A HISTORY OF BICYCLE ENVIRONMENTS IN CHINA:

COMPARISONS WITH THE US AND THE NETHERLANDS

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ABSTRACT

Physical inactivity is now associated with as many deaths worldwide as smoking. Daily-life physical activity is more beneficial than recreation, as many worldwide lack the time or money to pursue activities such as tennis. Of daily activities, bicycling is more beneficial than walking because of increased energy expenditure. Despite bicycling's risks, design solutions in the form of safe, low-pollution-exposure, and social-bridge bicycle environments allow bicyclists to achieve health. Worldwide, the Chinese, Americans, and Dutch had the most unique bicycle histories, each resulting in different environments. This article will compare the bicycle environments in the US, the Netherlands, and China around 1890, 1920, 1949, 1970, and today. China built an affordable bicycle mass transit (BMT) system that allowed side-by-side conversations on tree-alléed, 22-foot-wide cycle tracks (barrier-separated, bicycle-exclusive paths built beside sidewalks). Understanding China's historic bicycle environments may provide insights for new BMT systems that foster socializing.

INTRODUCTION

To understand the rationale for any country to dedicate road space and funding for a wide bicycle mass transit (BMT) system, it might be valuable to first understand the health crisis, the downsides to bicycling of pollution exposure and injury, the ways in which we can mitigate these downsides, and the health benefits from bicycling. With this background, a discussion about bicycling and the bicycle environments in the US, the Netherlands, and China since the invention of the bicycle can reveal insights. These three countries produced the most bicycles, had the highest percentage of bicyclists at certain times, and had the most unique bicycle facilities.

The methodology applied in this research on bicycling and bicycle facilities in the US, the Netherlands, and China most closely resembles a systematic review. While a meta-analysis could have been conducted, the data available have different measures and levels of completeness, especially as the data are from different time periods and three countries. A systematic review involves a summary of the literature and

The above image, taken by the author, shows a cycle track in Hangzhou, China.

allows for gaps in some data. The literature for this paper was found through web and PubMed searches using a wide variety of key words. Only articles written in English were cited. If authors had cited another reference, the article in which this reference was made was cited. Without the ability to verify the original source, which may have been in Dutch or Chinese, the preference was to cite the article that was in English. The following data remains as data points and story telling, as that was the original form of the information. The content focused on bicycling, bicycle facilities, and the introduction of the vehicle that lessened bicycling and reduced safety.

While many cities are now creating bus and subway mass transit systems, cities cannot also build new roads as these roads become congested and pollution levels rise with more vehicles. If, in addition to adding bus and subway lines, cities copied China and built wide BMT systems, the cities would better address health. The energy expenditure is higher when bicycling compared to when sitting on a bus or walking, there is no mobile source air pollution from bicycling, and similar to riding in a car, walking, or riding on a bus, on a BMT a bicyclist can bicycle side-by-side and have a conversation with a friend.

Environments that could be used for bicycling include: (1) roads in which there are no bicycle provisions; (2) roads with symbols painted in the roads (sharrows which include an arrow and a bicycle symbol) to suggest to car drivers to share the road; (3) traffic-diverted roads in which networks of residential neighborhood streets only allow slow-speed vehicles; (4) painted bicycle lanes beside parallel parked cars; (5) painted bicycle lanes beside sidewalk curbs; (6) shared-use paths for bicyclists but also walkers, joggers, skaters, baby carriage pushers, etc.; and (7) cycle tracks or barrier-protected bicycle-exclusive paths beside sidewalks (cycle tracks can be created with wide concrete islands, planted buffers, or affordable paint and delineator posts). This paper will discuss all of these bicycle environments but the focus will be on roads and bicycle-exclusive cycle tracks because these have been the primary bicycle facilities since 1890.

Worldwide, physical inactivity is associated with 5.3 million deaths per year.[1] Individuals could participate in physical activity at the gym or while skiing, playing tennis, or jogging, and yet not everyone has the time or money for these activities. Also, the individuals who go to the gym may reward themselves with compensatory eating and thus not control weight.[2] In comparison, individuals who use active transportation could view arrival at their destination as the reward.[3] People participating in active transportation would also have replaced their time spent during the day in the car or on a bus with time spent engaged in physical activity.

Bicycling, an activity that could be a part of daily life, is better for weight control compared to walking.[4] In a large cohort of nurses in the United States, bicycling was equal to brisk walking in weight control even without knowing the nurses' bicycling speed. Slow walking was not associated with weight control and 50 percent of the nurses reported that they walked slowly. Unlike brisk walking, overweight and lean nurses spent about the same time bicycling.[5] Bicycling also reduces cancer[6] and offers a myriad of other health benefits,[7]

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including weight control.[8] In children, bicycling was found to be better for cardio[9] and physical fitness[10] compared to walking or being driven to school. Bicycling may be better because the Metabolic Equivalent of Task (MET) intensity levels (1 MET is the resting metabolic rate sitting quietly) are higher for bicycling (4.0-16.0 METs) compared to walking (2.0-6.3 METs).[11]

Research in China supports the health benefits from bicycling studied in other countries. Exercising and using bicycling as a means of transportation among women enrolled in the Shanghai Women's Health Study were positively associated with lower all-cause mortality while walking as part of transportation was less associated with lower all-cause mortality.[12] Walking or bicycling to work for between 31 to 60 minutes in Tianjin, China was associated in men and women with the lowest levels of hypertension and in women with the lowest levels of mean blood pressure.[13] In research conducted in 8 provinces in China, 84 percent of the households in 1997 did not own a form of motorized transportation. For men or women in the households that owned a motorized vehicle, the odds for being obese were 80 percent higher ($p < 0.05$) compared to individuals in households that did not own a motorized vehicle. In the period between 1989 and 1997, if a man in the household obtained a motorized vehicle, they gained 1.8 kg ($p < 0.05$) plus had odds of becoming obese of 2 to 1.[14] Compared to traveling to work by bus, men and women in Tianjin, China were 50 percent less likely to be overweight if they bicycled to work for 15 minutes per day or greater.[15]

Even with the health benefits from bicycling, bicyclists are exposed to mobile source air pollution. The negative health effects from proximity to traffic-generated pollution include increased asthma,[16] aortic atherosclerosis,[17] cardiovascular risk,[18] lung cancer risk,[19] fatal myocardial infarction,[20] and all-cause mortality.[21] Bicycling in traffic and exposure to ultrafine particles with concentrations of CO and NO_2 was a significant predictor of DNA damage.[22] In research conducted on Peking University security guards who worked near a heavily traveled road, exposure to the traffic-generated particles was associated with oxidative DNA damage.[23]

While there are negative health impacts in bicycling, the health benefits described above outweigh the risks,[24] including

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the risks from exposure to ultra fine particles.[25] Environments can be created that lower a bicyclists' exposure to mobile source air pollution. While buses are highly recommended to reduce congestion, passengers inside a bus are exposed to more mobile source air pollution than bicyclists. For bicyclists on a low traffic route in Denmark compared to taking public transit on the shortest route, the low-traffic route reduced accumulated exposure to primary pollutants 10-30 percent.[26] Walking and bicycling environments in Sydney had significantly lower levels of benzene compared to riding in a car and significantly lower levels of NO_2 compared to riding the bus.[27] The pollution levels inside the bus in Manchester, England averaged 250 and 350 **µ**g/m^3 while the bicyclist's environment had far lower concentrations. The authors suggested that the bicyclists may have been traveling on the side of the road whereas the bus was directly behind vehicles.[28] Bicyclists may be able to move past vehicles and thus lower their exposure.[29]

Separate environments, such as cycle tracks, can also be created to lessen bicyclists' exposure to mobile source air pollution. In a street canyon in London the average $PM_{2.5}$ personal exposure for walkers on the sidewalk was 23.8 compared to 30.6 for bicyclists in the road (GM **µ**gm-3), the average ultrafine particle count was 64861 for walkers and 88055 for bicyclists (GM – particle range: 0.02-1**µ**m), and the average carbon monoxide exposure was 0.5 for walkers and 0.8 for bicyclists (GM ppm).[30] Cycle tracks can be created in the location where pedestrians walk and these areas have lower levels of levels of mobile source air pollution. On a cycle track with parallel-parked cars between the cycle track and moving vehicles, bicyclists are less exposed to mobile source air pollution due to the barrier provided by the cars and the distance from the tail pipe plume.[31]

Inside a car, in Denmark the concentrations of BTEX and particles were found to be two to four times as great as in the bicyclist's breathing area.[32] Even though the pollution levels were higher inside the cars, in inner city Amsterdam, bicyclists exhaled 2.3 times more air and had an equal uptake of CO, benzene, xylenes, and toluene and greater uptake of NO_2 than car occupants.[33] Due to heavier breathing rate of bicyclists compared to someone sitting in a car, the minute ventilation (VE) of bicyclists studied in three cities in Belgium was 4.3 times higher compared to someone sitting in a vehicle.[34] Knowing of these exposures and the higher breathing rate of bicyclists, cycle tracks might lower the breathing rate. Unlike bicyclists in the road competing in speed with the cars, bicyclists on a cycle track could bicycle at lower speeds. At lower speeds, they would have lower ventilation rates and thus experience lower exposure to ultra fine particles.

Bicyclists are also vulnerable to injury. In the US, just 0.56 percent of the population 16 and over bicycles for transportation and only 27 percent of these are female.[35] Many do not bicycle[36] because they have to ride with cars, a practice promoted as safe by some.[37] Females plus children, seniors, and parents with children on their bicycles are less comfortable bicycling with cars.[38] In the Nurses Health Study

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II population and with their bicycle environments in the US, though 48 percent of the nurses spent time bicycling, only 1.2 percent of the nurses bicycled for 30 minutes or more per day.[39] Roads may once have been more safe for bicyclists because when road bicycling was promoted in 1976,[40] road widths, vehicle speeds/numbers/height, and road rage were less and window tinting, wide window pillars, large head rests, and cell phones were non-existent. Yet even today, road-riding activists still suggest bicyclists are safe bicycling in the road with helmets and bicycling lessons.[41] In the US, the speed for a road shared with bicyclists is 30 mph[42] compared to 18.6 mph (30 km/h)[43] in the Netherlands where bicyclists do not wear helmets.

Just as exposure to mobile source air pollution can be reduced, injury to bicyclists can also be lessened with different bicycle environments. Recent research has suggested that cycle tracks had an injury rate 28 percent lower compared to bicycling in the road. Also, cycle tracks had 2.5 times as many bicyclists when compared to bicycling in the road.[44] In case/control research conducted in Vancouver, compared to bicycling on major roads with parallel parked cars, bicycling on roads without parallel parked cars was somewhat safer (adjusted odds ratio [OR] = 0.63) as was bicycling on a local street (adjusted odds ratio [OR] = 0.51). Cycle tracks were the safest (adjusted odds ratio [OR] = 0.11) environment compared to bicycling on major roads with parallel-parked cars. Thus, cycle tracks had approximately one ninth the amount of risk of bicycling on major roads.[45]

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BICYCLING AND BICYCLE FACILITIES: 1870-1913

United States

The Ordinary bicycle, invented in 1870, was difficult to ride due to its high front wheel. In 1880 in the US, a group of bicyclists met in Newport, Rhode Island to form the League of American Wheelmen and advocate for bicyclists' rights. As the roads for bicycling in the United States were primarily dirt, this group championed for the paving of roads before the introduction of the automobile.[46] In 1890, the Safety bicycle became popular because, unlike the high-wheeled Ordinary bicycle, the Safety featured two equal-sized pneumatic tires, suspension, gears, and a low cost from mass production. To make female bicyclists safer while maintaining their modesty, bloomers, or pant-like skirts, were sewn. Freedom and the accommodating attire prompted Susan B. Anthony to say of the bicycle, "I think it has done more to emancipate women than anything else in the world."[47]

Though the League of American Wheelmen members could have lobbied only on behalf of the bicycle, they instead, through their Good Roads Movement, advocated for paved roads to benefit farmers. Their 1891 booklet "The Gospel of Good Roads: A Letter to the American Farmer," offered depictions of why roads should be paved to carry goods in wagons.[48] Thus, the early rationale for paved roads was based on economic development. Perhaps League members also knew it would be harder to defend paving roads just for the use of bicyclists.

In 1894 during the heyday of the bicycle, the five-and-a-half-mile bicycle-exclusive Coney Island Cycle Path, or Ocean Parkway Bike Path, was built in Brooklyn, New York. The wide tree-lined path was designed by Frederick Law Olmsted and Calvert Vaux who had been influenced by the wide boulevards in Europe.[49] This path, that connected Coney Island with Prospect Park, was originally 17 feet wide. In 1896 on the other side of the boulevard, a path for return bicycle trips was added.[50]

On the other side of the US in California, others were inventing roads for smooth pedaling. In 1897, Horace Dobbins, who was Vice-President of the Cycle-way Company, proposed a nine-mile bicycle-exclusive path between Pasadena and Los Angeles as a toll road (10 cents one way). Much of

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50 C Reid, "League of American Wheelmen – Roads Were Not Built For Cars," 2012, accessed November 8, 2012, http://www.roadswerenotbuiltforcars.com/category/league-of-american-wheelmen/.

the wooden-decked bicycle path was elevated over roads, streets, and ravines with overpasses in some locations as high as fifty feet above ground. The width accommodated four bicyclists riding side-by-side but was planned to be doubled in width, specifically to allow cars to share the route. On both sides of the cycle way, incandescent lights provided bright illumination. At each end, terminal stations with small buildings in Moorish style entreated bicyclists. One destination included a Casino.[51] These destination end points might have taken inspiration from trolley parks. Built at the end of lines by streetcar owners, these amusement parks doubled the profits from streetcar riders who then traveled on the line in the evenings and on weekends and also spent more money in the parks.

In 1898, the first section of a concrete road was built in Ohio, an improvement over dirt, brick, or low quality macadam roads.[52] The Good Roads movement had been funded by Albert Pope, the manufacturer of the Columbia bicycle. The result of this advocacy was a request in the agriculture bill for the Office of Road Inquiry for road research that led to the formation of the Federal Highways Administration.[53] The League of American Wheelmen became advocates for cars as their passions, and perhaps profits, redirected their aspirations. In 1897, Albert Pope started manufacturing electric automobiles. Bicycle manufacturers became car manufacturers including George Robie, who manufactured bicycles in 1880.[54] George Robie was then followed by his son, Frederick Robie, who designed cars. Frederick Robie commissioned Frank Lloyd Wright to design the highly innovative Robie House in Chicago that included three garages.[55] Around 1902, the League of American Wheelman became the American Road Makers, an organization focused on the automobile.[56] In 1908, the Model T was introduced and in 1913, 23 miles of a concrete road was built in Arkansas.[57]

Netherlands

In the Netherlands in 1885, a bicycle-exclusive path was built for high-wheel Ordinary bicycle racers in Utrecht. This path was instigated by Englishmen, Charles Bingham, who had advocated for a similar racing facility in England.[58] While in 1890, Bingham had started to manufacture the regular two-wheeled bicycles in Utrecht, 85 percent of the bicycles ridden by the Dutch were made by English manufacturers even by 1895. To continue to meet the high demand in the Netherlands, bicycles were also imported from the US. Bicycle-exclusive facilities had previously been rare in the Netherlands but in 1902 along a 1400-meter stretch of the Breda-Tilburg cobblestone road, paved bicycle paths were completed on each side of the road.[59]

China

In China, a dignitary who had visited several European cities in 1866 told the court about the Ordinary bicycle. To embrace the bicycle would mean changing Chinese traditions and adopting industrialization, which, besides the bicycle, included the railroad, electricity, telephones, and gas streetlights. After the invention of the Ordinary, expatriates from America and Europe were seen riding in such cities as Shanghai. Bicycles were expensive and the wealthy Chinese preferred not to be seen riding a bicycle. The wealthy were not to show exertion and thus rarely walked, were often carried on chairs, or were pulled in rickshaws. As young Chinese students started studying abroad in the 1890's, they returned to China with bicycles. In Shanghai in 1902, an exhibit of English bicycles was held but, for the Chinese, the bicycles were still 40 percent more expensive than they would have been in England.[60]

Urban forms in the Chinese Qing dynasty (1644-1911) included gates and walls, as still seen around the Forbidden City.[61] Walls were of such significance to the Chinese that the traditional words for wall and city are the same.[62] Within these walls, avenues were straight and broad including the Qianmen Boulevard, designed to carry ten horse carriages side-by-side. All elements, including the walls, streets, or courtyards, were based on an imperial hierarchical system that codified Imperial power. During the New Policy period of 1903 to 1908, the urban environment was to serve social purposes. In 1914, the Municipal Council set out to rebuild the city.[63] The road configuration was to be a fish-boned grid with major roads connecting to secondary roads.[64]

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51 TD Denham, "California's Great Cycle-Way," 2012, accessed November 30, 2012, http://www.fhwa.dot.gov/infrastructure/the_great_cycle_way_.cfm.

52 American Concrete Pavement Association, "Concrete: 100 Years of Innovation," 2012, accessed November 8, 2012, http://www.pavement.com/concrete_pavement/about_concrete/100_years_of_innovation/index.asp.

53 Reid, "League of American Wheelmen."

54 World AAt, "Frederick C. Robie House," 2005, accessed November 8, 2012, http://www.buffaloah.com/a/virtual/us/chi/robie/index.html.

55 Frank Lloyd Wright Preservation Trust, "Introduction to Robie House Tour Interpretation," 2011, accessed November 8, 2012, http://gowright.org/MoodleWright/mod/book/view.php?id=59&chapterid=18.

56 Reid, "League of American Wheelmen."

57 American Concrete Pavement Association, "Concrete."

58 D Hembrow, "The First Cycle Path in the Netherlands," May 4, 2009, accessed November 24, 2012, http://www.aviewfromthecyclepath.com/2009/05/first-cycle-path-in-netherlands.html.

59 Directorate-General for Passenger Transport, "The Dutch Bicycle Master Plan: Description and Evaluation in a Historical Context," Ministry of Transport, Public Works and Water Management, 1999.

60 AM Esfehani, "The Bicycle's Long Way to China: The Appropriation of Cycling as a Foreign Cultural Technique (1860-1941)," 2004, accessed November 24, 2012, http://www.imperialtours.net/bicycle.htm.

61 M Shi, "Rebuilding the Chinese Capital: Beijing in the Early Twentieth Century," *Urban History* 25.1 (1998): 60-81.

62 SD Cheng, "The Morphology of Walled Capitals," in *The City in Late Imperial China,* ed. GW Skinner (Stanford: Stanford University Press, 1977), 75-100.

63 Shi, "Rebuilding the Chinese Capital."

64 Q Wang, *A Shrinking Path for Bicycles: A Historical Review of Bicycle Use in Beijing* (Vancouver: The University of British Columbia, 2012).

European landscape elements, including trees, were added with the intention of reflecting the city as a place for leisure and recreation. Some roads, including Qianmen, were not to be greatly changed because these had, based on yin-yang, embraced the historic design principles of flowing wind and water (*fengshui*).[65] The wider paved roads, built between 1904 and 1929, were between 16 to 30 meters (52 to 98 feet) wide. These Chinese main roads and secondary lanes or alleys served as social spaces for the lower urban classes. In these roads, city inhabitants could escape from the heat in their houses or gather to socialize with neighbors.[66]

BICYCLING AND BICYCLE FACILITIES: 1920-1948

United States

In 1920 after cars and road building were well established in the US,[67] Henry Wright and Clarence Stein designed Radburn, New Jersey, labeled "the town for the motor age."[68] Unlike other developments in the US of the time, this plan incorporated bicycle paths between the houses that enabled children to bicycle to school, a friend's house, or playgrounds. Though some have suggested these paths were for pedestrians,[69] Clarence Stein was an early advocate for bicycle paths that were separate from the street. An underpass was even built so children did not have to cross a road to bicycle to school or the swimming pool. Stein believed that by increasing the use of bicycles, trips to the store or to places for recreation would be lessened.[70] Radburn was the exception as most other US housing developments focused on the car, garages, and the road with sidewalks added in some neighborhoods for pedestrians.

While US road infrastructure predominantly served the car drivers, park areas, especially around crowded New York City, turned to serving the bicyclists' needs. As part of the New Deal projects that lessened the negative impacts from the 1939 Depression, Robert Moses used Work Progress Administration (WPA) funds to build bicycle paths along the Harlem River Speedway, along Pelham Parkway in the Bronx, in Hillside Park in Queens, and in Riverside Park. In 1940, Moses used these WPA funds to create 31 miles of bicycle paths that passed through Brooklyn and traveled alongside Shore Parkway. By 1944, 29 bicycle paths had been built in park settings including along roads such as the Belt Parkway, the Hutchinson River Parkway, and the Cross Island Boulevard and in parks such as in Prospect Park, Van Courtland Park, Allen Pond Park, and Silver Lake Park.[71] Moses had started building these bike path systems because, with the Depression, people couldn't afford cars so sales of bicycles increased.[72] During this period, a bike path was considered for the exclusive use of bicyclists and not as a shared-use or multi-use path to be frequented also by walkers, joggers, dog walkers, and baby carriage pushers. Typically, a parallel path would have been built for non-bicyclists.

To urban planners elsewhere in the United States, the bicycle had fallen out of favor as the fad has passed and the car had become king. In 1930, three cars were owned for every four households and this ownership happened before the creation of the interstate highway system.[73] In 1928, the number of cars spiked to 21,300,000 and by 1942, this number had increased to only 29,500,000.[74] This slow rise in sales could be attributable to the 1939 Depression as the cost of cars was still low.

Netherlands

Unlike the car-centric US, in the Netherlands in 1920 the bicycle became the most popular form of transportation. With this popularity, the Dutch government developed traffic policies for the bicycle. In 1922, bicyclists were to maintain the same maximum speed of 20 km/hr (12 mph) as the cars. In 1930, this speed increased to 35 km/hr (21 mph) and in 1939 to 45 km/hr (27 mph).[75] Somewhere in the transition it must have been assumed that vehicles would pass bicyclists or perhaps the cars could only travel at bicyclists' speed due to all the bicyclists. Vehicles were few as the majority of the Dutch residents could not afford to purchase a vehicle. In Hanover, a city with 400,000 where a system of public transit was not well established, the high numbers of bicyclists became a problem. Though Amsterdam had 750,000 residents and an established mass transit system, the bicycle still dominated. The solution was not separate bicycle facilities but the accommodation of the bicyclists as a legitimate user on the street. In 1928 in the Netherlands, the ratio was a bicycle for 3.23 inhabitants and a car for 208 inhabitants while at the same time in the US the ratio was a bicycle for 70,000 inhabitants and a car for 6 inhabitants. In 1930 in the Netherlands, there were 68,000 vehicles and 2,700,000 bicycles. In 1939-1940 in the Netherlands, there were 100,000 vehicles and 4,000,000

65 Shi, "Rebuilding the Chinese Capital"; VFS Sit, "Beijing: Urban Transport Issues in a Socialist Third World Setting (1949-1992)," *Journal of Transport Geography* 4.4 (1996): 253-73.

66 Shi, "Rebuilding the Chinese Capital."

67 American Concrete Pavement Association, "Concrete."

68 HM Wright, "Radburn Revisited," *Ekistics Reviews of the Problems and Science of Human Settlements Housing and Houses: Policies and Plans for Better Living* 33.196 (1972): 196-201.

69 Wright, "Radburn Revisited"; LC Gerckens, "Historical Development of American City Planning," in *The Practice of Local Government Planning,* ed. FS So (Washington, DC: International City Management Association, 1988), 20-59.

70 P Sigrist, "Sustainable Housing and the Legacy of Clarence Stein," 2009, accessed November 8, 2012, http://www.thepolisblog.org/2009/04/design-preservation-sustainability.html; CS Stein, *Toward New Towns for America* (Chicago: The University Press of Liverpool, 1951).

71 City of New York Parks and Recreation, "Bicycling: A Revolution in Parks," 2012, accessed November 25, 2012, http://www.nycgovparks.org/about/history/bicycling.

72 T Campanella, "Robert Moses, Pedal Pusher?," *Wall Street Journal,* June 25, 2012.

73 J Schwartz, "The Social Benefits and Costs of the Automobile," in *21st Century Highways: Innovative Solutions to America's Transportation Needs*, ed. W Cox (Washington, DC: Heritage Foundation, 2005).

74 Stein, *Toward New Towns for America*.

75 Directorate-General for Passenger Transport, "The Dutch Bicycle Master Plan."

bicycles.[76] In addition to bicyclists dominating the road, the Dutch imposed a Bicycle Tax to help pay for a national cycle track network. Though bicycle lanes could have been painted on the roads for bicyclists, these were considered as surrogates and not preferred by Dutch planners.[77] On the many roads where there were no parallel cycle tracks, the bicyclists ruled the road and slowed cars to bicyclists' speeds.

During World War II in the Netherlands, the innate bicycling skill of the Dutch was evident. When individuals with the Dutch underground were helping escaping Americans, they knew to not give a bicycle to an American. The Dutch would never fall off while the Americans could not bicycle as skillfully. A bicycle was a valuable form of transportation during the war to the Dutch and having a permit allowed midwives to keep their bicycle. Otherwise, the bicycle could be confiscated by the Germans.[78] To allow German troops to move in the Netherlands during the war, use of the cycle tracks was deemed compulsory by the Germans.[79]

China

In Shanghai in 1925, there were 2 million residents and 9,800 bicycles but in 1930 this increased to 20,000 bicycles because the bicycle become affordable for the masses.[80] In 1937, the Japanese had opened bicycle factories in three cities in China, thus making the bicycle more widely popular.[81] With imported parts and local labor, mass production started in the 1930's and just before 1949 there were over half a million bicycles in China.[82] Early in the consideration, the bicycle was perceived as disgraceful[83]; but by 1949, the bicycle was seen as fashionable and modern.[84]

BICYCLING AND BICYCLE FACILITIES: 1949-1970/78

United States

The US had been a hub for bicycle manufacturers and that didn't change after World War II. Instead of bicycles for transportation, as in the Netherlands and China, the bicycle was designed as a toy for children or teenagers or as a recreational pleasure for racers. Bikes featured fat tires, were heavy, and had coaster brakes or were thin tired, fast, and had multiple gears for racing.[85] Bicycles in the 1950's even featured a streamlined pseudo gas tank, as the car was the product to be idolized.

Florida was the start of the next new bicycle environment in the US. Concerned that roads were unsafe for bicycling, a group of club riders identified and labeled secondary roads as a bicycle route. The concept of the bicycle route was eventually copied in other cities including Chicago. Chicago also created the Chicago Lakefront Trail at the same time that Boston was exploring a path around the Charles River. Boston's path was named for Dr. Paul Dudley White, the heart surgeon who treated President Dwight Eisenhower for his heart attack. Dr. White, a touring bicyclist, recommended bicycling for health in the 1950's. At this time, approximately 15 percent of Americans were bicycling. By 1970, 37 percent of the population in the US would be considered bicyclists but these include individuals bicycling for recreation. At the same time and using the same broad definition, in the Netherlands 76 percent of the population were bicyclists. The US bicycle environment for all of these recreational bicyclists included bicycle paths or shared-use paths such as the Chicago Lakefront Trail. Touring or racing bicyclists with thin tires were riding in the road on long distance rides.[86] There were no bicycle-exclusive cycle tracks directly beside roads in the US though park-setting bicycle paths were initially intended only for bicyclists.

Netherlands

While in the Netherlands between 1930 to 1940 the bicycle was the dominant mode of transportation, controlling even the flow of vehicle traffic, after World War II bicycle use started to decline, lessening even more by the 1960's.[87] In the 1950's and 1960's, the cycle tracks that did exist were removed in Dutch cities to provide more room for cars.[88] The introduction of the moped in the 1960's also resulted in a lowering of the number of bicyclists. Up until 1960, bicycle use was higher than car use but by 1974, bicycle use was at the same level as in 1950. In 1950, there were 139,000 cars and in 1975, 3.4 million cars. To serve all the cars, budgets were increased for road building and in 1966 the American method was copied for accommodating vehicles on a grid network. Between 1950 and 1975, the bicycle was not a significant factor in planning. In some Dutch cities in the 1970's, the levels of bicycling fell far below 20 percent of mode share. Bicycle infrastructure was removed, some cities imposed a ban on bicycling in the city centers, and other cities replaced bicycle lanes with parallel parking spaces. Some cities justified not having bicycle facilities because installing traffic lights for bicyclists would be expensive and waiting for bicyclists at intersections would slow down car traffic. In the 1960's in Enschede, the city legitimized installing bicycle lanes because having bicyclists on these lanes would allow for faster moving vehicular traffic and the lanes could eventually become parking for cars. Alternatively and because bicyclists were considered

[76] *Ibid.*

[77] M Colville-Andersen, "Danish Bicycle Infrastructure History," February 22, 2012, accessed November 24, 2012, http://www.copenhagenize.com/2012/02/danish-bicycle-infrastructure-history.html.

[78] P Ames, "Battling the Germans by Bike," May 28, 2009, accessed November 30, 2012, http://www.boiseweekly.com/boise/battling-the-germans-by-bike/Content?oid=1057819.

[79] J Franklin, "A History of Cycle Paths," accessed November 30, 2012, http://www.cyclecraft.co.uk/digest/history.html.

[80] Esfehani, "The Bicycle's Long Way to China."

[81] Wang, *A Shrinking Path for Bicycles.*

[82] Esfehani, "The Bicycle's Long Way to China."

[83] *Ibid.*

[84] Wang, *A Shrinking Path for Bicycles.*

[85] D Mozer, "Bicycle History & Human Powered Vehicle History," 2012, accessed November 30, 2012, http://www.ibike.org/library/history-timeline.htm.

[86] TR Jarrell, *Bikeways – Design – Construction – Programs* (Arlington: National Recreation and Park Association, 1974).

[87] Directorate-General for Passenger Transport, "The Dutch Bicycle Master Plan."

[88] D Hembrow, "The First Cycle Path in the Netherlands."

a regular part of traffic in the 1960's in Amsterdam, no paths or lanes were constructed for bicyclists. Amsterdam City Council's Traffic Committee did not want to allocate separate space for bicyclists because of limited right-of-way, reasoning that bicyclists had an equal right to the road.[89]

China

With the founding of the People's Republic of China in 1949, the ruling communist government supported the bicycle.[90] Based on the Soviet model, their objective was to rapidly industrialize the country. To achieve industrialization, jobs had to be created for many workers and affordable and easy transportation had to be provided.[91] Thus, the existing Japanese bicycle manufacturing companies became state-owned. Smaller bicycle and bicycle-accessory shops were consolidated to form three large Chinese factories that generated many jobs and that produced nationally branded bicycles.[92] These bicycle manufacturers had an advantage in that the government provided the companies with rationed materials. Subsidies to purchase a bicycle were also given to the workers who commuted by bicycle. As a result, in 1958 there were one million bicycles in China, a doubling since the start of the revolution.[93] Even with increased production, the bicycles were still relatively few. Until 1978, the purchase was rationed through a coupon, the price was fixed, and the bicycle cost approximately six month's salary for the average worker.[94]

While the Soviet model for jobs was clear, in 1949 Beijing had difficulties in creating a modern transportation system due the existing Imperial grid of wide straight avenues and also the smaller grids of narrow neighborhood streets.[95] Building modern mass transit would have been complex and expensive.[96] Beijing's objective of moving many people was predicated on the socialist urban transportation model that had specific goals: (1) a short commute to work; (2) transportation to serve the general public; and (3) subsidies to provide affordable public transportation.[97] To lessen noise and congestion impacts, the transportation system would have to also have heavier traffic on designated streets. Based on the Russian symbolic model for a central city, the design should additionally glorify the socialist state and include extensive green space.[98] The bicycle fit this model and did not involve the installation of a mass transit system at a time when funds were scarce.

Though the bicycle was becoming popular, until 1965 the main roads were 14 to 21 meters wide (46 to 69 feet), primarily for cars, and without separation for bicyclists. In 1965, the first main road was built with two lanes for cars, each 14 meters (46 feet), and two lanes for bicyclists and carts, each 4 meters (13 feet). A green strip was included that was between 2.5 to 5.5 meters (8 to 18 feet wide). Thus, the streets included car lanes, designated bicycle lanes, and wide green planting strips that separated the cars from the bicyclists.[99] As the popularity of the bicycle increased, in Beijing some of the bicyclists' cycle tracks were 7 meters (22 feet wide).[100] These wide, imposing, and beautifully landscaped streets were designed to project the symbolism of Beijing, the nation's capital.[101]

BICYCLING AND BICYCLE FACILITIES: POST-1971/78

United States

Bicycling popularity and funding grew in the US in the 1970's. In 1969, sales of adult bicycles increased by 20 percent and in 1973 increased by 65 percent. Davis, California, a small university campus with proximate residential housing, had 25,000 residents and upwards of 20,000 bicycles. During the summer when students were not on campus, the levels of bicycling reached 40 percent. Oregon passed legislation in 1971 that set aside one percent of the state gas tax for bicycle facilities and other states, including Ohio, California, Maryland, Illinois and Florida, passed similar legislation. The Federal Highway Act of 1973 had provisions for up to $2 million per state to create walking or biking facilities. This funding was separate from funding for highways. Federal funds were also available to build bicycle facilities under the Land and Water Conservation Fund, based on a 50-50 match, and under the 1968 Trails Fund Act. States passed specific legislation, including in North Carolina which allocated funding for a statewide bikeway system. Bicycling was adopted for recreation on separate paths but also for transportation. One downside for transportation bicycling was the lack of safe infrastructure as bicycling was on main roads or on secondary roads that had been marked as bike routes.[102]

At this time, bicycle advocates could be divided into two groups including the hard core "Macho Militants," who did not want bike lanes and only wanted to operate a bicycle as a vehicle, and the "New Age Activists," who advocated for fewer cars and separate bicycle facilities. The differing infrastructure objectives of these two groups hindered progress for the bicycle.[103] John Forester wrote "Effective Cycling" and advocated only for biking in the road. His principles did inform bicyclists about how to be safer on the road but only bicyclists willing to bicycle with cars benefited from his forceful only-roads advocacy.[104] One of the oldest

89 Directorate-General for Passenger Transport, "The Dutch Bicycle Master Plan."
90 Esfehani, "The Bicycle's Long Way to China."
91 Sit VFS, "Soviet Influence on Urban Planning in Beijing, 1949-1991," *The Town Planning Review* 67.4 (1996): 457-84.
92 Wang, *A Shrinking Path for Bicycles.*
93 Esfehani, "The Bicycle's Long Way to China."
94 Wang, *A Shrinking Path for Bicycles.*
95 Sit, "Beijing."
96 Esfehani, "The Bicycle's Long Way to China."
97 Sit, "Beijing."
98 Sit VFS, "Soviet Influence on Urban Planning in Beijing, 1949-1991," *The Town Planning Review* 67.4 (1996): 457-84.
99 Sit, "Beijing."
100 Wang, *A Shrinking Path for Bicycles.*
101 Sit, "Beijing."
102 TR Jarrell, *Bikeways – Design – Construction – Programs*.
103 P Harnik, "Bicycle Activism: Taking It to the Streets," *New Age* (1980): 32-9.
104 J Forester, *Effective Cycling.*

community-based bicycle advocacy groups in the US, the San Francisco Bay Bicycle Coalition, was founded in 1970 by environmentalists and neighborhood groups. They were a grassroots organization and had to expend considerable volunteer energy to improve bicycle facilities. Bicycle access to the Golden Gate Bridge was a notable achievement.[105] One difficulty with the citizen-led bicycle advocacy, as compared to government-led policies, was the advocates who could attend the evening meetings, lobby on behalf of facilities, or write the bicycle facility design guidelines tended to be bicyclists who were comfortable bicycling in the road, as those were the primary bicycle facilities at the time. The individuals who did not bicycle did not attend the meetings, lobby, or write the bicycle design guidelines. Thus, the interests of the potential bicyclists were not as well served.

Netherlands

In the Netherlands from 1950 to 1975, levels of bicycling dropped considerably.[106] In 1950 in the Netherlands, there were 1,021 traffic fatalities. In 1972, this had increased to 3,264 fatalities, a 200 percent increase. The high number of fatalities was coupled around 1972 with the oil crisis and a boycott of oil from Arab countries. In response, vehicle traffic was regulated, parking fees imposed, and woonerfs (residential streets closed to through traffic) designed. Rather than having bicyclists share the road with cars, in 1972 space was taken from the cars for segregated bicycle facilities. This bicycle-allocated space on the road could only be as wide as feasible to still accommodate car traffic. Thus, in some places, the bicycle and car still had to use the same right-of-way. In the 1990's, the realization was that allowing the car to dominate the road short-changed the bicyclists. Therefore, congestion and longer car commutes were accepted as long as people had alternatives to driving, such as riding a bicycle or taking mass transit.[107]

China

Before 1978, Beijing only had 130,000 vehicles and the bicycle was a predominant form of transportation.[108] By 1983, 37 percent of commutes were by bicycle compared to 19.5 percent for mass transit. In 1988, 57.1 percent of commutes were by bicycle compared to 37 percent by mass transit. Bicycle use increased because the bus was the form of mass transit. The average speed for biking was 7.8 km/hr while the bus moved at 6.0 km/hr. Commuting by bicycle was subsidized by companies as arriving by bicycle better ensured the worker would arrive on time. This subsidy covered the cost of a new bicycle about every three years. Though better guaranteeing punctuality, the moving bicycle takes up two times as much space stopped and ten times as much space moving as a bus passenger. In concentrated cities such as Beijing, the slower bus offers a greater concentration of people who are moved.[109] Yet the bus would, at least for part of its trip, be empty whereas, for its square footage taken on the street, the moving bicycle would always have a passenger.

In 1990, the bicycle still dominated as the numbers of vehicles in Beijing was 270,655 compared to 8,380,000 bicycles.[110] The Urban Transport Road Design Code of 1995 stated that if traffic flows exceed 10,000 vehicles per hour, cycle tracks were to be provided. From 1993 to today, bicycle ownership has not increased but been flat or decreased slightly. Even though people still owned bicycles, they bicycled less. In 2005, 30 percent of people in Beijing drove a car whereas 29.8 percent bicycled.[111]

BICYCLING AND BICYCLE FACILITIES: PRESENT

United States

The Ocean Parkway Bike Path, built in 1894 as the world's first leisure cycle track and 17 feet wide, is now only a nine-foot wide path with a parallel seven-foot section for pedestrians. The cycle track is separated from cars by a grass strip and trees and from pedestrians by a three-foot-high metal fence.[112] The bicycle-exclusive nine-mile-long wooden path in California that, in 1897, fit four bicyclists riding side-by-side is now a road for cars.[113] Narrow cycle track segments are being built in the US by taking some space from the road. Though cycle tracks are not in the 2012 "Guide for the Development of Bicycle Facilities," produced by the American Association of State Highway and Transportation Officials (AASHTO),[114] cycle tracks are included in the National Association of City and Transportation Officials (NACTO) "Urban Bikeway Design Guide." The NACTO guide recommends that cycle tracks be a minimum of five feet wide and a maximum of seven feet wide to allow another bicyclist to pass.[115] On these narrow cycle tracks, bicyclists typically bicycle one behind the other. In other bicycle facilities in the US, including the road, painted bike lanes beside parallel-parked cars, and painted bike lanes beside curbs, bicyclists also travel single file as their attention has to be focused on sharing the road with vehicles. Bicyclists on a park-setting shared-use path might be able to bicycle side-by-side and converse but these facilities also have walkers, joggers, in-line skaters, dog walkers, and baby carriage pushers. Complete Streets guidelines[116] feature

[105] San Francisco Bicycle Coalition, "About Our Work," 2012, accessed December 1, 2012, http://www.sfbike.org/?about.

[106] Pucher and Buehler, "Making Cycling Irresistible."

[107] Directorate-General for Passenger Transport, "The Dutch Bicycle Master Plan."

[108] Wang, *A Shrinking Path for Bicycles.*

[109] Sit, "Beijing."

[110] *Ibid.*

[111] Wang, *A Shrinking Path for Bicycles.*

[112] NYC Bicycle Land and Trail Inventory Brooklyn Data, "Ocean Parkway Bicycle Trail," accessed November 8, 2012, http://www.nyc.gov/html/dcp/pdf/transportation/blt1_3.pdf.

[113] Denham, "California's Great Cycle-Way."

[114] American Association of State Highway and Transportation Officials, "Guide for the Development of Bicycle Facilities" (Washington, DC: American Association of State Highway and Transportation Officials, 2012).

[115] National Association of City Transportation Officials, "NACTO Urban Bikeway Design Guide," 2011, accessed June 1, 2011, http://nacto.org/cities-for-cycling/design-guide/.

[116] National Complete Streets Coalition, "Complete Streets," 2011, accessed May 24, 2011, http://www.completestreets.org/complete-streets-fundamentals/resources/.

benches, lighting, trash cans, landscaping, water fountains, and public art[117] on wide sidewalks with bicyclists most often in the road. The Complete Street guidelines do not reflect gender differences.[118] Perhaps due to the dominance of the vehicle, that bicyclists have to share the road with cars, and that cycle tracks, when built, are a maximum of seven feet wide, the percentage of bicyclists who commute by bike in the US is only 0.56 percent and only 27 percent of these commuting bicyclists are female.[119]

The Netherlands

The Dutch have produced the "Design Manual for Bicycle Traffic" (CROW) that describes how to build bicycle facilities. The recommendation is for cycle tracks that are a maximum of four meters wide (13 feet), including for both one-way and two-way cycle tracks. The CROW guidelines also describe a wide variety of other bicycle facilities, including provisions for bicycling on the road.[120] Networks of cycle tracks exist in the Netherlands such as perimeter cycle tracks on roundabouts, in underpass tunnels, and on car-less bridges. While the US Complete Street guidelines[121] do not reflect differences in gender preferences, the Dutch CROW bicycle guidelines do reflect gender.[122] Perhaps as a result of the CROW guidelines, prior bicycle facility guidelines, and the history of bicycling in the Netherlands, in 2005, 27 percent of the population bicycled for transportation and of these bicyclists, females comprised 55 percent.[123]

China

Bicycling in China has been on the decline. In Beijing since 1986, the use of cars has increased six times. In 2010, use of the bicycle was only 17 percent compared to the earlier years that saw highs of 60 percent.[124] Yet even though Beijing came in last or near the end in a scan of the most bicycle-friendly cities worldwide, Beijing still made this short list.[125] Having a 17 percent bike share in Beijing is low compared to prior years, but this is high in comparison the 0.56 percent of commuter bike share for the US.[126] Other Chinese cities, including Hangzhou, had bicycling populations in 1997 of 60.8 percent yet in 2007 in Hangzhou, 33.5 percent of the population still was bicycling.[127] In 2003 in Tianjin, bicycle trips were 51 percent and Shi-Jia-Zhuang, 56 percent, thus reflecting a still-strong bicycle presence in China.[128]

CONCLUSION

From 1949 and the beginnings of the People's Republic of China, Chinese cities were changed in shape. Building a mass transit system would have been expensive and complex, given the historic urban forms. With the Soviet influence, the goal was to convey industrialization with a grand scheme. Wide cycle tracks for exclusive use of bicyclists were built to carry workers efficiently, quickly, and promptly from home to work. In some locations, these cycle tracks were 22 feet wide with landscaped separations from car traffic that were 18 feet wide. With these expansive and handsomely planted boulevards, Beijing could project the symbolism of the nation's capital and, at the same time, provide an affordable mass-transit-by-bike system.

In comparison in the US, 17-foot wide cycle tracks were built in 1897 for bicyclists recreating but these routes were soon narrowed or disappeared, transformed into roads for cars. Until today, the road has been the main route for bicyclists wanting to commute. This has involved sharing the road with cars where not every bicyclist has been comfortable. Now in the US, cycle track segments are slowly being built but they are a maximum of seven feet in width and for the lone bicyclist traveling single file. To converse, a bicyclist has to talk to the bicyclist ahead or behind.

The Dutch had built a few cycle tracks in the early days of the bicycle and cycle tracks existed during World War II. After the war, hordes of bicyclists took over the roads, slowing cars to the bicyclists' speed. After a decline in bicycle use, bicycle popularity increased after 1970. The Dutch then started taking space away from the car to make room for the bike. Now, the Dutch have networks of well-traveled cycle tracks that are a maximum of 13 feet wide. These are most often placed alongside roads with only cobblestones or different colored pavement as a separation. These cycle tracks only rarely, where adjacent parkland allows, include buffers of plants as in the grand avenues of China. Still, the Dutch cycle tracks are wide enough for friends to talk and bike alongside friends or for a parent to reach out a hand to gently help their

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[117] Complete Streets, "Complete Streets Policy Fact Sheet," November 2007, accessed September 27, 2011 http://greatcommunities.org/intranet/library/sites-tools/great-communities-toolkit/CompleteStreets.pdf.

[118] C Emond, "Gender Considerations in Performance Measures for Bicycle Infrastructure," in *Women's Issues in Transportation: Summary of the 4th International Conference*, TRBS Report (Irvine: TRBS, 2009), 254-63.

[119] US Census Bureau, "American Fact Finder."

[120] "C.R.O.W. Design Manual for Bicycle Traffic."

[121] National Complete Streets Coalition, "Complete Streets."

[122] "C.R.O.W. Design Manual for Bicycle Traffic."

[123] Pucher and Buehler, "Making Cycling Irresistible."

[124] P Calthorpe, "Weapons of Mass Urban Destruction," *The Cities Issue: An Foreign Policy Special Report 2012,* September/October 2012, accessed December 2, 2012, http://www.foreignpolicy.com/articles/2012/08/13/weapons_of_mass_urban_destruction.

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[126] US Census Bureau, "American Fact Finder."

[127] S Shaheen, H Zhang, E Martin and S Guzman, "China's Hangzhou Public Bicycle: Understanding Early Adoption and Behavioral Response to Bikesharing," *Transportation Research Record: Journal of the Transportation Research Board* 2247 (2011): 33-41.

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child bicycling at their side.

In 1949, China was not concerned about providing a bicycle environment to address obesity. Wide cycle tracks were at the time a better alternative to buses, streetcars, or subways. Yet, for comparisons now, a bus can carry 44 passengers. The Metabolic Equivalency of Task (MET) of a sitting bus passenger is only 1 MET[129] and, thus, a bus would equal 44 total METs. Compared to the bus passenger, bicyclists might occupy two times the road space while stationary and ten times the road space while moving.[130] Depending on speed, bicyclists can generate from 4-16 METs.[131] Even standing at 2.3 METs, with two bus passengers for every bicyclists standing, the total METs for 22 bicyclists would be 50.6 METs. If there were approximately four and a half bicyclists for the 44 bus passengers and they bicycled at a comfortable speed (10 METs), their METs would be approximately 45 METs overall. Though these numbers are similar, it is important to remember that a bus or train is sometimes partially empty when picking up passengers while a bicycle is never empty. The moving bicyclist also always has to generate higher METs because if they bicycle too slowly they will fall over. Comparing on a one-to-one basis, the 44 passengers in the bus (one MET sitting) equal 44 METs while 44 bicyclists (eight METs bicycling) equal 352 METs. If maintaining roads and bridges and adding bus/subway mass transit is the sustainable-city goal, BMT should also be built. The BMT will result in lower mobile source air pollution and much higher levels of physical activity.

China also created landscaped islands between vehicles and the cycle tracks that were up to 18 feet wide. While it would be difficult to justify that amount of right-of-way for landscaping in a road today, for this new BMT system perhaps new landscaping designs could be developed. These could be narrower but lessen the movement of mobile source air pollution from the vehicle lane to the cycle track.

For an additional space-justification perspective, cycle tracks have been suggested as safer compared to bicycling in the road[132] and important for increasing bicycling.[133] Safe bicycle routes coupled with paying people to bicycle and providing destination facilities, such as bicycle parking, better guarantee people would bicycle to work.[134] Studies conducted in China, where wide cycle tracks have existed, suggested that bicyclists prefer wide cycle tracks though the bicyclists did not prefer to have heavily crowded cycle tracks.[135] Wide-cycle tracks may be preferred for the ease in bicycling but also for the opportunity to talk to a friend. Environments can be built that contain "Social Bridges" or elements in the built environment that enable a positive interaction, even between strangers.[136] In the Netherlands, bicycling side-by-side is fostered.[137] The Dutch do not prefer to ride behind one another, especially if they are riding with children.[138]

In the US, walkable neighborhoods with wide plaza sidewalks and café table areas are lauded, especially as part of Complete Streets.[139] Cities, including Burlington, Vermont with Church Street and Denver, Colorado with the 16th Street Mall have created pedestrian-zoned/bicycle-banned streets that foster economic development but not high calorie burning. New York City closed much of Broadway to create café table sections that are to be widened more.[140] These spaces are deemed successful if people stay for a considerable period, called "staying activity."[141] In these spaces that can serve as rewarding trip destinations, individuals can socialize with friends. Yet, out of a 24-hour day, these individuals are also spending more time sitting in addition to the time they spend sitting in the car, at work, eating, or in front of the TV. China, with its 22-foot wide cycle tracks and up to 18 foot wide landscaped buffers that could provide distance from mobile source air pollution, might have the better solution. Compared to sitting on a bus or a café table at a MET level of one, many bicyclists could travel on a BMT system at a MET level of eight and talk as they can on China's wide *social cycle tracks.*

[129] Ainsworth et al., "Compendium of Physical Activities: An Update of Activity Codes and MET Intensities."

[130] Sit, "Beijing."

[131] Ainsworth et al., "Compendium of Physical Activities: An Update of Activity Codes and MET Intensities."

[132] F Wegman, F Zhang and A Dijkstra, "How to Make More Cycling Good for Road Safety?," *Accid Anal Prev* 44.1 (2010): 19-29; Lusk et al., "Risk of Injury for Bicycling"; Teschke et al., "Route Infrastructure and the Risk of Injuries to Bicyclists."

[133] L Yang, S Sahlqvist, A McMinn, SJ Griffin and D Ogilvie, "Interventions to Promote Cycling: Systematic Review," *Bmj* 341 (2010): c5293.

[134] M Wardman, M Tight and M Page, "Factors Influencing the Propensity to Cycle to Work," *Transportation Research Part A* 41 (2007): 339-50.

[135] Z Li, W Wang, P Liu and DR Ragland, "Physical Environments Influencing Bicyclists' Perception of Comfort on Separated and On-Street Bicycle Facilities," *Transportation Research Part D* 17 (2012): 256-61.

[136] AC Lusk, "Promoting Health and Fitness through Urban Design," in *The Humane Metropolis: People and Nature in the 21st-Century City*, ed. RH Platt (Amherst & Boston: University of Massachusetts Press, 2006).

[137] "C.R.O.W. Design Manual for Bicycle Traffic"; U Lehner-Lierz, "Cycling Side by Side: Is It Allowed and Does It Occur in Other Countries?," 2006, accessed October 5, 2011, http://www.fietsberaad.nl/index.cfm?lang=en&repository=Cycling+side+by+side:+is+it+allowed+and+does+it+occur+in+other+countries?.

[138] R Rietveld and V Daniel, "Determinants of Bicycle Use: Do Municipal Policies Matter?," *Transportation Research Part A* 38.7 (2004): 531-50.

[139] National Complete Streets Coalition, "Complete Streets."

[140] M Grynbaum, "A New Look Is Coming to Times Square: Minimalism," *The New York Times,* September 27, 2011, accessed December 12, 2012, http://www.nytimes.com/2011/09/28/nyregion/times-square-pedestrian-plazas-to-get-a-makeover.html?_r=1&adxnnl=1&adxnnlx=1317755920-aiYdOnmzOw-4pyPT4rh8Nsw.

[141] Gehl Associates, "Public Spaces & Public Life Study" (Adelaide: Gehl Architects Urban Planning Consultants Denmark, 2011).