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Puget Sound Regional Council

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Executive summary

Introduction
In the fall of 2010, the University of Washington’s Department of Urban Design and Planning’s transportation-planning studio undertook the following tasks in support of ongoing bicycle planning and modeling efforts at the Puget Sound Regional Council (PSRC):

- An extensive literature review on bicycle best practices related to policy, facility design, and data collection;
- Content analysis of bicycle and pedestrian plans for the metropolitan, core, and large cities in the Puget Sound Region; and
- Statistical analysis and regression model development for the interpolation of whole-day and specific off-peak period estimates from peak period counts.

The main findings and methods are presented below.

Literature review
An extensive literature review was completed that focused on three main topics: a review of planning and policy best practices, design best practices, and bicycle count methods and models. The findings from the process are highlighted below.

Planning and policy best practices
The best practices section highlights plans and policies that are regarded as effective in bolstering a community’s bicycle and pedestrian network and facilities as well as framing bicycle and pedestrian issues into the larger transportation and planning context. In addition to best practices, the literature review also depicts widespread trends—be they positive or negative—in the bicycle and pedestrian planning field.

- Effective plans/projects: quality plans generally establish an inventory and assessment of bicycle facilities and prioritize projects aimed at safety and overall level of service;
- Encouragement/education: specific programs such as bike-to-work days/months and the Safe Routes to School program have helped to increase bicycle mode share;
- Policy approach: a long-term approach in tandem with effective design, encouragement, and educational efforts is most effective; and
- Implementation: should consider prioritization and evaluation.

Design best practices
Major findings and recommendations for best practices in bicycle facility design include the following:

- Design of adequate bicycling facilities will likely have to go beyond the American Association of State Highway and Transportation Officials (AASHTO) and the Washington State Department of Transportation (WSDOT) minimum design guidelines.
- Planning and design are contextually sensitive and should fit the needs of individual communities.
- Plans should include an evaluation and prioritization method for implementation.
- Shared-use paths (trails) must be integrated into a larger network, and clearly signed.
- Shared-use paths must consider users to determine appropriate width and material.
• Bicycle boulevards should be considered as facilities where potential conflict with automobiles is reduced.
• Bicycle lanes, while cheap to implement, should include street modifications, and policy guidelines such as Complete Streets.
• Cycle tracks, an emerging practice rather than a best practice in the U.S., have been successful in Europe.
• There are many tools that should be considered part of a bicycle network to enhance the quality and safety of bicycle riding.

**Bicycle count and modeling literature review**
A literature review was conducted on best practices for modeling and counting bicycle commute activity. Main findings from the model include identifying nine variables that are most hypothesized in the literature to affect bicycling. The variables identified are:
- Population density
- Income
- Age
- Mix of land uses
- Employment density
- Temperature
- Rain
- Facility type.

The literature review also suggested how these should affect counts.

The literature suggests that, in accordance with standard automobile traffic counting, counts should be conducted on Tuesdays, Wednesdays, and Thursdays because these are considered the most “normal” commute days. The planning and engineering literature as well as national guidance suggests that May and October are good times to collect bicycle count data because it is not too cold, not too hot, school is in session, and people are not on summer vacations —i.e. people are in a regular routine.

**City bicycle and pedestrian plan content analysis**
The purpose of this content analysis is to examine bicycle and pedestrian facility policy components in order to determine which components are commonly used and which are often overlooked in comprehensive plans in the region. Further, unique or remarkably extensive policies are noted. The analysis highlights policy components that should be included in a bicycle and pedestrian facility plan. Policy components are divided into the following categories:
- Existing conditions
- Proposed facilities
- Implementation strategies
- Other components.

Inconsistencies were found in the type of components included in the plans, and in the depth to which those components are discussed. In particular, discrepancies were found in the treatment of existing conditions and implementation plan components of the plan documents. Though almost all cities discussed their existing facilities, few conducted a facilities inventory and needs assessment. Similarly, a mere quarter of cities in the region included maintenance policies and
procedures, and only two cities identified their desired level of service for bicycle and pedestrian facilities.

Bicycle and pedestrian facilities development plans could often be linked to similar plans in neighboring jurisdictions and to other elements in the city’s comprehensive plan—e.g., land use, and parks, recreation, and open spaces. Therefore, such plans should include methods of collaboration and coordination with other city departments and other municipalities.

While the scope of bicycle and pedestrian facilities plans differ between cities based on their needs, a complete and effective plan should include all components discussed in the content analysis to ensure the plan’s effectiveness.

**Bicycle count modeling**
In October 2010, PSRC hired sixteen interns to count bicyclists and pedestrians at 384 locations throughout the four-county region. Peak-period counts were taken in fifteen-minute increments during two periods: AM (6:00–9:00) and PM (3:00–6:00). These counts are ultimately intended to provide the basis for a later modeling effort at PSRC. However, use in this context will require some prediction of counts during the non-peak time periods for which no data were collected.

To assist this modeling effort, the planning studio sought to address the following three questions:

1. How do counts vary by season?
2. How do counts vary by day of the week?
3. How do counts vary by time of day?

**Seasonality**
Due to lack of data that spans the entire year, this question proved unanswerable. While count interpolation models control for seasonally variable factors such as precipitation and temperature, no conclusions can be drawn as to how bicycle counts vary by season.

**Variation by day of the week**
Contradicting the findings of the literature review, an analysis of three data sets and the Washington Commute Trip Reduction (CTR) survey failed to show any systematic difference that warrants exclusion of Monday and Friday bicycle counts.

**Variation by time of day**
The planning studio has developed a set of regression models that show the effect of multiple variables on bicycle counts.

First, a conceptual regression model was developed from the literature review. Nine variables were identified from the literature as being most likely to affect bicycle counts. Based on this information, it was hypothesized that higher population density, median income, percentage of young adults, mix of land uses, employment density, and temperature should all affect the likelihood of seeing bicycles. Rain and high levels of traffic should decrease the number of bicyclists, and there should be more bicyclists on separated-grade and dedicated bicycle facilities.
The data for these variables were collected, and a model was developed based on the data and 24-hour bicycle counts from the cities of Bellevue, Olympia, and Seattle.

**Implications for future bicycle counts**
The inability to satisfactorily answer the seasonal adjustment factor question, together with the ambiguous variation between days of the week, suggests that more and better data are required. From the findings presented here, it is recommended that, in the future PSRC do, or note, the following:

1. Carry out automated 365-day, 24-hour counts at enough locations to be able to make conclusive determinations of seasonality and day-of-week variations. Fewer locations with more complete information would better address these questions than more locations for a smaller subset of the year.
2. Focus counts on areas that are expected to have moderate-to-large numbers of bicyclists—perhaps selected from sites counted this year. This will improve model prediction by not focusing on sites where margins of error are high.
3. Excluding Monday and Friday counts appears to have no greater validity than excluding other weekday counts. Combined with otherwise limited count opportunities, including Monday and Friday counts may yield an improvement given the opportunity for increased sample size.
4. Predictions of other time periods made from evening counts tended to be more accurate than predictions made from morning counts. This suggests that PSRC may get more value from performing evening counts rather than morning counts.
1. Policy, design, and indicators of bicycle use

1.1. Planning and policy best practices
This section outlines the key features and best practices for components that are regularly included in bicycle and pedestrian plans. Examples of programs that have proved successful in other communities are included. Ideally, communities can use this information in developing bicycle and pedestrian strategies as part of their comprehensive plans.

It should be acknowledged that communities in the central Puget Sound region are geographically, demographically, and socioeconomically diverse. Therefore, a best practice in one community may not be the right fit for another community. Due to the context-sensitive nature of the region and within communities, discretion should be used in how these best practices are implemented.

There are many components to consider when incorporating bicycle and pedestrian planning into the comprehensive planning process. Thinking holistically about bicycle and pedestrian planning creates links with transportation issues and other comprehensive plan elements more thoroughly. In Pedestrian and Bicycle Planning: Guide to Best Practices, Litman (2006) describes the process and thoughtful deliberation required for including bicycling and pedestrian planning in the comprehensive plan. Specifically, Litman cites connections within the plan between connections with other plans, traffic management, design considerations, education, and law enforcement. These factors will form the basis for how content in transportation plans in the Puget Sound is assessed, as is discussed further in Chapter 2.

The rest of this document will outline the best practices used by jurisdictions or prescribed by academics and industry leaders as they relate to bicycle and pedestrian planning. Specifically, the discussion covers the planning process; examples of effective plans and projects; encouragement, education, and design efforts; policy approaches; implementation efforts; and best practices as defined by other groups.

Planning Process
Effectively implementing a planning vision is often contingent upon a quality planning framework; navigating from vision to implementation might be difficult for communities that have given little thought to bicycle and pedestrian planning. This section will explore some commonly held steps in the bicycle and pedestrian planning process. The section will also illustrate the interdependencies of the planning process within the context of a specific geographic area. Awareness of interdependencies is vital to understanding the gaps in a bicycling network and how bicycling fits into the wider transportation context.

Lagerwey (2009) discusses the myriad steps necessary for creating an effective bicycle master plan. While components of a bicycle master plan are different from those of the bicycling component in a transportation element of a comprehensive plan, it is nonetheless instructive in highlighting the relevant process steps for consideration in bicycling and pedestrian planning. Lagerwey’s process is reproduced in Table 1.
<table>
<thead>
<tr>
<th>Phase 1 – Pre-planning (6–12 months)</th>
<th>Phase 2 – Development (9–18 months)</th>
<th>Phase 3 - Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establish a need and create buy-in</td>
<td>Define the project manager’s new role</td>
<td>Get the plan adopted</td>
</tr>
<tr>
<td>Secure funding</td>
<td>Establish communication rules</td>
<td>Immediately begin implementing the accountability strategies contained in the plan</td>
</tr>
<tr>
<td>Find a home for the plan</td>
<td>Reporting and billing</td>
<td>Develop an annual work plan</td>
</tr>
<tr>
<td>Develop a plan for internal review and involvement</td>
<td>Set internal review team (IRT) meetings</td>
<td>Ongoing public outreach</td>
</tr>
<tr>
<td>Invite public involvement by creating a Bicycle Advisory Committee (BAC)</td>
<td>Maintain public outreach</td>
<td>Document your success</td>
</tr>
<tr>
<td>The BAC agrees on its mandate and role</td>
<td>Prepare a draft plan</td>
<td>Take advantage of every public and private project to look for improvements</td>
</tr>
<tr>
<td>BAC develops a work plan and time line</td>
<td>Setting priorities</td>
<td></td>
</tr>
<tr>
<td>BAC decides plan type: policies, projects, or programs?</td>
<td>Plan implementation</td>
<td></td>
</tr>
<tr>
<td>Develop consensus on goals for plan</td>
<td>Plan accountability, evaluation, and updating</td>
<td></td>
</tr>
<tr>
<td>Develop consensus on the objectives of the plan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop consensus on the content of the plan</td>
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<tr>
<td>Determine what role consultants will play (if any)</td>
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<td></td>
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<tr>
<td>Write the RFP (if using a consultant)</td>
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<td></td>
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<tr>
<td>Select your consultant</td>
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Lagerwey incorporates detailed explanations and strategies in executing his stepped approach to bicycle master planning.

The New South Wales (Australia) Roads and Traffic Authority published *How to Prepare a Bike Plan: An Easy 3 Stage Guide* (2002) that prompts those developing bicycling plans and policy with tactics and questions to ask during the planning process. Similar to Lagerwey, the New South Wales report parses the planning process into three major sections—research, preparation, and follow-up (New South Wales Roads and Traffic Authority, 2002). The document is more specific to planning for facilities and networks, with emphases on engineering and design, whereas Lagerwey’s document is more focused on the structure and development of the plan itself.

A common approach for incorporating bicycle and pedestrian planning into a comprehensive plan is the League of American Bicyclists’s “5-E” approach, which promotes the notion of engineering, education, encouragement, enforcement, and evaluation and planning. These principles can be found in many transportation elements or bicycle plans (including Boulder, CO; Portland, OR; and Davis, CA—the three League of American Bicyclists’s *platinum* level award winners for bicycle friendliness—where major chapter headings are explicitly framed by the 5-E approach). The *City of Davis Bicycle Plan* utilizes a 6-E approach, with equity being an
additional consideration. The 5-E approach is generally found, if not overtly, in many bicycle plans and bicycle sections in transportation elements. Using a 5-E approach as a way to frame bicycle issues ensures that communities are taking a holistic approach to the planning process. It should be noted that these factors are used to judge a city on its “bicycle friendliness,” as bestowed by the League of American Bicyclists.

Feske (1994), in evaluating cities that adequately plan for bicycling (e.g. Portland, Davis, Palo Alto, Gainesville, Boulder, Seattle) finds that the following characteristics, working in tandem with the comprehensive plan, are often successful in bolstering the bicycle and pedestrian plan of a city:

- Organization of a bicycle/pedestrian program
- Planning and construction of needed facilities
- Promotion of bicycling and walking
- Education for bicyclists, pedestrians, and motorists
- Enforcement of laws and regulations.

These cities include four of the 5-E principles of encouragement, enforcement, education, and engineering in shaping the bicycle and pedestrian program in their community. What sets these cities apart is continued focus on bicycle and pedestrian issues. That is, these cities have set aside considerable financial and other resources to better incorporate bicycles and pedestrians into transportation planning. These efforts better inform local design as it relates to bicycle and pedestrian issues and creates the impetus for the creation of bicycle facilities.

Yet another effective guidance document, *Best Practices for Bicycle Master Planning and Design*, (Sacramento Transportation & Air Quality Collaborative, 2005) continues to echo the work of Lagerwey and New South Wales. Although designed for California municipalities, there are many transferable components. Heavy emphasis is placed on the presence of maps depicting existing and proposed bicycle networks, parking facilities, end-of-trip facilities, transit connections, a summary of education programs, proposed projects and implementation strategies, community involvement techniques, connections with other agencies and plans, and required funding to execute the proposed projects (Sacramento Transportation & Air Quality Collaborative, 2005).

While lessons can be taken from bicycle master plans, pedestrian master plans, or plans that consider bicycle and pedestrian issues with more specificity than a transportation element might, it is nonetheless important to consider what components might be included in a transportation element of comprehensive plans. A 2005 Washington State, Growth Management Act amendment (RCW 36.70A.070(6)(a)(7)) now requires a specific bicycle and pedestrian component in the transportation element. As municipalities are required to address bicycle and pedestrian planning in the comprehensive plan, it is important to recognize key considerations for inclusion. Litman (2006) recommends five points to be addressed in the transportation element as they relate to bicycle and pedestrian planning:

1. Goals to increase mobility choices and encourage alternatives to automobile travel
2. Specific objectives for modal split, facility use, and increased road safety
3. Policies to review transportation projects and incorporate consideration of bicycle and pedestrian travel where appropriate
4. Specific objectives for making roadways compatible to walking and cycling
5. Land use and development codes that accommodate and encourage nonmotorized travel.

Examples of effective projects/plans
There are numerous plans and projects that utilize many of the tenets of effective planning (the 5-E approach and consistency with other elements in the comprehensive plan) described earlier in this section. Plans that clearly define projects, determine methodologies upon which a plan is based, and seek to create a hierarchy of needs that prioritizes projects are especially effective because they examine the specific place in which they are planning, and thus the models used are more specific to a particular place than general principles prescribed by national guidance.

The Association of Metropolitan Planning Organizations (AMPO) highlights MPO best practices and reports. Included as one of the best bicycle and pedestrian plans is the Champaign County Regional Planning Commission: Urbana Bicycle Master Plan. It is heralded for the extensive use of a bicycle level of service (BLOS) for prioritizing and implementing bicycle projects. BLOS is measured by identifying a network segment and identifying traffic volume, lane and shoulder width, speed limits, parking, pavement condition, and heavy vehicle use (Champaign County Regional Planning Commission, 2008). Based on the result, the score corresponds to an A–F grade that is then generally associated with a rider’s comfort level on that road. The equation below illustrates the BLOS calculation.

Bicycle LOS = 0.507 ln(Vol_{15}/L) + 0.199 SP_t(1+10.38HV)^2 + 7.066(1/PR_s)^2 – 0.005 W_c^2 + 0.760,

where
Vol_{15} = volume of directional traffic in 15-minute time period
L = total number of through lanes
SP_t = effective speed limit = 1.1199 ln(SP_{p20}) + 0.8103, SP_{p20} is posted speed
HV = percentage of heavy vehicles
PR_s = FHWA’s 5-point surface condition rating (5 = best)
W_c = average effective width of outside through lane = W_{t} + W_{l} - \Sigma W_r
W_t = total width of outside lane and shoulder/parking pavement
W_l = width of paving from outside lane stripe to pavement edge
\Sigma W_r = width reduction due to encroachments in outside lane
(League of Illinois Bicyclists, 2003)

The Champaign County plan incorporates a BLOS data table that includes the factors that contribute to the overall BLOS, images of various BLOSs, and maps showing where and what BLOS roads in Urbana were involved. The example, shown in Figure 1 from Urbana, shows the inventory of roads and their corresponding BLOS grades.
Bicycle level of service can be an important tool in prioritizing projects because it characterizes the street network into a hierarchy that can help determine which type of facility or network is most suitable for a rider. Determining the BLOS for a municipality’s road network can increase understanding of the forces that inhibit and encourage bicycle travel and also can help to create a community-wide hierarchy that can be used to determine where bike facilities should be built and where the network can be expanded. In the case of Champaign County, developing a BLOS at the onset of the planning process created an effective framework for developing the rest of the bicycle plan.

The Wisconsin Bicycle Planning Guidance document, in addition to outlining the planning process, recommends projects that will improve the bicycle network and facility structure. These are cost-effective projects that are easily implementable after a road has been built. Projects, shown in Table 2, are grouped by street type serving to create a rough hierarchy:
Table 2: Cost-effective projects by street type (Wisconsin Bicycle Planning Guidance, 2003)

<table>
<thead>
<tr>
<th>Category</th>
<th>Project Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Streets</td>
<td>Fix or replace dangerous drain grates</td>
</tr>
<tr>
<td></td>
<td>Patch and sweep carefully</td>
</tr>
<tr>
<td></td>
<td>Use current bike facility guidelines</td>
</tr>
<tr>
<td>Major Streets</td>
<td>Create wide curb lanes</td>
</tr>
<tr>
<td></td>
<td>Install bike-sensitive traffic signals</td>
</tr>
<tr>
<td>Local Streets</td>
<td>Improve sight distances at crossings</td>
</tr>
<tr>
<td></td>
<td>Implement traffic-calming measures</td>
</tr>
<tr>
<td></td>
<td>Add effective intersection controls</td>
</tr>
<tr>
<td>Rural Roads</td>
<td>Pave shoulders on busy roads</td>
</tr>
<tr>
<td></td>
<td>Use rumble strips</td>
</tr>
</tbody>
</table>

This approach might be used in tandem with the BLOS approach or serve as a guide in determining which projects are to be included on a certain BLOS.

The city of Portland, OR is widely regarded as one of the most bicycle-friendly cities in the country (Cote and Coffee, 2001; League of American Bicyclists; Fiske, 2008). The city’s bicycle plan, Portland Bicycle Plan for 2030, incorporates substantial sections on policy, network, and facility implementation. The plan examines existing conditions, implementation strategies, and a prioritized project list. The prioritized project list includes the responsible entities for project execution.

Encouragement/education

The national Safe Routes to School program, conceived in the 1970s but actually implemented in the late 1990s (Safe Routes to School, 2010), focuses on encouraging young students to walk and bicycle to school safely. Evidence suggests that Safe Routes to School programs encourage and raise the bicycling and pedestrian mode share to school. A program in Marin County, outside of San Francisco, witnessed gains of 64% and 119% for walking and biking, respectively, after the launch of the program (Boarnet, 2005). The effort to get more students walking and bicycling was successful as a result of committed community support, corresponding financial contributions, and a strong education/encouragement approach. Successful programs take varying approaches to encourage walking and bicycling to school such as focusing on construction projects, safety, engineering, and enforcement (Boarnet, 2005).

Bicycle-to-work days can be an effective way to create awareness about bicycling and potentially converting casual riders into bicycle commuters. Bicycle-to-work days and months can help to increase visibility and fulfill education components contained in the transportation element. An outreach effort in California in 1995 resulted in an increase in the number of miles commuted by bicycle on their May launch day (Pedestrian and Bicycle Professionals & Rails-to-Trails Conservancy, 1998).

Design

Design standards for bicycle facilities and networks are primarily generated from the American Association of State Highway and Transportation Official’s (AASHTO) Guide for the Development of Bicycle Facilities and the Federal Highway Administration’s Manual on Uniform Traffic Control Devices (MUTCD). So prevalent are these design norms in bicycle plans that when investigating the best bicycling cities in America (Cote and Coffey 2001), not a single city excluded the citation of using the AASHTO guide.
However, it is apparent that the AASHTO guidelines are no longer sufficient for cities experiencing high bicycling mode share because their infrastructure, designed according to standards that did not anticipate a high bicycle share, do not take into account the higher volumes. In Portland, OR the “transportation system has begun to exceed the capacity of developed facilities,” with the result that “new design guidelines need to be adopted to ensure safe traffic conditions in the future for all travel modes” (Portland Bureau of Transportation, 2010). Others have critiqued specific elements of the AASHTO guide—e.g., not including enough space in the door zone (Pein, 2004). The City of Madison, WI, in an effort to slow traffic, has rejected some lane widths as prescribed by AASHTO (Wisconsin Bicycle Planning Guidance, 2003).

The appendix to the San Diego Regional Bicycle Plan describes and visually depicts sections on general design references, design principles, standard designs of bicycle facilities, innovative treatments and signage, and bicycle parking. These sections are culled from AASHTO, the CalDOT Highway Design Manual, and the FHWA’s Best Practices Guide for Designing Sidewalks and Trails for Access and Bicycle Parking Design Guidelines, among other sources. An example of bicycle lane design guidance from the plan is shown in Figure 2. A more detailed review of design considerations can be found in Chapter 1, Section 3: Bicycle Facility Design.

![Figure 2: Bike lane design guidance (San Diego Association of Governments, 2010).](image-url)
Identifying gaps
Effective design can help to identify gaps in the bicycle network. Identifying gaps can take a policy-oriented approach or utilize the community for recommendations or suggestions. The City of Seattle’s Bike Spot Improvement Program is recognized as an effective method for allowing the community to submit requests for the installation of bike racks, filling of potholes, and other network/facility improvements (Pedestrian and Bicycle Professionals, & Rails-to-Trails Conservancy, 1998). Other design improvements, including leading pedestrian intervals (LPA) travel implementation at intersections, and traffic-calming measures such as neighborhood traffic circles, have been shown to decrease conflict with pedestrians and cyclists (Pedestrian and Bicycle Professionals, & Rails-to-Trails Conservancy, 1998).

Policy
Long-term policy should be considered when developing a bicycle and pedestrian section in a comprehensive plan. Approaching bicycle and pedestrian encouragement from a policy perspective sets into place a longer-range commitment of a municipality in taking bicycling and walking issues seriously.

Pucher, Handy, and Dill (2010) present an extensive literature review summarizing what major bicycle infrastructure projects are, where they are generally implemented, and the degree to which research can validate a project’s effectiveness in increasing ridership and/or safety. Their research involved scouring 139 studies based on pre-determined hypothesized factors that determine bicycling levels. Their research then focused on “travel-related infrastructure, bike parking and end-of-trip facilities, integration of bicycles with public transport, programs and legal interventions to promote bicycling, and multiple interventions” and associated impact on ridership as evidenced from the literature. They conclude that there is generally a positive association with implementing one of the aforementioned treatments and bicycling levels. The most effective instruments appear to be the installation of cycle tracks, on-road bicycle lanes, signed bicycle routes, and adequate maintenance of facilities. This research illustrates in tabular form the common and less-implemented bicycle programs and policies and their relative effectiveness. Table 3 shows a summary of travel-related infrastructure, prevalence, the countries that generally implement the project, and the project’s impact on ridership.
<table>
<thead>
<tr>
<th>Travel-related Infrastructure</th>
<th>Implementation/prevalence</th>
<th>Where</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-road bicycle lanes</td>
<td>high</td>
<td>Many U.S. cities</td>
<td>Generally, a positive association occurs; proximity matters (closer to the lane, more likely to cycle)</td>
</tr>
<tr>
<td>Two-way travel on one-way streets</td>
<td>low-medium</td>
<td>Europe, rarely U.S.</td>
<td>No found effect, but accidents remained steady or decreased after building a contra-flow lane</td>
</tr>
<tr>
<td>Shared bus/bike lanes</td>
<td>medium</td>
<td>Europe, Australia, some U.S.</td>
<td>Influenced route choice</td>
</tr>
<tr>
<td>Off-street paths</td>
<td>high (but limited mileage)</td>
<td>U.S.</td>
<td>Conflicting evidence; less-experienced cyclists generally prefer off-road paths</td>
</tr>
<tr>
<td>Signed bicycle routes</td>
<td>high</td>
<td>U.S.</td>
<td>&quot;Positive correlation between cyclists’ perception of facility quality and the presence of signed, shared roadways,&quot; though not comparable to bike lanes; preference for routes to no routes</td>
</tr>
<tr>
<td>Bicycle boulevards</td>
<td>low</td>
<td>West coast U.S.</td>
<td>Associated with biking on a quiet street; more applicable to novice riders</td>
</tr>
<tr>
<td>Cycletracks</td>
<td>high</td>
<td>Europe</td>
<td>Increased ridership (on that route); decreased accidents; often preferable to bike lanes</td>
</tr>
<tr>
<td>Colored lanes</td>
<td>high</td>
<td>Europe, limited U.S.</td>
<td>Volume increase along &quot;treated&quot; intersections (colored lanes and raised lane)</td>
</tr>
<tr>
<td>Shared lane markings</td>
<td>medium</td>
<td>U.S.</td>
<td></td>
</tr>
<tr>
<td>Bike boxes</td>
<td>medium</td>
<td>Europe, Portland</td>
<td>Perceived safety; lack of understanding of what a bike box is</td>
</tr>
<tr>
<td>Bicycle phases-traffic signals</td>
<td>medium</td>
<td>Europe, Davis, NYC, Portland</td>
<td>Increased safety</td>
</tr>
<tr>
<td>Maintenance of facilities</td>
<td>n/a</td>
<td>n/a</td>
<td>High perceived correlation; large increases in traffic after improved surface</td>
</tr>
<tr>
<td>Wayfinding signage</td>
<td>low-medium</td>
<td>Scattered U.S.</td>
<td>n/a</td>
</tr>
<tr>
<td>Techniques to shorten cyclists' routes</td>
<td>low</td>
<td>Scattered U.S.</td>
<td>n/a</td>
</tr>
<tr>
<td>Traffic calming</td>
<td>medium-high</td>
<td>Netherlands, Aus, Japan, U.S.</td>
<td>Increase in number, increase in perceived safety</td>
</tr>
<tr>
<td>Home zones</td>
<td>low</td>
<td>Netherlands, Germany, U.K.</td>
<td>Little change</td>
</tr>
<tr>
<td>Car-free zones</td>
<td>low</td>
<td>Europe, scattered U.S.</td>
<td>Main result generally decreased driving</td>
</tr>
<tr>
<td>Complete streets</td>
<td>medium</td>
<td>U.S.</td>
<td>n/a</td>
</tr>
</tbody>
</table>
Pucher et al. (2010) also note substantial increases in bicycle commuting in Boulder as a result of network and facility expansion and policy aimed at bicycling. Working in tandem, policy and infrastructure approaches often are the most effective at increasing bicycling mode share. Their review concludes by stating:

the most compelling evidence we found came from communities that have implemented a fully integrated package of strategies to increase bicycling. The cases reviewed here suggest that a comprehensive approach produces a much greater impact on bicycling than individual measures that are not coordinated. The impact of any particular measure is enhanced by the synergies with complementary measures in the same package. In that sense, the whole package is more than the sum of its parts. However, the more successfully a city implements a wide range of policies and programs simultaneously and fully integrates them with each other, the more difficult it becomes to disentangle the separate impacts of each measure. Both the apparent success of the comprehensive approach and the complexity of dissecting its effects point to a need for a metalevel approach to evaluation that examines the impacts of different sets of strategies across a large number of cases, taking into consideration the potential moderating factors in each of the cases examined, rather than a focus on the impacts of specific interventions in isolation. (Pucher et. al., 2010).

Heinen, van Wee, and Maat (2009) also conducted a literature review on the main determinants and hindrances related to commuting by bicycle. In addition to how bicycling facilities and networks influence travel behavior, they examined literature that included psycho-social norms, attitudes, and behaviors. The authors note the importance of attitude—the more positive one views the bicycle, the stronger the association with bicycling. This notion of an attitudinal shift, especially as it relates to safety, is reinforced by “safety in numbers” studies; the more people who ride or walk, the less likely it is that accidents with motorists will occur (Jacobsen, 2003). Opportunities to improve visibility of bicyclists and pedestrians include education and outreach events as well as scheduled rides.

Policy case studies: Davis, CA; Cambridge, MA; Arlington County, VA
Davis, CA is often at the vanguard of bicycle planning because of their traditionally high bicycle mode share (about 17%). Davis offers an important case study in how and what factors determine high shares of bicycling and how continuous work needs to be done to maintain that mode share level.

Davis’s rise to one of the most prominent bicycle-friendly cities in America is a result of its university campus situated among the flat fields of central California. Davis shows that an effective network and prevalence of bicycle facilities is not necessarily the result of a singular plan. Rather, long-range historical and political occurrences, geographic proximity and siting, and presence of large institutions helped to create a strong bicycling network and facilities in Davis. While these forces shaped the Davis context, every community will experience a different context that may inhibit or encourage the promotion of bicycling and pedestrian activities.

Cambridge, MA is an example where long-range policy and political will has created a setting in which conflicts involving cars, pedestrians, and bicyclists have remained static in spite of increased miles traveled (Parenti, 2006). The approach in Cambridge was realized through a bicycle-friendly city council, engineering solutions such as signal upgrades to better accommodate cyclists and pedestrians, and extensive community outreach.
Arlington County, VA, outside of Washington, D.C., began to rigorously consider bicycling and pedestrian planning when federal policies and the energy crisis of the 1970s created a need for rethinking the transportation network in the area (Hanson and Young, 2008). Also instrumental in setting long-term policy is the dedication of local officials in advocating for policies that reflect the importance of the built environment in dictating travel patterns (Hanson and Young, 2008).

**Implementation/funding**

No plan is effective unless it gets implemented, and the only path to implementation is the securing of funding. The *Portland Bicycle Plan for 2030* (2010) parses out all bicycle projects and attaches an associated cost to each project. To finance the projects, a summary of existing funding sources is presented, including federal, state, and local funding. The plan also explores potential future funding opportunities such as instituting licensing fees for bicyclists and innovative advertising techniques. Given Portland’s reputation and statute regarding its commitment to bicycling, the rather exhaustive implementation section within the *Portland Bicycle Plan for 2030* may be of relevance to many communities.
1.2. Bicycle facility design

Bicycle design minimum guidelines in the United States are defined generally in the American Association of State Highway and Transportation Officials’ (AASHTO) Guide for the Planning, Design, and Operation of Bicycle Facilities (AASHTO, 2010). In Washington State, roadway facilities are also addressed by the Washington State Department of Transportation’s Design Manual for Roadway Bicycle Facilities (WSDOT, 2010). Design standards for bicycle facilities and networks based on the AASHTO and WSDOT guides, as well as manuals developed by select cities across North America, are discussed in the following section. A resource section is provided at the end, and use of these reports is recommended for further exploration of bicycle design practices.

Bicycle facilities and networks range on a scale from full separation to full integration with the automobile road network. Facilities also range based on their ability to function as a network, taking cyclists to places they want to go, and integrating with other transportation modes, such as connections to rail stations and bus stops.

Off-road facilities

Shared-Use Paths/Trails

Shared-use paths can provide rich cycling experiences, allowing users to visit places unsuitable for or protected from vehicle traffic. These paths can travel into a natural preserve, take users across jurisdictional lines, or cut through a segment of the city that would not be possible on a regular road. However, trails are most effective when integrated into a larger bicycle network. Left alone, they can remain disconnected and serve primarily recreational purposes. They may attract a different level of cyclists, such as those who are unlikely to want to ride in traffic, beginner cyclists, and those who would like a dedicated route where they can practice high-speed cycling.

Many trail users will drive their bicycle to a connection point with the road network, and then use the trail for recreational cycling. For a trail to truly serve as part of an integrated transportation network, it must be clearly signed, logically routed, and wide enough to accommodate recreational and commuting cyclists. For bicycling to be a convenient means of transportation, designated bicycle routes must follow direct arterial routes for major destinations, and should not require a significant amount of extra travel distance. That being said, it has also been found that cyclists are willing to travel on a less-direct route if it is a more pleasant cycling environment, such as lower traffic speeds, fewer hills, and better bicycling facilities.

AASHTO recommends that the path be between 8 and 10 feet wide, and that trails should be either widened or separated based on volume and expected users. WSDOT’s design manual states:

- The desirable paved width of a shared-use path is 12 feet. The minimum paved width is 10 feet. The provision of 12- to 14-foot paved paths is desirable when substantial use by both pedestrians and bicyclists is expected or maintenance vehicles are anticipated. Shoulders are typically unpaved and are to be at least 2 feet wide. (WSDOT, 2010b)
As guidelines for this type of facility involve interaction with pedestrians and other users, the variety of speeds must be considered in the design of the trail. Portland’s shared-use path design guidelines in the *Trail Design Guidelines for Portland’s Park System* recommends trail designs that consider safety, connectivity, context, and diversity (Portland Parks and Recreation, 2009). Figure 4, from the guide, shows considerations that must be provided to accommodate the needs of each type of trail user and for situations in which there will be multiple users. The guide recommends that for bicycling and walking shared-use trails a range between 8 feet and 25 feet is provided to accommodate both types of users. Portland notes that it is critical to occasionally provide separated-use trails, to provide a unique and rewarding experience to certain uses that function best in isolation, which includes bicycling for commuting.
Figure 4: Trail type matrix. (Portland Parks and Recreation, 2009).

<table>
<thead>
<tr>
<th>Trail Type</th>
<th>User Type</th>
<th>Trail Surface</th>
<th>Trail Width</th>
<th>Longitudinal Grade</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>Hiking</td>
<td>Soil/wood</td>
<td>6'-8'</td>
<td>0.0% (to 12% for inclines)</td>
<td>Suitable for use with variety of challenges (A, M).</td>
</tr>
<tr>
<td>I</td>
<td>Mountain</td>
<td>Soil/wood</td>
<td>3'-6' (pair of nails)</td>
<td>0.0% (prefer 5% max.)</td>
<td>Wood chips difficult to maintain</td>
</tr>
<tr>
<td>J</td>
<td>Hiking</td>
<td>Soil/wood</td>
<td>4' (with passing area)</td>
<td>10'</td>
<td>Adjust width for user volume &amp; wheelchair use; 6' gravel allows wheelchair to pass</td>
</tr>
<tr>
<td>K</td>
<td>Hiking</td>
<td>Soil/wood</td>
<td>4' (pair of nails)</td>
<td>10'</td>
<td>Adjust width for user volume &amp; wheelchair use; use gravel or wood chips for pavers; wood chips difficult to maintain</td>
</tr>
<tr>
<td>L</td>
<td>Walking</td>
<td>Gravel/asphalt</td>
<td>8'-25'</td>
<td>0.0% (5% max.)</td>
<td>If asphalt for minor park paths; 8' asphalt (6' min - 10' max) for major park paths; note: may need to be adjusted by trail users.</td>
</tr>
<tr>
<td>M</td>
<td>Walking</td>
<td>Gravel/asphalt</td>
<td>8'-25'</td>
<td>0.0% (5% max.)</td>
<td>If asphalt for minor park paths; 8' asphalt (6' min - 10' max) for major park paths; note: may need to be adjusted by trail users.</td>
</tr>
<tr>
<td>N</td>
<td>Fire and maintenance</td>
<td>Gravel/hot mix</td>
<td>10'-14'</td>
<td>0.0% (0% allowed)</td>
<td>Forest Park Fire line often function as trails for hiking and/or mountain biking.</td>
</tr>
</tbody>
</table>

* Mobility devices that can equal bicycle speed
** Sometimes specialized wheelchair on multi-use trail
*** Trail type unlikely to meet environmental zone standards due to width and/or paving material; will need environmental review if in a zone.
Off-road trails are particularly at risk for issues of disconnectedness from the network. Often, trails in the U.S. were created from the rails-to-trails program, such as the Burke-Gilman Trail in Seattle, WA. These trails follow a route that was laid out during older settlement periods, but growth in the city may have led to these trails being located in out-of-the-way or underutilized locations. It is important to recognize that this type of trail will not take every cyclist where they want to go and that it should be well signed to direct cyclists to key destinations. The street network that connects to the trail should include bicycle facilities and a continuation of wayfinding signage. Additionally, nearby streets should be signed to direct cyclists to the trail. Map kiosks at key locations may assist in helping cyclists determine if the trail will take them where they want to go. Street intersections should be carefully designed to maximize safety and in determining which route will have the right-of-way. Excessive stop signs on a trail will cause cyclists to disregard their presence, especially due to the fact that cyclists are more able to hear and see approaching cars than cars are to hear and see approaching cyclists (Fajans & Curry, 2009).

**On-road facilities**

*Bicycle boulevards*

Vancouver, B.C.’s network of bicycle boulevards is an outstanding example of a highly accepted new form of bicycle facility that removes bicycle traffic from main arterial streets and puts it on low-speed residential streets. Bicycle boulevards utilize existing, nearby, parallel neighborhood streets to create a safe, low-traffic bicycle route that does not compromise a cyclist’s ability to reach key destinations, which are commonly located along arterial streets.

AASHTO and WSDOT provide quite different details regarding design of a bicycle boulevard. WSDOT considers any low-volume traffic street that has been designated for bicycle use to be a shared roadway. For these roadways, very few improvements are recommended to make it suitable to bicycle travel. WSDOT advises that if a bicycle route is intended to guide longer-distance bicycle trips through an area, then signage should be used and shoulders widened.

![Figure 5: Bicycle boulevard street markings (Marr Consulting Services, 2008)](image-url)
AASHTO provides a more thorough description of bicycle boulevards, distinguishing them from shared roadways. A bicycle boulevard is a street that has been identified as a primary bicycle route while discouraging through-traffic by automobiles. This requires a number of improvements to the roadway, particularly at intersections with major arterials. Modifications must be made to allow cyclists to continue through on local streets, which often face disconnects and hazardous crossings with main arterials.

Bicyclists should be provided with signals to cross very busy intersections that do not detect vehicles but are triggered by a bicyclist or pedestrian. These are very common in Vancouver, where the signal shows a flashing green light to arterial traffic, alerting them of the possibility of changing when triggered by a bicyclist or pedestrian.

![Figure 6: Bicycle signal at shared-use path crossing (Burden, 2000).](image)

Entry to neighborhood streets can be limited to one-way vehicular traffic, while permitting bicyclists to enter and travel in both directions. In Figure 7, a forced right-hand turn for automobiles provides cyclists with the ability to continue straight where automobile traffic is low.
Crossings with smaller streets, where stop signs are present, should give the bicycle route the right-of-way to maintain speed and continuity.

**Bicycle lanes**

Bicycle lanes are a commonly used form of bike facility in the Puget Sound. A bicycle lane consists of a painted white stripe on the right-hand side of a drive lane, located to the left of parked traffic, when parking is allowed. There is variance in the width and buffer treatment of bicycle lanes, and they are often used in tandem with wayfinding signs that designate a bicycle network. WSDOT’s Bicycle Design Manual states that jurisdictions should “provide bike lanes where it is desirable to delineate available road space for preferential use by bicyclists” (WSDOT, 2010a). AASHTO states that “bicycle lanes are used to delineate available road space for preferential use by bicyclists and to facilitate more predictable movements by bicyclists and motorists” (AASHTO, 2010). While these are logical statements, it is often challenging for
jurisdictions to determine how much of the available road space should be dedicated to cyclists and what roads are appropriate for bicycle use.

Many cities have bicycle master plans that list streets where bicycle lanes are recommended, but this is not based on a standardized method of bicycle lane planning. For example, Chicago and Seattle have passed Complete Streets ordinances that suggest that those cities intend to provide some type of bicycle facility on all arterial streets when time and funding permit. Seattle’s Complete Streets ordinance, passed in 2007, states that all future “transportation improvements are planned, designed and constructed to encourage walking, bicycling and transit use while promoting safe operations for all users” and to “provide appropriate accommodation for pedestrians, bicyclists, transit riders, and persons of all abilities, while promoting safe operation for all users” (Seattle City Council, 2007).

Chicago has made particular strides in terms of standardizing a bicycle lane typology suited to the layout of the city’s streets. This manner of careful consideration for existing conditions in the city has allowed Chicago to increase facilities while measuring safety and progress. Chicago practice has found that a bike lane narrower than 5 feet does not provide adequate space to avoid drainage grates or potential car door openings. The Chicago Bike Lane Design Guide explains how the city bases bike lane width on overall street width, the presence of on-street parking, and the number of travel lanes (Pedestrian and Bicycle Information Center, 2002). This design guide is excellent in displaying how a jurisdiction must define its own best practice based on the existing condition of its roads. AASHTO acknowledges that where there is parking with high turn-over, it is wise to provide a wider bicycle lane, between 6 and 7 feet, to allow cyclists to move away from the “door zone” while a motorist is operating the vehicle (AASHTO, 2010).

Figure 9: Street section for bicycle lane design (AASHTO, 2010).
Cycle tracks (raised or separated bike lanes)
Separate-grade bicycle lanes have long been discouraged in State and Federal DOT planning manuals and AASHTO. WSDOT states:

do not place bike lanes between the parking area and the curb. Such facilities increase the potential conflicts for bicyclists, such as the opening of car doors and poor visibility at intersections. Also, they restrict bicyclists leaving the bike lane to turn left and they cannot be effectively maintained (AASHTO, 2010).

However, a few U.S. cities have experimented with cycle tracks as an element of their bicycle network. Portland considers cycle tracks to be critical in creating integrated bicycle facilities, where cyclists have a safe and comfortable place on main arterial streets. The Portland Bicycle Master Plan defines a cycle track as “An exclusive bicycle facility adjacent to the roadway but separated from motor vehicle traffic by a physical barrier or other buffer” (City of Portland Bureau of Transportation, 2010).

WSDOT points out that a bicyclist in a cycle track, between on-street parking and the sidewalk, is at risk for injury by hitting a car door as it is being opened, or that is already open. This is a major safety concern for bicyclists that is not eliminated simply based on the side of parking on which the bike lane is located. Portland (Figure 11) has installed new cycle tracks that use hatch lines to buffer the cyclist from on-street parking.
In sections of New York City where there is no on-street parking, the city has opted to place bollards in the buffer zone of bicycle lanes to prevent cars from pulling onto the bicycle lane for parking or use as a drive lane. See Figure 13 for a diagram of the cycle track layout. On streets without parking, cycle tracks may appear to be very similar to bicycle lanes. The distinction is the level of separation. Cycle tracks either have a physical barrier (in the case of Portland, the cars and the hatch marks constitute a physical barrier) or a grade separation.

Figure 12: Cycle track in New York City (New York City, 2009).
Figure 13: NYC cycle track diagram (New York City, 2009).

A buffer, ideally including grade and/or pavement color separation (see Figure 12), discourages cars from pulling into the bike lane or failing to yield when exiting from a driveway.

Figure 14: Cycle track in Copenhagen (Rose, 2010).

As with pedestrian crosswalks, cycle tracks must be emphasized at intersections, and design techniques must be utilized to enhance visibility as cycle tracks approach intersections. Reducing
vegetation and parking near an intersection can draw attention to approaching cyclists. It is also critical that intersections do not allow right turns on red lights, as this behavior is one of the biggest threats to cyclist safety. Bicycle signals may also be included to improve the intersection visibility. The signal should be timed, as it is in Copenhagen, to release the cyclists first into the intersection, thus increasing their visibility.

WSDOT states that cycle tracks restrict bicycle left turn movements. It is important to note that bicycle culture can heavily influence rider behavior. In Copenhagen, cyclists are not allowed to enter the left turn lane on arterial streets, but rather must make a “pedestrian-left” by crossing the intersection on the right side and waiting for the signal to change. This keeps the cyclist on the right hand side of traffic at all times and eliminates another potential point of conflict between bicyclists and vehicles or pedestrians.

**Sharrows (shared lane marking)**

Sharrows are indications placed on main routes that show where in the lane a bicyclist should be travelling. Sharrows often complement bicycle lanes in a bicycle network, being placed on streets where a bicycle lane is determined to be unnecessary or infeasible due to street width restraints. Sharrows should be placed in conjunction with “share the road” signs, to remind drivers of the presence of cyclists. In essence, a sharrow is simply a reminder that bicyclists have a legal right to the road, and should ride in a location on the street where they can be seen, and are out of risk from car door openings.

![Figure 15: Sharrow on downhill travel lane (City of San Diego, 2009).](image)

San Diego has produced a simple and clear document that guides the city in decision-making for bicycle facility implementation (City of San Diego, 2009). Many cities have begun to use sharrows, and clarification is necessary to guide planners and engineers where they can be safely implemented. In San Diego, the recommended placement of a sharrow is 2.5 feet out from the left edge of the parking lane (Figure 15). Many cities are now implementing sharrows paired with bicycle lanes on sloped streets. The painted lane is located on the uphill side, known as a “climbing lane” due to the slower travel of cyclists up hills. This provides a protected place for cyclists to travel more slowly without feeling pressure from passing motorists. The sharrow is placed on the downhill lane, as speeds of the downhill-travelling cyclist are more similar to those of vehicles. When parked cars are present, it is especially important for the cyclist to move away from the “door zone” because the increased speed of the cyclist requires increased stopping time and a decreased ability to avoid sudden obstacles such as a car pulling out of the parking lane or opening a door.
Bicycle boxes

Bicycle boxes are located at the limit line of an intersection where a bicycle lane has been present on the road. The purpose is to increase visibility of cyclists at intersections. Typically, a cyclist will stop either to the right side of a vehicle or occasionally behind vehicles stopped at an intersection. Studies have shown that this is a dangerous place for cyclists to be located, due to increased activity and distraction of intersections; it is critical for a cyclist to be highly visible (Dill, Monsere, & McNeil, 2010). Bicycles have slower starting speeds at intersections and may be at risk if located between two vehicles. Bicycle boxes also place cyclists in the furthest right travel lane that is going in their direction. This is the legal placement of cyclists and allows right turning cars to turn freely without conflict from cyclists.

Bicycle signal priority

At intersections that rely on loop detectors to trigger the signal, it is necessary to provide a way for cyclists to trigger the loop. In Seattle, bicycle loop detectors have been installed at certain intersections. This allows cyclists to know they must place their wheel over the bicycle marking to trigger the signal. Both bicycle and motorcycle advocacy groups have lobbied for better signal detectors.
Other facilities and tools

Bicycle parking

Bicycle parking is typically provided on sidewalks outside of restaurants, businesses, and other destinations. Most commonly, the city or business owner will provide a bicycle rack suited to hold 2–3 bicycles at one time. In Seattle, the Department of Transportation maintains a bicycle rack request program. Any resident or business owner may fill out an online form to request a bicycle rack, and the city will install and maintain this rack. Commute Seattle, a downtown public-private partnership has conducted an inventory of bicycle parking available to commuters in downtown Seattle. An inventory is a useful tool for a jurisdiction in identifying gaps in bicycle parking.

Commuter bicycle parking, according to Commute Seattle, should be secure, protected from the weather, and constructed with high-quality materials. They have also developed an assessment tool that awards points for meeting the criteria of successful commuter parking. This can be used to evaluate businesses in a jurisdiction and provide guidance for how to improve bicycle parking (Commute Seattle, 2010). Bicycle parking is critical to reducing theft and managing street space to keep bicycles out of pedestrian walkways. Seattle also has a program to allow businesses to convert the on-street parking space directly in front of their business into a large bicycle rack (see Figure 20). This allows for more bicycle parking and sends a clear message about the amount of space it takes to park many bicycles, as opposed to just one car.
Colored bike lanes
Colored bicycle lanes are utilized heavily in Europe and are growing in popularity in U.S. cities. A segment of a bicycle lane that is potentially in conflict with vehicle traffic is painted a bright color to alert motorists of the presence of the bike lane. When used sparingly at key locations, these lanes prevent motorists from driving over the bicycle lane without looking for cyclists.

Bicycle-friendly drainage grates
As drainage grates are ubiquitous elements of streets, often located adjacent to the curb, cyclists are at risk of riding over the grate. When grate holes are located parallel to the direction of travel, bicycle wheels may be caught in the grate, causing a very serious safety issue. A cyclist may be thrown into moving traffic if his or her front wheel is suddenly caught. AASHTO provides images of bicycle-compatible drainage grates in Figure 22 (AASHTO, 2010).
Contraflow bicycle lanes are used on one-way streets to allow cyclists to still travel in both directions. AASHTO’s manual expresses caution that contraflow lanes may encourage cyclists to ride against traffic (AASHTO, 2010). Still, one-way streets in towns with very wide one-way couplets often contain desirable businesses and attractions on both streets. If the street is wide enough, some cities have found it useful to provide cyclists with multi-direction access to both streets. Providing a safe place for cyclists to travel can decrease conflict and increase cyclist safety. Separated lanes, such as the one shown in Figure 23, may provide extra comfort and encourage new cyclists to begin riding on city streets.

Figure 23: Contraflow lane in Madison, WI (FHWA, 2006).

Signage
The Manual on Uniform Traffic Control Devices (MUTCD) delineates appropriate bicycle signs for different bicycle facilities. Signage should be used as frequently as can be afforded by the jurisdiction. Signage can be used to alert motorists of the presence of bicycles on the road. It can also inform bicyclists of the proper place to ride and provide wayfinding information to help new and visiting cyclists reach the places they want to go. These MUTCD should be consulted to determine jurisdiction-appropriate signage.

Bicycle maps
Many cities provide bicycle maps to residents and visitors to help them with wayfinding while cycling. Some maps are very detailed and cover the entire city, with street names and details about varying facilities. Seattle’s bicycle map is very large and detailed, and it is useful for citywide travel. In Vancouver, B.C., the city offers a bicycle map that covers the downtown and most densely populated neighborhoods just outside of downtown. The map is pocket sized and can fit into a wallet, which makes it easy to bicycle with and unfold, but it provides less detail about specific areas and only outlines the main routes of the bicycle network.

Other innovative/emerging practices
Staircase bicycle wheel gutters
A staircase wheel gutter is a cheap and useful tool that is often overlooked in bicycle planning. Staircases can create a large impediment for cyclists, especially those unable to carry their bicycle up the staircase. It should not be assumed that cyclists are willing to go out of their way
to find another way up the staircase (e.g., in the case of bridges). Wheel gutters or bicycle ramps, depending on the slope of the staircase, can increase accessibility and equity for cyclists who use staircase facilities. Figure 24 shows a very low-technology and easy-to-install wheel gutter from Copenhagen, Denmark.

![Figure 24: Bicycle wheel gutter for staircase in Copenhagen (Rose, 2010).](image)

**Bike share programs**
While bicycle sharing is not considered to be a bicycle facility that improves the rideability of the network, its rise in popularity should not be overlooked. A 2009 University of Washington studio (for King County) addressed the feasibility of a bicycle-sharing program in Seattle. The studio concluded that there is sufficient demand for bicycle use in the city, and that it should be implemented in downtown Seattle and close-in neighborhoods (University of Washington Department of Urban Design and Planning, 2010). Before initiating such a program, jurisdictions in the area will have to address the King County helmet law for all cyclists. This is an impediment to unmonitored bicycle rental stations where helmets are not available with the bicycle. Seattle is currently looking into this issue, and their progress should be monitored by nearby jurisdictions.
Figure 25: Bicycle share station (University of Washington Department of Urban Design and Planning, 2010).

Bicycle repair station
In addition to bicycle parking, jurisdictions or private businesses may want to provide additional amenities to cyclists along popular routes. In Minneapolis, TREK has sponsored seasonal bicycle repair and refueling stations, where cyclists can access tools and other items from a vending machine and use the free air and repair stand (City of Minneapolis, 2009). Along a popular trail in Florida, air stations are provided to cyclists (Burden, 2000). This can be a vital amenity to new cyclists who may travel with a spare tube or patch kit, but are less likely to carry their own pump with them. On trails that take cyclists away from heavily trafficked areas, such assistance can be critical.
Figure 26: Bicycle repair station, Minneapolis (City of Minneapolis, 2009).

Figure 27: Air station at trailhead in Florida (Burden, 2000)
1.3. Factors influencing bicycle use

The purpose of this section is to provide a summary of literature that helps explain the factors that influence bicycle use. Most of the literature surveyed in this review was initially collected by PSRC. The initial review was augmented by the planning studio, while acknowledging that the final list may exclude the most recent publications or articles being published at the time of the literature search.

The final literature review consists of 48 publications, which includes 31 government publications, 10 peer-reviewed journal articles, 5 publications from workshops and seminars, and 2 publications from non-profit organizations. While peer-reviewed journal articles were considered the most reliable sources of information, non peer-reviewed research was also a valuable source of information, due in part to a lack of peer-reviewed studies on bicycle count measures. In fact, more than half of our literature comes from government sources, indicating that bicycle counting is increasing in popularity as a government activity.

The planning studio surveyed the literature in search for the most important indicators that influence bicycle use in the Puget Sound region. After a detailed review, 26 variables were found to be most relevant to the Puget Sound region. Based on the recurring theme of the variables, we grouped them into seven different categories: temporal, land use, bicycle facility, traffic, weather, topography, and demographics (see Table 4).
<table>
<thead>
<tr>
<th>Category</th>
<th>Variable Name</th>
<th>Definition</th>
<th>Supporting Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporal</td>
<td>Time of day</td>
<td>Morning peak or not, afternoon peak or not, exact time of the count</td>
<td>Jones, 2010; Schwartz, 1999; Niemier, 1996; Halifax, 2002</td>
</tr>
<tr>
<td></td>
<td>Season</td>
<td>4 seasons, month of the count</td>
<td>Niemier, 1996; Vancouver, 2009</td>
</tr>
<tr>
<td>Land use</td>
<td>Population density</td>
<td># of persons / land area</td>
<td>Turner, 1997; Parkin, 2008; Pinjari, 2009; McCahil, 2008</td>
</tr>
<tr>
<td></td>
<td>Employment density</td>
<td># of employees / land area</td>
<td>Pinjari, 2009; Turner, 1997; Turner, 1998; McCahil, 2008</td>
</tr>
<tr>
<td></td>
<td>Mix of use</td>
<td>Land use mix, land use type, land use policies,</td>
<td>Pinjari, 2009; Turner, 1997; Turner, 1998</td>
</tr>
<tr>
<td></td>
<td>Transit access</td>
<td>Local index of transit availability</td>
<td>Vandenbulcke, 2009</td>
</tr>
<tr>
<td>Bike facility</td>
<td>Facility type</td>
<td>Number of effective bicycle lanes, existence of separated bicycle lane or bicycle path, lane width, pavement quality</td>
<td>Allen, 1998; Schwartz, 1999; Hunter, 2007; Jones, 2010</td>
</tr>
<tr>
<td></td>
<td>Connectivity/access/density</td>
<td>Length of bike/street network within buffer of site</td>
<td>Jones, 2010</td>
</tr>
<tr>
<td></td>
<td>Bike parking</td>
<td># of bike parking facilities within buffer of site of major bicyclist destination</td>
<td>Hunter, 2007; Jones, 2010</td>
</tr>
<tr>
<td>Traffic</td>
<td>Traffic volume</td>
<td>Annual average daily traffic (ADT)</td>
<td>McDonald, 2007; McCahil, 2008; Jones, 2010</td>
</tr>
<tr>
<td></td>
<td>Traffic speed</td>
<td>Average speed limit</td>
<td>Fehr, 2010</td>
</tr>
<tr>
<td>Weather</td>
<td>Rain</td>
<td>Rainy or not on the day</td>
<td>Niemier, 1996; Parkin, 2008; Halifax, 2002; Vancouver, 2009</td>
</tr>
<tr>
<td></td>
<td>Temperature</td>
<td>&lt;55F or not, temperature of the day</td>
<td>Niemier, 1996; Parkin, 2008; Halifax, 2002</td>
</tr>
<tr>
<td>Topography</td>
<td></td>
<td>Proportion of 1-km squares in district with mean slope 3% or greater</td>
<td>Halifax, 2002</td>
</tr>
<tr>
<td></td>
<td>Income</td>
<td>Income, household income</td>
<td>Turner, 1997; Turner, 1998; Parkin, 2008; Pinjari, 2009</td>
</tr>
<tr>
<td></td>
<td>Sex</td>
<td>% of male v, % of female</td>
<td>Parkin, 2008; Santa Clara, 2000</td>
</tr>
<tr>
<td></td>
<td>Race</td>
<td>% of non-white v. % of white</td>
<td>Parkin, 2008; Pinjari, 2009</td>
</tr>
<tr>
<td></td>
<td>0 car household</td>
<td># of households without a car</td>
<td>Fehr, 2010; Santa Clara, 2000</td>
</tr>
<tr>
<td></td>
<td>Student population</td>
<td>Student pop in census blocks, # of schools</td>
<td>Fehr, 2010; Turner, 1997</td>
</tr>
<tr>
<td></td>
<td>Transportation disadvantaged person</td>
<td>People unable to transport themselves due to physical disability, income, or age</td>
<td>Turner, 1997; Turner, 1998</td>
</tr>
<tr>
<td></td>
<td>School</td>
<td># of schools</td>
<td>Pinjari, 2009</td>
</tr>
<tr>
<td></td>
<td>Level of qualification</td>
<td>% of employees (aged 16–74) with high qualification</td>
<td>Parkin, 2009</td>
</tr>
<tr>
<td></td>
<td>Household Size</td>
<td>Average household size</td>
<td>Pinjari, 2009</td>
</tr>
<tr>
<td></td>
<td># of bicycles</td>
<td># of full-size bicycles in household</td>
<td>Pinjari, 2009</td>
</tr>
</tbody>
</table>
Selection of primary indicators
In searching for the primary indicators that influence bicycle use, the planning studio systematically chose the most plausible factors based on the following set of criteria:

1. Number of supporting literature sources
2. Relevance to the central Puget Sound region
3. Relevance to the bicycle count data/model
4. Availability of data
5. Expert judgment.

Temporal aspect
Temporal aspects such as time of day and seasonality are important in the study because the Puget Sound region has a distinct seasonal variation and commuting patterns contingent to a certain time of day. Multiple articles in the review discuss both time of day and seasonal variation as having an impact on bicycle use (Jones, 2010; Schwartz, 1999; Niemier, 1996; Halifax, 2002; Vancouver, 2009).

Land use
It is widely accepted that areas with high population and employment density, with a diverse mix of land uses, lead to higher bicycling rates. In the literature review, many articles consider land-use factors as the most important indicators of bicycle use (Turner, 1997; Parkin, 2008; Pinjari, 2009; McCahil, 2008). In the Puget Sound region, population and employment densities, as well as the mix of uses, are particularly relevant factors because of the current land-use policy focusing growth in centers throughout the region. Vandenbulcke (2009) suggests that transit access could have some impact on bicycle use. However, the final list of variables excludes this variable, partly because of its insignificant relevance to the bicycle-count models and the difficulty of obtaining transit access data and delineating an appropriate metric.

Bicycle facility
Based on the literature review and best practices in terms of facility design, it is evident that some elements of bicycle facilities are directly related to bicycle use. Bicycle facility types, availability of bicycle parking, and access to and connectivity of bicycle facilities are all relevant indicators. The most frequently discussed indicator, however, is a bicycle facility type. Our literature review indicates that dedicated bicycle paths directly increase bicycle use (Allen, 1998; Schwartz, 1999; Hunter, 2007; Jones, 2010).

Traffic
Multiple articles conclude that traffic volume is negatively correlated with bicycle use (McDonald, 2007; McCahil, 2008; Jones, 2010). Other traffic indicators, such as vehicle speed and availability of vehicle parking, are less frequently discussed, and thus are excluded from the final list of indicators (Fehr, 2010). One of the challenges in utilizing traffic-volume data is the lack of local traffic-volume data in most of the local governments. However, some local traffic data are available in close proximity to many of the bicycle-count locations.

Weather
Weather, most notably rain and temperature, is discussed in multiple sources (e.g., Niemier, 1996; Parkin, 2008; Halifax, 2002; Vancouver, 2009). Because of low temperature and frequent
rain in the Puget Sound area, rain and temperature are important variables in the study. Other extreme meteorological events such as severe snow are also potential barriers to cycling; however, none of the articles reviewed discuss these issues.

**Topography**

Few articles mention topography as a potential barrier to cycling (Halifax, 2002). This is counter-intuitive because steep hills and slopes might discourage people from bicycling. Topography is excluded from the final list of indicators because it is more related with bicyclists’ route choice than their propensity to bicycle. Difficulties in obtaining objective measures of topography also influenced the decision to avoid including this variable in the study.

**Demographics**

Factors associated with demographics show the widest spectrum of variables, ranging from income to ethnicity. The most frequently used indicators throughout the literature are income and age (Turner, 1997; Turner, 1998; Parkin, 2008; Pinjari, 2009). These two variables are included in the study because of their relevance to the general profile of bicyclists.

**Summary of literature on selected primary indicators**

After a careful review of the potential indicators, the planning studio selected eleven variables to be used in the bicycle count model. The primary indicators are: time of day, season, population and employment densities, mix of use, bicycle facility type, traffic volume, rain and temperature, income, and age. This section outlines the key points made in the literature that are most relevant to each of the selected variables.

**Time of day**

- Jones et al. (2010) conclude that morning peak hours from 6 AM to 9 PM accounts for a consistent 95% of the total bicycle volumes, and therefore they recommend counting bicyclists during the morning peak hours to capture a consistent snapshot of the vast majority of activity (p. 14).
- Schwartz et al. (1999) describe and compare the various methods and tools that can be used to forecast non-motorized travel demand. They also suggest making weekday counts by assuming that the peak period represents 10% of the daily usage.
- Niemeier (1996) concludes that the variability found in bicycle volumes may be related to many factors, including location, time of year, and time of counts. The locations chosen for the study show greater variability in the PM peak period than in the AM peak period. This suggests that the AM peak-period counts appear generally more useful for estimating bicycle commuter flow.

**Season**

- Niemeier (1996) finds increased variability for counts conducted in the later months of the year. Niemier suspects that this variability may be strongly associated with an influx of recreational bicyclists during more favorable climate conditions.
- Vancouver (2009) uses one automatic bicycle counter to analyze monthly variation in average daily bicycle volume. Typically, bicycle volumes reach their peak at mid-week, and fall significantly at the weekend. The total number of cyclists on a rainy September day, mid-week, corresponds closely to the average daily volume of cyclists for the month of November. Niemier speculates that those cyclists committed to riding on a rainy day in
Summer or early Fall may be those who remain committed even when the weather turns cold and rainy later in the year (p. 7).

**Population density**
- Turner et al. (1997) introduce a Bicycle Needs Index developed by the North Texas Council of Government (NTCOG), which uses a regression equation between bicycle mode share and a series of factors within the Transportation Analysis Process (TAP) Zone. The factors include percentage of residents under sixteen years of age, number of hours worked per week, percentage of land devoted to employment uses, population density, employment density, population density of residential land uses, and ratio of workers to population. The $R^2$ value for the regression equation was 0.42 (p. 16). Their recent 2009 report suggests that they use only four factors to calculate bicycle needs index: percentage of total trips 5 miles or less, employment density, population density, and median household income.
- Parkin et al. (2008) conclude that an increase in population density has the effect of increasing the likelihood of cycling or the journey to work. This result appears reasonable given that cycling can be expected to be more attractive in more tightly packed and localized neighborhoods because of increased parking problems and because the finer grain will be less conducive to motorized travel. This effect could stem from journey distance, but it was not highly correlated with population density. The coefficient is small, but this is due to the large average size of the variable (p. 103).
- Pinjari et al. (2009) point out the possibility that employment, residential, and travel choices are not independent of one another, and that individuals and households adjust with combinations of short-term travel-related and long-term location-choice-related behavioral responses to land-use and transportation policies.
- McCahil et al. (2008) conclude that the two important variables are population density ($R^2 = 0.3063$) and worker density ($R^2 = 0.2647$). The strongest two-variable model described bicycle volumes in terms of population density and worker density within each volume count location’s census tract ($R^2 = 0.6559$).

**Employment density**
- Turner et al. (1997) suggest that employment density is as important as population density, suggesting the weighting factor of 2.5 for calculating the bicycle needs index.
- Pinjari et al. (2009), similar to population density, infer that employment, residential, and travel choices are not independent of one another, and that individuals and households adjust with combinations of short-term travel-related and long-term location-choice-related behavioral responses to land-use and transportation policies.
- McCahil et al. (2008) again conclude that the two important variables are population density ($R^2 = 0.3063$) and worker density ($R^2 = 0.2647$). The strongest two-variable model described bicycle volumes in terms of population density and worker density within each volume count location’s census tract ($R^2 = 0.6559$).
- Turner et al. (1997) conclude that the employment density is one of the necessary factors to estimate bicycle trip generation.
Mix of use

- Turner et al. (1997) identify the affecting factors of bicycle use such as land-use mix, ease of crossing streets, sidewalk continuity, street connectivity, building setbacks, topography, traffic calming, and bicycle network connectivity/facilities.
- Turner et al. (1998) find that the trip-generation rates varied significantly between sites and attempted to identify the reason for this variability. It is hypothesized that a contributing factor is the type of development at or near each site. Because of trip-generation rate differences, the analysis categorizes the trip-generation rates by area type (land-use type).
- Pinjari et al. (2009) point out that there has been an increasing interest in land-use policies (such as mixed land-use development and transit-oriented development) that attempt to modify the land-use configuration in an effort to reduce auto-oriented travel and promote other means of transportation.

Type of bicycle facility

- Allen et al. (1998) conclude that the number of effective bicycle lanes is much more important than the actual width of a bicycle facility. Each additional effective lane being used by bicyclists dramatically increases capacity, regardless of the width of the facility.
- Schwartz et al. (1999) find an "S-shaped" relationship, in which there is a minimum level of bicycle use even with a poor network and a maximum level that relates to a good network. A slight improvement to a poor network has little effect until a certain minimum standard is achieved.
- Hunt et al. (2007) suggest three broad categories of cycling facilities that influence preferences:
  - "mixed traffic," where cyclists share the full roadway with other traffic without any longitudinal separation
  - "bicycle lane," where cyclists use the roadway with other traffic but have a separate lane that is longitudinally separated from the other traffic lanes and is exclusively for cyclists
  - "bicycle path," a separate facility that is typically much narrower than a roadway that cyclists use exclusively or share with other non-motorized traffic.
- Jones et al. (2008) conclude that several factors should be considered, such as measurable characteristics of a link in a road or path network (e.g., traffic volume, lane width, or pavement quality) when developing a non-motorized transportation model, or when incorporating non-motorized transportation into a traditional four-step model.

Traffic volume

- McDonald et al. (2007) use the Annual Average Daily Traffic (AADT) as an independent variable of a dependent variable "bicycle volume," in the method to estimate the volume of bicycle transportation.
- McCahil et al. (2008) conclude that the bicycle traffic volume is affected by the quality of bicycle facilities. To measure the quality, information specific to the safety and comfort of cyclists, such as the speed and volume of motor vehicle traffic, is necessary.
- Jones et al. (2008) conclude that several factors should be considered, such as measurable characteristics of a link in a road or path network (e.g., traffic volume, lane width, or
pavement quality) when developing a non-motorized transportation model, or when incorporating non-motorized transportation into a traditional four-step model.

Rain
- Niemeier (1996) suggests that count volume decreases by 15–25% on rainy days (p. 203).
- Parkin et al. (2008) find that rainfall has a relatively high negative impact (elasticity of 0.665), despite its measurement at the regional rather than the ward level (p. 104).
- Vancouver (2009) uses one automatic bicycle counter to analyze monthly variation in average daily bicycle volume. Typically, bicycle volumes reach their peak at mid-week and fall significantly at the weekend. The total number of cyclists on a rainy September day, mid-week, corresponds closely to the average daily volume of cyclists for the month of November. Vancouver speculates that those cyclists committed to riding on a rainy day in Summer or early Fall may be those who remain committed even when the weather turns cold and rainy later in the year (p. 7).

Temperature
- Niemeier (1996) estimates that lower temperature (< 55 °F) decreases bicycle volume by 27%.
- Parkin et al. (2008) conclude that the physical condition of the highway, rainfall, and temperature affect the proportion of the population that cycles to work. Temperature also has a high elasticity (+0.703), with higher mean temperatures being linked with a greater proportion cycling to work.
- Environmental Design and Management (2002) uses 1998 National Survey on Active Transportation, which revealed that 27% of the respondents considered weather as one of the important barriers to cycling (p. 16).

Age
- Parkin et al. (2008) find socio-economic variables relevant to the use of bicycles, including age, sex, car ownership, income, extent of higher or further education, ethnicity, household size and marital status, type of employment, and experience of cycling and engagement in other physical activity and exercise.
- Turner et al. (1997) find that the characteristics of the trip maker that influence travel mode choice include age, income, and vehicle ownership, and they conclude that age less than 25 correlates with bicycle use (r = 0.31).
- Hunt et al. (2007) point out that bicycling is an important means of transport for people under 16.

Income
- Turner et al. (1997) assume that characteristics of the trip-maker, including income, influence travel mode choice.
- Turner et al. (1998) assume that people with low incomes are likely to use bicycles more. They give a weighting factor of 1.5 to median household income for calculating the bicycle needs.
- Parkin et al. (2008) find that lower income has the effect of lowering the proportion of bicyclists commuting to work.
- Pinjari et al. (2009) use an activity-based approach to travel-demand analysis to determine self-selection effects of bicycle use. Their result suggests that high-income
households have a preference for out-of-home recreational activities/travel. They conclude that ignoring income effects can lead to a spuriously estimated negative effect of employment density and street block density on out-of-home recreational activities/travel.
1.4 Best practices annotated bibliography

There are many examples to draw upon for successful bicycle plans and bicycle related literature that could be used in guiding development of a bicycle toolkit. This document will serve as a summary of select research that might be useful in developing that framework upon which a toolkit can be designed.

- Association of Metropolitan Planning Organizations (http://www.ampo.org), cites four plans that are deemed exemplary models of pedestrian planning, bicycle master plan, trail partnership, and a regional transportation plan (link to all plans with brief description: http://www.ampo.org/content/index.php?pid=223). Examples cited include:
  - San Diego Association of Governments’ Pedestrian Design Guidelines. (http://www.ampo.org/assets/133_sandagped.pdf) – exhaustive look at design guidelines, especially in challenging topographies and built environments
  - Champaign County Regional Planning Commission: Urbana Bicycle Master Plan (http://www.ccrpc.org/bike/report.php) – heavy focus on defining and utilizing bicycle level of service in effort to prioritize projects
  - Northwest Arkansas RPC Heritage Trail Partnership
  - Flagstaff Metropolitan Planning Organization 2030 Regional Transportation Plan (http://www.ampo.org/assets/943_flagstaff2030rtp.pdf) – highlights implementation strategy of directing tax money to help build out network

  - (note: older version, new version is paid) This document examines the effectiveness—from specific examples of programs implemented throughout U.S. cities—of bicycle and pedestrian facility improvements and plans. Examples include community focus, bike and pedestrian plans, off-road facilities, on-road facilities, education/enforcement/encouragement, transit-related, and ancillary facilities.

  - Describes, in detail, the bicycle compatibility index shown above. If desired, how the compatibility index was developed can be found here: http://safety.fhwa.dot.gov/tools/docs/bcifinalrpt.pdf.

  - Somewhat dated document but fairly exhaustive in looking at primarily design considerations for pedestrians in a variety of built-environment contexts.

Compares two similar SF Bay Area neighborhoods (proximity to transit, freeway, and income levels) and their relationship with driving and non-motorized travel. The research suggests that the neighborhood with denser, mixed-use development opposed to less-dense development exhibits more non-motorized trips less than one mile.

  - A helpful section on “Recommended Programs: Education, Enforcement, Encouragement, & Evaluation” includes proposed projects that identifies target audience, primary agency, partners, key elements, time frame, cost, potential funding sources, sample programs, and a brief write-up. Helpful in making communities not only think about an abstract project but how that project is implemented, who it impacts, and where funding originates.

  - Summary approach to why, where, and what makes a successful bike city. Though dated, “bike cities” include those currently at the vanguard of cycling promotion (Portland, Davis, Palo Alto, Gainesville, Boulder, and Seattle). They cite a “formula” that has led to success, including the following characteristics that should be worked in tandem with the comprehensive plan.
    - “organization of a bicycle/pedestrian program”
    - “planning and construction of needed facilities”
    - “promotion of bicycling and walking”
    - “education for bicyclists, pedestrians, and motorists”
    - “enforcement of laws and regulations”

  - Place-based example (Arlington, VA) of the policies of the past thirty years have transformed Arlington, County into a more bicycle-friendly area.

  - Literature review that reveals why people commute or do not commute by bicycle. Determinants include built environment (urban form, infrastructure, facilities at work), natural environment (hilliness and landscape, seasons and climate, weather), socio-economic factors (socio-economic and household characteristics), psychological factors: attitude, social norms, and habits, (attitudes and social norms, perceived behavioral control, habits, reasons for (not) cycling), cost, travel time, effort, and (safety, transportation costs, travel time and effort).

  - Shows the results of two methods used in collecting information about how people wish to commute (i.e. on what facility type) and the impact bike paths have on land value.
  o Whereas Litman and the NSW Roads & Traffic Authority focus primarily on what to include in a bike plan, this report focuses on the actual process of developing a bike plan.

  o This is relevant because so many communities strive for this sort of recognition (be it a legitimate, founded, or compelling reason to promote cycling is not, in this context, up for debate). Cities often cite anointed titles as part of their promotional material. Though the title may be founded and thus pertinent, it may also lead to directing policy aimed at maintaining that title.
  o Communities are rated on 5-Es to become a bicycling community. They are Engineering, Education, Encouragement, Enforcement, and Evaluation and Planning.
  o Bicycle Friendly Communities are numerous (http://www.bikeleague.org/programs/bicyclefriendlyamerica/) with many Washington cities holding a ranking including Bainbridge, Bellingham, Olympia, Port Townsend, Redmond, Seattle, Spokane, and Vancouver while the state holds the overall #1 rank in the country. Seattle is one of x number of “gold” level cities.

  o Aimed at policy makers, planners and advocates and provides a framework by which to evaluate current bicycle and pedestrian practices and conditions. The report also poses questions and methods to develop plans.
  o Pages 80-88 lists resources and links to evaluating non-motorized transportation conditions, effective bike plans, pedestrian plans, roadway design, general bicycle and pedestrian planning, publications, and links to organizations (such as bicycling clubs, federal agencies, advocacy groups, and city agencies).

  o Though routed in Australia, this publication is more concise than the *Pedestrian and Bicycle Planning: A Guide to best practices* and contains a linear approach in developing a bike plan. Rather introductory, but perhaps a good starting point for smaller municipalities to begin thinking about a bicycle or pedestrian plan.

Parenti takes a multi-pronged approach when looking at the motivations and policies that drive Cambridge, MA in becoming a livable community, mainly through pedestrian and bicycle considerations. Emphasis is placed on a long-term approach (“A single project or program is unlikely to make a locality walkable or bikeable overnight.”). Support by the city council and a priority on safety drives Cambridge in becoming pedestrian-friendly and bikeable. Additionally, strong community support and involvement, employee programs, and engineering have all led to Cambridge becoming more bicycle and pedestrian friendly.

  - Examines best practices using a policy lens to determine what makes cycling successful and what policies deter it from gaining a higher mode share.

- Pucher, J., Dill, J., & Handy, S. (January 01, 2010). Infrastructure, programs, and policies to increase bicycling: An international review. *Preventive Medicine, 50*.
  - This document summarizes what major bicycle infrastructure projects are, where they are generally implemented, and the degree to which research can validate a project’s effectiveness on increasing ridership and/or safety.

  - From the perspective of behavioral health academics, this article concisely summarizes the main correlates of walking and cycling (e.g. density, connectivity, land use mix). They also provide a conceptual mock-up of the interplay of neighborhood environment, demographic and socioeconomic factors, and trip purpose.

  - Authors cite major tenets for promoting non-motorized transportation:
    - Integrate non-motorized planning into all transport and land use planning activities.
    - Educate all transportation professionals in non-motorized transportation planning principles.
    - Fund non-motorized planning at a comparable rate as other travel modes.
    - Insure that all roads are suitable for walking and cycling unless these modes are specifically prohibited and suitable alternatives are available.
    - Use current planning practices and design standards, including Universal Design ([http://www.vtpi.org/tdm/tdm69.htm](http://www.vtpi.org/tdm/tdm69.htm)).
    - Include non-motorized travel in transportation surveys and models.
    - Create pedestrian-oriented Commercial Centers and neighborhoods.
    - Perform user surveys to identify problems and barriers to non-motorized travel.
- Use traffic calming and other traffic control measures to make street environments safer and more pleasant for non-motorized transport (Victoria Transport Policy Institute, 2010)

  - Top-down commitment from the Virginia DOT that “initiates all highway construction projects with the presumption that the projects shall accommodate bicycling and walking.” While potentially outside the scope of our research, it does demonstrate the importance or developing top-down policy that encourages bike and pedestrian activity.

  - Offers suggestions regarding where communities should focus bicycle facility development and implementation. Though broad in scope, they recommend funding stand-alone bike improvements and identify the following as opportunities: new construction, reconstruction, resurfacing, sewer and gas line reconstruction, communications cable installation, major planned unit developments, and industrial/commercial/business park developments. Other sections include what to include in a bicycle element, how to obtain the information a municipality needs (i.e. process), summary of the bicycle compatibility index and level of service.

![Figure 28. Bicycle compatibility index](image)

- Also provides some resistance to strict AASHTO guidelines: “AASHTO and the National Committee on Uniform Traffic Control Devices have commented in favor of reducing existing inside vehicle lanes from 12 feet to 11 feet for the purpose of widening the right-hand lane for bicycle use. The City of Madison has made these improvements on several of its arterial streets. This should be performed after careful review of present and projected traffic characteristics along a corridor” (29).
- Includes *Basic Improvements for Bicyclists* appendix (51)
In addition to specific documents that highlight procedural and facility best practices for cycling, there are numerous advocacy groups, government websites, and other sites that list a wealth of links to other websites and documents. The informational scale, comprehensiveness, and reputation vary widely. However, many of the links in the following resources are found on numerous other sites. The duplication of online resources suggests that these are best practices, in that groups consistently recognize the same information.

This section will highlight the organizing body of the resources, the location, and main subject headers.

**Best online resources listings/Best Practice Reports:**

- **Complete Streets Resource Toolkit** created by the Sacramento Area Council of Governments: Links to many federal agencies, state departments and programs, large scale advocacy and firms groups separated by topic. [http://www.sacog.org/complete-streets/toolkit/START.html](http://www.sacog.org/complete-streets/toolkit/START.html)

- **Federal Highway Administration (FHWA) Publications** (legislation and funding; facility planning; facility design; facility operations; education and training; safety; additional publications) [http://www.fhwa.dot.gov/environment/bikeped/publications.htm](http://www.fhwa.dot.gov/environment/bikeped/publications.htm)
  → FHWA Resources: [http://www.fhwa.dot.gov/environment/bikeped/resources.htm](http://www.fhwa.dot.gov/environment/bikeped/resources.htm)


- **The Pedestrian and Bicycle Information Center Case Study Compendium** is an exhaustive look at case studies throughout the country that have proved effective. Main headings include Comprehensive, Education, Engineering, Encouragement, Planning, and Other. [http://katana.hsrc.unc.edu/cms/downloads/pbic_case_study_compendium.pdf](http://katana.hsrc.unc.edu/cms/downloads/pbic_case_study_compendium.pdf)

- **Planning Resources** - [http://planning.rudi.net/](http://planning.rudi.net/)
  - Extensive list of references in a multitude of planning topics, including Sustainable Transportation. Sub-sections include a comprehensive bibliography, names and addresses, and web resources (noticeable U.K. perspective but lots of United States context)
- List originally designed for students at University of Nottingham but is now facilitated through RUDI, Resources for Urban Design Information (www.rudi.net)

- Portland State University’s Initiative for Bicycle and Pedestrian Innovation, Bicycle and Transportation Pathfinder: Resources for Researchers, Practitioners, Students and Community Members (includes: pedestrians; urban transportation; streets, roads and traffic safety; bicycles, bicycle commuting and bicycle trails; city planning; other books and cd roms; web resources; useful search terms).

  - More links: [http://www.ibpi.usp.pdx.edu/links.php](http://www.ibpi.usp.pdx.edu/links.php) (links to Portland-based resources, advocacy groups and professional associations, universities and research institutions, planning and design firms, federal agencies, state bicycling agencies/coordinators)
2. Content analysis

2.1 Bicycle and pedestrian facilities policy analysis

Introduction
This content analysis examines bicycle and pedestrian facility plans in metropolitan, core, and large cities in the Puget Sound area. The analysis is based on the cities’ comprehensive plan transportation element, as well as other supporting documents, such as transportation master plans and bicycle and pedestrian master plans, which were specifically addressed in the comprehensive plan.

The purpose of this content analysis is to examine bicycle and pedestrian facility policy components in order to determine which components are commonly used and which are often overlooked in comprehensive plans in the region. Unique or remarkably extensive policies are noted. The finding of this analysis will highlight policy components that should be included in a bicycle and pedestrian facilities plan.

Review of bicycle and pedestrian plans
Below is a comprehensive list of the components found in the reviewed plans. As will be discussed later, most plans did not address all of the components. Table 5 presents an overview of policy components commonly used by the municipalities in the region. For a full review of each municipality’s plan, please see Section 2: Bicycle and Pedestrian Facilities Policy Content Review.

For the purpose of this content analysis, “network” refers to sidewalks, trails, and lanes, while “facilities” include networks, pedestrian crossing lights, bicycle parking, and other such amenities.
Table 5: Commonly used policy components

<table>
<thead>
<tr>
<th>City</th>
<th>Existing Conditions</th>
<th>Proposed Network Plan</th>
<th>Design Guidelines</th>
<th>Maintenance Policies and Procedures</th>
<th>Costs and Funding</th>
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Plan components

Existing conditions
- Inventory of existing facilities
- Map of existing network
- Condition of existing facilities
- System connectivity
- Needs assessment
- Safety issues and collision information
- Barriers and challenges for pedestrian and bicyclists.

Proposed facilities
- Location of improvements or new facilities
- Map of proposed network.

Implementation strategies
- Prioritization
- Desired level of service for bicycle and pedestrian network
- Plan update schedule
- Design guidelines
- Estimated costs
- Funding resources
- Maintenance plan
- Collaboration with other city departments
- Collaboration with other jurisdictions
- Relation to other elements of the comprehensive plan or city plans.

Other components
- Education and school programs
- Enforcement
- Program evaluation criteria
- Community participation and engagement
- Relation to existing regional networks
- Access to schools, parks, commercial areas, transit, etc.

Discussion
A comparison of the Planning and Policy Best Practices presented in Chapter 1 (Section 1) and content analysis of bicycle and pedestrian facility plans in the Puget Sound area indicate inconsistency in the type of components included in the plans, and the depth at which those components are discussed. In particular, discrepancies were found in the treatment of the existing conditions and implementation plan components of the plans. An evaluation of existing facilities and their needs provides information regarding facilities and a framework to suggest future projects. Currently, most plans provide only partial information regarding the conditions and needs of a city’s facilities, and many lack information regarding
physical conditions, barriers, and challenges for pedestrians and bicyclists, as well as safety issues and collision information.

The content analysis indicates that most municipalities in the region include only a few components of implementation strategies in their plan. Roughly a quarter of the cities in the region addressed facility maintenance in the plan, indicating procedures and level of maintenance. Of the cities that indicated a desired level of service, most defined it by the length of the network provided and considered it a part of the concurrency requirement for new development or redevelopment in appropriate areas. Though the length of the network provided may be a good indicator of network quality, it does not directly assess the level of service of provided facilities in a manner similar to roadway level of service. An example of level-of-service standards that addresses network quality could be found in the City of Mercer Island Pedestrian and Bicycle Facilities Plan, which defines level of service as a measure of a facility’s performance, including safety, continuity, connectivity, condition, directness, destination, distance, route attractiveness, and accessibility.\(^1\) Incorporating such a level of service enables the city to evaluate not only the existence of facilities but also their quality and condition.

An important component of implementation strategies is a prioritization plan, by which the location of future facilities is evaluated and chosen. Location prioritization criteria most commonly include improved access to transit, access to schools and other centers of activity, system connectivity, safety issues, and roadway hierarchy; other criteria may include recreational value, lack of alternative routes, community feedback, estimated costs, and potential for other funding sources. At present, not all plans provide such information. Finally, the inclusion of program evaluation criteria provides clear standards against which the success and progress of implementation could be measured. Program evaluation, used to measure the successes and progress of a program’s execution, is an essential part of implementation strategies, although only three cities include such criteria in their plans,\(^2\) and two cities discuss the need to develop such criteria in the future.\(^3\) The program evaluation of those cities’ matrixes includes measurable performance, performance targets, and current baseline measurements. The measurable performance used for the evaluation could include, but is not limited to, network miles added, percentage of the network completed, and the number of bicycle racks added.

Bicycle and pedestrian facilities development plans could often be linked to similar plans in neighboring jurisdictions and to other elements in the city’s comprehensive plan—e.g., land use, parks and recreation, and open spaces. In order to assure the effective execution of the plans’ objectives, economic efficiency, and the increase of system connectivity, such plans should include methods of collaboration and coordination with other city departments and other municipalities.

The extent, complexity, and condition of bicycle and pedestrian facilities differ among cities in the region. While the scopes of plans differ among cities, a comprehensive policy should include all components discussed in the review above to ensure its effectiveness. As noted in the Planning and Policy Best Practices section of this document, effective bicycle and pedestrian network and facility plans need to approach the planning process holistically and interdependently. By integrating with the components in the transportation and other elements in

\(^1\) City of Mercer Island Pedestrian and Bicycle Facilities Plan, p. 28
\(^2\) City of Mercer Island, City of Seattle, City of Shoreline.
\(^3\) City of Bellevue, City of Tacoma.
the comprehensive plan, communities can help to foster a long-term bicycle and pedestrian planning approach that works in tandem with effective design, encouragement, and educational efforts. Design guidelines could be used to categorize and evaluate the conditions of existing facilities, helping to guide future facilities development. Based on existing conditions and needs assessments, cities should use a variety of design tools to provide adequate facilities for bicycling for transportation. In this effort, cities will likely have to go beyond AASHTO and WSDOT minimum design guidelines.
2.2 Bicycle and pedestrian facilities policy content review

The purpose of this report is to provide an overview of bicycle and pedestrian facility plans in metropolitan, core, and large cities in the Puget Sound area. The overview is based on the cities’ policies, goals, and background information that specifically relates to bicycle and pedestrian facilities in the comprehensive plan’s transportation element. Additionally, the review includes other supporting documents, such as transportation master plans and bicycle and pedestrian master plans, which were specifically addressed in the comprehensive plan.

The overview includes a sample of representative policies for each city, as well as a comprehensive list of all policy components addressed in the plan. Unique or notably extensive policies or components are marked with an asterisk. The report is organized by cities’ size (metropolitan, core, large), followed by a review of supporting documents.

Bicycle and pedestrian components in comprehensive plans in metropolitan cities

City of Bellevue Comprehensive Plan

Bicycle and pedestrian facilities development is also addressed in the City’s Bicycle and pedestrian Transportation Facility Plan and the Pedestrian-Bicycle plan.

Components included
- Inter-jurisdictional implications.
- Incorporate bicycle and pedestrian facility improvements into roadway projects
- Providing new roadways in redevelopment and new development areas.
- Safety
- Accessibility and connectivity
- Consideration of non-motorized transportation when developing the transportation system
- Implementation
  - Designing and constructing a safe and connective non-motorized transportation system.
- Location priorities for future facilities based on:
  - Safety issues
  - Access to schools, parks, and commercial areas
  - Access to transit
  - System connectivity
  - Based on roadway hierarchy
- Facility maintenance
- “Develop an effective “share the road/share the trail” concept for bicycle and pedestrian education programs for the motorized and non-motorized public”.
- Existing conditions
- Map of existing facilities network
- Bicycle and pedestrian facilities relations to transit facilities development
- Providing development bonuses and/or incentives for incorporating TOD elements, walkability, and/or bicycle and pedestrian facilities.*
• Financing and funding sources

City of Bremerton Comprehensive Plan
Bicycle and pedestrian facilities development is also addressed in the City’s Non-Motorized Transportation Plan.
Components included
• Existing conditions
  o Complete bicycle routes network.
  o Lack of bicycle lanes
  o Identified missing links
  o Map of existing bicycle routes and arterial pedestrian facilities.
• Require new development or redevelopment to provide pedestrian facilities
• Location priorities for future facilities based on:
  o System connectivity
  o Access to and on ferries
  o Access to transit
  o Specified locations
• Safety
• Street standards which require bike lanes on identified bike routes.*
• Inter-jurisdictional coordination *
• Improvements and implementation plan

City of Everett Comprehensive Plan
Bicycle and pedestrian facilities development and connectivity are also covered under the City’s Station Area Plan, Everett Downtown Plan, and the Urban Design element of the comprehensive plan.
Components included
• Existing conditions
  o Number of existing back rakes and storage facilities
  o Location and design of existing trail and sidewalk systems
  o Map of existing facilities network
  o Special pedestrian zones
• Develop a Bicycle and pedestrian System Plan
• Safety
• Access to transit
• Encourage new development or redevelopment to provide bicycle and pedestrian facilities
• Financing
• Develop design standards
• Coordination with other jurisdictions
• Location priorities for future facilities based on:
  o Access to schools, parks, commercial areas, etc.
City of Seattle Comprehensive Plan

Bicycle and pedestrian facilities development and connectivity are also covered under the City’s Urban Village and Neighborhood Planning elements of the comprehensive plan, as well the under the City’s Bicycle Master Plan and Pedestrian Master Plan.

Components included

- Safety
- Bicycle network classification
- Map of existing bicycle network
- Implementation plan, including transportation choices education
  - Recognize that stairways located within Seattle’s public rights-of-way serve as pedestrian facility
  - Maintenance
  - Develop and apply performance measurements
  - Enforcement
  - Develop design guidelines
- Improve access to transit
- Improve access to schools, parks, commercial areas, etc.
- Increase walking and bicycling to help achieve City transportation, environmental, community and public health goals
- Network connectivity
- Regional connectivity
- Recognize that stairways located within Seattle’s public rights-of-way serve as
- Location priorities for future facilities based on:
  - Access to schools, parks, commercial areas, etc.
  - Access to transit
  - Safety problems
  - High level of growth
- Bicycles are classified as “vehicles” in the Seattle.
- History of facilities development
- Location and length of bicycle lanes
- Bicycle facilities definitions
- Bicycle and pedestrian facilities relations to land use planning and environmental stewardship

System connectivity
- Specified locations

Implementation plan
Map of future facilities
City of Tacoma Comprehensive Plan

Bicycle and pedestrian facilities development and connectivity are also covered under the City’s Open Space, Habitat, and Recreation Element, Neighborhood Element, and Downtown Element of the comprehensive plan. The non-motorized transportation section of the Transportation Element is derived and extracted from the Mobility Master plan. Bicycle and pedestrian facilities development is also addressed in the City’s Bicycle and pedestrian Design Guidelines.

Components included

- Location priorities for future facilities based on:
  - Designated centers and commercial areas
  - Specified locations
  - System connectivity
  - Access to transit
  - Access to schools
- Design guidelines (complete street)
- Provide height bonuses and other incentives to developments that promote walkability
- System connectivity
- Bicycle and pedestrian facilities relations to land use planning, Commuter Trip Reduction, environmental stewardship
- Financing and funding sources
- Regional connectivity
- Coordination with other jurisdictions
- Equality in access to facilities
- Safety
- Implementation strategies and costs
- Maintenance strategies
- Transit integration
- Education and encouragement
- Enforcement
- Establish performance evaluation
- Facilities definitions
- Elaborate infrastructure Project Evaluation Criteria
  - System connectivity
  - Equity
  - Cost effectiveness
  - Suitability for bicycling and/or walking with improvements
  - Integration into the existing local and regional networks
  - Projected reduction in vehicle trips and vehicle miles traveled
- Short term project priority list
- Need for way-finding signage
- Map of existing and planned networks
- Intersection Improvement Recommendations
Bicycle and pedestrian components in comprehensive plans in core cities

*City of Auburn Comprehensive Transportation plan*

**Policies and goals**

- Include the role of non-motorized transportation in all transportation planning, programming, and if suitable, capital improvement projects.
- Plan for continuous non-motorized circulation routes within and between existing, new or redeveloping commercial, residential, and industrial developments.
- Appropriate street furniture, lighting, signage, and landscaping should be installed along non-motorized routes.
- Minimize hazards and obstructions on the non-motorized transportation system by properly designing, constructing, managing, and maintaining designated routes in the system.

**Components included**

- Existing conditions
- Location of existing bicycle trails
- Inventory of existing facilities
- System connectivity
- Map of existing facilities
  - Improvements needed
- Design guidelines
- Funding
- Safety
- Education
- Enforcement
- Location priorities for future facilities based on:
  - Specified locations
  - Access to schools, parks, commercial areas, etc.
  - Access to transit
  - Roadway hierarchy
  - Regional connectivity
  - Criteria for bike facilities projects location

- Map of proposed network

*City of Bothell Comprehensive Plan*

**Goals and policies**

- Include bicycle facilities and amenities as components in future roadway construction and maintenance projects.
- Update the Transportation Improvement Program to identify a priority list of proposed bicycle facilities.
- Include pedestrian facilities in new or renovated arterials and collectors.
• Pedestrian connections and easements should be required of developers of subdivisions to provide convenient and direct connections to schools, bus stops, parks, and businesses.

**Components included**

- Existing conditions
  - Location of sidewalks
  - Existing bicycle lanes length
  - Needs assessment
  - Map of existing facilities
- Access to transit
- Map of proposed networks
- Design guidelines
- Estimated costs

**City of Burien Comprehensive Plan**

**Goals and policies**

- The City should consider multimodal transportation alternatives and land use coordination when feasible. The adequate provision of pedestrian and bicycle facilities shall be as important consideration as adequate street in the city review of development projects for transportation system impact.
- Requiring pedestrian facilities in all new development and redevelopment.
- Create a safe environment for bicyclists and pedestrians by physical separation, pedestrian walk lights and bicycle activated signals, wherever possible,
- The City should require bicycle parking at all City-owned facilities and parks.

**Components included**

- Existing conditions
  - Pedestrian/Bicyclist accidents information
  - System connectivity
- Safety
- Education and school programs
- Relation to other City plans
- Regional connectively
- Community participation and engagement
- Location priorities for future facilities based on:
  - Safety
  - Access to schools, parks, commercial areas, etc.
  - System connectivity
  - Specified locations
- Implementation strategies
- Map of proposed facilities
- Enforcement
- Funding
- Plan update schedule
- Coordination with other jurisdictions

City of Federal Way Comprehensive Plan

Goals and policies
- Provide a one-mile grid of bicycle facilities connecting major activity centers, recreational facilities, and schools
- Incorporate bicycle and pedestrian features as design elements in the City Center
- Work with high capacity transit agencies to ensure such non-motorized travel amenities are incorporated in the design and improvement of transit facilities.
- Emphasize the enforcement of laws that reduce pedestrian, cyclist, and vehicle conflict.
- Provide sidewalks on both sides of all arterial streets as funding allows

Components included
- Education and school programs
- Access to schools, parks, commercial areas, etc.
- System connectivity
- Safety
- Coordination with other jurisdictions
- Enforcement
- Short-, mid-, and long-term implementation strategies
- Desired level of service
- List of future bicycle facilities
- TIP provides a prioritized listing for facilities improvements
- Improvements options
- Funding
- Map of existing network

City of Kent Comprehensive Plan

Goals and policies
- Encourage new bicycle and pedestrian facilities wherever possible
- Establish a network of bicycle routes within the City to connect those land uses likely to produce significant concentrations of bicycle usage.
- Use incentive or regulations to encourage new construction to promote pedestrian and bicycle facilities
- Whenever practical, provide safe access for pedestrians and bicyclists to transit stops

Components included
- Existing conditions
  - pedestrian facilities conditions and standards
  - length of existing bicycle network
  - map of existing bicycle facilities
- Implementation
  - Require facilities in new development.
• Design guidelines
• Access to transit
• Map of proposed bicycle network
• The City has not established a LOS standard for walking and does not yet have an adopted sidewalk map.

City of Kirkland Comprehensive Plan
Goals and policies
• Develop and promote system of bicycle and pedestrian routes that forms an interconnected network between local and regional destinations
• Design streets with features that encourage walking and bicycling.
• Promote a comprehensive and inter-connected network of pedestrian and bike routes within neighborhoods.
• Ensure that there is sufficient right-of-way

Components included
• Existing conditions
  o Map of existing network
• Access to schools, parks, commercial areas, etc.
• Safety
• List of improvements proposed
• System connectivity
• Desired level of service
• Coordination with other jurisdictions

City of Lynnwood Comprehensive Plan
Goals and policies
• Develop an integrated non-motorized “skeleton” transportation system of sidewalks and bicycle facilities
• Public sidewalks shall be required of new development, in residential areas and along arterials.
• Identify safe walk routes for students and work with school district staff to enhance the safety of crosswalks.
• The city shall evaluate codes with regards to operation and maintenance of sidewalks and develop the appropriate policies to ensure adequate, long-term maintenance of facilities.

Components included
• System connectivity
• Existing conditions:
  o Existing pedestrian network
  o Condition and length of existing pedestrian facilities
  o System connectivity
  o Maps of existing networks
- Proposed improvements
- Location priorities for future facilities based on:
  - Access to schools, parks, centers of activity, etc.
  - Safety
  - Access to transit
  - System connectivity
  - Roadway hierarchy
  - Right of way necessary to construct improvements.
  - Potential for redevelopment of segment by private developer or capital project
  - Potential for other funding sources
  - Active Neighborhood groups

Funding

The City of Puyallup Comprehensive Plan

Goals and policies
- A comprehensive non-motorized circulation plan and implementation program will be developed and used to guide alignment, improvements, and standards for walkways and bikeways.
- Connection of community trails to regional trail systems should be emphasized in the planning process.
- The City shall develop and implement design and construction standards for walkways which consider the intensity of the surrounding land uses and the classification of the associated roadway.
- Streets associated with bicycle routes should be swept on a regular basis to maintain debris-free roadway surfaces, and should be maintained free of paving gaps and deformities to the extent feasible.
- The City should utilize non-motorized system improvement priorities as a factor in determining the time of roadway improvement projects such that emphasis is given to improving the overall transportation circulation system.
- The City should coordinate with other agencies in determining the need for and placement of bicycle and pedestrian facilities.
- The City shall consider implementing interim improvements which connect key missing links within principle walkways and bikeways when the timing of permanent facilities is uncertain.
- The City should consider strategies such as crime prevention through environmental design (CPTED) as bicycle and pedestrian facilities are developed.
- The zoning code should be amended to establish bicycle parking standards.

Components included
- Existing conditions
  - Map of existing networks
 Sidewalk inventory and locations
 Facilities classification by use
- Community participation and engagement
- Access to transit
- Planned improvements should be incorporated into capital facilities planning.
- Maps of proposed networks
- Design guidelines
  - Location, and width of route
  - Separation from roadway
  - Signed Bicycle Routes
  - Bicycle Paths
- Maintenance
- Education program
- Access to transit
- Implementation strategies
- Funding
- Coordination with other jurisdictions and agencies

**City of Redmond Comprehensive Plan**
Bicycle and pedestrian facilities development and connectivity are also covered under the City’s Transportation Master Plan.

Goals and policies
- Wherever possible, create a physical separation between pedestrians and traffic lanes.
  - Establish an ongoing allocation of funds for the construction and maintenance of non-motorized improvements.
  - Interconnect neighborhoods and be connected with surrounding jurisdictions to allow people to travel within and between them
  - Prepare bicycle and pedestrian programs at the citywide and neighborhood levels.
  - Require that during the review process for new development or redevelopment projects are consistent with the bicycle and pedestrian plans

Components included
- Safety
- System connectivity
- Regional connectivity
- Funding

**City of Renton Comprehensive Plan**

Goals and policies
- Integrate Renton's non-motorized transportation needs into a comprehensive transportation system serving both local and regional users.
- Bicycle and pedestrian traffic should be accommodated within all areas of the City.
• Where right-of-way is available and bicycle demand justifies them, bicycle lanes should be marked and signed to accommodate larger volumes of bicycle traffic on select streets designated by the City.
• Secure bicycle parking facilities, such as bike lockers and bike racks should be provided at residential, commercial, and public establishments to encourage bicycle use.
• Foot/bicycle separation should be provided wherever possible; however, where conflict occurs, foot traffic should be given preference.

Components included
• Existing conditions:
  o Map of existing facilities network
• Needs assessment
  o Types of bicycle facilities needed.
  o Improvements needed
• Location of proposed facilities.
• Safety
• System connectivity
• Regional connectivity
• Creation of trails for recreational use.
• Estimated costs
• Funding

City of SeaTac Comprehensive Plan
Goals and policies
• Provide sidewalks or other designated pedestrian facilities on both sides of the street along principal and minor arterials and some designated collector arterials where appropriate. Pedestrian facilities on non-arterial streets may be constructed on only one side of the street.
• Focus safety and pedestrian capacity improvements on streets that provide access to schools, parks, transit facilities and other public facilities.
• Develop a system of bicycle routes providing for travel within the City with connections to regional facilities and major local destinations (such as North SeaTac Park or SeaTac International Airport).

Components included
• Design guidelines
• System connectivity
• Regional connectivity
• Implementation strategies
• Identify the need for a comprehensive system of non-motorized facilities to serve recreational needs.
City of Tukwila Comprehensive Plan

Goals and policies
- Implement specific improvements that provide safe bicycle and walking capacity for regional and local trips.
- Include bicycle improvements in street improvement projects on designated bicycle-friendly streets.
- Require secure bicycle racks in appropriate locations.
- Public/private funds to augmented pedestrian network

Components included
- Collaboration with other jurisdictions.
- Implementation strategies.
- Location priorities for future bicycle and pedestrian facilities.
- Non-motorized transportation safety issues are addressed in Transportation Safety and Maintenance section.
- Tukwila Urban Center plan will include inventory of existing facilities.

Bicycle and pedestrian components in comprehensive plans in large cities

City of Arlington Comprehensive Plan

Goals and policies
- Encourage the use of bicycles as a transportation alternative by providing bicycle lanes on arterial and collector streets.
- Provide adequate traffic signs to assist in safeguarding pedestrians, bicycle riders, and especially children on streets near schools and playgrounds.
- Revenue designated to sidewalk improvements should be prioritized to first facilitate safe movement for elderly and handicapped persons between residences and shopping/social activity centers, and facilitate safe movement for children to and from school facilities and school bus stops.
- Coordinate bicycle/pedestrian facility improvements, including the Centennial and Airport Trails, with neighboring jurisdictions to connect routes where possible.
- All new public facilities should incorporate measures or facilities that encourage alternate modes of transportation, such as showers/dressing rooms, locker, and bike lockers.

Components included
- Existing conditions
  - Map of existing trail network.
- Policies regarding bicycle and pedestrian development are also covered under Parks, Recreation and Open space elements.
- Funding.
- Coordination with other jurisdictions.
City of Bainbridge Island Comprehensive Plan

Goals and policies

- Develop non-motorized design standards that provide safe and efficient access, encourage use and mobility.
- Promote the safety of non-motorized users through effective transportation improvements, maintenance operations and enforcement.
- Provide mechanisms for funding, prioritizing and implementing the non-motorized transportation system plan.
- Locate and design bicycle facilities that effectively accommodate both commuters and recreational users. The system shall include separated bicycle pathways, on-road bicycle lanes, paved shoulders, and shared facilities.
- Develop a system of trails for non-motorized use that connects Neighborhood Service Centers, the ferry terminal, schools, parks, road ends, shoreline trails and greenways of Bainbridge Island, including existing equestrian use trails.
- At driveways, construct walkways that remain at the walking surface plane wherever possible.

Components included

- Safety
- Desired level of service
- Existing conditions
  - Facilities inventory and location
  - Inventory of Non-Motorized Attractions
  - Informal travel routes
  - Barriers for users, such as the lack of safe crossing at intersection, roadway shoulders, and natural barriers.
  - Inventory of known barriers locations on bicycle and pedestrian networks
- Location of proposed facilities.
- Location and priorities of proposed facilities.
- Facility type definitions
- Design guidelines for material, color, width, and height of bicycle and pedestrian facilities.
- Implementation strategies
  - Advocacy. The formation of Non-Motorized Advocacy Committee.
  - Public involvement strategies.
- Financing
- Estimated costs
- Education-school programs
- Encouragement and promotion programs.
- Enforcement
City of Des Moines Comprehensive Plan
Goals and policies

- Provide a connected network of non-motorized transportation facilities, and improved existing facilities.
- Prioritize bicycle and pedestrian improvements that provide access to schools, parks and other public buildings. Provide bicycle racks at schools, parks, and other public buildings.
- Provide a bicycle network that supports the use of bicycles as a means of general transportation as well as a recreational activity.
- Construct new streets with sufficient width to allow for bicycling on identified bicycle corridors

Components included
- Network connectivity
- Location priorities for future facilities based on:
  - Access to schools, parks, center of acidities, etc.
- Implementation strategies
- Collaboration with other jurisdictions

City of Edmonds Comprehensive Plan
Bicycle facilities development and connectivity are also covered under the City’s Bikeway Comprehensive Plan.
Goals and policies

- The City should construct pedestrian facilities on all major streets and highways where there is sufficient pedestrian traffic
- Pedestrian facilities should interconnect with other modes of transportation.
- Sidewalks should be constructed of concrete (and in limited circumstances, asphalt) materials. Variation in surface texture should be provided wherever possible.
- Sidewalks should be lighted where nighttime use is common.
- Sidewalks should be located to take advantage of views and other amenities.
- Bicycle facilities should be separated from sidewalks in congested areas.
- Bicycle racks or bicycle lockers should be provided in commercial and recreational areas.
- Provision must be made for maintenance of City bicycle facilities.

Components included
- Existing conditions:
  - Location of existing facilities
  - Map of existing facilities
- Recreational walkways are designated in City of Edmonds Comprehensive Walkway Plan.
- Connectivity of facilities to other modes of transportation
- System connectivity
• Safety
• Design guidelines
• Location priorities for future pedestrian facilities based on:
  o safety
  o Access to schools, parks, commercial areas, etc.
  o System connectivity
  o Level of activity
  o Consistency with other city plans.
  o Environmental impact.
  o Public support.
• Location of proposed facilities
• The plan includes Sidewalk Construction Policy, clarify when sidewalks should be constructed as a condition of development

City of Fife comprehensive Plan
Goals and policies
• Develop bicycle and pedestrian systems.
• The Transportation Element supports the construction of bicycle paths along designated routes as part of street development standards.

Components included
• Existing conditions
  o Inventory of existing pedestrian facilities.
  o Map of existing pedestrian network under the Land Use Element
  o Lack of bicycle and pedestrian alternatives
• The City's Park and Recreation Plan address future facilities.
  o Create a network of interconnected, multipurpose non-motorized trails for walking, hiking, cycling and to promote connectivity between parks, neighborhoods and public amenities.
  o All city residents should live within one mile of an improved trail corridor.

City of Issaquah Comprehensive Plan
Goals and policies
• A presumption that bicyclists and pedestrians will be accommodated in the design of new and improved transportation facilities.
• The decision NOT to accommodate them should be the exception not the rule, and there must be exceptional circumstances for denying access through design or prohibition.
• Establish annual funding used to construct and maintain non-motorized projects identified on the
• Use the Sidewalk Priority Criteria to establish a performance system to determine the location of sidewalks to be constructed or restored
Components included
- Existing conditions
  - Map of existing facilities network
- Distinguish between recreational trails and non-motorized corridors, pedestrian walkways and bicycle transportation facilities.
- Access to schools and parks
- Design guidelines
- Map of proposed network
- Location priorities for future pedestrian facilities based on:
  - Safety
  - Access for senior citizen groups or disabled
  - System connectivity
  - Roadway hierarchy
  - Access to transit
  - Non-conformance width of existing sidewalk
- Funding
- Implementation strategies
- Require new or redeveloping properties to design and build bicycle and pedestrian facilities
- Education and school programs
- Safety

City of Kenmore Comprehensive Plan
Goals and policies
- Require development to provide additional sidewalks along local streets
- Based upon the City’s sidewalk inventory, denote some neighborhoods and the local streets within them, as “sidewalk free”.
- Apply street and sidewalk design standards and develop a system that responds to the needs of persons who are elderly, disabled or have other special needs.
- Require roadway development along identified links to include bicycle lanes.
- Facilities improvements prioritization.
- Accommodate bicycles and non-motorized vehicles in the design and management of the City street network

Components included
- Existing conditions
  - Inventory of existing facilities.
  - Map of existing sidewalks and shoulders.
- Proposed improvement projects
- Map of proposed facilities
- Estimated costs
- Funding
• Location priorities for future facilities based on:
  o Roadway hierarchy and condition
  o System connectivity
  o Accessibility to disable users
  o Safety
  o Promotion of intermodal trips
  o Remove a significant barriers

• Criteria for areas that will remain “sidewalk free”, e.g. environmentally sensitive areas, or areas where the likelihood of a sidewalk LID forming is poor.

• Implementation strategies.

City of Maple Valley Comprehensive Plan
Bicycle and pedestrian facilities development is also addressed in the City’s Non-Motorized Transpiration Plan.
Goals and policies
• When appropriate, place conditions on proposed new developments to ensure convenient walking and bicycling systems
• Integrate walking and bicycling facilities into the City’s Capital Improvements projects.
• Cooperate and coordinate with regional agencies and adjoining jurisdictions.
• Recognize the importance of non-motorized travel within Maple Valley
• Strive to integrate bicycle and pedestrian facilities, services, and programs into City of Maple Valley Transportation Systems where appropriate.
• Develop a map of Maple Valley’s bicycle routes and trail system

Components included
• Collaboration with other jurisdictions
• Facilities on trails and trailheads

City of Marysville Comprehensive Plan
Goals and policies
• Establish right-of-way and design standards that accommodate non-motorized transportation facilities
• Promote roadway designs that allow for alternate travel mode choices.
• Complete the arterial sidewalk system
• Create a comprehensive network of bicycle facilities in Marysville

Components included
• Existing conditions
  o Inventory of existing facilities
• Location of proposed facilities
• System connectivity
• Location priorities for future facilities based on:
  o Roadway classification and condition
- Accessibility to disable users
- Safety
- Located in an area where there are no parallel pedestrian routes
- Access to residential and commercial areas

- Implementation strategies
- Funding
- Access to residential and commercial areas

**City of Mercer Island Comprehensive Plan**

Bicycle and pedestrian facilities development is also covered in the City’s Bicycle and Pedestrian Facilities Master Plan

**Goals and policies**

- The City of Mercer Island will work to provide for and encourage non-motorized travel modes
- Promote bicycle networks that safely access and link commercial areas, residential areas, schools, and parks within the City.
- Emphasize non-motorized improvements that provide alternatives to single-occupancy vehicles.
- The City of Mercer Island will provide facilities for pedestrians and bicyclists designed in keeping with individual neighborhood characteristics.

**Components included**

- Inventory of existing facilities.
- System connectivity
- Collaboration with other jurisdictions and agencies.
- Access to schools, parks, and centers of activity.
- Safety

**City of Mill Creek Comprehensive Plan**

**Goals and policies**

- Pedestrian circulation should be provided by public sidewalks throughout the central business district and residential neighborhoods. Wherever possible, sidewalk should be provided on both sides of the street and separated from the curb.
- Sidewalks shall be "transit oriented" (i.e., located to connect neighborhoods to transit stops and include pedestrian boarding pads where appropriate).

**Components included**

- Level of service for bicycle and pedestrian facilities.
- Existing condition
  - Inventory of facilities
  - Condition and adequacy of existing facilities.
- Planned improvements
- Design guidelines
- Safety
- Access to transit

**City of Monroe Comprehensive Plan**

**Goals and policies**
- Design new facilities to appropriate standard
- Design new local access streets to provide safe movement of pedestrians and bicycles, and automobiles.
- Provide safe crossing for pedestrians and bicyclists across major conflict points.
- Provide bicycle racks in commercial and recreational areas
- Integrate parking facilities in the downtown area with pedestrians, bicycle, and transit circulations.
- Develop design standards for non-motorized transportation facilities, and site design criteria to enhance pedestrian access.

**Components included**
- Safety
- Pedestrian accessibility
- Connectivity within and between residential and commercial areas
- Existing conditions
  - Map of existing facilities network
  - School accessibility
  - Inventory of pedestrian facilities located along arterials and collectors
- Map of existing and proposed facilities
- Recommended improvements

**City of Mountlake Terrace Comprehensive Plan**

Bicycle and pedestrian facilities development is also addressed in the City’s Transportation Master Plan.

**Goals and policies**
- Sidewalks are required on both sides of new development
- Encourage landscaping, benches, lighting, and other amenities along key pedestrian corridors.
- Design sidewalks in ways that provide a buffer between pedestrians and vehicle traffic.
- Encourage the provision of bicycle racks in convenient locations.
- Seek partnerships to develop or maintain bicycle routes

**Components included**
- Needs assessment
  - Sidewalk network repair and development
- Inventory of existing facilities
- Map of existing network
- Location priorities for future pedestrian facilities based on:
City of Mukilteo Comprehensive Plan
Goals and policies

- Bicycle and pedestrian facilities should be developed to link schools, businesses, recreational areas, and other activity centers with public transportation and ferry system facilities.
- Convenient and secure bicycle parking should be provided in activity and transportation centers

Components included

- Existing conditions
  - Pavement condition
- Inventory of existing conditions
- Map of existing network
- Access to schools, parks, centers of activity, and commercial areas
- Access to transit

City of Sammamish Comprehensive Plan

Bicycle and pedestrian facilities development is extensively addressed in the City’s Trails, bikeways, and Paths Plan.

Goals and Policies

- Develop and enforce adequate safety expectations and ordinances.
- Emphasize Recreational Trail Experiences.
- Promote high standards for the design and maintenance of trails bikeways and paths.
- Coordinate development of right of way and off-street opportunities
- Ensure local access to transit centers and bus stops
- Ensure plan remains relevant and current.

Components included

- Existing conditions
  - Inventory of existing facilities
- Recommended improvements
  - Locations
  - Estimated costs
• Public participation is encouraged
• Access to schools, parks, and commercial areas
• Collaboration with other jurisdictions
• Design guidelines
• Safety
• Enforcement
• Plan update
• Access to transit
• Under parks, rec. and open space
  o Provide amenities at parks and recreation open space facilities such as lighting, seating, drinking fountains, trash receptacles, bicycle racks, and shelters wherever possible and appropriate to extend hours of use and service quality.

*City of Shoreline Comprehensive Plan*

Bicycle and pedestrian facilities development is also extensively addressed in the City’s Transportation Master Plan.

**Policies and goals**

• Evaluate and field test installation of devices that increase safety of pedestrian crossings
• Implement the Transportation Master Plan that integrates “Green Streets”, bicycle routes, curb ramps, major sidewalk routes, street classification, bus routes and transit access, street lighting and roadside storm drainage improvements.
• Place high priority on sidewalk projects that abut or provide connections to schools, parks, transit, shopping, or large places of employment.
• Work with the bicycle community to develop bicycle routes connecting schools, recreational and commuter destinations, including transit linkages. Aggressively pursue construction of the Interurban Trail as the spine of the City’s bicycle system.
• Require all commercial, multi-family and residential developments to provide bicycle and pedestrian facilities

**Components included**

• Existing conditions
  o Community impute
  o Location of existing bike lanes
  o Map of existing facilities network
  o Pedestrian-bicycle accident data
• Safety
• Implementation
• Community engagement and participation
• Collaboration with other jurisdictions
• Location priorities for future facilities based on:
  o Access to schools, parks, centers of activity, and commercial areas
City of University Place Comprehensive Plan
Policies and goals
- Require sidewalks on all public streets
- Develop a system of bicycle routes that provides for travel within the city with connections to local parks and regional facilities.
- Encourage installation of pedestrian pathways in new and existing developments.
- Providing adequate sidewalks, bikeways, pathways, and crosswalks

Components included
- Needs assessment
  - lack of sidewalks and bicycle lanes
  - Need for bicycle and pedestrian network connectivity around schools
- System connectivity
- Safety
- Access to schools
- Proposed improvements
- Map of existing facilities
- Map of proposed improvements
- Inventory of existing facilities

City of Woodinville Comprehensive Plan
Policies and goals
- Actively promote the use of bicycle and pedestrian transportation.
- Pursue opportunities for expansion of multipurpose trails separated from the street systems.
- Provide bicycle and pedestrian facilities on all new and existing links of the City’s arterial system, trails, and commercial centers.
- Require pedestrian amenities to reduce pedestrian, non-motorized and motor vehicle conflicts at activity centers
- Providing adequate sidewalks, bikeways, pathways, and crosswalks

Components included
- Previous studies of bicycle facility use.
- Itemized list of facilities
- Inventory of off-street multipurpose trails
- Access to schools, Parks, centers of activity and commercial areas
- Map of proposed facilities
- Implementation plan
- Plan monitoring
Other transportation plans

City of Bellevue Pedestrian and Bicycle Transportation Facility Plan
The Plan’s purpose is to direct the creation of bicycle and pedestrian facilities system that is continuous and safety-oriented. The Plan expands on relevant policies in the City’s comprehensive plan but mostly covers the same planning elements.

Components included
- Location for future facilities should be based on:
  - System connectivity
  - Safety issues
  - Access to transit
  - Access to schools, parks, and activity centers
- Consider non-motorized transportation in planning decisions and project stages, including roadway construction and maintenance, easements
- Short and mid-term implementations strategies
- Protect and ensure access to all public trail easements.
- Install way finding
- Education
  - Provide maps and internet based information
  - School programs
- Design guidelines
- Factors in design guidelines (Intended use, travel speed, cost, etc)
- Safety
- Enforcement
- Frequency of update
- Develop procedures to collect data for performance evaluation
- Inter-departmental coordination
- Locations and priorities of proposed projects
  - Maps of proposed projects

City of Bellevue Pedestrian-Bicycle Plan
The City’s Pedestrian Bicycle Plan contains information on the policies and projects in the Comprehensive Plan and the Bicycle and Pedestrian Transportation Facility Plan. The Pedestrian Bicycle Plan is not a regulatory document but a “guide toward a common vision”.

Components included
- policies a noted in the Comprehensive Plan and the Bicycle and pedestrian Transportation Facility Plan:
  - network integration
  - prioritization
  - regional coordination
  - accessibility
  - implementation
- benefits and barriers for biking and walking
- Existing Bicycle and pedestrian Facilities
Existing Bicycle Facilities and Typologies

- Network planning process
- Locations and priorities of proposed projects
- Maps of proposed projects

City of Bremerton Non-motorized Transportation Plan

The plan provides an inventory and assessment of existing bicycle and pedestrian facilities conditions and recommends strategies for improvements.

Components included

- Existing Conditions
  - Location and condition of facilities
  - Positive system attributes, including design and condition of facilities
  - System’s deficiencies, design and condition of facilities
  - Bicycle and pedestrian crash history
  - Access to transit and ferries
  - Access to schools and Olympic College
  - Map of existing facilities
- Stakeholder and public outreach process
- Recommendations for improvements and implementation strategies
  - Improve network connectivity
  - Way-finding signage
  - Education and school programs
  - Update Municipal Code bicycle parking requirements
  - Create a Bicycle/Pedestrian Technician position
  - Improve enforcement
- Recommended bicycle and pedestrian projects
- Regional connectivity
- Map of exiting network
- Maps of bicycle and pedestrian issues and opportunities (unsafe crossing, activity center, etc.)
- Maps of proposed network
- Location priorities for future facilities based on:
  - System connectivity
  - Multi-Modal coordination
  - Access to schools, parks, and commercial areas
  - Aesthetics and visual amenities for pedestrian and cyclists.
- Funding

City of Everett Bicycle Master Plan Draft

The plan currently available is a bicycle master plan draft. The plan expands on the City’s Comprehensive Plan with route prioritization, physical design and programmatic support, and provides an updated inventory and assessment of Everett’s bikeway network

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Components included
• Planning process, public and agency involvement.
• Existing conditions
  o Past planning efforts
  o Climate & topography
  o Transportation infrastructure
  o Positive system attributes, including design and condition of facilities
  o System’s deficiencies design and condition of facilities
  o Map of existing facilities
  o Bicycling events
  o Data collection and public involvement summary
  o Inventory and evaluation of existing facilities
• Recommendations
  o Proposed connections between existing facilities
  o Proposed facility additions - short, mid, and long term implementation schedule
• Map of proposed facilities
• Location priorities for future facilities based on:
  o Overcomes obstacles (connectivity and access)
  o Connectivity
  o Provides access to CTR employers
  o Access to schools, parks, and commercial areas
  o Access to transit
  o Lack of alternative routes
  o Recreational value
  o Community stated need
  o Topography requires facility
  o Roadway traffic volume and bicycle suitable
• List of proposed projects
• Education and school programs
  o Existing education and outreach efforts
  o Recommendations for improvements and development
• Maintenance
• Enforcement
• Way-finding Signage
• Design standards
• Implementation strategies
• Estimated cost
• Funding
City of Edmonds Bikeway Comprehensive Plan

Components included

- Facilities’ definitions
- Location priorities for future facilities, including relative importance, based on:
  - Access to schools
  - Access to transit
  - Access to recreational opportunities
  - Access to commercial areas
  - System connectivity
  - Route directness
  - Motorized traffic speed
  - Roadway width
  - Roadway grade
  - Sight distance
  - Traffic volume
  - Problem intersections
- Existing conditions
  - Existing facilities inventory, locations and conditions
- Implementation strategies
  - Short- mid- and long-range projects
- Location of proposed facilities.
- Design guidelines
- Maintenance
- Estimated cost
- Funding

City of Maple Valley Non-Motorized Transportation Plan

The plan reiterates the city’s goals and policies presented in the comprehensive plan, and expand on implementation strategies.

Components included

- Existing conditions
  - Location of existing facilities
  - Maps of existing networks
- Relation to regional non-motorized transportation plans
- Relation to other City plans and policies
- Ensure consistency between policies and plans
- Collaboration with other jurisdictions
- Implementation strategies
- System connectivity
- Safety
Location priorities for future facilities based on:
  - Access to centers of activity
  - Specified locations
  - Safety
  - Improved accessibility
  - System connectivity

Education and encouragement programs

Enforcement

Address the needs of pedestrian and bicyclists in all new construction and retrofitting of City transportation facilities.

Design guidelines

Community participation

Implementation

Estimated costs

Project prioritization process

Plan administration

Map of proposed facilities

Design alternatives for trail system connection

Funding

*City of Mercer Island Pedestrian and Bicycle Facilities Plan*

Components included

- Existing conditions
  - Inventory of existing facilities
  - Map of existing facilities
  - Map of local destinations
  - Map of elementary school Walk zone
  - Status of 1996 Plan projects
  - Traffic generators and elementary school walk zones

- Desired level of service and performance criteria
- Design guidelines
- List of proposed facilities
- Map of proposed networks
- Map of proposed improvements
- Map of potential parking concerns
- Location priorities for future facilities based on high, medium and lower priorities:
- Community participation and engagement
- Public outreach
- Vision and guiding principles for bicycle and pedestrian facilities
- System connectivity
- Safety

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- Maintenance
- Access to schools, parks, centers of activity, etc.
- Education and school programs
- Consider the needs of users with limited or alternative mobility, such as individuals with strollers, skaters, dog walkers, joggers, seniors and people with disabilities.
- Estimated costs
- Signage
- Funding

City of Mountlake Terrace Transportation Master Plan
Components included:
- Design standards and guidelines
- Existing conditions
  - Inventory of existing facilities
  - Maps of existing facilities
  - Needs assessment
- Location properties for future facilities based on:
  - Safety
  - Improve condition and reduce barriers
  - Access to schools
  - System connectivity
  - Access to transit
  - Existence of infrastructure
  - Public support
- Recommended projects
- Maps of proposed facilities
- Implementation strategies
- Estimated costs
- Funding

City of Mukilteo Bicycle, Pedestrian and Trails Plan
Components included:
- Safety
- System connectivity
- The Plan distinguishes between four types of facilities: bike/pedestrian (on-road), pedestrian trails (off-road), mountain bike trails (off-road), and waterfront access.
- Existing conditions
  - Mile of bike lanes is needed to meet the City’s current level of service
  - Inventory of existing facilities
  - Map of existing bicycle and pedestrian trails
- Waterfront access
• Level of service standards
• Access to transit
• Access to parks, schools, and centers of activity
• Waterfront access
• Relation to other city plans
• Location priorities for future facilities based on:
  o Safety issues
  o System connectivity
  o Roadway hierarchy
  o Specified locations
• Implementation recommendations
  o Opportunities Identified in the Parks, Open Space & Recreation Plan
  o Waterfront opportunities
  o Recreational trails opportunities
  o Needed improvements in bicycle-pedestrian paths and trails
• Facility demand
• Community engagement and participation
• Proposed facilities
• Map of proposed facilities
• Estimated cost
• Design and maintenance guidelines including drainage, critical areas buffer, border planting, and trail surfaces and amenities
• Signage
• Facilities location and accessibility

City of Redmond Transportation Master Plan
The Transpiration Master Plan is an element of the City's Comprehensive Plan and provides the policy basis for transportation projects funding and development.

Components included
• Funding
• Design standards
• Location priorities for future facilities based on:
  o Roadway hierarchy (all arterial and local streets)
  o Specified locations
  o Based on community feedback in neighborhood planning process
  o Access to schools, parks, and commercial areas
• Safety
  o Pedestrian/Bicyclist Accidents
• Network connectivity
• Regional connectivity
• Facilities definition
Classification of pedestrian supportive, tolerant and intolerant walking environments.
Definition of Pedestrian Place destinations
Components of the pedestrian environment
Urban design elements influencing usability
• Identify areas to be designated as pedestrian promenades.
• Prepare a planned pedestrian program at a citywide and neighborhood level
• Update the planned bicycle program at a citywide and neighborhood level
• Require new development or redevelopment to be consistent with the Bicycle and pedestrian Plans
• Existing conditions
  o Inventory and condition of facilities under corridor analysis
  o Design and users of different bicycle facilities
  o Missing links in bicycle network
  o Needed transitions between trails and roadways
- Level of service measurement includes bicycle system implementation and pedestrian environment adequacy.
  - Implementation
  - Maps of proposed networks
    • Map of hierarchy of pedestrian network
    • Primary and secondary bicycle corridors
  - Estimated costs of several projects
  - Way-finding signage
  - Balance right-of-way allocations and roadway design to give priority to pedestrians
  - Public engagement and participation
  - Education and school programs
  - Enforcement
  - Addressing bicycling in pedestrian places

City of Sammamish Trails, Bikeways and Paths Plan
The Trails, bikeways, and Paths Plan is the first plan addressing those issues on a local scale. Previous plans were developed under King County jurisdiction prior to Sammamish becoming a city in 1999. The plan addresses both recreational trails and non-motorized transportation facilities within the city.
Components included
• Community engagement and participation
• Existing conditions
  o Inventory and condition of existing facilities, including private trails owned homeowners associations.
  o System fragmentation
  o Map of existing network, including private trails owned homeowners associations.
• System’s challenges and deficiencies
• Inventory of barriers and challenges to non-motorized Travel
• Implementation challenges including staffing, maintenance, property rights, and funding
• Relation to other city and regional plans
• Safety
• Education and proportion
• Provide a variety of trail types within the trail system
• Design guidelines
• Identify and develop a hierarchy of facilities
• Maintenance
• Regional connectivity
• System connectivity
• Access to transit
• Access to schools
• Require all new development to conform with the Plan
• Plan update
• Coordination with other jurisdictions
• Location priorities for future transportation-based facilities based on:
  o Projects identified in the Transportation Improvement Plan
  o Safety
  o System connectivity
  o Estimated costs
  o Access to transit
  o Access to school and centers of activity
• Location priorities for future recreation-based facilities based on:
  o Providing aesthetic recreational experience
  o System connectivity
  o Estimated costs
  o Access to schools and centers of activity
  o Project provides recreational opportunities for a variety of users
• Implementation strategies
• Improvement recommendation for specific locations
• Estimated costs
• Funding
• Maps of proposed trails, bikeways, paths, and right-of-way corridors
City of Seattle Bike Master Plan
The City of Seattle Bicycle Master Plan was created to increase use of bicycling in Seattle and improve safety of bicyclists
Components included
- Performance evaluation measurements
- Monitor progress using performance measures
- Safety
- Miles of recommended facilities
- Short-, mid- and long-term implementation target
- Implementation strategies
- System connectivity
- Relation to other city plans and programs
- Collaboration with other jurisdictions and city departments
- Collaboration with community organizations
- Funding
- Estimated costs
- Community engagement and participation
- Relation to other city plans
- Design guidelines
- Explore new design and signage options
- Existing conditions
  - Length of bicycle lanes and multi-use trails
  - Maps of existing facilities and network
  - Downtown bike counts data
  - Map of Seattle bicycle commuting –percentage of workers commuting by bicycle
  - Bicycle Trip Purposes information
  - Bicycle Trip Potential
  - Bicycle crashes information
  - Map of police-reported bicycle crashes
  - Facilities inventory including non-arterial roadways, arterial roadways, multi-use trails, roadway crossings, bridge crossing, and supporting bicycle facilities
  - Bicycle facility issues by location
- Barriers, challenges, and system deficiencies
- Plan development process
- Plan update
- Education, encouragement, and school programs
- Enforcement
- Coordination with other modes
- Way-finding signage
- Access to transit
- Bicycle storage facilities at transit stations
- Identified improvement projects
  - Lower-cost projects
  - Higher-cost projects
  - Further evaluation of bicycle facility recommendations
- Improve bicycle accommodations on bridges
- Bicycle facility network and amenities definition
- Map of proposed network
  - Map of designated bicycle facilities on arterial streets
  - Map of recommended signed bicycle route system
- Need to address users’ needs, including senior citizens and children
- Maintenance
  - During road construction
  - Collaboration with other city departments
  - Maintenance during different weather conditions
  - Routine and spot maintenance activities
- Location priorities for future facility improvements based on:
  - User volumes
  - Safety issues
  - Cost-effectiveness
  - Geographic equity
- Recommended changes to existing bicycle parking requirements
- Require office development and redevelopment projects to include shower and locker facilities.
- Provide bicycle facilities as a part of all transportation projects
- Map of key locations for coordinating bicycle facility design with future rapid transit service
- Map of key locations for coordinating bicycle facility design with future rapid freight transportation

City of Seattle Pedestrian Master Plan
Components included
- Safety
  - Pedestrian collisions information
  - Map of pedestrian collisions at midblock and intersection locations
  - Crossing and pedestrian lighting treatments
- Equity in accessibility and service
- Relation to other city plans and programs
- Related land use and zoning information
- Collaboration with other jurisdictions and city departments
- Collaboration with community organizations
• Existing conditions
  o Existing opportunities and constraints to walking along and across roadways
  o Land use types in Seattle and typical pedestrian issues
  o Length, number and type of existing facilities
  o 24 maps of maps related to pedestrian facilities and pedestrian activity in Seattle
  o Seattle strength and opportunities

• Access transit
• Access to trails
• Maintenance
• Pedestrian Master Plan planning process
• Short-, mid-, and long-term implementation strategies
• Need to define walkable zones
• Pedestrian access through and across major barriers, including freeways and rail corridors
• Location priorities for future facility improvements based on:
  o Access to major pedestrian destinations
  o Specified high priority centers of activity based on potential pedestrian demand, equity, and corridor function
  o Specified projects
• Maps of high priority areas, potential pedestrian demand, equity, and corridor function
• Provide a range of design choices
• Prioritization methodology and process
• Design guidelines for streets, sidewalks and public spaces
• Continue to review and update all design guidelines, standards, and policies
• Implementation strategies and partners
• Funding
• Pedestrian demand assessment
• Map of pedestrian demand assessment
• Performance evaluation and monitoring
• Education, encouragement and school programs
• Enforcement
• Community engagement and participation
• Design guidelines

City of Shoreline Transportation Master Plan

The Transportation Master Plan is an element of the City's Comprehensive Plan and provides the policy basis for transportation projects evaluation, development, and funding.

Components included
• Existing conditions
  o Maps of existing networks
  o Description and location of existing facilities
  o Pedestrian/Bicyclist accidents information
City of Tacoma Mobility Master Plan
The Mobility Master Plan was adopted On June 15, 2010 as a new section of the Transportation Element of the Comprehensive Plan. The Plan is reviewed under the City of Tacoma Comprehensive Plan.

City of Tacoma Pedestrian and Bicycle Design Guidelines
The Pedestrian and Bicycle Design Guidelines are the implementation strategy of the Mobility Master Plan and as a part of the Complete Streets Design Guidelines.

Components included
- Relation to other city plans
- Safety
- System accessibility and connectivity
- Federal, State, and local guidelines
- Best practices
- Design guidelines
  - Sidewalks
  - Intersections
  - Bus stops
  - Construction zones
  - Bike lanes
  - Share-roads
  - Bicycle boulevards
  - Cycle tracks
- Bicycle parking
  - Way-finding signage
  - Implementation
  - Maintenance
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3. Bicycle counts and analysis

Introduction
PSRC intends to augment its travel-modeling capabilities and assign bicycles to the travel network. In order to accomplish this task, there is a need to develop a bicycle count validation data set to provide full understanding of the existing use of bicycle facilities. The UW planning studio was tasked with defining adjustment factors that could be applied to the peak period counts collected by PSRC in order to populate values for whole-day and off-peak period estimates and to determine any variation between the days of the week and different seasons.

About the counts
In October 2010, PSRC hired sixteen interns to count bicyclists and pedestrians at 384 locations throughout the four-county region. The region includes King, Pierce, Snohomish, and Kitsap Counties. AM and PM peak period counts were taken in fifteen-minute increments. The AM peak period is defined as 6:00 AM–9:00 AM and the PM period as 3:00 PM–6:00 PM. In accordance with standard automobile traffic counting, counts were taken only on Tuesdays, Wednesdays, and Thursdays, because these are considered the most “normal” commute days.

The data were collected in October because the planning and engineering literature as well as national guidance suggests that this is a good time to collect bicycle counts since it is not too cold, not too hot, school is in session, and summer vacations are over—i.e., people are back to a regular routine. Information recorded includes the number of bicycles and the direction they are traveling out of the intersection, where they came from, whether a helmet was worn, the number of pedestrians, and the number of bicycles on buses.

Approach
In developing a model, the planning studio performed a literature review to determine which variables are relevant to the relationship between peak-period and whole-day bicycle counts. The literature review assisted the formation of a conceptual model for the analysis. From this conceptual model, a regression model was hypothesized. To interpolate time periods between the peaks, a data set that has both peak counts as well as the periods in between is necessary. Therefore, in order to test the model, 24-hour count data were needed. Three data sets were identified and provided by the Cities of Bellevue, Seattle, and Olympia.

The Bellevue data were collected at ten locations using tubes that count every time a bicycle passes over them, very similar to the tubes routinely used to count automobile traffic. Tubes can be problematic because bicycles may be tempted to avoid them instead of riding over them; however, this is less of an issue, especially on trails, if the loops are spread across the entire width of the facility. For the sake of the analysis, the tube counts are assumed valid. These counts were conducted during the last week of September and the first week of October in 2009, and again in the first two weeks of October in 2010. They contain the number of bicycles aggregated on an hourly basis.
The Olympia data come from eighteen count locations using tube counters as well. These data were collected in June 2008, October 2008, March 2009, October 2009, March 2010, June 2010, and October 2010, and they contain the hourly number of bicycles counted.

In the case of the Seattle data, all 10 of the readings were taken along the Burke-Gilman trail, which is a major bicycle facility in the region, with considerably higher bicycle volumes than witnessed elsewhere. The Seattle Department of Transportation (SDOT) utilized magnetometers to collect the data. The counts occurred between September 8, 2009 and May 24, 2010, with data being collected in September, October, November, December, February, March and May. These are also aggregated to an hourly rate.

**Variables for the models**
The variables identified in the literature review are time of day, season, population density, employment density, the mix of land uses, the type of bike facility, traffic volume, median income, age, and the amount of rain and the temperature. See Table 6 for a summary of relevant variables for which the studio collected data.
Table 6: Variable used in regression model, including metric used, data source, and the hypothesized effect

<table>
<thead>
<tr>
<th>Variable</th>
<th>Metric</th>
<th>Source</th>
<th>Hypothesized effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population density</td>
<td>Population per non-water acre</td>
<td>U.S. Census</td>
<td>Increase bicycles</td>
</tr>
<tr>
<td>Income</td>
<td>Median income by block group</td>
<td>U.S. Census</td>
<td>Higher income increase bicycles</td>
</tr>
<tr>
<td>Age</td>
<td>% 17–24</td>
<td>U.S. Census</td>
<td>Increase bicycles</td>
</tr>
<tr>
<td>Mix of use</td>
<td>Employees per housing units (jobshousing balance)</td>
<td>PSRC and U.S. Census</td>
<td>Increase bicycles</td>
</tr>
<tr>
<td>Employment density</td>
<td>Employees per non-water acre</td>
<td>PSRC</td>
<td>Increase bicycles</td>
</tr>
<tr>
<td>Temperature</td>
<td>Daily avg degrees by zip code</td>
<td>Weather underground</td>
<td>Higher temperature increases bicycles</td>
</tr>
<tr>
<td>Rain</td>
<td>Daily avg inches by zip code</td>
<td>Weather underground</td>
<td>More rain should decrease bicycles</td>
</tr>
<tr>
<td>Facility type</td>
<td>Data were aggregated into A = Off-road trail B = On-road bike lane C = Wide shoulder/signed bike route D = Shared roadway E = No facility</td>
<td>Municipalities; County GIS departments and select cities</td>
<td>Off-road trails and separated facilities should increase bicycles</td>
</tr>
<tr>
<td>Traffic volume</td>
<td>AWDT</td>
<td>Municipalities</td>
<td>Higher traffic volume should decrease traffic</td>
</tr>
</tbody>
</table>

**Hypothesized model**

A conceptual regression model was developed based on the literature review. Nine variables were identified from the literature as being the most likely to affect bicycle use. It was hypothesized that higher population density, median income, percentage of young adults, mix of land uses, employment density, and temperature should all increase the likelihood of bicycle use. Rain and high levels of traffic should decrease the number of bicyclists, and there should be more bicyclists on separated grade and dedicated bicycle facilities than on other facilities.

**Data processing**

PSRC provided a Geographic Information System (GIS) shapefile with each of the 384 count locations geo-coded. The count data was then assigned block group data using a spatial join in the GIS. A new shapefile was produced with the variables from the 2000 census data in the attribute table, which include population, age, acres in block group, and housing units. A different process was used for the other variables.
The 2000 Census Transportation Planning Products (CTPP) report does not have block-group-level data for King County. This would have provided the number of employees or jobs per block group, as opposed to the standard census package that provides the number of people employed but residing within a block group. PSRC provided employment data by block group for 2000 so that it would be comparable to the CTPP data. It is recommended that, once the next CTPP and census are published, those data be used.

The weather variables, temperature and rain, were collected from Weather Underground, a weather site with archived historic data. The data were collected by zip code for the 384 count sites and added to the final table. Data were scraped from the Weather Underground web site using a custom Python script. The code used to collect the data can be found in the appendix.

Limited GIS data were available for the City of Olympia, and therefore the traffic volumes and bicycle facility types were determined by a visual analysis of documents. The City of Olympia Traffic County Summary Report 2000–2009, found on the City of Olympia Web site under “Plans and Studies—Traffic Counts,” was used to determine the traffic volumes, using the most recent year and nearest logical traffic volume point. The bicycle facility type was determined by performing the same analysis using the Thurston County bike map. For consistency, the same method was used on the 24-hour Seattle and Bellevue counts.

To collect the data for the 384 PSRC counts, GIS was utilized. The jurisdictions provided traffic volume data. The traffic volume was then assigned to the bicycle count locations using a GIS analysis tool to generate a table of nearest traffic count points. The points were then manually assessed to determine the validity of the locations. Volumes taken at points farther than a mile away from the bicycle count were deleted from the data.

Municipalities through PSRC provided the GIS bicycle facility information. There is a classification issue in conducting this part of the process. Every municipality has its own classification system. For the purpose of this analysis, the data were classified as:

A = Off-road trail
B = On-road bike lane
C = Wide shoulder / signed bike route
D = Shared roadway
E = No facility.

A spatial join was then used to determine the closest facility type. This provided a table of facility types and information on how near they were to the points, and these data were analyzed to determine the validity of points. Over half of the points were closer than 30 feet to the facility type and points that were over 1000 feet away were determined to be invalid and deleted from the data set.

**Suitability of counts by day of the week**

From the literature review, there is consensus that bicycle counts should be undertaken on Tuesdays, Wednesdays, and Thursdays because Mondays and Fridays would differ from the midweek counts. However, excluding Mondays and Fridays comes at a cost. Given other
restrictions placed on counts (such as not counting in the rain and only counting in the spring and autumn), excluding Mondays and Fridays considerably shortens the window of opportunity for bicycle counts. In the Pacific Northwest, where rain is a frequent occurrence, manual counts could be profoundly affected.

A comparison of each of the days of the week using 24-hour counts yields the following:

1. Weekend counts are, as expected, significantly and consistently different from weekday counts.
2. Monday and Friday counts are not consistently different from other weekday counts.
3. Tuesday, Wednesday, and Thursday counts are not consistently similar.

These results suggest that excluding Monday and Friday counts has no greater validity than excluding other weekday counts. Combined with otherwise limited count opportunities, including Monday and Friday counts may yield an improvement given the opportunity for increased sample size.

Weekend counts, however, do significantly and consistently differ from weekday counts. This fits the hypothesis that different populations (commuters vs. errand/leisure riders) cycle on the weekdays versus the weekends. Further discussion of these results can be found in the detailed analysis section.

**Seasonality**

To assess seasonality effectively, counts would have to be compared across the range of seasons. However, in this region, bicycle counts tend to be confined to a few times per year. Unfortunately, no data set could be identified that provided year-round coverage of bicycle counts. Thus, no guidance on seasonal adjustments can be given beyond what is reported in the literature review.

Because future PSRC modeling efforts will depend on knowing a seasonal adjustment factor for the sake of being able to determine the cross-section (an average day), year-round counts will need to be collected or otherwise identified.

**Prediction of other time periods from peak counts**

The literature review identified a number of variables expected to influence bicycle counts. This in turn suggests a multiple regression analysis to account for and control for these other factors.

Here, two sets of regression models are used to predict counts in other time periods from:

1. AM peak counts
2. PM peak counts.

Though both sets of models are a reasonably good fit, one problem with these models is the multicollinearity between job density and the crude measure of mixed use. As discussed later, developing a better measure of land use mix would be a first step in improving these models.

The effect of each of the variables is largely in line with expectations. Higher median incomes, a high proportion of young adults, higher daily temperatures, and increased job density all
correspond to higher bicycle counts. Similarly, lack of an off-road bicycle facility, and increased precipitation correspond to decreased bicycle counts. Results for three variables, however, deviate from the hypothesis:

Traffic volumes were hypothesized to have a chilling effect on bicycle travel. However, as demonstrated in the morning peak counts model, increased traffic volumes were accompanied by slight increases in bicycle counts. Upon reflection, this result makes sense. None of the road segments counted had a truly high vehicle volume—the highest observed volume was 19,900 vehicles per day. Because all of the collected segments had reasonably low volumes, this variable is most likely capturing the optimality of a route.

Population density was hypothesized to increase counts, but increased population density was correlated with a reduction in counts. However, in areas with relatively high population densities but low job density this result is consistent with the hypothesis that predominantly residential areas would have few destinations and would therefore not be strong attractors of bicycle traffic—especially in the observed peak periods during which commuting travel occurs.

Mixed use was hypothesized to increase counts. However, a strong decrease in bicycle counts is seen where there is a very high proportion of jobs to housing. In reality, this reflects a problem with this measure of mixed use. A suburban office park is expected to have low bike counts, but a high ratio of employment. This highlights the need for a more robust metric because, at the very least, this metric is difficult to interpret.

Precipitation was, as hypothesized, significantly correlated with reduced bicycle counts. However the magnitude of the effect is smaller than expected. Perhaps this is due to a feature of when the counts are taken, which is that the maximum rainfall seen during the counts was less than one inch.

Variable significance is summarized in Table 7 and Table 8.

Because PSRC’s future modeling and network assignment will be broken down by time period, regression models are presented for each time period. In addition, models are included that predict full-day counts from the peak periods. Finally, peak counts are predicted from the non-count variables to determine the relative effect of each of the hypothesized coefficients. Note the higher sensitivity to non-count variables in the AM peak set as compared with the PM peak set, but the lower overall model fit.


<table>
<thead>
<tr>
<th>Dependent Variable:</th>
<th>AM Peak Counts</th>
<th>Midday Counts</th>
<th>PM Peak Counts</th>
<th>Evening Counts</th>
<th>Night Counts</th>
<th>Full-Day Counts</th>
</tr>
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<tr>
<td><strong>Independent Variables:</strong></td>
<td>Traffic volume 2.5e-03</td>
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<td>Traffic volume 5.7e-04</td>
<td>Traffic volume 2.0e-04</td>
<td>Traffic volume 7.0e-03</td>
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<td>-1.7e02 Bike facility type B</td>
<td>-6.4e01 Bike facility type B</td>
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<td>7.4e02</td>
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<td>6.6e-01 Average temperature</td>
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**Bold = Significant** (p <= 0.05), **Italic = Significant** (p < 0.1), **Normal = Not significant**
Table 8: Regression Summary - PM Counts

<table>
<thead>
<tr>
<th>Dependent Variable:</th>
<th>PM Peak Counts</th>
<th>Midday Counts</th>
<th>AM Peak Counts</th>
<th>Evening Counts</th>
<th>Night Counts</th>
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<td><strong>Independent Variables:</strong></td>
<td>Traffic volume 4.3e-03</td>
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**Bold** = Significant (p = < 0.05), **Italic** = Significant (p = < 0.1), **Normal** = Not significant
Detailed analysis

Suitability of counts by day of the week
To test the validity of excluding Mondays and Fridays, each of the 24-hour count data sets is inspected, first graphically to identify major features, then making pairwise comparisons using a two-tailed t-test.

To reduce the effects of overplotting, jittered scatterplots with transparency are used. Plotting daily counts for the aggregated three data sets does not reveal any major differences between counts across weekdays. As expected, counts on Saturday and Sunday are noticeably lower—presumably due to a reduction in commuter travel (see Figure 29).

![Figure 29: Counts for each day of the week using aggregated (Seattle, Bellevue, and Olympia) data sets.](image)

Because the magnitude of the counts differs between cities, each city’s data set was similarly plotted. Again, no definite conclusions about day of the week can be drawn (see Error! Reference source not found., Error! Reference source not found., and Error! Reference source not found.).
Figure 30: Bellevue bicycle counts by day of the week.

Figure 31: Olympia bicycle counts by day of the week.
Figure 32: Seattle Burke-Gilman Trail bicycle counts by day of the week.

With no clear pattern being evident from the plots, two-tailed t-tests are used to discriminate between each day of the week. T-tests are run on all three data sets separately. The first set of t-tests compares each unique pairing of the days of the week. The second set of t-tests combines Tuesday, Wednesday, and Thursday as “midweek” and then compares each unique pairing of the midweek counts to Saturday, Sunday, Monday, and Friday (see Table 10 and Table 11).

In the Olympia and Seattle data sets, where weekend counts are provided, weekends clearly differ from most of the rest of the week. However, the results of the t-tests are somewhat ambiguous when comparing midweek counts with Monday and Friday counts. In the Olympia data set, no significant difference exists between midweek and Monday or midweek and Friday. In the Seattle data set, however, there is strong significance in both of the same comparisons. Bellevue, perhaps because of the relatively small sample size, shows no significance in any comparison.

Looking more deeply into the Seattle data set, the expected similarity between Tuesday, Wednesday, and Thursday counts fails to materialize. Here there is significance between Tuesday-Thursday, Tuesday-Wednesday, and Wednesday-Thursday.

This result indicates that, while differences exist between weekday counts, differences are not consistent enough to warrant excluding Monday and Friday from the “standard” midweek counts. Similarly, the dissimilarity between Tuesday, Wednesday, and Thursday counts contradicts the expected result given the literature review.
Washington Commute Trip Reduction survey data corroborates the disagreement in counts throughout the day of the week. In this case, no two days of the week were significantly similar.

Figure 33: Comparison of days of the week using Washington CTR survey data.

Table 9: Washington CTR survey data compared by day of the week

<table>
<thead>
<tr>
<th>P.Value</th>
<th>Factors_Compared</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2367320</td>
<td>Mon-Fri</td>
</tr>
<tr>
<td>0.9626951</td>
<td>Thu-Fri</td>
</tr>
<tr>
<td>0.7830518</td>
<td>Tue-Fri</td>
</tr>
<tr>
<td>0.9229096</td>
<td>Wed-Fri</td>
</tr>
<tr>
<td>0.2524449</td>
<td>Mon-Thu</td>
</tr>
<tr>
<td>0.1462964</td>
<td>Mon-Tue</td>
</tr>
<tr>
<td>0.2766136</td>
<td>Mon-Wed</td>
</tr>
<tr>
<td>0.7462372</td>
<td>Tue-Thu</td>
</tr>
<tr>
<td>0.9596773</td>
<td>Wed-Thu</td>
</tr>
<tr>
<td>0.7098991</td>
<td>Tue-Wed</td>
</tr>
</tbody>
</table>
Table 10: T-Test results comparing counts by day of the week (bolded values show significance \( p < 0.5 \))

<table>
<thead>
<tr>
<th>P Value</th>
<th>Days Compared</th>
<th>P Value</th>
<th>Days Compared</th>
<th>P Value</th>
<th>Days Compared</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.01E-01</td>
<td>Friday-Monday</td>
<td>1.35E-01</td>
<td>Friday-Monday</td>
<td>2.89E-09</td>
<td>Friday-Monday</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.57E-11</td>
<td>Friday-Saturday</td>
<td>8.00E-02</td>
<td>Friday-Saturday</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.16E-40</td>
<td>Friday-Sunday</td>
<td>7.13E-01</td>
<td>Friday-Sunday</td>
</tr>
<tr>
<td>3.62E-01</td>
<td>Thursday-Monday</td>
<td>3.50E-15</td>
<td>Saturday-Monday</td>
<td>3.01E-14</td>
<td>Saturday-Monday</td>
</tr>
<tr>
<td>8.64E-02</td>
<td>Tuesday-Wednesday</td>
<td>2.16E-11</td>
<td>Saturday-Sunday</td>
<td>2.07E-01</td>
<td>Saturday-Sunday</td>
</tr>
<tr>
<td>4.30E-01</td>
<td>Tuesday-Monday</td>
<td>1.06E-46</td>
<td>Sunday-Monday</td>
<td>2.59E-09</td>
<td>Sunday-Monday</td>
</tr>
<tr>
<td>9.50E-01</td>
<td>Thursday-Friday</td>
<td>5.21E-01</td>
<td>Thursday-Friday</td>
<td>9.84E-01</td>
<td>Thursday-Friday</td>
</tr>
<tr>
<td>2.91E-01</td>
<td>Wednesday-Monday</td>
<td>4.10E-01</td>
<td>Thursday-Monday</td>
<td>4.78E-09</td>
<td>Thursday-Monday</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.56E-12</td>
<td>Thursday-Saturday</td>
<td>9.05E-02</td>
<td>Thursday-Saturday</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.72E-41</td>
<td>Thursday-Sunday</td>
<td>7.32E-01</td>
<td>Thursday-Sunday</td>
</tr>
<tr>
<td>8.35E-01</td>
<td>Tuesday-Friday</td>
<td>8.27E-02</td>
<td>Tuesday-Friday</td>
<td>2.98E-16</td>
<td>Tuesday-Friday</td>
</tr>
<tr>
<td>8.91E-01</td>
<td>Tuesday-Thursday</td>
<td>8.20E-01</td>
<td>Tuesday-Monday</td>
<td>2.64E-02</td>
<td>Tuesday-Monday</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.34E-16</td>
<td>Tuesday-Saturday</td>
<td>9.99E-23</td>
<td>Tuesday-Saturday</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.18E-49</td>
<td>Tuesday-Sunday</td>
<td>6.38E-16</td>
<td>Tuesday-Sunday</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.91E-01</td>
<td>Tuesday-Thursday</td>
<td>7.74E-16</td>
<td>Tuesday-Thursday</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.29E-01</td>
<td>Tuesday-Wednesday</td>
<td>9.92E-06</td>
<td>Tuesday-Wednesday</td>
</tr>
<tr>
<td>5.28E-02</td>
<td>Wednesday-Friday</td>
<td>5.99E-01</td>
<td>Wednesday-Friday</td>
<td>4.46E-05</td>
<td>Wednesday-Friday</td>
</tr>
<tr>
<td>7.09E-02</td>
<td>Wednesday-Thursday</td>
<td>3.33E-01</td>
<td>Wednesday-Monday</td>
<td>3.45E-02</td>
<td>Wednesday-Monday</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.02E-12</td>
<td>Wednesday-Saturday</td>
<td>4.76E-09</td>
<td>Wednesday-Saturday</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.18E-42</td>
<td>Wednesday-Sunday</td>
<td>2.77E-05</td>
<td>Wednesday-Sunday</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.99E-01</td>
<td>Wednesday-Thursday</td>
<td>5.78E-05</td>
<td>Wednesday-Thursday</td>
</tr>
</tbody>
</table>
Table 11: T-Test results comparing counts by day of the week, with Tuesday, Wednesday, and Thursday recoded as "midweek" (bolded values show significance $p < 0.5$)

<table>
<thead>
<tr>
<th>Bellevue</th>
<th>Olympia</th>
<th>Seattle</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P Value</strong></td>
<td><strong>Days Compared</strong></td>
<td><strong>P Value</strong></td>
</tr>
<tr>
<td>3.01E-01</td>
<td>Friday-Monday</td>
<td>1.35E-01</td>
</tr>
<tr>
<td>4.57E-11</td>
<td>Friday-Saturday</td>
<td>8.00E-02</td>
</tr>
<tr>
<td>1.16E-40</td>
<td>Friday-Sunday</td>
<td>7.13E-01</td>
</tr>
<tr>
<td>3.20E-01</td>
<td>Midweek-Friday</td>
<td>2.27E-01</td>
</tr>
<tr>
<td>8.11E-01</td>
<td>Midweek-Monday</td>
<td>5.29E-01</td>
</tr>
<tr>
<td>2.56E-21</td>
<td>Midweek-Saturday</td>
<td>2.45E-14</td>
</tr>
<tr>
<td>3.01E-83</td>
<td>Midweek-Sunday</td>
<td>7.53E-08</td>
</tr>
<tr>
<td>3.50E-15</td>
<td>Saturday-Monday</td>
<td>3.01E-14</td>
</tr>
<tr>
<td>2.16E-11</td>
<td>Saturday-Sunday</td>
<td>2.07E-01</td>
</tr>
<tr>
<td>1.06E-46</td>
<td>Sunday-Monday</td>
<td>2.59E-09</td>
</tr>
</tbody>
</table>
Interpolating other time period bicycle volumes from peak counts

As identified in the literature review, a number of factors are expected to influence bicycle counts. Here, multiple regression analysis is used to determine the relative weighting of each of the bicycle counts.

Knowing the relative predictive power of morning peak counts versus evening peak counts could help PSRC prioritize collection during future counts. Therefore, two sets of regression models—one for morning and the other for evening peaks—are presented here. First, morning peak counts are compared against the other non-count variables. Next, other time periods are compared against the other non-count variables plus the morning peak counts. The same process is repeated for evening peak counts. Time periods are defined in Table 12.

All regressions are run using the R statistical programming language. Regression runs together with diagnostic plots are included in the appendix. All variables are interval-ratio data with the exception of the bike facility variable, which is coded as a dummy variable.

<table>
<thead>
<tr>
<th>Time period</th>
<th>Code</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning peak</td>
<td>AM</td>
<td>06:00 – 08:59</td>
</tr>
<tr>
<td>Midday</td>
<td>MD</td>
<td>09:00 – 14:59</td>
</tr>
<tr>
<td>Evening peak</td>
<td>PM</td>
<td>15:00 – 17:59</td>
</tr>
<tr>
<td>Evening</td>
<td>EV</td>
<td>18:00 – 21:59</td>
</tr>
<tr>
<td>Night (non-contiguous, includes early morning and late evening)</td>
<td>NT</td>
<td>00:00 – 05:59, 22:00 – 23:59</td>
</tr>
<tr>
<td>Full day</td>
<td>FD</td>
<td>00:00 – 23:59</td>
</tr>
</tbody>
</table>

Comparing interval-ratio data highlights two potential problems with multicollinearity: job density-mixed use, and age-median income (see Error! Reference source not found.). At \( R^2 = \sim 0.6 \), the relationship between age and median income is clear but not severe.
Table 13: Correlation matrix for interval-ratio variables (Pearson’s R)

<table>
<thead>
<tr>
<th></th>
<th>Traffic Vol</th>
<th>Pop density</th>
<th>Median Income</th>
<th>Age 17-24</th>
<th>Avg temp</th>
<th>Precip</th>
<th>Job density</th>
<th>Mixed use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Vol</td>
<td>1</td>
<td>-0.15</td>
<td>-0.26</td>
<td>0.18</td>
<td>0.12</td>
<td>-0.1</td>
<td>0.37</td>
<td>0.49</td>
</tr>
<tr>
<td>popDensity</td>
<td>-0.15</td>
<td>1</td>
<td>0.13</td>
<td>0.15</td>
<td>0</td>
<td>-0.03</td>
<td>0.35</td>
<td>-0.16</td>
</tr>
<tr>
<td>median Income</td>
<td>-0.26</td>
<td>0.13</td>
<td>1</td>
<td>-0.64</td>
<td>0.04</td>
<td>0.01</td>
<td>-0.16</td>
<td>0</td>
</tr>
<tr>
<td>age17.24</td>
<td>0.18</td>
<td>0.15</td>
<td>-0.64</td>
<td>1</td>
<td>0.02</td>
<td>-0.09</td>
<td>0.54</td>
<td>0.28</td>
</tr>
<tr>
<td>avgTemp</td>
<td>0.12</td>
<td>0</td>
<td>0.04</td>
<td>0.02</td>
<td>1</td>
<td>0.04</td>
<td>0.16</td>
<td>0.13</td>
</tr>
<tr>
<td>precip</td>
<td>-0.1</td>
<td>-0.03</td>
<td>0.01</td>
<td>-0.09</td>
<td>0.04</td>
<td>1</td>
<td>-0.12</td>
<td>-0.09</td>
</tr>
<tr>
<td>jobDensity</td>
<td>0.37</td>
<td>0.35</td>
<td>-0.16</td>
<td>0.54</td>
<td>0.16</td>
<td>-0.12</td>
<td>1</td>
<td>0.79</td>
</tr>
<tr>
<td>mixedUse</td>
<td>0.49</td>
<td>-0.16</td>
<td>0</td>
<td>0.28</td>
<td>0.13</td>
<td>-0.09</td>
<td>0.79</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 14: Correlation of interval-ratio data to bike facility dummy variable

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Age</th>
<th>Median Income</th>
<th>Job Density</th>
<th>Mixed Use</th>
<th>Pop Density</th>
<th>Precip</th>
<th>Avg Temp</th>
<th>Traffic Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjusted R^2</td>
<td>0.01</td>
<td>0.4</td>
<td>0.09</td>
<td>0.12</td>
<td>0.07</td>
<td>0.02</td>
<td>-0.002</td>
<td>0.43</td>
</tr>
</tbody>
</table>

While job density and the mix of use are expected to be somewhat related, at R^2 = 0.79 the relationship is severe. This suggests problems with the inclusion of both variables. However, dropping either job density or mixed use from the model yields a much weaker R^2 value for the model.

As previously noted, the measure of mixed use used in this model (jobs/housing units) is crude. A refined model should consider including a more sophisticated measure of mixed use that either encapsulates density or that is better able to distinguish between density and land-use mix. This would be expected to both resolve the multicollinearity issue and better capture the relationship between land-use mix and bicycle travel.

Checks for multicollinearity fare better when comparing the bike facilities dummy variable with our interval-ratio data. Comparisons were made using single regression and are summarized in Table 14: Correlation of interval-ratio data to bike facility dummy variable. With no adjusted R^2 value above 0.5, no issues of multicollinearity are apparent.

Regression coefficients are summarized again in the following tables. Again, the results are in line with what was hypothesized with the exception of the mixed use, job density, traffic volume, and precipitation variables. Of these, the mixed use variable poses the greatest threat to the validity of the model—largely due to the conceptual crudeness and the resultant multicollinearity.

In interpreting these results, it should be noted that the overall predictive power of the PM peak counts was higher than that of the AM peak counts; however the sensitivity to each of the non-count variables tended to decline. This could potentially be explained by the higher number of
bicyclists at the evening peak. Because PM peaks are typically higher, this also suggests that these counts capture a broader cross-section of daily bicycle ridership. This, combined with higher predictive power of models that contain PM peaks, indicates that PM peak counts may have more value than morning peak counts.

**Implications for future bicycle counts**

One of the objectives of this studio was to determine the seasonal adjustment factor for future modeling. While seasonality is somewhat controlled by incorporating temperature and precipitation in the model, the question of seasonality is not satisfactorily resolved. More data will be required to answer this question definitively. Furthermore, more data may also help to resolve the ambiguity surrounding how counts differ throughout the week.

Based on the results of the day of week, seasonality factor, and count regression analyses, several recommendations can be made:

1. Carry out automated 365-day, 24-hour counts at enough locations to be able to make conclusive determinations of seasonality and day-of-week variation. Fewer locations with more complete information would better address these questions than more locations for a smaller subset of the year.

2. Focus counts on areas that are expected to have moderate-to-large numbers of bicyclists—perhaps selected from sites counted this year. This will improve model prediction by not focusing on sites for which margins of error are high.

3. Excluding Monday and Friday counts appears to have no greater validity than excluding other weekday counts. Combined with otherwise limited count opportunities, including Monday and Friday counts may yield an improvement given the opportunity for increased sample size.

4. Predictions of other time periods made from evening counts tended to be more accurate than predictions made from morning counts. This suggests that PSRC may get more value from performing evening counts than from morning counts.
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Appendix A – Regression runs and diagnostic plots

AM.lm

Call:
  lm(formula = AM ~ trafficVol + bikeFacility + popDensity +
      medianIncome +
      age17.24 + avgTemp + precip + jobDensity + mixedUse)

Residuals:
     Min      1Q  Median      3Q     Max
-269.42  -18.70   -2.58   17.30  351.38

Coefficients:
                               Estimate Std. Error t value Pr(>|t|)
(Intercept)                  1.777e+01  1.524e+01   1.166  0.24393
trafficVol                   2.518e-03  5.470e-04   4.603 5.03e-06 ***
bikeFacilityB               -8.721e+01  6.178e+00  -14.116 < 2e-16 ***
bikeFacilityC               -4.807e+01  6.590e+00  -7.295 8.84e-13 ***
bikeFacilityE               -7.784e+01  7.225e+00  -10.773 < 2e-16 ***
popDensity                  -1.151e+01  1.264e+00  -9.105 < 2e-16 ***
medianIncome                -1.014e-03  9.971e-05  -10.165 < 2e-16 ***
age17.24                     1.098e+02  6.112e+01   1.797  0.07284 .
avgTemp                     -2.093e+01  7.489e+00  -2.795  0.00535 **
precip                       5.061e+01  2.606e+00  19.418 < 2e-16 ***
jobDensity                  -8.261e+01  4.738e+00  -17.434 < 2e-16 ***
jobDensity                  -8.261e+01  4.738e+00  -17.434 < 2e-16 ***

---
Signif. codes:  0 ‘***’  0.001 ‘**’  0.01 ‘*’  0.05 ‘.’  0.1 ‘ ’ 1

Residual standard error: 39.43 on 641 degrees of freedom
(122 observations deleted due to missingness)
Multiple R-squared: 0.6551,  Adjusted R-squared: 0.6491
F-statistic: 110.7 on 11 and 641 DF,  p-value: < 2.2e-16
AMMD.lm

Call:
lm(formula = MD ~ trafficVol + bikeFacility + popDensity + medianIncome + age17.24 + avgTemp + precip + jobDensity + mixedUse + AM)

Residuals:
   Min     1Q Median     3Q    Max
-539.32 -40.95  -13.85   39.73 1035.04

Coefficients:  Estimate Std. Error t value Pr(>|t|)
(Intercept)   2.947e+01  3.896e+01   0.757 0.449619
trafficVol    4.436e-03  1.420e-03   3.124 0.001863 **
bikeFacilityB-9.209e+01  1.752e+01  -5.257 1.99e-07 ***
bikeFacilityC-1.486e+02  2.006e+01  -7.412 3.97e-13 ***
popDensity    -1.521e+01  3.432e+00  -4.432 1.10e-05 ***
medianIncome  1.861e-03  2.744e-04   6.780 2.73e-11 ***
age17.24      4.196e+02  1.565e+02   2.681 0.007527 **
avgTemp       2.296e-01  5.458e-01   0.421 0.674145
precip        -3.613e+00  1.925e+01  -0.188 0.851127
jobDensity    8.367e+01  8.390e+00   9.972  < 2e-16 ***
mixedUse      -1.455e+02  1.469e+01  -9.899  < 2e-16 ***
AM             3.629e-01  1.009e-01   3.597 0.000347 ***

---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 100.7 on 640 degrees of freedom
(122 observations deleted due to missingness)
Multiple R-squared: 0.5946,  Adjusted R-squared: 0.587
F-statistic: 78.22 on 12 and 640 DF,  p-value: < 2.2e-16
AMPM.lm

Call:
lm(formula = PM ~ trafficVol + bikeFacility + popDensity +
    medianIncome +
    age17.24 + avgTemp + precip + jobDensity + mixedUse + AM)

Residuals:
               Min       1Q  Median       3Q      Max
-576.91 -16.96  -4.03   12.75  485.02

Coefficients:                      Estimate Std. Error t value Pr(>|t|)
(Intercept)      -9.957e+00  2.072e+01   -0.481 0.631005
trafficVol       1.617e-03  7.545e-04    2.143 0.032497 *
bikeFacilityB   -3.489e+01  9.393e+00   -3.714 0.000222 ***
bikeFacilityC   -6.305e+01  9.633e+00   -6.672 5.62e-11 ***
bikeFacilityE   -6.427e+01  9.633e+00   -6.672 5.62e-11 ***
popDensity       8.289e+00  1.900e+00    4.362 1.51e-05 ***
medianIncome     8.186e-04  1.498e-04    5.463 6.78e-08 ***
age17.24         1.528e+02  8.305e+01    1.840 0.066313 .
avgTemp          6.590e-01  2.863e-01    2.302 0.021664 *
precip           -1.276e+01  1.012e+01   -1.261 0.207622
jobDensity       3.844e+01  4.672e+00     8.228 1.13e-15 ***
mixedUse         -6.560e+01  8.194e+00   -8.006 5.91e-15 ***
AM               9.935e-01  5.890e-02    16.867 < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 52.56 on 617 degrees of freedom
(145 observations deleted due to missingness)
Multiple R-squared: 0.7788,  Adjusted R-squared: 0.7745
F-statistic: 181 on 12 and 617 DF,  p-value: < 2.2e-16
AMEV.lm

Call:
  lm(formula = EV ~ trafficVol + bikeFacility + popDensity +
      medianIncome +
      age17.24 + avgTemp + precip + jobDensity + mixedUse + AM)

Residuals:
   Min      1Q  Median      3Q     Max
-162.261  -6.396  -0.479   7.193  256.689

Coefficients:
            Estimate Std. Error    t value  Pr(>|t|)
(Intercept) -1.861e+01  7.962e+00  -2.337   0.01974 *
trafficVol  5.735e-04  2.899e-04   1.978   0.04838 *
bikeFacilityB -1.079e+01  3.705e+00  -2.912   0.00372 **
bikeFacilityC  6.075e+00  3.607e+00   1.684   0.09261
bikeFacilityE -1.206e+01  4.075e+00  -2.961   0.00319 **
popDensity   -6.455e+00  7.326e-01  -8.811  < 2e-16 ***
medianIncome  3.062e-04  5.763e-05   5.313  1.51e-07 ***
age17.24       1.377e+02  3.189e+01  11.983  < 2e-16 ***
avgTemp        2.974e-01  1.101e-01   2.702   0.00707 **
precip        -6.986e+00  3.884e+00  -1.799   0.07258
jobDensity    2.166e+01  1.808e+00  11.932  < 2e-16 ***
mixedUse      -3.782e+01  3.170e+00 -11.932  < 2e-16 ***
AM             8.643e-01  2.262e-02  38.206  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 20.18 on 616 degrees of freedom
   (146 observations deleted due to missingness)
Multiple R-squared:  0.9115,  Adjusted R-squared:  0.9098
F-statistic: 528.9 on 12 and 616 DF,  p-value: < 2.2e-16
AMNT.lm

Call:
lm(formula = NT ~ trafficVol + bikeFacility + popDensity +
    age17.24 + avgTemp + precip + jobDensity + mixedUse + AM)

Residuals:
          Min       1Q   Median       3Q      Max
-48.636 -2.309  -0.313   2.100  70.679

Coefficients:            Estimate Std. Error t value Pr(>|t|)
(Intercept)  -3.375e+00  2.231e+00  -1.513 0.130843
trafficVol    2.043e-04  8.132e-05   2.512 0.012249 *
bikeFacilityB -6.893e+00  1.035e+00  -6.663 5.80e-11 ***
bikeFacilityC -3.787e+00  1.003e+00  -3.776 0.000175 ***
bikeFacilityE -7.697e+00  1.149e+00  -6.701 4.53e-11 ***

Residual standard error: 5.767 on 640 degrees of freedom
(122 observations deleted due to missingness)
Multiple R-squared: 0.7838,  Adjusted R-squared: 0.7798
F-statistic: 193.4 on 12 and 640 DF,  p-value: < 2.2e-16
AMFD.lm

Call:
lm(formula = FD ~ trafficVol + bikeFacility + popDensity +
    medianIncome +
    age17.24 + avgTemp + precip + jobDensity + mixedUse + AM)

Residuals:
    Min     1Q    Median     3Q    Max
-751.16 -61.06  -20.05    47.78 1499.61

Coefficients:          Estimate  Std. Error   t value   Pr(>|t|)
  (Intercept)    3.817e+00   6.025e+01    0.063  0.94951
trafficVol     6.970e-03    2.194e+03    3.177  0.00156 **
bikeFacilityB -1.261e+02   2.804e+01   -8.769  < 2e-16 ***
bikeFacilityC -2.280e+02   3.084e+01  -7.395 4.65e-13 ***
bikeFacilityE -2.313e+01   5.544e+00  -5.976 3.87e-09 ***
popDensity     3.201e+02   4.361e-03    7.340 6.80e-13 ***
medianIncome   3.201e-03   4.361e-04    7.340 6.80e-13 ***
age17.24       3.450e+02   2.414e+02    3.068 0.00225 **
avgTemp        1.193e+00   8.328e-01    1.433 0.15243
precip         2.854e+01   2.939e+01   -0.971  0.33201
jobDensity     1.521e+02   1.368e+01   11.116 < 2e-16 ***
mixedUse       2.650e+02   2.399e+01  -11.048 < 2e-16 ***
AM             3.575e+00   1.712e-01  20.886 < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 152.7 on 616 degrees of freedom
(146 observations deleted due to missingness)
Multiple R-squared: 0.843,    Adjusted R-squared: 0.8399
F-statistic: 275.5 on 12 and 616 DF,  p-value: < 2.2e-16
PM.lm

Call:
lm(formula = PM ~ trafficVol + bikeFacility + popDensity +
    medianIncome +
    age17.24 + avgTemp + precip + jobDensity + mixedUse)

Residuals:
      Min       1Q     Median       3Q      Max
-580.05   -34.68     -8.72   30.65  424.03

Coefficients:
                         Estimate Std. Error t value Pr(>|t|)
(Intercept)                2.717e+01   2.579e+01    1.053  0.29254
trafficVol                4.276e-03   9.290e-04    4.603  5.03e-06 ***
bikeFacilityB          -8.472e+01   1.124e+01   -7.537  1.64e-13 ***
bikeFacilityC           -1.442e+02   1.225e+01  -11.775  < 2e-16 ***
bikeFacilityE           -1.442e+02   1.225e+01  -11.775  < 2e-16 ***
popDensity               -1.989e+01   2.143e+00    -9.280  < 2e-16 ***
medianIncome             1.826e-03   1.687e-04     10.821  < 2e-16 ***
age17.24                 2.670e+02   1.039e+02     2.570  0.01038 *
avgTemp                  8.291e-01   3.578e-01     2.317  0.02080 *
precip                   -3.554e+01   1.262e+01    -2.815  0.00503 **
jobDensity               9.053e+01   4.376e+00    20.686  < 2e-16 ***
mixedUse                -1.504e+02   7.990e+00   -18.823  < 2e-16 ***
---
Signif. codes:  *** 0.001 ** 0.01 * 0.05 . 0.1 1

Residual standard error: 66.88 on 640 degrees of freedom
(123 observations deleted due to missingness)
Multiple R-squared: 0.6945,    Adjusted R-squared: 0.6892
F-statistic: 132.2 on 11 and 640 DF,  p-value: < 2.2e-16
**PMM.D.lm**

Call:

```r
lm(formula = MD ~ trafficVol + bikeFacility + popDensity +
    age17.24 + avgTemp + precip + jobDensity + mixedUse + PM)
```

Residuals:

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>-632.90</td>
<td>-16.48</td>
<td>-3.78</td>
<td>10.69</td>
<td>755.30</td>
</tr>
</tbody>
</table>

Coefficients:

|                  | Estimate | Std. Error | t value | Pr(>|t|) |
|------------------|----------|------------|---------|---------|
| (Intercept)      | -1.408e+00 | 3.101e+01  | -0.045  | 0.96381 |
| trafficVol       | 1.074e-03  | 1.134e-03  | 0.947   | 0.34416 |
| bikeFacilityB    | -4.660e+01 | 1.458e+01  | -3.197  | 0.00146 **|
| bikeFacilityC    | -2.905e+01 | 1.409e+01  | -2.061  | 0.03967 * |
| bikeFacilityE    | -3.703e+01 | 1.623e+01  | -2.281  | 0.02286 * |
| popDensity       | 1.142e-01  | 2.743e+00  | 0.042   | 0.96681 |
| medianIncome     | 4.418e-04  | 2.205e-04  | 2.004   | 0.04548 * |
| age17.24         | 1.842e+02  | 1.254e+02  | 1.468   | 0.14248 |
| avgTemp          | -8.740e-02 | 4.317e-01  | -0.202  | 0.83962 |
| precip           | 1.616e+01  | 1.526e+01  | 1.059   | 0.29005 |
| jobDensity       | 1.274e+01  | 6.792e+00  | 1.876   | 0.06109 .|
| mixedUse         | -2.689e+01 | 1.197e+01  | -2.247  | 0.02498 * |
| PM               | 9.519e-01  | 4.749e-02  | 20.045  | < 2e-16 ***|

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 80.35 on 639 degrees of freedom
(123 observations deleted due to missingness)
Multiple R-squared: 0.7443,  Adjusted R-squared: 0.7395
F-statistic: 155 on 12 and 639 DF,  p-value: < 2.2e-16
PMAM.lm

Call:
lm(formula = AM ~ trafficVol + bikeFacility + popDensity +
    medianIncome +
    age17.24 + avgTemp + precip + jobDensity + mixedUse + PM)

Residuals:
   Min     1Q Median     3Q    Max
-327.28 -8.69  -0.62    7.35  202.39

Coefficients:
                       Estimate Std. Error t value  Pr(>|t|)
(Intercept)         2.108e+01  1.169e+01   1.803  0.07180 .
trafficVol         1.210e-03  4.255e-04   2.845  0.00459 **
bikeFacilityB   -3.503e+01  5.461e+00  -6.415 2.80e-10 ***
bikeFacilityC   -2.116e+01  5.303e+00  -3.990 7.39e-05 ***
bikeFacilityE   -2.918e+01  6.053e+00  -4.820 1.81e-06 ***
popDensity      -5.744e+00  1.066e+00  -5.388 1.02e-07 ***
medianIncome   4.373e-04  8.494e-05   5.149 3.53e-07 ***
age17.24         1.723e+01  4.708e+01   0.366  0.71456
avgTemp         3.105e-02  1.626e-01   0.191  0.84860
precip         -6.923e+00  5.722e+00  -1.210  0.22677
jobDensity       2.194e+01  2.639e+00   8.316 5.83e-16 ***
mixedUse       -3.505e+01  4.659e+00  -7.523 1.90e-13 ***
PM            3.177e-01  1.883e-02  16.867  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 29.72 on 617 degrees of freedom
(145 observations deleted due to missingness)
Multiple R-squared: 0.7678,  Adjusted R-squared: 0.7633
F-statistic: 170 on 12 and 617 DF,  p-value: < 2.2e-16
PMEV.lm

Call:
lm(formula = EV ~ trafficVol + bikeFacility + popDensity +
    medianIncome +
    age17.24 + avgTemp + precip + jobDensity + mixedUse + PM)

Residuals:
  Min       1Q   Median       3Q      Max
-292.513 -5.583  -0.650    6.625  314.071

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  -1.026e+01  1.047e+01  -0.980  0.32757
trafficVol   7.712e-04  3.848e-04   2.004  0.04546 *
bikeFacilityB -1.277e+01  5.083e+00  -2.512  0.01224 *
bikeFacilityC  4.367e+00  4.789e+00   0.912  0.36210
bikeFacilityE -1.122e+01  5.593e+00  -2.006  0.04531 *
popDensity   -6.873e+00  9.484e-01  -7.247 1.24e-12 ***
medianIncome  3.169e+00   7.607e-05   4.166 3.53e-12 ***
age17.24      1.141e+02   4.237e+01   2.693  0.00728 **
avgTemp      -2.127e-01  1.455e-01  -1.462  0.14415
precip       -6.230e+00   5.149e+00  -1.210  0.22678
jobDensity    2.237e+01   2.450e+00   9.128 < 2e-16 ***
mixedUse     -3.800e+01  4.291e+00  -8.855 < 2e-16 ***
PM           4.584e-01   1.711e-02  26.799 < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 27.07 on 638 degrees of freedom
(124 observations deleted due to missingness)
Multiple R-squared: 0.8684,  Adjusted R-squared: 0.8659
F-statistic: 350.7 on 12 and 638 DF,  p-value: < 2.2e-16
PMNT.lm

Call:
  lm(formula = NT ~ trafficVol + bikeFacility + popDensity +
      medianIncome +
      age17.24 + avgTemp + precip + jobDensity + mixedUse + PM)

Residuals:
   Min      1Q  Median      3Q     Max
-41.155 -1.781 -0.236    1.800  48.893

Coefficients:       Estimate  Std. Error    t value   Pr(>|t|)
(Intercept)  -4.625e+00  1.974e+00  -2.343   0.0194 *
trafficVol     1.431e-04  7.221e-05    1.982   0.0479 *
bikeFacilityB -3.736e+00  9.278e-01  -4.027  6.33e-05 ***
bikeFacilityC -1.790e+00  8.969e-01  -1.996   0.0464 *
bikeFacilityE -4.525e+00  1.033e+00  -4.379  1.39e-05 ***
popDensity    -1.151e+00  1.746e-01  -6.594  8.96e-11 ***
medianIncome   1.004e-04  1.403e-05    7.157  2.27e-12 ***
age17.24       3.795e+01  7.985e+00    4.752  2.49e-06 ***
avgTemp       -6.003e-02  2.748e-02    2.185   0.0293 *
precip         9.563e-02  9.715e-01   0.988   0.3216
jobDensity    -4.542e+00  4.324e-01  -10.505 < 2e-16 ***
mixedUse       7.735e+00  7.617e-01  -10.154 < 2e-16 ***
PM             6.182e-02  3.023e-03    20.448 < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 5.115 on 639 degrees of freedom
(123 observations deleted due to missingness)
Multiple R-squared: 0.8314,  Adjusted R-squared: 0.8283
F-statistic: 262.7 on 12 and 639 DF,  p-value: < 2.2e-16
PMFD.lm

Call:
  lm(formula = FD ~ trafficVol + bikeFacility + popDensity + 
      medianIncome + 
      age17.24 + avgTemp + precip + jobDensity + mixedUse + PM)

Residuals:
     Min      1Q  Median      3Q     Max
-516.98  -15.21   -1.30   11.44  695.22

Coefficients:
     Estimate Std. Error t value Pr(>|t|)
(Intercept)   9.312e+00  2.146e+01   0.434 0.664427
trafficVol   1.233e-03  7.857e-04   1.570 0.117035
bikeFacilityB -3.860e+01  1.039e+01  -3.716 0.000220 ***
bikeFacilityC -2.052e+01  9.814e+00  -2.090 0.036995 *
bikeFacilityE -2.720e+01  1.136e+01  -2.394 0.016973 *
popDensity    -3.332e+00  2.015e+00  -1.653 0.098791 .
medianIncome   4.980e-04  1.600e-04   3.113 0.001941 **
age17.24      1.848e+02  8.650e+01   2.136 0.033080 *
avgTemp       -2.659e-01  2.979e-01  -0.892 0.372501
precip        1.129e+01  1.050e+01   1.076 0.282519
jobDensity    2.008e+01  5.210e+00   3.854 0.000128 ***
mixedUse     -3.856e+01  9.140e+00  -4.218 2.83e-05 ***
PM            3.236e+00  3.699e-02  87.487 < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 54.46 on 616 degrees of freedom
(146 observations deleted due to missingness)
Multiple R-squared:  0.98,  Adjusted R-squared: 0.9796
F-statistic:  2518 on 12 and 616 DF,  p-value: < 2.2e-16
Appendix B – code for analysis and data processing

Parse and aggregate PSRC bike counts spreadsheets into a data file

# USAGE: python bikeimport.py [excelworkbook1 excelworkbook2 ...]
# Outputs a .csv file named with the current timestamp to the current
directory
# Example: "python bikeimport *.xls"

from optparse import OptionParser
from time import strptime, strftime, asctime
from xlrd import open_workbook, xldate_as_tuple
from os import getcwd
import os.path, csv, string

def readExcel(file):
    # Load the workbook
    wb=open_workbook(file)

    # Read the relevant sheets
    sh0 = wb.sheet_by_index(0)
    sh2 = wb.sheet_by_index(2)

    # Grab the location from the summary sheet
    locationID = "J"+str(int(sh0.cell(4,2).value))

    # Build a dictionary of our eight "locations"
    locations = {}
    for x in range(0,4)+range(5,9):
        desc = string.strip(str(sh0.cell(rowx=13+x, colx=1).value))
        eid = sh0.cell(rowx=13+x, colx=2).value
        try:
            eid = str(int(eid))
        except:
            pass
        inode = sh0.cell(rowx=13+x, colx=3).value
        try:
            inode = str(int(inode))
        except:
            pass
        jnode = sh0.cell(rowx=13+x, colx=4).value
        try:
            jnode = str(int(jnode))
        except:
            pass
        locations[x]= [locationID, desc, eid, inode, jnode]

    # Now iterate our twelve times
    records = []
    for x in range(0,12):
        # Get the actual times and format them sanely
        rawtime = sh2.cell(rowx=1+x, colx=1).value
        ampm = sh0.cell(rowx=6, colx=2).value
        convtime = strftime("%I:%M:%S", xldate_as_tuple(rawtime,
wb.datemode)+(0,0,0))+str(ampm)
formattedtime = strftime("%H:%M:%S", strptime(convtime, "%I:%M:%S%p"))

# Now read each of the twelve time worksheets (TP1 starts on 4th wksht)
tpws = wb.sheet_by_index(x+3)

# Now iterate each of the locations on each worksheet
for y in locations:
    count = tpws.cell(rowx=y+17, colx=6).value
    try:
        count = int(count)
    except:
        pass
    record = locations[y]+[formattedtime, count]
    records.append(record)

return(records)

def main():
    # Even though we don't have options to parse, parsing the arguments is easier this way
    parser = OptionParser()

    (options, args) = parser.parse_args()

    # Optional filenames are for wimps. I'll be naming the output files around here!
    csvfile=os.path.join(os.getcwd(), asctime()+".csv")

    # Set up a csv file
    csvwriter = csv.writer(open(csvfile, mode='w'), delimiter=",")

    # Grab data from each spreadsheet
    # Assume that everything included as an argument is a spreadsheet
    for workbook in args:
        data=readExcel(workbook)

        for row in data:
            csvwriter.writerow(row)

if __name__ == '__main__':
    main()
Collect historical data from Weather Underground

# USAGE: python WUndergroundParser.py
# Simple script that scrapes historic precipitation and daily average temperature
# from the Weather Underground

import urllib2, datetime
from BeautifulSoup import BeautifulSoup

# Do dates smarter
def daterange(start_date, end_date):
    for n in range((end_date - start_date).days):
        yield start_date + datetime.timedelta(n)

# Create/open a file called wunder-data.txt (which will be a comma-delimited file)
f = open('wunder-data.txt', 'w')

# Define start and stop dates:
startdate = datetime.date(2008, 1, 1)
enddate = datetime.date(2010, 11, 15)

# Define which weather station to collect data for
stationid = "KOLM"

# Iterate through year, month, and day
for x in daterange(startdate, enddate):

    # Open wunderground.com url - note: wund.com is the "lite" version of the site
    url = "http://www.wund.com/history/airport/" + stationid + "/" + str(x.year) + "/" + str(x.month) + "/" + str(x.day) + "/DailyHistory.html"
    page = urllib2.urlopen(url)

    # Get temperature from page
    soup = BeautifulSoup(page)
    meanTemp = soup.find(name="td", text="Mean Temperature").findNext(name="span").renderContents()

    # Get precipitation
    precip = soup.find(name="td", text="Precipitation").findNext(name="span").renderContents()

    # Build timestamp
    timestamp = x.strftime("%Y-%m-%d")

    # Write timestamp and temperature to file
    f.write(timestamp + ',' + meanTemp + ',' + precip + stationid +'
')

# Done getting data! Close file.
f.close()
Convenience functions for statistical processing in R

### Required packages
# ggplot2 (for graphs, but also loads plyr)
require(ggplot2)
require(plyr)

# gtools (required to figure out permutations)
require(gtools)

# Mini data prep for combined data set
mprep.data <- function() {
  # Function takes no arguments
  # Name of the file to read
  d <- read.csv("/Users/peter/Dropbox/Fall2010/BikeCounts/Analysis/BelOlySeaCombo/data/combined.csv", header=TRUE)

  # Dates are easier to work with than factors
  d$data <- as.Date(d$date)

  # Times are best as ordered factors
  d$time <- as.ordered(d$time)

  # Day of the week can be useful too. Because it's useful, we let R know the order of the days of the week.
  d$DOW <- factor(d$DOW, levels=c("Sunday", "Monday", "Tuesday", "Wednesday", "Thursday", "Friday", "Saturday"), ordered=TRUE)
  d$DOWm <- factor(d$DOWm, levels=c("Sunday", "Monday", "Midweek", "Friday", "Saturday"), ordered=TRUE)

  # Purge this extraneous variable that crops up.
  d$X <- NULL

  return(d)
}

time.bin <- function(Data) {
  # Takes a dataframe with a variable 'time' and returns a new dataframe with a variable called 'timeBin'
  # Note: Not called directly--called by counts.time.bin
  am <- Data[Data$time >= "06:00:00" & Data$time < "09:00:00",]
  md <- Data[Data*time >= "09:00:00" & Data$time < "15:00:00",]
  pm <- Data[Data$time >= "15:00:00" & Data$time < "18:00:00",]
  ev <- Data[Data$time >= "18:00:00" & Data$time < "22:00:00",]
  nt <- Data[Data*time >= "22:00:00" | Data$time < "06:00:00",]

  am$timeBin <- "AM"
  md$timeBin <- "MD"
  pm$timeBin <- "PM"
  ev$timeBin <- "EV"
  nt$timeBin <- "NT"

  c <- rbind(am, md, pm, ev, nt)

  return(c)
}
counts.time.bin <- function(Data) {
  # Takes our "standard" data format and gives us separate
  # variables for our binned time periods.
  require(plyr)

  Data <- time.bin(Data)
  Data$time <- NULL
  bc <- ddply(Data, .(date, site, timeBin), summarize, count=sum(count))

  molten <- melt(bc, measure.vars="count")
  casted <- cast(molten, date + site ~ timeBin)

  Data$count <- NULL
  ml <- join(Data, casted, by=c("date", "site"))
  ml$timeBin <- NULL

  ml <- unique(ml)
  ml <- ml[order(ml$date, ml$site), ]
  ml$FD <- ml$AM + ml$EV + ml$NT + ml$MD + ml$PM

  return(ml)
}

prep.data <- function() {
  ### Read and format the data convenience function

  # We could just have people select their data set interactively.
  #d <- read.csv(file.choose(), header=TRUE)

  # Some hard-coded paths that make my life easier.
  d <-
  read.csv("/Users/peter/Dropbox/Fall2010/BikeCounts/Analysis/Olympia/Data/FormattedCSV/Olympia_Complete.csv", header=TRUE)
  #d <-
  read.csv("/Users/peter/Dropbox/Fall2010/BikeCounts/Analysis/Bellevue20092010/Data/Bellevue20092010.csv", header=TRUE)
  #d <-
  read.csv("/Users/peter/Dropbox/Fall2010/BikeCounts/Analysis/SeattleMagnetometer/FormattedData/SeattleMagnetometer.csv", header=TRUE)

  # Dates are easier to work with than factors
  d$Date <- as.Date(d$Date)

  # Times are best as ordered factors
  d$Time <- as.ordered(d$Time)

  # Day of the week can be useful too. Because it's useful, we let R know the
  # order of the days of the week.
  d$DOW <- factor(weekdays(d$Date), levels=c("Sunday", "Monday", "Tuesday", "Wednesday", "Thursday", "Friday", "Saturday"), ordered=TRUE)

  # Tue, Wed, and Thu are special. There's probably a more elegant way of
  # doing this, but I'm creating a DOWm column that separates these. Also
  # refactoring for order...
d$DOWm <- as.character(d$DOW)
d$DOWm[d$DOWm=='Tuesday' | d$DOWm=='Wednesday' | d$DOWm=='Thursday'] <- 
'Midweek'
d$DOWm <- factor(d$DOWm, levels=c('Sunday', 'Monday', 'Midweek', 'Friday', 'Saturday'), ordered=TRUE)

return(d)
}

### Useful plots
### Compare counts by day of week
# This plot uses jitter and alpha transparency to mitigate overplotting.
cbdow <- function(DOW, Count, Alpha=0.15) {
p <- ggplot(data.frame(DOW, Count), aes(x=DOW, y=Count))
p <- (p
  + layer(geom="jitter", alpha=Alpha)
  + xlab("Day of the week")
  + ylab("Number of bicycles")
)
return(p)
}

# Plot average counts by time of day
# For some reason I could never seem to get function to work quite right,
# though keying in the plot as written works...
avgcbt <- function(Count, Time) {

  average <- ddply(.data=data.frame(Count, Time), .(Time), summarize,
                    count=mean(Count))

  p <- ggplot(average, aes(x=average$Time, y=average$Count))

  p <- (p
    + layer(geom="bar")
    + opts(axis.text.x=theme_text(angle=-90, hjust=0))
    + ylab("Average number of bicycles")
    + xlab("Time of day")
  )

  return(p)
}

### Useful tests
### Multi t-tests
mega.t.test <- function(Values, Factors) {
  # This takes a vector of values and a vector of factors and compares all
  # permutations using a t_test
  require(gtools)
  require(plyr)
# This is inefficient
Data <- data.frame(Values, Factors)

Perms <- permutations(length(unique(factor(Factors))), 2, 
unique(as.character(factor(Factors))))

Sliced <- alply(Perms, .margins=1, function(x) subset(Data, 
Factors==x[1]|Factors==x[2]))

Tests <- ldply(Sliced, function(x)
data.frame(t.test(x$Values-x$Factors)$p.value, paste(unique(x$Factors)[1], 
unique(x$Factors)[2], sep="-")))

Tests <- Tests[2:3]

names(Tests) <- c("p.value", "factors_compared")

# This is less efficient than getting pairwise unique permutations BEFORE 
running the t.test. C'est la vie.
Tests <- unique(Tests)

return(Tests)

}

join.data <- function(CountsData, cityName) {
  # This is a convenience function for joining GIS output to the data tables 
  we've been working with here. Annoyingly, city name has to be included 
  because of site naming collisions.

  # Load the facilities table as was output from GIS 
facilities <- read.csv("/Users/peter/Dropbox/Fall2010/BikeCounts/bike_data_1123.csv", 
header=TRUE)

  # Load the weather station mapping table 
wmap <- read.csv("/Users/peter/Dropbox/Fall2010/BikeCounts/Analysis/Weather/ZipToStat 
ionMaps.csv", header=TRUE)

  # Load the weather data 
weather <- read.csv("/Users/peter/Dropbox/Fall2010/BikeCounts/Analysis/Weather/weatherda 
tal.csv")

  m1 <- merge(facilities, wmap, by="zipcode")
m2 <- merge(m1[m1$city==cityName,], CountsData, by.x="site_no", 
by.y="Site")
m3 <- merge(m2, weather, by.x=c("station", "Date"), by.y=c("station", 
"date"))

  # Some of the variable names were starting to get to me.

cleaned <- data.frame(groupId=m3$groupid, station=m3$station, date=m3$Date, site=m3$site_no, zip=m3$zipcode, city=m3$city, acre=m3$acre, trafficVol=m3$traffic_vol, bikeFacility=m3$bike_facil, jobs=m3$jobs, popDensity=m3$PopDensity...Acre., medianIncome=m3$Median.Income, housingUnits=m3$Housing.Units, age0.16=m3$X0.16age, age17.24=m3$X17.24age, ageOver24=m3$over24, time=m3$Time, count=m3$Count, DOW=m3$DOW, DOWm=m3$DOWm, avgTemp=m3$avgTemp, precip=m3$precip)

# Calculate jobs / area, and jobs / housing
cleaned$jobDensity <- (m3$jobs / m3$acre)
cleaned$mixedUse <- (m3$jobs / m3$Housing.Units)
return(cleaned)

join.priv.data <- function(JoinedData) {
  # Should be used after the join.data function. This will join private
  # employment data in the case of the Bellevue and Seattle data where we have
  # good (but privileged) employment data.

  # Use the 'xlsx' package to read the xlsx file
  require(xlsx)

  # Load our private jobs data from PSRC
  privjobs <- read.xlsx("/Users/peter/Desktop/PRIVATE_2000_Employment_Data.xlsx", sheetIndex=1, header=TRUE)

  cleaned <- merge(JoinedData, privjobs, by.x="groupId", by.y="STFID")

  cleaned$jobs <- cleaned$JOBS00

  # Calculate jobs / are, and jobs / housing for private data
  cleaned$jobDensity <- (cleaned$jobs / cleaned$acre)
cleaned$mixedUse <- (cleaned$jobs / cleaned$housingUnits)

  cleaned$JOBS00 <- NULL

  return(cleaned)
}

cbSiteDate <- function(Data) {
  # Fold data so that we're looking at total counts by site / date
  counts <- ddply(Data, .(site, date), summarize, count=sum(count))

  Data$count <- NULL
  Data$time <- NULL
  Data$X <- NULL

  counts <- join(counts, Data, by=c("site", "date"))

  return(counts)
}
regPretty <- function(Data) {
  # Get rid of variables that we aren't likely to use in the regressions
  Data$groupId <- NULL
  Data$station <- NULL
  Data$zip <- NULL
  Data$city <- NULL
  Data$city <- NULL
  Data$acre <- NULL
  Data$jobs <- NULL
  Data$housingUnits <- NULL
  Data$age0.16 <- NULL
  Data$ageOver24 <- NULL
  Data$DOW <- NULL
  Data$DOWm <- NULL
  return(Data)
}

# Prettier linear model diagnostics with ggplot2
ggResid <- function(LM) {
  # argument: a linear model
  p <- ggplot(LM, aes(.fitted, .resid)) +
      geom_hline(yintercept = 0, color = "gray50", size = 0.5) +
      geom_point() +
      geom_smooth(size = 0.5, se = F) +
      ylab("Fitted") +
      xlab("Residuals") +
      opts(title=LM$call, size=6) +
      opts(plot.title = theme_text(size=7))

  return(p)
}

ggQQ <- function(LM) {
  # argument: a linear model
  y <- quantile(LM$resid[!is.na(LM$resid)], c(0.25, 0.75))
  x <- qnorm(c(0.25, 0.75))
  slope <- diff(y)/diff(x)
  int <- y[1L] - slope * x[1L]
  p <- ggplot(LM, aes(sample=.resid)) +
      stat_qq(alpha = 0.5) +
      geom_abline(slope = slope, intercept = int, color="blue") +
      opts(title=LM$call, size=6) +
      opts(plot.title = theme_text(size=7))

  return(p)
}

# Regressions - for reference

#AM.lm <- lm(AM ~ trafficVol + bikeFacility + popDensity + medianIncome +
#age17.24 + avgTemp + precip + jobDensity + mixedUse)
#AMMD.lm <- lm(MD ~ trafficVol + bikeFacility + popDensity + medianIncome + age17.24 + avgTemp + precip + jobDensity + mixedUse + AM)

#AMPM.lm <- lm(PM ~ trafficVol + bikeFacility + popDensity + medianIncome + age17.24 + avgTemp + precip + jobDensity + mixedUse + AM)

#AMEV.lm <- lm(EV ~ trafficVol + bikeFacility + popDensity + medianIncome + age17.24 + avgTemp + precip + jobDensity + mixedUse + AM)

#AMNT.lm <- lm(NT ~ trafficVol + bikeFacility + popDensity + medianIncome + age17.24 + avgTemp + precip + jobDensity + mixedUse + AM)

#AMFD.lm <- lm(FD ~ trafficVol + bikeFacility + popDensity + medianIncome + age17.24 + avgTemp + precip + jobDensity + mixedUse + AM)

#PM.lm <- lm(PM ~ trafficVol + bikeFacility + popDensity + medianIncome + age17.24 + avgTemp + precip + jobDensity + mixedUse)

#PMMD.lm <- lm(MD ~ trafficVol + bikeFacility + popDensity + medianIncome + age17.24 + avgTemp + precip + jobDensity + mixedUse + PM)

#PMAM.lm <- lm(AM ~ trafficVol + bikeFacility + popDensity + medianIncome + age17.24 + avgTemp + precip + jobDensity + mixedUse + PM)

#PMEV.lm <- lm(EV ~ trafficVol + bikeFacility + popDensity + medianIncome + age17.24 + avgTemp + precip + jobDensity + mixedUse + PM)

#PMNT.lm <- lm(NT ~ trafficVol + bikeFacility + popDensity + medianIncome + age17.24 + avgTemp + precip + jobDensity + mixedUse + PM)

#PMFD.lm <- lm(FD ~ trafficVol + bikeFacility + popDensity + medianIncome + age17.24 + avgTemp + precip + jobDensity + mixedUse + PM)