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Planning Essentials

Simple Techniques for Forecasting Bicycle and Pedestrian Demand

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Bicycle lanes, sidewalks, and shared-use paths are some of the most commonly requested transportation improvements in many parts of the country. Increased fuel costs, desire to fit exercise into personal routines, and land-use changes all are driving increased interest in improving bicycle and pedestrian infrastructure. Professional planners, health advocates, and others are seeking solutions to promote bicycling and walking as active transportation, offering "savings in fuel costs, a smaller carbon footprint, and a practical way to achieve recommended levels of physical activity ... an irresistible all-in-one package" (Gotschi and Mills 2008, 3).

A stumbling block for a potential bicycle and pedestrian facility project sometimes occurs in the early scoping stages when a commissioner or other decision maker asks, "How many people would really use this facility if we spent the money on it?" Techniques to forecast bicycle and pedestrian demand vary in complexity. This article provides practicing planners with a toolbox of simple techniques to forecast demand for potential projects based on land-use data planners likely already have on-hand. Recent research indicates some of the more complicated methods may not provide more robust results than simpler techniques, particularly where bicycle and pedestrian modes form a smaller share of the area's full transportation choices. Results from these simple forecasts can be used to help evaluate the potential benefits of a particular project, can be performed quickly, and are easily understood by decision makers.

This article reviews two existing methods for forecasting bicycle and pedestrian demand at the corridor level (Turner, Shunk, and Hotterstein 1998; Krizek, Barnes, et al. 2006) and adapts them to provide planners with a relatively simple, though experimental, method using geographic information systems (GIS) and data readily available in most areas to forecast demand for an entire roadway network. In this article I simplify and combine these two methods into what I call Bicycle and Pedestrian Demand Sketch (BPDS), then illustrate how the methods are applied to a five-county regional roadway network of the Austin-Round Rock (Texas) Metropolitan Statistical Area.

Before a planner can choose a technique that is best for a particular situation, a review of a few of the benefits and challenges of bicycling and walking is warranted.

BICYCLES AND PEDESTRIANS HAVE DEMANDS, TOO?

Planners have known bicycle and pedestrian transportation to be vital components of plans through early Garden City designs, smart growth, and more recent "Healthy City" (Duhl 1986; Kushner 2007) movements. Well-planned facilities for bicycle and pedestrian travel have been shown to have positive impacts on accessibility of destinations (Krizek , Barnes, et al. 2006; Weitz 2003), air quality (Litman 2004; Nelson 1995; and Sharples 1995), congestion (Litman 2004; Nelson 1995), local economies (Buis 2000; Fix and Loomis 1997), personal savings (Litman 2004; Nelson 1995), road maintenance (Litman 2004; Nelson 1995) and safety (Sharples 1995).

Accommodation of bicycle and pedestrian roadway use in the past largely was determined at the engineering design phase, and not a matter-of-course consideration in many roadway projects. Since the 1990s, research and guidelines for bicycle and pedestrian accommodation have increased in the field to be considered a best development practice (Ewing 1996). More recently, research has confirmed that persons with on-road bike facilities near their residence are more likely to ride a bicycle (Krizek, Barnes, et al. 2006, p. 25; Douma and Cleaveland 2008, p. 16).

The Federal Highway Administration has led development of guidelines to help practitioners choose appropriate facilities for both bicyclist (Wilkinson et al. 1994; AASHTO 1999) and pedestrian (Knoblauch et al. 1988; AASHTO 2004) modes. In general, bicycle lanes and separated sidewalks provide a "complete street" accommodation for bicyclists and pedestrians along most major arterial roadways. Streets with lower speeds and traffic volumes may require lesser facilities, including sidewalks on one side of the street in some low-density residential areas.

Infrastructure facilities are only one component related to bicycling and walking. Sener, Eluru, and Bhat (2008) summarize bicycling behavior as involving three major categories: individual and household demographics; individual attitudes and perceptions; and neighborhood characteristics, bicycle facilities, and related amenities. Some of the latest research focuses on use of surveyed actual bicycle and pedestrian traffic, because it incorporates both environmental and behavioral influences on demand (Krizek, Barnes, et al. 2006, 22).

SURVEY SAYS!

Traditional techniques for forecasting future vehicular demand have been found to be not very accurate in most areas of the United States, for the simple reason that there is rarely enough demand to reach the statistical significance needed for most models. The 2002 National Survey of Pedestrian and Bicyclist Attitudes and Behaviors (U.S. Department of Transportation 2003) found only 0.9 percent of all trips in the United States were taken by bicycle, so bicycle counts on a route can vary by a large percentage, with only a small change in numbers. To say it another way, if less than 1 percent of people in a city consider themselves bicycle commuters, would a travel model notice? Many of the popular transportation models do not explicitly include bicycle or pedestrian traffic in the end analysis results, not through lack of interest, but because the results for these modes often cannot meet the statistical minimums for significance. The sampling error alone can reach as high as five times the true value (Krizek, Barnes, et al. 2006, 26).

There are also some real practical challenges with predicting these modes for individual corridors, not the least of which is that very few areas take traffic counts that include bicycles or pedestrians on a broad basis, which would be necessary for calibrating a traditional travel demand model. Recent research on the topic has aimed to develop simple techniques to forecast demand, bypassing some of the problems of statistical prediction within sophisticated travel demand models.

TWO CORRIDOR METHODS

There have been a number of good research projects seeking to find similar answers to those proposed in this article, particularly in the last 20 years or so. Two recent studies and simple techniques are used as a basis for the present work, because recent work has shown a limit to the number of statistically valid variables for bicycle and pedestrian forecasting (Krizek, Barnes, et al. 2006, A-4).

Turner and Colleagues (1998)

Shawn Turner and colleagues' study (Turner, Shunk, and Hottenstein 1998) developed sketch-level techniques for forecasting both bicycle and pedestrian modes using a detailed process that is dependent on localized data, such as occupied housing unit densities and square footage of commercial space. Their procedures "are based on the premise that bicycle and pedestrian travel demand is largely influenced by location, type, and intensity of land use along and for a specific distance away from bicycle or pedestrian facilities" (Turner, Shunk, and Hottenstein 1998, p. 31). The results are not sensitive to the type of facility provided, but they assume that some type of adequate bicycle or pedestrian facility does or will exist in the corridor. The project developed trip generation rates from several Texas cities for use within the state, so the rates may need to be refined in other areas of the country. The authors describe their research as guidelines, breaking down the steps necessary to estimate bicycle and pedestrian travel in a corridor:

1. **Define Study Corridor and Analysis Sub-Sections**. The authors recommend sub-sections break at major intersections or where land-use character changes, between two and four miles for estimating bicyclists, and one-half to one mile for pedestrians.
2. **Define the Influence Area Along the Study Corridor**. The influence area is described as the area from which bicycle and pedestrian travel demand will originate, recommended to be two to three miles for bicyclists on either side of the corridor, and one-half to one mile on each side for pedestrians.
3. **Identify and Quantify Land Uses in the Influence Area**. Land-use data is needed for each sub-section of the corridor, with a single variable needed for each land-use type: single-family residential (dwelling units), multi-family residential (dwelling units), college/university (full-time equivalent students), and commercial (square feet of occupied space). Other potential trip generators should be included, such as transit stations, schools, and recreational areas.
4. **Apply Trip Generation Rates to the Analysis Sub-Sections**. The analyst then applies daily trip generation rates for each land-use type, and densities including suburban, mixed-use urban, and dense or special use. Bicycle trips range from a residential low found in suburban multi-family sites of 0.2 trips per 100 dwelling units, to a high residential land use of six trips per 1,000 full-time students. Pedestrian trips were lowest in suburban single-family residential areas at 0.5 per 100 dwelling units, and highest at dense, multi-family sites at 4 trips per 100 dwelling units.
5. **Sum Trip Estimates for each Sub-Section**. The land uses within each sub-section are multiplied by the trip generation rates to estimate bicycle or pedestrian trips within the influence area.
6. **Sum the Trips for the Entire Study Corridor**. The sub-sections are then added to yield the entire corridor's trips.
7. **Apply Reasonableness Checks and Adjust Trip Estimates if Necessary**. The authors provide the estimated average daily volumes from the test sites to allow the analyst to judge whether results should be revised based on local conditions, which ranged from a low daily bicycle count of 65 on Loop 260 in Austin, to a high of 500 on George Bush Drive near Texas A&M University. Pedestrian daily counts varied from only six on Loop 360 in Austin to 659 on the Allen Parkway/Buffalo Bayou shared-use path in Houston.

Turner and colleagues' technique is somewhat unique, in that it is a single method to estimate two different modes: bicyclist and pedestrian, within the same corridor. The data needed for the estimates are likely available in most metropolitan areas, though the process could take some time for a long corridor, or multiple routes.

Krizek and Colleagues

Kevin Krizek and colleagues (Krizek, Barnes, et al. 2006) recently proposed a very easy-to-use, yet robust bicycle forecasting technique to develop estimates for existing facilities and to forecast potential use following construction of a bike lane or shared-use path. Not only did the researchers devise a straightforward process, they created a simple web application that works for individual sections of a given bike facility called the Benefit-Cost Analysis of Bicycle Facilties tool (available atwww.bicyclinginfo.org/bikecost). Their tool goes much further than estimating potential demand; it provides estimates of how a few bicycle facility types could affect both the induced bicycle commuters, and total bicyclists, in addition to providing detailed estimates of cost and benefits of specific facilities. Following is a brief overview of their bicycle demand estimation process (Krizek, Barnes, et al. 2006, 27):

1. Estimate the number of current adult bicyclists in a corridor using existing commute share, and adding recreational use, expecting more users closer to the facility. The researchers developed three formulas characterizing low, medium, and high amounts of bicycling from studying rates around the United States. The lowest bicycling rates are equivalent to the commuting rate found in U.S. Census Journey-to-Work data, with no significant recreational riding. The medium rate uses a national average of 80 percent of adults who ride bicycles, assuming that 50 percent of them commute (0.4), then adds them to the commute share times 1.2 to include non-commute trips. The high rate doubles the potential commuters (0.8), and includes three times the commute rate.
2. After estimates are developed for low, medium, and high rates of bicycling, the analyst chooses the most appropriate value based on local knowledge and qualitative factors.

These techniques have been developed to work with relatively detailed information at the corridor level. Since many roads are not planned in isolation, but within the context of a network, and limited staff resources have traditionally been devoted to bicycle and pedestrian modes, new techniques are needed to provide rough estimates of bicycle and pedestrian travel using minimal staff time. The proposed adaptation for an entire road network uses some basic components of each of the two corridor methods, applies them using a GIS technique to the roadway system, and can be used for developing a citywide or even regional transportation plan.

Like many of the current planning tools developed for bicycle and pedestrian forecasting, the proposed technique does not include the "supply" component of existing infrastructure or environment. So, it is not sensitive to the induced demand effect of building bike lanes or wide sidewalks, but instead provides a quick look as to potential demand for roadway corridors. The data later can be combined with analyses of existing conditions to prioritize improvements. For example, a jurisdiction may want to complete gaps in sidewalks along roads with the greatest potential pedestrian demand before projects that may serve fewer people.

SOMETHING'S BETTER THAN NOTHING

If you are looking for the definitive answer to know precisely how many people will walk or bike on a specific facility, stop reading now. The proposed Bicycle and Pedestrian Demand Sketch (BPDS) method incorporates any and all of the potential errors in a regular travel demand model, adds some sampling error from journey-to-work modes estimates, compounds them with estimates of non-work trips, and assumes that similar land-use densities draw the same rates of bicycling and walking. Pedestrian volumes are particularly sensitive to local environmental conditions, which are not included in this method.

The reader should note that there are other, very good techniques for estimating pedestrian demand unrelated to bicycle demand such as the pedestrian environment factor (Cambridge Systematics, Inc. 1994) and others. On the other hand, it uses the same information as that used for forecasting automotive modes, without making any claims of actual trip routing or regional travel behavior, and can be very quick and inexpensive to perform. So, this method is seen as a first step in developing estimates across a large area, in lieu of a more in-depth study. It can be performed very quickly and easily, and refined as more data become available.

Though the relative amount of bicycling and walking can vary widely, because of the small proportion of total traffic, the absolute estimates may not be off by a large amount. In addition, Krizek, Barnes and others (2006, 27) point out that because of the relatively low cost of bicycle facilities, the financial risk of mis-estimation is often lower than other facilities. After all, most bicycle and pedestrian facility decisions are made without any traffic counts or notion of potential demand for these modes.

BICYCLE AND PEDESTRIAN DEMAND SKETCH: RUNNING THE NUMBERS

This section illustrates use of the Bicycle and Pedestrian Sketch method. The specific technique used should be catered to both the individual study needs and available information. For this example, data sources include the 2007 American Community Survey 1-Year Estimates, and preliminary regional traffic assignments by the Capital Area Metropolitan Planning Organization for the years 2005 (base year) and 2035 (ultimate forecast year). Most urbanized areas with populations greater than 50,000 have a regional travel demand model, either developed by the Metropolitan Planning Organization for the region or the state department of transportation.

The Bicycle and Pedestrian Sketch method technique can be described as "post-model," because it uses the outputs of a travel demand model as a chief input to estimate future potential demand for a corridor in the region. If a travel demand model is not available for the study area, recent traffic counts also could be used.

In a nutshell, the following method uses forecasted automotive traffic volumes as a proxy for bicycle and pedestrian trip demand, which is then adjusted according to local land-use densities. The process results in estimated bicycle and pedestrian potential traffic volumes for each segment of roadway included in the network, which can be readily visualized with GIS and shared with decision makers. Here are the steps to the method:

1. Assemble Mode Share and Roadway Network Data

The American Community Survey (U.S. Census Bureau 2009) is a readily available source of data for determining an area's transportation modes for workers ages 16 or older for their journey to work, but it does not capture trips made for shopping, school, leisure, or trips by persons under 16 years of age. Using the American Factfinder website data, choose a geography set to represent the area you wish to study. The annual estimates are only available for selected geographies with populations greater than 65,000, so do not be alarmed if your favorite rural county seems to be missing from the list. Try to include a range of city, county, and regional geography to gather mode share data in your area, since that range will allow you to apply more reasonable mode share rates in more and less densely developed areas. Depending on the geography chosen, several specific subject or detailed tables could provide the needed data, but the Subject Table "S0801 Commuting Characteristics by Sex" provides the breakdown of bicycle and pedestrian modes. The Austin-Round Rock metro area data revealed a wide range of bicycle and pedestrian commute shares (see Table 1).

Table 1. Bicycle and Pedestrian Commute Mode Shares, Austin-Round Rock Metro Area

	Bicycle Commute Share	Pedestrian Commute Share
Austin, Texas	0.95%	2.01%
Travis County, Texas	0.73%	1.79%
Austin-Round Rock Metro Area	0.48%	1.69%
Williamson County, Texas	0.06%	1.30%

Source: American Community Survey 2007 Estimates.

A travel demand model network with automotive traffic assignments is not as readily available as Census data, but it may be easier than you think to obtain. The Association of Metropolitan Planning Organizations (AMPO) maintains an online directory of Metropolitan Planning Organizations across the nation. Give your local travel demand modeler a call to be sure to get the data in the format you need, and to determine which field in the database includes total traffic volumes by roadway segment. Once the data are loaded into GIS, consider removing network segments from the analysis that do not accommodate bicyclists or pedestrians, such as freeway lanes or "centroid connectors," which are not actual roads but are used by travel modelers to approximate the travel behavior of a group of local roads. Journey-to-work data is, of course, only one type of bicyclist or pedestrian trip. The next step will add in an estimate of the total trips made, including work commutes.

2. Estimate Total Trips by Mode

Krizek, Barnes, et al. (2006) used surveyed bicycle trip data from around the nation to develop a simple formula that adds all bicycle trip purposes together. The team tested different equations to explain the relationship between the total percentage of adult bicyclists and adult bicycle commuters, and found 0.3 percent plus 1.5 times the commute share was a best fit for metropolitan regions in the United States:

Total bicycle mode share = 0.3% + (1.5 x bicycle commute share)

Running this simple formula for each area type yields an estimated total bicycle commute share for each land density (see Figure 1)

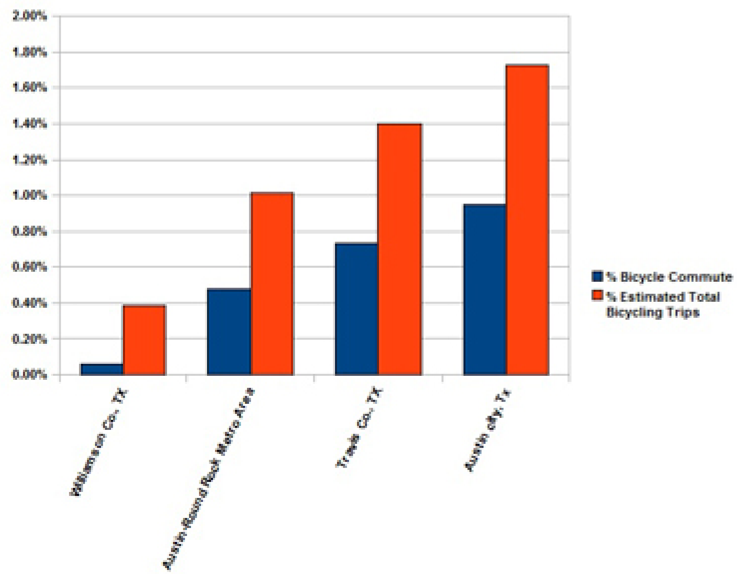

Figure 1
2007 Bicycle Commute and Estimated Bicycle Share of Total Trips for Selected Areas (CAMPO)

A pedestrian corollary to the formula is not currently known to the author, so an un-calibrated estimate is proposed, roughly relating the pedestrian share to bicycle share found in the American Community Survey data.

Total pedestrian mode share = 2.2 x pedestrian commute share

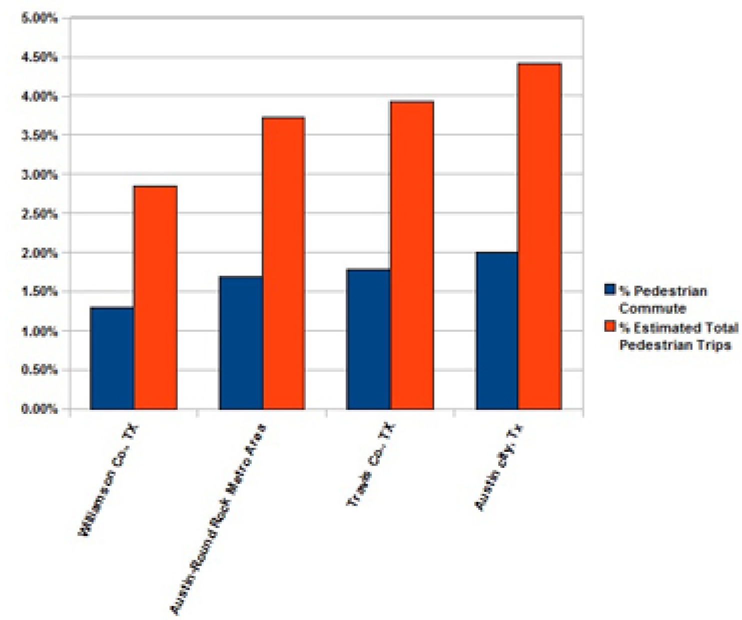

Figure 2
2007 Pedestrian Commute and Estimated Pedestrian Share of Total Trips for Selected Areas (CAMPO)

The coefficient of 2.2, as shown in the formula above for determining pedestrian mode share, should be adjusted with local observations and varied based on the densities in the study area. For illustrative purposes in this paper, the value is held constant as a "straw man." A forthcoming systematic bicycle and pedestrian traffic count in the Austin-Round Rock metro area will provide data for making more accurate estimates in this region.

3. Estimate Mode Shares by Area Type

The next step applies local area mode shares to land-use categories "area types" found in travel demand models. Techniques by both Krizek, Barnes, et al. (2006) and Turner, Shunk, and Hottenstein (1998) utilize land-use densities to form the basis for the number of potential travelers. Fortunately, regional travel demand models also use population and employment densities as broad categories of land use attributed to each network segment. If you have "area types" included in the network, use the mode share data by geography to estimate mode share according to area type. As Table 1 shows, the Austin-Round Rock metro area example includes the highest bicycle and pedestrian rates for the City of Austin, and logically lower rates for more suburban and rural areas. Table 2 is an estimated conversion of these mode shares to area type. Downtown and university areas likely will have higher rates than the densest city in the region, as is the case in Austin, so the most dense area types logically would exceed the mode shares of the most dense city. Conversely, expect rural areas to have considerably lower commute rates, approaching zero where distances are not easily traveled by these modes.

Table 2. Area Type Mode Shares Estimated from American Community Survey Data, Austin Example

	Estimated Bicycle Commute Share	Estimated Pedestrian Commute Share
Central Business District	2.0%	5.0%
CBD Fringe	2.0%	4.5%
Urban	1.5%	4.0%
Suburban	0.8%	2.0%
Rural	0.4%	1.0%

Depending on local conditions, the analyst also could choose to apply the American Community Survey mode shares by county or city on all the roadways corresponding to that area. Adjacent cities or counties with relatively similar densities may be the best candidates for this technique.

4. Apply Bicycle or Pedestrian Rates to Roadway Segments

The trip generation rates as a proportion of automotive traffic are multiplied (likely in a GIS table) by the current, or projected vehicular volumes in the travel demand model network. The author selected each area type in the region and calculated all of the segments using the rates estimated in the previous steps. The other area types then were calculated, yielding an entire regional roadway network with a magnitude-level bicycle and pedestrian estimate and forecast, as depicted on Figure 3 (for bicyclist volumes) and Figure 4 (for pedestrian volumes):

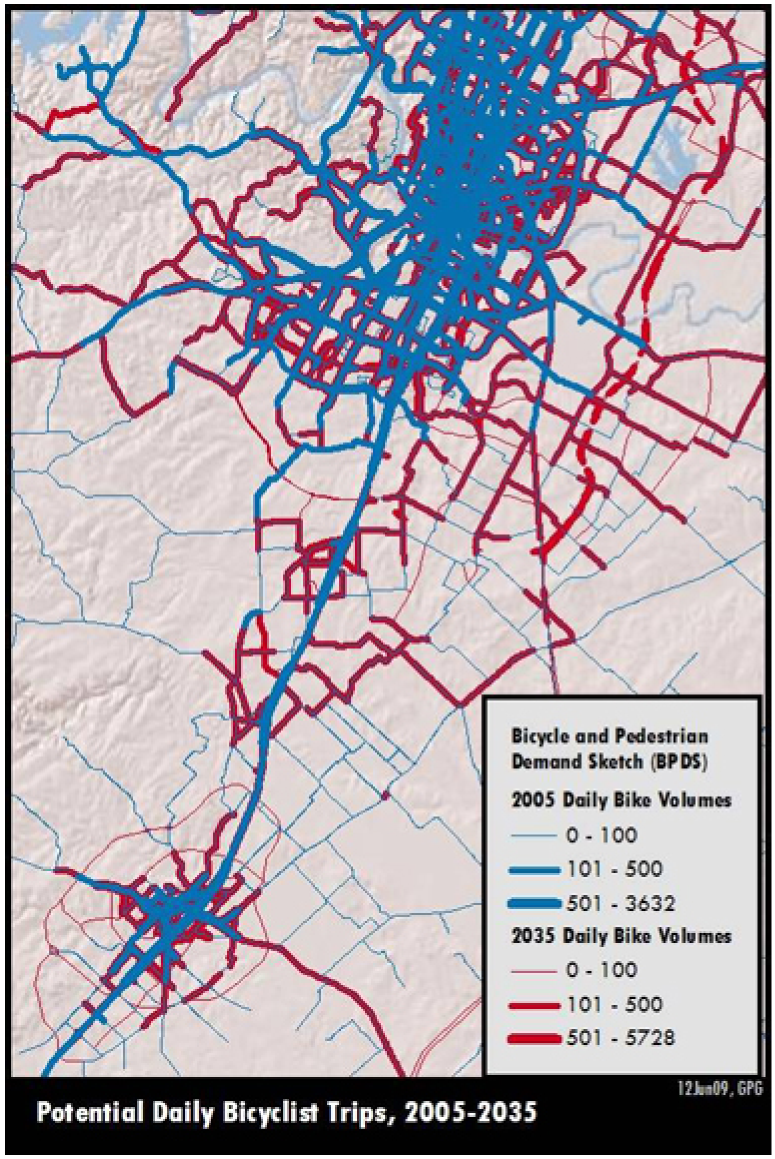

Figure 3
Potential Daily Bicyclist Trips, 2005, 2035, City of Austin and San Marcos

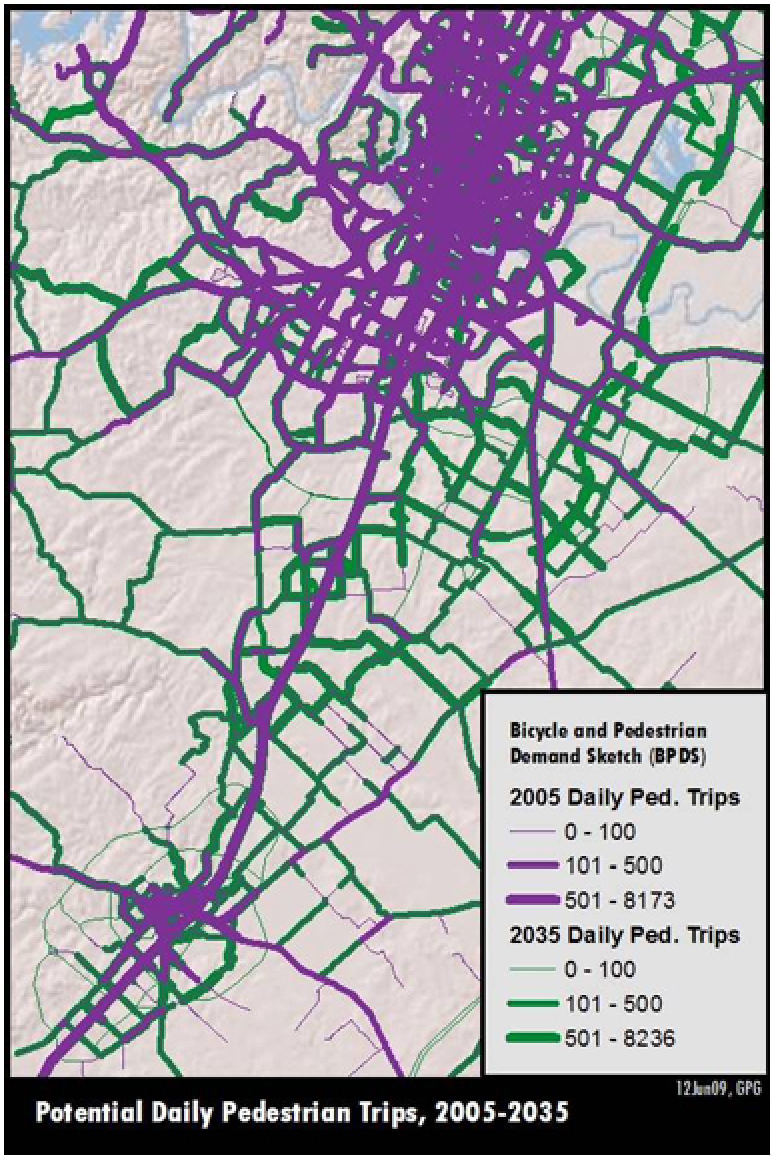

Figure 4
Potential Daily Pedestrian Trips, 2005, 2035, City of Austin and San Marcos

5. Review Reasonableness and Adjust Trip Rates, if Necessary

One advantage of this GIS-based technique over many roadway segments is that the results are immediately available for comparison among different routes. If any bicycle or pedestrian traffic counts are available in the area, they should be used to compare the BPDS process results for accuracy. If not, comparable sites in other areas, such as those provided by Turner, Shunk, and Hottenstein (1998) may be used. More refined estimates may be developed by employing different rates not only by land-use density, but within specific geographies used in the American Community Survey data, as well. In the Austin-Round Rock metro area, Williamson County was found to have very low rates of bicycle commuting (0.6 percent), so using regional estimates may not be as accurate as applying local rates in rural parts of the region.

CONCLUSION

Two corridor-level bicycle and pedestrian estimate techniques have been described and are represented as the state-of-the-practice for the use of planning practitioners interested in current and future rates of active transportation. An additional, network-wide method called the Bicycle and Pedestrian Demand Sketch (BPDS) is proposed as an experimental technique that may merit additional evaluation. Each of these methods uses data readily available to professional planners. I contend that they may find broad application in the field for evaluating competitive project proposals or estimating the magnitude of potential traffic safety issues.

Projecting bicycle and pedestrian trips is a first step in quantifying the benefits for a range of projects that often have been evaluated anecdotally, or in the realm of advocacy for particular modes of transportation. Professional planners should seek to understand a range of issues relating current and future generations to the built and natural environments. Gaining a notion of the volumes of use of our most fundamental transportation modes can be a valuable skill for planners negotiating an often complex relationship between various professionals, advocates, and citizens.

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