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Bicycling renaissance in North America? Recent trends and alternative policies to promote bicycling

John Pucher [a,*], Charles Komanoff [b,1], Paul Schimek [c,2]

[a] *Department of Urban Planning, Rutgers University, 33 Livingston Avenue, Suite 302, New Brunswick, NJ 08901-1900, USA*

[b] *Komanoff Energy Associates, 636 Broadway, Suite 602, New York, NY 10012, USA*

[c] *Volpe National Transportation Systems Center, US Department of Transportation, DTS-49, Cambridge, MA 02142, USA*

Abstract

Over the past two decades, the number of bicycle trips in the United States has doubled. Since 48% of trips by all modes in American cities are shorter than three miles, the potential for further growth in bicycling seems enormous. So far, efforts to promote bicycling have focused on building bike paths and bike lanes. Although necessary, separate cycling facilities must be complemented by a comprehensive program to make all roads bikeable, through both physical adaptations and enforcement of cyclists' right to use the road. It seems likely that cycling will continue to grow in North America, but that its mode share will remain far lower than levels in northern Europe. Bicycling in Canada and especially the United States is impeded by the lack of a tradition of cycling for utilitarian purposes and by the marginal legal, cultural and infrastructure status of cyclists in both countries' automobile-based transport systems. As long as car use remains cheap and transportation policy remains dominated by motoring, bicycles will continue to be used primarily for recreation and not for daily urban travel in North America.

Keywords: Bicycle; Cycling; Non-motorized transport; Safety; Health promotion

1. Introduction

Several northern European countries have been enjoying a bicycling boom. Over the past two decades, cycling has increased significantly in Denmark, Germany, Switzerland, and the Neth-

* Corresponding author. Tel.: +1-732-932-3822; fax: +1-732-932-2253; e-mail: pucher@rci.rutgers.edu

[1] E-mail: kea@igc.org

[2] E-mail: schimek@volpe.dot.gov

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erlands (Dutch Ministry of Transport, 1995; Zegeer, 1994; Tolley, 1997; Pucher, 1997). The number of bicycle trips has grown substantially in these countries, and in many cities cycling's share of travel has risen as well. In Germany, for example, bicycling's modal share for urban trips rose by half between 1972 and 1995, from 8% to 12% (Pucher, 1997). Currently, the bicycle's share of local trips is 30% in the Netherlands, 20% in Denmark, 12% in Germany and 10% in Switzerland – over 10 times higher than in the United States (Pucher, 1997).

All these European countries have very high standards of living, and all have experienced rising incomes, growing auto ownership, and rapid suburbanization. Yet bicycling is thriving in this environment, primarily due to long-term commitments to enhance the safety, speed and convenience of bicycling while making driving more difficult and expensive. These policies were adopted by democratic political systems, partly to mitigate the social and environmental harm of excessive auto use in cities, and also to accommodate rising demands for mobility within the physical constraints of congested urban roads, high-density cities and limited land supply for parking.

Many groups have been advocating increased bicycling in the United States, not just for recreation but also for commuting and other utilitarian purposes. The League of American Bicyclists, the Bicycle Federation of America and bicycling groups in virtually every state and many cities coordinate bicycling events, offer training courses, and lobby for cycling facilities and cycling-friendly roads and traffic policies. Many environmental organizations, community activists and urban planners support cycling because it is an energy-efficient and non-polluting transport mode, and some transport planners view space-efficient cycling as a way to reduce roadway congestion. Apart from the cost of travel time, cycling is also cheaper than any mode except walking and thus affordable to even the poor. Moreover, the public costs of bicycling are modest, especially compared to motorized transport. Finally, fitness experts and health professionals advocate cycling for its cardiovascular benefits.

In recognition of the benefits of bicycling, and in response to strong public pressure, public policies in the United States have become more supportive of bicycling, especially since passage of the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991. The successor to ISTEA, the 1998 Transportation Equity Act for the Twenty-First Century (TEA21), continues this trend. As described in this article, the decade of the 1990s has witnessed a dramatic increase in funding of bicycling facilities in the US, with the focus so far on investments in new bike paths.[3] Most states and many cities now have programs to facilitate bicycling, including bicycle coordinators in state departments of transportation.

Traffic policies and roadway design in some locales are gradually becoming more conducive to bicycling. Unfortunately, little has been done to educate motorists about cyclists' rights and to enforce traffic laws that allow cycling on most streets and roadways. As argued in this article, the lack of a societal consensus and commitment to protect cyclists' right of way is a powerful impediment to increasing cycling levels in the US. Accordingly, a key to increased cycling may be policies that compel motorists to respect non-motorized users of roadways (Komanoff, 1997).

[3] Several American terms used in this article have British variants, shown in parentheses: bike path or shared use path (cycle track or cycle path); bike lane (cycle lane); sidewalk (pavement); intersection (junction), and roadway (carriageway). The article is written based on the right-side driving convention.

Do the growing interest in bicycling and the accompanying policy shifts suggest that America may be poised for a bicycling renaissance? Some bicycling advocates and trade publications already claim a massive boom in bicycling in the United States in recent years (Sani, 1997). While cycling has certainly increased, sightings of a boom are open to question. This article uses a variety of sources to assess the actual extent of growth in cycling in the United States over the past two decades, and to portray the socioeconomic characteristics of cyclists and their reasons for cycling.

However, the only comprehensive information is at a nationwide level and is too aggregate to reveal important variations in cycling levels and their relation to public policies toward cycling. Thus, much of the article is devoted to case studies of cycling in six American cities: New York, San Francisco, Boston, Seattle, Madison (WI) and Davis (CA). A seventh city, Toronto, is also surveyed because of its high cycling levels and also to contrast Canadian with American policies. We explore the range of policies concerning bicycling and report observed increases in bicycling in each city, noting the many factors that affect cycling levels. On the basis of our seven North American cities, and using information from European experience, we conclude by assessing the effectiveness of alternative policies to promote cycling.

2. Aggregate trends in bicycling

The only comprehensive information on daily travel behavior in the United States is the Nationwide Personal Transportation Survey (NPTS), which the US Department of Transportation has conducted periodically since 1969. Only since 1977, however, has the survey included bicycling, and these data are shown in Table 1.

The adjusted figures in Table 1 indicate a 41% increase in bike trips from 1977 to 1983, a 2% drop from 1983 to 1990, and a 55% increase from 1990 to 1995. Over this period, total bicycle trips approximately doubled and the percentage of trips by bike rose from 0.6% to 0.9%.

Table 1
Annual US bicycle trips and bicycle modal share, 1977–1995

	1977	1983	1990	1995
Bicycle tips (millions)	1272	1792	1750	3141
Adjusted bicycle trips (millions)	1476	2078	2030	3141
Bicycle modal share (%)	0.6	0.8	0.7	0.9
Auto modal share (%)	83.9	85.0	87.1	89.3
Transit modal share (%)	2.4	2.2	2.0	1.8
Walking modal share (%)	9.3	8.5	7.2	5.5

Sources: US Department of Transportation (1994); Pickrell and Schimek (1998); tabulations by the authors from US Department of Transportation (1997).

Note: The 1995 survey introduced several changes to improve reporting of trips such as the use of travel diaries; therefore the 1995 data are not directly comparable to earlier years. "Adjusted bicycle trips" increases the earlier figures by 16% to reduce the difference (Pickrell and Schimek, 1998). Note also that the NPTS excludes students living on campus, thus understating bike travel for all years.

Other estimates of national bicycling levels claim much higher bicycle mode shares, but these cover shorter periods of time, use dubious methodologies and may be biased by the interest groups conducting them. For example, the Bicycle Institute of America's *Bicycling Reference Book* reported that there were 3.5 million US bicycle commuters in 1990, and recently *Bicycle Retailer and Industry News* claimed a figure of 7.0 million bike commuters in 1997 (Bicycle Institute of America, 1994; Sani, 1997). However, the 1990 figure included occasional as well as regular cycle commuters, while the 1997 number was calculated by applying a conjectural 10% annual growth rate to earlier bike commuter estimates (Elliot Gluskin, *Bicycling* magazine, personal communication, 1998). Nevertheless, journalists and advocates alike frequently cite both figures.

NPTS data shown in Table 2 indicate that only 9% of bike trips in the US are work trips, while well over half are social or recreational trips. Even including trips for shopping, school and personal business, utilitarian trips account for less than half of American cycling. The percentages are reversed in the most cycling-oriented European countries, with roughly two-thirds utilitarian trips and one-third recreational. The higher the overall bike modal split, the higher the percentage of utilitarian cycling (Tolley, 1997; Zegeer, 1994).

In the US, cycling falls sharply with increasing age. According to the 1995 NPTS, the bicycle's modal split share is 3.3% among those aged 5–15, but falls to 1.0% for ages 16–24, 0.5% for ages 25–39, 0.3% for ages 40–64, and just 0.2% for those 65 and over. Cycling is far more common among men than women, with modal split shares of 1.3% and 0.5%, respectively. Whereas bicycle use in America is concentrated among children and young men, the full spectrum of society cycles in Europe (Tolley, 1997).

US cycling is also inversely correlated with income. Bike modal split is three times higher among households earning less than $15,000 than for households earning more than $80,000 – 1.6% vs. 0.5%. The poor are less likely to own a car, and cycling is an inexpensive way to get around. Low-income households are also more concentrated in central cities, where trips tend to be shorter and thus more bikeable. While high-income households may choose to cycle for fun or exercise, they obviously can afford the automotive alternative.

3. Bicycling dangers

Around 800 cyclists are killed and 500,000 injured annually in the United States (NHTSA, 1998; Tinsworth et al., 1993). In Canada 59 cyclists were killed in 1996, down from 102 in 1991

Table 2
Bicycling by trip purpose, US, 1995

Trip purpose	Percent of all bicycle trips
Work commuting	9.0
Shopping	12.7
Personal business	12.5
Social or recreational	57.0
School	8.8
All trip purposes	100.0

Source: Author's calculations based on US Department of Transportation (1997).

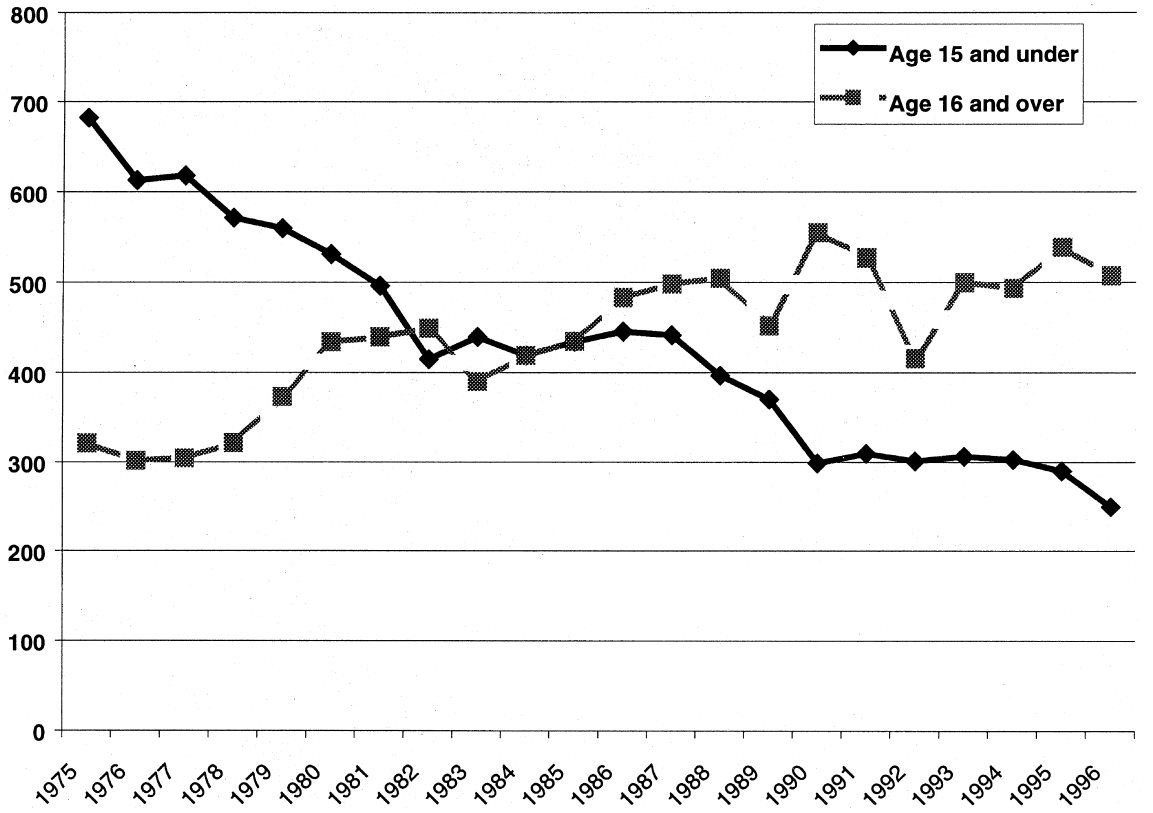

Fig. 1. Bicyclist fatalities by age of bicyclist, USA, 1975–1996. Source: Insurance Institute for Highway Safety (1997).

(Transport Canada, 1998). The American figures almost certainly understate injuries, since many cycling accidents are never reported to authorities (Stutts and Hunter, 1996). The prospect of accident and injury is a major obstacle to bicycling. Whether measured on the basis of trips, distance or hours, accident risks from cycling are several times those for driving, not only in the US and Canada but in Germany, the Netherlands and the UK (Komanoff, 1997; Aultman-Hall and Kaltenecker, 1998; Zegeer, 1994; Dutch Cyclists Union, 1993; The Economist, 1997).[4]

As shown in Fig. 1, US bicycling fatalities have stayed roughly constant since the mid-1970s, with a slight decline recently. Since the number of bike trips increased over the same period, there has evidently been a significant drop in the fatality rate per bike trip, and probably per mile cycled as well. More striking is the reversal in the age distribution of cyclist fatalities. From 1975 to 1996, cycling fatalities among children aged 15 or younger fell from 682 (68% of all fatalities) to 250 (33%). Although some of the drop in juvenile fatalities is attributable to increased helmet use, a bigger factor may be a decline in child cycling due to higher traffic volumes on residential streets, reductions in unsupervised child play and heightened risk aversion among parents (Templin, 1996).

[4] When comparing the average risk between motoring and cycling, one should recall that children account for more than half the cycling in North America.

Most cycling accidents and injuries result from falls or collisions with fixed objects, and are thus considered single-vehicle accidents (Rivara et al., 1996; Tinsworth et al., 1993). However, collisions with motor vehicles increase the risk of hospitalization nearly fourfold (Rivara et al., 1997) and account for well over 90% of cycling fatalities (Rogers, 1995), including 95% of fatalities among children (Youth Bicycle Education Network, 1998).

Bicycle safety campaigns in North America have focused on bicycle helmet use, especially among children. Some injury prevention professionals are questioning this emphasis, based on the evidence that helmet laws have not reduced the incidence of hospitalization of bicycle riders for head injuries (Robinson, 1998). Few communities provide on-road bicycle training for children, and some "bicycle safety" programs have taught dangerous practices such as cycling against traffic. There is no American program for school children comparable to the National Bicycle Proficiency Scheme in the United Kingdom or similar programs in the Netherlands and Germany.

Many motorists and even some police officers appear unaware that vehicle codes of all US states and Canadian provinces grant cyclists the right to ride on most roads. Lawfully traveling cyclists are frequently told by drivers to move to the side or get off the road (Mathews, 1998), even when there is no shoulder or when a line of parked vehicles presents the risk of a car door being opened into the cyclist's path. Motorists who intimidate bicyclists through aggressive driving are almost never ticketed, and those who injure or kill cyclists are seldom prosecuted (Komanoff, 1997).

4. Bikeways or roadways?

Much of Europe, especially Germany, the Netherlands, and the Scandinavian countries, has a long tradition of constructing extensive systems of special bicycle facilities called bikeways (Hartman, 1997; Hulsmann, 1997; Tschopp, 1997; Welleman, 1997; Pucher, 1997). These include bike paths independent of the road network; sidepaths alongside but separated from roadways by a barrier such as a curb, fence, or parking lane; and traffic lanes reserved for cycling. Since the 1970s, similar bikeways have been promoted in North America by national and local cycling advocacy groups, with mixed results.

4.1. Bikeway guidelines in North America

During and following the bicycle boom in the early 1970s, a number of US and Canadian cities sought to create facilities to encourage cycling. Most plans followed a classification system developed by researchers at UCLA for the California Department of Transportation based on studies of European practice (UCLA, 1972). The original guidelines identified three categories of bikeways:

- Class I: *bike paths* on rights-of-way separate from roadways.
- Class II: *bike lanes* on roadways, separated from motor traffic by a barrier or a painted line.
- Class III: *bike routes* on roads shared with cars or sidewalks shared with pedestrians.

This hierarchy implied that Class I facilities were the best and safest because they are most separated from motor traffic, and Class III the least safe. This bikeway system was modified over

time on the basis of experience and criticism from cyclists opposed to being shunted off of roads and onto potentially substandard lanes or paths. Current practice, as codified by the American Association of State Highway and Transportation Officials (AASHTO, 1999) acknowledges that most cycling takes place on ordinary roads. The "class" designation and its implied preferences are no longer used. Instead, "Class I bikeways" are called *shared use paths,* recognizing their use by pedestrians, skaters and others as well as cyclists. Because of the potential for conflicts at intersections, the guidelines discourage sidewalk bikeways and barrier-separated bikeways along roads (sidepaths). In their place, the AASHTO Guide favors bicycle lanes separated from the rest of the road only by paint, not by barriers or a parking lane.

4.2. European guidelines for bikeways

In Europe, the desirability of barrier-separated urban paths has come under question. While separate paths have helped encourage high levels of cycling, concerns have grown over intersection conflicts with right-turning cars and trucks, as discussed below, as well as the cost to construct and maintain bike paths. Some German cities are removing poorly maintained bike paths and replacing them with on-street lanes, or simply allowing cyclists to use the parallel streets instead (Allgemeiner Deutscher Fahrradclub, 1997).

European cycle planners now recommend a range of solutions depending on circumstances (Godefrooij, 1997; McClintock and Cleary, 1996). For example, German governmental guidelines for bicycle facilities differentiate according to criteria such as volume of motor vehicle traffic, average vehicle speed, level of truck traffic, volume and mix of bike traffic, roadway width, parking turnover and frequency of intersections (German Ministry of Transport, 1995). In general, the heavier and faster the traffic, especially bus and truck traffic, the more grade-separated bike paths are preferred to on-street bike lanes. In Germany, separate paths are recommended for roads with traffic volumes over 18,000 vehicles per day, or where bus and heavy truck volumes exceed 1000 vehicles per day, or where average speeds exceed 60 km/h (37 mph).

These volume and speed criteria can be overridden by intersection criteria. On stretches of roadway where frequent intersections and private driveways raise the potential for conflict, bike lanes tend to be preferred to paths. Conversely, on German streets with high parking turnover and frequent curbside deliveries, bike paths are preferred because vehicles are likely to block bike lanes and cause accidents when pulling in or out. Paths are also recommended where overflows from bike lanes during peak cycling traffic could lead to collisions with fast motor vehicles. The greater prevalence in Germany and throughout Europe of juvenile and elderly cyclists, many of whom need greater separation from moving car and truck traffic, also frequently tips the scales toward separate bike paths.

The widths of the existing roadway, shoulder and sidewalk – and availability of land for widening – also affect facility choice. In some situations, there simply is no room for an appropriately wide bike path or lane; the shoulder may then be designated for cycling, but with special striping to alert car drivers to cyclist use. In short, the current German approach recognizes the complexity in choosing the optimal alternative and the need to balance conflicting criteria.

4.3. Vehicular cycling

Proposals to designate some sidewalks as mandatory-use bikeways in the early 1970s provoked a strong counterattack by bicycle club members who had been using the roads. A leader of this movement, John Forester, subsequently codified club cycling techniques (Forester, 1993). This book came to form the basis of the bicycle instruction programs of the League of American Bicyclists (US) and the Canadian Cycling Association as well as *Cyclecraft* (Franklin, 1997) in the UK. Forester terms his principles "vehicular cycling," the concept that cyclists should practice and obey traffic laws applicable to drivers of vehicles, and also should be treated by other drivers and by law as drivers of vehicles.

For example, cyclists should ride in the roadway with the flow of motor traffic, obey traffic control devices, pass on the left, and make left turns from the left lane. Vehicular cycling also holds that motorists and cyclists alike should be cited when they disobey traffic rules and prosecuted when they cause collisions. Roads should be designed and maintained with the operating requirements of a bicycle in mind, and motorists should be educated to treat cyclists as lawful users of roadways (Forester, 1993, 1994).

Vehicular cyclists believe most bikeways are unnecessary for bicycle transportation and instead want existing roads improved for cycling through better surface quality, bicycle-detecting traffic sensors, and wider lanes on high-speed roads, for example. Vehicular cyclists often oppose sidepaths or designated bicycle lanes on the grounds that they make cycling slower and more dangerous, and that they promote the belief that cyclists are not legitimate users of ordinary roads.

Critics counter that few people are interested in working to develop vehicular cycling skills (Wilkinson et al., 1994; Wilkinson, 1998b). Further, they argue, most people will not even attempt to cycle unless they are provided with paths or lanes separated from motor traffic.

4.4. Bikeways and bicycle safety

Urban bicycle paths can increase the risk of car–bike collisions at intersections to the point that overall risk can be greater than on ordinary roads (Gårder et al., 1994; McClintock and Cleary, 1996). Paths adjacent to major urban roads tend to place cyclists out of the view of motorists who may then turn into their path at intersections. Such paths also generally require left-turning cyclists to cross in the pedestrian manner, causing delay or increased danger if a cyclist attempts a left turn from the right side of the road. Two-way paths place cyclists at further risk by putting them against the flow of traffic, where motorists do not expect them (AASHTO, 1999).

To mitigate the intersection conflicts accentuated by sidepaths, European designers employ a number of techniques: brightly painted crossings, raised crossings and outward displacement of bike paths at intersections so that turning cars encounter cyclists after, not during, their turn. Moreover, European cities often provide separate signal phases for cyclists, permitting cyclists to cross intersections while right-turning cars wait (Godefrooij, 1997). Left-turning cyclists are aided by designs that permit them to wait at intersections well ahead of stopped cars and then give cyclists priority through advanced green lights.

On average, rates of bicycle crashes and serious injury are higher on sidewalks and shared use paths than on roads, since such facilities are often narrow, poorly paved and shared with

pedestrians (Kaplan, 1976; Aultman-Hall and Kaltenecker, 1998; Moritz, 1998; Gårder et al., 1994). On the other hand, cyclist fatalities are more common on roads than on separate bikeways, since those crashes that do occur tend to be more serious because of higher rates of motor vehicle involvement.

4.5. The politics of bikeways

By implementing a bikeway system, cities can make a concrete demonstration that cyclists belong, that they are important, and that motorists must be mindful and respectful of cyclists. Provision of bicycle lanes is often coupled with other improvements such as wider curbside lanes and bicycle-sensitive traffic signal activators. Moreover, as a visible counterweight to the dangers of cycling, both real and perceived, bikeways can be a powerful way to encourage non-cyclists or occasional riders to cycle for regular transportation. Bike paths and lanes have widespread appeal, and surveys indicate that the general public rates such separate facilities as their top cycling priority. This helps explain the strong emphasis on separate bicycle facilities in both ISTEA and TEA21.

On the other hand, the presence of pedestrians, child cyclists and skaters, along with sub-standard widths and surfaces, can make segregated paths slow and cumbersome for cyclists wanting to travel at higher speeds. Vehicular cyclists particularly object to separate paths when their use is mandatory, as it is in some states and provinces in North America and in Germany and the Netherlands. Even where use is not compulsory, construction of paths can reduce the political impetus to make the road network more suitable for cycling. The focus of federal bicycling expenditures on off-highway facilities may also deflect attention from the need to improve roadways for cycling (Wilkinson, 1998a).

5. Government spending on bicycle facilities

Physical facilities for cyclists can be improved either through bicycle-specific projects or bicycle-related improvements incidental to road projects. Prior to 1990, few US states spent money specifically to improve bicycling conditions (Clarke, 1997). Although the Federal-Aid Highway Act of 1973 (and subsequent legislation) permitted some highway allotments to be used for bicycle programs, few states elected to spend highway funds on bicycle-specific projects. The few exceptions were programs in cities with large and vocal cycling constituencies, mainly university towns.

Since 1991, governments at all levels in the US have dramatically increased spending on bicycling-specific projects. The catalyst was the 1991 Intermodal Surface Transportation Efficiency Act. ISTEA compelled states and metropolitan planning organizations (MPOs) to include cycling and walking in their transportation plans, required states to designate bicycling coordinators, and earmarked federal transportation funds for "enhancements" restricted to non-traditional transportation projects, specifically including bicycling facilities. Moreover, as described by Clarke (1997), virtually every federal funding program now permits expenditures to improve walking and bicycling. Nevertheless, many states and MPOs have simply met the letter of the law by

mentioning bicycling, without proposing or enacting programs to improve conditions for bicycling (Moe et al., 1997).

The vast majority of federally funded bicycle projects have been via ISTEA's Enhancements Program. Over the six-year life of ISTEA (1992–1997), $972 million of federal enhancement funds were programmed for bicycle projects, versus a mere $41 million in federal funds for pedestrian and bicycling projects combined in the 20 prior years. Most (86%) of the bicycling expenditures under ISTEA were used for off-highway paths and trails, with 13% for on-road bicycle facilities, and 1% for bicycle parking or bicycle connections to public transit (Rails-to-Trails Conservancy, 1998a).

The enhancement program reveals the dramatic success of the movement to convert disused rail lines into bicycle paths. The number of rail trails increased tenfold in just 13 years, from 100 in 1985 to 982 in 1998. Total mileage of rail trails reached 10,015 miles in 1998, with another 8500 miles planned (Rails-to-Trails Conservancy, 1998b). Pathways are also being constructed or upgraded in parks and greenways and along canals, rivers and lakeshores. Because rail and other bike trails are predominantly rural and do not form an integrated network, they are used overwhelmingly for recreational cycling rather than for utilitarian trips like commuting, shopping or school.

The federal transportation legislation of 1998, TEA21, extends and strengthens most of the bicycling provisions of ISTEA. The act maintains the enhancements set-aside at a 50% higher funding level and makes "safety and educational activities for pedestrians and bicyclists" eligible as enhancement projects.

Nevertheless, in most jurisdictions it is still not standard practice for highway designers to accommodate bicyclists' needs in new or rebuilt roadway facilities (Schimek, 1996a). Even recent legislation that mandates such accommodation in Massachusetts and Rhode Island allows transportation officials to exclude bicycle provisions where they "would conflict with existing rights of way." Similarly, TEA21 only vaguely requires that bicycle facilities "shall be considered, where appropriate, in conjunction with all new construction and reconstruction of transportation facilities".[5] TEA21 also requires development of highway design standards with regard to cycling, but does not mandate their use.

6. Case studies

Aggregate information on trends and policies is useful for gauging the overall cycling situation in the United States, but it misses important details at the local level. Programs to encourage cycling must be evaluated in a local context. While the Federal government can encourage adoption of pro-bike policies through planning requirements or funding, such policies can only be implemented by municipalities. Moreover, local variations provide useful information for analysis.

[5] A bicycle facility is defined as "a new or improved lane, path, or shoulder for use by bicyclists and a traffic control device, shelter, or parking facility for bicycles".

Table 3
Case study cities: population data, 1990

	Population (000)		University students		Pop. density City pop./km^2
	Metro area	City	Thousands	As % of city pop. [a]	
New York	18,100	7000	319	5%	9151
Manhattan		1490			20,239
San Francisco	6250	724	37	5%	5985
Boston	4170	574	126	19%	4579
Cambridge		96			5748
Brookline		55			3112
Toronto [b]	4200	2276	120	5%	3612
Pre-1998 city		635	65	10%	6544
Seattle	2560	516	44	9%	2376
Madison	367	200	46	23%	1278
Davis [c]	1480	46	23	50%	2113

[a] Not all students reside within the jurisdiction. Boston student share is for Boston–Cambridge.
[b] City population is for the new city, formerly Metropolitan Toronto, as of 1991.
[c] Sacramento metropolitan area.
Sources: US Bureau of the Census (1998); World Almanac and Book of Facts (1994); Municipality of Metropolitan Toronto (1992).

We have selected six American cities and one Canadian city for detailed analysis. While they are not perfectly representative of North American cities as a whole, they offer a basis for examining differences in cycling levels. New York, San Francisco, Seattle and Boston are major cities in which cycling appears to have increased considerably over the past decade. Toronto provides a Canadian contrast to these cities and is the largest city to receive *Bicycling* magazine's annual designation as best cycling city in North America. We also examine two bicycling-oriented small cities: Davis, California and Madison, Wisconsin.

The seven cities span a wide range of population size and density, student population, and topography (see Tables 3 and 4). Climate merits special attention since cycling is easier and less stressful at moderate temperatures in dry conditions, and less so in wet weather and at extreme temperatures. Mild winters in Seattle, San Francisco and Davis contrast with the cold and sometimes snowy winters in Boston and New York, and even harsher winters in Madison and Toronto. At the same time, San Francisco's and Seattle's moderate summers contrast sharply with the hot weather in Davis (with temperatures often over 100°F) and humid conditions in the eastern cities. Seattle is notoriously cloudy and damp much of the year, whereas rain in Davis and San Francisco is largely limited to a few months in the winter. Similarly, the flat terrain of Davis, Madison, Toronto and Boston is more conducive to cycling than the hills of San Francisco and Seattle.

High-density environments tend to attract utilitarian cycling because more destinations are within easy cycling distance. Moreover, traffic congestion and limited parking in dense cities make driving more costly and difficult, providing incentives to use alternative modes. On the other hand, heavy traffic might discourage less experienced cyclists from venturing onto busy city streets.

College students have a much higher rate of cycling than the general population. Indeed, one statistical analysis of US cycling levels found the percentage of college students to be the most

Table 4
Case study cities: climate summary, 1961–1990 averages

City	Days per year with measurable rainfall	Days per year with min. temp. < 0°C	Months per year with min. avg. temp. < 0°C	Snowfall per year (cm)
New York	121	79	3	72
San Francisco	68	0	0	0
Boston	127	98	4	106
Toronto	108	not avail.	4	135
Seattle	150	19	0	17
Madison	120	161	5	112
Davis [a]	58	17	0	0

[a] Sacramento metropolitan area
Sources: Canadian Meteorological Centre, Environment Canada (1998; US National Oceanographic and Atmospheric Administration (1998).

important explanatory variable by far (Baltes, 1996). College students are more likely to cycle for a number of reasons: low incomes, limited campus parking, preponderance of short trips to classes and nearby activities, and compatibility with cycling's casualness and sportiness. The high bicycling rates in Madison and Davis conform to the expectation that college-oriented towns would have more cycling.

Table 5 summarizes the only strictly comparable data on bicycling for the American case studies – work trips, as surveyed by the 1990 US Census. Because the data were collected in late March, still in the off-season for most of our case study cities, they probably understate the true extent of work trip cycling. The Census statistics show considerable variation in cycling levels among the US cities, from a high of 22% in Davis to a low of 0.3% in New York City. A 1991 survey found that more than 4% of Toronto residents claimed to be cycle commuters at least on occasion, but this percentage is not directly comparable to the mode shares shown for US cities.

Table 5
Case study cities: bicycle work trips and modal split, March 1990

City	Region		City	
	Number	%	Number	%
New York	19,930	0.23	9643	0.30
Manhattan	–	–	4892	0.65
San Francisco	34,882	1.09	3634	0.95
Boston	9148	0.43	2456	0.87
Cambridge	–	–	1540	2.93
Brookline	–	–	534	1.74
Seattle	6744	0.52	4179	1.49
Madison	3970	1.94	3547	3.35
Davis [a]	12,440	1.81	5190	21.59

[a] Sacramento region.
Source: Author's tabulaton from US Bureau of the Census (1998). Excludes on-the-job cycling, e.g., couriers and food delivery.

Virtually every city profiled here has expanded its efforts to encourage bicycling in recent years, and all indicate some increase in cycling since 1990, although few definitive statistics are available. There is considerable variation in the mix of policies and programs as well as in the overall intensity of pro-cycling initiatives. Also important is the institutional process by which cycling policies have been implemented at the local level. The case studies demonstrate that pressure from organized bicycling groups is crucial to adopting strong policies at the local level.

6.1. New York City[6]

New York could be America's leading cycling city, not just in total numbers but in mode share. The terrain is relatively flat, the streets are well lit and destinations are packed closely together. The low cost and casualness of cycling suit the city's many artists and free-lancers, and an extensive transit system lets New Yorkers travel exclusively via the complementary "green modes" – bike, walk and public transport.

Yet anyone venturing onto New York's streets atop two wheels confronts a legion of obstacles. Pavement is torn and treacherous, bike paths on bridges connecting Manhattan to the other boroughs are substandard and often closed, and car and truck exhaust fill the air. Most office buildings refuse entry to commuter bikes, and theft is rampant. Worst of all, traffic is heavy, and cyclists must constantly battle for a place on the road. Around 20 cyclists are killed in traffic each year, and hundreds more are seriously injured (Transportation Alternatives, 1993).

With an estimated 100,000 bike travelers on a typical day (Transportation Alternatives, 1998), the city's regular cycling populace outstrips that of any other American city, but is still just 2% of adult residents. Ridership swelled in 1980, when a transit strike forced many New Yorkers to try new ways to get around. According to data compiled by the New York City Department of Transportation (1998), daily cycling trips entering the Central Business District (Manhattan south of 60th Street) increased 65% from 1980 to 1990, and by an additional 45% from 1990 to 1997.

Several thousand of the daily cyclists are hired riders – bike messengers conveying business parcels or cyclists delivering carry-out meals. Their trips and those of bicycle commuters are concentrated in the CBD. Annual surveys during 1988–1992 measured per-avenue midtown Manhattan cycling volumes of 125 to 200 per hour, accounting for an average of 8.6% of vehicles (Transportation Alternatives, 1993).

Yet even this impressive mode share does not fully reflect the interest in cycle commuting suggested by anecdotal evidence and confirmed in a 1990 government survey (New York City Department of Transportation, 1990). Half of 700 office workers living within 10 miles of their job, and one-fifth of 1600 others with longer commutes, said they would bike to work if provided with safe lanes, secure parking and wash-up facilities. Even allowing for exaggeration or selection bias, the survey is powerful evidence of pent-up desire for utilitarian cycling in New York City.

Key to a bicycle-friendly New York would be a network of on-street bike lanes offering respite from cars. Currently, some 80 kilometers of streets have bicycle lanes, or less than 1% of the city's 10,000 km street network (New York City Department of Transportation, 1998). The traditional

[6] Some text in this case study was adapted from the *Bicycle Blueprint* (Transportation Alternatives, 1993), edited by one of the authors.

policy of devoting most street space to automobiles has made appropriating vehicle lanes for bicycles politically daunting.

Recognizing this difficulty, most of the 151 infrastructure improvements proposed in a book-length *Bicycle Blueprint* published by advocates in 1993 concerned non-road facilities such as bike parking and bike-transit links (Transportation Alternatives, 1993). Only a handful of these simple and inexpensive prescriptions have been implemented, in part because antipathy to cyclists is so widespread.

For the past decade-and-a-half, coinciding with the waning of enthusiasm for conserving petroleum fuels, bicyclists in New York have been typecast as "kamikaze" riders who willfully endanger pedestrians and themselves. Although this perception has been most closely associated with for-hire riders and is wildly at variance with actual accident rates, it strongly colors attitudes and ensures that no cycling proposal goes forward without protracted debate. Nor does it help that cyclists are an unglamorous and somewhat faceless part of the city's traffic mix. Indeed, the vulnerability of cyclists seems to inspire scorn, as if cyclists should pay for the folly of venturing onto the streets in the first place.

Still, the existing New York City street network provides a modicum of room for cycling. Curbside lanes on most Manhattan avenues are extra-wide, and some side streets function as one wide lane. Although pervasive double-parking constantly forces cyclists to change lanes, moving vehicles often yield to cyclists, particularly faster riders. After years of delay, a city bike racks program has installed close to 1500 bicycle parking spaces on sidewalks, although in many areas cyclists still must lock to lampposts, construction scaffolding and even garbage cans.

In late 1997 New York City began a campaign to improve compliance with traffic laws by motorists, pedestrians and cyclists. Hundreds of city speed limit signs (30 mph) were posted, and "zero tolerance" for speeding violations was enforced for one day. Although cyclists have criticized the campaign as uneven and one-sided, many appreciate even the occasional ticketing of lane-blocking or speeding motorists, sometimes by bicycle-riding police. Preliminary police data indicate that bicyclist and pedestrian fatalities decreased sharply in the first half of 1998, suggesting that enforcement efforts and public awareness may be increasing safety.

Yet cyclists remain politically marginal, and cycling progress is piecemeal at best. Still unchanged is the unspoken sense that cyclists only impede car and foot traffic, that the city would be better off without bicycles altogether. The vision of cycling humanizing and liberating New York remains the dream of embattled cycle advocates. Even in America's least car-dependent city, the dominance of pro-auto policies consigns cycling to the fringe.

6.2. San Francisco

San Francisco hosts the most vibrant cycling community in North America. By any measure – growth in numbers, effective advocacy, political visibility and sheer exuberance – San Francisco stands at big-city cycling's leading edge. Although definitive time-series data are not available, cycling in San Francisco appears to have at least doubled during the 1990s. The share of residents identifying themselves as bike commuters jumped from 1.0% in 1990 to 3.7% in 1997, and bicycle traffic counts along several major corridors grew by 80% in just three years (San Francisco Bicycle Coalition, 1998). The San Francisco Bicycle Coalition claims that cycling is reaching "critical

mass,'' with the power of example creating new converts, while increased volumes socialize motorists to tolerate cyclists, engendering still more cycling.

The metaphor of a self-sustaining chain reaction is deliberate, as San Francisco's cycling resurgence has been sparked by ''Critical Mass'' rides held monthly since 1992. Begun as ''organized coincidences'' of a hundred or so cyclists, the rides have grown into mass happenings of thousands of riders who revel in commandeering the streets and sometimes taunting luckless drivers stuck in their midst. The Mass rides have erased the image of the lonely, beleaguered cyclist and made bike-riding a hip expression of community. Critical Mass rides have spread to other cities throughout the world, including London, Rio de Janeiro, Sydney, Zurich and Tel Aviv.

Curiously, the city's hilly topography helps cycling by fostering a proud and cohesive bicycling community. Navigating San Francisco by bike takes both conscious planning and cycling muscles, so residents who ride often identify with cycling. Bike messengers are more immersed in cycle culture than their counterparts elsewhere and are less prone to the feckless behavior that has impeded bicycle progress in other cities.

Another ingredient in San Francisco's successful cycling mix is the San Francisco Bicycle Coalition (SFBC). Over a period of extraordinary growth – from a handful of ''refounding'' members in 1991 to 1700 members in 1998 – the SFBC has stayed connected to cycling's grassroots as it maneuvers inside the city bureaucracy. After police arrested a hundred Critical Mass riders in July 1997, leading to a mini-riot, a monumental traffic jam, and front-page coverage, the SFBC deftly steered the ensuing debate toward the more prosaic but real shortcomings of the city's transportation system, ranging from dangerous cycling conditions to downtown gridlock and inadequate transit.

Nevertheless, in a stunning reversal a year later, the city administration withdrew support for an on-street bike lane network that officials had painstakingly mapped from dozens of routes blazed by cyclists. The network would have significantly expanded the city's bike routes, which now comprise approximately 20 km of multi-use paths, 30 km of on-street lanes, and 50 km of streets with widened curb lanes, out of a total of 1425 km of streets and highways (Tannen, 1998). Activists hope to counter with ''Bike Summer,'' a world showcase for cycling in San Francisco in 1999.

By working creatively and persistently for fewer cars, better transit and pedestrian safety, as well as improved bicycle facilities, the SFBC is transcending the customary narrow focus of cycling advocacy to promote a fully pluralistic transportation system. Notwithstanding the lane-network setback, the dream of a cyclist-led movement to make city streets safe for all is alive and well in San Francisco.

6.3. Boston

Boston and its near neighbors Cambridge and Brookline are characterized by a large student population, walkable neighborhoods, and an urban core that is almost European in its density, compactness and narrow streets. Not surprisingly, there is more cycling in the Boston area than in most American cities. In 1991, bicycles accounted for 2.7% of trips in Cambridge, 2.5% in Brookline, and 1.5% in Boston (calculations based on CTPS, 1995).

Utilitarian cycling is popular in the Boston area for the same reasons it is widespread in Europe – it is often the quickest way to get around. Only recently, however, have local governments

attempted to improve cycling conditions. Cambridge established a governmental bicycle committee in 1991, with the City of Boston following in 1996 and Brookline in 1997.

Between 1995 and 1998, Cambridge striped 6 km of on-street bike lanes, mostly on streets with wide lanes. Less progress has been made in Boston, however, where some major streets feature lanes so narrow that cyclists must completely occupy a travel lane or risk riding into opening doors of parked cars.

As in Boston, officials in neighboring Brookline have expressed interest in bike lanes, but not where it requires removing on-street parking or reducing through traffic to only one lane. In one road reconstruction project, the town plans to stripe an intermittent bike lane – marked only where the road width permits maintaining at least two through lanes and a parking lane.

Cambridge has required bicycle parking as part of its zoning code since the 1980s, and racks are included as part of standard street furniture in reconstruction projects in all three municipalities. Cambridge has installed 330 cycle parking racks on sidewalks and is planning more. Boston recently requested bids to install its first 350 racks.

The Cambridge school system began mandatory bicycle safety presentations in elementary schools in 1997, but otherwise there is little school-based bicycle education in the area. In the 1980s the Boston-based advocacy group Bikes not Bombs was one of the pioneers of the "Earn-a-Bike" program, in which kids earn a recycled bicycle after they have learned to overhaul it and ride it safely. The program has spread to 40 American and Canadian cities under the auspices of the Youth Bicycle Education Network.

In 1997, spurred by complaints from walkers about cycling on sidewalks, Cambridge trained its entire police force in bicycle enforcement and began ticketing scofflaw cyclists. In Boston, heavily publicized collisions between bicycle messengers and pedestrians in 1991 and 1997 led to laws requiring licensing and registration of bicycle messengers and their employers. Still, citations remain rare for road users of any type, and illegal and dangerous traffic maneuvers are common among cyclists and motorists. Even some Boston bicycle police officers regularly violate traffic rules.

Cyclists flock to the 29 km of traditional recreational paths along the Charles River, despite their narrow width (under 2 m in some places), unsignalized intersections, and space competition from joggers, skaters, and walkers. The 18 km Minuteman Bike Path through three northwest suburbs opened in 1992 and has attracted many new bicycle trips (Lewis, 1996). Similar rail trails have been designed in many of Boston's suburbs but are being fought by abutters who fear crowds of cyclists in their back yards.

Demographics, topography and urbanity make Boston and environs a candidate for a bicycle boom. Although the area has more cycling than the typical US metropolis, its vast biking potential remains untapped.

6.4. Toronto

Toronto is one of the coldest of our case study cities, yet it has one of the highest rates of bicycle use of any large North American city.[7] In 1991, 2.3% of Toronto adults said they cycled to work

[7] All references in this section are to the new City of Toronto which was formed on January 1, 1998 by consolidating the former Municipality of Metropolitan Toronto and its six constitutent local municipalities (the old City of Toronto and five others).

at least occasionally, with twice that many in the old city of Toronto (Daniel Egan, personal communication, 1998). The number of bicycle trips to the Toronto central area increased by 75% between 1987 and 1993 (City of Toronto TCCC, 1994, 1996), and more recent traffic counts suggest that usage has held steady at this higher level (Daniel Egan, personal communication, 1998).

In Toronto, as in many other cities, a threat to cyclists' rights served as a catalyst to cyclist organizing and progress. In 1974, Toronto planners proposed prohibiting cyclists from arterial roads and relegating them to sidewalk bikeways and park trails. Out of the ensuing protest and debate an official city advisory board, the Toronto City Cycling Committee (TCCC), was established a year later. The city's Planning and Development Department created a professional staff to support the committee in 1983.

Toronto is one of the few cities that sponsors a substantial bicycle education program. The TCCC produces posters, flyers and public service announcements, sponsors cycling classes and stages occasional high-profile traffic enforcement events. The training program may be the largest in North America, with 500 child and adult students each year (City of Toronto TCCC, 1995). Although the 12–18 hour classes attract a small portion of the cycling population, graduates' knowledge is spread informally to other cyclists.

For years, the annual Bike Week during May has been a catalyst for cycling outreach and advocacy. The city's myriad bicycle-related groups hold neighborhood tours, bicycle art auctions, parades, demonstrations, festivals, and lectures. Bicycle user groups started as Bike Week organizing committees in the early 1990s but have grown into year-round cycling support networks in dozens of neighborhoods and workplaces. In some cases they now include promoting "green" transport modes such as transit.

Businesses that accommodate cycling customers (for example by providing bicycle parking) can receive plaques identifying them as Bike Friendly Businesses. This effort has expanded into a larger joint public-private initiative, Moving the Economy, promoting economic development in sustainable transportation.

Cycle activists have created other innovative programs. *Intersection* trains community bicycle activists, houses a sustainable transportation library, and publishes materials on cycling and transport. The *Community Bicycle Network* (*CBN*) provides bike trailer rental, operates a bike delivery program for local businesses, and co-ordinates a network of volunteer-run, bike recycling, repair and training centers serving people in need. *Advocacy for Respect for Cyclists (ARC)* provides legal support for crash victims, organizes memorials for cyclists killed on the streets and promotes changes in traffic law to improve bicycle safety.

After two cyclists were killed within a week in Toronto in 1996, ARC persuaded the regional coroner to undertake a comprehensive study of cycle accidents – the first such epidemiological study in North America in over a decade. After a two-year study, the coroner recommended amending Ontario's Highway Traffic Act to give cyclists precedence over motorists where the right of way would otherwise be ambiguous, and requiring sideguards on heavy trucks to keep falling cyclists from being swept under the wheels. These and other proposals by the coroner break new ground in urging motorists' responsibility for cyclists' safety (Lucas, 1998).

The ubiquitous symbol of city support for bicycling is the post and ring. About 4000 of these simple bicycle parking devices were installed on Toronto sidewalks between 1984 and 1998. In the 1970s and 1980s, Toronto established 35 km of signed bicycle routes (generally residential streets

with "Bike Route" signs), 43 km of bike paths, and 9 km of bike lanes. In one such project, one of six lanes on the high-speed Prince Edward Viaduct was converted to a shoulder bike lane; it is now one of the most heavily used bicycle corridors.

A new effort begun in 1993 to mark on-street bicycle networks brought the aggregate bike lane length to 50 km in 1998, out of 1053 km of roads in the old Toronto. Another 15 km of bike lanes per year are planned. Despite constant blockage by parked vehicles, Toronto streets with bicycle lanes show an average 23% increase in bike traffic two years after implementation (Daniel Egan, personal communication, 1998). Some of the increase may be from re-routed rather than new trips.

Toronto also leads most North American cities in maintaining and improving off-road paved trails, which total 125 km. The most popular of these shared-use paths run along the two river valleys surrounding the central area and along the lake shore. These paths are generally 3 m wide, but are being upgraded to the 4 m standard for new paths. In other improvements, crowded sections along the waterfront have been separated into parallel pedestrian and cyclist paths, gaps in one river valley path have been filled, and two new bicycle-pedestrian bridges have been opened (Barber, 1998). Some 200 km of new trails along hydro and rail corridors are under study (Daniel Egan, personal communication, 1998).

Toronto's experience shows that a high level of utilitarian cycling is attainable, particularly in older, dense North American cities, and that active involvement by advocacy groups and city officials can more than offset natural disadvantages such as cold weather.

6.5. Seattle

Seattle's damp climate and hilly terrain present more challenging conditions for cycling than most US cities. Yet *Bicycling* magazine has twice rated Seattle "best bicycling city," and cycling appears to be more widespread there than in any other major American city. Surveys show that 16% of Seattle residents cycle at least two days a week, and another 20% ride at least occasionally. Depending on the time of year and weather, between 4000 and 8000 residents commute by bike each day, with an overall work trip modal share of 2.3% (City of Seattle, 1991, 1998).

Over the past decade, the city government has implemented a wide range of programs to encourage bicycling. Seattle's Urban Trails System now includes 45 km of bike paths, 24 km of on-street bike lanes, and 145 km of signed bike routes with wide curb lanes and shoulders. The City has set aside $8 million for an additional 68 km of lanes, paths and routes, and further extensions are planned.

Complementing its Urban Trails System, the city is working to make all its roads bikeable through resurfacing, pothole patching, widening of curb lanes, drain grate replacement, better signage and lane striping and bike-activated traffic signals, along with free distribution of bike-route maps (City of Seattle, 1998). The city's Spot Improvement program circulates postcard forms to cyclists to identify road and path maintenance needs (Rails-to-Trails Conservancy and the Association of Bicycle and Pedestrian Professionals, 1998).

Another Seattle innovation is police bicycle patrols, which began with only four officers in 1987 but now includes several dozen officers. The program has markedly improved criminal apprehension, reduced costs, and brought the police closer to the citizenry. Inspired by this success, over 2000 other American cities have adopted police bike patrols.

Seattle also abounds in cycle racks and bike-bus connections. From 1993 to 1997, the city installed 1622 bike racks, both downtown and in neighborhood business districts. In addition, all city buses are equipped with two-bike external mounts serving passengers who cycle to and from a bus stop. Bicycle-bus trips, 300,000 annually, make both cycling and transit use more efficient and widespread.

Since 1977, a Bicycle Advisory Board meeting monthly has reviewed proposed bicycling projects and helped set funding priorities. The board includes representatives of local cycling advocacy groups, who are strongly rooted in the region's outdoor-adventure culture of mountaineering, hiking, kayaking, and cycling. Cycling advocacy is formally organized by the Cascade Bicycle Club (CBC) and the Bicycle Alliance of Washington (BAW, formerly Northwest Bicycle Federation).

CBC offers training classes for both children and adults and is the first bicycle club in the United States to contract with professional educators to provide cycling programs through schools, libraries, community centers and civic clubs. Although the focus is on safety (with free helmet distribution), there are also classes in bike repairs, health benefits of cycling, and expert cycling techniques. CBC also coordinates media campaigns for safer cycling, makes public presentations in Seattle neighborhoods, runs demonstrations and information booths at events and fairs and runs cycling summer camps (Cascade Bicycle Federation, 1997; Northwest Bicycle Federation, 1998).

CBC and BAW also organize mass events such as Bike to Work Day to publicize cycling and raise community and political support, and organize large-scale bike tours in and around Seattle. Both also lobby for bicycling-friendly transport policies at every government level.

Although such lobbying and public relations campaigns have generated support for pro-cycling policies in Seattle, it is not clear how much bicycling has actually increased as a result. The only time-series data available indicate that peak morning cycling in downtown Seattle grew 28% from 1992 to 1995, thus mainly reflecting commuting trips, which account for almost 30% of all bike trips in Seattle (much higher than the national average) (City of Seattle, 1991, 1998). Seattle's director of bicycling programs reports that bike path traffic has increased to the point of congestion during peak periods (Peter Lagerwey, personal communication, 1998).

Frequent drizzle and hilly topography remain deterrents to cycling for many residents. Indeed, surveys show that on rainy days utilitarian cycling in Seattle falls by 45%, and recreational cycling by 80% (Washington State Transportation Commission, 1995). Nevertheless, Seattle is a leading model among major US cities for innovating and implementing policies to encourage bicycling.

6.6. Madison, Wisconsin

Madison has a tradition of cycling and government support of cycling dating to the bike boom of the early 1970s. Although smaller than most other cities in our study, it is much more urban than Davis, the other university town profiled here, and has harsher weather. Yet Madison has one of the highest rates of cycling in the US, and features more bike lanes and paths than most US cities of any size. It has also done much to improve the less visible elements of cycling infrastructure – roadway design, street maintenance, traffic enforcement, parking facilities, and theft prevention.

For several years in the 1980s, Madison had a corps of police volunteer "bicycle monitors" empowered to warn and ticket bicyclists violating traffic rules. Currently, a bicycling training class is offered in the public schools, and a state-aided program teaches *Effective Cycling* classes to adults (Flucke, 1998), including state Department of Transportation staff. Madison publishes a Bicycle Map and Resource Guide with route and road quality information, safe cycling tips, and contact information.

Madison's network of bicycle paths and lanes, begun in the 1970s, now includes 35 km of bike paths, 26 km of streets with bike lanes, and 16 km of streets with wider than normal outside lanes. All new arterials have a 1.2 m bike lane, a 0.6 m gutter, and no on-street parking (Arthur Ross, personal communication, 1998). As in Toronto, some streets in the center city have "managed parking" lanes, where parking is prohibited during peak periods; at other times the additional width in the parking lane provides sufficient room for bicyclists.

Madison's zoning laws have required provision of bicycle parking since 1988, and the city recently began providing racks in public areas. Madison has well organized and promoted Bike to Work week events. The city circulates a bicycle request form similar to the spot improvement form pioneered by Seattle. Madison's form also includes space for entering bikeway suggestions and reporting bicycle-motor vehicle conflicts.

6.7. Davis, California

Davis, a small city a dozen miles west of Sacramento, is by far America's most bicycle-oriented municipality. As a university town with ideal cycling weather nearly year-round, Davis is well disposed to be bicycle friendly. Both the city of 52,000 and the University of California campus, with 20,000 students, are unique in America for their high levels of bicycling, the quality and completeness of their cycling infrastructure, and the extent to which cycling is now ingrained in their identity.

Bicycle facilities include thousands of parking racks serving virtually all stores, government offices and other public places; 56 km of off-street bike paths, another 56 km of wide on-street bike lanes on 80% of arterials and collector streets; and 11 grade-separated bike bridges and tunnels crossing expressways and other major roads. Many Davis neighborhoods are built around a network of superbly maintained greenways that provide recreation and transportation alike and foster children's independent mobility (Bicycle Federation of America, 1995).

More than 20% of all trips in the city are by bike, and many of these are with or by children. The city dispensed with school buses years ago, so kids reach school by bike or on foot. Bike trailers – two-wheeled buggies that attach behind any conventional bike – are as common a sight in Davis hauling kids and groceries as are ordinary bikes in some cities.

The centrally situated University of California, Davis campus is even more bicycle-oriented – half of all trips are by bicycle, and most of the remainder are on foot. The core area was closed to ordinary car traffic in the mid-1960s, and all campus roads have wide, clearly marked bike lanes. Electronic gates exclude private vehicles without permits, so car-bike conflict on campus is rare. Every building sports huge clusters of bike racks, totaling 15,000 campus-wide. Roundabouts at major path intersections allow streams of crossing cyclists to pass safely. Indicative of the care given to cycling infrastructure, different radii were field-tested in the 1970s to determine the

optimal geometry before the traffic circles were constructed (David Takemoto-Weerts, personal communication, 1996).

Davis city and campus resemble the best cycling cities and towns of northern Europe, not just in high cycling percentages but in attitude and custom. Cyclists observe traffic laws, and drivers keep out of bike lanes and defer to bike riders' right-of-way. Both the city and campus police enforce traffic laws applying to cyclists and offer optional traffic safety lectures in lieu of payment of traffic fines. Motorists and cyclists alike seem pleased to be out of each other's way. In Davis, bike riders are neither eccentrics nor enthusiasts; they are ordinary people riding bicycles.

By rough estimate, the Davis campus alone accounts for about one in every thousand miles bicycled in America. If its cyclist fatality rate were the same as the nation's as a whole, the university could be expected to suffer at least one cycling fatality every few years. In fact, the campus has never had a bike-related fatality – a tribute to the quality of its facilities, its philosophy of separating motor vehicle traffic from bikes, and seemingly equitable rules that command adherence by all. Davis campus and the surrounding city prove that a genuine cycling infrastructure can attract and sustain high levels of responsible use even in the car-dependent US.

7. Factors affecting cycling in North America

The preceding sections report that cycling has increased in North America over the past two decades, both in the aggregate and for seven case study cities. While the increases are encouraging, the share of total trips by bike in the US still stands at only about 1%, far lower than in most European countries (Pucher, 1997). In the final sections of this paper we assess the potential for increasing bicycling in American cities, and consider what policies and programs might be effective at promoting cycling.

Although climate and topography affect cycling levels, the case studies show that they do not explain differences in cycling rates among North American cities. A more important deterrent is the low-density sprawl of most American metropolitan areas, which increases average travel distances and renders utilitarian cycling less feasible. This factor alone may explain the higher cycling levels in Canadian cities, which are more than twice as dense as American cities (Schimek, 1996b; Pucher, 1994). European cities are denser still, leading to average trip lengths only about half those in the US (Pucher, 1995).

Nevertheless, even in the US, a considerable percentage of urban trips are within cycling distance. According to the NPTS, 28% of trips by all modes are one mile or shorter, and another 20% are 1–3 miles. Of course, some of those short trips are links of longer trip chains that are less readily bikeable. Nevertheless, the high percentage of short trips suggests great potential for increased bicycling, even in the low-density, sprawled cities of the US.

Why, then, does bicycling in the United States remain at low levels? Here we summarize eight key factors.

7.1. Public attitude and cultural differences

Is bicycling for transportation considered a normal thing to do? In the Netherlands and Denmark, it is usual for young and old, rich and poor, and students and executives alike to bicycle

for many different purposes. In the United States, most cycling is for recreation, and most cycle commuters are men. Even though a majority of Americans own a bicycle, cycling is considered a "fringe mode" in the US (Gordon and Richardson, 1998), befitting its 0.9% share of total trips. Utilitarian cycling is even less mainstream, with the bicycle used for only 0.3% of all work trips in 1995, according to the NPTS.

Culture, custom and habit are important. While the other factors listed below help explain which forms of travel behavior become widespread and thus considered "normal", countries with unbroken traditions of utilitarian cycling have an easier time maintaining that tradition. Where cycling is viewed as normal, people consider doing it when it is convenient, and they have access to the necessary equipment and knowledge. Similarly, motorists exhibit more respect toward cyclists, partly because they are more likely to cycle themselves or know others who do. In general, where there are few bicyclists, cycling is considered abnormal and this climate tends to be self-perpetuating.

7.2. Public image

There is no single image of bicycling in America, but a multiplicity of perceptions dependent upon the type of cycling and the context in which it is viewed. Recreational cycling has a youthful, vigorous image since it is associated with sport and fitness; some car ads even feature recreational cyclists. Bicycling as a whole also has a positive environmental image, thanks to zero air pollution, negligible noise, and minimal energy use. In cities, where the vast majority of utilitarian cycling takes place, cyclists suffer from a renegade image associated with disobedience of traffic laws, and a pervasive sense of cyclists as an alien presence on roads intended for cars. Indeed, the various images of cycling are so heavily determined in relation to automobiles that utilitarian cyclists are variously seen as too poor to own a car, "anti-auto," eccentric, or deviant. The perceptions of cycling as lying outside the mainstream of American life discourage bicycle use.

7.3. City size and density

Small, compact cities are more amenable to cycling since more destinations are accessible within a short bike ride, motor traffic volumes are lower, and there are less likely to be obstacles such as expressways and bridges. Indeed, to our knowledge, no very large city (2 million or larger) in either Europe or North America has bike use exceeding 10% of trips. Europe has many more small, dense cities where biking is convenient for reaching many destinations.

7.4. Cost of car use and public transport

The cost, speed, and convenience of alternative modes have a crucial impact on modal choice. In the US, the low user-cost of autos is crucial in discouraging virtually all other modes, even walking. Low gasoline taxes, few road tolls, and ubiquitous free parking make auto use almost irresistible in the United States. At negligible marginal user costs, car use becomes a habit even for short trips that could be walked or cycled (Pucher, 1995). Not only are road tolls, taxes and fees far higher in Europe, but the extensive availability of transit makes car ownership less essential,

thus reducing the number of car-owners and increasing the tendency to use bicycles for many utilitarian trips.

7.5. Income

Rising incomes make car ownership and use more affordable. Every econometric analysis of the relationship between income and auto ownership finds a very high positive correlation. This helps explain why university students are more likely to bicycle, and suggests that the bike share of travel should decrease over time as countries get richer and an ever-larger share of the population can afford cars. This generalization does not always hold, however. Although Denmark, the Netherlands, and Germany are among the wealthiest countries in the world, they have very high bike modal shares.

7.6. Climate

Cycling levels are obviously affected by climate. Three case study cities with relatively high levels of cycling (Davis, San Francisco, and Seattle) enjoy mild winters and, in the case of the first two, little rain. The extreme heat and humidity of summers in the southern United States clearly discourage cycling there. Yet the effect of climate on cycling may be exaggerated. In spite of mostly cloudy days and frequent rain and drizzle, northern Europe has the highest cycling levels, far higher than in southern Europe, where it is drier, sunnier and warmer.

7.7. Danger

As discussed in Section 3, the possibility of accidental injury and death is a major obstacle to bicycling. Making cycling as safe or safer than driving will require behavioral changes by both drivers and bike riders, as well as development of more cycle-appropriate infrastructure. While several European countries have national cycle training programs and more strictly enforce traffic rules for both drivers and cyclists, efforts at such behavior modification have been far less extensive and less successful in the US.

Moreover, in the United States the elevated risks of cycling appear to be magnified by cultural attitudes that attribute cycling accidents to the supposedly intrinsic perils of bicycles. In contrast, motorist casualties are not ordinarily associated with the idea that driving is dangerous (Komanoff, 1997). From there it is a short step to blaming cyclists for their own peril, an attitude that permeates the reactions of everyone from police and courts to the cyclist's own family and friends and contributes to cyclists' marginal status. Thus, measures to reduce the statistical frequency of cycling accidents may need to be coupled with efforts to change public understanding of the nature of road dangers – a difficult task at best.

7.8. Cycling infrastructure

Unquestionably, separate bike lanes and paths for cyclists, together with better parking facilities, make cycling more attractive to non-cyclists. However, we are not aware of any rigorous statistical studies of their actual impact on increasing cycling levels; to some extent, such facilities may be a response to increased cycling instead of its cause. Nevertheless, every European city with

high cycling levels has an extensive route system, including separate bike paths and lanes as well as general street use in traffic-calmed neighborhoods.

8. Steps to increase cycling in North America

Following are seven proposals for making cycling more widespread in the US and Canada.

8.1. Increase cost of auto use

Probably the most effective way to increase bicycling in North America would be to discourage auto use and increase its marginal cost, particularly for short auto trips that are both underpriced and most amenable to cycling. A sizeable increase in the price or inconvenience of driving would encourage people to seek other ways to travel and begin loosening the automobile's domination of daily transportation. Unfortunately, this approach is politically difficult. Indeed, the new federal transportation legislation (TEA21) fixes the federal gasoline tax at the same low level (approximately two cents per liter) for the next six years, and recently taxes on auto ownership have been rolled back in several states.

A more promising approach may be restructuring road taxes and auto insurance to shift lump-sum charges into marginal use fees, thus providing positive incentives to shorten trips and make greater use of non-auto modes (Litman et al., 1998). Blocking highway expansion also increases the time cost to drive and can make cycling more attractive, although it could also work against cycling by fomenting "rat-running" (driver use of local streets) and "road rage".

8.2. Clarify cyclists' legal rights

To a great extent, cyclists in the United States and Canada operate outside the prevailing system of traffic governance. As we have noted, many motorists and even police are not cognizant of cyclists' right to use ordinary roads, and there is scant appreciation of the vulnerability cyclists feel when autos impinge too closely. In contrast, many northwestern European cities actively promote cycling through conferences, fairs, and school programs, and their traffic rules, policing, licensing, and judicial systems uphold cyclists' rights far more than do their North American counterparts.

However difficult it may be, establishing motorists' accountability for their actions toward cyclists is crucial to improving bicycling safety and encouraging cycling. A key first step, noted in the Toronto case study, would be to establish as a principle of law that cyclists have precedence over motor vehicles where both are vying for the same road space and neither clearly has right of way over the other. With their preferential right of way established in law, cyclists might improve their adherence to traffic laws, leading in turn to greater consideration from motorists in a reinforcing process of mutual respect.

8.3. Expand bicycle facilities

As discussed earlier, separate facilities (bike paths and lanes) are not a panacea for making cycling easier and safer. Nevertheless, rail trails and mixed-use greenway paths have increased

recreational bicycling, and strategically located cut-through paths (as in Davis) can reduce trip times and thus encourage utilitarian cycling as well. The most successful bicycling programs examined in this article – in Davis, Madison and Seattle – include separate facilities in their overall strategy. Moreover, in every European country with at least 10% bike modal split, separate cycling facilities (and traffic-calmed neighborhood streets) are integral parts of the bike route system.

Separate paths and lanes are especially important for those unable or unwilling to do battle with cars for space on streets. Training courses may help, but they do not eliminate the inherent danger of cycling on the same right of way with motor vehicles, particularly for those whose mental or physical conditions limit their capacity to safely negotiate heavy traffic. The slowed reflexes, frailty, and deteriorating hearing and eyesight of many elderly make them especially vulnerable, while limited experience, incomplete judgment, and unpredictable movements put children at special risk on streets. And regardless of age, many people prefer to avoid the anxiety and tension of cycling in mixed traffic, aside from safety hazards. Bicycling should not be reserved for those who are trained, fit, and daring enough to navigate busy traffic on city streets.

8.4. Make all roads bikeable

More than other countries, the United States must rely heavily on the general road network for bicycling. Some cities have bike lanes and paths that link up to some extent, but none has a complete route network approaching the dense network of bike paths and lanes in virtually every Dutch, Danish and German city and throughout the countryside, with official route designations, signage and maps. Even Davis and Seattle, with their impressive cycleways, must also rely on the general road system. Thus, a fundamental strategy to make America bikeable must be to improve roads through wider curbside lanes and shoulders, drain grate replacement, pothole patching, clear lane striping, and bike-activated traffic signals, while punishing motorist behavior that infringes upon cyclists' legal right of way. Seattle's efforts to improve the road infrastructure are a good model, but no US jurisdiction has taken real steps to inculcate motorist responsibility for cyclist safety.

8.5. Hold special promotions

Bike-to-work weeks and employer-based promotions appear to have been helpful in inducing North Americans to try – and then continue – cycling for transportation. Similarly, large-scale rides ranging from recreational and charity events to San Francisco's monthly Critical Mass rides help build cyclist confidence and provide mutual support and enthusiasm for cycling. In some cases such rides have also focused public attention on the needs of cyclists and helped force a shift toward more cycling-friendly public policies.

8.6. Link cycling to wellness

Numerous studies have documented the health benefits of regular exercise, and physical inactivity has come to be seen as a major cause of premature death in industrial societies, second only to tobacco. Cycling, potentially an ideal, low-cost way of getting that activity, has been

linked in the public mind to risk-taking and danger, in part by health-based helmet promotions that implicitly link cycling to danger. The British Medical Association's finding that cardiovascular-related gains to longevity from cycling far outweigh collision risks, though widely reported in Europe, is little known in North America (BMA, 1992). New programs from the California Department of Health Services and the US Centers for Disease Control and Prevention seek to integrate routine physical activity into people's travel, work, leisure and family life by making physical environments more amenable to walking and bicycling (Seeley, 1998). Holistic and proactive efforts by the health community could boost cycling by casting it as a prudent, healthful choice.

8.7. Broaden and intensify political action

As emphasized by Wachs (1998), political action is essential to bring about changes in public policy to encourage more and safer cycling. Bicyclists in many parts of the United States are already well-organized, and have learned to wield political clout to obtain funding for cycling facilities. Cyclists have won pro-bicycling provisions in ISTEA and TEA21 that portend major expansions and improvements to systems of bike paths, lanes and parking. TEA21 also encourages better roadway design, which provides an important basis for making more roads bikeable.

Nevertheless, it remains to be seen how effectively cycling groups can pressure state highway departments to carry out the federal mandates. Similarly, cycling groups will have to continue to exert pressure at the local level to maintain and improve existing elements of the cycling infrastructure, such as bridge access, against the threat of prohibitions or banishment to substandard facilities. Cyclists will also need to open up another front: inducing police and courts to enforce the rights of bicyclists to use city roads and to curb driving privileges of motorists who violate those rights.

9. Prospects for bicycling in North America

With the right set of public policies, bicycling in the United States could increase dramatically. As noted by both Wachs (1998) and Gordon and Richardson (1998), to date there has not been sufficient political support to pass and implement those policies. So far, only the easiest no-conflict measures have been implemented; most new bike paths and lanes in the United States do not directly compete with auto use. By contrast, many European cities have implemented policies that sharply restrict auto use in favor of walking and bicycling, especially in city centers (Pucher, 1997, 1998).

German, Dutch, and Danish cities give cyclists priority on certain streets and intersections and routinely employ "advanced" green lights and traffic-calmed streets. Some one-way streets have been made two-way for bicyclists, and cyclists are exempted from many turn restrictions for cars. Some European cities have dedicated car parking space to bike lanes or bike parking, not just to enable cycling but to discourage auto use. Enacting such measures has taken concerted political pressure, even in cities where 20% of the populace cycles regularly. Such auto-restrictive initiatives do not yet appear politically feasible in America. Too many Americans drive cars (and would feel

hurt by such measures), and too few Americans presently bicycle (and feel they would benefit enough to fight for such measures).

It is possible to imagine a *deus ex machina* giving a strong boost to cycling in America – perhaps an oil shock, or a cultural or style change toward bikes and away from cars, or ascendancy of a charismatic politician closely identified with cycling. But the more likely scenario is slow, painstaking progress: modest extensions and improvements in separate bicycle facilities, even more modest improvements in roadway design, and isolated instances of effective enforcement of cyclist rights to use public roads. Those measures may produce significant growth in bicycling in those cities that implement them. But overall, they will not produce a bicycling boom, unless the visible success of cycling enhancements in one or two major cities attracts imitators elsewhere.

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