

Bicycling Renaissance in North America? An Update and Re-Appraisal of Cycling Trends and Policies

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Please cite this article as forthcoming:

**Pucher, J., Buehler, R., Seinen, M. “Bicycling Renaissance in North America?
An Update and Re-Appraisal of Cycling Trends and Policies” *Transportation Research A*,
*Vol. 47, 2011, in press.***

Note: All tables and figures can be found at the end of the text. Their approximate location in the final article is indicated in the text.

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Abstract

This paper reviews trends in cycling levels, safety, and policies in Canada and the USA over the past two decades. We analyze aggregate data for the two countries as well as city-specific case study data for nine large cities (Chicago, Minneapolis, Montréal, New York, Portland, San Francisco, Toronto, Vancouver, and Washington). Cycling levels have increased in both the USA and Canada, while cyclist fatalities have fallen. There is much spatial variation and socioeconomic inequality in cycling rates. The bike share of work commuters is more than twice as high in Canada as in the USA, and is higher in the western parts of both countries. Cycling is concentrated in central cities, especially near universities and in gentrified neighborhoods near the city center. Almost all the growth in cycling in the USA has been among men between 25-64 years old, while cycling rates have remained steady among women and fallen sharply for children. Cycling rates have risen much faster in the nine case study cities than in their countries as a whole, at least doubling in all the cities since 1990. They have implemented a wide range of infrastructure and programs to promote cycling and increase cycling safety: expanded and improved bike lanes and paths, traffic calming, parking, bike-transit integration, bike sharing, training programs, and promotional events. We describe the specific accomplishments of the nine case study cities, focusing on each city's innovations and lessons for other cities trying to increase cycling. Portland's comprehensive package of cycling policies has succeeded in raising cycling levels 6-fold and provides an example that other North American cities can follow.

Keywords: Urban transport policy; Cycling; Safety; Bike infrastructure; United States; Canada

Bicycling Renaissance in North America? An Update and Re-Appraisal of Cycling Trends and Policies

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1. Introduction

In 1999 this journal published a paper that posed exactly the same question as appears in the title of this article (Pucher et al., 1999). It is now over a decade later, and much has happened during the intervening years. Cycling infrastructure has grown dramatically in many cities, and more programs are now in place to encourage cycling (ABW, 2010; PBIC and FHWA, 2010). Some cities report a doubling or tripling in cycling levels since 2000 (City of Portland, 2011a; City of Minneapolis, 2011; NYCDOT, 2011). Thus, we present this article as an update to the 1999 review of cycling developments in North America, including a reappraisal of whether or not a cycling renaissance is really underway.

We examine aggregate trends and policies for Canada and the USA as well as city-specific developments in three large cities in Canada (Montréal, Toronto, and Vancouver) and six large cities in the USA (Chicago, Minneapolis, New York, Portland, San Francisco, and Washington). The 1999 article had only one Canadian city (Toronto); we have expanded that to three by adding Montréal and Vancouver, providing greater geographic coverage for Canada. We have also expanded the range of American cities by including Chicago, Minneapolis, Portland, and Washington, in addition to New York and San Francisco, which were case studies in the previous article. All nine of the case study cities have been at the vanguard of cycling policies in North America over the past decade.

We explicitly avoid a repetition of the lengthy discussion in the 1999 article about the choice of bikeway vs. roadway cycling facilities and the many other factors affecting cycling volumes and safety. Given the broad scope of our overview, it is not possible to analyze in any detail, let alone with rigorous multivariate methods, the impacts of specific types of infrastructure or programs on cycling levels. We do, however, cite the key literature related to the specific points we examine, with a focus on articles published since 2000. For a comprehensive review of the cycling literature, readers may consult four recent international surveys (Heinen et al., 2010; Krizek et al., 2009; Pucher et al., 2010a; Reynolds et al., 2009).

Our purpose in this article is two-fold: 1) to portray national trends in cycling levels, safety, and funding over the past two decades; and 2) to examine cycling trends, safety, and policies in large American and Canadian cities that have been especially innovative and successful at increasing cycling. As explained in this article, the cities we have chosen for detailed analysis have increased cycling far more than their countries as a whole, suggesting that their experience may provide valuable lessons for other cities seeking to promote cycling. Based on the results of our aggregate, national analysis and the city case studies, we assess to what extent the past decade has brought North America closer to a true bicycling renaissance.

2. National trends in cycling levels and trip purpose

As shown in Table 1, there has been considerable growth in cycling over the past few decades. The National Personal Transportation Surveys (NPTS) of 1977 to 1995 and the National Household Travel Surveys (NHTS) of 2001 and 2009 are the only sources of information on travel for all trip purposes in the USA. These surveys indicate that the total number of bike trips in the USA more than tripled between 1977 and 2009, while the bike share of total trips almost doubled, rising from 0.6% to 1.0%. The U.S. Census Bureau also surveys

travel but only for the trip to work. It reports a roughly constant level of daily bike commuters over the period 1980 to 2000 and a slight fall in the bike share of work commuters, from 0.5% to 0.4%. There appears to have been a turnaround since 2000, however, as the U.S. Census Bureau's American Community Survey (ACS) reports almost twice as many daily bike commuters in 2009 as in 2000 and an increase in bike mode share to 0.6% (Table 1).

Cycling has increased in Canada as well, but only work trip data from the Canadian Census are available for tracking trends, and only since 1996. They reveal a 42% increase in the number of daily bike commuters between 1996 and 2006 and slow but steady growth in bike share of work commuters, from 1.1% to 1.3% (Table 1). That is more than twice as high as the 0.6% bike mode share for work commuters in the USA. Canada does not have a national travel survey with information on non-work trips, so it is not possible to compare cycling levels in the two countries for all trip purposes.

Although Canada generally has higher cycling levels than the USA, there is much spatial variation in cycling levels within each country. The map of North America (Figure 1) highlights differences among the 50 US states (and District of Columbia) and the 13 Canadian provinces and territories in the percentage of workers cycling to work. In 2006 the bike share of daily work commuters in Canada ranged from a low of 0.2% in Nunavut to a high of 2.6% in Yukon Territory (Statistics Canada, 2010). Over the period 2005 to 2009 (averaged), the bike share of workers in the USA ranged from a low of 0.1% in Alabama, Tennessee, and West Virginia to highs of 1.9% in Oregon and the District of Columbia (USDOT, 2010a). In both countries, western states and provinces have higher levels of cycling to work than those in the east, but the difference is much greater in the USA than in Canada. The bike share of work commuters is especially low in the southeastern USA. The highest levels of cycling in North America are in

Yukon (2.6%) and Northwest Territories (2.1%), two of the northernmost and coldest parts of Canada. The overall geographic pattern of bike commuting rates in North America does not support the assumption that cold climates deter cycling.

Table 2 provides additional spatial disaggregation for the USA: by Census Region, by urban vs. rural status, and by MSA size. Confirming the pattern shown in Figure 1, the South had, by far, the lowest percentage of workers commuting by bike in 2009 (0.29%), less than a third the percentage in the West (0.94%). The Northeast (0.41%) and Midwest (0.44%) are between those extremes. The bike shares of workers from the 2009 American Community Survey (ACS) differ considerably from the bike shares of trips for all purposes reported by the 2009 National Household Travel Survey (NHTS). The West still leads with 1.38% bike share of trips, but the Midwest is not far behind at 1.20%. The lowest bike mode share for all trip purposes combined is in the Northeast (0.58%). According to the NHTS, the bike share of trips (all purposes) in the South was 0.96% in 2009, more than three times as high as the ACS bike share of commuters in the South. The reason for these differences in the pattern of geographic variation for work commuting vs. all trip purposes is not clear. It might be that the hot, humid summers in the South discourage cycling to work but not recreational cycling. By comparison, the much drier climate in the West probably encourages cycling for all trip purposes but especially the work commute. Unless showers are provided, arriving sweaty at the workplace can be a problem.

Table 2 reveals a spatial pattern of bike mode shares between urban and rural areas that also varies by trip purpose. The percent of workers commuting by bike is almost four times higher in urban areas than in rural areas (0.60% vs. 0.16%), while the bike share of trips for all purposes is only about a third higher in urban areas (1.12% vs. 0.78%). Cycling is mainly

recreational in rural areas, accounting for 62% of all trips (vs. 47% in urban areas). City size might also be expected to affect cycling levels, but no clear pattern is evident in Table 2. Neither the 2009 ACS work commute data nor the 2009 NHTS all-purpose data reveal any consistent impact of MSA size on bike mode share or trip purpose. That contrasts with evidence from Europe showing that cycling rates are highest in small and medium-sized cities and lower in large cities (Martens, 2004; Heinen, et al., 2010; Pucher and Buehler, 2007; Rietveld and Daniel, 2004; Vandenbulcke, 2011; Witlox and Tindemans, 2004).

The 2001 and 2009 NHTS surveys for the USA reveal some interesting trends in trip purpose over the previous decade. As shown in Table 3, there has been a considerable increase in utilitarian cycling, growing from 43% of all bike trips in 2001 to 52% of bike trips in 2009. For example, the share of bike trips made for the journey to work rose from 8% to 12%, and the share made for shopping rose from 8% to 10%. Bike trips to and from public transport stops rose from only 1% in 2001 to 3% in 2009. In spite of their declining share of all bike trips, social and recreational trips continue to have a higher bike mode share than other trip purposes: 2.5% compared to 0.7% for work trips, for example. By comparison, cycling in the Netherlands, Denmark, and Germany is primarily for daily, utilitarian purposes such as the trip to school, work, shopping, or visiting friends (Fietsberaad, 2010; NMOT, 2009; Heinen, 2010; Pucher and Buehler, 2008).

3. Socioeconomic characteristics of cyclists

As documented in an earlier article, cycling in northern Europe is common across a broad range of social groups (Pucher and Buehler, 2008). For example, Dutch, German, and Danish women cycle as often as men, and rates of cycling fall only slightly with age. The situation is quite different in North America.

3.1. Gender

As shown in Table 4, most of the growth in cycling in the USA over the preceding decade has been among men. From 2001 to 2009, the percent of all bike trips in the USA made by women fell from 33% to 24%. The bike mode share for women for all trip purposes remained at 0.5% from 2001 to 2009, while bike mode share for men rose from 1.2% to 1.6% over the same period. The gender of cyclists in the USA and Canada can only be compared for the work trip. As noted above, Canada does not have a national travel survey for all trip purposes, but its 2006 Census reports that 29% of daily bike commuters in Canada were women (Statistics Canada, 2010). That compares to a 24% female share of daily bike commuters in the USA reported by the 3-year average estimates of the 2006-2008 ACS (USDOT, 2010a). Women comprise roughly the same proportion of the labor force in Canada as in the USA (47% vs. 46%), so the higher bike commute share for women in Canada is not due to a higher rate of labor force participation (Statistics Canada, 2010; USDOT, 2010). The gender difference might be due to much safer cycling in Canada compared to the USA, as discussed later in this article. Several studies show that women are more sensitive to cycling dangers than men (Baker, 2009; Emond et al., 2009; Garrard et al., 2008; Geddes, 2009; Pucher et al., 2010a).

3.2. Age distribution

From 2001 to 2009 most of the growth in cycling in the USA has been in the age group 40-64, with only slight increases in cycling among those 16-24 and 65 and older (USDOT, 2004a, 2010a). Indeed, the age group 40-64 more than doubled its share of all bike trips, from 10% in 2001 to 21% in 2009. In contrast, the share of all bike trips made by persons younger than 16 fell from 56% in 2001 to 39% in 2009.

3.3. Income, car ownership, and ethnicity

In 2001 there was almost no difference in bike mode shares among the four income quartiles (Table 4). By comparison, the 2009 NHTS indicates a somewhat higher bike mode share in the lowest income quartile (1.3%) than in the top two income quartiles (1.0% and 1.1%, respectively). Although cycling rates do not vary much by income, it seems likely that low-income persons cycle mainly for work trips and other utilitarian purposes, while high-income persons may cycle more for recreation and exercise (Krizek, 2009; Heinen, 2010; Smart, 2010).

Cycling rates decline sharply with increased car ownership (Table 4). In both 2001 and 2009, bike mode share was more than twice as high for households without cars as for households with three or more cars. Bike mode share grew the most among households with no cars or only one car. Such households also increased their share of all bike trips from 24% in 2001 to 35% in 2009. Thus, car ownership appears to have become a stronger determinant of cycling rates over the past decade. That is consistent with other studies examining the impact of car ownership on cycling levels (Pucher et al., 2011a; Parkin et al., 2008; Stinson and Bhat, 2004; Rietveld and Daniel, 2004).

As shown in Table 4, non-Hispanic whites have the highest bike mode share among ethnic groups, but cycling rates are rising fastest among African Americans, Hispanics, and Asian Americans. Those three groups also account for an increasing share of total bike trips, rising from 16% in 2001 to 23% in 2009. Clearly, however, cycling is still dominated by non-Hispanic whites, who make 77% of all bike trips in the USA but account for only 66% of the population (USDOD, 2010a).

Comparable breakdowns of cycling rates by age, income, car ownership, and ethnicity were not possible for Canada due to the lack of data. Even if the Canadian Census permitted such breakdowns, they would be skewed because only work trips are surveyed.

4. National trends in cycling safety

In both the USA and Canada, cycling has become safer. Over the 20-year period from 1988 to 2008, the total number of cyclist fatalities fell by 21% in the USA and by 66% in Canada, but with considerable fluctuations from year to year in both countries (Figure 2). It is noteworthy that the percentage decline in fatalities was three times larger in Canada. Yet trends in serious cycling injuries have been similar in the two countries. From 1988 to 2008, there was a 31% decline in serious injuries in the USA, with a slow but fairly steady decline until a sharp rise in 2008. Over the slightly shorter period from 1988 to 2007, there was a 40% decline in serious injuries in Canada, roughly paralleling the trend in the USA except for 2008. In short, Figure 2 suggests a greater improvement in cycling safety in Canada than in the USA, although these fatality and injury totals do not control for rates of exposure.

Cycling levels have grown considerably in both countries. Thus, on a per trip basis, cycling safety has improved far more than suggested by Figure 2. For the USA, fatalities per 10 million bike trips (all trip purposes) fell by 65% between 1977 and 2009, from 5.1 to 1.8 fatalities per 10 million trips. Relative to work trips only, fatalities per 10,000 bike commuters in the USA fell from 21 in 1980 to 14 in 2000 and 9 in 2008, with an overall decrease of 57% since 1980. In Canada, fatalities per 10,000 bike commuters fell from 4 in 1996 to 3 in 2006, only a third the fatality rate in the USA.

In short, cycling has become safer in both countries, but it is much safer in Canada than in the USA, at least relative to the only available exposure measure that can be compared

between the two countries. As noted earlier, greater safety might help explain the higher percentage of women cyclists in Canada.

5. Growth in federal funding of cycling facilities

Over the past decade there has been impressive expansion in programs and policies to promote cycling, especially in the USA, where the federal government has taken the lead in providing increased funding and programmatic support (Clarke, 2003; Cradock et al., 2009; Handy et al., 2009; PBIC and FHWA, 2010; USDOT 2004b). Due to space limitations, we cannot examine in detail each of the federal programs, but they reflect the federal government's growing interest in encouraging active travel. Rising federal funding is probably the best indicator of support. Figure 3 shows average federal funding levels for walking and cycling in each of the major periods of transport legislation, with amounts expressed in constant 2009 dollars to control for inflation. It is not possible to separate out funding for cycling alone because official federal statistics only report on combined spending for walking and cycling. With each of the last three major federal transportation acts, funding for walking and cycling has increased considerably. From 1988 to 1990, in the three years just prior to the passage of the Intermodal Surface Transportation Efficiency Act (ISTEA), average annual federal funding was only about \$5 million per year, and then rose to about \$150 million per year with ISTEA from 1992 to 1998. Funding increased to an average of \$360 million per year from 1999 to 2005 under the Transportation Equity Act for the 21st Century (TEA21), and then to almost \$1 billion a year from 2006 to 2009 under the Safe, Accountable, Flexible, Efficient, Transportation Equity Act (SAFETEA-LU), including the added stimulus funds during the recession. Even excluding the \$405 million in temporary stimulus spending, it is clear that federal funding for walking and cycling infrastructure and programs has increased dramatically over the past two decades. That

infusion of federal funding for pedestrian and cycling infrastructure and programs has unquestionably encouraged local and state governments to construct new and improved cycling facilities.

There are no national data on the total extent of cycling facilities in the USA, but the Rails-to-Trails Conservancy (2010b) reports that the total length of bike trails grew from 2,044 miles in 1990 to 11,029 in 2000 and 15,964 in 2010. That represents a nearly 8-fold increase in the trail network over the two decades since passage of ISTEA. Those mileages only include rail trails and thus exclude most mixed use paths and bike paths in urban areas, but they are suggestive of the rapid expansion of cycling facilities thanks to ISTEA, TEA21 and SAFETEA-LU.

In contrast to the USA, there is no regular federal funding for cycling facilities in Canada, so financing depends almost entirely on provincial and local funds. There are no national statistics for cycling facilities and funding in Canada.

6. Analysis of cycling trends and policies in nine large cities

The aggregate national data presented earlier in this paper hide the variation among cities in cycling levels, safety, and policies. Virtually all infrastructure measures and programs are actually implemented at the local level, even if funding comes partly from the federal or state/provincial level. Thus, it is crucial to examine what is happening at the local level and how that varies among cities.

6.1. Choice of case studies

The remainder of this paper examines cycling developments in three large cities in Canada (Montréal, Toronto, and Vancouver) and six large cities in the USA (Chicago, Minneapolis, New York, Portland, San Francisco, and Washington). The nine cities cover a

broad range of locations, climates, topographies, demographics, density, history, and urban structure. We have restricted our case studies to large cities because that is where most Canadians and Americans live. Towns such as Davis, CA and Boulder, CO are more bike-oriented than most of the large cities we chose, but they are atypical and small. Moreover, in recent years, the most innovative cycling developments have been in large cities (ABW, 2010). The nine case study cities comprise the full range of policies and programs being implemented in North American cities to encourage more cycling and make it safer.

We explicitly excluded large cities with extremely low levels of cycling such as Dallas, Detroit, Houston, Kansas City, and Memphis, all of which have less than 0.3% of commuters by bike (ABW, 2010; USDOT, 2009). Not only do these cities have very low levels of cycling, but they have done very little to increase cycling. Thus, case studies of them would mainly entail listing all the things they do not do, which offers little guidance to cities seeking to promote cycling.

6.2. Data sources

Our case study analysis relies on information from four categories of sources:

- Federal, state/provincial, and local government statistics and reports providing information for specific cities (such as the Census, traffic injury databases, and travel surveys)
- Transportation sections of each city's official website, which generally include long-range bike plans, cycling statistics, bike maps and route planning, updates on infrastructure expansion, and guides to the cycling programs and activities in each city
- Websites of national cycling organizations and research centers, such as the League of American Bicyclists (LAB, 2010a), Alliance for Biking and Walking (ABW, 2010),

Pedestrian and Bicyclist Information Center (PBIC, 2010), and National Center for Walking and Bicycling (NCBW, 2010)

- Unpublished information and feedback provided directly by bike planners, city planning departments, transportation departments, and cycling organizations in each of the nine cities.

6.3. Descriptive statistics for case study cities

Table 5 summarizes some key demographic and climatic information about the nine case study cities. The population size of the cities themselves ranges from 8.4 million in New York to 361,000 in Minneapolis, a ratio of about 20-to-1. Population density of the cities also varies greatly: from 10,576 per km² in New York to 1,584 per km² in Portland. Studies suggest that larger cities tend to have lower cycling levels due to their greater land area, longer trip distances, and more extensive public transport systems (Heinen et al., 2010). The higher densities of larger cities might be expected to facilitate cycling due to the concentration of many origins and destinations, but density might also discourage cycling due to high traffic levels on roads and limited space for bikeway facilities.

The nine cities also vary considerably along two dimensions that probably affect cycling: percentage of college students and car-free households. Several studies show that college students are among the most likely to cycle, so that cities with high shares of students tend to have higher bike mode shares (Dill and Carr, 2003; Heinen et al., 2010; Nelson and Allen, 1997). Similarly, low rates of car ownership are also associated with higher rates of cycling. Among the nine case studies, the percentage of college students ranges from about 5% in Toronto to 12% in Minneapolis. The percentage of car-free households ranges from 15% in Portland to 54% in NYC.

Previous research shows that climate and topography can affect cycling levels. Several studies find that cycling is deterred by rain as well as by very cold or hot weather (Bergström and Magnusson, 2003; Dill and Carr, 2003; Gatersleben and Appleton, 2007; Heinen et al., 2010; Nankervis, 1999; Stinson and Bhat, 2004; Winters et al., 2007). Almost all studies find that flat topography facilitates cycling, and that cyclists choose routes that avoid steep gradients (Hunt and Abraham, 2007; Menghini et al., 2009; Rietveld and Daniel, 2004; Timperio et al., 2006; Vandenbulcke et al., 2011). Topography uninterrupted by harbors, bays, and rivers also favors cycling by enabling more direct routes (Pucher et al., 2011b).

The nine case studies cover a wide range of climates with considerable variation in temperature and precipitation. As shown in Table 5, there is a ratio of 2-to-1 in the amount of precipitation per year, ranging from 126cm (49.6”) in New York to 57cm (22.4”) in San Francisco. The average number of days with temperature below freezing (0°C/32°F) ranges from 164 in Montréal and 154 in Minneapolis to only one in San Francisco. The average number of days with temperature of 32.2°C (90°F) or higher ranged from 36 in Washington to none in Vancouver. Of all the cities, San Francisco has the least precipitation as well as the mildest climate, with few days that are very hot or very cold. There are no comparable statistics for humidity, which raises the heat index and further discourages cycling during hot summers. Washington probably has the most humid summers of our case study cities.

Similarly, we could not find standardized statistics on topography, but San Francisco is the hilliest of the nine cities, followed by Vancouver and Portland, while Chicago, Minneapolis, and New York are mostly flat. While cycling in some cities such as Minneapolis or Chicago is favored by their flat topography, their harsh climates would be expected to discourage cycling. Conversely, cities with hilly topography, such as San Francisco, have very mild climates that

favor cycling. One might expect a city such as Portland, which is both hilly and rainy, to have little cycling, but in fact, it has the highest cycling rates in the USA, perhaps due to its comprehensive package of cycling policies, as described in detail later in this article.

Our sample of nine case studies is obviously too small to isolate out the independent impacts of climate or topography on cycling. As noted above, these aspects of the natural environment may offset each other in some cities, and there are important differences in cycling policies as well, thus further complicating the task of determining the impact of any particular factor. For that purpose, the multivariate regression studies cited earlier in this section are far more appropriate, since they analyze much larger samples.

6.4. Variation in cycling levels and trends

Over the past two decades, cycling has increased considerably in all nine cities. Figure 4 shows trend data from the U.S. and Canadian Censuses on the share of commuters who bike to work, the only comparable statistics for all cities. The most impressive growth has been in Portland, where the bike mode share rose more than 5-fold between 1990 and 2009, from 1.1% to 5.8%, the highest cycling rate of any large North American city. Chicago quadrupled its bike mode share (from 0.3% to 1.2%) and San Francisco tripled its bike share (from 1.0% to 3.0%). All the other cities at least doubled their bike share of work commuters. These large increases in cycling in the case study cities contrast sharply with the slow growth in the bike share of work commuters for each of the two countries as a whole (0.4% to 0.6% in USA; 1.1% to 1.3% in Canada). Thus, our case studies stand out as being far more successful than other American and Canadian cities at promoting cycling—all the more reason to examine in detail what they have been doing to promote cycling.

In addition to the Census data shown in Figure 4, most of the case study cities have their own sources of information on cycling levels, either through travel surveys or cordon counts of cyclists at particular locations. Without exception, they also confirm strong growth in cycling, especially since 2000. For example, the annual survey by the City of Portland (2008a) reports almost a tripling in bike mode share of work commuters from 3% in 2000 to 8% in 2008. Similarly, cordon counts for four Willamette River bridges in Portland show almost a tripling in cycling volume over the same period (178% increase) (City of Portland, 2008b). Screenline counts of bike trips to and from the Manhattan CBD indicate a tripling (220% increase) between 2000 and 2009, far higher than the 51% increase in bike commuting in New York reported by the U.S. Census for the same period (NYCDOT, 2011; Pucher et al., 2010b; USDOT, 1980-2000 and 2009). Although most of the case study cities have such cordon counts or travel surveys, we are not reporting them in detail because they use different methodologies, trip definitions, geographic coverage, and timing and are thus incomparable.

Cycling has grown in all nine cities, but there are large differences in cycling levels, ranging in 2009 from only 0.6% in New York to 5.8% in Portland, a ratio of almost 10-to-1. There is also great spatial variation in cycling levels within each metropolitan area, with central cities having much higher cycling rates than their corresponding metro areas (see Figure 5). The difference between bike mode share in the central city and the overall metropolitan area ranges from about 4-to-1 in Washington and Minneapolis to 3-to-1 in Portland and about 2-to-1 in most of the other cities. All nine of the cities show the same pattern of cycling rates being much higher in the central cities.

Even within the cities themselves, there is much spatial variation. Cycling rates tend to be higher in older, gentrifying neighborhoods near the city center. Such bike-friendly

neighborhoods are usually located within close cycling distance of university campuses and downtown jobs and feature a mixture of residential and commercial land uses. As shown in Figure 6, the bike mode share of work commuters exceeds 2% in Lower Manhattan and northwestern Brooklyn but falls to only 0.2% in Staten Island and the outer portions of Brooklyn, Queens, and the Bronx. As documented in a detailed case study of cycling in New York City, the highest cycling rates are in the gentrifying neighborhoods of Greenpoint, Williamsburg, and the Lower East Side, which are located near the Manhattan CBD and various universities (Pucher et al., 2010b). As shown in Figure 7, the highest cycling rates in Portland are in the Inner Northeast and Inner Southeast districts, within cycling distance of the CBD and Portland State University.

The bike share of commuters exceeds 2.0% in the Northwest of Washington, DC but is almost nonexistent (0.05%) in Anacostia (the easternmost part of DC). The inner suburbs to the north and northwest of the city have bike mode shares ranging from 0.70% to 1.11%, while the inner suburbs to the southeast of the city have bike mode shares as low as in Anacostia. South of the Potomac River in Virginia, the two inner suburbs of Alexandria and Arlington have bike mode shares of 0.82% and 0.89%, respectively. Thus, cycling levels vary not only by distance but also by direction from the city center. Although too disaggregated to be shown on the map in Figure 8, the U.S. Census tracts in Washington with the highest bike mode shares are the neighborhoods of Capitol Hill, U Street, Adams Morgan, and Georgetown, which are relatively high income, gentrified, and centrally located (Buehler and Sonenklar, 2011; USDOT, 2010a).

Roughly the same pattern holds in large Canadian cities. For example, the bike mode share exceeds 10% in several of the central neighborhoods of both Toronto and Vancouver compared to less than 1% in most of their outlying residential districts (City of Toronto, 2010b;

City of Vancouver, 2009a and 2009b). In short, the case study cities generally exhibit much higher bike mode shares in central vs. outer neighborhoods, with yet lower cycling rates in suburbs. There are exceptions to that generalization, however, as evident by the very low cycling rates in Anacostia and the relatively high rates of the inner suburbs in Montgomery County, Maryland.

6.5. Gender differences

As noted earlier, cycling is slightly less male-dominated in Canada than in the USA: 29% vs. 24% female share of bike commuters for the countries as a whole. For the specific case study cities, women make up 35%-37% of bike commuters in Vancouver, Montréal, and Toronto, higher shares than in any of the six U.S. cities (Figure 9). Washington and Portland come closest at 34% and 33%, respectively. New York has, by far, the lowest percentage of women bike commuters, only 20%, perhaps due to the relatively high cyclist fatality rate there compared to the other cities. These data on commuting by bike probably underestimate the female percentage of bike trips for all purposes, since the labor force participation rates of women are lower than men (Statistics Canada, 2010; USDOT, 2010). But women comprise almost identical shares of the workforce in the USA and Canada (46% and 47%, respectively). Thus, using work commute data does not distort the comparison between countries. Data are not available for comparison of other socioeconomic characteristics of cyclists in the cities. The U.S. and Canadian Censuses only report on work commuters, thus excluding children, retired seniors, and the unemployed.

6.6. Cycling safety

Figure 6 shows the cyclist fatality rate per 10,000 daily commuter cyclists in each of the nine cities, ranging from 8.58 in NYC to 0.93 in Vancouver. Because the number of cyclist fatalities fluctuates from year to year, we calculated the average number of fatalities over the past

five years for each city. For the exposure rate, we used the number of daily commuter cyclists because those data are derived from very large Census surveys that can be disaggregated to the city level. There is no other source of nationally comparable and statistically reliable data on cycling levels in each city in either country. The problem with this methodology is that the number of fatalities in the numerator is due to cycling for all trip purposes, while the number of cyclists in the denominator only includes work commuters. Despite its limitations, the indicator provides the only feasible adjustment for different levels of cycling, and thus different exposure rates across the nine cities.

Figure 10 plots the different cycling fatality rates against the bike mode shares of the nine cities. The relationship appears to be consistent with the principle of safety in numbers (Elvik, 2009; Jacobsen, 2003; Vandenbulcke, 2009). Cities with highest bike mode shares have the safest cycling, and cities with the lowest bike mode shares have the most dangerous cycling. It is likely that causation runs in both directions: safer cycling encourages more cycling, and more cycling encourages greater safety. A closer look at Figure 10 reveals that city size might also be a determining factor. New York and Chicago, the largest cities, have the lowest bike mode shares and, by far, the most dangerous cycling. Vancouver, Portland, and Minneapolis are the smallest of the nine cities and have the safest cycling. Thus, city size may also play an important role in affecting cycling safety, perhaps due to the density of motor vehicle traffic. It is not clear to what extent differences in fatality rates among cities are really due to differences in cycling rates (via safety in numbers) or differences in city size or some other factor, such as better infrastructure. At any rate, Figure 10 highlights the vastly different levels of cycling safety in the nine cities, with a 9-to-1 ratio of cyclist fatality rates between New York and Portland, almost exactly matched in reverse by the 10-to-1 ratio of bike mode shares in the same two cities.

It is difficult to compare non-fatal injury data across cities because each city collects its injury data in a somewhat different way, using different definitions and methodologies. Yet cyclist injuries in the USA outnumber fatalities by at least 100-to-1 (CDC, 2010). Thus, only examining fatalities presents an incomplete picture of overall cycling safety.

6.7. Cycling policies and programs

All the case study cities have been implementing a wide variety of infrastructure, programs, and policies to promote cycling. There is considerable variation among the cities, however, both in the overall extent of their efforts and in the specific mix of measures.

6.7.1. Expansion and improvement of bikeway networks

In both Europe and North America, the main approach to increasing cycling and making it safer has been the provision of more and better bike paths and lanes (ECMT, 2004; Fietsberaad, 2010; Heinen et al., 2010; Pucher et al., 2010; USDOT, 2010d). The scientific evidence in the existing literature generally supports that strategy. Results from aggregate cross-sectional studies indicate that there is a positive correlation between cycling levels and the supply of bike paths and lanes, even after controlling for other explanatory factors such as city size, climate, topography, automobile ownership, income, and student population (Dill and Carr, 2003; LeClerc, 2002; Moudon et al., 2005; Nelson and Allen, 1997; Parkin et al., 2008; Rietveld and Daniel, 2004; Vandenbulcke, 2011). Disaggregate, individual-level studies report a strong preference for separate paths and lanes over cycling in traffic (Abraham et al., 2002; Akar and Clifton, 2009; Broach et al., 2011; Dill, 2009; Dill and Gliebe, 2008; Howard and Burns, 2001; Hunt and Abraham, 2007; Krizek et al. 2007; Menghini et al., 2010; Tilahun et al., 2007; Wardman et al., 2007). Both stated-preference surveys and revealed-preference surveys find that women, seniors, and inexperienced cyclists, in particular, prefer riding on bicycle paths and lanes

over cycling on streets without facilities (Aultman-Hall, 1998; Emond, et al., 2009; Garrard et al., 2008; Jackson and Ruehr, 1998; Larson and El-Geneidy, 2010; Rose, 2007; Shafizadeh and Niemeier, 1997; Vernez-Moudon, et al., 2005). For example, two studies found that cyclists were willing to increase trip distance and travel time to ride on bike paths compared to shorter, more direct routes that require cycling on roads with motor vehicle traffic (Dill, 2009; Tilahun et al., 2007). Thus, there is considerable scientific evidence that improving cycling facilities is essential for increasing cycling.

Without exception, the focus of cycling policy in all nine of our North American case study cities has been the expansion and improvement of bikeway facilities, including on-street bike lanes, on-street bike paths (cycle tracks), and off-street bike paths. As shown in Figure 11, Minneapolis and Portland have, by far, the largest supply of bike lanes and paths per capita of any of the cities, with 70km and 73km, respectively, per 100,000 population. At the other end of the spectrum, New York and Chicago have the fewest bike lanes and paths per capita, at 8km and 9km per 100,000 residents, respectively. That is only about an eighth the supply in Minneapolis and Portland. Nevertheless, New York almost tripled the extent of bike lanes and paths between 2000 and 2010 (from 274km to 670km), and Chicago has more than doubled its network (from 121km to 253km) (CDOT, 2010; NYCDOT, 2011). The largest increase on a per capita basis has been in Minneapolis, which added 29km per 100,000 population over the ten year period (City of Minneapolis, 2008 and 2010a).

As shown in Table 6, the bike lane and path networks in some of the cities such as Chicago, New York, and Portland consist mainly of on-street bike lanes while in other cities, such as Montréal and Minneapolis, bike paths make up more than half of the overall network (with paths including physically separated on-street cycle tracks in this table). In almost all the

cities, however, recent investment has been mainly in on-street bike lanes, probably due to higher cost and space requirements of off-street paths. Between 2000 and 2010, for example, km of bike lanes increased about twice as much as km of bike paths in Toronto and Portland, three times as fast in Washington and Minneapolis, and ten times as fast in Chicago and New York (CDOT, 2010; City of Minneapolis, 2010a; City of Portland, 2008a and 2010a; City of Toronto, 2010c; DDOT, 2010; NYCDOT, 2011). The two largest cities, in particular, have opted for bike lanes instead of bike paths. Bike paths tend to serve mainly recreational purposes, while on-street bike lanes generally are more useful for reaching practical destinations and offer a more direct route (Pucher et al., 2010a). Thus, the increased focus on bike lanes might also reflect a shift toward promoting daily, utilitarian cycling and away from the previous emphasis on recreational cycling.

Cycle tracks, which are typical in northern Europe, are now being installed in some North American cities. Unlike regular bike lanes, they are on-street bike paths separated by physical barriers from motor vehicle traffic. Montréal was the first city in North America to install such cycle tracks, which are bi-directional in Montréal and located on one side of the street (75km in 2010) (Pucher and Buehler, 2005; Ville de Montréal, 2010). New York was the first U.S. city to introduce cycle tracks, partly as response to the serious problem of motor vehicles blocking bike lanes. As of 2010, there were 16km of cycle tracks on 10 streets in New York City, featuring innovative traffic signals that reduce conflicts between cyclists and turning motor vehicles at intersections (NYCDOT, 2011). In 2010, there were also cycle tracks on three streets in Washington, two streets in Portland, and on two bridges and two streets in Vancouver.

New York, Portland, San Francisco, and Vancouver have been painting some of their bike lanes bright green, blue, or red to enhance visibility and increase cycling safety, especially

where conflicts between cars and bikes are most problematic. New York, Portland, San Francisco, and Washington have installed buffered bike lanes (City of Portland, 2010a; DDOT, 2010; NYCDOT, 2011; SFMTA, 2010). Unlike cycle tracks, they provide no physical barriers from cars but offer some separation from motor vehicles via a diagonally striped lane between the bike and car lanes.

Many of the cities have also been installing bike boxes with advance stop lines for cyclists at key intersections, about 3-5 meters ahead of the stop line for cars, thus enhancing cyclist visibility and safety. New York has taken the lead, with 215 bike boxes in 2010, almost always connected to on-street bike lanes (NYCDOT, 2011). In the same year, there were 20 bike boxes in Vancouver, 17 in Portland, 6 in Minneapolis, and 7 in San Francisco and Washington (City of Vancouver, 2010; City of Portland, 2010a; City of Minneapolis, 2010a; SFMTA, 2010; DDOT, 2010).

Although the recent focus has been on expanding bike lanes, off-street bike paths are often the most heavily used and highest profile cycling facilities. Off-street paths provide the most separation from motor vehicle traffic and the highest level of comfort and perceived safety for most cyclists (Pucher et al., 2010a). Most bike paths in North America are, in fact, multi-use paths shared with pedestrians and located in parks or along rivers, lakes, or harbors, and mainly used for recreational cycling. All nine of the case study cities provide such paths, and they generally are the best known and most popular of the cycling facilities: e.g., the Hudson River Greenway in New York; the Midtown Greenway in Minneapolis; the Willamette River Esplanade paths in Portland; the Seawall and Central Valley Greenway in Vancouver; and the Lakefront Trail in Chicago.

Traffic-calmed residential streets can serve as convenient, comfortable, and safe bike routes, even without any special bike facilities. Many Dutch, Danish, and German cities, for example, impose speed limits of 30km/hr (19mph) or lower on most residential streets, often accompanied by infrastructure modifications such as street narrowing, chicanes, traffic circles, speed humps, median islands, curb extensions, raised intersections and crosswalks, special pavement, diverters, and mid-block street closures with pass-throughs for bikes (Buehler and Pucher, 2011; Pucher and Buehler, 2008). Vancouver has been at the forefront of traffic calming in North America. It has reduced speed limits to 30-40 km/hr (19-25mph) on many residential streets and reinforced those legal limits through extensive redesign of streets (City of Vancouver, 2010; TransLink, 2009). Vancouver has focused on providing safe and convenient bike routes on low-volume, traffic-calmed streets instead of building extensive systems of bike lanes and paths. Chicago, Portland, San Francisco, and Toronto also have some traffic calmed neighborhoods, but not nearly as many as Vancouver (CDOT, 2010; City of Toronto, 2010b; City of Portland, 2010a; SFMTA, 2008).

Bicycle boulevards are a modification of traffic-calmed streets specifically designed to facilitate cycling. Special pavement markings and signage reinforce bicycle priority on such streets, which includes right of way when riding through most intersections (i.e. stop signs for traffic crossing bike boulevards), and special bike traffic signals to cross arterials. Various traffic calming devices—such as traffic circles, median refuges, curb extensions, and barriers to motor vehicle traffic—are used to lower motor vehicle speeds and discourage or physically block through traffic. The legal speed limit is also reduced.

In Vancouver, the speed limit on bike boulevards is 30km/hr (19mph), the same as for traffic calmed streets in Europe. Portland and Minneapolis permit 40km/hr (25mph), which is

typical in American cities for reduced speed districts such as near schools. In 2010, there were 129km of bike boulevards in Vancouver, 58km in Portland (with another 30km planned and funded), and 16km of bike boulevards in Minneapolis (City of Minneapolis, 2010a; City of Portland, 2010a; City of Vancouver, 2010). As of 2011, the City of San Francisco was planning to install a bike boulevard, and four of its suburbs already had bike boulevards: Berkeley, Oakland, Emeryville, and Palo Alto (NACTO, 2011). Bike boulevards require only modest infrastructure investment. Thus, they are inexpensive and relatively quick to implement. That might explain why they are being installed in an increasing number of North American cities. In 2011 there were 12 cities with bike boulevards, and 23 cities were planning new or expanded bike boulevards (NACTO, 2011).

Bike boulevards appear to be popular with cyclists. Using revealed preference GPS data, Broach et al. (2011) found that cyclists in Portland were willing to make large detours to ride on bike boulevards instead of more direct arterial roads, even roads with bike lanes.

Most of the case study cities have been experimenting with innovative measures such as cycle tracks, bike boxes, buffered bike lanes, bike boulevards, bike traffic signals, and bike routes on traffic calmed neighborhood streets. Nevertheless, the main approach of most North American cities in recent years has been the provision of unprotected, on-street bike lanes, supplemented by off-street multi-use paths intended mostly for recreational uses.

6.7.2. Bike parking

There is a general consensus on the need to provide good bike parking for cyclists (AASHTO 1999; APBP 2010; Fietsberaad 2010; USDOT 2007). There are few rigorous studies of the impacts of bike parking on cycling levels, but they confirm the importance of bike parking for cyclists, with a strong preference for secure, sheltered parking to prevent theft and protect

bicycles from inclement weather (Abraham et al., 2002; Hunt and Abraham, 2007; Taylor and Mahmassani, 1996; Wardman et al., 2007).

As shown in Table 6, the nine case study cities vary widely in the amount of bike parking provided in 2010, from only 221 spaces per 100,000 residents in New York to 4,599 in Minneapolis, about twenty times as much. Even without controlling for population size, New York falls far short of Toronto and Chicago, each of which has five times as much bike parking as New York, although they are much smaller cities. Only Portland and San Francisco have less total bike parking than New York, but on a per capita basis, they have more than twice as much. Moreover, the bike parking in New York is lacking in quality, with no secure public bike parking anywhere in Manhattan.

The supply of bike parking has been increasing in all nine of the case study cities. Even New York expanded bike parking by more than 10-fold between 1996 and 2009, from 600 to 6,100 spaces, and is planning to provide additional bike parking spaces in each of the coming years through their CityRacks program (NYCDOT, 2011; NYCDCP, 2009). Chicago, Minneapolis, and Toronto have been expanding public bike parking in sidewalk racks by about 1,000 additional racks each year, thus further widening their lead over other cities in total bike parking (CDOT, 2010; City of Minneapolis, 2010a; City of Toronto, 2010b; TLC, 2008). Portland has been especially innovative at installing so-called “bike corrals”, on-street bike parking converted from one or two car parking spaces. As of 2011, Portland had 86 such bike corrals, each with a capacity of 10-20 bikes, providing 1,428 parking spaces in total (City of Portland, 2011b). San Francisco had 11 bike corrals in 2010 (SFMTA, 2010). Both cities are planning to install more in the coming years. The corrals have been attracting customers for local businesses, prompting even more requests to the city to convert on-street car parking to

bike corrals. Except for New York, the case study cities have also been providing more long-term parking in bike lockers or bike stations, often located near transit stops, as described in the following section.

In addition to the increased supply of public bike parking, all of the case study cities now have laws that require the private provision of bike parking in both commercial and residential buildings (City and County of San Francisco, 2010; City of Chicago, 2007; City of Minneapolis, 2009; City of Portland, 2010a; City of Toronto, 2010b; City of Vancouver, 2001; DDOT, 2005 and 2010; NYCDCP, 2009; Ville de Montréal, 2010). Vancouver, San Francisco, Toronto, and Portland were the first cities to implement such bike parking ordinances, but the other case study cities have followed their lead in recent years. Although they vary from city to city, the requirements generally involve either a minimum percentage of bike parking relative to car parking (e.g., Chicago and Washington) or a minimum number of bike parking spaces per residential unit, per 1,000 ft² of commercial space, or per 10,000 ft² of general floor area of retail stores, sports facilities, community centers, etc. Bike parking requirements for private parking garages are generally based on the size of the garage, with bike parking often set as a percentage of car parking spaces. City ordinances in Portland, Minneapolis, San Francisco, Toronto, and Vancouver also include requirements or incentives to provide lockers and showers, which facilitate bike commuting to work (De Geus, 2007; Hunt and Abraham, 2007).

In sum, all nine of the case study cities have greatly increased their supply of public bike parking since 2000, mostly in sidewalk racks, while requiring significant levels of bike parking in both residential and commercial buildings. Just as car parking is essential to car use, bike parking is essential to cycling. Thus, the recent expansion of bike parking is an important measure to encourage more cycling in North American cities.

6.7.3. Integration with public transport

Coordinating cycling with public transport is mutually beneficial, enhancing the benefits of both modes and encouraging more cycling as well as more public transport use (Brons et al., 2009; Givoni and Rietveld, 2007; Hegger, 2007; Martens, 2004 and 2007; TRB, 2005; USDOT, 1998). Cycling supports public transport by extending the catchment area of rail stations and bus stops far beyond walking range and at much lower cost than neighborhood feeder buses and park and ride facilities for cars. Access to public transport helps cyclists make longer trips than possible by bike. Public transport services can also provide convenient alternatives when cyclists encounter bad weather, difficult topography, gaps in the bikeway network, and mechanical failures.

With the sole exception of New York, the case study cities have made impressive progress at integrating cycling with public transport (Pucher and Buehler, 2009). As shown in Table 7, most of the cities have equipped 100% of their buses with bike racks. Only New York and Montréal have no racks at all on their buses. Most of the rail systems in the nine cities permit bikes on board except during peak hours on weekdays. Except for New York, rail systems in the case study cities have vastly improved bike parking at stations by providing racks for short-term parking and bike lockers for long-term parking. The Chicago Transit Authority has been a leader in integrating bike racks into the stations themselves to increase shelter, convenience, and security (CTA, 2010). San Francisco and Washington, however, have been the leaders in providing secure bike lockers at most stations. Overall, the metro/subway and regional rail systems in Chicago (6,720 spaces) and San Francisco (6,472 spaces) provide the most bike parking at their stations, with Washington a distant third (3,250 spaces). New York again takes last place, with no bike parking at all provided by its extensive subway system and major bus,

train, and ferry terminals, although the NYC Department of Transportation provides racks on sidewalks near a few key stations.

Bike stations are the most recent development in bike-transit integration, providing secure, sheltered bike parking, usually with an attendant, as well as bike rental and repair services. Bike stations are usually sited adjacent to a public transport terminal or key rail station. Chicago has the largest bike station, with 300 spaces, but the San Francisco Bay Area has five bike stations with a total of 659 spaces (CDOT, 2010; SFMTA, 2010). In 2009, Washington and Toronto opened up bike stations next to their main railroad terminals (both called Union Station), with 150 and 180 bike parking spaces, respectively (DDOT, 2010; City of Toronto, 2010b). Several of the case study cities are planning additional or expanded bike stations in the coming years.

6.7.4. Bike sharing programs

Following the boom in bike sharing programs worldwide, four of the case study cities now have bike sharing systems (DeMaio, 2009; Shaheen et al., 2010). Montréal's BIXI bike sharing is North America's largest, by far, with 5,000 bikes, 400 stations, and over 3 million rides in 2009 (BIXI Montréal, 2010). Washington's SmartBike started in 2008 with 120 bikes and 10 stations, and was expanded in 2010 to 1,100 bikes and 114 stations and renamed Capital Bikeshare (SmartBike DC, 2010; Capital Bikeshare, 2010). In 2010 Minneapolis inaugurated Nice Ride Minnesota, a bike sharing system with 700 bikes and 65 stations (City of Minneapolis, 2010a). B-Cycle started operations in Chicago in 2010 with 100 bikes and 6 stations (Chicago B-Cycle, 2010). Bike sharing is scheduled to start in Toronto in mid-2011 with BIXI Toronto, which will feature 1,000 bikes and 80 stations (BIXI Toronto, 2010).

The available evidence indicates that bike sharing programs in Europe have encouraged more cycling as well as improved coordination of cycling with public transport (DeMaio, 2009; Ecoplan, 2010; Nadal, 2007; Shaheen, 2010; Pucher et al., 2010a). Thus, the rapid expansion of bike sharing in North America may provide further impetus to the growth of cycling.

6.7.5. Training and education

All of the case study cities have some sort of bike training programs for children as well as adults, but they all fall far short of the comprehensive bike training and traffic education programs in most German, Dutch, and Danish schools (Pucher and Buehler, 2008). Unlike northern Europe, cycling training programs in North America are offered in only a small percentage of schools, thus reaching a limited number of children.

Thanks to \$612 million in Federal funding from SAFETEA-LU, 6,489 schools in all 50 states have been participating in the Safe Routes to School Program (SRTS). Coordinated by state departments of transportation, the program supports both infrastructure improvements (such as sidewalks, crosswalks, bike paths, and better signage) and education and enforcement efforts to improve conditions for children walking and cycling to school (PBIC and FWH, 2010). This is the most important initiative for walking and cycling education in the USA for decades, but it reaches less than 7% of the 98,706 primary and secondary schools in the country (NCES, 2010).

All of the U.S. case study cities have schools taking part in the SRTS program. In Minneapolis, for example, 10 of 66 schools participate, but only 700 schoolchildren took part since SRTS is voluntary, and it is up to the parents whether or not to participate (BWTC, 2010). In 2010, Portland's SRTS programs reached over 11,000 students at 81 of 155 schools and provided 10 hours of cycling safety education for 4th and 5th graders at 40 schools (City of

Portland, 2010a). As the SRTS program in Portland expanded from 25 schools in 2006 to 81 schools in 2010, the cycling and walking share of trips to school rose from 31% to 39%, while the share of school trips by car fell from 42% to 36% (City of Portland, 2011b). In San Francisco, 15 schools participated in the SRTS program in 2010, reaching a total of 6,000 students. The San Francisco program includes bike safety training for 4th graders and bike to school days (SFMTA, 2011). The potential of SRTS programs to increase walking and cycling to school is confirmed by other studies as well (Jensen, 2008; McDonald and Aalborg, 2009; Orenstein et al, 2007; Staunton et al., 2003).

There are many other cycling training programs in the case study cities, often coordinated with community outreach, such as the Bicycling Ambassador programs in Toronto, Chicago, Minneapolis, and Portland, which send well-trained cyclists into neighborhoods throughout their cities to promote cycling and offer bike training (CDOT, 2010; City of Portland, 2010a; City of Minneapolis, 2010a; City of Toronto, 2010b). CAN-BIKE courses are offered in most of Canada (including Vancouver and Toronto) for a wide range of age groups, skill levels, and purposes. Local cycling organizations often offer cycling training courses in cooperation with the League of American Bicyclists, which trains instructors for such courses throughout the USA. Many courses target specific groups such as children, women, older adults, and recent immigrants, who have special needs. In addition to courses, there are bike camps, rodeos, races, and festivals for children.

Some of the case study cities have made a special effort to educate motorists about cyclist rights and their legal responsibility to avoid endangering cyclists. All nine cities have “share the road” campaigns of some sort. Chicago has been a leader on this front, requiring “share the road” instruction in high school driver education classes as well as for all taxi and bus drivers

(CDOT, 2010). The states of California, Illinois, Minnesota, New York, and Oregon have added questions to their driver license exams to highlight the responsibility of motorists to respect the rights of non-motorists. Portland employs plainclothes police to catch motorists guilty of endangering cyclists, and then requires the offending motorists to take a special “share the road” safety class (City of Portland, 2010a). Chicago, Minneapolis, Portland, San Francisco, and Washington provide their police with special training on cyclist rights. Putting police on bikes helps convey the perspective of cyclists, and again, Chicago is in the lead, with 306 full-time equivalent police on bike, followed by San Francisco, with 89 (ABW, 2010; CDOT, 2010; SFMTA, 2010). By comparison, relations between police and cyclists are highly confrontational in New York, as documented in a report by the NYC Department of City Planning, with many cyclists accusing the police of harassment, mistreatment, and ignoring the needs of cyclists (NYCDCP, 2005; Pucher et al., 2010b).

6.7.6. Information and promotional programs

All nine cities distribute free printed bike maps as well as interactive, on-line versions that permit trip planning. The Cycling Route Planner developed by the University of British Columbia for Metro Vancouver is especially impressive, allowing cyclists to choose routes with the shortest distance, least traffic, least pollution, most vegetation, fewest hills, or most separation from motor vehicle traffic (Su et al., 2010; UBC, 2010). But all of the cities have bike route planners of some sort, often integrated with Google Maps. Most city departments of transport have extensive websites offering a wide range of information on cycling routes, parking, safety, training, special events, recent and proposed projects (CDOT, 2010; City of Minneapolis, 2010a; City of Portland, 2010a; City of Toronto, 2010b; City of Vancouver, 2010; DDOT, 2010; NYCDOT, 2011; SFMTA, 2010; Ville de Montréal, 2010).

There are Bike-to-Work days and/or months in all nine of the cities as well as Bike-to-School days in some of the cities, coordinated with the Safe Routes to Schools programs mentioned earlier. The case study cities offer a wide range of group bike rides and races, bike festivals and art shows, food and wine tours by bike, and fundraising rides for special causes. Portland leads with over 4,000 rides, races, festivals, and special cycling events per year, including the Naked Bike Ride, which averages over 5,000 participants, and the Bridge Ride, which had 18,500 participants in 2010 (Birk and Roberts, 2008; Maus, 2010; City of Portland, 2010a). The other cities have fewer but similar large group rides: Bike DC in Washington, with almost 10,000 participants; Bike the Drive in Chicago, with about 20,000 participants; and the Five-Borough Bike Tour in NYC, with over 30,000 riders.

Ciclovías are an important development of recent years. An increasing number of cities throughout the world have been closing down parts of their street network to motor vehicle traffic on selected weekends (Sarmiento et al., 2010). Cycling, walking, and other non-motorized modes can use the car-free streets for recreation and physical activity, encouraged by a wide range of educational and fun events. Four of our case study cities have established ciclovías since 2008. The ciclovía in New York is called Summer Streets and attracts over 150,000 cyclists and pedestrians on the three Saturdays in August when it is held (ABW, 2010; NYCDOT, 2011). Ciclovías are called Open Streets in Chicago, Sunday Parkways in Portland, and Sunday Streets in San Francisco. Participation in those three cities ranges from 15,000 to 50,000 per ciclovía, and the number of ciclovías has been increasing each year. Unlike some group bike rides, ciclovías are designed to appeal to all age groups and skill levels.

In addition to organized rides and officially sanctioned ciclovías, there are Critical Mass rides, which started in San Francisco in 1992 and eventually spread to over 300 cities worldwide,

including most of the other case study cities (Blickstein and Hanson, 2001). Critical Mass rides often involve thousands of riders, usually meeting on the last Friday evening of the month at a pre-arranged place but without a predetermined route, and then proceeding spontaneously through the city streets. It is not entirely clear what role Critical Mass has played in encouraging cycling, but it has engendered a vibrant cycling subculture in some cities (Blickstein and Hanson, 2001; Pucher et al., 1999). Critical Mass rides attracted thousands of riders in New York as well until a police crackdown in 2004, with massive arrests and confiscation of bikes (TA, 2010).

There are few studies that systematically evaluate the influence of such promotional programs on cycling levels. For example, two Australian studies report increasing cycling levels for participants of cycling education and training programs (Telfer et al. 2006; Bauman, et al. 2008). Similarly, Rose and Marfurt (2007) find positive impacts of a Bike-to-Work event in Victoria, Australia, with 27% of first-time cyclists still cycling five months later. Ciclovías have been shown to generate large increases in cycling during the events themselves as well as increased utilitarian cycling afterwards (Gomez et al., 2005; Sarmiento et al., 2010).

6.7.7. Advocacy and policy implementation

Cycling advocacy organizations have played a key role in cycling promotion in all of the case study cities, sometimes even more important than the city departments of transportation. Some cities have several cycling organizations, but the most important in our case studies are the Active Transportation Alliance in Chicago (ATA, 2010); Bicycle Transportation Alliance in Portland (BTA, 2010); Bike Walk Twin Cities in Minneapolis (BWTC, 2010); San Francisco Bicycling Coalition (SFBC, 2010); Transportation Alternatives in New York City (TA, 2010); Toronto Cyclists Union (TCU, 2010); Vancouver Area Cycling Coalition (VACC, 2010); Vélo Québec in Montréal (VQ, 2010); and the Washington Area Bicyclist Association (WABA,

2010). These cycling organizations disseminate information about the benefits of cycling to generate public and political support, and they have actively lobbied for more funding for cycling programs and infrastructure. They help organize and publicize many of the cycling events and group rides in their cities. They also provide useful information for cyclists and sometimes offer bike training programs in conjunction with their city departments of transport and the League of American Bicyclists.

San Francisco probably has the strongest bike advocacy in North America, with the most members, funding, and staff per capita. For example, the San Francisco Bicycling Coalition has 16 times as many members per capita as New York's Transportation Alternatives (1,316 vs. 85 per 100,000 population), six times as many full-time equivalent advocacy staff per million population (10.5 vs. 1.8), and six times as much advocacy funding per capita (\$1.35 vs. \$0.24) (ABW, 2010). Most of the other cities fall between these two extremes.

Comprehensive, long-range bike plans have been crucial in almost all of the case study cities for guiding overall strategies to increase cycling, coordinating a range of programs, and phasing infrastructure investments over time so they are most effective (CDOT, 2006; City of Minneapolis, 2010b; City of Portland, 2010b; City of Toronto, 1999; City of Vancouver, 1999; DDOT, 2005; TPB, 2006; NYCDOP, 1997; SFMTA, 2009; Ville de Montréal, 2008). These plans set overall goals and lay out in detail the measures that will be taken to increase cycling. They also provide a look back at recent trends in cycling levels and cycling safety, and recap what has been done so far. But the most important issue has been the funding and actual implementation of those plans.

Strong leadership by charismatic and/or powerful individuals has been crucial to the implementation of pro-bike policies and programs. Mayor Sam Adams of Portland,

Transportation Commissioner Janette Sadik-Khan of New York, and Mayor Richard Daley of Chicago have been avid supporters of cycling and key to advancing cycling interests in their respective cities. But even the most committed of politicians depends on the coordinated efforts of NGOs, city departments of transport, talented bike planners, and public relations experts to garner the necessary public and political support. The story of cycling policy implementation is somewhat different in each city, but in all nine of the case study cities, it has required the complementary efforts of many different individuals and interest groups.

An analysis of the political and institutional process of cycling advocacy and implementation of pro-bike policies is beyond the scope of this article. Readers interested in this important issue can consult three recent books, which provide in-depth case studies of cycling policy implementation in several cities, including four of our case study cities: Chicago, New York, Portland, and San Francisco (Birk, 2010; Mapes, 2009; Wray, 2008).

6.8. Case study highlights and lessons

Table 8 lists four policy highlights for each of the nine case study cities, summarizing some of the special aspects of cycling policies and programs in each city. As promised at the outset of this article, all nine of the cities have indeed been implementing innovative measures to increase cycling, but each city has a somewhat different mix and focus.

Portland does almost everything in terms of infrastructure, programs, and policies to promote cycling and comes closest to the fully integrated policy packages found in successful European cycling cities. It is the coordination and integration of all these measures that explains the 6-fold increase in cycling in Portland since 1990. The cornerstone of Portland's policy package is the steadily expanding and improving bikeway network, consisting of bike paths and lanes as well as superbly designed bike boulevards through residential neighborhoods. The city

has continuously improved the safety, convenience, and connectivity of its bikeways. Every year, many intersections are redesigned by installing bike boxes (advance stop lines), priority signage, and advance green lights for cyclists. Portland has been increasing the quantity and quality of bike parking—including bike corrals in commercial districts, bike cages, lockers, and racks at transit stops, and local zoning ordinances requiring bike parking for new construction and incentives for employers to provide lockers and showers. Portland also promotes cycling through a wide array of marketing programs, educational campaigns, and cycling events such as Sunday Parkways, the Smart Trips individualized marketing program, the Bicycle Ambassador Program, and cycling training courses for both children and adults. Moreover, Portland police enforce cyclists' rights and require offending motorists to take "share the road" courses. Dedicated funding for cycling infrastructure and promotion assures continued support of these programs. It is the combination of all these policies which is so effective. Of the nine case studies, Portland clearly stands out as the most successful.

But all of the other case study cities have also made impressive progress. Minneapolis has an extensive system of off-street bike paths, the most bike parking per capita of any city, and offers an impressive adaptation of cycling to cold, snowy winters. Vancouver has been a model of traffic calming, bike boulevards, and bike-transit integration. San Francisco has been at the vanguard of bike culture in the USA for two decades, leading the way in bike advocacy and cyclist rights as well as bike-transit integration. Montréal has North America's largest and oldest network of cycle tracks as well as the largest bike sharing system. Washington has the first bike sharing program in the USA, excellent bike-transit integration (including a bike station), and an extensive mixed-use trail network that extends into the entire region. Toronto stands out for its bike parking and pioneering role in bike training and community outreach with the Bicycling

Ambassador program. Chicago has led the way in bike-transit integration, bike parking, community outreach, and enforcement of cyclist rights.

New York is a special case. Not only is New York by far the largest of the case study cities, but it has the most mixed record on cycling policies and accomplishments. New York has built the most bikeways since 2000 and has been especially innovative in its use of cycle tracks, buffered bike lanes, bike traffic signals, bike boxes, and sharrowed streets. Yet New York has almost completely failed in the important areas of bike-transit integration and cyclist rights and falls far short on bike parking and cycling training. Moreover, the refusal of New York's police to protect bike lanes from blockage by motor vehicles has compromised cyclist safety (Pucher et al., 2010b).

New York and Chicago had the same bike mode share in 1990 (0.3%), but by 2009 Chicago's rate was twice as high as New York's (1.2% vs. 0.6%). The much slower growth in cycling in New York is instructive. It emphasizes the need to implement a coordinated package of complementary policies. That was also the main conclusion of a recent international review of the entire range of infrastructure, programs, and policies to increase cycling (Pucher et al., 2010a). That review found that individual measures, such as the extensive bikeways built in New York since 2000, help promote cycling, but that they have limited impact unless supported by many other kinds of programs and policies. Portland is the North American city that comes closest to implementing a truly comprehensive, well-integrated, long-term package of infrastructure, programs, and policies to promote cycling. Portland's success is evident in the numbers, with a 6-fold increase in cycling levels since 1990, compared to a doubling in New York.

The comparative case studies offer a few other possible lessons. Climate does not appear to be a serious obstacle to increasing cycling, as shown by Portland and Vancouver, with their rainy climates, and Minneapolis and Montréal, with their long and very cold winters. Similarly, even hilly cities like San Francisco can generate high cycling levels with the right infrastructure and policies in place. Very large cities appear to present special challenges to cycling: high density of traffic, long trip distances, and the sometimes harrowing experience of cycling in heavy traffic with high levels of noise and air pollution. Those factors might help explain the relatively low bike mode shares in both New York (0.6%) and Chicago (1.2%). The two largest cities in Europe, London (1.6%) and Paris (2.5%), also have relatively low bike mode shares in spite of many policies to encourage cycling (Pucher et al., 2010a).

7. Conclusions: Bicycling renaissance in North America?

The short answer to the question posed in the title of this article is: Yes. A bicycling renaissance has indeed been underway over the past two decades, with growing cycling levels and widespread interest in cycling in both the USA and Canada. There was much less evidence of such a renaissance when we wrote our 1999 article, which was based on data up to about 1995 (Pucher et al., 1999). Since 2000, the initial trends we had identified for the 1990s have strengthened, permitting a more definitive answer to the question.

The boom in cycling, however, has been limited to a few dozen cities which have implemented a wide range of programs to aggressively promote cycling, such as the nine case study cities portrayed in this article (ABW, 2010; LAB, 2010b). Even in those cities, cycling growth has been highly concentrated in the central cities, and especially in gentrifying neighborhoods near the CBD and university districts, while cycling remains at very low levels in most suburbs (Figures 6-8). Moreover, cycling levels vary greatly by region (Figure 1). The

western states/provinces of the USA and Canada have, by far, the highest cycling rates, while most states in the American South, from Texas all the way to North Carolina, have extremely low levels of cycling (ABW, 2010; Pucher and Buehler, 2006).

Over the past decade, there has been a large increase in funding for cycling and in the range and magnitude of pro-bike policies to promote cycling. That suggests that cycling is less of a fringe mode than it was considered even a decade ago. Indeed, cycling is becoming a mainstream mode in a few cities. Portland's 2008 survey found that 18% of its residents used bikes as their primary or secondary mode for the work trip. That is comparable to cycling mode shares in northern Europe (City of Portland, 2010a; Pucher and Buehler, 2008). The success of Portland is important because it shows that even car-dependent American cities can greatly increase cycling by implementing the right package of infrastructure, programs, and policies.

Thus, a bicycling renaissance is indeed underway in many cities of North America, but they are islands in a sea of car-dominance. Over the 19-year period from 1990 to 2009, the bike share of daily commuters in the USA rose from 0.4% to 0.6%, and from 1996 to 2006, bike share of commuters in Canada rose from 1.1% to 1.3% (Table 1). That is quite a slow pace for the countries as a whole. But for the nine case study cities, truly dramatic progress has been achieved, and they offer superb examples that other cities can follow. Portland, in particular, is a model of what is necessary to dramatically increase cycling in North America. Americans and Canadians need not look solely to Europe for models of successful cycling policies.

8. Acknowledgements

This paper is based on a three-year research project funded by the U.S. Department of Transportation, Research and Innovative Technology Administration: “Analysis of Bicycling Trends and Policies in Large American Cities: Lessons for New York.” It is part of the Research Initiatives program of the University Transportation Research Center, Region 2, for New York and New Jersey. The authors are deeply indebted to the many bicycling experts who provided us with detailed information and feedback for the nine case study cities. We list them here grouped by city: Chicago (Randy Neufeld, Melody Geraci, Andrew Kay, Ron Burke, Daniel Thomas, Robert Vance, Chris Gagnon, Ben Gomberg); Minneapolis (Shaun Murphy, Donald Pflaum, John Siqveland, James Andrew, Barb Thoman, Tony Hull, Joan Pasiuk); Montréal (Marc-Andre Lavigne, Marc Panneton, Marc Jolicoeur, Marie Demers, Catherine Morency); New York (Charles Komanoff, John Kaehny, Noah Budnick, Caroline Sampanaro, Paul White, Steve Vaccaro, Rich Conroy, Ryan Russo, Steve Weber, Joshua Benson); Portland (Mia Birk, Roger Geller, Sarah Figliozzi, Greg Raisman, Colin Maher); San Francisco (Heath Maddox, Dave Snyder, Nick Carr, Laura Timothy, Sarah Syed, Leah Shahum, Andy Thornley); Toronto (Dan Egan, Adam Giambrone, Sean Wheldrake, Jennifer Niece, Jana Neumann); Vancouver (Gavin Davidson, Kamala Rao, Andrew Curran, Peter Sary, Gordon Price, Michelle Babiuk, David Lewis); and Washington (Jim Sebastian, Heather Deutsch, Eric Gilliland, Kristin Haldeman, Paul DeMaio). Andy Clarke (League of American Bicyclists), Gabe Rousseau (U.S. Department of Transportation), Jeff Miller (Alliance for Biking and Walking), and Peter Jacobsen provided valuable information and advice over the three years of this research project. Our research assistants, Lisa Dewey-Mattia, Daniel Sonenklar, and Lewis Thorwaldson, helped to collect and organize data from the many reports and websites of the case study cities. We thank Nick Klein for creating the GIS maps of the Portland and New York areas and Daniel Sonenklar for the GIS map of the DC area. Finally, we thank Charles Komanoff for his detailed feedback and editing of the text.

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Table 1.

Trends in cycling levels in Canada and the USA, 1977-2009.

	United States				Canada	
	Annual Bike Trips (millions)	Bike Share of Trips (%)	Daily Bike Commuters (thousands)	Bike Share of Workers (%)	Daily Bike Commuters (thousands)	Bike Share of Workers (%)
1977	1,272	0.6	-	-	-	-
1980	-	-	468	0.5	-	-
1983	1,792	0.8	-	-	-	-
1990	1,750	0.7	467	0.4	-	-
1995	3,141	0.9	-	-	-	-
1996	-	-	-	-	137	1.1
2000	-	-	488	0.4	-	-
2001	3,314	0.9	-	-	163	1.2
2006	-	-	-	-	196	1.3
2008	-	-	786	0.5	-	-
2009	4,081	1.0	766	0.6	-	-

Sources: USDOT (2004a, 2010a); USDOC (1980-2000, 2009, 2010a); Statistics Canada (1996-2010).

Table 2.

Geographic variation in cycling levels in the USA, 2009.

	<u>Bike Share of All Trips (%)</u>	<u>Bike Share of Workers (%)</u>	<u>% Recreational Trips</u>
<i>Census Region</i>			
West	1.38	0.94	37.0%
Midwest	1.20	0.44	53.2%
South	0.96	0.29	55.7%
Northeast	0.58	0.41	57.2%
<i>Urban vs. Rural Census Tracts</i>			
Urban	1.12	0.60	46.9%
Rural	0.78	0.16	61.5%
<i>MSA Size</i>			
<250,000	1.10	0.44	51.5%
250,000-499,999	1.16	0.67	42.1%
500,000-999,999	1.35	0.43	52.7%
1,000,000-2,999,999	1.11	0.44	53.3%
3,000,000 and over	0.97	0.55	47.6%
<i>Sources: USDOT (2010a); USDOC (2010a)</i>			

Table 3.

Trends in cycling by trip purpose in the USA, 2001-2009.

Trip Purpose	Bike Share of All Trips		Share of All Bike Trips	
	2001	2009	2001	2009
Commute or Work Related	0.4	0.7	8%	12%
Shopping	0.3	0.5	8%	10%
Personal Business	0.3	0.5	7%	8%
School/Church/Doctor	0.5	0.5	6%	6%
Visit Friends	1.5	2.0	15%	13%
Recreational/Vacation	2.4	2.5	57%	48%
Transit Access/Egress	0.3	0.6	1%	3%

Sources: USDOT (2010a).

Table 4.

Trends in cycling by socioeconomic and demographic characteristics in the USA, 2001-2009.

	Bike Share of All Trips		Share of All Bike Trips	
	2001	2009	2001	2009
<i>Gender</i>				
Male	1.2	1.6	67%	76%
Female	0.5	0.5	33%	24%
<i>Age Group</i>				
5 to 15 years	3.3	3.1	56%	39%
16 to 24 years	0.6	0.9	8%	11%
25 to 39 years	0.5	0.7	21%	23%
40 to 64 years	0.4	0.7	10%	21%
65 and older	0.4	0.6	4%	6%
<i>Automobiles Owned in Household</i>				
No car	1.6	2.5	7%	10%
One car	0.7	1.2	17%	25%
Two cars	0.9	1.0	47%	41%
Three and more cars	0.7	0.8	29%	24%
<i>Household Income</i>				
Lowest Quartile	0.8	1.3	25%	29%
Second Quartile	0.8	0.8	25%	22%
Third Quartile	0.9	1.0	22%	26%
Highest Quartile	0.8	1.1	28%	24%
<i>Ethnicity</i>				
White	0.9	1.1	83%	77%
African American	0.5	1.0	8%	10%
Hispanic	0.6	0.9	6%	9%
Asian	0.5	0.9	2%	4%

Sources: USDOT (2005, 2010a)

Table 5.

Demographic and climatic characteristics of nine case study cities.

	Population (1,000)		Population	Percent of	Percent of Car-free	Annual	Annual Days	Annual Days
	City	Metro	per km ²	University Students	Households	Precipitation (cm)	≤ 0 ⁰ C	≥ 32.2 ⁰ C*
New York	8,364	19,007	10,576	7.4	54.2	126	77	17
Chicago	2,741	9,570	4,633	7.6	25.9	92	129	17
Toronto	2,503	5,113	3,972	5.2	-	83	107	10
Montréal	1,621	3,636	4,439	10.7	-	105	164	9
San Francisco	809	4,275	6,600	9.4	29.3	57	1	3
Washington	592	5,358	3,700	10.8	35.5	100	68	36
Vancouver	578	2,117	5,039	10.1	-	120	46	0
Portland	560	2,207	1,584	8.1	14.8	94	40	11
Minneapolis	361	3,230	2,524	11.9	18.4	75	154	14

Notes: Precipitation and temperature data are 30-year averages from 1970 to 2000

* ≥ 30⁰ C for Canadian cities

Sources: Environment Canada (2010); Statistics Canada (2010); USDOC (1980-2000, 2009, 2010b); City of Toronto (2010a); City of Vancouver (2008); McGill University (1998).

Table 6.

Supply of bike lanes and paths and bike parking in nine case study cities, 2008.

	Bike Lane and Path Network				Bike Parking	
	On-Street Lanes (km)	Off-Street Paths (km)	On-Street Lanes and Off-Street Paths (km)	Kilometers of Bike Paths and Lanes per 100,000 Population	Bike Parking Spaces	Bike Parking Spaces per 100,000 Population
New York	454	216	669	8	6,260	75
Portland	291	119	411	73	4,059	725
Montréal	107	328	435	27	13,000	802
Toronto	113	168	281	11	32,200	1,286
Minneapolis	116	137	253	70	16,600	4,599
Chicago	185	68	253	9	30,720	1,121
Washington	72	90	162	27	6,249	1,056
Vancouver	60	70	130	26	n.a.	n.a.
San Francisco	101	59	160	20	4,773	589

Source: Information collected by the authors directly from the case study cities.

Table 7.

Supply of bike parking at transit stations and share of buses with bike racks, 2008.

	Parking at Transit Stations				Bike-Transit Integration
	Racks	Lockers	Spaces in Bike Stations	Total	Percent of Buses with Bike Racks
Chicago	6,420	0	300	6,720	100
San Francisco	3,703	2,110	659	6,472	100
Washington	1,800	1,300	150	3,250	100
Toronto	1,771	114	180	2,065	90
Montréal	1,500	0	0	1,500	0
Vancouver	660	400	0	1,060	100
Portland	812	527	0	1,339	100
Minneapolis	271	226	0	497	100
New York*	0	0	0	0	0

Sources: APTA (2008); Pucher and Buehler (2009); and information collected by the authors directly from the case study cities.

Note: Table shows parking for entire regional rail systems and not just the central city.

*The NYC subway system does not directly provide any bike parking at its rail stations, but the city provides some sidewalk parking near some stations. Those sidewalk parking spaces are included in Table 5. The Long Island Railroad and Metro-North Railroad provide some parking at suburban stations, but were not able to provide any data on the number of spaces.

Table 8.

Policy highlights in the case study cities.

Portland	Tightly connected bike network with access to bike facilities within three to six blocks from anywhere in the city. Extensive network of bike boulevards with traffic calming and priority for bicycles. Lively bike culture, including bike education, promotion, and fun events such as Ciclovias (up to 25,000 participants). Regulations require new or reconstructed roadways to include bike facilities.
Minneapolis	Most bike parking per capita in North America. Annual dedicated cost sharing fund for bike racks for private businesses. Metro area received \$25 million from federally funded Nonmotorized Transportation Pilot Program (NTPP). Extensive network of off-street bike paths serves as backbone of the city's bikeway network. The city plows multi-use paths within 24 hours of the end of a snowfall.
Vancouver	Only case study city with helmet law for adults. Extensive bike training programs for all age groups. Most extensive bike boulevard network in North America (139km). Leader in traffic calming and intersection treatments to accommodate cyclists. Strong regional bike-transit integration under TransLink.
San Francisco	Good bike-transit integration, with most bike stations of any city in North America. Extensive road-based bike network, including numerous road diets and traffic calming programs. Leader in bike training and education, including bike clubs at high schools, bike safety courses, and training parcours. Strong bike advocacy, lively bike culture, and originator of Critical Mass rides, which spread throughout the world.
Montréal	Most extensive off-street path network of any case study city (328 km). North America's largest network of cycle tracks. Largest bike sharing system in North America (BIXI), with over 5,000 bikes. During cold winter months BIXI is discontinued and cycle tracks are used for snow storage.
Washington	Extensive regional mixed-use trail network. First regional bike sharing program in North America (Capital Bike Share). All Metrorail stations have elevators for easy bike access during off-peak hours. Bike station at Union Station offers parking for 150 bicycles, bike rentals, and bike repair.
Toronto	Iconic post-and-ring bike racks doubled from 7,500 to over 16,000 from 2000 to 2010. Bike station at Union Station offers parking for 180 bicycles; 2 more bike stations under construction. First city with bicycling ambassador program, providing community outreach and range of bike training programs. Length of bikeway network more than doubled between 2001 and 2010, from 166 km 425km.
Chicago	Best bike parking at transit stations, racks inside stations for shelter and security. Largest bike station in USA, 300 spaces. Over 12,000 bike racks on sidewalks, with continuous expansion every year based on usage survey Extensive bicycling ambassador program for community outreach, bike training, and cycling promotion New bike safety ordinance increases penalties for motorists who endanger cyclists or block bike lanes.
New York	Biggest increase in bikeway network: built over 450 km of lanes and mixed-use paths between 2000 and 2010. Innovative infrastructure including cycle tracks, bike boxes, green bike lane markings, and bike only traffic signals. Police failure to enforce bike lanes leads to frequent blockage of lanes by motor vehicles. Worst bike-transit integration of any city; no racks on buses, no bike parking at subway stations or major transit terminals.

Source: Information collected by the authors directly from the case study cities.

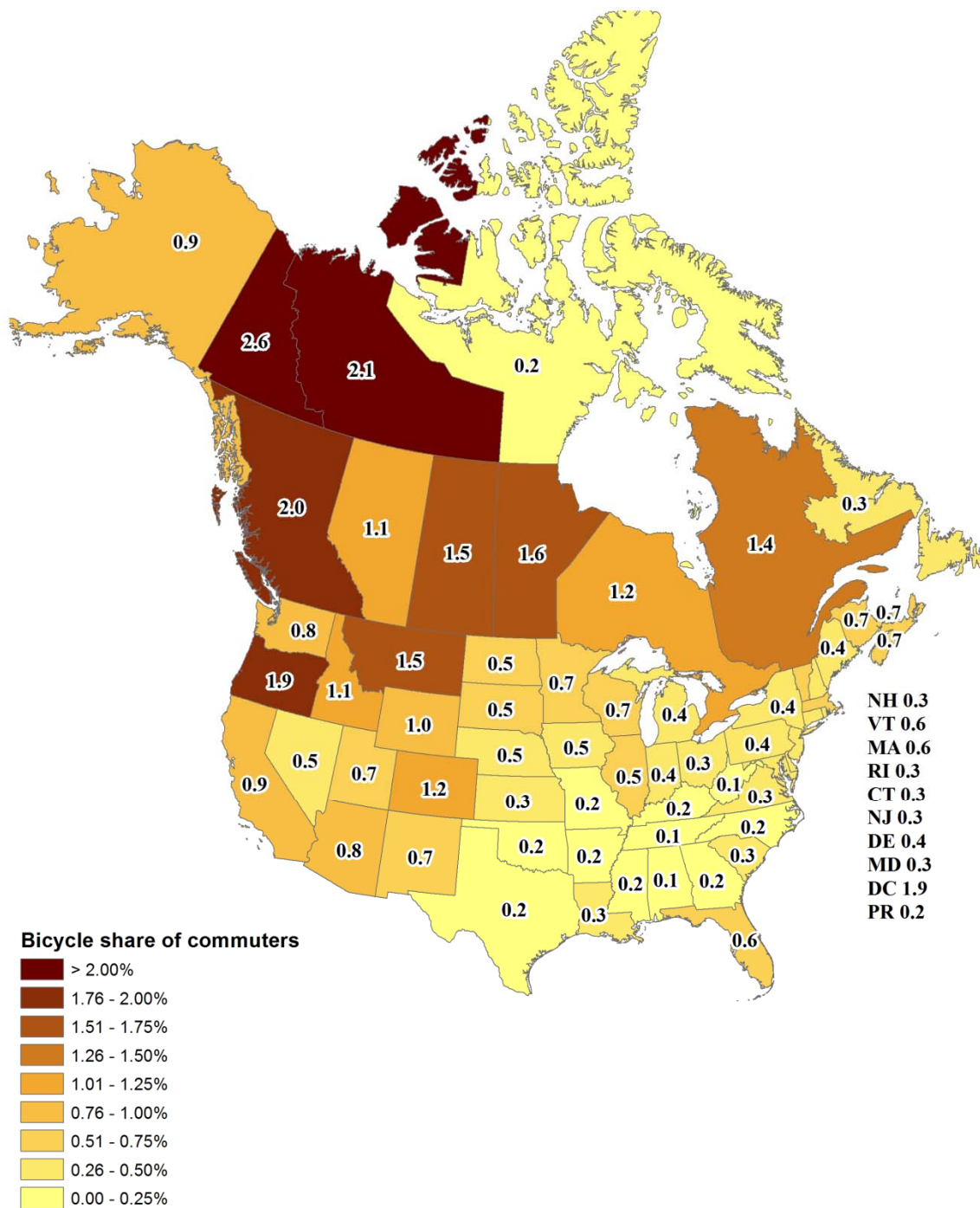


Fig. 1. Variation among States and Provinces in the Bicycle Share of Work Commuters in the USA (2005-2009, averaged) and Canada (2006). *Sources: USDOT (2010a); Statistics Canada (2010). Note: GIS Map created by Mark Seinen.*

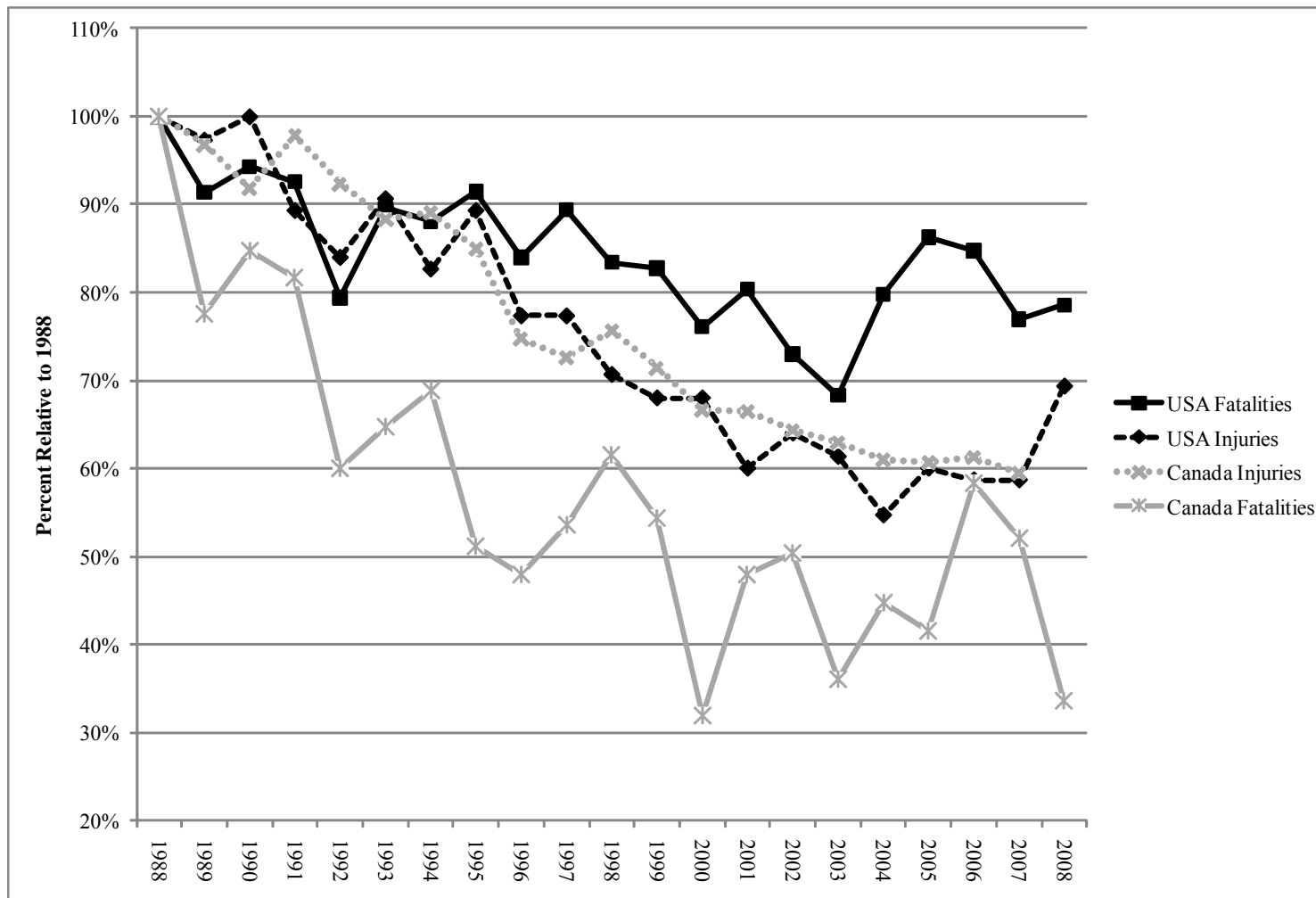


Fig. 2. Trends in Cyclist Fatalities and Injuries in the USA and Canada, 1988-2008 (as percent relative to 1988). Sources: USDOT (2010b); Transport Canada (2010).

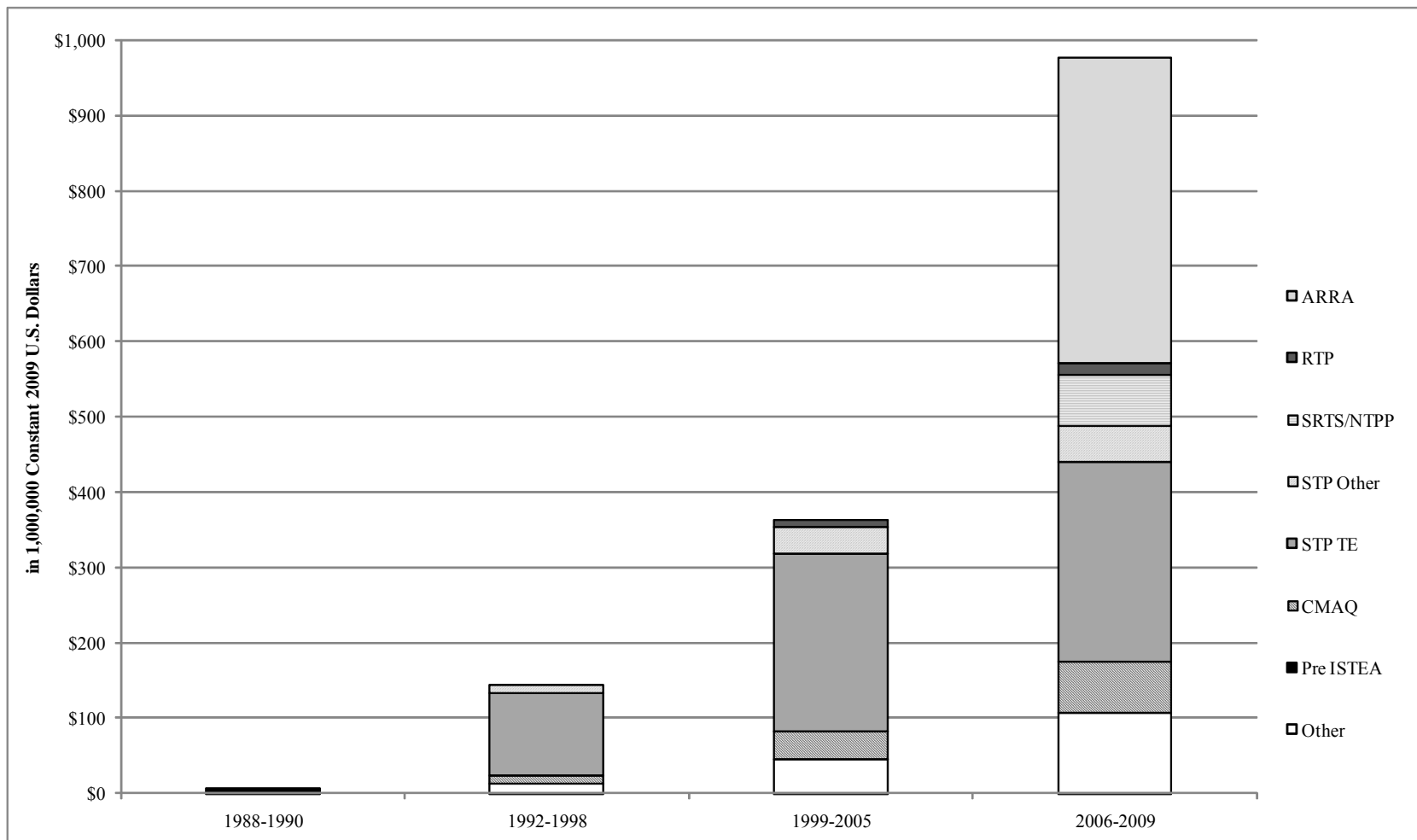


Fig. 3. Inflation Adjusted Average Annual Federal Obligations for Cycling and Walking, 1988-2009. Sources: USDOT (2010c); Rails to Trails Conservancy (2010a).

Note: ARR (The American Recovery and Reinvestment Act of 2009 including 3% set-aside for TE); RTP (Recreational Trails Program); SRTS & NTPP (Safe Routes to School and Nonmotorized Transportation Pilot Programs. These programs had their first obligations in FY 2006); STP Other (Surface Transportation Program (STP except TE; includes STP Safety)); STP TE (Surface Transportation Program set-aside for Transportation Enhancement Activities); CMAQ (Congestion Mitigation and Air Quality Improvement Program); Other includes: High Priority Projects; National Highway System; Bridge; Interstate Maintenance; Federal Lands Highway Program (primarily Public Lands Highway Discretionary earmarks); Corridor Planning and Development and Border Infrastructure; Transportation, Community, and System Preservation; National Scenic Byways; Ferry Boats; Congressionally-earmarked funds, etc. Prior to 1999, this categories includes the Recreational Trails Program.

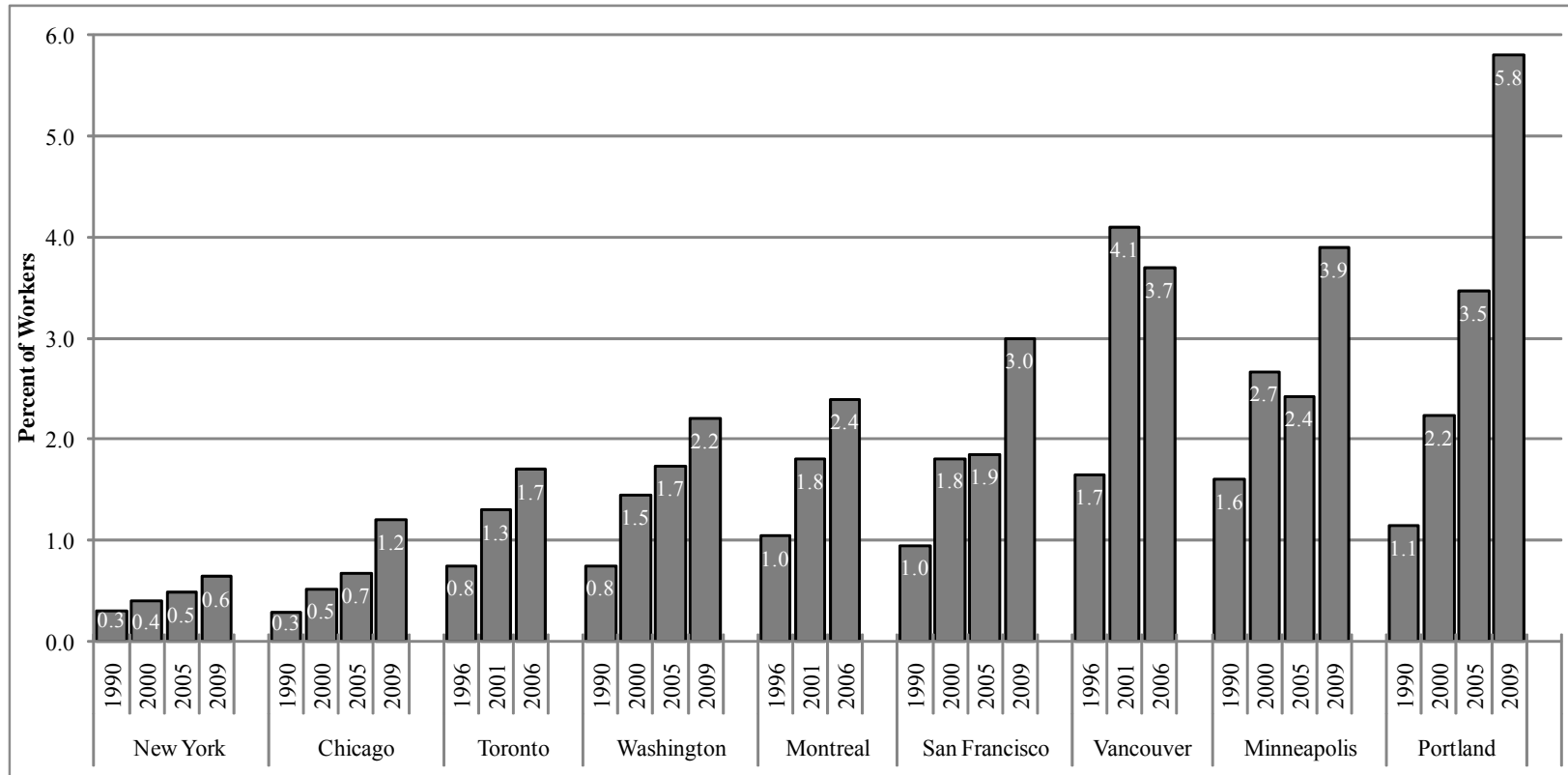


Fig. 4. Trend in Share of Workers Commuting by Bicycle in Large North American Cities, 1990-2009. Sources: USDOC (1980-2000, 2010a); Statistics Canada (1996-2010). Note: 2001 bike share for Vancouver was inflated due to public transport strike during census data collection period.

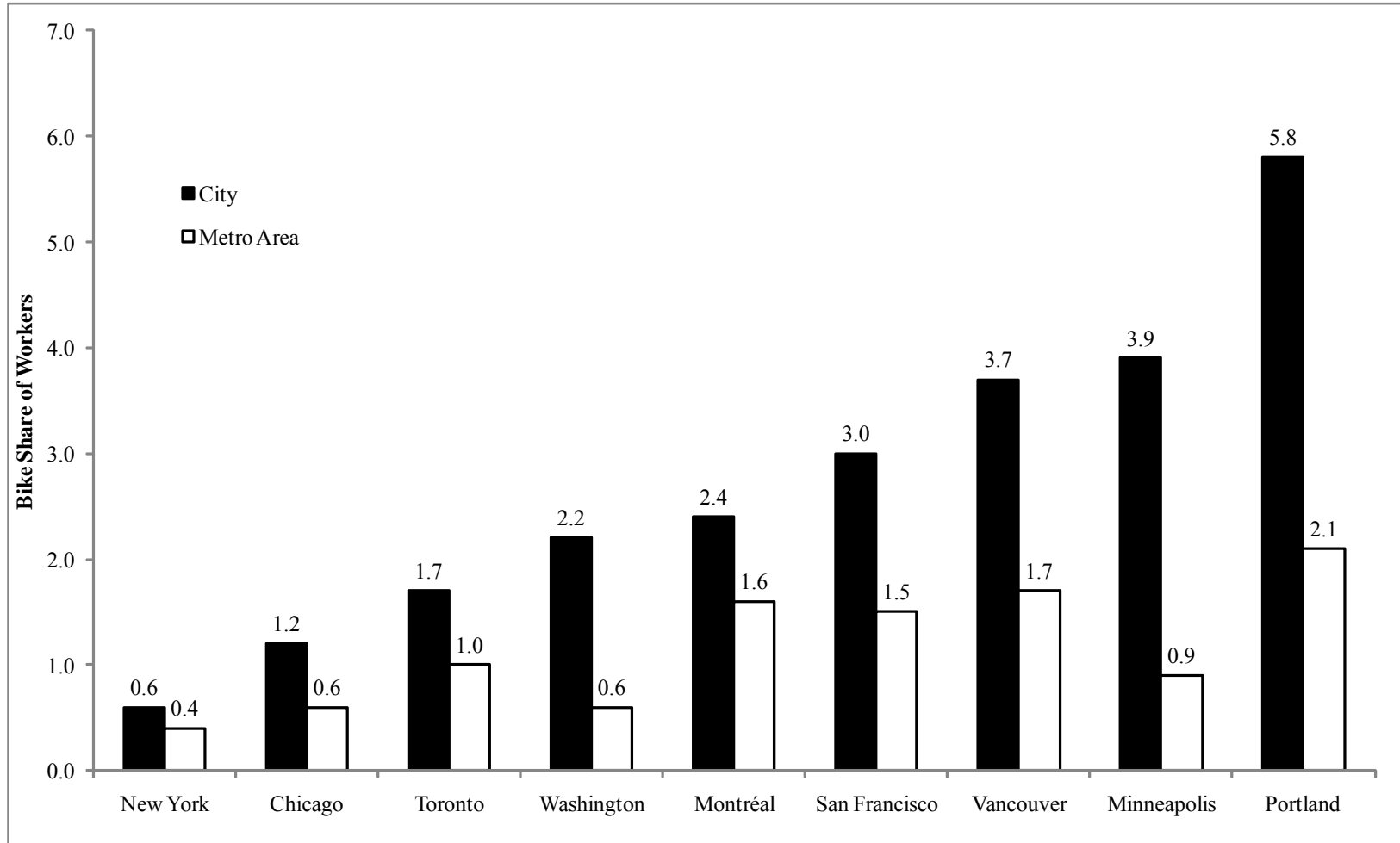


Fig. 5. Bicycle Share of Workers in U.S. and Canadian Cities and Metropolitan Areas, 2006/2009. *Sources: USDOC (2010a); Statistics Canada (2010).*

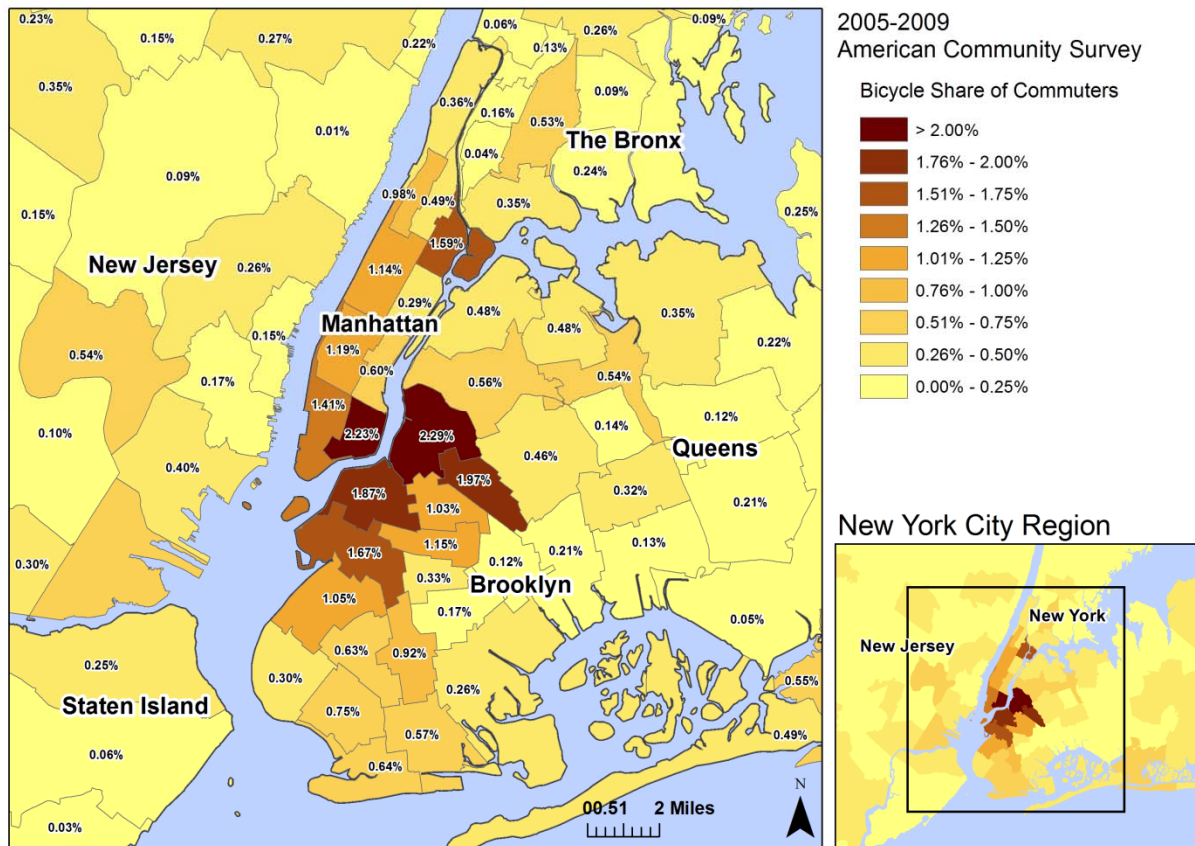


Fig. 6. Spatial Variation in Bicycle Share of Work Commuters in New York City Area, 2005-2009. Sources: USDOC (2010a); Statistics Canada (2010). Note: GIS Map created for the authors by Nick Klein.

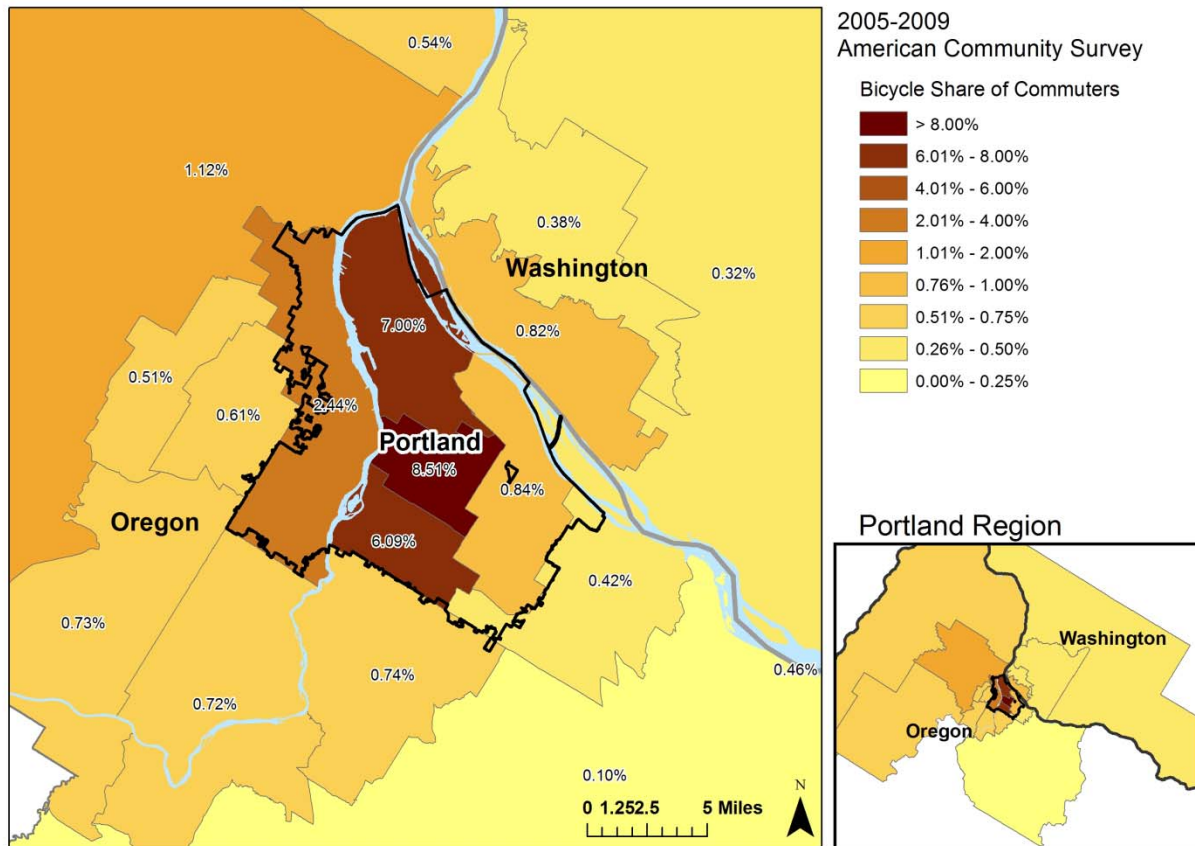


Fig. 7. Spatial Variation in Bicycle Share of Work Commuters in Portland Area, 2005-2009.
Sources: USDOC (2010a); Statistics Canada (2010). Note: GIS Map created for the authors by Nick Klein.

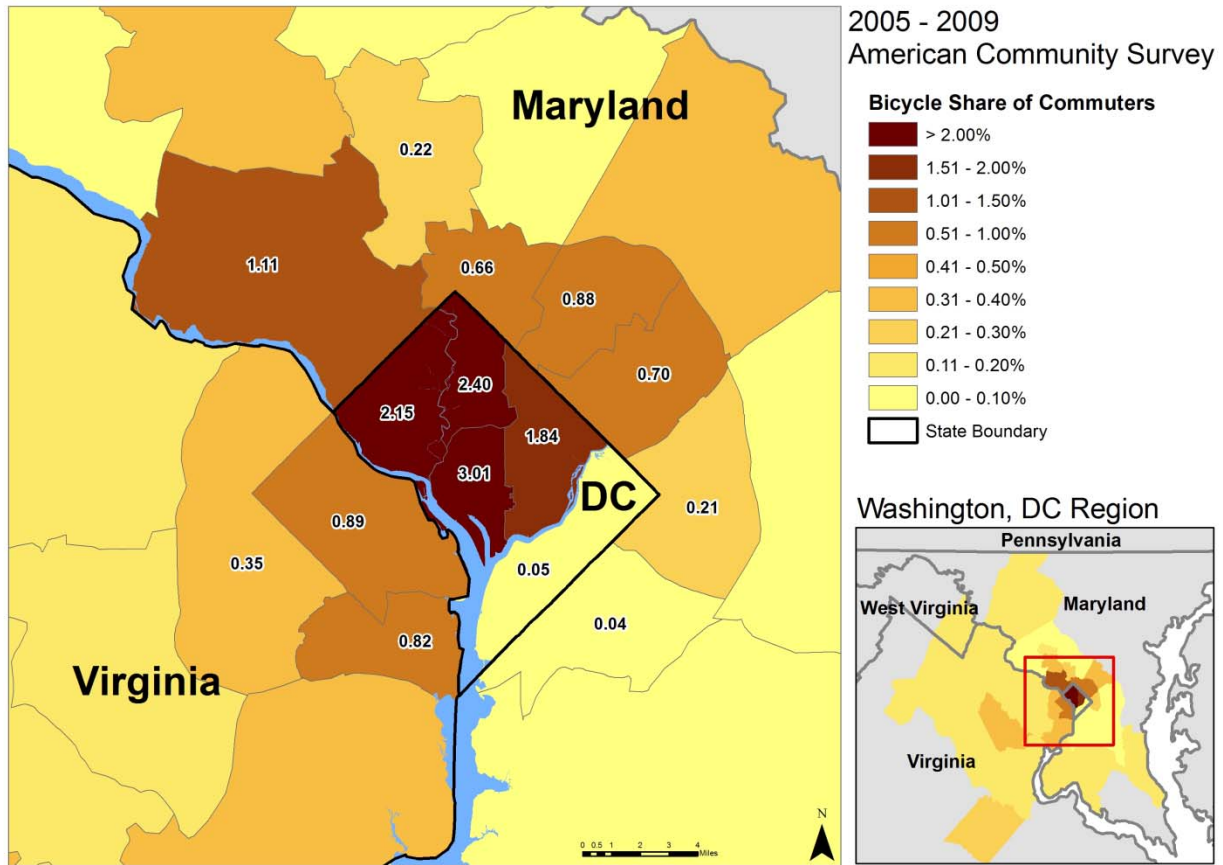


Fig. 8. Spatial Variation in Bicycle Share of Work Commuters in Washington, D.C. Area, 2005-2009. Sources: USDOC (2010a); Statistics Canada (2010). Note: GIS Map created for the authors by Dan Sonenklar.

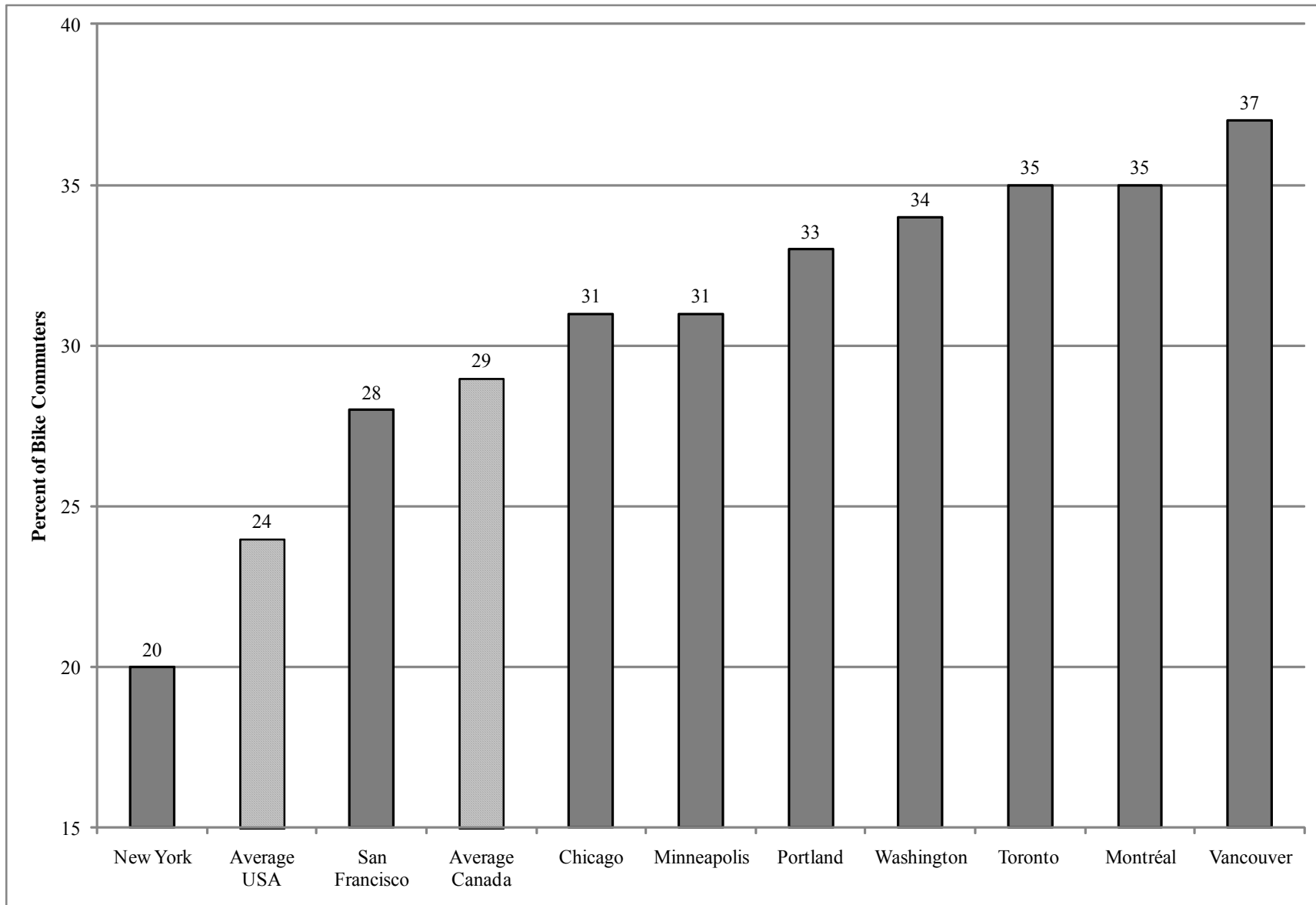


Fig. 9. Percent of Female Bicycle Commuters in U.S. and Canadian Cities, 2006/2008. Sources: USDOC (2009); Statistics Canada (2010).

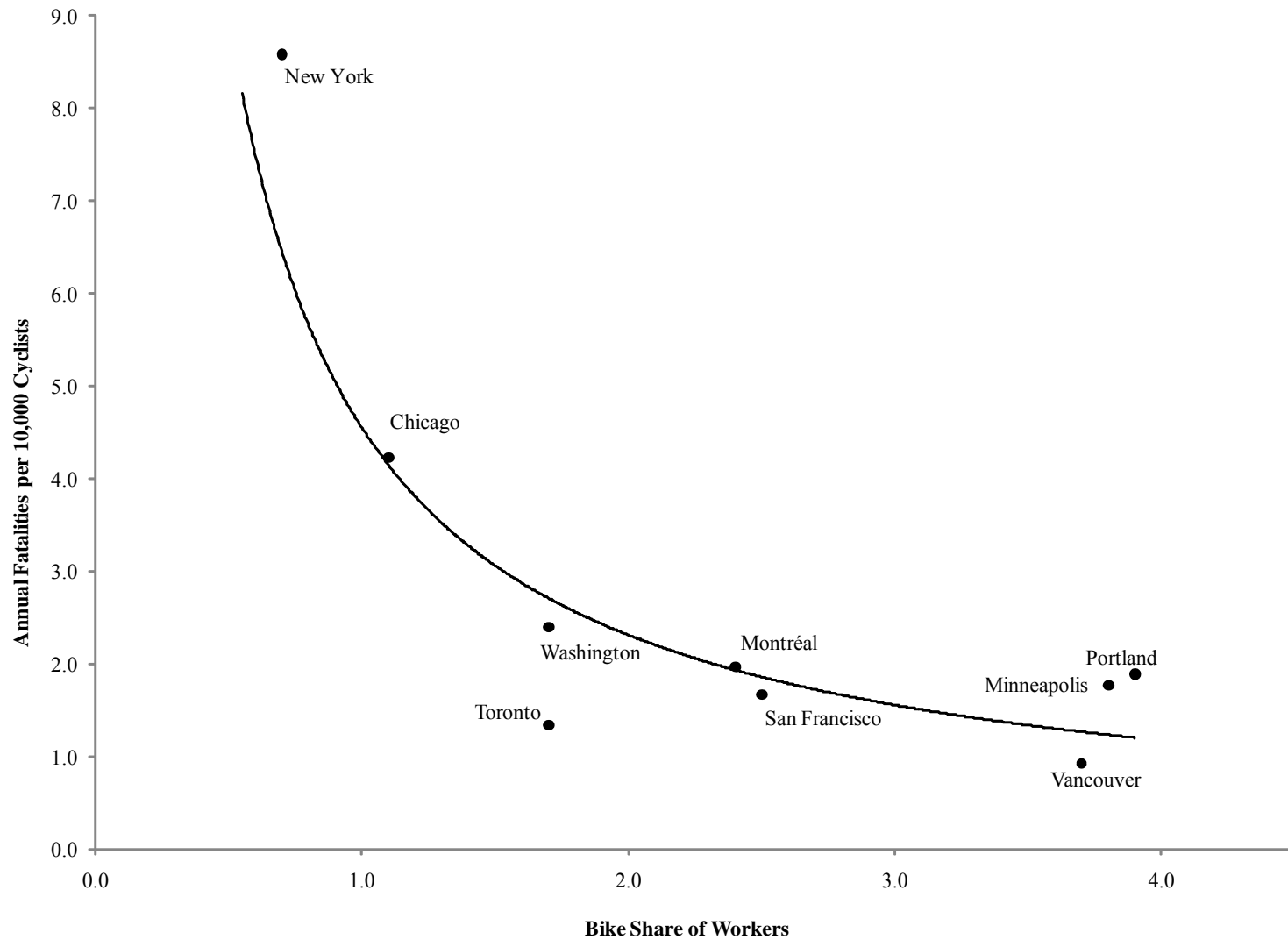


Fig. 10. Bicycle Share of Workers and Average Annual Fatality Rate per 10,000 Cyclists, 2004-2009. Sources: USDOT (2009, 2010a); Statistics Canada (2010); and injury data collected by the authors directly from the case study cities.

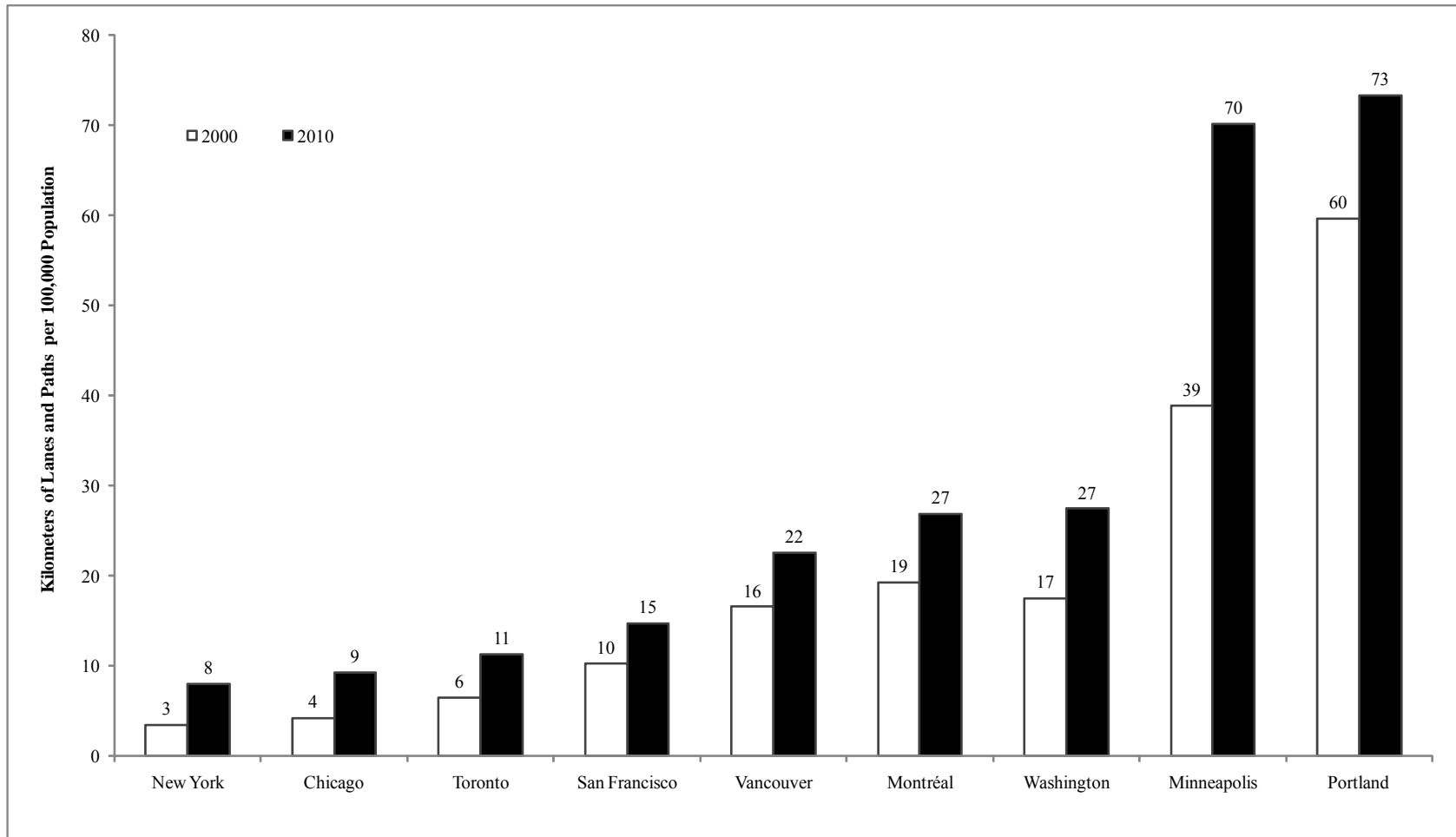


Fig. 11. Trend in Bike Paths and Lanes per 100,000 Population in Nine Large North American Cities, 2000-2010. *Source: Information collected by the authors directly from the case study cities.*