Estimating the Economic Benefits of Bicycling and Bicycle Facilities: An Interpretive Review and Proposed Methods

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Abstract
Planning and policy efforts at all levels of transportation planning aim to increase levels of bicycling. An initial step in doing so is to ensure that a variety of facilities exist for bicycling, such as relatively wide curb lanes, on-street bike paths, or off-street bike paths. But bicycle facilities cost money, their merits are often called into question, and many consider spending on them a luxury. Planners and other transportation specialists often find themselves justifying that these facilities benefit the common good and that they induce increased use. Especially in austere economic times, they are often grasping for ways to “economize” such facilities.

The purpose of this paper is to review and interpret existing literature that evaluates the economic benefits of bicycle facilities and suggest strategies for evaluating economic benefits in future work. We first provide an overview of central issues and, in a consistent framework, identify factors that confound the manner in which bicycle benefits are estimated. We then briefly describe 25 studies that speak to economic dimensions of bicycle facilities. The third section interprets the existing literature by describing six core benefits of municipal and regional bicycle facilities. These benefits include direct benefits to the user (mobility, health, safety) and indirect benefits to society (decreased externalities, livability, fiscal). We conclude by proposing how this framework could be built on and challenges that lie ahead.

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Introduction

Planning and policy efforts at all levels of transportation planning aim to increase levels of walking bicycling. In many cases, initiatives are motivated by a desire to reduce auto use and its attendant environmental consequences (e.g., pollution, natural resource consumption). Alternatively they are motivated by concerns of livability, public health, or physical activity. In response, urban planners, transportation specialists, elected officials, and health advocates are all looking to non-motorized travel to address myriad concerns, whether they are environmental, congestion, health or quality of life.

An initial step in doing so is to ensure that adequate facilities exist to encourage use of these modes. For walking, this includes sidewalks, public spaces or street crossings. For bicycling, this includes relatively wide curb lanes, on-street or off-street bike paths, and even parking or showers at the workplace. But bicycle facilities cost money, their merits are often called into question, and many consider spending on them a luxury. Planners and other transportation specialists often find themselves justifying that these facilities benefit the common good and that they induce increased use. Especially in austere economic times, they are often grasping for ways to "economize" such facilities.

Estimating the economic aspects of cycling remains a topic often discussed in policy circles but has yet to be tackled head on. Urban planners, policy officials, and decision-makers lack a consistent framework from which to understand the merits of such facilities. These officials are often bombarded with information and arguments about how much these facilities cost. Opponents of bicycle projects consistently use such information to argue how trimming particular projects would preserve funds. Cost data is readily obtained; it is relatively straightforward to account for the acquisition, development, maintenance and other costs for site-specific or aggregate cases. The benefits, however, are considerably more difficult to estimate.

To respond to such policy and planning needs, the purpose of this paper is twofold. The first is to review and interpret existing literature evaluating the economic benefits of bicycle facilities. The second is to suggest methods and strategies for doing so in future work. As such, the remaining sections of this paper are as follows. We first provide an overview of issues central to this pursuit and identify factors that confound the manner in which bicycle benefits are estimated in a consistent framework. We comment on 25 studies that speak to economic dimensions of bicycle facilities. The third section interprets the existing literature by describing six core benefits of municipal and regional bicycle facilities and suggests example strategies for how each could be estimated. The final section suggests issues to consider and recommendations for future work.

Overview of issues central to estimating bicycle benefits

To set the stage for any effort estimating the economic benefits of bicycle facilities it is necessary to overview of the main issues involved, the matters that confound such endeavors, and a justification for more structured research.

Conventional evaluation techniques suggest that any bicycle facilities should be considered in the same manner as other transportation facilities (e.g., roadways, light rail, HOV lanes) or, for that matter, any major public capital investment (e.g., wastewater treatment plant, sports stadium). Doing so subjects bicycle facilities to the same methodologies or criteria used in these projects such as benefit-cost analysis, economic impact assessment (local, regional or state), cost-effectiveness evaluation, and financial or risk analysis. Of these approaches, benefit-cost analysis is the most well-known and most frequently relied on in transportation projects. It compares the effects of proposed policies or projects on social welfare. It requires identifying all project impacts (positive or negative) in the present and the future and then assigning an economic value to these impacts.

A handful of research studies attempt to calculate benefit cost ratios for bicycle-specific projects. The general approaches and data used in doing so are presented in Table 1, together with ratios. All show that benefits exceed costs. Such consensus is a reflection of a variety of factors, including the inexpensive nature of bicycle facilities (i.e., a low valued denominator) and optimistic adoption rates of such facilities. Most often, however, these studies are troubled by the relatively unreliable manner in which demand is estimated and benefit values are derived.

<Table 1>

The overarching problem is reliably attaching and economic value to a facility for which there is no market value and little data for its use. Bicycle facilities, like wilderness, a clean environment, and access to open space, represent non-market goods not bought and sold. Markets for their price and use fail to exist. There are no prices for their use that can be manipulated and as a result, they represent a good for which it is extremely difficult to derive an economic value. Furthermore, given current levels of bicycling use, the majority for most facilities could be considered a good that is both non-rivalrous and non-excludable. They exhibit characteristics closely resembling "public good" (or at least a quasi-public good).

But if certain goods are thought to contribute positively to human well being, they *are* considered to have economic value (the reverse is also true). The Fields of economics and transportation have devised general methods for estimating economic values attached to non-market goods and services. These include strategies to measure both revealed and stated preferences for a good. The former aim to identify ways in which non-market goods influence the actual market for some other good are can be estimated using methods such as hedonic pricing, travel cost or unit day values. The latter attempts to construct markets, asking people to attach an economic value various goods and services and is estimated using methods such as contingent valuation or conjoint analysis.

Measuring any aspect of bicycling facilities is further complicated because transportation facilities are typically discussed in terms of auto, transit or non-motorized travel; this aggregates walking and cycling. For abstract or general purposes this may suffice and is often done in transportation research. In terms of daily use and facility planning, however, bicycling and walking differ significantly. Pedestrian travel and infrastructure have the following unique characteristics. First, all trips—whether by car, rail transit, or bus—require pedestrian travel because they start and end with a walk trip. Second, sidewalks and other pedestrian related amenities are now often required in zoning codes. Third, pedestrian concerns typically relate to relatively confined travel-sheds or geographic scales (e.g., city blocks). Bicycle travel and facilities, on the other hand, apply to longer corridors, fail to be used as frequently as walking facilities, and are considered more discretionary in nature. Where pedestrian planning applies to a clear majority of the population (nearly everyone can walk), bicycle planning applies to a considerably smaller market of travelers—those who choose to own and ride a bicycle. During the summer months in most of the U.S., this includes just over a quarter of the American population (U.S. Department of Transportation 2003).

The black cloud looming over all analysis of non-motorized transportation (bicycling or walking) is poor data. There exist a variety of sources from which bicycle behavior can be gleaned; for example, the census, metropolitan/nationwide travel surveys, facility specific surveys or counts, or national surveys such as that administered by the Bureau of Transportation Statistics (U.S. Department of Transportation 2003). Specific use and facility information may be available for select areas throughout the country. The strengths and weaknesses of these data sources are adequately documented (U.S. Department of Transportation 2000). A common theme is that existing behavioral bicycle data lacks the both the breadth and quality necessary for reliable analysis. Analysis of cycling use has been especially marginalized because of its relatively low levels of use.

Such data deficiencies are well recognized by the transportation planning community; procedures and protocol for collecting improved bicycle data are in place. In addition, matters of bicycle and pedestrian travel are increasingly on radars outside the transportation community. For example, transportation and urban planning researchers are joining forces with public health researchers to better understand both derived and non-derived forms of "active" transportation (i.e., bicycling and walking). Given that better data is a well recognized matter, it is best to direct attention to other issues important.

There remains considerable range in how to measure bicycle facilities. Confounding issues include: (a) at what geographic level, (b) for whom, (c) specific to which benefits, and (d) using what units. How does one compare the economic benefits gained from Colorado's mountain biking industry to the quality of life or neighborhood-scale benefits from building a neighborhood bike path for children? How do the air pollution benefits of increased cycling relate to quality of life benefits from the serenity of a nearby rail-trail? How reliable are the safety estimates for different types of bicycle facilities, especially given existing debate over on-road versus off-road facilities (Forester 2001; Pucher 2001)? The studies and approaches to date represent initial attempts to understand such benefits. They often do so, over inconsistent geographic scales and making a host of assumptions. Below, we describe in more detail each consideration.

At what geographic scale or type of facility?

The first consideration pertains to the geographic scale of the inquiry or facility in question. Past work has analyzed the benefits of a specific greenway or active recreation trail (Moore, Graefe et al. 1994; PKF Consulting 1994; Siderlis and Moore 1995; Sumathi and Berard 1997; Przybylski and Lindsey 1998; Schutt 1998; Betz, Bergstrom et al. 2003), a specific trunk roadway (Sharples 1995a), a region (Fix and Loomis 1997; Fix and Loomis 1998), an entire city (Buis 2000), or an entire state (Argys and Mocan 2000). Some studies focus on a system of bicycle trails across the state, while others focus the benefits of on-road versus off-road facilities. Different geographic scales demand different data, ranging from individual counts of a facility to aggregated or numbers for a specific area interpolated to an entire state.

For whom?

A second matter relates to the population for whom the benefits apply. Any question of benefits can been tackled in a number of ways depending on the audience of interest and the geographic scope. State legislators may be interested in understanding how bicycling, the bicycle industry or bicycle-oriented tourism impact a state's economy. Such analysis would resemble input/output models examining expenditures across an entire state. In contrast, a city council member may seek to learn how bicycle facilities enhance quality of life for a given municipality. Advocates want to document induced demand for facilities or relationships to decreased traffic congestion. Public health professionals are concerned about the use and safety benefits of such facilities.

Can a single review do justice to the myriad interests and beneficiaries involved? An answer depends on the level of specificity and need of the study. There are competing interests and multiple perspectives to capture. While actual users are likely to be similar for any given facility (i.e., people riding bicycles), the information likely to be of benefit to the state bureau of tourism differs from a municipality looking to justify different types of bicycle investments.

One report identifies three user groups impacted by cycling facilities: road-users, non road-users (e.g., occupants of adjacent properties) and planning/financing agencies (Sharples 1995a). The first group of 'road users' includes all users, cyclists, motorists, pedestrians and horse riders, and public transport. Alternatively, some studies divide the benefits of non-motorized travel into internal versus external benefits. The former include the financial savings, health benefits, increased mobility, and enjoyment for cyclists; the latter include the benefits to others, such as reduced congestion, road and parking facility expenses, accidents, pollution, and natural resource consumption.

Which benefits?

The range of benefits of cycling facilities include (but not limited to) reduced pollution, congestion, capital investments (at least compared to roads and auto use), and increased livability, health, well-being, and quality of life. But anecdotally describing such benefits has limited value. Politicians and lobbyists seek quantifiable estimates. Benefits range from the direct and easy-to-understand to the almost impossible to reliably calculate. Counting the number of cyclists using a new bicycle trail is relatively straightforward. The difficulty is translating such levels of ridership into monetary amounts.

One study suggests seven benefits to consider when estimating the economic value of walking: livability, accessibility and transportation costs, health, external costs, efficient land use, economic development, equity (Litman 2004). Focusing just on greenways, Lindsey (2003) articulates six valued benefits: recreation, health/fitness, transportation, ecological biodiversity and services, amenity visual/aesthetic, economic development. Which benefits are most important? Is it those that are accrued, those in which the sponsoring agency is primarily interested, or those for which there is available data? As an example, Table 2 depicts values calculated for different benefits from six different studies.

<Table 2>

Using what units/method?

A final matter lies in the units and/or methods used to calculate different benefits. An ideal analysis considers benefits in a framework using a common unit. But how does an increase in riders compare to a reduced need for parking spaces? How does increased livability compare with decreased health concerns? Only one article focuses exclusively on methods, reviewing the Travel Cost Method (TCM) for imputing economic value and suggesting better alternatives for measurement (Randall 1994). Quite simply, most studies simply throw their best “guesstimates” at the problem. Methods and units are different, yielding varied output that precludes the desired aim of a common unit.

These include simple counts (e.g., reduced casualties), decibels, monetary amounts (e.g., vehicle operating costs), and descriptive measures (e.g., overall convenience). More specifically, hedonic pricing could measure livability or amenity visual/aesthetic values; economic input/output models could describe economic development; time could measure transportation savings; and surveys of different kinds (e.g., contingent valuation) could capture a host of values or benefits.

Review of previous research

Reviewing past research on this subject in a systematic manner is troublesome on two accounts. First, existing literature can be described “spotty” at best. While growing, the geographic scale, research depth, overall quality, and focus of past study varies considerably. Little is cumulative. Second, there is no clear strategy to delineate what constitutes such a paper. We cast a relatively wide net in what we consider a study of bicycle benefits. Our definition includes any research effort describing or attributing an economic value to bicycling or bicycle facilities.

By our tally this includes more than 25 studies; this comes close to representing the universe of all available and published research efforts. Each of these studies are presented in alphabetical order (authors name) in Table 3, showing the date, title, geographic level, and an indication of whether the report appears in a peer-reviewed outlet. The research ranges from general overview pieces anecdotal in nature to those examining ridership data within a traditional benefit-cost framework. Only ten or so are published in peer review outlets. Among other issues, this suggests that most studies have not been prepared to meet the levels of research quality required in peer reviewed publications. Furthermore, it suggests that many of the studies have a tone of advocacy to their analysis and findings. Such literature needs to be considered in that light. Below we provide a brief review of each of these studies. In lieu of a good strategy to organize the discussion, we use the level of geography to do so.

<Table 3>

The largest geographic area includes a series of studies conducted for individual states to calculate the economic impact of cycling and related industries. In Colorado, more than 6,000 households and a sample of bicycle manufacturers, retail bicycle shops and ski resort operators were surveyed to glean a better understanding the impact bicycling has on Colorado's economy in the form of production, sales, jobs and income and tax revenue (Argys and Mocan 2000). A study from Maine conducted for the Department of Transportation surveyed bicycle tour operators to estimate the total economic impact of bicycle tourism in the state and to develop marketing recommendations (Maine Department of Transportation 2001). From this research, they estimated the size and characteristics of the bicycle tourism market in terms of socio-economic class, spending patterns, direct and indirect impacts. Finally, Michigan has also estimated spending by users of local rail-trails while participating in organized bike rides (Nelson, Vogt et al. 2001).

A second level of analysis focuses on regional geographic areas or entire cities. Buis (2000) offers an international application describing calculations in Amsterdam, Bogotá, Delhi and Morogoro. Using existing data from each municipality about proposed or existing bicycle policy, such as investments in infrastructure and saved motorized journeys, this research captures cost . The benefits in the four different cities, while not calculated consistently for each setting due to the availability of data, employed infrastructure, user, and safety information which were translated into U.S. dollars. The calculations demonstrate that the benefits exceed the costs; the benefit-cost ratio was more pronounced in cities that have not yet invested in cycling facilities. A study prepared on behalf of the Institute of Transport Economics in Oslo is perhaps the most robust among available work (Saelensminde 2002). This research estimates the average bicycle ridership in three Norwegian cities (Hokksund, Hamar and Trondheim) to determine a project's calculated profitability or net benefit. This research claims to have used low benefit estimates and concludes that spending on future infrastructure serves to benefit society in those three cities. Saelensminde ascribes monetary values to all aspects from security and accident reduction to health benefits and parking.

Research by Fix and Loomis (1997) use a travel cost model to estimate the economic benefits to users of mountain bike trails in Moab, Utah. They did so measuring consumer surplus and individual per-trip values. The second of these studies, also focusing on the Moab area, compares non-market valuation techniques by applying the TCM and the dichotomous choice contingent valuation method (CVM) (Fix and Loomis 1998). Also included in this group of studies is an exercise, now over a quarter-century old, to create a computer model analyzing savings reaped from increased cycling on a college campus (Everett 1976). The computer simulation results generate a benefit-cost ratio by multiplying the benefits per mile for each commuter type by the miles per year traveled by that commuter type and sums it over commuter types and years. Subsequent research discusses the applicability of applying management economic techniques to bicycle and pedestrian transportation systems (Everett and Dorman 1976).

The Sharples work (1995a) is valuable because it lists a variety of applicable issues and demonstrates how to evaluate related costs and benefits (Sharples 1995b). She generates specific values around diverse costs as air pollution and accident reduction. However, her benefits rely almost exclusively on first-hand experience of one particular corridor using personally collected data. Lindsey and Knaap (1999) use contingent valuation to understand how much residents are willing to spend for a greenway facility. A different approach applied unit day values to estimate the benefits of proposed greenway projects (Lindsey and Przybylski 1998). Using a rating system established by the U.S. Army Corps of Engineers (USACE), scores based on the USACE project evaluation scheme are converted to dollar values, also established by the USACE. While useful for estimating value, this work is limited because it only estimates use value. The same study also estimates use and net benefits of the greenway projects and includes a regional economic impact analysis for the two trails.

Betz et al. (2003) combine contingent valuation and TCM methods to estimate demand for visiting a greenway in northern Georgia and measures of consumer surplus. More recently, Lindsey et al. (2003) demonstrated how different values of a specific greenway could be estimated using complimentary techniques. They measured the impacts of greenways on property values in Indianapolis using residential real estate sales data, GIS, and hedonic price modeling. Recreation values for the trail were estimated using the TCM method. A more general work absent of a geographical context (Litman 2004) focuses on walking aspects that can also serve as useful reference for cycling research. This piece suggests that benefit-cost analysis offers the broadest brush at identifying the full range of benefits but again, stops short of suggesting specific methods and strategies for doing so.

Proposed Benefits and Methods

Past research offers widely varying perspectives to show how audiences demand different information on bicycle facilities. Attempting to satisfy all often ends up satisfying few. The central challenge for urban planners, policy officials, and researchers focuses on the benefits of bicycle facilities that pointedly satisfy certain criteria. After reviewing existing literature, canvassing available data and/methods, and consulting a variety of policy officials, we suggest that to be most useful, bicycling benefits need to satisfy five criteria. They need to be (1) measured on a municipal or regional scale; (2) central to assisting decision makers about transportation/urban planning; (3) estimable via available existing data or other survey means; (4) converted to measures comparable to one another; (5) be measuring benefits for both users and non-users.

It is also important to describe the range of benefits, to whom they apply, and to suggest compelling methods in which they could be measured. Our itemized list of benefits are guided by previous research and include *direct* benefits to the user—in the form of mobility, health, and safety benefits—and *indirect* benefits to society—in the form of decreased externalities, increased livability, and fiscal savings).

Other benefits certain exist and the beneficiaries are not always that clear. Our aim is not to dismiss their significance but merely suggest that practical considerations related to data, methodologies, and measurement often preclude more detailed analysis. The six benefits mentioned usually have different beneficiaries. These range from society-at-large to individual users (potential and current) to agencies; there is crossover between beneficiaries for each benefit. Consider, for example, that the most common argument in favor of cycling suggests that an increase in facilities will result in increased levels of cycling. This assumed increase in cycling will be derived from: (1) existing cyclists whose current levels of riding will be heightened (because of more attractive facilities), and/or (2) potential cyclists whose probability for riding will be increased. Thus, we see potential benefits for two different populations of beneficiaries (current and potential cyclists). But if any of these heightened levels of cycling result in decreased auto use, then an third beneficiary results—society-at-large—in terms of reduced congestion and resource consumption.

Below we describe what each benefit refers to, the primary user group to whom it applies, and a thumbnail sketch for a method that could be used to estimate each benefit. The proposed method is not to imply there is a single strategy for estimating this benefit but to merely provide the reader and researcher with an example of how it could be measured. Figure 1 shows a simplified depiction of potential beneficiaries along with an indication of the primary benefit as alluded to above.

<Figure 1>

(1) Mobility

The most directly cited benefits are often gleaned from users of the bicycle facilities. These come in the form of greater satisfaction of existing cycling (e.g., cyclists would be able to reach their destination faster, safer, via a more attractive means). A major problem, however, is that existing information by itself (e.g., ridership counts) cannot reliably shed light on this issue. For this reason, the different transportation benefits for the user are best uncovered through stated preference surveys or experiments. Since stated preference methods provide individuals with hypothetical situations, it becomes feasible to analyze situations that are qualitatively different from the actual ones seen in practice (Bradley and Kroes 1990).

Because individuals respond to several different hypothetical choice situations offered to them, the efficiency of data collection is improved; enough data is hence available to calculate functions describing their preferences or utility. Against this backdrop, the disadvantage in stated preference methods is that people may not always do what they say. Individuals' stated preferences might not be similar to the preferences they actually show (Wardman 1988). This arises because of the systematic bias in survey responses or because of the difficulty in actually carrying out the posed task.

Two techniques used in stated preference analyses are contingent valuation and conjoint analysis. The former is based on the premise that the best way to find out the value that an individual places on something is known by asking. Like other non-market goods, the concept has been applied to wilderness, open space, or even more specifically to greenways (Lindsey and Knaap 1999). The second stated preference technique, conjoint analysis, applies designed of experiments to obtain the preferences of the individual (customer). This market research technique can provide important information about new product development, forecasting market segmentation and pricing decisions. In this case it would help understand the type of cycling facilities that residents value. Conjoint analysis enables researchers to calculate the value that people place on the attributes or features of products and services; the aim is to assign specific values to the options that buyers look for when making a decision to use a good. It is a highly respected technique to explore trade-offs to determine the combinations of attributes that satisfies the consumer.

In these cases, an individual is provided a choice of alternatives; for example, the various travel routes by which a particular travel destination can be reached. The choice of a particular mode is assumed to depend on the relative attractiveness of the various travel options that the individual faces. These methods use experimental procedures to obtain individuals preferences based on the individual's evaluation of the various options given. Typically, these experiments generally provide hypothetical travel scenarios to obtain an individual's preferences (Fowkes and Wardman 1988).

An important point is that stated preference surveys need to be stratified by audience: current users versus potential users. For the former, current cyclists could be asked to respond to questions about factors that would provide for a more attractive cycling environment through different types of environments or facilities. It is necessary to have forced trade-offs so that a better environment might be coupled with higher costs for bicycle storage or a higher travel time. This will allow one to value each component of the user's preference. These preferences can then be translated to economic benefits using consumer's surplus measures (Ben-Akiva and Lerman 1989) to determine, for example, the value of an off-road bicycle facility for users of that facility.

For the latter category, potential users, it would be important to create scenarios based on constructed markets, asking people to attach a value to a goods or services. This technique is applicable to quantify the benefits that non-bicycling residents would accrue from a more desirable bicycling infrastructure. For example, questions could ask what mode they would choose for work and non-work trips based on the quality of the transportation environment, including auto, walk, transit, and bicycle travel. It would query residents about the degree to which they perceive different bicycling services or how facilities will improve the conditions of their commute, recreational activities, etc. By measuring how demand might change, one can ascertain the preferences for current non-users, some of whom would become users if a certain infrastructure package were constructed.

(2) Health

Researchers and practitioners from a variety of disciplines are building the scientific literature to better understand relationships between community design, transportation facilities, and levels of physical activity (Handy, Boarnet et al. 2002; Sallis, Frank et al. 2004). So-called "sprawling" land use practices and resulting auto-dependent travel are themes that now have moved front and center into the American consciousness; the link to public health and the declared obesity epidemic remains an important component of this discussion (Frank 2000; Wilkinson, Eddy et al. 2002; Pucher and Dijkstra 2003). One overarching goal of this active line of inquiry is to learn the extent to which rates of physical inactivity can be linked to features of the built environment (see for example, Krizek, Birnbaum et al. 2004). At a regional or neighborhood scale, most inquiries focus on land use patterns characterized by relatively scattered, single use and low-density development. At a street or facility level, such research focuses on access to sidewalks, trails, other non-motorized facilities, and destinations. While the past dozen or so years have seen a proliferation of research linking neighborhood design to travel behavior (Crane 2000; Ewing and Cervero 2001), surprisingly little of it has exclusively focused on relationships between specific facilities, bicycling and walking travel, and levels of physical activity.

To establish a health-care, cost-based reason for bicycle facilities, several types of specific empirical evidence must be gathered and broadly communicated to interested parties. Doing so is a tall order and one that some claim to be insurmountable. Borrowing reasoning from Goetzel et al. (1998), researchers must first demonstrate relationships between a given feature of the built environment (e.g., a bicycle facility) and levels of cycling. Doing so would be similar to methodologies previously described to measure the demand induced from various facilities. The active line of international research tackling this question is likely to have reliable results that can inform this line of inquiry in relatively short order time (i.e., a couple of years). Second, any amount of induced cycling that could be "teased" out from a facility would then need to be translated into an average percentage of one's weekly physical activity. For example, the daily recommended level of physical activity is defined as 30 minutes of moderate physical activity on five or more days per week (Pronk, Goodman et al. 1999; Blair, LaMonte et al. 2004). Cycling five miles in 30 minutes or four miles in 15 minutes would meet these current public health guidelines for physical activity for health (Pate, Pratt et al. 1995; U.S. Department of Health and Human Services 1999; U.S. Department of Health and Human Services 2003).[i]

Third, researchers must then demonstrate that lack of physical activity—because it is indicative of certain risk factors—imposes a financial burden to the individual or to society. A fourth step would be to show that improved certain risk factors (i.e., increasing physical activity) does result in reduced cost. The final step is for researchers to demonstrate that health habits can be changed and that the resultant lower risk can be maintained over time. As can be seen, the challenges associated with documenting a "health" financial payback from a bicycle facility are significant. Looking at the problem optimistically and from the perspective of needing analytical justification, we see such exercise not completely out of the realm of possibility. For this reason, these later steps (three through five) comprise the focus of the below review.

The benefits of physical activity in enhancing overall health are well established. The task of attaching monetary amounts to levels of physical activity is a more challenging endeavor. One attempt is offered by Wang et al. (2004) who derive cost-effectiveness measures of bicycle/pedestrian trails by dividing the costs of trail development and maintenance by selected physical activity-related outcomes of the trails (e.g., number of trail users). The average annual cost for persons becoming more physically active was found to be $98; the cost was $142 for persons who are active for general health, and the $884 for persons who are active for weight loss.

Estimating the effect of physical inactivity on direct medical costs is a strategy more often employed, though considerably less straightforward. Part of the reason for ambiguity in this line research is that the amount of physical activity required to realize certain health benefits is relatively unknown (i.e., what is the elasticity?) (Hansen, Stevens et al. 2001; Rankinen and Bouchard 2002; Blair, LaMonte et al. 2004). In the field of public health, this matter is often approached from the perspective of dose-response relationships. The aim is to learn what change in amount, intensity, or duration of exposure (in this case, cycling) is associated with a change in risk of a specified outcome (in this case, cost of health care).

Existing literature examining relationships between levels of physical activity and health costs varies considerably in methodology and scope. The majority of existing studies pursue a dichotomized approach, separating respondents into two classes: those that satisfy the accepted "dose" of 30 minutes per day for five days and those who do not. In this first group of studies, there are at least five statewide reports whose methodology and assumptions are relatively general in nature. In most cases, estimates are derived from an aggregation of medical expenditures that can in some form be traced back to physical inactivity. For example, a study commissioned by the Michigan Fitness Foundation (Chenoweth, DeJong et al. 2003) concentrated on the economic costs to the residents of Michigan. The authors used estimates (acknowledged to be conservative) to derive direct costs (e.g., medical care, workers' compensation, lost productivity) and indirect costs (e.g., inefficiencies associated with replacement workers). The final amount totaled $8.9 billion in 2003 ($1,175 per resident). A 2002 report from the Minnesota Department of Health (Garrett, Brasure et al. 2001) estimates that in 2000, $495 million was spent treating diseases and conditions that would be avoided if all Minnesotans were physically active. This amount converts to over $100 per resident. Additional reports claim that too little physical inactivity was responsible for an estimated $84.5 million ($19 per capita) in hospital charges in Washington State (Claybrooke 2001), $104 million ($78 per capita) in South Carolina (Powell, Greaney et al. 1999), and $477 million in hospital charges in Georgia ($79 per capita) (Bricker, Powell et al. 2001).

These reports from various state agencies are complemented with more academically oriented research. For example, Colditz (1999) reviewed past literature on the economic costs of inactivity and concluded that the direct costs for those individuals reporting lack of physical activity was estimated to average approximately $128 per person. A separate analysis by Pratt et al. (2000) analyzed a stratified sample of 35,000 Americans from the 1987 national Medical Expenditures Survey. Examining the direct medical costs of men and women who reported physical activity versus those who did not reveals that the mean net annual benefit of physical activity was $330 per person in 1987 dollars. An alternative method used a cost-of-illness approach to attribute a proportion of medical and pharmacy costs for specific diseases to physical inactivity in 2001 (Garrett, Brasure et al. 2001). The authors first identified medical conditions associated with physical inactivity and then collected claims data related to those conditions from approximately 1.6 million patients 16 and older from a large, Midwest health plan. While the resulting conditions from lack of physical inactivity include depression, colon cancer, heart disease, osteoporosis, and stroke, the results from this study conclude that the costs of claims to the health plan attributable to physical inactivity translates to $57 per member. One challenge of these analyses is the decision whether to include diseases causally related to obesity.

A different approach than the dichotomized strategy estimates the impact of different modifiable health risk behaviors and measures their impact on health care expenditures. After gathering information from more than 61,500 employees of six employers gathered over a five-year study period, Goetzel et al. (1998) focused on a cohort of just over 46,000 employees. The analysis found that a "risk-free" individual incurred approximately $1,166 in average annual medical expenditures while those with poor health habits had average annual medical expenditures of more than $3,800. Thus they estimated the per-capita annual impact of poor exercise habits to be approximately $172. Pronk et al. (1999) also identify the relationship between modifiable health risks and short-term health care charges. This research surveyed a random sample of 5689 adults aged 40 years or older enrolled in a Minnesota health plan. Multivariate analysis on the modifiable health risks (diabetes, heart disease, body mass index, physical activity and smoking status) concluded that an additional day of physical activity (above zero) would yield a 4.7 percent reduction in charges (or a $27.99 reduction). The overarching result of the study is that obesity costs approximately $135 per member, per year and those with low fitness (inactivity) cost approximately $176 per member per year.

A couple of matters stand out to inform applicable methods. First, annual per capita cost savings vary between $19 and $1,175 with a median value of $128 (See Table 4). Second, some studies are disaggregate in nature and estimate costs by inpatient, outpatient, and pharmacy claims; others compare average healthcare expenditures of physically active versus inactive individuals. Third, some use a dichotomized approach to operationalize physically active individuals while others employ a modifiable health risks approach and do so in a relatively continuous scale. The studies are difficult to compare, however, because some 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.

<Table 4>

(3) *Safety*

Increased cyclist safety is an often assumed, poorly understood, and highly controversial benefit of bicycle facilities. The task of establishing a safety derived, cost-based justification for bicycle facilities is similar to the process described in the previous section estimating public health benefits, albeit with different data. Researchers must first demonstrate relationships between a given cycling facility and safety outcomes. They then need to demonstrate that the measured outcomes of conditions with decreased safety imposes a financial burden to the individual or to society.

In general, the literature about the safety dimensions of bicycling manifests itself in three respects: (1) helmet use, (2) safety programs, and (3) levels of accidents or perceived level of safety that can be ascribed to facility design. The latter category is most germane to the construction of facilities and therefore comprises the heart of the below discussion. A key question seeks to marry data about safety (e.g., accidents or perceived comfort) with different attributes of cycling facilities. Our perspective on this literature aims to understand the degree to which different cycling facilities lead to an incremental safety benefit, measured in terms of decreased accidents or medical costs.

Existing literature in this respect measures safety in one of three ways: (1) number of fatalities, (2) number of accidents, and (3) perceived levels of comfort for the cyclist. Key explanatory variables behind these outcome measures are myriad and complex to identify. For example, the overwhelming majority of bicycle accidents resulting in fatalities are caused by collisions with motor vehicles (Osberg, Stiles et al. 1998). Less severe accidents tend to occur at intersections or at locations where motor vehicles and bicycles come in contact with each other (Hunter, Pein et al. 1995); it is further suggested that accidents are caused by differing expectations between auto drivers and bicyclists (Rasanen and Summala 1998). However, there is also evidence to suggest that some bicycle accidents do not involve any other party (Eilertpetersson and Schelp 1997); this is especially true for children (Powell and Tanz 2000).

The prevailing argument is that enhanced facilities—bike lanes, bikeways and special intersection modifications—improve cyclist safety (Pucher and Dijkstra 2003). This claim, however, is the source of a rich controversy within the literature as evidenced by the debate between Forester (2001) and Pucher (2001). Part of the controversy around this topic is fueled by differences between what cyclists state they prefer (i.e., their perception) and what studies with collision data actually reveal.

It is widely acknowledged that increased perception of safety is important to encourage cycling as a means of transportation and recreation (Noakes 1995); (Federal Highway Administration 1999). Subsequently, providing separated bicycle facilities along roadways is mentioned as a key ingredient in the burgeoning literature related to bicycle related stress factors (Sorton and Walsh 1994); bicycle interaction hazard scores (Landis 1994), relative danger index (Moritz 1998), compatibility indexes (Harkey, Reinfurt et al. 1998).

While a variety of labels appear in the literature, the overriding goal of these works is to determine and predict conditions for safe bicycling based on different cyclists perceptions of safety. The culmination of these works can best be described under the banner of Level of Service models, originally developed in 1987 in Davis, California and level of service (LOS) models (Epperson 1994; Landis, Vattikuti et al. 1997). The participants of this study were of diverse demographic and skill backgrounds and cycled 30 roadway segments. Including the variables of traffic volume per lane, posted speed limit weighted with the percentage of heavy vehicles, adjoining land use, width of outside through lane, and pavement conditions, the researchers were able to explain almost 75% of the variation. The model consists of four basic factors—pavement conditions, traffic speed, lane width, and traffic volume per lane which aim to serve as a tool for predicting accident along roadways between automobiles and bicycles.

The bulk of the existing literature on bicycle level of service and perceived safety focuses primarily on through mid-block roadway segments. It rarely separates bicycle lanes from other shared use conditions (wide curb lanes or paved shoulders) and rarely considers the role of intersections. While stretches of roadways are important, often the most significant and complex design and safety challenges occur at street intersections (Jackson 2002). In response to this void, two recent research papers have aimed to shed light on this matter (Landis 2003; Krizek and Roland 2004). Landis' recent work (2003) derived a model to evaluate the perceived hazard of bicyclists riding through intersections. Again, with a highly varied demographic and cyclist ability sample, this study produced a model with a high degree of explanatory power (R^2=0.83) for bicycle intersection level of service. Significant variables included motor vehicle volume, width of the outside lane, and the crossing distance of the intersection. In this study there was no control for the presence or absence of a bicycle lane, but the width of the outside lane variable did include the bicycle lane were it present. The research by Krizek and Roland (2004) analyzed the severity of instances where existing bicycle lanes and the corresponding physical characteristics. Using multi-variate analysis, the findings suggest that bicycle lane discontinuities ending on the left side of the street, with increased distance of crossing intersections, having parking after the discontinuity, and wider width of the curb lane are statistically elements that contribute to higher levels of discomfort for the cyclist.

The degree to which perception of safety translates into actual increased safety, however, is still debated. It proves difficult to translate perceived measures of safety into quantifiable or economic estimates. We therefore turn to discussing research showing correlations between bicycle facilities and accidents which yields far from a clear picture.

There is evidence to support the notion that collision-type accidents are lower on off-road paths (Aultman-Hall and Kaltenecker 1999). Using before and after analysis, Garder's research (1998) found raised bicycle crossings to be more appealing and safer for cyclists than at-grade crossings. However, there exists an equal, if not greater body of research suggesting no relationships or relationships in the opposite direction. Research examining conflicts at approaching intersections on bike lane and wide curb lane segments determined that both facilities improve riding conditions for bicyclists, but that the two facilities themselves are not different in safety (Hunter, Stewart et al. 1999). Smith and Walsh analyzed before and after accident data for two bike lanes in Madison, Wisconsin finding no statistically significant difference (Smith and Walsh 1988). Also, Hunter's analyses of bike-boxes in Eugene, Oregon (Hunter 2000) and blue bike lanes in Portland, Oregon (Hunter, Harkey et al. 2000) demonstrate that no bike-car conflicts took place while the boxes were used as intended, but that the bike boxes did not seem to improve the number of conflicts in general (Hunter 2000).

There appears to be good reason for the existing debate over the safety benefits of bicycle facilities. While there is considerable literature suggesting cyclists perceive greater safety with facilities—and advocates certainly argue for such—the bottom line is that there little conclusive evidence to suggest such. For this reason, it is extremely difficult to prescribe guidelines, though, the research methodologies certainly exist as described above.

(4) Decreased Externalitites, Congestion

The most common assumption asserted is that cycling trips substitute for auto trips, yielding transportation benefits to society-at-large such as decreased congestion, improved air quality, and decreased of energy sources such as non-renewable natural resources. While the substitution element may hold true for some cyclists it is extremely difficult to reliably parse out such trips that would otherwise be made by car.

The nature and magnitude of any substitution is important to determine and could be estimated via a variety of means. In some instances, a bike trip may replace a car commute; in many cases, however, bicycle are likely made in addition to trips that would otherwise occur (Handy 1992) or for a different reason (e.g., recreation). Assuming a fixed demand of overall travel, a best-case scenario for bicycle substitution stems from an assumption well known in the field of travel behavior modeling referred to as Independence from Irrelevant Alternatives (IIA). That is, bicycles draw from other modes in proportion to their current mode shares. For instance, bicycles would draw 85 percent from current drive alone trips, five percent from auto passenger trips, five percent from transit trips, and five percent from walk trips. This of course is unlikely to be strictly true, so an important part of the benefit analysis would be to determine which of these groups is more likely to switch to bicycling and furthermore, and which socio-economic characteristics could be targeted to result in higher rates of cycling.

Assuming bicycling can help bicyclists travel faster, more safely, in a better environment or for shorter distances, its utility compared to other modes will increase. There may be an estimable effect in terms of substitution and there are different approaches for measuring this phenomenon. At a crude level, one could estimate the number of bicycle miles of travel and auto miles of travel. Assuming a fixed rate of substitution (i.e., 60 percent of all cycling trips are utilitarian in nature and are substituting for a car trip), one could estimate an upper bound of all mileage that is substituted and the overall social costs being saved. However, this does not account for the possibility that bicycle trips may be substituting for other modes than driving. Furthermore it says little about how many additional trips from potential cyclists that could be induced. Such information would be most reliably obtained by estimating a mode-choice model for different types of cycling trips and calculating the likelihood of substitution rates in that manner. The latter strategy is one subject to elaborate modeling schemes and survey data.

It is important to recognize, however, that any reduced congestion benefit to society needs to be tempered by “induced demand” phenomenon which may obviate congestion or pollution reductions due to diversion (Downs 1992). This implies that reduced traffic congestion that may result from the construction of an additional bike lane may largely (though not entirely) be consumed by other drivers making additional trips, drivers lengthening trips, and additional development. This suggests that any reduction in congestion (and subsequently pollution and energy benefits) will be small at best. (Nevertheless, the additional opportunities for drivers to pursue activities that previously had been too expensive prior to the capacity expansion (of roads or bike lanes) engender some benefits on part of those new drivers).

(5) Livability

A third benefit refers to social attributes accrued by individuals who receive benefits of such facilities, either directly or indirectly. One of the reasons people pay a premium to live in desirable areas is that they are paying for the option to use specific facilities, whether or not they actually do. For instance people may pay a premium to live near a bike path despite not cycling themselves because they might want to in the future. In this respect, such proximity would be valued by current and potential users. These benefits are revealed through preferences which represent an elusive phenomenon to which an economic value can be attached. A compelling strategy to measure these non-market goods analyzes the choices households reveal in their purchase of home locations in efforts to understand how they implicitly or explicitly evaluate the desirability of a certain good. A revealed preference approach would measure individuals’ actual behavior and this can be done through hedonic modeling to learn if and how much residents value accessibility to bicycle facilities.

Discerning the relative value of non-market goods using hedonic modeling techniques is a method that has been employed for years ever since first applications by Lancaster (1966) and Rosen (1974). An extensive review of this literature (Sirmans and Macpherson 2003) documents nearly 200 applications that have examined home purchases to estimate values of several home attributes including structural features (e.g., lot size, a home’s finished square feet, and number of bedrooms), internal and external features (e.g., fireplaces, air conditioning, garage spaces, and porches), the natural environment features (e.g., scenic views), attributes of the neighborhood and location (e.g., crime, golf courses, and trees), public services (e.g., school and infrastructure quality), marketing, and financing. The application germane to this inquiry focuses on the relative impact of bicycle lanes and trails. It is important, however, to understand the relative value of different types of facilities as they may have substantially different appeal. Some trails are on existing streets (demarcated by paint striping), some are next to existing (separated by curbs), while others are clearly separated from traffic and are often contained within open spaces. The latter category, being the most attractive for many bicyclists is likely to have the largest effect. To effectively estimate the value of such facilities it is important to be able to explain and control for the degree to which open space versus the bike trail contained within the open space contribute to a home's value. In many metropolitan areas bike trails and open space share a spatial location and at minimum exhibit similar recreational qualities. Any research failing to account and control for such correlation would be misguided in its attempt to estimate the independent value of bicycle trails. For this reason, not only is it important to control for structural attributes of the home, characteristics of the neighborhood, geographic location, but it is important to consider the value of adjacent open space. The value of open space has been estimated several applications of hedonic regressions (Quang Do and Grudnitski 1995; Benson, Hansen et al. 1998; Luttik 2000; Irwin and Bockstael 2001; Geoghegan 2002; Anderson and West 2004).

The hedonic pricing method is appealing because it is rooted firmly in market prices and provides a strategy to perform an economic valuation for non-market facilities. To our knowledge the only attempt to extend such methodology to bicycle facilities is offered by Lindsey et al. (2003) who analyze the property value using a half-mile buffer around a greenway. The outcome of this methodology would then be econometric models that can be used to reliably measure if residents value access to bicycle facilities and if so, to what degree. This value could be then be easily converted to monetary amounts.

(6) Fiscal

Right-of-way preservation is the process of preserving land needed for future infrastructure, most often in the form of transportation. It is a benefit reaped exclusively by the public agencies planning such facilities. Consider the situation where there may be a plan to build a rail transit corridor in ten years; it may be economically prudent to acquire the land sooner rather than later for several reasons (Dye Management Group 2002). First, the price of land may rise faster than inflation. Second, acquiring the land now may ensure it is not developed, while not acquiring it now may require the destruction of recently constructed buildings. There are, of course, risks associated with right-of-way preservation. Land may be acquired but the resources never found to complete the project. Right-of-way acquired prior to use for a future road or transit line may still be used for transportation. Placing a bicycle facility along the right-of-way is relatively inexpensive, ensures a transportation use for the corridor (ensuring it will not be viewed as a park land) and provides user benefits instead of allowing the land to lie fallow.

The economic value of right-of-way preservation can be estimated by multiplying the probability of use in the future by the difference of the net present value of future cost if not preserved and the present cost. Since acquiring right-of-way that is already developed is more expensive, this should output a positive value. The probability of future use is an important variable that is usually case specific, but it gets at the idea of preserving options. For example, a plan may suggest three alternative rights-of-way for a route. The probability of any route would then be less than one-third. Thus, the right-of-way preservation benefit would depend on the difference in costs multiplied by that probability. There are similar ways of estimating this value that might produce different results.

For example, the present cost of the right-of-way could be estimated in the cost category, and then consider "selling" the right-of-way in the future to the other transportation project as part of the salvage value of the bicycle facility. This salvage value is an estimate of the market value of the land. If the net present value of the salvage value exceeds the present cost, there may also be a right of preservation benefit. In such deliberations, it would be important to account for the discount value of completing the project—the present value of using available funds to complete a project and buying land for future projects later. For example, a benefit/cost ratio of 1.1 that would imply that one million dollars spent on a project will generate stream of benefits worth 1.1 million in present dollars. We could take this as the baseline and compare early ROW purchase to it. That is, the baseline is that some amount of money “x” greater than $1M will be spent to buy ROW in the future.

To estimate the present value of using the million dollars to buy ROW for future use, delaying a hypothetical project that would have been done with that money, consider how that benefit stream would change. First, a given project may eventually generate the same stream of benefits, but delayed by “n” years, giving a lower present value. However, the money that is saved (x minus $1M) by not paying a higher price later for the land, means that an additional project can be done at that time, yielding extra benefits, again starting “n” years in the future.

Summary and Conclusions

This essay interprets literature analyzing the benefits of bicycling or bicycle facilities. We do so by discussing the relatively sporadic nature of this body of knowledge (a primary shortcoming of this work is that it is not cumulative) and other confounding issues inherent to this endeavor. We articulate the population of interest in most studies, the benefits that are measured, the geographic scale at which they are measured, and discuss the difficulties involved with varying methodologies. We next review almost 25 studies that attach an assumed or economic benefit to such goods or areas. A main finding of the review is that studies in different locations use varied data and methodologies to arrive at widely varying conclusions.

For such information to be useful in policy circles, several actions need to be taken (in addition to improving data collection efforts). First, the majority of past work has a clear advocacy bent; it is not always known how and where much of the data is derived. It is unclear from most of the studies if the available data was analyzed in a completely objective manner. Second, it is important that continued discussion be most appropriate and useful scale for analysis. The content of this type of work is often called for in policy discussions. In its current condition, however, it lacks appeal because many of the studies are conducted at a relatively abstract scale rather than a project scale. For this reason, we suggest in this paper that benefits be estimated on a municipal (or regional) scale or for even more disaggregate unites. Finally, there exists considerable room for improving the manner in which these methodologies are approached. Our intent is to provide the foundation for urging a consistent framework in which different benefits could be estimated and subsequently compared. If the goal is to implement plans that systematically integrate or account for such consideration, then such methods and improvements will ultimately lead to more sound policy decisions and bicycle facility investment.

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Tables and Figures

Table 1. Listing of cost-benefit studies

Author/Date	Context	Ratio	Comments
Everett (1976)	University of So. Mississippi	1.7 : 1	Uses computer and hand-calculations to estimate benefits and costs on a university campus. Dated, difficult to replicate
Buis (2000)	Amsterdam, Netherlands	1.5 : 1	Each case attempts to answer: "What economic benefits can be attributed to an increase in bicycle use due to local bicycle policies?" Wealthier, currently bicycle-friendly countries benefit at a lesser significance than do poorer, less well-invested countries
	Bogotá, Columbia	7.3 : 1	
	Morogoro, Tanzania	5 : 1	
	Delhi, India	20 : 1	
Saelensminde (2002)	Hokksund, Norway	4.09 : 1	Ratio based on "best estimates" of future cycling/pedestrian traffic. Cities with the least amount of infrastructure in place see the most benefit from new infrastructure.
	Hamar, Norway	14.34 : 1	
	Trondheim, Norway	2.94 : 1	
Przybylski & Lindsey, (1998)	Central Indianapolis Waterfront Greenway	1.43 : 1	Estimates benefits by Unit Day Values and costs (based on construction costs) to establish cost-benefit ratio.
	Ohio River Greenway	1.9 : 1	

Table 2: Comparing the values of different benefits from six studies

	Betz	*Fix & Loomis*	*Lindsey*	*Litman*	*Nelson*	*Sharples*
Benefit						
Air Pollution				$0.20 - $0.40	$0.24 - $0.40	184 kg of CO2
Congestion				$0.04 - $0.40	$0.03 - $0.32	varies
Earnings			$14,434,000			
Ecological/ Environmental				$0.23	$0.23	
Economic Benefits	$18.46 - $29.23 (surplus)	$197 - $205 (surplus)	$1.43-$6.13 UDV			
Energy Costs					$0.10 - $0.12	
Jobs			982 FTE			
Noise				$0.05 - $0.10	$0.02	1.5 dB
Parking				$0.25 - $1.50	$0.23 - $2.25	varies
Road Maintenance				$0.05 - $0.10	$0.02	varies
Road Safety						£450,000
Sales (from derived demand)			$21,000,000 est.			
User Savings/ Driver Costs				$0.55 - $0.85	$0.40 - $0.60	£7,472
Total				**$1.37 - $3.20**	**$1.27 - $3.42**	

Table 3. Summary of all literature

Author (date)	Title	Geography	Summary	Peer Review
Argys, Mocan (2000)	Bicycling and Walking in Colorado	State	Provides statistical information regarding the economic impact of bicycling in Colorado, and documents bicycling behaviors and attitudes of residents of Colorado.	No
Buis (2000)	The Economic Significance of Cycling	City	The results of four cost-benefit calculations: Amsterdam, Bogotá, Delhi, Morogoro	No
Everett (1976)	Measuring the Economic Value of Exercise in Labor-Intensive Urban Transportation Systems	University campus	Analysis of how labor-intensive transportation modes provide needed exercise. Quantifies health benefits and the economic benefit of reducing coronary heart disease.	Yes
Everett, Dorman (1976)	New Approach to Economic Evaluation of Labor-Intensive Transportation Systems	University campus	Applies managerial economics tools to quantify the benefits of a proposed bicycle-pedestrian transportation system.	Yes
Fix, Loomis (1997)	The Economic Benefits of Mountain Biking at One of Its Meccas	Mountain bike trails, Moab, Utah	Compares non-market valuation techniques by applying a data travel cost method and contingent valuation method to mountain biking.	Yes
Fix, Loomis (1998)	Comparing the Economic Value of Mountain Biking Estimated Using Revealed and Stated Preference	Mountain bike trails, Moab, Utah	Estimates the value of mountain biking using travel cost method.	Yes
Lindsey et. al (2002)	Use of Greenway Trails in Indiana	Greenway system	Informational report on trail use in Indiana.	No
Lindsey, Knaap (2003)	Sustainability and Urban Greenways (Indiana)	Greenway system	This case study examines whether the greenways system in Indianapolis, Indiana, is sustainable using a framework based on six principles of sustainability recently proposed in the planning literature.	Yes
Lindsey, et al (2003)	Amenity and Recreation Values of Urban Greenways (Indiana)	Greenway system	Presents a taxonomy of the values of greenways and demonstrates how different values can be measured using complementary techniques.	No

Litman (2002)	Economic Value of Walkability	General	Uses economic evaluation methods to investigate the value of walking. Analysis may be applied to other non-motorized travel modes.	No
Litman (1999)	Quantifying the Benefits of Non-Motorized Transport for Achieving TDM Objectives	General	Examines the degree to which non-motorized travel help achieve Transportation Demand Management objectives, including congestion reduction, road and parking facility cost savings, consumer cost savings etc.	No
Maine DOT (2001)	Bicycle Tourism in Maine	State (three trails)	Summarizes study to estimate the total economic impact of bicycle tourism by estimating the tourism market.	No
Moore (1994)	The Economic Impact of Rail-Trails	Three trails	Examined economic impact generated by three diverse rail-trails in Iowa, Florida and California. Impacts were broken down into users' expenditures related to trail visits.	Yes
Moore, Barthlow (1998)	The Economic Impacts and Uses of Long-distance Trails	Trail	Investigates use patterns and economic impacts of long distance trails. Case study of Overmountain Victory National Historical Trail.	No
Nelson A. (1995)	Private Provision of Public Pedestrian and Bicycle Access Ways	National	Presents findings to support that implementing bicycle and pedestrian access ways will result in economic benefit.	Yes
Vogt, Nelson (2002)	A Case Study Measuring Economic and Community Benefits of Michigan's Pere Marquette Rail-Trail	Trail	Compiles executive summaries from research reports that have been completed as part of this case study. Includes economic benefit generated by trails use for organized rides, property owners' opinions.	No
PKF Consulting (1986)	Analysis of Economic Impacts of the North Central Rail Trail (Maryland)	State	Investigated seven categories including tourism, property values, local resident expenditures and public sector expenditures to determine an economic value.	No
Przybylski, Lindsey (1998)	Economic Evaluation of Major Urban Greenway Projects	State	Describes procedures used in economic evaluations of two major greenway projects in Indiana. Includes benefit-cost	No

			analyses and regional economic impact analyses.	
Saelensminde (2002)	Walking- and cycling-track networks in Norwegian Cities	City	Cost-benefit analyses of walking- and cycling-track networks based on use of the networks.	No
Schutt (1998)	Trails for Economic Development: A Case Study	Trail	Summarizes a user and economic impact study of the Bruce Trail in Ontario.	Yes
Sharples (1995)	A framework for the evaluation of facilities for cyclists – Part 1	General	Suggests framework for how to determine who will be affected by new cycling infrastructure and how.	Yes
Sharples (1995)	A framework for the evaluation of facilities for cyclists – Part 2	Roadway	Applies the above framework to Wilmslow Road Corridor in Manchester, England.	Yes
Siderlis, Moore (1995)	Outdoor Recreation Net Benefits of Rail-Trails	Trails in multiple states	Estimates net economic values with the individual travel cost method for three rail trails in different U.S. Regions.	Yes
Sumathi, Berard (1997)	Mountain Biking the Chequamegon Area of Northern Wisconsin	Trail system	Profiles mountain biking user characteristics from the Chequamegon Area Mountain Biking Association trail system	No
Wittink (2001)	On the Significance of Non-Motorized Transport	City	Presents the effectiveness of non-motorized transport in relation to economic growth, poverty reduction and quality of life urban areas and on the applicability of arrangements in the Netherlands.	No

Table 4. Estimated annual per capita cost savings (direct and/or indirect) of physical activity

Study/Agency	Per Capita Cost Savings ($)
Washington State Department of Health	19
Garrett et al.	57
South Carolina Department of Health	78
Georgia Department of Human Resources	79
Colditz (1999)	92
Minnesota Department of Health	>100
Goetz et al.	172
Pronk et al.	176
Pratt	330
Michigan Fitness Foundation	1,175

Figure 1: Beneficiaries of bicycle facilities

Beneficiary					
To the User (direct)			***To the Community (indirect)***		
Mobility	***Health***	***Safety***	***External***	***Livability***	***Fiscal***
-enhanced conditions -shorter travel distance	-increased physical activity -decreased health care costs	-decreased crashes -increased comfort	-decreased congestion -reduced pollution	-proximity to recreational amenities -increased open space	-increased economic activity -decreased taxes

[i] Based on an analysis of several sources (e.g., travel diaries such as the National Household Travel Survey, direct questionnaires administered by the Bureau of Transportation Statistics), we project that approximately three percent of the U.S. population cycles one day per week and an estimated one percent of the population cycles three times per week. When people do ride a bike, it appears as if they do so for approximately 30 minutes at a time. Overall, however, current statistics suggest that less than one percent of the U.S. population receives their recommended weekly level of physical activity by cycling.