

Bridging the Gaps:

How the Quality and Quantity of a Connected Bikeway Network Correlates with Increasing Bicycle Use

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Abstract

Since the mid-1990s Portland, Oregon has pursued a “build it and they will come” strategy by developing its bikeway network to promote increased bicycle use. Between 1992 and 2005 Portland increased its developed bikeway network by 215%, from 83 miles to 260 miles. During this same period, bicycle use in Portland soared. A comparison of 1990 and 2000 census data shows a doubling of bicycle commute trips citywide, with more dramatic increases in close-in neighborhoods.

Annual bicycle counts on Portland’s central city bridges, which connect close-in residential neighborhoods across the Willamette River to the city’s primary commercial and employment center, show a 210% increase in bicycle trips between 1991 and 2004. This dramatic increase in bicycling occurred primarily in those corridors where the city has made significant investment to: improve bicycling conditions on the river bridges; create connected bicycle facilities leading to the bridges; and mitigate for traffic designs that are not particularly bicycle-friendly. The corridors where the network is most connected, and where the quality of the facilities is the highest, display the largest growth in bicycle trips.

Data collected by Portland demonstrates a strong correlation between a connected, bikeway system constructed to the highest standards, and increases in bicycle use. The authors believe that the City’s investments in specific facility improvements to its downtown Willamette River bridges, as well as to key bridge access routes and connections, have been the primary impetus behind increasing bicycle use.

Bridging the Gaps: How the Quality and Quantity of a Connected Bikeway Network Correlates with Increasing Bicycle Use

Introduction

One of the greatest challenges facing the bicycle and pedestrian field is the lack of documentation on usage and demand. Without accurate and consistent demand and usage figures, it is difficult to measure the positive benefits of investments in these modes, especially when compared to the other transportation modes such as the private automobile. The Institute of Transportation Engineers (ITE) “Trip Generation Manual” is the basis of automobile usage projections that lead to all manners of decisions about roadway and intersection capacity design. It is based on decades of experience with automobile counts. There is nothing comparable in the bicycle and pedestrian planning field as of yet; a national ITE-sponsored program has just begun development of such a database via systematic counts of bicyclists.

The City of Portland has been a leader in conducting bicycle counts. Over the past two decades, it has developed an extensive count database. This has included:

- Before-and-after counts related to specific projects,
- Regular “cordon” counts of all entry points to the Downtown, and
- Annual counts on its Downtown bridges and key access routes.

The count data reveals that bicycle use in the inner parts of Portland has soared. The authors believe that the City’s investments in specific facility improvements to its downtown Willamette River bridges, as well as to key bridge access routes and connections, have been the impetus behind this trend. The authors analyze the City’s bicycle count database related to these improvements, and discuss results and key factors in achieving success. Particular attention is given to both the quality and quantity (or level of bikeway network completion) of the facilities in specific corridors.

Background

Portland's Willamette River cuts through the heart of the City and provides social, economic, and recreational benefits. The Willamette River bridges connect the City's east and west sides — on the west side is Portland's vibrant and economically critical downtown, on the east side are light industries, emerging business districts, and pedestrian and bicycle-friendly neighborhoods. Simply put, the bridges are critical for mobility.

In the early 1990s, the City embarked upon a major program to engage cyclists and potential cyclists in a dialogue about ways to increase cycling as a means of transportation. Overwhelmingly, improvements to the bridges' approaches and spans, as well as to the network feeding the bridges¹, were seen as the highest priority because of the poor conditions. The City and its partners² then adopted a "build it and they will come" approach by investing in improving bridge facility quality and access.³ They collaborated on an ISTEA-funded study called the Willamette River Bridges Access Project (WRBAP), for which consultants CH2MHill identified over \$15 million in potential bicycle, pedestrian, and ADA improvements. The City and County subsequently implemented many of these via grants from ODOT, ISTEA, and through routine City of Portland, Multnomah County, and ODOT bridge and approach maintenance work.

At the time, all bridges had access problems, such as:

- Cyclists having to cross motor vehicle ramps with no markings or yield control.
- Lack of bikeway facilities on approaching congested streets and structures.
- Conflicts between bicyclists and pedestrians on narrow sidewalks and other points.

On the Steel Bridge upper deck, the sidewalks were so narrow that bicyclists were supposed to walk their bikes, while on the Morrison Bridge the sidewalks were—and still are—inaccessible and cross freeway exit ramps. On the Hawthorne and Broadway Bridges, cyclists could share narrow, slippery sidewalks and had no connecting bike lanes or curb cuts. On the Burnside and Morrison Bridges,

¹ The "network feeding the bridges" is defined as those developed bikeways within approximately 3 miles of the bridge that, in our estimation, most directly serve cyclists either coming to or leaving the bridges.

² Jurisdictional responsibility for the bridges is relatively complex. The City of Portland is responsible for signing, striping, and access to all bridges. Multnomah County owns and operates four of the bridges (Hawthorne, Morrison, Burnside, and Burnside), with split ownership and operation over the Steel Bridge between Multnomah County (upper deck) and the Union Pacific Railroad (the lower deck is a railroad bridge with mainline freight and passenger rail cars about once an hour.)

³ The City based its concept on a controlled cross-sectional study in Delft, Netherlands, in which households in an "intervention" suburb with improved bicycle connections reported a 3% increase in bicycle mode share compared to no net increase in bicycle mode share in the control area without bicycle improvements.

bicyclists could theoretically use the outside, relatively narrow 10' wide, fast-moving outside travel lanes. All in all, the entire situation was dismal.

Improvements Implemented

Over \$12 million worth of improvements have been implemented, primarily on and leading to and from four of the downtown bridges: Hawthorne, Burnside, Steel, and Broadway. Preliminary design for improvements on the fifth downtown bridge—Morrison—is underway as of Fall 2005. The measures implemented on the four main bridges are shown in the photos below and described for each bridge in Table 1.

The measures include:

- Improvements to bridge facilities (widening sidewalks on Hawthorne Bridge, sidewalk in-fill in approach areas, replacement of slippery sidewalk surface on both Hawthorne and Broadway Bridges, addition of shared use path on Steel Bridge).
- Striping bicycle lanes, signing (on the bridge span on Burnside Bridge, and on most approaches and access streets within about a mile of the bridges on Portland's inner eastside).
- Designation and then implementation of a network of feeder bicycle routes within about three miles, including striping bicycle lanes and implementing bicycle boulevards.⁴
- Focus on safety at conflict areas (closure of on-ramp from Naito to Hawthorne Bridge, reconstruction of conflict areas on approaches to Hawthorne and Broadway Bridges, blue bike lane implementation in conflict zones on approaches to Broadway and Hawthorne Bridges).
- Redesigning sidewalk ramps to meet ADA (all bridges).

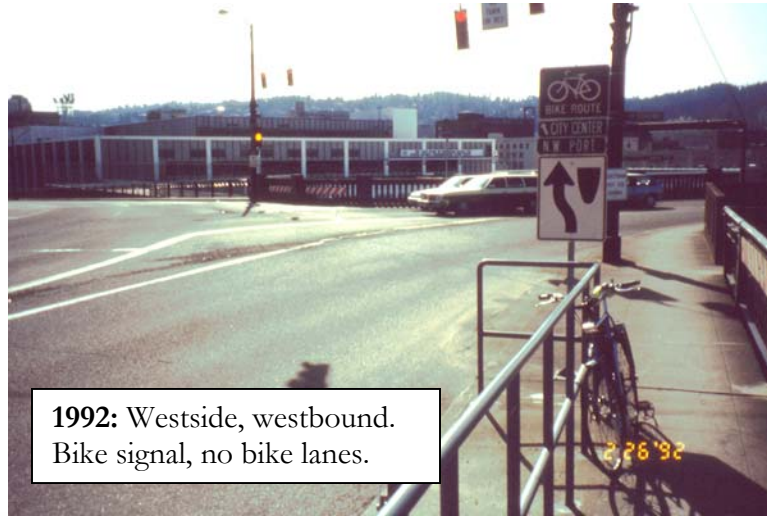
It should be noted that many of the improvements were made in conjunction with other bridge upgrade or reconstruction projects, thus costs for specific bike/pedestrian improvements are not always available. Also note that the City used blue pavement areas in bike/motor vehicle conflict areas on the approaches from the eastside for two bridges as a means to mitigate for roadway designs not generally considered "bicycle-friendly. Blue bike lanes as a safety technique are discussed in the City of Portland publication, "Blue Bike Lanes for Cycling Safety" (City of Portland, 1997).

⁴ A bicycle boulevard" is defined by the Portland Bicycle Master Plan as a shared roadway (bicycles and motor vehicles share the space without marked bicycle lanes) where the through movement of bicycles is given priority over motor vehicle travel on a local street. Traffic calming devices are used to control traffic speeds and discourage through trips by motor vehicles. Traffic control devices are designed to limit conflicts between automobiles and bicycles and favor bicycle movement on the boulevard street. Portland has a number of excellent, highly used boulevards that run parallel to major roadways.

It is also worth noting that the majority of improvements made to Portland's bikeway network were state of the art facilities that followed the highest standards and best practices in the U.S. Portland striped bicycle lanes of ample width and eliminated traffic hazards wherever possible. Transitions between bicycle lanes and off-street paths were well designed and clearly marked. Facilities were created with an emphasis on maximum connectivity. Boulevard arterial crossings are designed effectively and individually for each situation, and include bicycle-only signals where needed, adjustments to timing on other signals, and installation of bicycle boxes at one intersection to assign priority to cyclists. Portland also uses traffic calming techniques on boulevards when speeds are found to be too high. Six of Portland's ten blue bicycle lanes, which assign priority to bicyclists in an area of an auto-bicycle weave, are found along approaches to the Hawthorne and Broadway bridges. While Portland has striven to complete a large proportion of its bikeway network, it has tried to provide the highest quality of facilities possible.

Photo Gallery: Portland Bridge Improvements

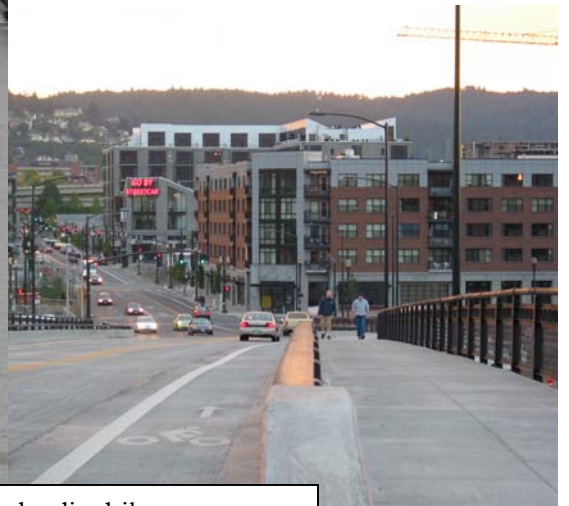
Photoset 1. Broadway Bridge Improvements



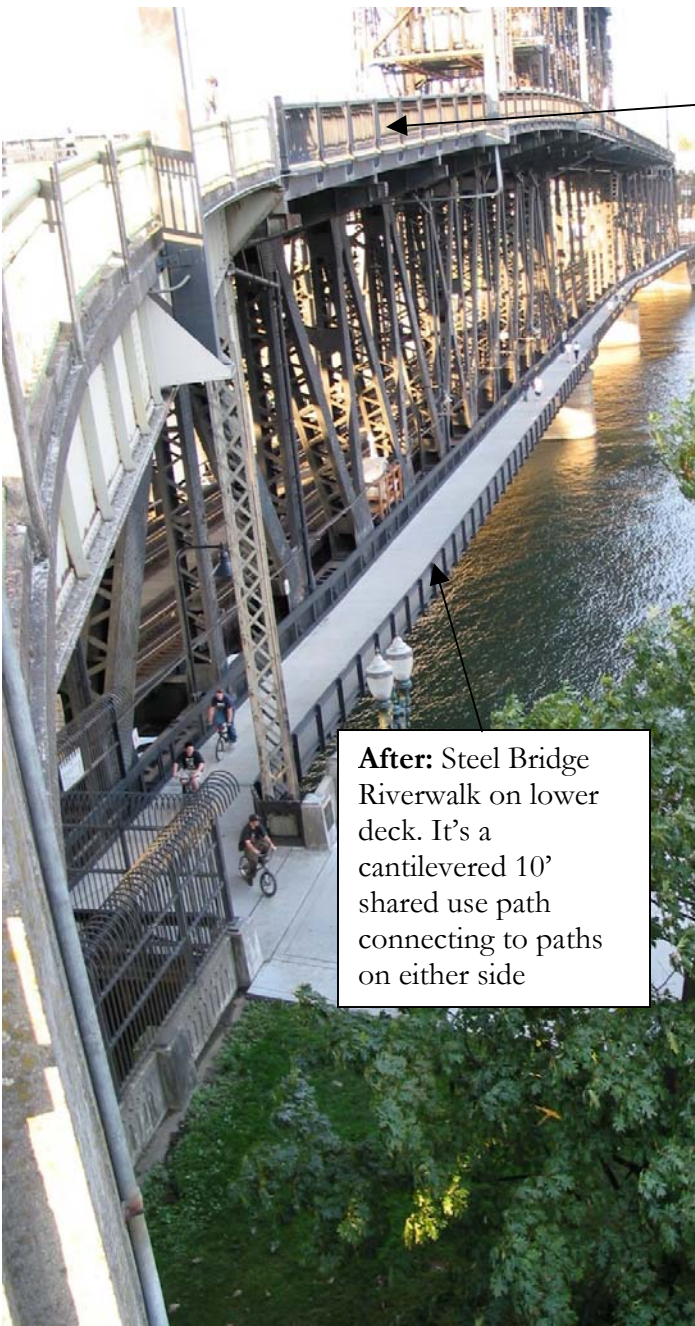
1992: Westside, westbound.
Bike signal, no bike lanes.



2002: Westside, westbound. New bike signal splits bike movements. Bike lanes on approaches and connecting streets.



Photoset 2. Steel Bridge Improvements

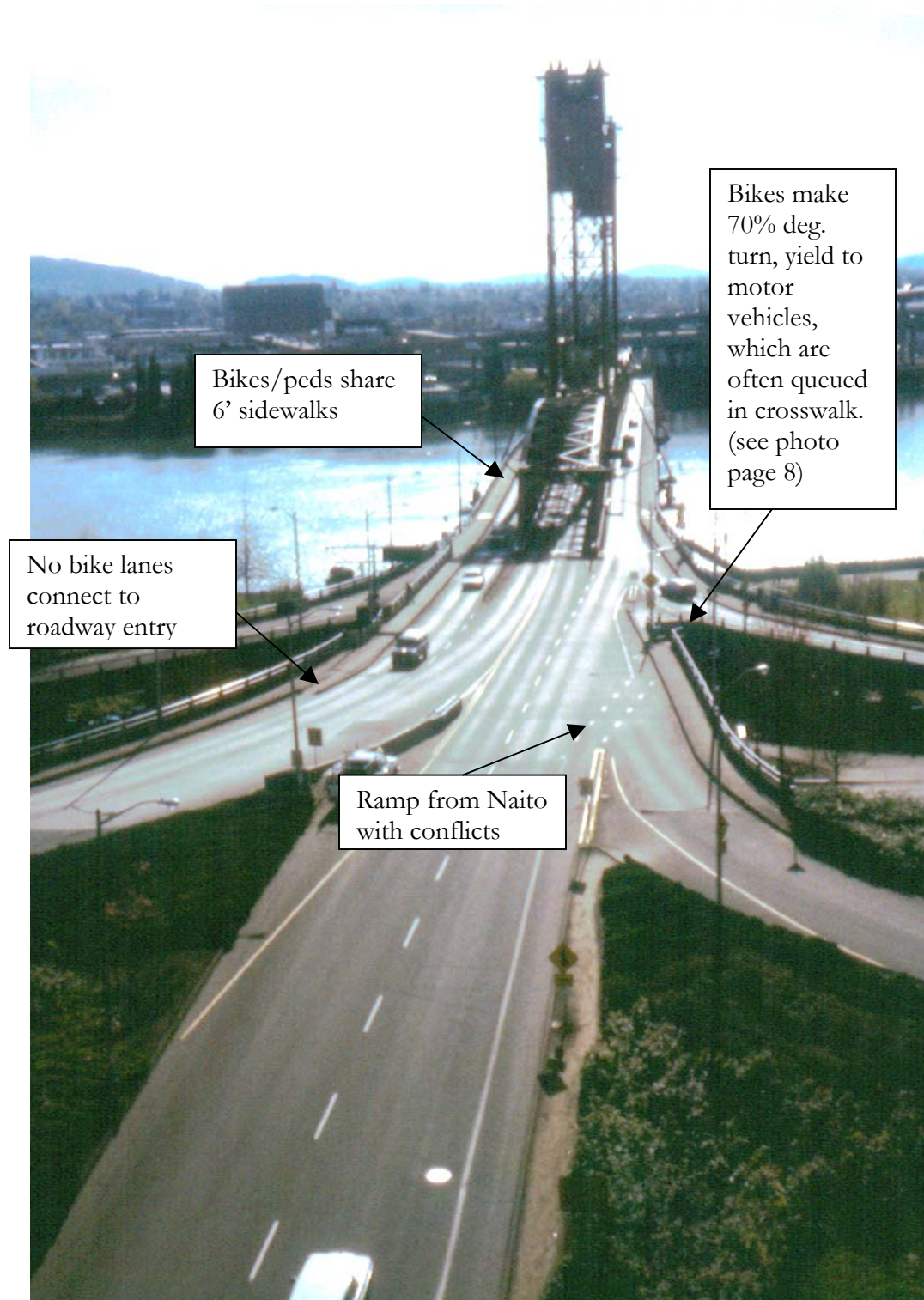


Before: Steel Bridge, upper deck. Bicyclists and pedestrians sharing one 5' sidewalk with guardrail.



After: Steel Bridge Riverwalk on lower deck. It's a cantilevered 10' shared use path connecting to paths on either side

Photoset 3. Hawthorne Bridge Before Improvements



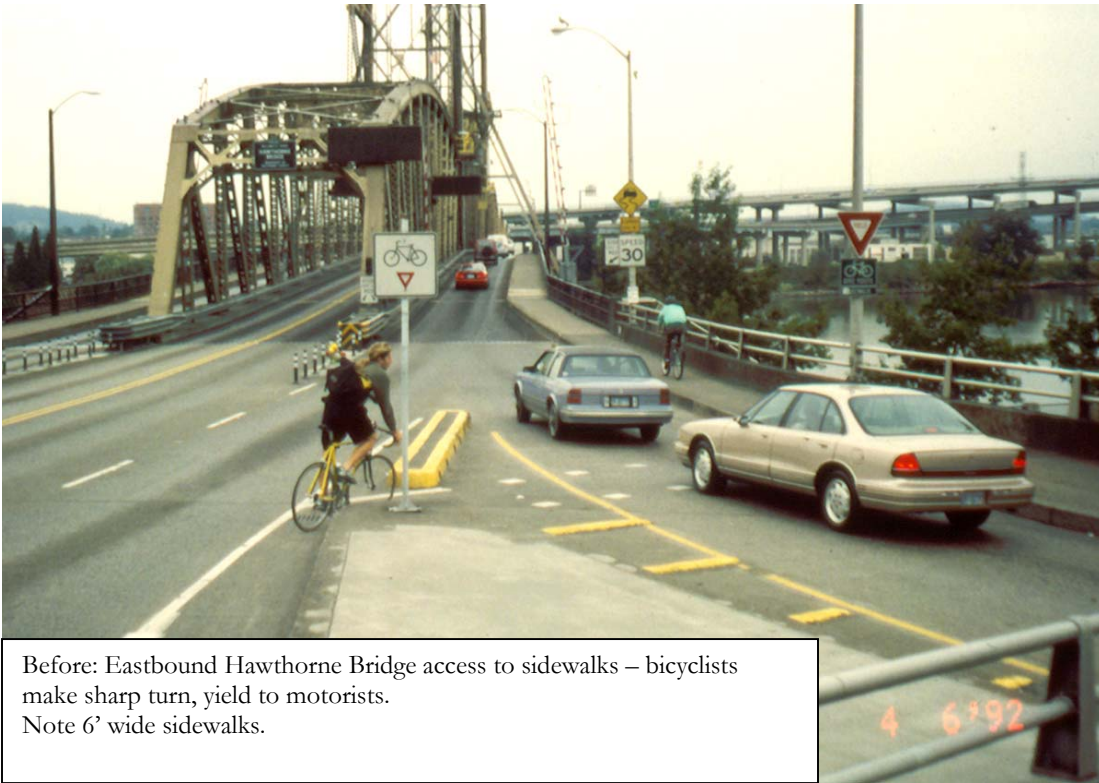
Hawthorne Bridge westside, eastbound, before improvements made.

Photoset 4. Hawthorne Bridge After Improvements

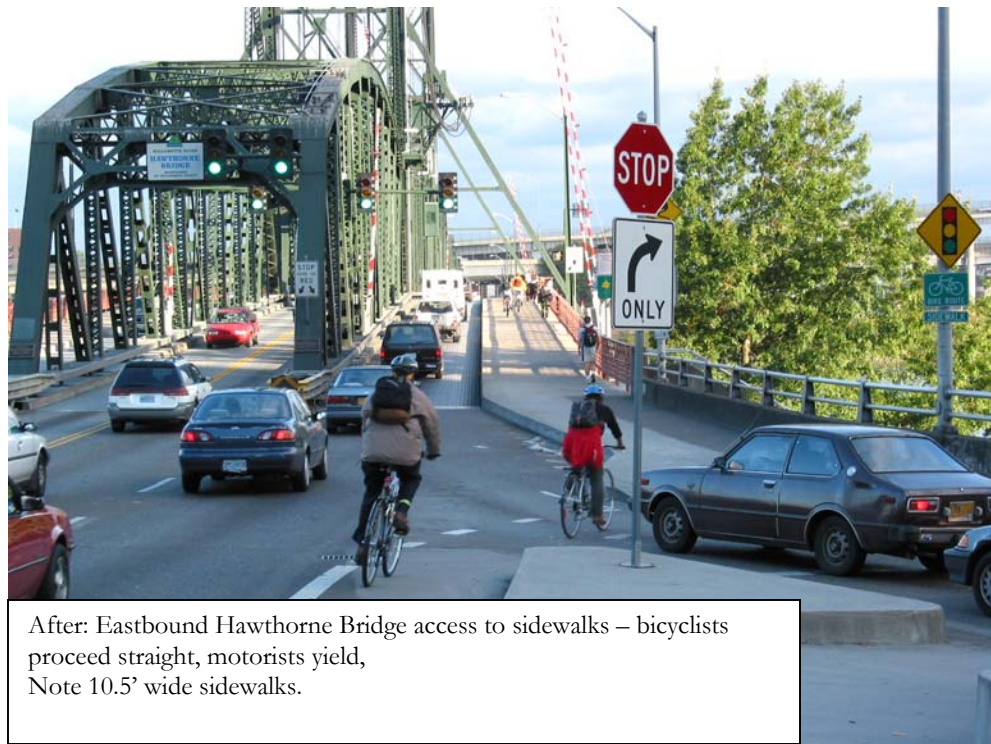


Hawthorne Bridge westside, eastbound, after improvements made.

Photoset 5. Hawthorne Bridge Improvements before & after

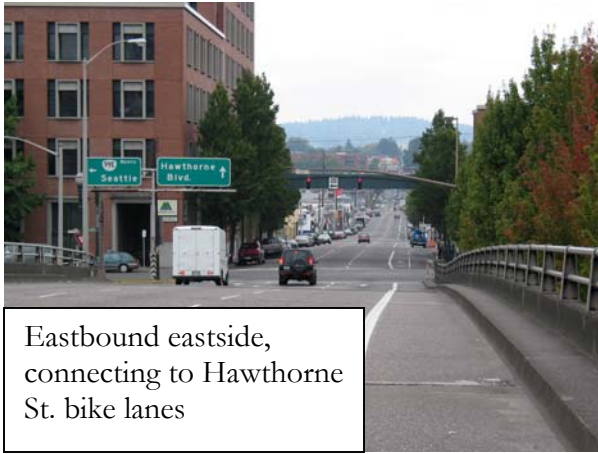


Before: Eastbound Hawthorne Bridge access to sidewalks – bicyclists make sharp turn, yield to motorists.
Note 6' wide sidewalks.



After: Eastbound Hawthorne Bridge access to sidewalks – bicyclists proceed straight, motorists yield,
Note 10.5' wide sidewalks.

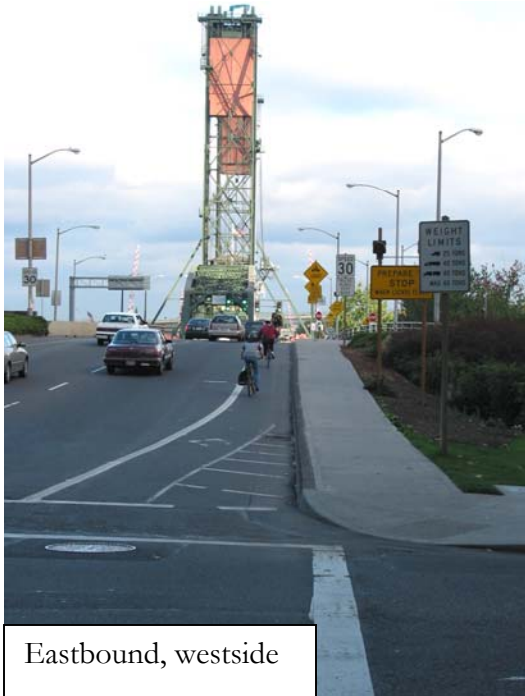
Photoset 6. Hawthorne Bridge Improvements before & after 2



Eastbound eastside,
connecting to Hawthorne
St. bike lanes



Blue area on eastbound
viaduct at off-ramp



Eastbound, westside



Westbound, eastside

Hawthorne: Bike lanes added on all approaches. Bike lanes added to all connecting streets: SW Main, SW Madison, SE Hawthorne, SE Madison. Blue bike area used at areas where motorists cross bicycle lane.

Table 1: Bridge improvements, costs, funding sources

Bridge	Status Before	Measures Implemented	Cost*	Remaining deficiencies
Hawthorne	Cyclists and pedestrians sharing six-foot wide sidewalks. No bike lanes and minimal sidewalks on approaches and access routes. Bicyclists shared roadway or used sidewalks to access. Problematic interaction between cyclists and motor vehicles in several areas.	Sidewalks widened to 10.5-feet on each side. Bike lanes striped on all approaches and connecting roadways. Sidewalk in-fill on approaches. Curb ramps rebuilt to meet ADA. Eastbound approach, Westside: 1 st ramp from Naito Parkway closed, eliminating conflict area. Second ramp reconfigured to force motorists to stop and give cyclists and pedestrians priority, separate bike and pedestrian crossing areas. Blue bike lanes introduced in conflict zones on east side.	Sidewalk widening: \$1.2 million Other changes: \$200,000	None.
Burnside	Bikes and pedestrians on 10' wide sidewalks. Bike access via bicycle boulevard treatment on SE Ankeny.	Deck restriped with bike lanes by removing one travel lane in non-peak direction	\$20,000	Poor connections to/from SE Ankeny Bikeway and downtown
Steel	Bikes and pedestrians sharing approx 5-foot sidewalk on south side, upper deck. Some cyclists on roadway.	New 12' bike/ped path added to lower deck, along with new shared use path (Eastbank Esplanade) and bike lanes on eastside approaches. "Bikes on roadway" signing on upper deck.	\$10 million	Poor access on eastside through Rose Quarter
Broadway	Bikes and peds on 10' wide sidewalks with slippery surface. No bike lanes on connecting surface streets. Approaches with numerous ill-defined conflict areas.	Sidewalk surface replaced (sidewalk width same). Bike lanes added to all connecting surface streets and ramps. Conflict areas on approaches modified and defined (by blue bike areas in two cases).	\$300,000	None.

Bridge	Status Before	Measures Implemented	Cost*	Remaining deficiencies
Morrison	Bikes and peds on narrow sidewalks. Very constrained. Dangerous conflict areas at highway ramps.	Design underway as of Fall 2005, with wide esplanade to be added on south side, along with access improvements	N/A	See previous columns

* Funding sources: Oregon Department of Transportation Bike/Pedestrian Grants; Federal Intermodal Surface Transportation Efficiency Act and Transportation Equity Act for the 21st Century funding through Surface Transportation Program, Enhancements, and Congestion Mitigation Air Quality funds; local tax increment financing; and Multnomah County & Portland transportation funding

Data Collection and Evaluation Methodology

Many methodologies claim to predict potential bicycle and pedestrian use given various changes to the physical environment. These range from surveys (discrete choice models) to comparisons with similar facilities (comparison models) to estimates based on demographic and land use data (sketch plan models). However, none of these have been correlated to actual use over time as of yet.

In Portland, hand and automated tube counts have been used to track bicycle use in various locations around the city over a 20-year period. This gives Portland the ability to compare both trends over time and before and after correlations at specific locations. Each summer, the City works with students for the hand counts of downtown feeder routes. City data collection personnel also routinely count bicyclists and pedestrians whenever they conduct motorist hand counts (for intersection movements.) On routes with separated sidewalks or bicycle lanes 24-hour tube counts are utilized. Finally, the City has used video cameras for 24 hour counts in specific circumstances.

The City typically gathers hand count data as two-hour peak-period counts. Through examination of 24-hour videotapes and 24-hour tube counts at many of these same locations, the City has determined that this peak two-hour period is approximately one-fifth of average daily bicycle traffic.

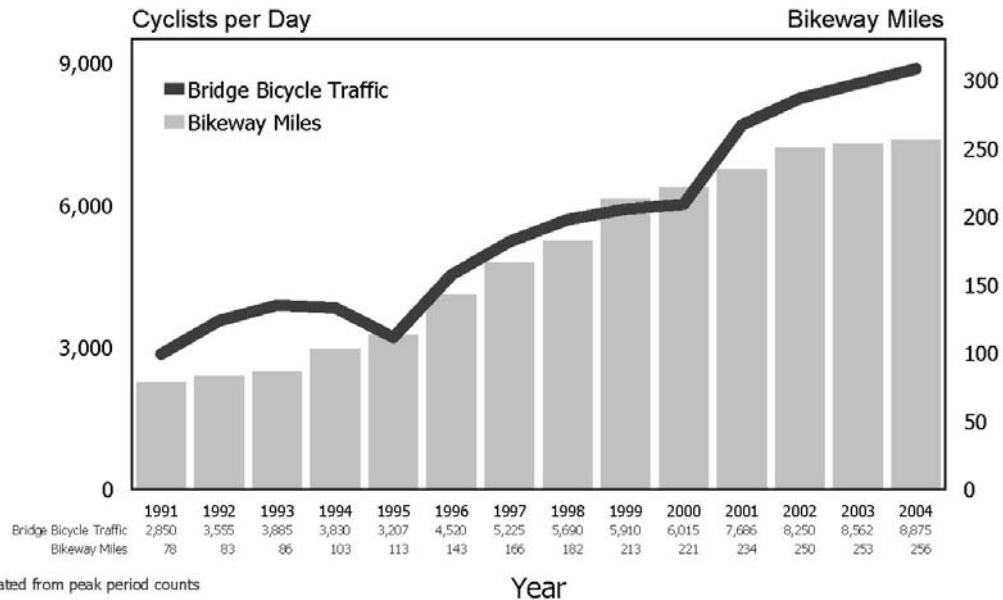
Overall City Bicycle Usage Trends

In terms of trends, based on extrapolations from peak-hour counts on the four key Willamette River bridges, Portland's ridership increased 210% between 1991 and 2004. During this time, the number of miles of overall bikeways increased 215%, from 65 miles in 1991 to over 230 miles in 2004 (see **Figure 1**). It should also be noted that during this time, bicycle use increase has eclipsed increases in overall population as well as motor vehicle trips on these same bridges. A Portland survey administered on the four bridges in 2001 showed that one-third of the 600 respondents began bicycle commuting within the past two years, with another one-third reporting began bicycle commuting within the past five years.

Evaluation of before and after counts at specific locations around and over the Bridges will be discussed in the following section.

The census has shown an increase as well (see **Figure 2**), with bicycle mode share rising from approximately 1% to 3%, with greater increases in specific areas (mostly the dense, flat inner City neighborhoods).

Combined Bicycle Traffic over Four Main Portland Bicycle Bridges Juxtaposed with Bikeway Miles



Portland's Bikeway Network increased 215% between 1991 and 2004. During that same period, the number of bicycle riders daily crossing the four main bicycle bridges in Portland increased 210%. This increase was especially noticeable on the Broadway, Hawthorne, and Steel Bridges, where combined daily ridership went from 2,115 in 1991 to 7,910 in 2004. During this period, the bikeway network feeding these bridges was greatly improved, as were facilities on the bridges themselves.

Figure 1: Portland Bridge Bicycle Traffic (Hawthorne, Broadway, Steel, and Burnside) Relative to Increasing Bikeway Network Mileage

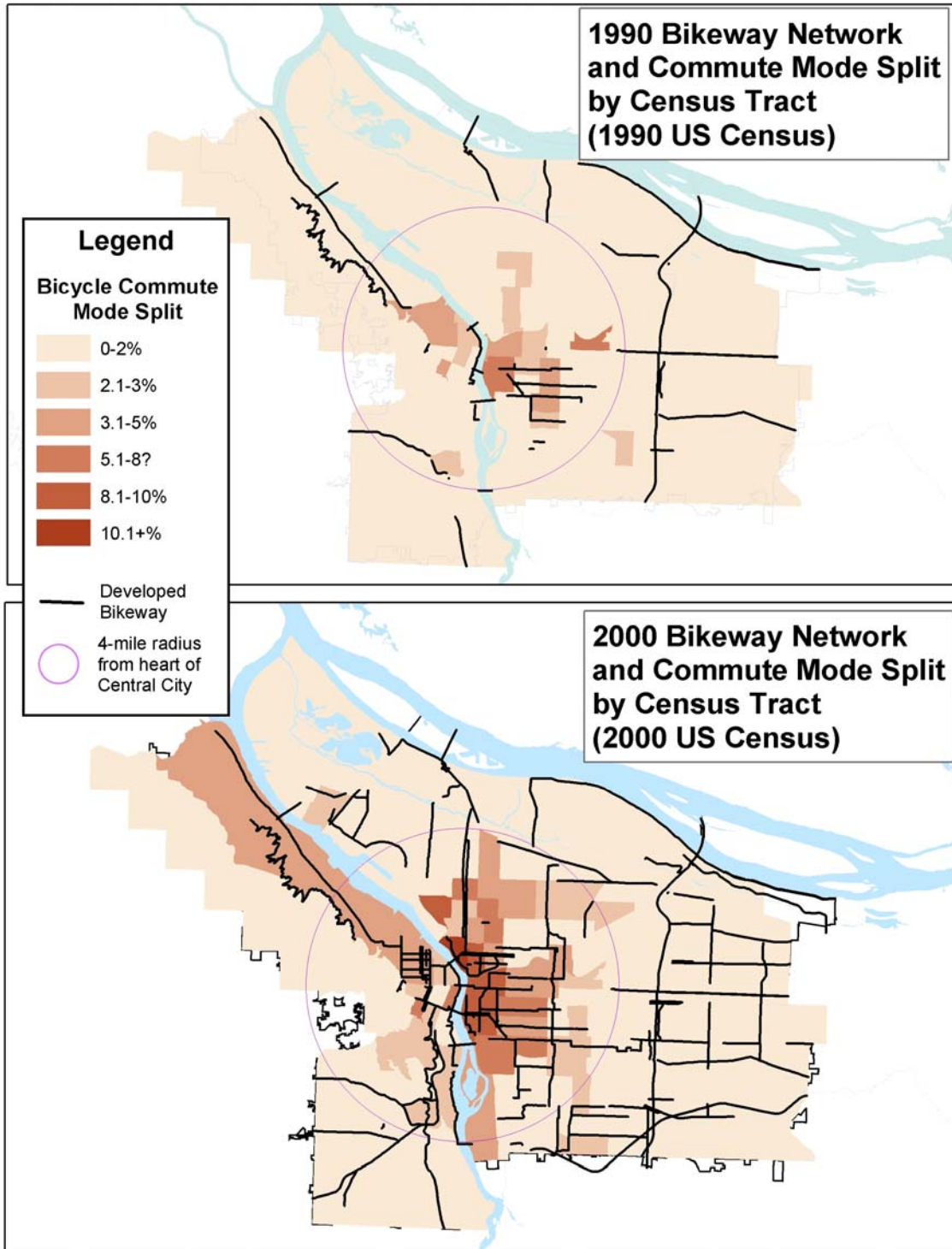


Figure 2: Bike mode split by census tract, 1990 and 2000, with bicycle network shown in black

Results/Analysis

The City of Portland’s count data shows an enormous increase over time in bicycle use on the four main bridges and their connecting bikeways. Recreational trips have increased enormously as well. Joggers and cyclists frequently use the Hawthorne and Steel bridges and their connecting paths as a downtown exercise loop during the day and on weekends.

A clear correlation can be seen between the increased bike use and improved facilities on and leading to the four bridges discussed. On the Hawthorne, Burnside, and Broadway bridges alone, bike use went up 78% in the 1990s, compared with a 14% increase in the population and an 8% increase in motor vehicle use on these bridges.

Based on our knowledge of these bridges, their access routes, and the trends we’ve seen, we believe that there are two key factors at play:

- Quantity of facilities: Completeness of network (bikeways on all routes leading up to the bridge, gaps, clarity of route connections)
- Quality of facility itself: Separation on bridge spans versus bike lanes or shared lanes. On connector street routes, presence of bicycle lanes or bicycle boulevard improvements, and quality of intersection improvements. Below, we examine each bridge, the sequence of improvements made, and the resulting increases in bicycle use (see **Table 2.**) Bicycle count increases on these four bridges are shown in **Figure 3.**

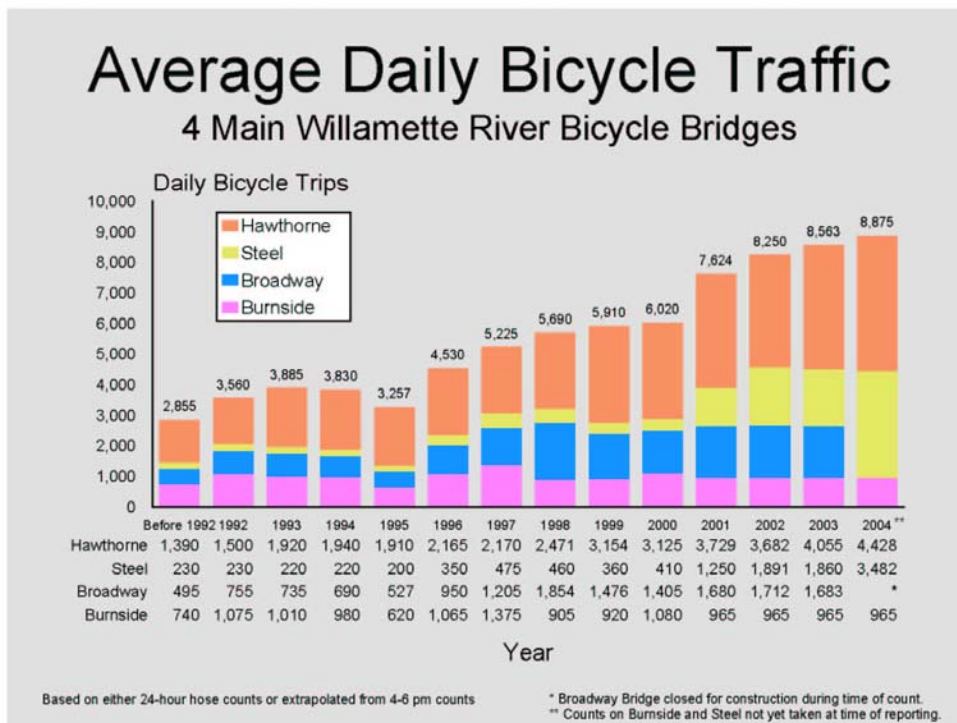


Figure 3: Average daily bicycle traffic, Willamette River Bridges

Table 2. Network Completion and Daily Trips

Year	Broadway Bridge		Hawthorne Bridge		Burnside Bridge	
	% completion of network feeding bridge	Daily Bicycle Trips	% completion of network feeding bridge	Daily Bicycle Trips	% completion of network feeding bridge	Daily Bicycle Trips
Pre-1992	5%	495	53%	1,390	0.3%	740
1992	4.5%	755	53%	1,500	0.3%	1,075
1993	4.5%	735	53%	1,920	0.3%	1,010
1994	4.5%	690	53%	1,940	0.3%	980
1995	4.5%	527	53%	1,910	1.2%	620
1996	8%	950	55%	2,165	1.2%	1,065
1997	24%	1,205	63%	2,170	12%	1,375
1998	27%	1,854	72%	2,471	19%	905
1999	28%	1,476	74%	3,154	22%	920
2000	65%	1,405	77%	3,125	30%	1,080
2001	74%	1,680	77%	3,729	30%	965
2002	77%	1,712	82%	3,682	30%	965
2003	89%	1,683	99%	4,055	38%	965+
2004	89%	*	99%	4,428	38%	965+
2005	97%	2,081	100%	4,829	38%	1,170

* Broadway Bridge during season of count

+No actual count—assumption of 0 increase based on experience of previous 2 years.

Hawthorne Bridge

The Hawthorne Bridge has always carried the heaviest bicycle traffic of any Portland bikeway, reflecting the longer history of developed bicycle boulevards feeding it and its proximity to Downtown. By 1992 a network of bikeways brought cyclists close to the bridge. (See **Figure 7.**) By 1998 both arterial approaches to the Hawthorne were striped with bicycle lanes. These arterials in turn connected directly to the bicycle boulevard network, creating a stronger and more complete link to the bridge. The average daily bicycle traffic in the period before the arterials were striped (1992-1997) was almost 1,900. The average daily traffic on the bridge grew steadily between 1997 and 2002 and averaged a bit more than 3,200 during this period. This represents an increase of approximately 70%. The most significant jump in use occurred in 1999, after the sidewalks were widened, from about 2400 cyclists to over 3100—a 32% increase in one year.

In 2001, bicycle use jumped by over 20%. No specific improvements were made that year to the Hawthorne Bridge. However, this is the year that the Steel Bridge Riverwalk opened, which created a recreational/exercise loop using the Hawthorne Bridge, Eastbank Esplanade, Steel Bridge Riverwalk, and Tom McCall Waterfront Park.

By 2003 Portland had built a riverfront pathway (“Springwater on the Willamette”) that connected between a large residential area to the south of the Central City and the Hawthorne Bridge. Prior to the construction of this pathway residents of this neighborhood had only an out-of-direction bikeway connection to the central city, with substandard facilities. With the opening of this pathway connection, ridership continued to grow across the Hawthorne. Daily bicycle trips on the bridge

averaged almost 4,500 between 2003-2005, with the highest number of daily trips recorded in 2005. From 2003 on, bicycle use increased 9-10% per year. All in all, bicycle traffic on the Hawthorne grew 220% between 1992 and 2005 (See Figures 7-12 showing the expansion of the bikeway network around the bridges. See Figure 4 showing the correlation of the network expansion with usage.)

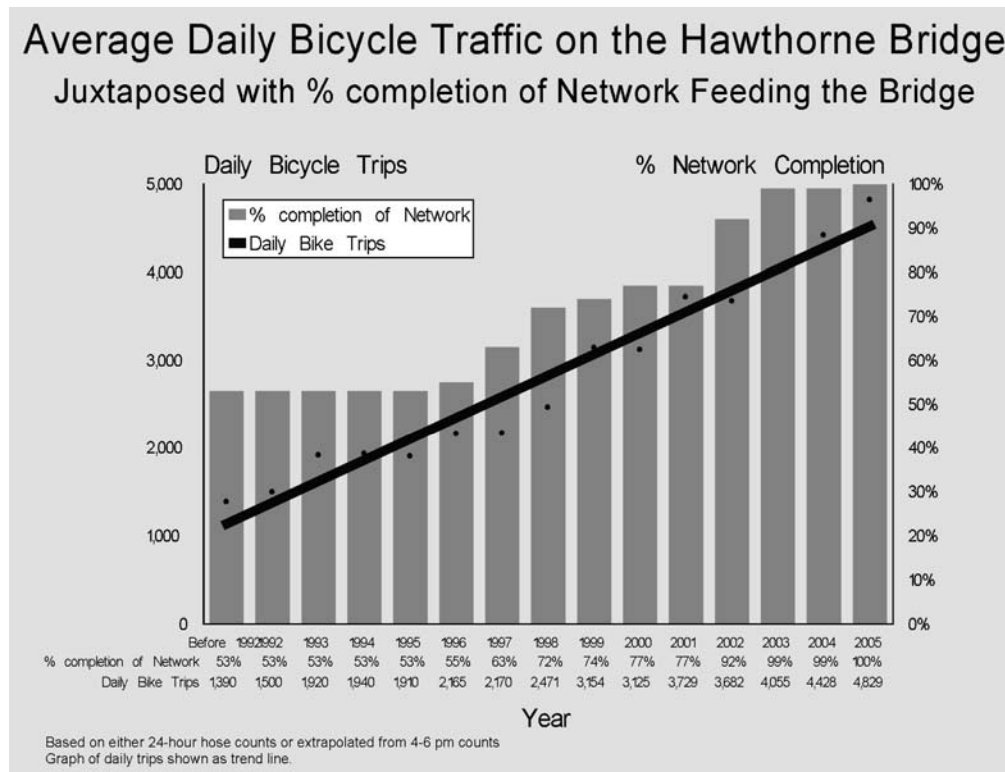


Figure 4. Increasing Bicycle Use on Hawthorne Bridge

Broadway Bridge

The Broadway Bridge itself has generally been amenable to bicycling during the study period. Sidewalks have 8.5 feet of clear space and mostly carry only one direction of bicycle travel. Pedestrians are few. However, the bikeway network feeding this bridge essentially did not exist until late into the 1990s.

Prior to 1996, cyclists could choose to either wend their way through a local street network—crossing arterial streets as they best were able—or sharing arterial travel lanes with relatively high volumes of high speed motorists. Along the route they needed to negotiate dual right-turns onto a freeway on-ramp and various auto-bicycle crossovers and merges. Whether primarily riding arterial streets or local streets, all cyclists needed to ride on some segments of arterial streets in the final approach to the bridge, and also had to ride unstriped arterial streets after crossing the bridge. Daily bicycle trips across the Broadway, in the absence of bicycle facilities, averaged 640 during this period between pre-1992 through 1995.

By 1996 Portland had striped a short segment of bicycle lanes on both an approach to the bridge and leading away from the bridge. Though short in length, the segment was high in quality, as it allowed cyclists on parallel local streets to avoid sharing arterial lanes in their final approach to the

bridge. Daily trip numbers across the bridge jumped to 950 cyclists in 1996. By 1997, improvements included bicycle lane striping on 1.5 miles of an arterial couplet that served the close-in residential neighborhoods east of the river, as well as bicycle lanes on a viaduct leading away from the bridge. Daily trips across the bridge jumped 25%.

In 1998, the sidewalks on the Broadway Bridge’s lift span were replaced with a non-slippery surface. A 54% increase in cycling occurred the year after the major improvements were made. Also, by 1998 Portland established a bikeway connection from the bridge to the edge of the Downtown core and bicycle trips jumped another 50% compared to the previous year. During this period between 1996 and 1998, when the network feeding the bridge grew from 8% to 27% complete, average daily ridership was 1,340, more than double that of the previous period, which had been characterized by its lack of developed bikeways.

Between 2000 and 2005, the city made significant improvement in corridors serving the bridge. (See **Figures 10-12.**) These improvements included a major north-south bikeway and development of a bicycle boulevard east-west. By 2003, the bikeway network west of the bridge was continuous through the Downtown, and knitted through Portland (and Oregon’s) most dense residential and mixed-use neighborhood. Broadway Bridge bicycle traffic counts between 2000 and 2005 averaged approximately 1,700 trips per day, representing an increase of 167% compared to the period one decade earlier. The highest recorded count on the bridge—2,081 daily trips—was recorded in 2005. (See **Figures 7-12 showing the expansion of the bikeway network around the bridges. See Figure 5 showing the correlation of the network expansion with usage.**)

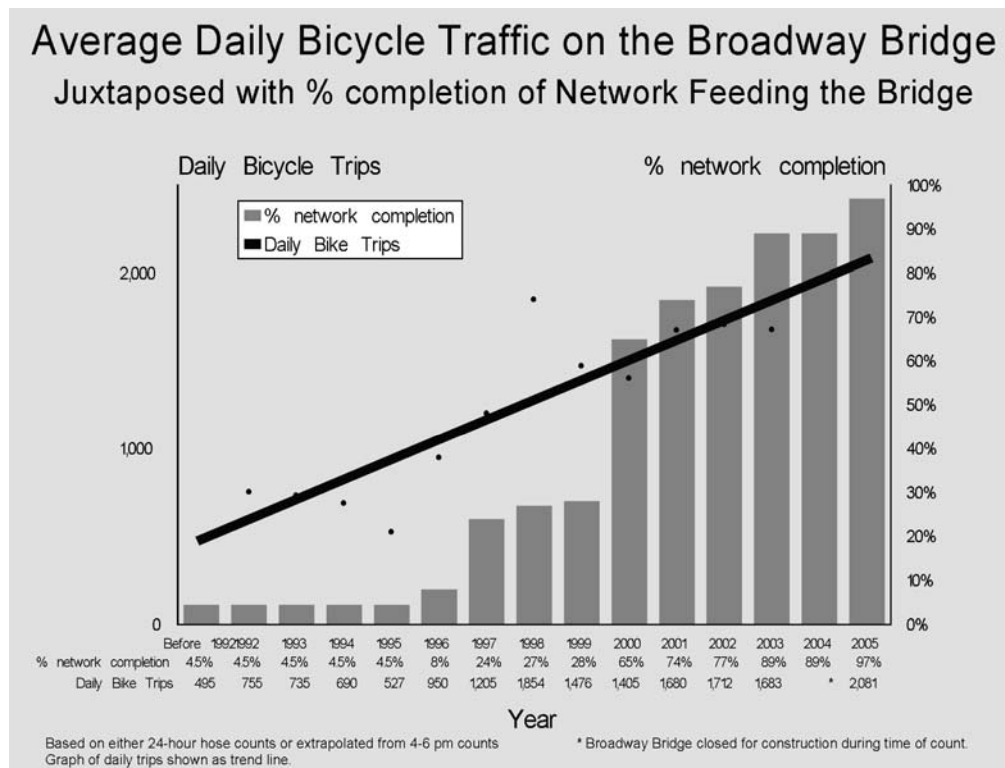


Figure 5. Increasing Bicycle Use on Broadway Bridge

Steel Bridge

On the Steel Bridge, bike use went up 220% after the Steel Bridge Riverwalk and Eastbank Esplanade opened in May 2001. In 2004, during the Broadway Bridge closure, the Steel Bridge absorbed much of this traffic. The Steel Bridge primarily serves recreational traffic due to the difficulty in accessing it from the eastside and Westside neighborhoods.

Burnside Bridge

On the Burnside Bridge, bike use tripled from 300 daily cyclists in the late 1980s to approximately 1,000 once bike lanes were installed in 1993, but has remained flat since that time. The current bikeway network feeding that bridge has been substantially in place since 1997. However, daily trips across the bridge have hardly grown at all. Why have the other three bicycle-friendly bridges experienced such a surge in bicycle traffic in the past decade and not the Burnside?

Though in place, only approximately 40% of the network planned to feed the Burnside has been developed. This is a significant contrast to the almost 100% completion of the networks feeding the Broadway and Hawthorne bridges. In addition, the quality of access to the Burnside Bridge remains poor. The eastside Ankeny Street Bikeway ends two blocks before the bridgehead. The connection to the bridge requires navigating two extremely congested four-lane roadways, using auto lanes for turning. Only very confident cyclists handle these movements best. Portland cyclists have routinely ranked this area as one of the most difficult and in need of improvement. Westside downtown access is also unclear and somewhat challenging in both directions. These deficiencies clearly suppress potential bicycle use. In comparison, bikeways to access the Hawthorne and Broadway Bridges are on the most direct route, well signed, and continuous. It is crystal clear where you are supposed to ride and how you are supposed to do it.

The quality of the bridge facility itself is also significant for this bridge. The Burnside Bridge is the only of the Willamette River Bridges that uses a bicycle lane rather than an off-street path (prior to

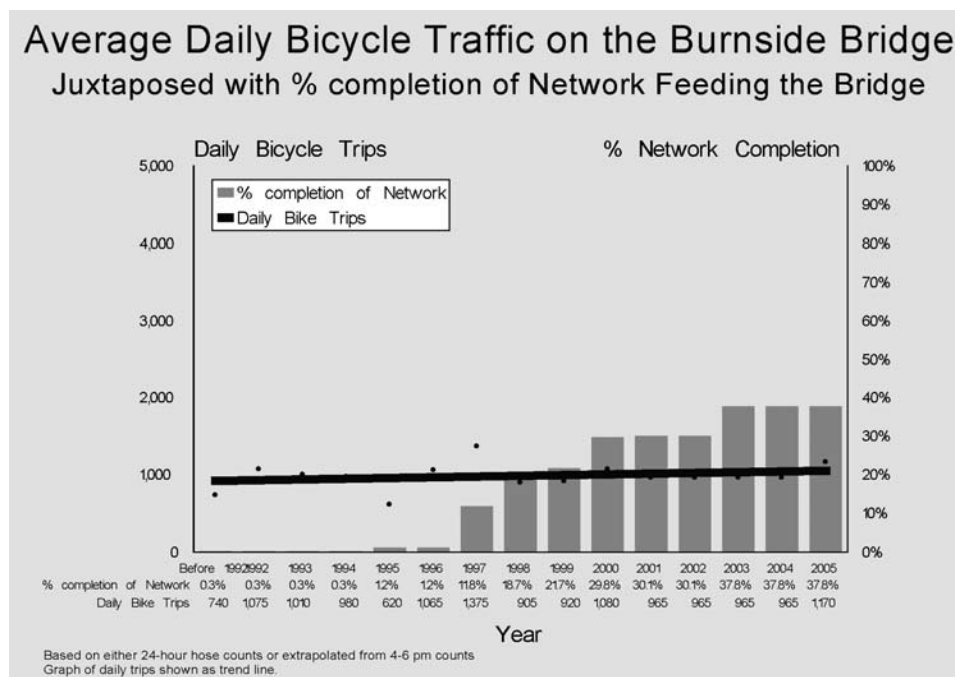


Figure 6. Bicycle Use on the Burnside Bridge

1993 cyclists could share a sidewalk across the bridge with pedestrians). This exposes the cyclist more directly to traffic, which tends to drive faster on this half-mile open roadway. In addition, the bicycle lane drops in both directions when exiting the bridge, requiring cyclists to merge into arterial travel lanes. While experienced and confident cyclists can readily negotiate this route, it is not close to the quality of facilities one finds riding to and on the other bridges. **(See Figure 6 showing the correlation of the network expansion with usage.)**

Figures 7-12: The bikeway networks feeding the bridges are shown in bold. Other bikeway improvements in the same time period that do not directly feed the bridges are shown in a lighter screen.

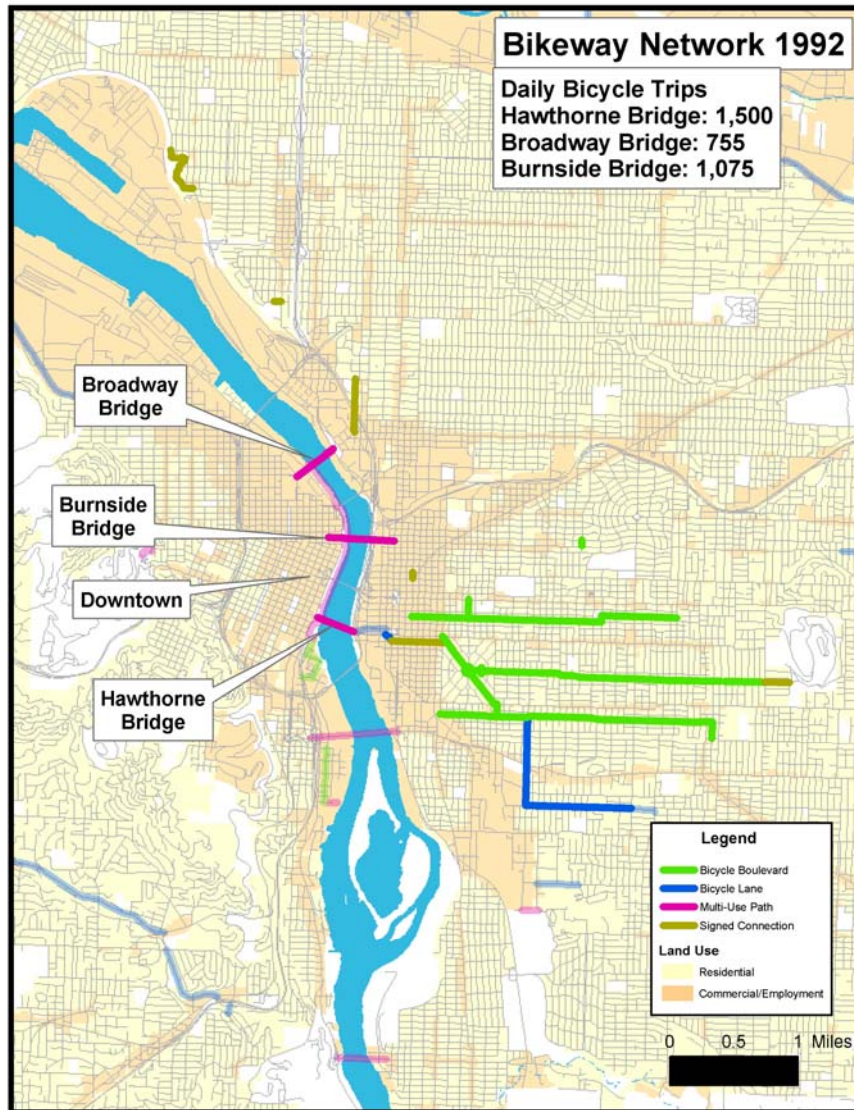


Figure 7. Network Feeding Bridges 1992

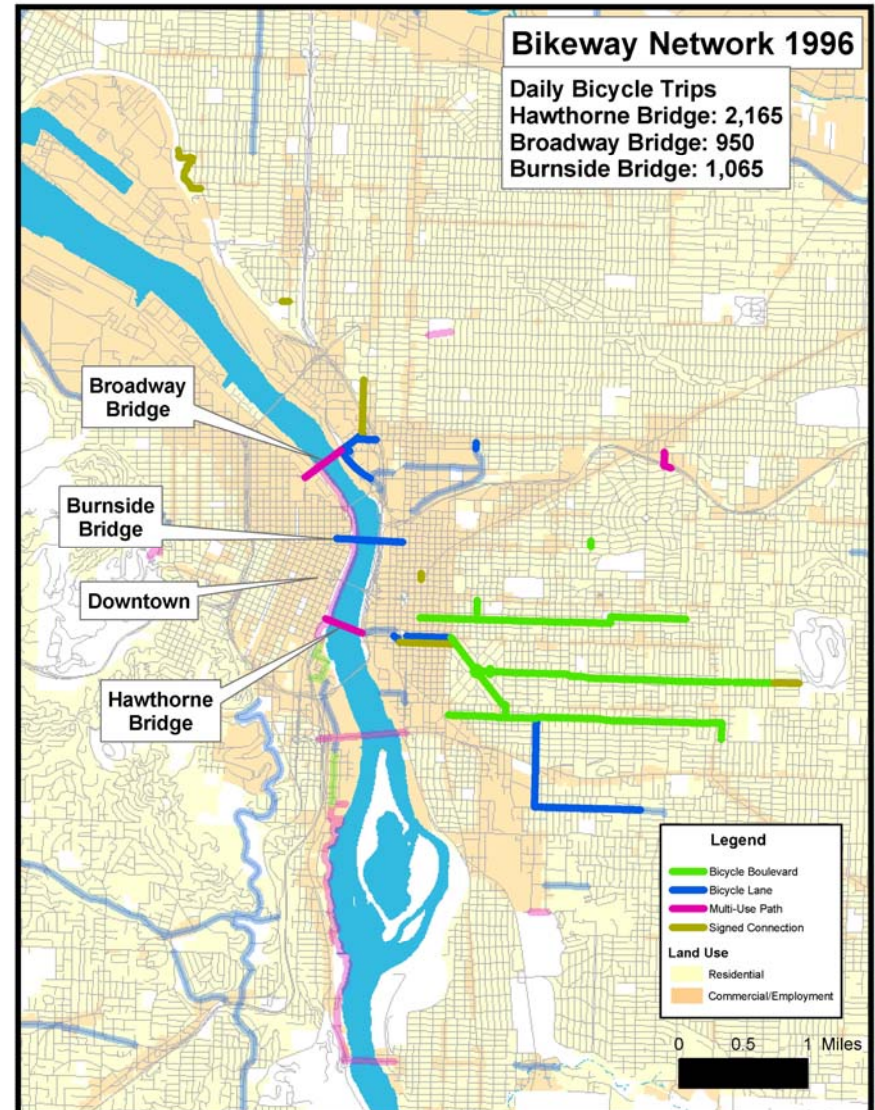


Figure 8. Network Feeding Bridges 1996

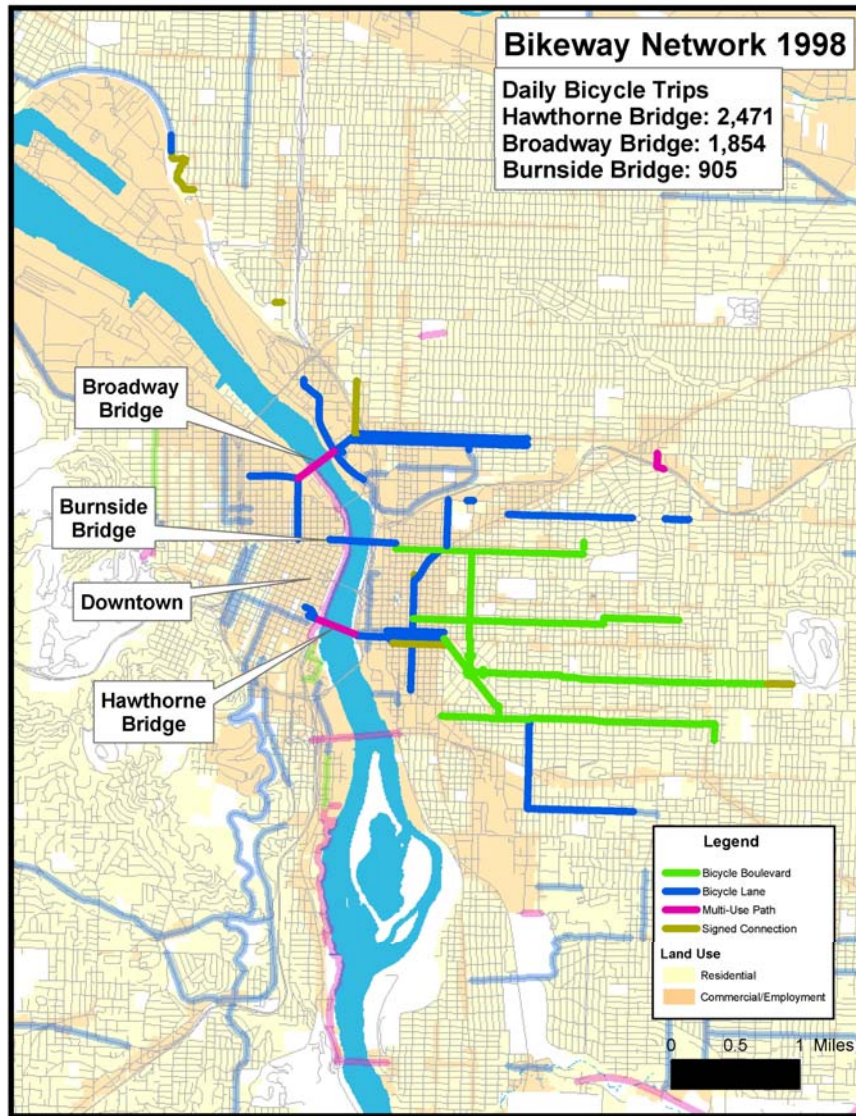


Figure 9. Network Feeding Bridges 1998

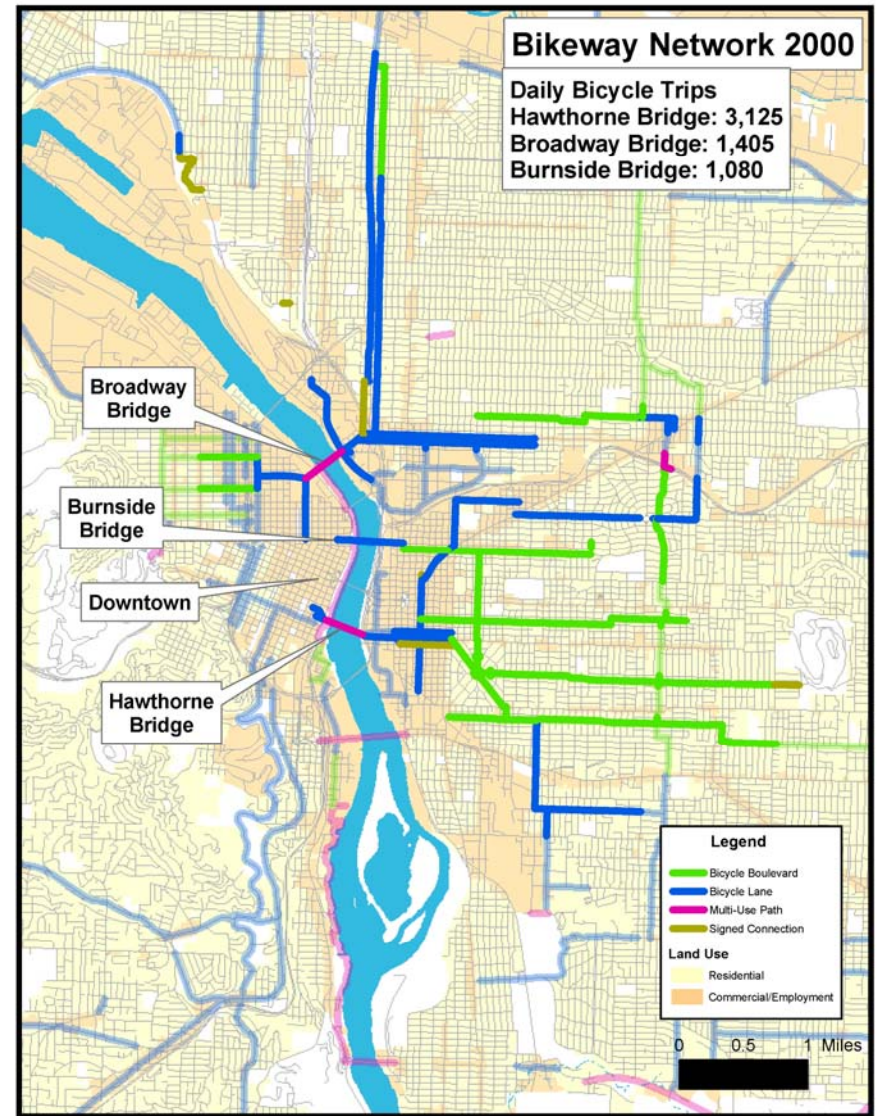


Figure 10. Network Feeding Bridges 2000

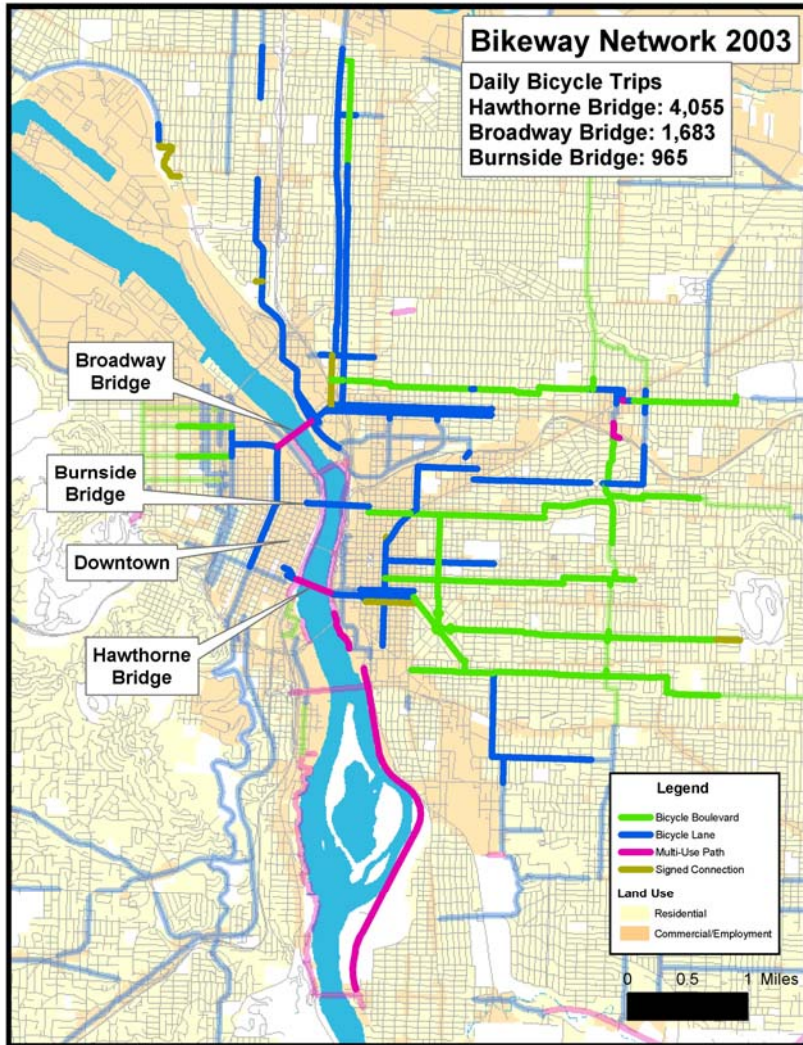


Figure 11. Network Feeding Bridges 2003

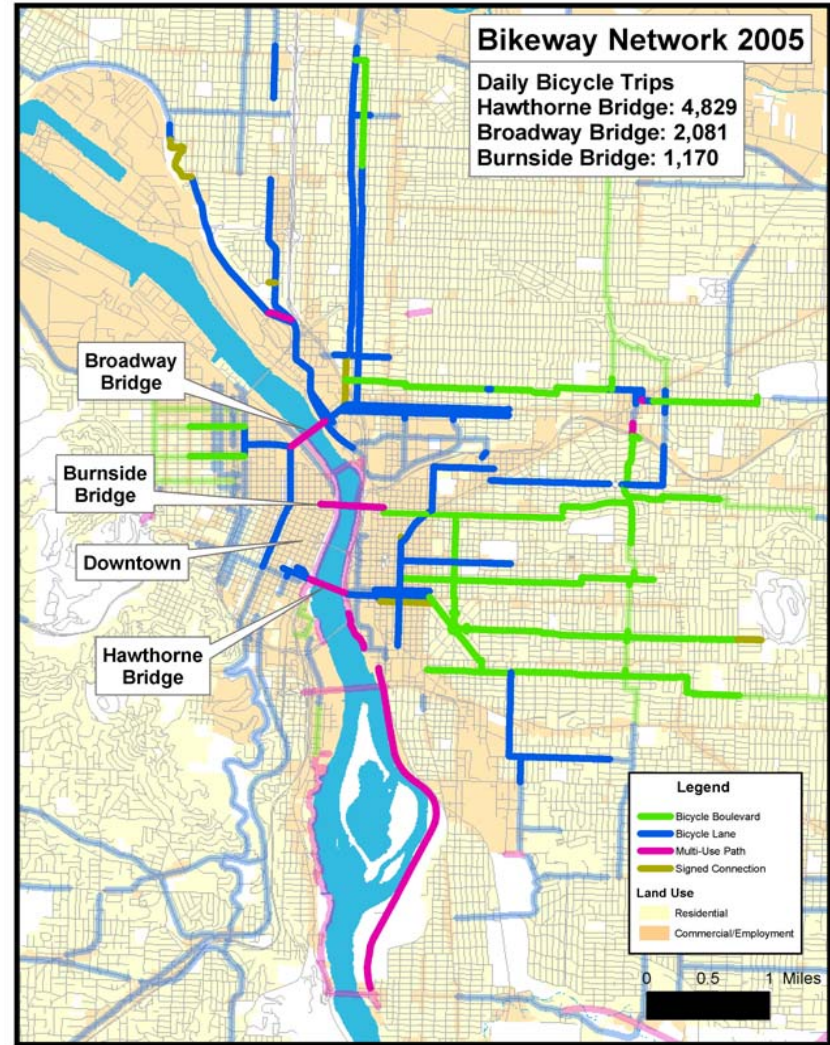


Figure 12. Network Feeding Bridges 2005

Conclusions

Portland's "build it and they will come" approach has proven largely successful in promoting increased bicycle use. This is especially true in Portland's inner city where factors other than the presence of bikeways contribute to conditions amenable to bicycling. These other factors include: a mixed-use land use pattern that results in short trip distances; relatively small, low-volume and low-speed arterial streets; a grid street network that gives people alternative to riding on arterial streets. However, these other factors predate the past 12 years of bikeway improvements that Portland has undertaken. Thus, this paper demonstrates that the creation of well-connected and high quality facilities correlates with increasing bicycle use. As Portland's bikeway network feeding its central city bridges grew, so did bicycle use reliably and steadily grow. Where the bikeway network was not well connected and not of the highest quality, then bicycle use stayed essentially flat and at levels that existed prior to network expansion.

Based on our knowledge of Portland's Central City bridges, their access routes, and the trends we've seen, we believe that there are two key factors at play relating to the bikeways themselves:

- Quantity of facilities: Completeness of network (bikeways on all routes leading up to the bridge, gaps, clarity of route connections)
- Quality of the facility itself: Separation on bridge spans versus bike lanes or shared lanes. On connector street routes, presence of bicycle lanes or bicycle boulevard improvements, and quality of intersection improvements.

A key to the heavy and increasing concentration of bicyclists on the Hawthorne, Steel and Broadway Bridges, as opposed to the Burnside and other bridges, is the fact that on these three bridges' spans, bicyclists are off-street on either wide sidewalks or a shared use path, with bike lanes on the approaches. In addition, the City added bicycle lanes and boulevards to and improved intersections on all streets connecting to the Hawthorne, Steel and Broadway Bridges, overcoming major hurdle in getting people to the bridges.

Caveats to this approach are:

- The bikeway network must be well connected, providing continuous, or near-continuous service to be effective
- Facilities must be constructed to the highest standards to as to minimize the potential for negative bicycle-automobile interactions and to maximize cyclists' ease of use
- The use of bikeways seems best supported in areas where trip distances are relatively short and land use patterns and urban design supports bicycle use.

The utilization of bicycle counts to gauge bicycle use trends has been effective in guiding the City toward these conclusions. The authors recommend that other cities participate in the ITE National Bicycle and Pedestrian Documentation program, conduct regular bicycle counts, and maintain and analyze a database of counts.

Future research should be conducted to develop better methods of comprehensively counting bicycle trips; more accurately quantifying the qualitative aspects of bicycle facilities; and better assessing and quantifying users' perceptions of the quantity and quality of specific corridor routes.

Such research will continue to assist planners, policy makers and engineers in designing urban areas in general, and bicycle facilities in particular.