies. The first approach involves use of information from a regional travel behavior inventory to adjust and extrapolate results from the Census journey-to-work question. The second involves extrapolation of results from questions about bicycling from a general transportation survey administered annually by the Minnesota Department of Transportation (MnDOT). Each approach has limitations, but allowing for known sources of error, the measures result in estimates of the same order of magnitude. Each approach also can be replicated over time given current commitments of agencies to survey administration and data collection. Refinement of measures will be required, however, to increase their utility and integrate them into institutional systems for planning and decision-making.

We begin with a brief overview of the need for new performance measures in transportation, focusing on recent developments related to bicycling. We then present two survey-based approaches to estimating NBT and BMT. Following comparison of results and limitations, we discuss the implications for performance management and the need for additional bicycling-related performance measures.

THE NEED FOR PERFORMANCE MEASURES

Policy-makers have long recognized the need for data and evidence to improve transportation planning and management, and transportation officials at all levels of government have advocated use of indicators of performance to guide decision-making. The U.S. Congress took a major step towards institutionalizing performance management in federal, state, and regional transportation agencies when it enacted *Moving Ahead for Progress in the 21st Century Act (MAP-21)* legislation. MAP-21 requires the U.S. Department of Transportation (USDOT) and the Federal Highway Administration (FHWA) to implement performance management and establish performance measures related to key national goals including, among others, safety, infrastructure condition, congestion reduction, and environmental sustainability. Transportation performance management is defined by the FHWA "*as a strategic approach that uses system information to make investment and policy decisions to achieve national performance goals*" (*2*). There are six key steps in the FHWA framework for performance management: national goals, performance measures, performance targets, performance plans, target achievement, and performance reporting (*3*). For example, with the national goal of increasing sustainable transportation, a performance measure might be the bicycle mode share for commuting, and a performance target might be a bicycle commuter mode share of 5%. The performance plan would be the set of strategies and programs to increase bicycle mode share from its current level to 5%. Target achievement would encompass the set of monitoring and measurement activities to determine whether the 5% target has been attained, and performance reporting would involve reporting of the relative success to policy-makers and the public. Performance management is an iterative process, with performance reporting resulting in revisions to goals, targets, plans, and methods of measurement.

Transportation researchers have contributed to both the theory and practice of performance management, advocating for performance management (*4*), exploring data requirements for assessing multimodal system performance (*5*), proposing sustainable frameworks for implementation and assessment (*6*), and developing dashboards for reporting (*6, 7, 8*). More generally, researchers in the field of public administration have explored strategies for introducing performance management (*9*) and assessed whether commitment to performance management actually leads to better outcomes (*10*). The FHWA has promulgated rules governing performance management by state and regional transportation agencies, and the process of institutionalizing performance management systems is ongoing. Neither scholars nor practitioners have proposed, implemented, or assessed a comprehensive set of performance assessments for bicycling, but measures are being developed.

As noted, the most commonly reported performance measure related to bicycling is bicycle mode share based on the U.S. Bureau of the Census journey-to-work question in the American Community Survey (ACS):

> *How did this person usually get to work LAST WEEK? If this person usually used more than one method of transportation during the trip, mark (X) the box of the one used for most of the distance* (*11*)

This question provides valid, reliable measures of the most frequent mode of commuting, and estimates of bicycling mode share based on this question are the most commonly-reported performance measure related to bicycling. This measure is reported by many state, regional, and municipal agencies and used by federal agencies, nonprofit organizations, and advocates to compare and rank cities (e.g., *12*). The limitations of this measure, however, also are well known. Because it asks only about journey-to-work, it does not include bicycle trips for other purposes. Because it asks only about mode used "usually" for "most of the distance", it does not include part-time bicycle commuters or people who bicycle for part of their commutes. Because it does not ask about frequency of commuting trips, estimates of the number of trips cannot be made. Additional performance measures clearly are needed to plan and assess efforts to provide efficient, safe bicycle infrastructure.

The FHWA has not formally established performance measures for bicycling as part of the federal Transportation Alternatives Program, but the agency has identified "bicycle mode share" and "bicycle activity and safety" as examples of "sustainable transportation performance measures" such as (16). The FHWA also has identified several safety-related performance measures, including number of number of fatalities and serious injuries per mile traveled (*13*). Adapting these safety-related measures for bicycling presents significant challenges because estimates of BMT (i.e., the denominator in the measure) are not generally available.

Researchers are exploring methods for estimating BMT. Nordback et al. (*14, 15* has explored count based approaches that are analogous to approaches used by FHWA and every state DOT to estimate AADB. This approach involves systematic sampling of traffic flows on network segments and use of adjustment factors from automated continuous traffic monitors to estimate annual average daily traffic (AADT) for each segment. Miles traveled for each segment is the product of the segment AADT and its length, and the total miles traveled is the sum for all segments in the network. El Esaway et al. (*16*) have demonstrated this approach to estimating annual average daily bicyclists (AADB) in Vancouver, British Columbia, but did not report estimates of miles traveled. Researchers working with local planners in Minneapolis, Minnesota and Columbus, Ohio have used this approach to estimate annual average daily trail traffic and miles traveled on urban trail networks. Their results show that trail users traveled approximately 28 million miles in 2013 on an 80-mile trail network in Minneapolis (*17*) and about 12 million miles in 2014 on a 110-mile trail network in the Columbus metropolitan area (*18*, *19*).

In Minnesota, the Metropolitan Council has summarized network statistics (i.e., measures of system facilities), reported mode share based on ACS data and its own travel behavior inventory (TBI), and noted the need for additional measures (*20*, p. 107-112). Comparisons of the two bicycling commuter mode share estimates showed that the diary-based measure (2.1%) for the 16-county Twin Cities Metropolitan Area (TCMA) was more than double the Census estimate (0.9%; *1*). Similarly, for the city of Minneapolis, the TBI-based measure of bicycle commuter mode share (9.2%) also was more than double the widely reported ACS estimate of 4.2%. Nonprofit organizations also have proposed various performance measures (*12, 21)*.

In addition to bicycle commuter commode share, other commonly reported performance measures related to bicycling have been measures of infrastructure such as miles of bicycle lanes or protected bikeways and indicators of quality of facilities such as bicycle level of service. These measures of supply are important and useful, but by themselves are inadequate for assessing the performance of a system. Better measures of demand for bicycling are more difficult to develop than measures of supply but are a priority given the need for efficient allocation of resources.

APPROACH, METHODS, AND DATA

Researchers and practitioners interested in measures of demand for bicycling typically work with two complementary types of data:

- Survey data, specifically self-reports of frequency and duration of bicycling and other bicycling-related behaviors; and
- Counts of bicyclists on transportation facilities.

Survey data and self-reports of bicycle-related behaviors are needed to understand how many people within a population bicycle, how often they bicycle, how far they bicycle, why they bicycle, whether they wear helmets when they bicycle, and other behaviors needed to plan public infrastructure and programs. Samples of populations are required to obtain this information because it typically is too costly to conduct censuses of entire populations. Sources of error in sample surveys that ask questions about behaviors include errors in self-reports, sample selection, and random error. Errors in self-reports occur when respondents provide inaccurate responses because their memories fail them or when they minimize negative behaviors or exaggerate positive behaviors (e.g., say they exercise more frequently than they actually do). Good surveys control for these sources of error, but they are present to some degree in virtually all surveys. Sample selection bias is a problem where people who are interested in a topic are more likely to “self-select” to participate in a survey, thereby reducing the sample’s representativeness of the population. Random error occurs simply by chance, that is, results of well-designed sample surveys sometimes may yield results that are not representative of a general population simply by chance. All three sources of error are limitations that are useful to keep in mind in interpretation of results presented here.

Counts of bicyclists on public infrastructure are useful for understanding where and when people bicycle, but they cannot be used to determine how many people in a population bicycle, how far they go when they ride, how often they ride, why they ride, or anything else specific to an individual cyclist's behaviors. As noted in the literature review, traffic counts are used to develop performance indicators for motorized traffic and researchers are exploring using counts to estimate AADB and BMT. In general, however, no state has yet established monitoring networks sufficient for estimating BMT. The approach taken here, therefore, is to rely on survey-based approaches, specifically, re-analysis and extrapolation from existing, routinely administered surveys.

Survey-based Data about Bicycling in Minnesota

Our objective is to quantify measures of demand for bicycling in Minnesota, specifically the number of trips and BMT. Information about bicycling behaviors in Minnesota is available from three scientifically designed, randomized, population-based sample surveys:

- The U.S. Bureau of the Census American Community Survey (ACS). The Census Bureau administers the ACS annually on a rolling basis throughout the year in every county in every state. Results are reported for multiple-year periods to increase the reliability of estimates. As noted, the ACS provides information about commuting mode share, including bicycling, but not frequency of commuting, number of trips, or distances traveled.
- The Metropolitan Council's Travel Behavior Inventory (TBI; *22*, *23*). The Metropolitan Council conducts its TBI for the 16-county TCMA (plus three counties in Wisconsin not analyzed here) approximately decennially. The TCMA accounts for 63.5% of the population over age five in Minnesota. The 2010 TBI, conducted between December 2010 and April 2012, obtained 24-hour, weekday travel diaries from 30,284 individuals in 14,055 randomly selected households. Each person recorded the origin, destination, mode, and purpose of each trip. The TBI provides information about all trips taken during weekday, but because it was not administered on weekends, does not fully account for recreational bicycle trips that likely are taken disproportionately on weekends. Because the TBI classifies multimodal trips by dominant mode in which bicycling is, by definition, lower on the hierarchy than motorized vehicles or transit, it also undercounts bicycling participation during weekdays. The TBI does not record length of trips explicitly, but a shortest-path length can be imputed from origin-destination pairs for individual trips using GIS.
- The MnDOT Omnibus 2013 Public Opinion Survey (*24*). MnDOT annually administers its Omnibus Survey to a sample of individuals that is representative of the adult population in Minnesota. In 2013, Minnesota's population was approximately 5.42 million; the population of adults 18 and over was approximately 4.14 million. The sample size for the 2013 Omnibus Survey was 1,127. The survey, which asks people their opinions about all transportation modes and a wide range of issues, asks people about their frequency of bicycling, perceptions of safety, and other factors that affect their propensity to bicycle.

In sum, relative to our objectives, the ACS data summarize participation in bicycle commuting consistently for the entire state, but do not include information about bicycling for other purposes or miles traveled. The TBI data summarize bicycle trips made for all purposes, including miles traveled, in the TCMA, but they do not include weekend trips when recreational bicycle trips disproportionately occur (Table 1). They include no data about bicycling by people in the state outside the 16-county TCMA metropolitan region, but they can be analyzed for different geographies (i.e., cities, suburban counties, and the exurban and rural "ring" counties that surround the suburban counties. The ring counties are characterized by low population densities, sparse development clustered in small towns, and agricultural/rural land uses, and they serve as a reasonable proxy for the Greater Minnesota counties. The Omnibus survey includes information about frequency of cycling for the entire adult population in the state, but no information about trip purposes or lengths. The Omnibus Survey sample is too small to disaggregate accurately to the county level.

Table 1. Travel and Trip Data Available in Surveys.

Type of Information	U.S. Bureau of the Census, American Community Survey	Metropolitan Council Travel Behavior Inventory (2010-11)	MnDOT Omnibus Survey (2013)
Frequency	Annually	Decennially	Annually
Sample period	Year-round	Year-round	Partial year
Key data	Journey-to-work question	24-hour weekday travel diaries	Frequency of bicycling question (April – Oct.)
Characteristics	"Full-time" Commuting Only	Mode Share, all purposes	Frequency (times / year), no trip purpose data
Specificity of location data	County level	Trip origin and destination by city and county	Twin Cities Metropolitan and Greater Minnesota regions
Trip length	No	Can be imputed	No

To estimate the number of bicycle trips and BMT in Minnesota, we combine information from these complementary surveys to produce two estimates of number of bicycle trips and BMT. In Method 1, we adjust county estimates of bicycle commuting from the ACS to account for the fact that people defined as bicycle commuters likely do not always bicycle to work, and we use results from the TBI to augment ACS estimates of bicycle commuting mode and account for part-time bicycle commuting and non-commuting trips made by bicycle. We then extrapolate results for exurban, ring counties to Greater Minnesota. This procedure rests on the assumption that bicycling patterns in the ring counties are roughly characteristic of patterns in counties in greater Minnesota. In Method 2, we augment measures of bicycling frequency for the "bicycling season" (April – October) from the MnDOT Omnibus Survey with measures of winter-time bicycling and miles traveled from the TBI.

<u>Method 1: Estimating Number of Bicycle Trips from ACS and TBI</u>

To estimate the total number of bicycle trips in Minnesota we:

1. Extracted variables from the US Census Bureau ACS 5-year estimates: Population (B01003), Number of workers (B08301), and Number of bike commuters (B08301) for the state and for each county. The number of workers was adjusted to exclude people who work from home.
2. Calculated bicycle mode share (number of bicycle commuters / number of workers) by county and for different geographies:
    a. TCMA: Minneapolis, St. Paul, Hennepin County minus Minneapolis, Ramsey County minus St. Paul, Suburban 5 counties, Exurban and Rural Ring 9 MN counties.
    b. Greater Minnesota: 71 MN counties outside TCMA
    c. State of MN (calculated as sum of aforementioned geographies)
3. Estimated the ratio of TBI bicycle commuting mode share to ACS commuting mode share for different geographies (to understand general magnitude of underestimation of bicycle commuting in ACS data).
4. Used TBI bicycle commuting mode share for the 9 ring (i.e., rural and exurban) counties to adjust ACS commuting mode estimates for 71 counties in Greater Minnesota.
5. Estimated the total number of bicycling trips in each county by multiplying adjusted number of bicycle commuters times 2 (for return trip home) x 235 (the number of work days in a year after accounting for holidays, vacation, sick, and personal days).

6. Accounted for non-bicycling commuter trips made by bicycle commuters because people classified by the ACS as bicycle commuters may not bicycle every day. The minimum number of days to be classified as a bicycle commuter would be three (of five); we multiplied the number of trips by 60% to obtain a lower, conservative range estimate.
7. Used the ratio of non-commute bicycle trips to commute bicycle trips from TBI to calculate non-work bicycle trips for TBI geographies and for Greater Minnesota and by assuming non-work trips may be made on 260 weekdays throughout the year.
8. Added estimated commuting and non-commuting bicycling trips in each county to obtain estimates of total bicycle trips made in each county during work week (because the TBI provides estimates for trips only on weekdays).
9. Scaled up the estimated number weekday commute and non-commute trips to account for weekend trips.
10. Aggregated estimates of county bicycle trips to obtain estimates of bicycle trips statewide.

As noted, the range of final estimates is believed to be conservative because some types of recreational trips are unlikely to be recorded in the TBI and because it assumes that weekend trips are proportional to weekday trips rather trying to account for the fact that trips for recreation, exercise, and non-commuting utilitarian purposes are disproportionately made on weekends.

Method 2: Estimating Number of Bicycle Trips from MnDOT Omnibus Survey.
Participants in the Omnibus Survey were asked about their frequency of bicycling. The survey question is worded (24):

> *On average, how often did you ride a bicycle in the past biking season (April to October) for any reason?*

The answer options included: *never; 1 time; once a month or a few times from April to October; at least once a week; and every day*.

An estimate of number of bicycle trips made in Minnesota can be obtained by multiplying the number of individuals in each response category by an estimate of the ride count during the cycling season (i.e., April – October) for that category, and then summing across all response categories. We assigned the following number of rides for individuals in each response category:

- Never: 0
- 1 time: 1
- Once a month or a few times from April to October: 7
- At least once a week: 29
- Every day: 214

This approach includes no trips during the five months of late fall, winter, and early spring. To estimate the number of bicycling trips in these months, we use ratios of TBI mode share estimates for the seven month (April – October) and five month (November – March) seasons constructed from data for the entire TCMA region. The ratio of winter to summer mode shares is: 0.25/2.32 = 0.108.

Procedures for Estimating Annual BMT
Estimation of miles traveled annually by bicyclists in Minnesota required information about the length of trips taken by bicyclists. The TBI provides the best data available in Minnesota about the lengths of trips taken by bicycle for different purposes. To estimate miles traveled, we calculated the mean and median trip distances separately for commuting trips and trips taken for all other purposes.

However, because outliers (e.g., a few cyclists with very long commutes) can influence mean values, we used median values for all estimates of miles traveled. Median values are not influenced by outliers and produce more stable estimates of a typical length.

To estimate BMT, we multiplied the median trip length for commute and non-commute bicycle trips times the number of trips taken during the year for each of the TBI geographies and for counties in greater Minnesota. Median trip lengths for trips in ring counties were used to estimate miles traveled for counties in greater Minnesota because it is assumed that travel patterns in these exurban counties are similar to those in counties in greater Minnesota. Mean and median bicycle trip distances for different geographies within the TBI are summarized in Table 2.

Table 2. Median and Mean Network Distance for Bicycle Trips

	Median Distance			
	HBW* (km)	**Non-HBW* (km)**	**HBW* (mi)**	**Non-HBW* (mi)**
Hennepin	9.21	1.88	5.72	1.17
MN-Ring	0.63	3.32	0.39	2.06
Minneapolis	4.90	2.63	3.05	1.64
Ramsey	4.01	2.49	2.49	1.55
St. Paul	8.14	2.37	5.06	1.47
Suburb-5	21.82	1.16	13.56	0.72
	Mean Distance			
Hennepin	10.15	3.61	6.31	2.24
MN-Ring	3.92	4.15	2.44	2.58
Minneapolis	6.68	3.76	4.15	2.34
Ramsey	5.36	3.28	3.33	2.04
St. Paul	8.52	4.50	5.29	2.79
Suburb-5	16.91	2.42	10.51	1.50
*HBW = home-based work trips. Non-HBW = all work trips that are not based in home and all nonwork trips. HBW + Non-HBW = All trips.				

RESULTS: BICYCLE TRIPS AND MILES TRAVELED IN MINNESOTA

Estimates of the total number of bicycle trips and annual BMT in the state of Minnesota and selected sub-geographies are presented in Tables 3 and 4 and in Figure 1. Using ACS and TBI data (Method 1), depending on whether it is assumed that regular bicycle commuters bicycle three or five days per week, the number of bicycle trips in Minnesota is between 87 and 96 million annually (Table 3).

A key assumption in this estimate is that the ratio of non-commuting to commuting trips in counties in greater Minnesota is similar to the ratio for the ring counties surrounding the suburban counties in the TCMA. Assuming that the median lengths of trips taken for commuting and non-commuting bicycle trips in the ring counties and counties in Greater Minnesota are similar, the annual BMT for bicyclists in Minnesota from Method 1 ranges from 165 million to 198 million. Because recreational trips may be longer than commuter trips on average, the underestimate of BMT is likely greater than the underestimate of number of trips.

Table 3. Method 1: Estimates of bicycle trips and BMT in Minnesota from ACS and TBI

Statewide	Population (Age ≥ 5)		Trips - Low Estimate		Trips - High Estimate		Miles - Low Estimate		Miles - High Estimate	
Core Cities	627,861	12.6%	31,568,455	36.3%	36,717,945	38.2%	64,330,319	39.0%	81,782,345	41.3%
Suburban TCMA (5 counties)	2,066,735	41.4%	28,487,560	32.7%	31,072,908	32.4%	47,997,399	29.1%	62,780,683	31.7%
7-County TCMA	2,694,596	53.9%	60,056,015	69.0%	67,790,852	70.6%	112,327,718	68.0%	144,563,029	73.1%
Exurban/Ring County TCMA (9 counties)	462,678	9.3%	5,439,864	6.2%	5,684,446	5.9%	10,608,246	6.4%	10,704,518	5.4%
Greater MN	1,839,126	36.8%	21,579,517	24.8%	22,522,578	23.5%	42,150,122	25.5%	42,521,326	21.5%
Statewide Total	**4,996,400**	100%	**87,075,396**	100%	**95,997,876**	100%	**165,086,086**	100%	**197,788,872**	100%

Figure 1. Estimated number of annual bicycle trips in Minnesota counties (Method 1).

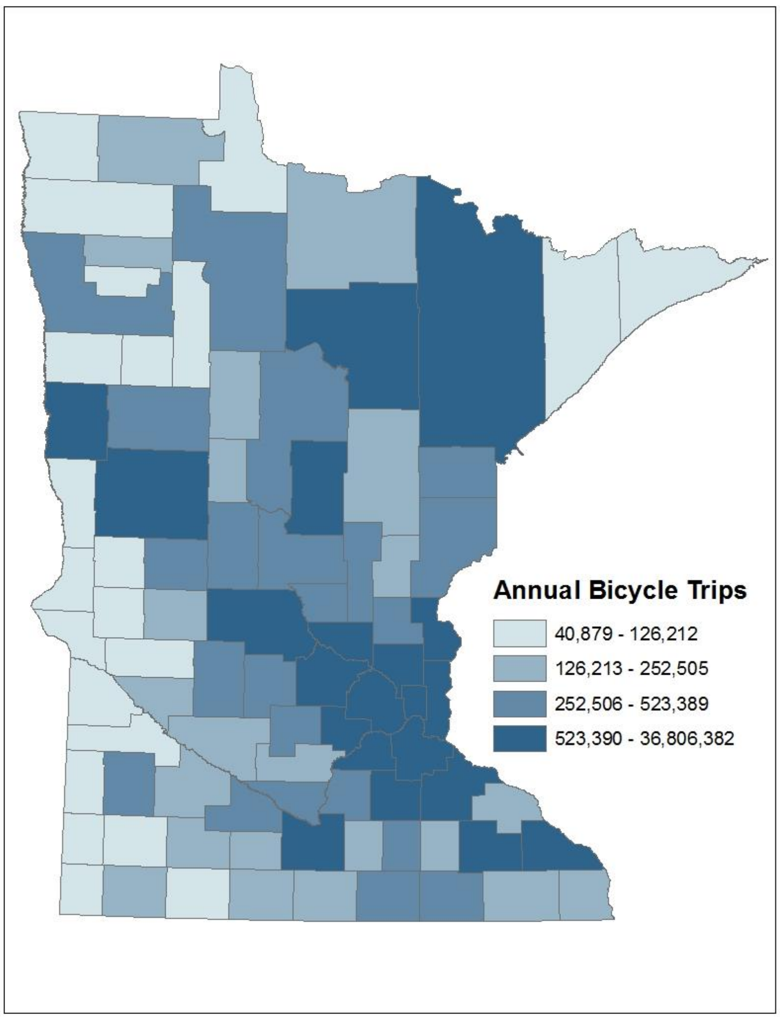

Table 4. Method 2: Estimated bicycle trips in Minnesota(2013) from MnDOT Omnibus Survey.

Reported Riding Frequency (April – October)	Percentage of Respondents in Frequency Category	Estimated Adult Population in Frequency Category*	Estimated Rides During Cycling Season	Estimated Rides April – October	Estimated Rides - 2013
Never	45%	1,897,231	0	0	0
One Time	6%	255,072	1	255,072	282,558
Once / Month	25%	1,043,477	7	7,304,338	8,091,443
Once / Week	21%	881,158	29	25,553,588	28,307,208
Every Day	4%	162,319	214	34,736,184	38,479,308
Total	101%	4,239,256	--	67,849,182	75,160,517

As illustrated in Figure 1 (with estimates using Method 1), trips are higher in counties and regions in the state with larger populations in urban areas. The TCMA accounts for 69%-72% of the total number of trips and miles traveled in the State even though it makes up only 54% of the state's population. This outcome is because the frequency of bicycling is much higher in the Twin Cities, particularly in Minneapolis. Minneapolis accounts for 29% of the number of trips taken annually and approximately 31% of the BMT.

The estimates of number of trips made using results from the Omnibus Survey (Method 2) are the same order of magnitude, but somewhat lower (Table 3). The majority of respondents to the Omnibus Survey (55%) said they had bicycled at least once; 45% percent said they never cycled. Most adults (25%) are infrequent cyclists – about once per month during the cycling season. Only a small percentage (4%) said they ride every day. The percentage of frequent riders – cyclists who said they ride at least once a week or daily – varied little across the state, from 24% in the metro counties to 26% in Greater Minnesota. This result provides support for assumptions made in extrapolating TBI numbers to the rest of the state. Assuming the ride frequencies in Table 3, this approach yields an estimate of 67.8 million trips for the bicycling season. Adding trips for the off-season, the total estimated number of trips for the entire year is 75.2 million, which is somewhat lower than the estimates developed using Method 1. Using the median trip length for all trips in the 16 county TCMA (1.85 miles), Method 2 yields an estimate of 139,046, 956 BMT for 2013.

IMPLICATIONS, OPPORTUNITIES, CHALLENGES AND LIMITATIONS

These analyses present the first-ever estimates of the annual number of bicycle trips and BMT in Minnesota. They also illustrate variation in bicycle traffic across the state in urban, suburban, and exurban/rural areas in the TCMA. The fact that two different methods using different sources of data produce estimates of the same order of magnitude is an indication of convergent validity.

Different sources of error are present in each approach that at least partially account for these differences. The ACS survey and TBI diary methods have been validated over time and yield reliable results. However, because both the ACS and TBI are designed to measure commuting or weekday trips, they undercount bicycle trips made for purposes of recreation and fitness, which disproportionately occur on weekends. The estimates of bicycle trips based on both the ACS and TBI data therefore are conservative. The estimates of trips from the MnDOT Omnibus survey are more likely to include more recreational trips but potentially have other limitations, including undercounting winter trips and, as noted, the possibility that people may have overstated their frequency of cycling. The structure of the ACS journey-to-work question and the TBI diary minimize the type of response bias (i.e., yea-saying) that potentially affects the Omnibus Survey results. Because none of the three surveys was designed specifically for the purpose of creating bicycling measures of performance, these types of limitations are unavoidable.

The procedures used to develop these estimates are relatively straightforward and could be replicated periodically as new results from the ACS or the MnDOT Omnibus survey become available. A limitation is that the TBI is administered only decennially. This means that median trip length and other data needed to estimate BMT could be updated only once a decade or so.

Analysts can use these sketch plan methods to produce meaningful estimates of bicycle travel where individual sources of data are insufficient but detailed travel inventories are available to supplement ACS data. The workflow for each method can be reproduced by following a basic set of steps: extract the relevant survey and ACS components, identify suitable sub-geographies to represent non-surveyed areas, account for the number of represented days per year, and apply the appropriate factors. A strength of these methods is that the assumptions on which they are based are clear: this transparency enables decision-makers to consider the limitations of the estimates explicitly when making policy decisions. Thus, despite these limitations, these methods can be a useful addition to an analyst's tookkit.

Together, these estimates show that Minnesota residents take tens of millions of bicycle trips annually and travel millions of miles by bicycle. From a practical perspective, these estimates can be used to inform and potentially help frame complex decisions. Research has shown clearly that the framing of policy choices influences subsequent decisions and outcomes. For example, based on the TBI results, the TCMA bicycle mode share for the winter season (November – March) is about one-quarter of one percent (0.25%), a proportion that often would be considered inconsequential. Yet this small proportion represents more than 7 million trips state-wide. Use of both statistics could result in different decisions than reliance on the mode-share measure alone. As refinements occur, these types of estimates potentially can be used to establish performance measures, track performance over time, and for other purposes. Further exploration of innovative ways to refine these methods and develop others would be useful.

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