Analysis of Bicyclist Counts in the Puget Sound Area and Spokane

Report 95.3

Washington State Transportation Commission
Innovations Unit

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1.0 Introduction and Research Approach

Beginning in January of 1993, a bicycle volume count program was established at several locations in the Puget Sound region and at one location in Spokane. The counts provide a preliminary basis for assessing: (a) the numbers of bikers during various times of the year and (b) the number of cyclists during any single count period. The report begins by describing how the count data were collected; this explanation includes a brief description of each count location. Additionally, this section overviews the number of counts by various time periods and weather conditions for each location. The remainder of the report is organized into three sections. The first section begins by describing results based on weekday counts at each location. This is followed by a review of weekend counts by location. The second section provides estimates of both average daily weekday and weekend volumes for each location. In the final section, a summary of major results is presented.

Sample Design

Collecting bike count data is difficult at best. The population is highly variable; on one day a count might be exceedingly high, while on another day the count might be very low. Factors contributing to count variability include weather conditions, time of day, and day of week. It is important that the count collection methodology adequately capture this variability in order to make reasonably confident estimates of average daily and peak-period volumes. Accordingly, a sampling methodology, based on random selection of count periods and days at each of the locations, was constructed.

Bicycle traffic counts were recorded at each of five locations (four in the Puget Sound area and one in Spokane): NE 65th and the Burke-Gilman Trail in the northern University District; Stone Way N and N 35th in Fremont; Mercer and Dexter in downtown Seattle; Lake Washington Blvd in Kirkland; and the Centennial Trail in Spokane. Counts were collected throughout most of a single year, although at several locations counts were limited to only a few months. Two types of counts were taken: (1) weekday, two-hour, AM and PM peak-period counts, and (2) weekend, five-hour, peak-period counts. During each week of counts, a randomly selected subset taken from all possible AM and PM count periods (Fridays were not included because preliminary counts revealed atypical commuting patterns on that day) and a Saturday or Sunday count period, was posted. Each person participating as a bicycle traffic counter then chose one or more count opportunities from this random subset of available weekly count periods. Each week, a new subset was posted.

During each count, counters were instructed to record the number of utility (e.g., commuters, students, and shoppers), social/recreational, and exercise/training cyclists in 15-minute intervals. Clearly, some degree of judgment must be applied in categorizing observed cyclists. To ensure consis-tency, counters were taken through several practice count sessions in which the type of cyclist was identified. The categorization was based in large part on the observed cyclist's appearance: during the peak-period counts, individuals with panniers, backpacks, or satchels were assumed to be utilitarian cyclists; individuals with standard bike apparel (e.g., lycra tights but no extra gear) were assumed to be training/exercise; and individuals with either children, no gear, or those leisurely riding individually or in a group were assumed to be primarily social/recreational riders.

During the first few weeks of counts, counters were rotated and counts were tallied and compared among all locations except Spokane. Results suggested consistency in count classification across counters and locations. Spokane counters did not get the same level of training, although detailed category descriptions for cyclists were distributed to each of the counters. Inspection of the various counts undertaken in Spokane suggests that internal consistency was maintained within Spokane counts; however, some caution is warranted when comparing the Spokane counts to the Seattle counts. Observed count proportions were also compared with results from the cyclist mail-back survey. Roughly 60 percent of the total observed cyclists during weekday counts were identified as utility cyclists. Of the total mail-back surveys, approximately 56 percent of the cyclists, on average, identified themselves as on a utility trip when handed the survey. Combined totals for weekday recreation and exercise training cyclists were 40 percent of those counted during the peak period and 44 from the mail-back survey.

In addition to classifying the type of cyclist, the weather conditions at the start of the count were also recorded. These conditions were based on visual observation at the start of the count. Three categories of classification were used: sunny, cloudy, and rainy. Sunny day counts are self-explanatory. Cloudy day counts were recorded for days in which rain, by appearance alone, was considered imminent, but no drizzle or steady rain was currently present. Rainy day counts are those in which drizzle or rain was occurring at the time of the count.

2.0 Count Analysis and Results

This section presents the results of the count program. The discussion begins with a description of each of the locations and the types of counts conducted. This is followed by a presentation and analysis of: (1) weekday counts at each location, and (2) weekend counts. In both the weekday and weekend discussion sections, each location is discussed independently and includes a review of both daily and yearly trends.

Count Locations

A total of five locations were ultimately included in the count program. At each location both directions were recorded. Each of these locations is as follows.

1. **Seattle CBD.** This count took place at the corner of Dexter and Mercer, focusing on counts of north- and southbound cyclists on Dexter. The Dexter route, which primarily serves downtown commuters, has a painted, on-street bike lane.

2. **NE 65th and the Burke-Gilman Trail.** This location is in the northeast University District. It is a completely separated and paved bike facility. The trail serves many purposes including basic utility travel, travel to the University of Washington (UW), and social/recreational outings.

3. **Stone Way N and the Burke-Gilman Trail.** Located in Fremont, this bike facility is separated and paved. Many CBD-bound commuters utilize this section of the Trail, as do many UW students.

4. **Lake Washington Blvd, Kirkland.** This location is a few blocks south of Central Way (south of downtown Kirkland). It is a painted on-street, bike lane. As will be seen, it is a low-volume location when compared to others in the count program.

Note: While searching for a representative count location east of Lake Washington, at least in terms of utility cyclists, the possible sites enumerated by King County and City of Bellevue bike representatives included the following locations:

Possible Eastside Location	Average 2-hour peak
Coal Creek Parkway, near Newport HS	(25)
Lake Hills Boulevard, near 148th Ave SE	(21)
Lake Washington Boulevard, near SE 8th	(41)
Main St, between 140th Ave SE/156th Ave SE	(5)
108th Ave NE, between NE 53rd and NE 59th	(14)
Old Redmond Road, near 1N 35th Ave NE	(1)

In the preliminary stages of this study, counts were conducted at all of these sites and, as can be seen, peak volumes were found to be extremely low, often with no cyclists observed during weekday peak periods. Consequently, only the Lake Washington Boulevard site in Kirkland was continued as part of the count program.

5. **Centennial Trail, Spokane.** This location, on the Gonzaga Bridge, is a completely separated bike facility used by both students and commuters.

Weekday Counts

Weekday bike counts were performed at five locations:

- Burke-Gilman and NE 65th
- Fremont (Stone Way N and N 35th)
- Seattle CBD (Mercer and 9th)
- Kirkland (Lake Washington Blvd)
- Spokane (Centennial Trail and Gonzaga)

The weekday counts were conducted during traditional AM and PM peak travel periods, with sliding time periods to reflect time of year daylight conditions. Between the late spring and early fall months, AM peak-period counts were collected between 7:00 AM and 9:00 AM (shifting to 7:30-9:30 AM during the winter months). Peak-period counts in the PM were conducted from 4:00 to 6:00 PM between the late spring early months (shifting to 3:30-5:30 PM during the winter months). The data collected from each of the five locations, beginning with NE 65th and the Burke-Gilman Trail, are described in detail in the following text.

<u>**Northern University District- Burke-Gilman and NE 65th**</u>

<u>**Daily Trends.**</u> 105 separate counts were made at this location; 51 were AM peak-period counts and 54 were PM peak-period counts. As Table 1 illustrates, volumes tend to be higher in the PM peak period and on sunny days. When volumes are compared to sunny days, PM peak-period volumes tend to drop more precipitously (by 41 percent on cloudy days and 68 percent on rainy days) than AM peak-period volumes (19 percent for cloudy days and 45 percent for rainy days). Table 1 also indicates, as will be seen, a recurrent weather pattern in counts, i.e., more sunny and cloudy counts than rainy counts; in part this was due to unseasonably dry winter and fall conditions. It is also important to examine the distributional aspects of volume data. These types of assessments lend insight into the variability by weather and count period. Boxplots represent one graphical means of examining distributions. Boxplots describe several important features of a data set, including the center of the data, how the data values are spread, the identification of any points lying unusually far from the bulk of the data, and the extent and nature of any departures from symmetry. These features are particularly important because all of them can affect, sometimes dramatically, certain summary statistics (e.g., the mean or standard deviation).

Figure 1 illustrates the key components of a boxplot. The length of the box corresponds to the inner 50 percent of the ordered data; it is commonly referred to as the interquartile range. The line through the center of the box represents the median; the median is used to determine the central tendency or location of the distribution. If the median is not centered, the data are skewed, having several data with very high or very low values relative to the bulk of the data. The lines extending from either end of the box incorporate data values less than 1.5 box lengths from the 25th (75th) percentile. Outliers are data points with values greater than 1.5 box lengths but less than 3.0 box lengths; extreme values are data points with values greater than 3.0 box lengths from the 25th (75th) percentile.

Table 1. AM/PM 2 Hr. Peak-Period Counts - Burke-NE 65th

Type	Weather	No. Counts	Mean No. Observed Cyclists	Std. Dev.
AM	Sunny	22	118.5	53.2
	Cloudy	20	95.1	45.8
	Rainy	9	59	15.1
PM	Sunny	29	299.6	106.7
	Cloudy	16	170	69.6
	Rainy	9	73	25.1

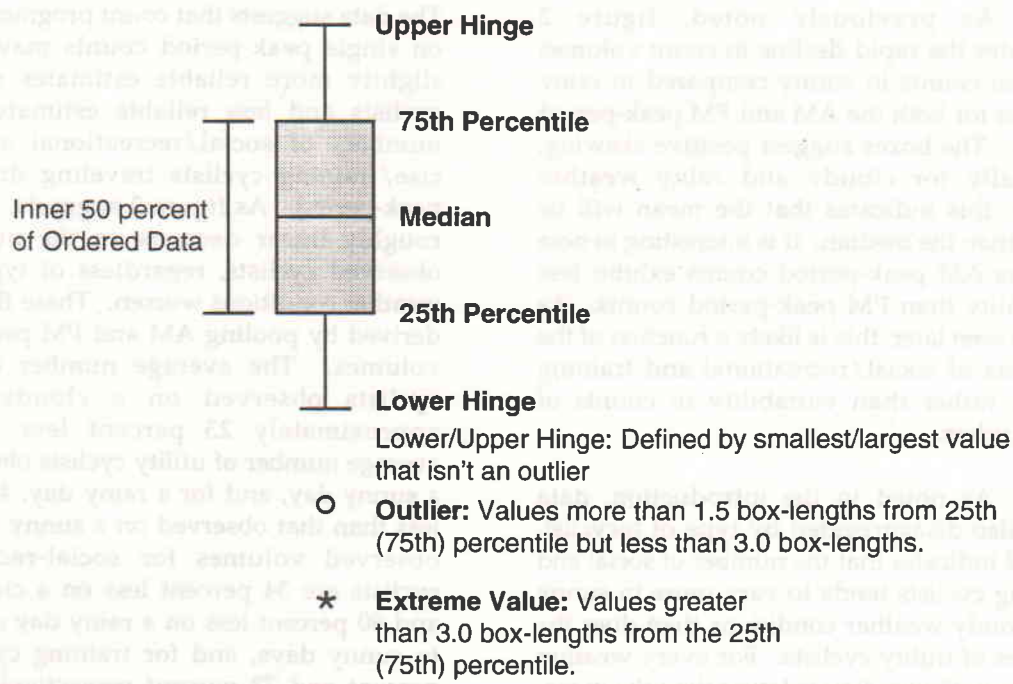


Figure 1. Annotated Boxplot of Normally Distributed Data

Table 2. Summary Statistics by Weather and Type - Burke-NE 65th (Pooled 2 Hr. Peak Periods)

	Min	Mean	Median	Max	Std. Dev.
Sunny					
Utility	17	86.5	86	165	39.3
Social	0	51.8	37	234	53.2
Train	0	54.9	43	246	57.3
Cloudy					
Utility	27	62.8	54.5	177	27.2
Social	0	29.8	12.5	117	34.1
Train	0	36	24	181	39.6
Rainy					
Utility	15	42	35	69	17.7
Social	0	9	4	38	11.4
Train	0	15	9	55	15.8

As previously noted, figure 2 illustrates the rapid decline in count volumes between counts in sunny compared to rainy weather for both the AM and PM peak-period counts. The boxes suggest positive skewing, especially for cloudy and rainy weather counts; this indicates that the mean will be larger than the median. It is interesting to note that the AM peak-period counts exhibit less variability than PM peak-period counts. As will be seen later, this is likely a function of the numbers of social/recreational and training riders, rather than variability in counts of utility riders.

As noted in the introduction, data were also disaggregated by type of bicyclist. Table 2 indicates that the number of social and training cyclists tends to vary more in sunny and cloudy weather conditions than does the number of utility cyclists. For every weather condition, the median is lower than the mean, indicating that the data distribution is positively skewed. Positive skewing suggests a preponderance of extreme values, i.e., counts with very large volumes relative to the mode.

The data suggests that count programs relying on single peak-period counts may provide slightly more reliable estimates of utility cyclists and less reliable estimates of the numbers of social/recreational and exercise/training cyclists traveling during the peak-period. As figure 3 suggests, there is a roughly linear decrease in the number of observed cyclists, regardless of type, when weather conditions worsen. These figures are derived by pooling AM and PM peak-period volumes. The average number of utility cyclists observed on a cloudy day is approximately 23 percent less than the average number of utility cyclists observed on a sunny day, and for a rainy day, 45 percent less than that observed on a sunny day. The observed volumes for social-recreational cyclists are 34 percent less on a cloudy day and 80 percent less on a rainy day compared to sunny days, and for training cyclists, 35 percent and 73 percent respectively. These figures indicate less decline in volumes, due to weather conditions, by utility cyclists than by other types of cyclists.

Figure 2. AM/PM Distributions

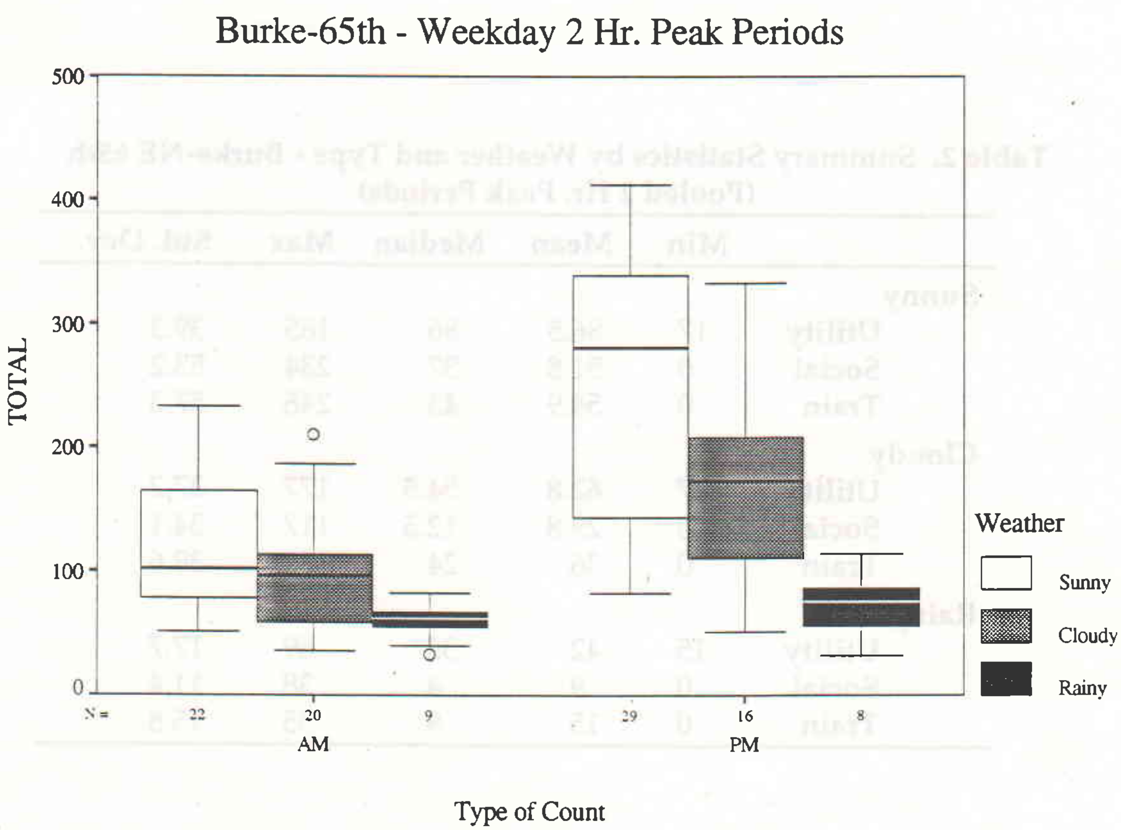
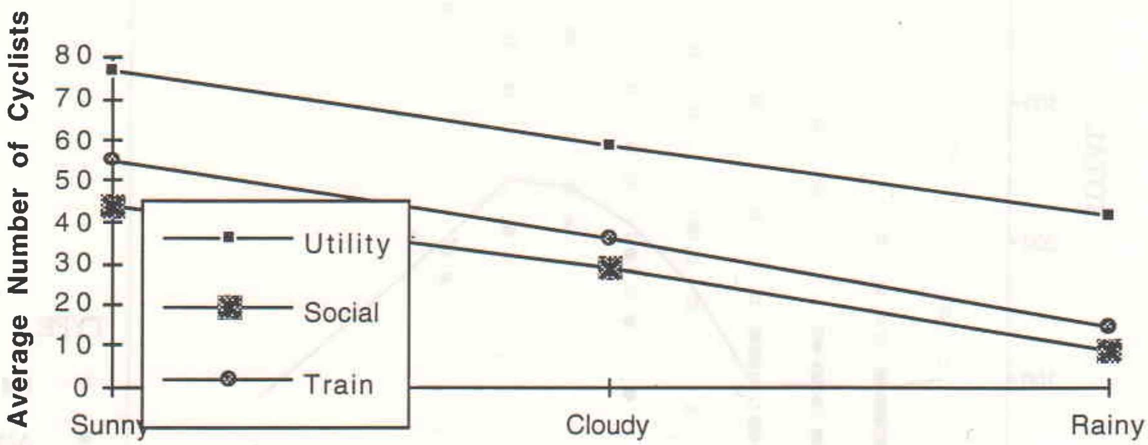


Figure 3. Average No. Cyclists by Weather and Type

Burke-65th - Weekday 2 Hr. Peak Periods



Seasonal Trends. As noted earlier, count data were collected over several months; in some locations data were collected over much of an entire year. In this section, data gathered at Burke and NE 65th are examined for yearly trends. Figure 4 presents two major elements of the data. First, each count period is identified by a unique marker, one for AM counts and one for PM counts. Second, a smoother (illustrated by the solid line) is employed to examine the yearly trend. A smoother provides a robust assessment of the patterns associated with the data. The smoother makes no assumptions regarding the spacing of the x-values and places less emphasis, or weight, on outliers or extreme values. As figure 4 illustrates, counts are available throughout much of the year. However, a limited number of counts were performed in the months of January, September, and December, and none were performed in several of the summer months. Thus, month-to-month appraisals should be considered exploratory in nature. Nonetheless, several interesting seasonal features can be discerned.

As might be expected, there is evidence of increasing volumes during late spring, summer, and early fall months. Average volumes in the summer months are approximately one to two times greater than those found in the winter months. The large number of counts in winter months helps to identify a clustering around 75 bikes per peak-period; the positive skewing is particularly apparent in the months of February, March, and April. This means that the mean will be greater than the median. Additional counts in the summer months would be useful for identifying whether a similar skewing also exists during these months.

As figure 5 demonstrates, the volume composition remains fairly consistent. Although the raw number of cyclists declines during certain months, the proportion of utility cyclists tends to hover between 65 and 80 percent of the total observed cyclists. Figure 5 also suggests that the proportion of social-recreation riders increased in May and December. There are really too few counts in December to speculate on the possible reasons for this increase; nonetheless, the phenomenon may be related to the unusually dry weather experienced during this month. It is also notable that the average percentage of individuals using the trail for training or exercise during the peak periods remains fairly consistent throughout the year, hovering around 17 percent.

Figure 4. Seasonal Trends

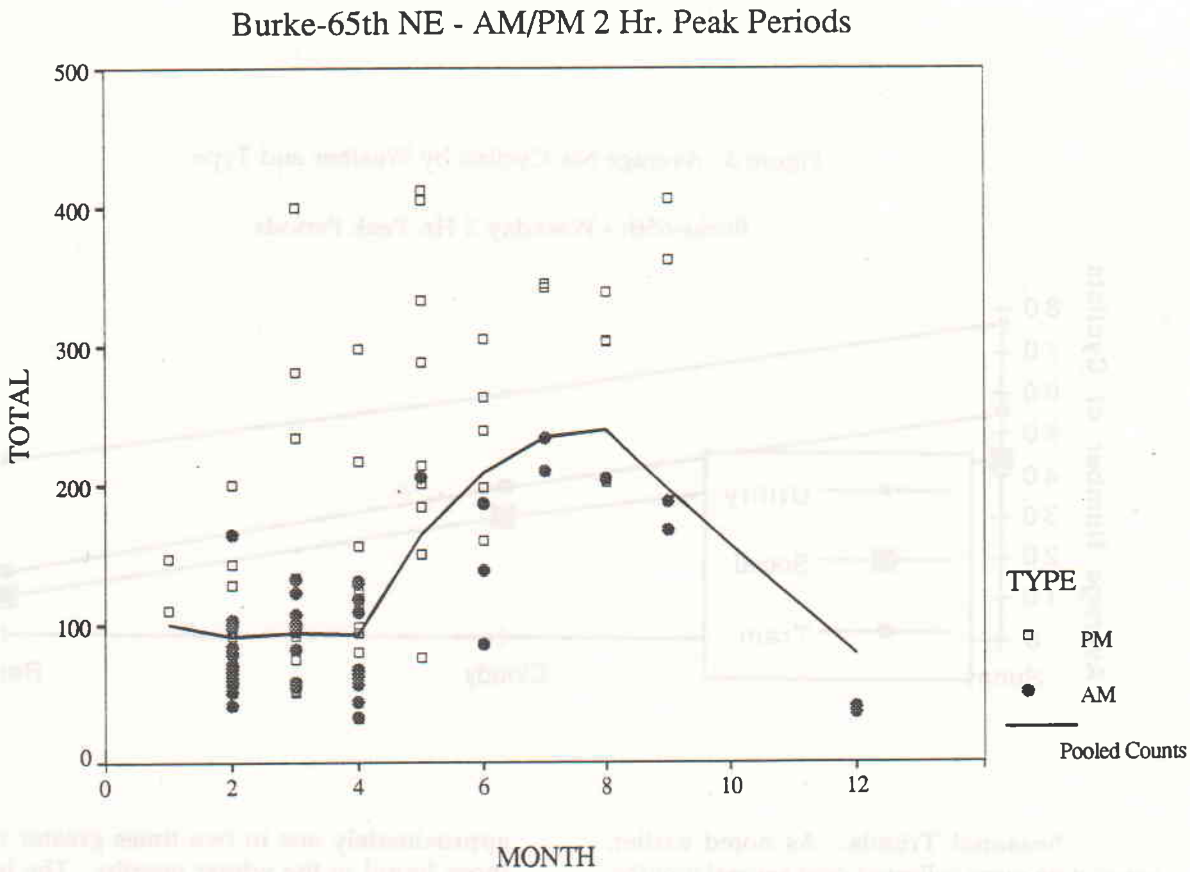
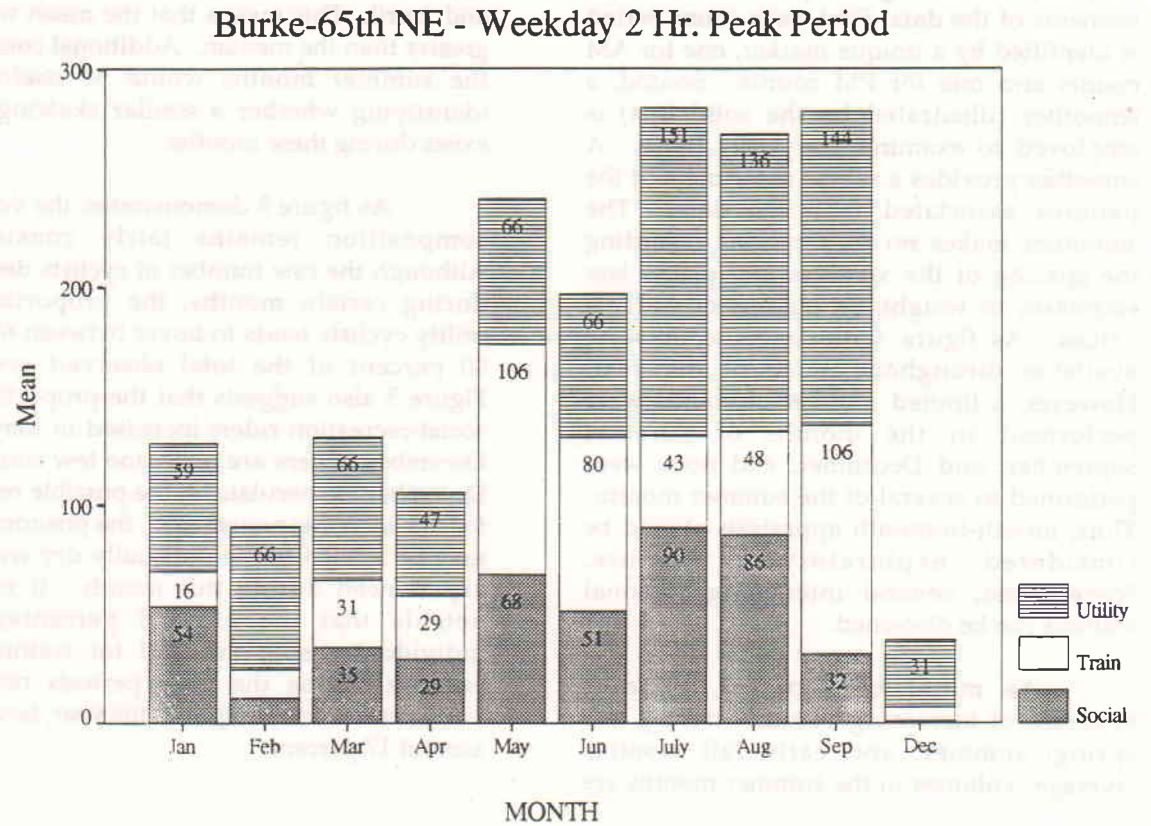


Figure 5. Average No. Cyclists by Type



Fremont - Stone Way N. and N 35th

Daily Trends. A total of 31 separate counts were made at this location; 39 were AM peak-period counts, and 32 were PM peak-period counts (Table 3). As the following table illustrates, volumes tend to be similar in both the AM and PM peak periods with slightly less depreciation in numbers as weather worsens when compared to the Burke-NE 65th location. Peak-period volumes in the morning drop by approximately 9 percent for cloudy days and by 64 percent for rainy days when compared to sunny days. PM peak-period counts decline more sharply, with a decrease of 31 percent on cloudy days and 55 percent on rainy days, when compared to sunny days.

As seen in figure 6, the Stone Way N and N 35th counts indicate a tendency for reduced volumes as weather becomes rainy. However, the falloff between sunny and cloudy days is less distinct than that noted for the Burke-NE 65th data. It is also interesting to note that volumes tend to be fairly comparable between AM and PM peak periods. One possible implication is greater regularity in utility cyclists traveling through this count location. The steep dropoff between cloudy days and rainy days may be indicative of a more consistent group of utilitarian cyclists willing to ride in cloudy or eminent rain conditions but less likely to ride in steady rain.

As Table 4 illustrates, utility cyclists are present in much greater numbers than seen at the Burke-NE 65th location. This may reflect the fact that many downtown commuters use this portion of the Burke as a hopping-off point. This location is also considered within the primary commuter target market identified by the Seattle Engineering Department (Goldsmith 1992). This suggests that a high number of bicycle commuters would be expected. Regardless of weather, utility cyclists average between approximately 66 and 70 percent of the total cyclists counted during any peak period.

Figure 7 illustrates the data contained in Table 4. In contrast to the Burke-NE 65th location, the number of utility cyclists does not steadily decrease as weather worsens. Rather, there is a slight decline in the numbers of utility cyclists for sunny versus cloudy counts, followed by a steep decline for rainy conditions. The number of social and training cyclists remains steady with small, consistent declines. However, these data should be interpreted cautiously; there were only a few rainy counts made during either of the peak periods.

Seasonal Trends. Turning to seasonal variations, the number of cyclists appears to steadily increase as the year progresses (figure 8). Based on the observations, the data suggest a tendency for declining volumes in the late fall. However, it should also be noted that only a limited number of counts were taken during the July through January period; as such, this observation is exploratory.

Table 3. AM/PM 2 Hr. Peak-Period Counts - Fremont

Type	Weather	No. Counts	Mean No. Obs. Cyclists	Std. Dev.
AM	Sunny	20	248.9	91.4
	Cloudy	14	206.3	55.8
	Rainy	5	108.6	81.8
PM	Sunny	16	283.1	139.6
	Cloudy	13	156.5	63.9
	Rainy	3	106	23.1

Table 4. Summary Statistics by Weather and Type - Fremont (Pooled 2 Hr. Peak Periods)

	Min	Mean	Median	Max	Std. Dev.
Sunny					
Utility	57	185.6	185	343	96.3
Social	0	40.6	18.5	175	50.3
Train	7	40.6	34	135	27.8
Cloudy					
Utility	46	131.3	116	258	56.4
Social	0	20	11	124	29.6
Train	10	34.4	31	81	17.9
Rainy					
Utility	18	76.5	59.5	193	55.9
Social	0	14	7.5	45	16.6
Train	0	15.13	10.0	38	14.7

Figure 6. AM/PM Distributions

Fremont - Weekday 2 Hr. Peak Periods

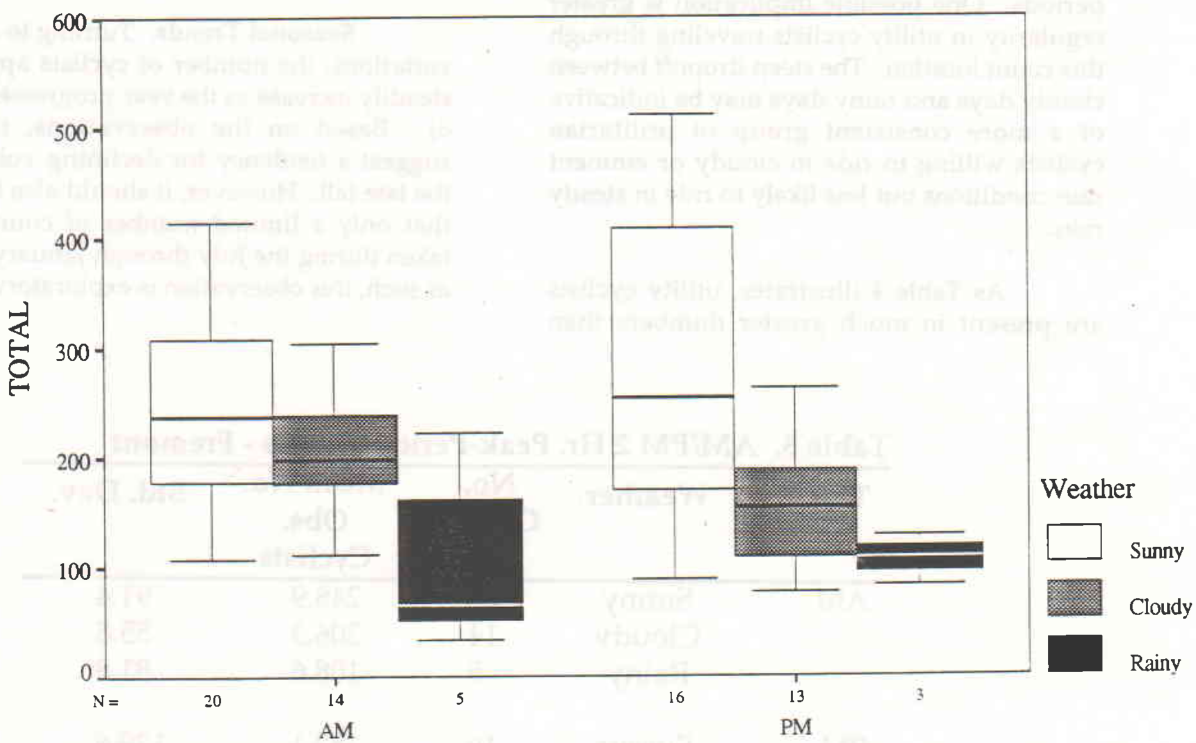


Figure 7. Average No. Cyclists by Weather and Type

Fremont - Weekday 2 Hr. Peak Period

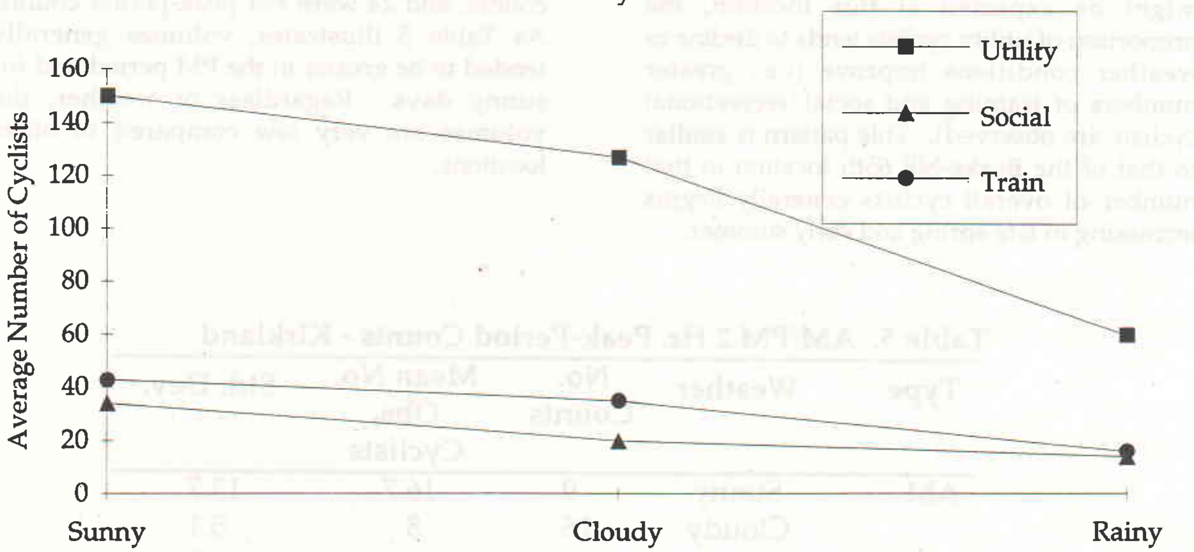
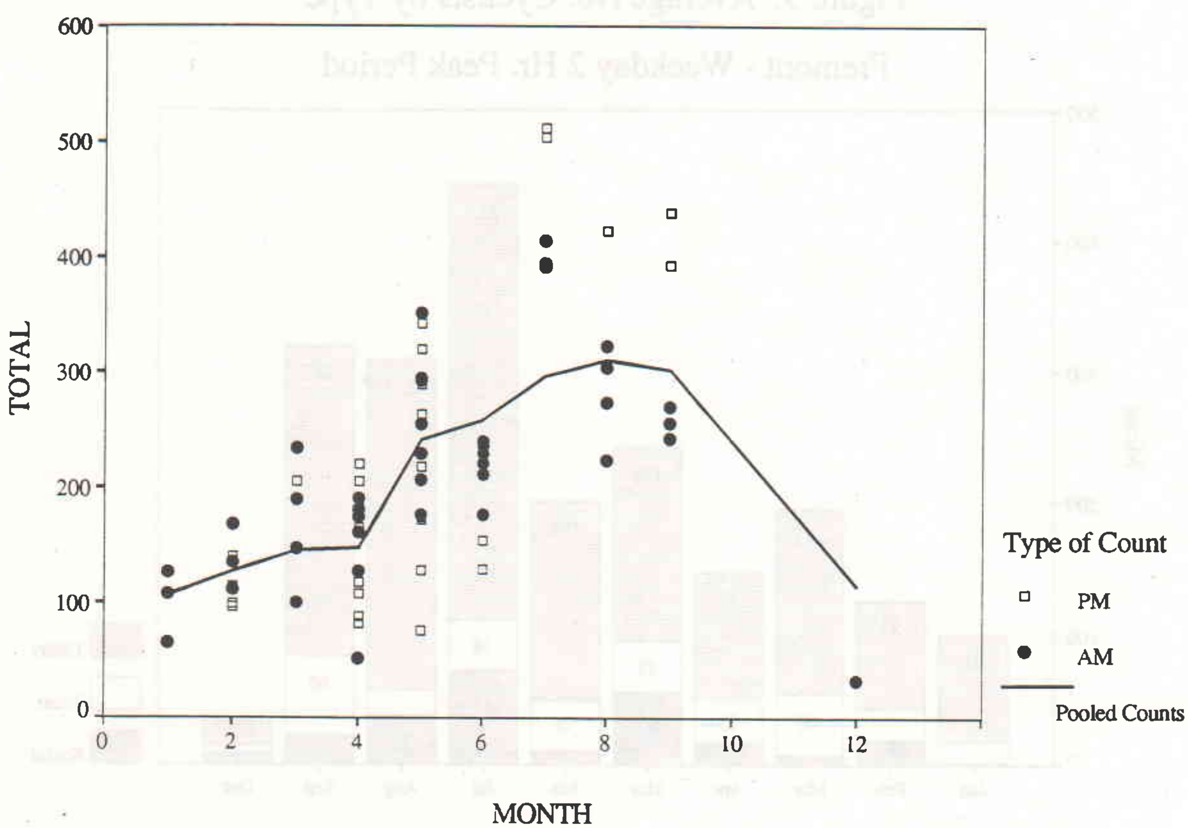


Figure 8. Seasonal Trends

Fremont - AM/PM 2 Hr. Peak Periods



As figure 9 shows, the proportion of utility cyclists at the Fremont location tends to fluctuate from month to month, yielding an overall average between 66 and 70 percent. As might be expected at this location, the proportion of utility cyclists tends to decline as weather conditions improve (i.e., greater numbers of training and social/recreational cyclists are observed). This pattern is similar to that of the Burke-NE 65th location in that number of overall cyclists generally begins increasing in late spring and early summer.

Kirkland - Lake Washington

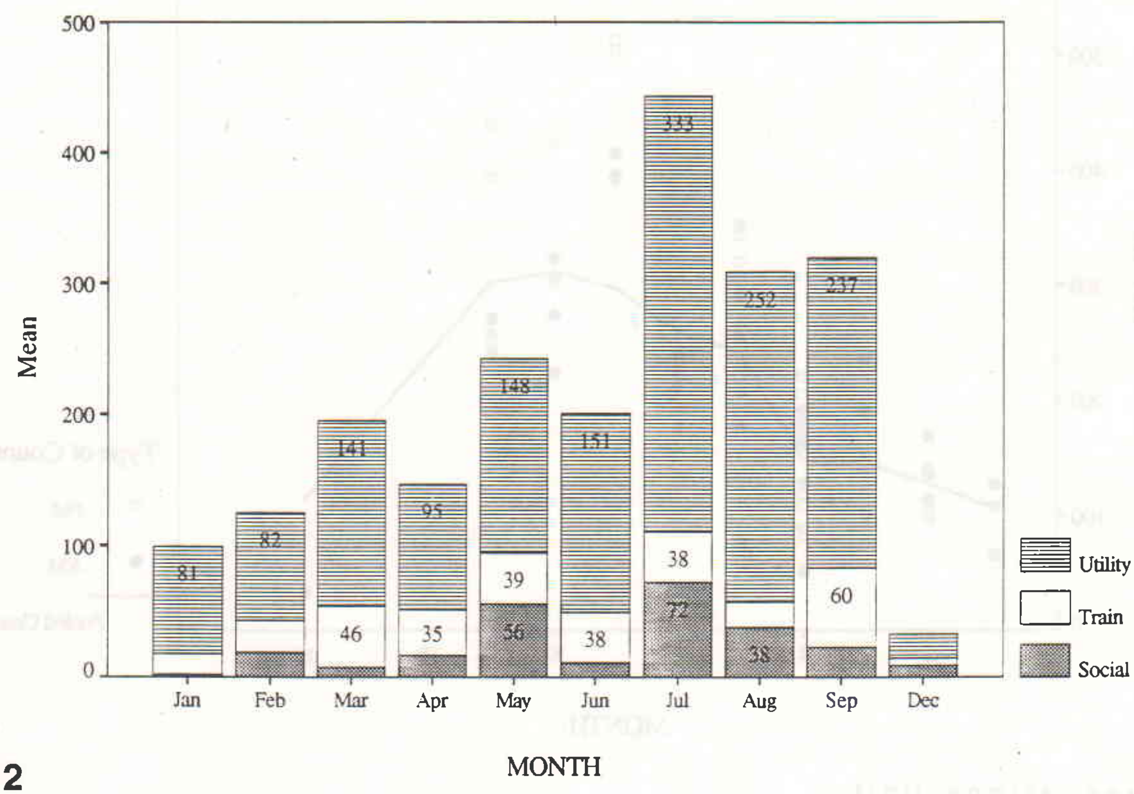
Daily Trends. Fifty-three counts were made at this location; 23 were AM peak-period counts, and 24 were PM peak-period counts. As Table 5 illustrates, volumes generally tended to be greater in the PM period and for sunny days. Regardless of weather, the volumes are very low compared to other locations.

Table 5. AM/PM 2 Hr. Peak-Period Counts - Kirkland

Type	Weather	No. Counts	Mean No. Obs. Cyclists	Std. Dev.
AM	Sunny	9	16.7	13.7
	Cloudy	16	8	5.1
	Rainy	4	3	1.0
PM	Sunny	14	38.7	18.7
	Cloudy	9	14	10.4
	Rainy	1	14	NA

Figure 9. Average No. Cyclists by Type

Fremont - Weekday 2 Hr. Peak Period



As can be seen on figure 10, the data again suggest a drop in volume during rainy conditions. It is also interesting to note that the distribution of sunny PM peak-period counts is negatively skewed, indicating an extended tail with low values. In other words, although the PM peak-period count appears to have slightly higher volume counts, in terms of the number of riders, there were a large number of very low counts as well.

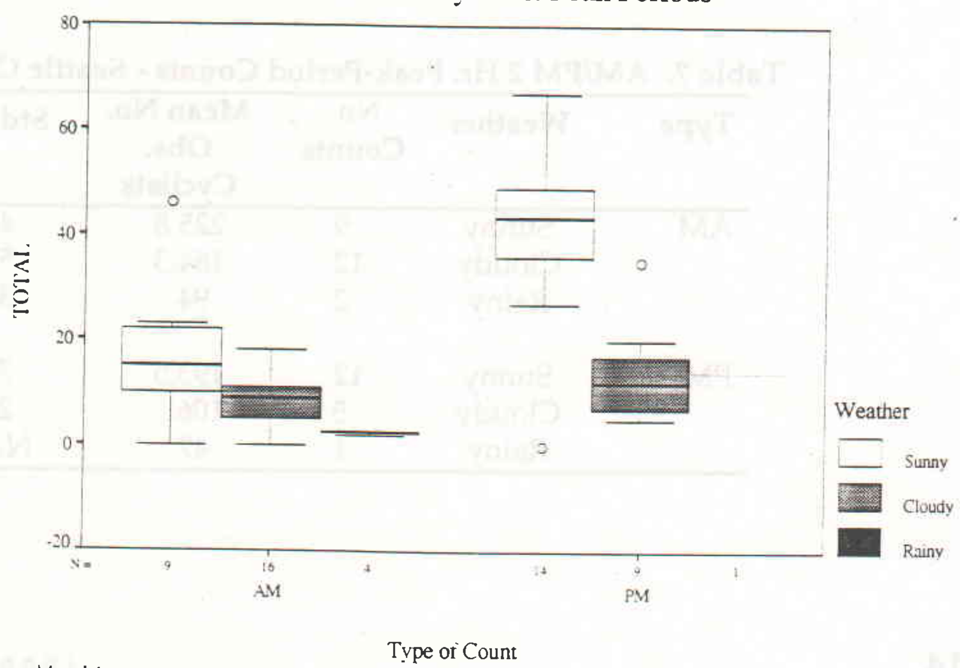
As Table 6 illustrates, on average the share of utility cyclists ranged from approximately 31 to 60 percent of the total volume. The commute component of the total volume is substantially less than at either of the prior locations (Burke-NE 65th or Fremont) during sunny counts.

Table 6. Summary Statistics by Weather and Type - Kirkland (Pooled 2 Hr. Peak Periods)

		Min	Mean	Median	Max	Std. Dev.
Sunny						
	Utility	0	9.7	10	21	7.0
	Social	0	12	7	35	12.3
	Train	0	8.5	10	21	6.8
Cloudy						
	Utility	0	5.7	4	16	4.8
	Social	0	1	1	7	1.8
	Train	0	4	2	23	5.1
Rainy						
	Utility	2	3	3	5	1.2
	Social	0	0	0	0	0
	Train	0	2	0	9	3.9

Figure 10. AM/PM Distributions

Kirkland - Weekday 2 Hr. Peak Periods



As figure 11 illustrates, the number of social/recreational cyclists tends to decline very rapidly as weather conditions worsen. Both utility cyclists and training cyclists appear to decline linearly when comparing average counts made under varying weather conditions.

Seasonal Trends. Although there are a very limited number of riders, the same seasonal patterns noted at previous locations appear here at Kirkland as well (figure 12). The data suggest higher volumes in the late spring, summer, and early fall months, declining in the winter months. Volumes rarely exceed 40 in number, and then only in the summer and early fall months. The number of individual cyclists training at this location appears to be roughly the same proportion as those using the route for utility purposes.

Seattle - Central Business District (CBD)

Daily Trends. Thirty counts were made at this location; 23 were AM peak-period counts, and 18 were PM peak-period counts (Table 7). The data collected at this location suggested a very different trend than noted at previous locations: PM peak-period volumes were considerably lower than AM peak-period volumes. At previously analyzed locations, the trend was for similar or higher PM volumes. The number of observed cyclists declined approximately 22 percent during cloudy conditions during both peak periods. However, the rate is considerably steeper (down 55 percent) when going from cloudy to rainy conditions in the PM peak period. It should be noted that only one count was made during rain in the PM peak period. Observed volumes are also consistent with those taken by the Seattle Engineering Department during September 1992 at a nearby location (Goldsmith 1993).

As can be seen on figures 13 and 14, there is a drop in volume during rainy conditions. Some skewing of the data can be observed, particularly on cloudy days. As Table 8 illustrates, on average, utility cyclists represented between approximately 93 and 98 percent of the total peak-period volume. The utility component of the total volume observed at this location is substantially higher than has been observed at prior locations. It is also interesting to note that the standard deviation does not vary greatly by weather condition, suggesting a certain degree of consistency in the counts. The number of utility cyclists declined by 13 percent for cloudy counts compared to sunny counts, and by 49 percent for rainy versus sunny counts. This decline is consistent with results noted at previous locations, (e.g., Burke-NE 65th, 23 percent for sunny-to-cloudy conditions and 45 percent for sunny-to-rainy and for the Fremont count, 15 percent for sunny-to-cloudy and 60 percent for sunny-to-rainy).

Table 7. AM/PM 2 Hr. Peak-Period Counts - Seattle CBD

Type	Weather	No. Counts	Mean No. Obs. Cyclists	Std. Dev.
AM	Sunny	9	225.8	47.1
	Cloudy	12	164.3	51.6
	Rainy	2	94	33.2
PM	Sunny	12	193.5	76.96
	Cloudy	5	106	22.5
	Rainy	1	47	NA

Table 8. Summary Statistics by Weather and Type - Seattle CBD (Pooled 2 Hr. Peak Periods)

	Min	Mean	Median	Max	Std. Dev.
Sunny					
Utility	63	195.4	201	275	58.1
Social	0	13.9	15	40	10.8
Train	0	8	7	19	6.2
Cloudy					
Utility	74	140.8	140	224	47.5
Social	0	4.2	3	15	4.8
Train	0	2.2	1	11	3.3
Rainy					
Utility	46	76	68	114	34.7
Social	1	2	2	2	0.6
Train	0	0	0	1	0.6

Figure 11. Average No. Cyclists by Weather and Type

Kirkland - Weekday 2 Hr. Peak Periods

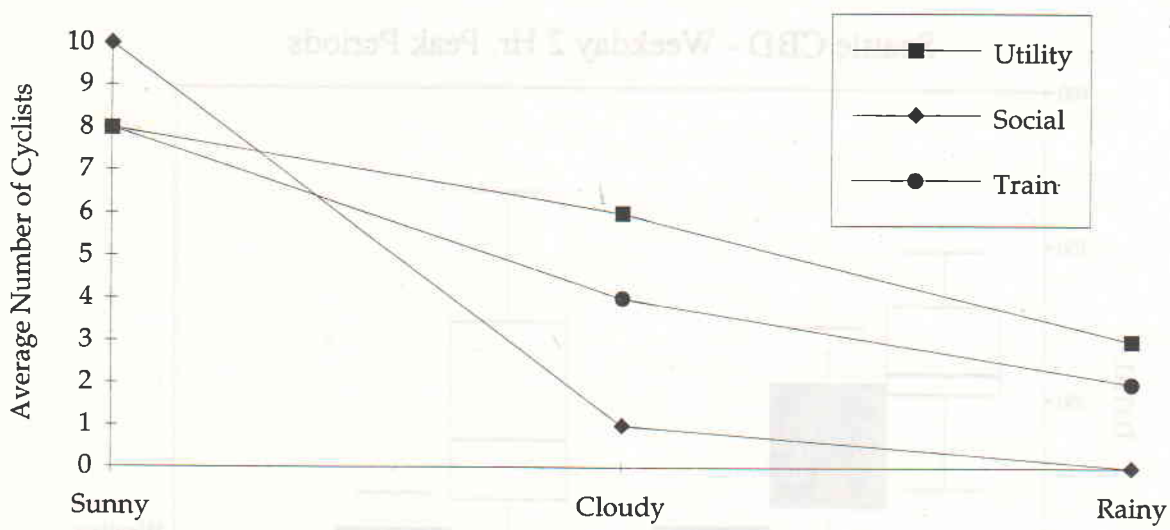


Figure 12. Average No. Cyclists by Type

Kirkland - Weekday 2 Hr. Peak Period

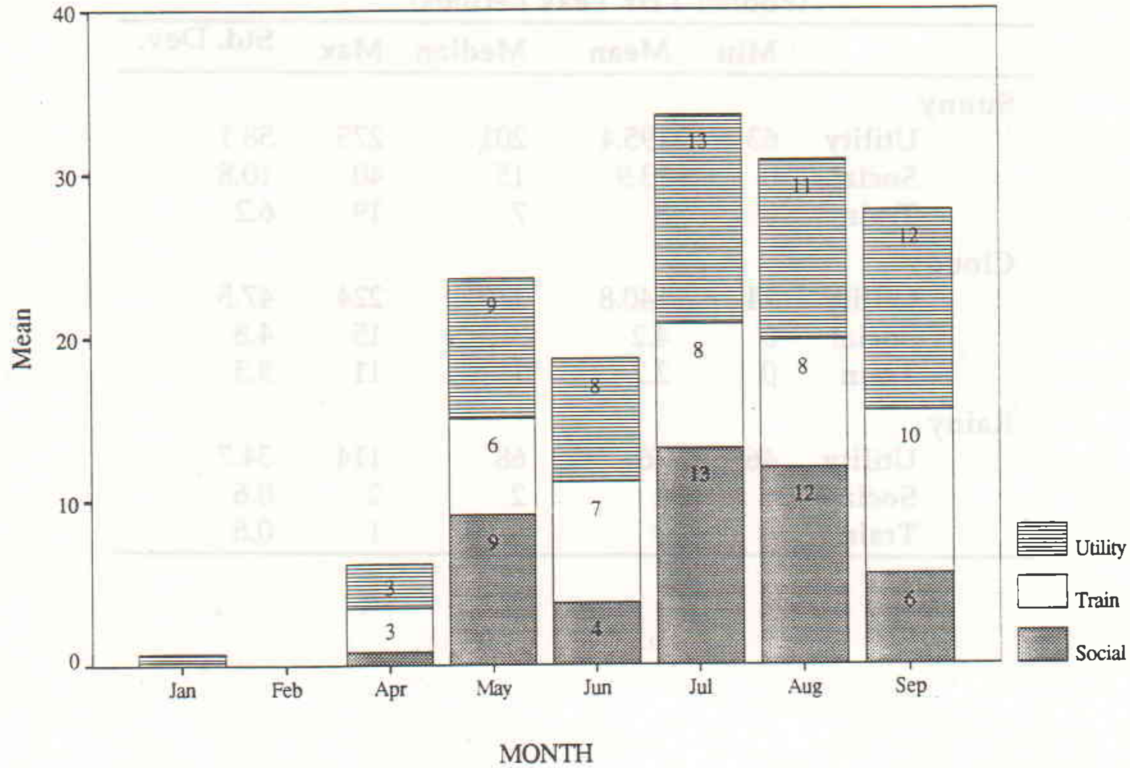


Figure 13. AM/PM Distributions

Seattle CBD - Weekday 2 Hr. Peak Periods

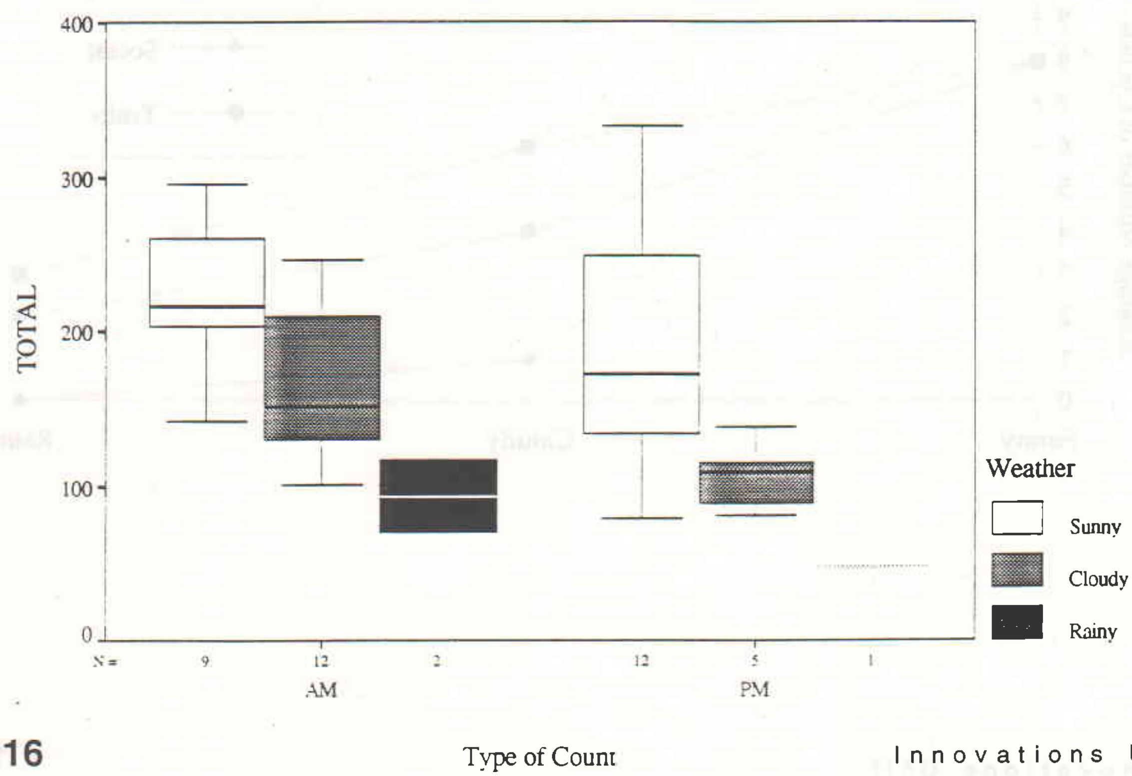
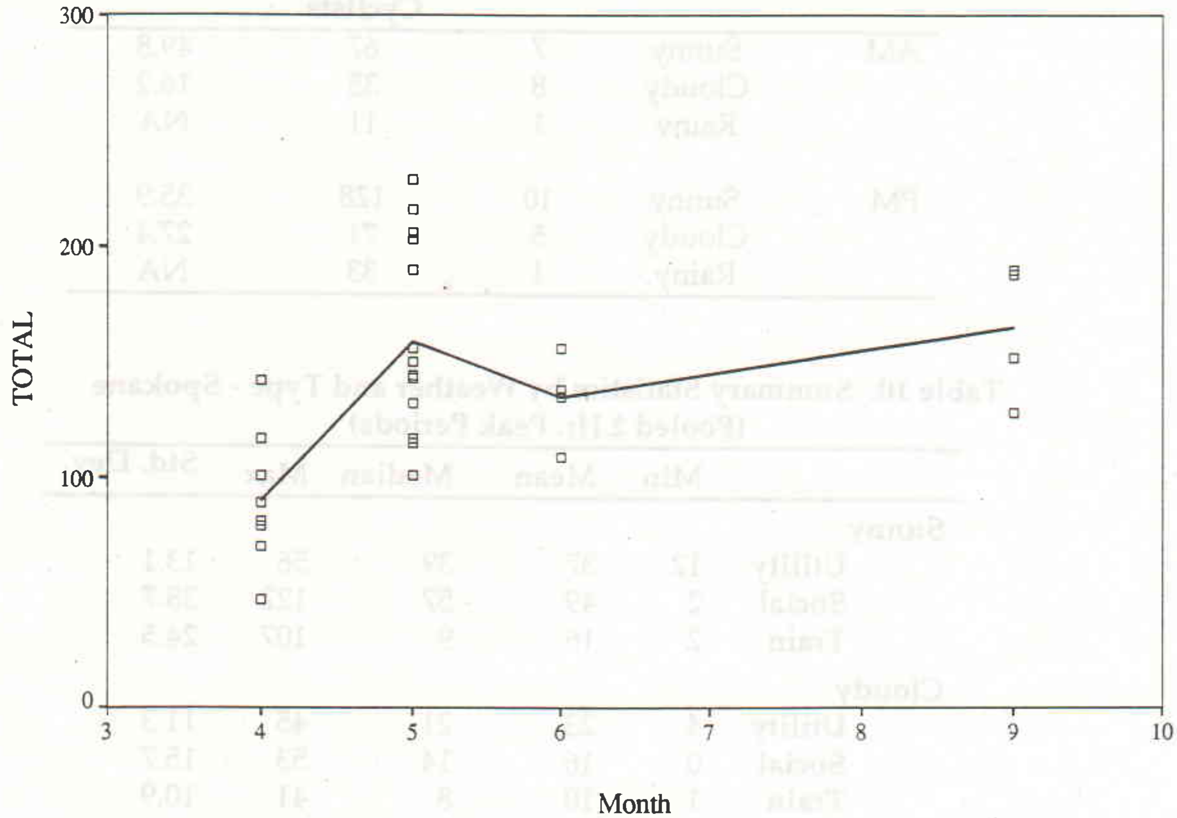


Figure 14. Seasonal Trends

Seattle CBD - Weekday Peak Period



Seasonal Trends. Looking at figure 15, it is clear that many of the same seasonal patterns noted at earlier locations also begin to appear for this location. The data suggest higher volumes in the late spring, summer, and early fall months, possibly declining in the winter months. The lack of counts during winter months makes this observation highly exploratory, but early April counts would tend to support this speculation. Figure 16 illustrates the breakdown of cyclists by month and type of cyclist. There is an extremely large utility population throughout the year.

Spokane - Centennial Trail

Daily Trends. Thirty-two counts were made at this location; 16 were AM peak-period counts, and 16 were PM peak-period counts (Table 9). Counts were higher in the PM peak period and under sunny conditions. As with earlier analyses, sharp declines in volumes are experienced as weather becomes rainy. As with several locations discussed earlier, care should be exercised when evaluating rainy conditions because of the small sample size. The data suggest that PM sunny counts tend to vary less about the mean than do AM sunny counts, indicating some degree of consistency in the volumes. The AM cloudy counts tend to be more consistent than the PM cloudy counts.

The fact that cloudy counts tend to vary less around the mean seems reasonably intuitive. Travel by bike is probably more likely to be altered on cloudy mornings — most utility cyclists may simply choose not to go — the smaller volumes in the AM tend to support this hypothesis. However, in the PM peak period, there is greater flexibility for completing a trip by bike and greater knowledge of weather conditions.

Table 9. AM/PM 2 Hr. Peak-Period Counts - Spokane

Type	Weather	No. Counts	Mean No. Obs. Cyclists	Std. Dev.
AM	Sunny	7	67	49.8
	Cloudy	8	35	16.2
	Rainy	1	11	NA
PM	Sunny	10	128	35.9
	Cloudy	5	71	27.4
	Rainy	1	33	NA

Table 10. Summary Statistics by Weather and Type - Spokane (Pooled 2 Hr. Peak Periods)

		Min	Mean	Median	Max	Std. Dev.
Sunny						
	Utility	12	37	39	56	13.1
	Social	2	49	57	122	38.7
	Train	2	16	9	107	24.5
Cloudy						
	Utility	4	23	21	45	11.3
	Social	0	16	14	53	15.7
	Train	1	10	8	41	10.9
Rainy						
	Utility	9	10	10	10	0.7
	Social	0	9	9	17	12.0
	Train	1	4	4	7	4.2

As can be seen in figures 17 and 18, the data again suggest somewhat of a drop in volume during rainy conditions. The data suggest that AM volumes drop less than during cloudy conditions than do PM volumes. The single bars on the rainy category represent the single observation, and as such, cannot be interpreted usefully.

As Table 10 illustrates, the utility and social-recreation riders appear in comparable proportions during the peak-period counts. This may be suggestive of a large proportion of social cyclists during the peak-periods or, because counters were not trained in precisely the same way. Thus, this may reflect differences in classification methods among counters. Taken alone, the counts indicate roughly a 38 percent decline in utility count volumes from sunny to cloudy conditions. A similar comparison for sunny to rainy cannot be made because of the small sample.

Possible eastside location preliminary peak count

- Coal Creek Parkway, near Newport High School (number of obs. cyclists = 25)
- Lake Hills Boulevard, near 148th Ave SE (number of obs. cyclists = 21)
- Lake Washington Boulevard, near SE 8th (number of obs. cyclists = 41)

Figure 15. Seasonal Trends

Seattle CBD - AM/PM 2 Hr. Peak Periods

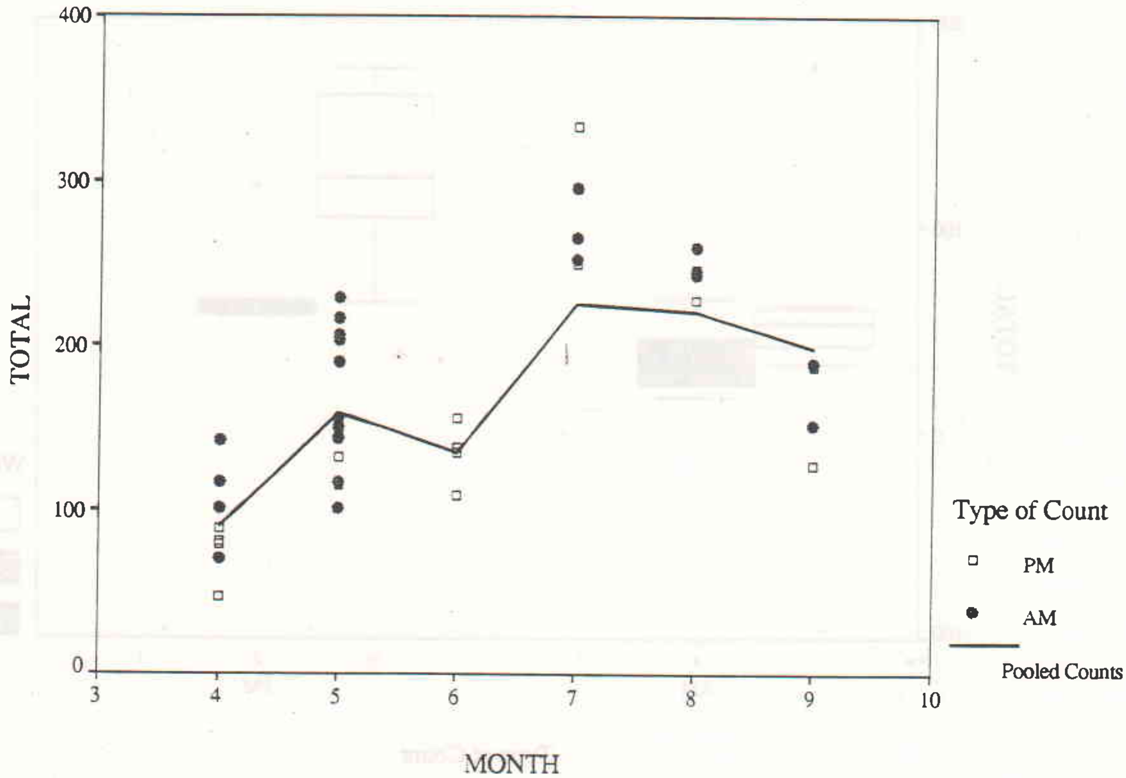


Figure 16. Average No. Cyclists by Type

Seattle CBD - Weekday 2 Hr. Peak Period

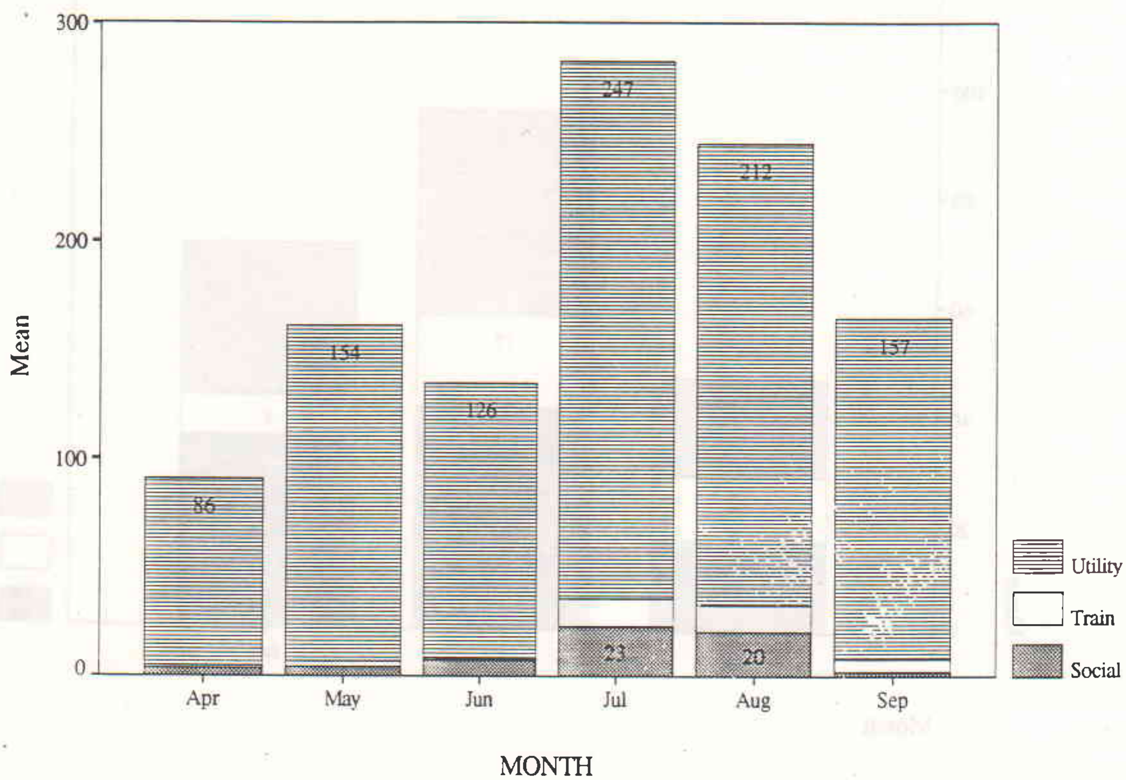


Figure 17. AM/PM Distributions

Spokane - Weekday 2 Hr. Peak Periods

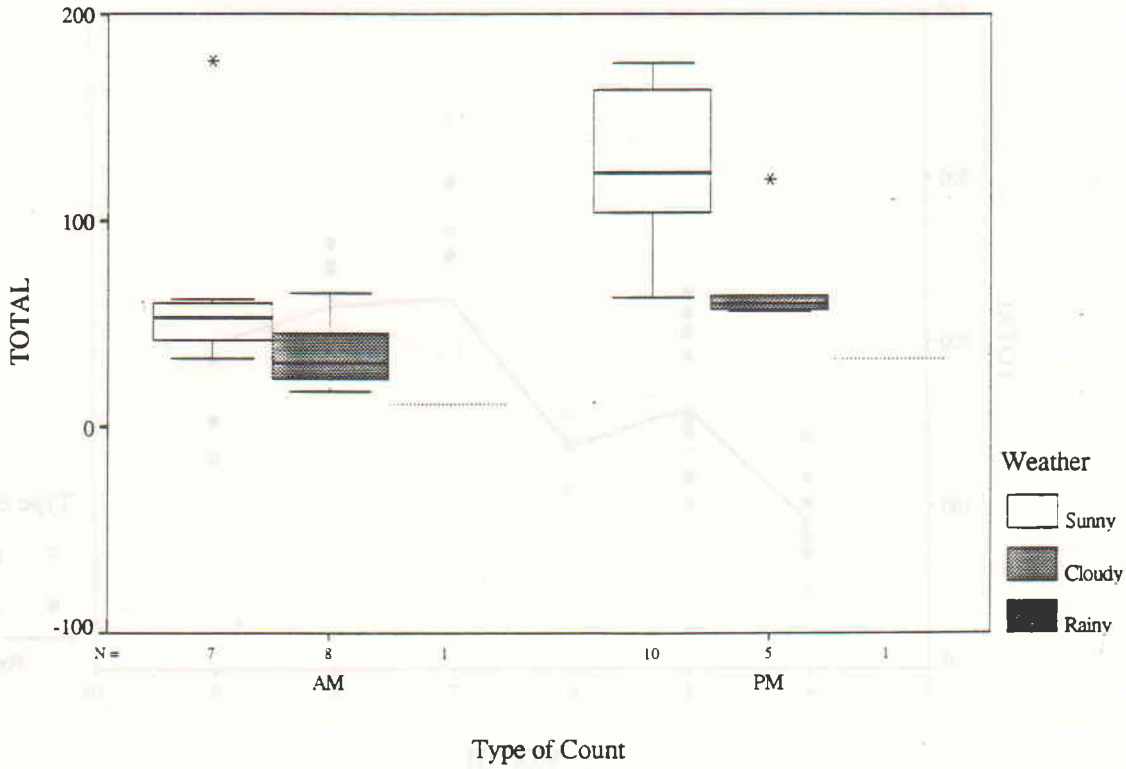
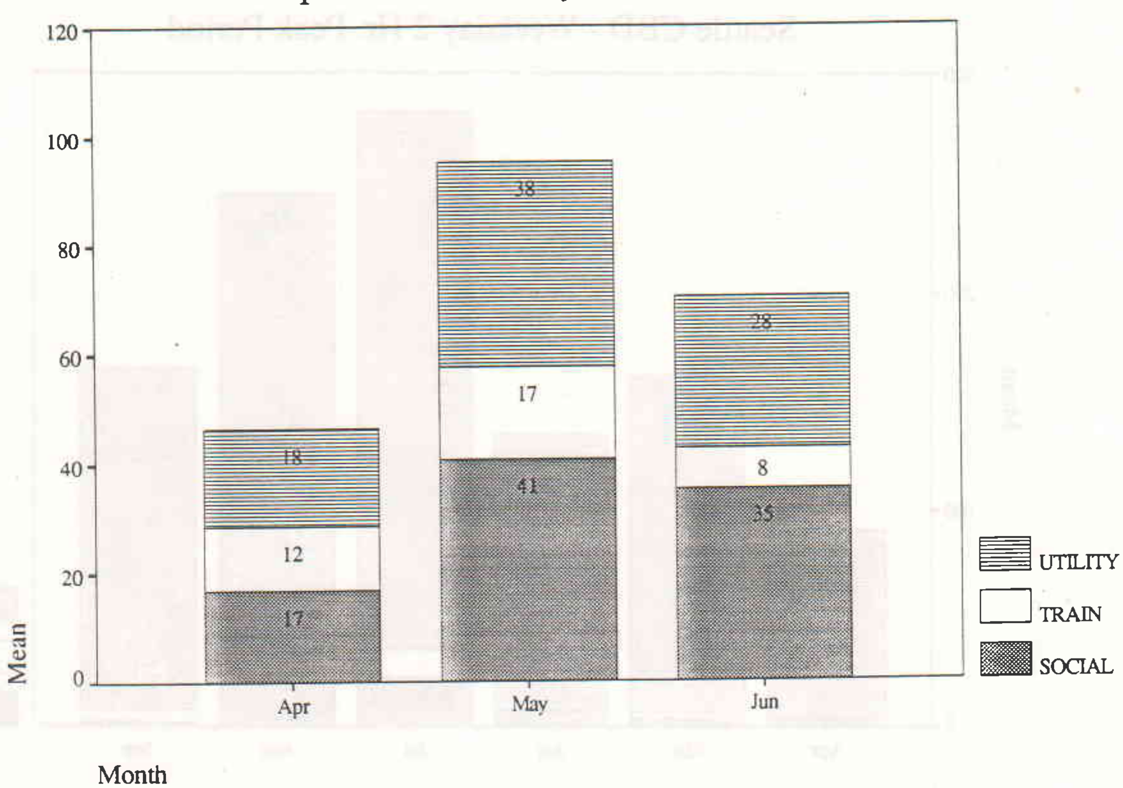


Figure 18. Average No. Cyclists by Type

Spokane - Weekday Peak Period



- Main Street, between 140th Ave SE and 156th Ave SE (number of obs. cyclists = 5)
- 108th Ave NE, between NE 53rd and NE 59th (number of obs. cyclists = 14)
- Old Redmond Road, near One N 35th Ave NE (number of obs. cyclists = 1)

Seasonal Trends. Turning to figure 19, there is slight evidence of higher volumes during the peak summer months, tapering off in early fall. The lack of sufficient counts precludes greater emphasis. Finally, examining the proportion of utility cyclists shown on figure 20 confirms earlier discussions indicating nearly equal proportions of utility and social-recreational riders.

Weekend Counts

As noted in the introduction, weekend counts were performed at three locations:

- Burke-Gilman and NE 65th
- Kirkland (Lake Washington Blvd)
- Spokane (Centennial Trail and Gonzaga Bridge)

Figure 19. Seasonal Trends

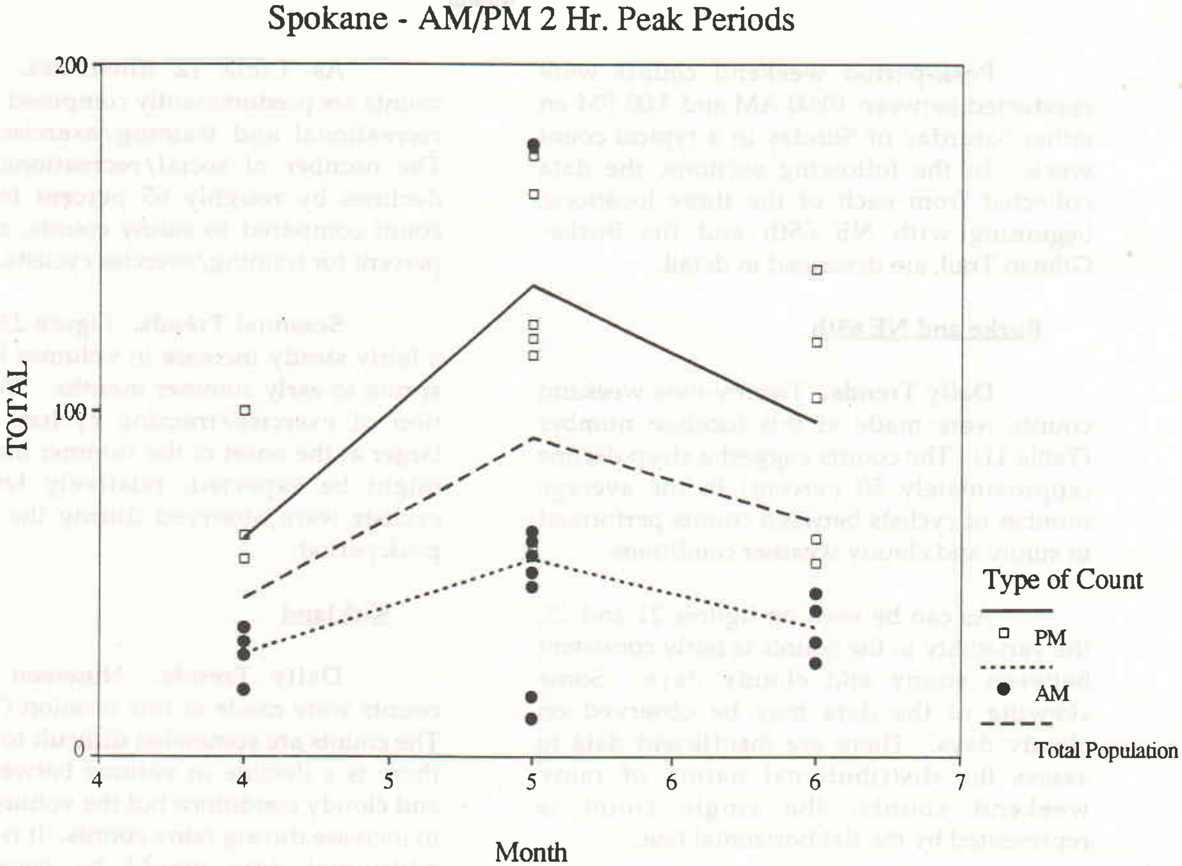
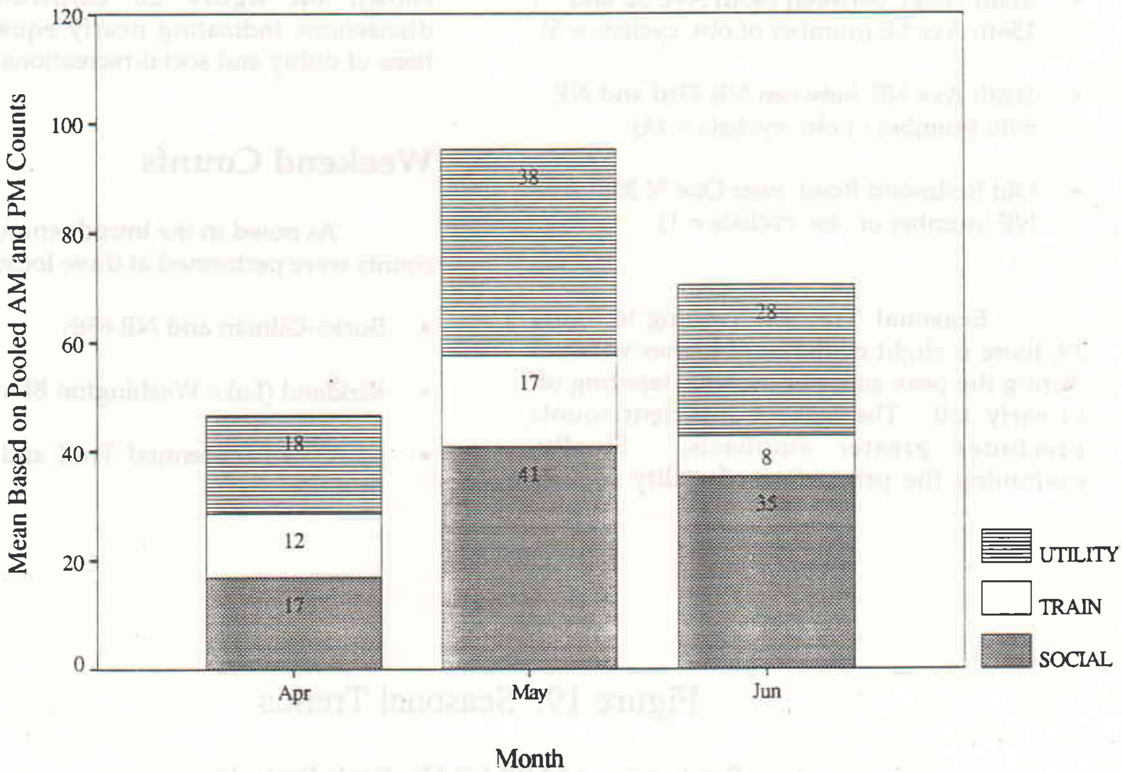


Figure 20. Average No. Cyclists by Type

Spokane - Weekday 2 Hr. Peak Period



Peak-period weekend counts were conducted between 10:00 AM and 3:00 PM on either Saturday or Sunday in a typical count week. In the following sections, the data collected from each of the three locations, beginning with NE 65th and the Burke-Gilman Trail, are described in detail.

Burke and NE 65th

Daily Trends. Twenty-nine weekend counts were made at this location number (Table 11). The counts suggest a steep decline (approximately 50 percent) in the average number of cyclists between counts performed in sunny and cloudy weather conditions.

As can be seen on figures 21 and 22, the variability in the counts is fairly consistent between sunny and cloudy days. Some skewing of the data may be observed on cloudy days. There are insufficient data to assess the distributional nature of rainy weekend counts; the single count is represented by the flat horizontal line.

As Table 12 illustrates, weekend counts are predominantly composed of social/recreational and training/exercise cyclists. The number of social/recreational cyclists declines by roughly 65 percent for cloudy count compared to sunny counts, and by 41 percent for training/exercise cyclists.

Seasonal Trends. Figure 23 suggests a fairly steady increase in volumes in the late spring to early summer months. The proportion of exercise/training cyclists becomes larger at the onset of the summer months. As might be expected, relatively few utility cyclists were observed during the weekend peak period.

Kirkland

Daily Trends. Nineteen weekend counts were made at this location (Table 13). The counts are somewhat difficult to interpret; there is a decline in volume between sunny and cloudy conditions but the volumes appear to increase during rainy counts. It is clear that additional data would be necessary to evaluate these count volumes properly.

Figure 21. Weekend Distributions

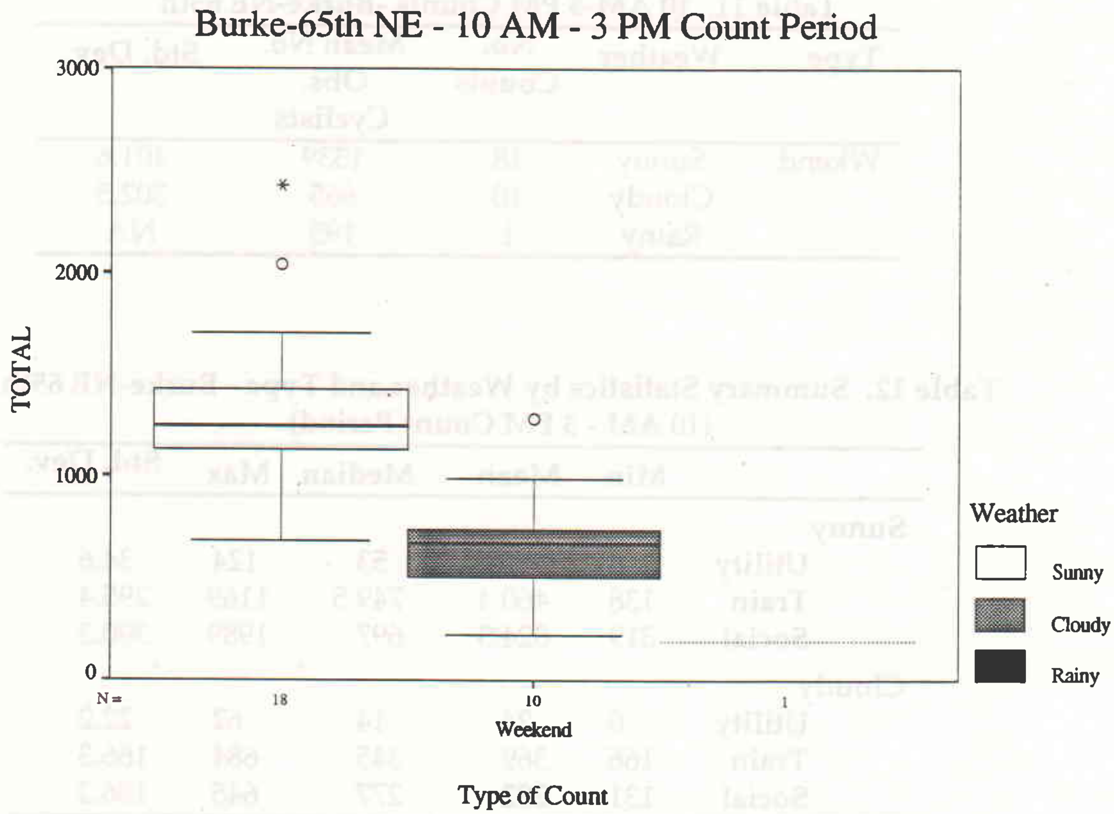


Figure 22. Seasonal Trends

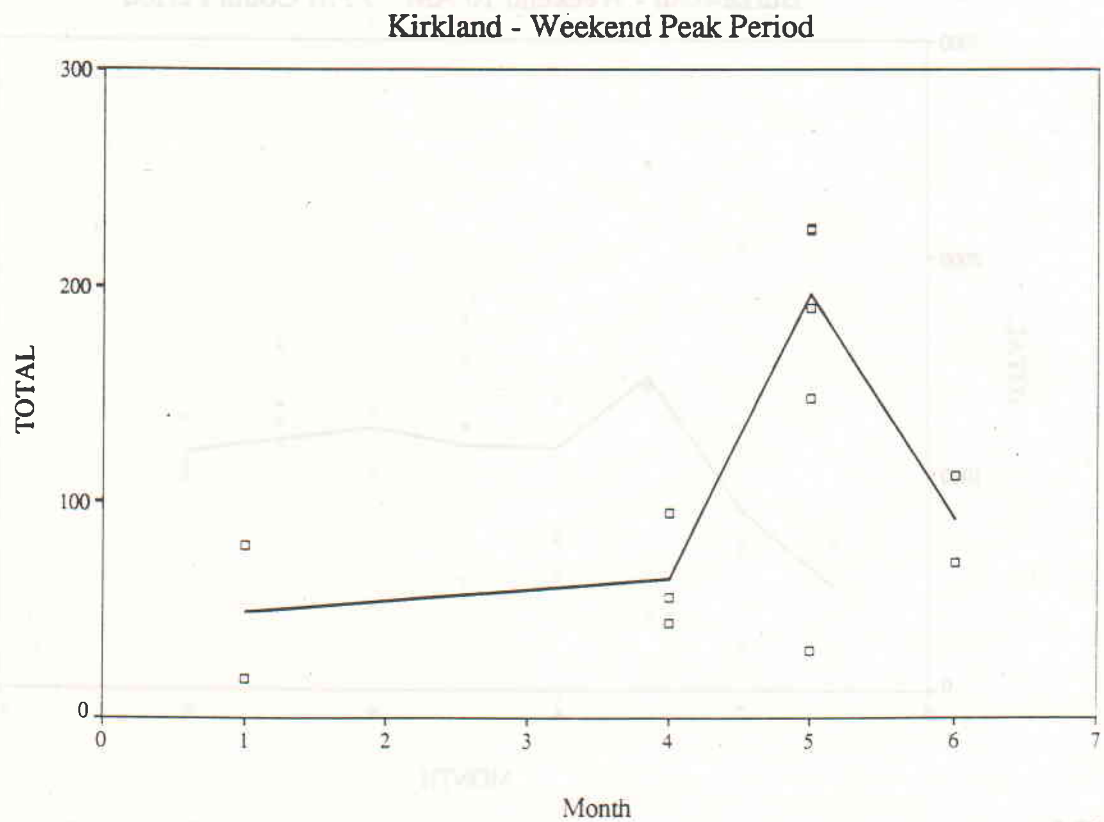


Table 11. 10 AM-3 PM Counts -Burke-NE 65th

Type	Weather	No. Counts	Mean No. Obs. Cyclists	Std. Dev.
Wkend	Sunny	18	1339	401.6
	Cloudy	10	665	302.5
	Rainy	1	195	NA

Table 12. Summary Statistics by Weather and Type - Burke-NE 65th (10 AM - 3 PM Count Period)

	Min	Mean	Median	Max	Std. Dev.
Sunny					
Utility	6	54.3	53	124	34.6
Train	138	460.4	749.5	1169	295.4
Social	319	824.3	697	1989	390.3
Cloudy					
Utility	0	24	14	62	22.2
Train	166	369	345	684	166.3
Social	131	282	277	645	156.2

Figure 23. Seasonal Trends

Burke-65th - Weekend 10 AM - 3 PM Count Period

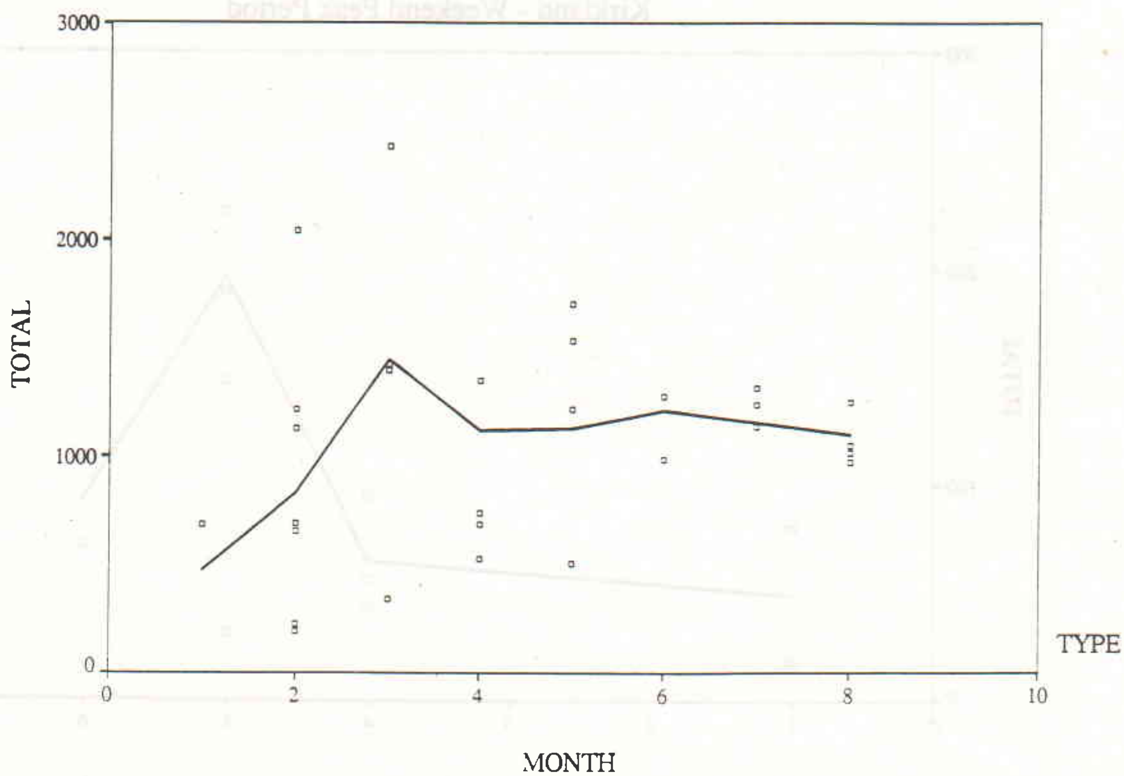


Table 13. 10 AM-3 PM Counts - Kirkland

Type	Weather	No. Counts	Mean No. Obs. Cyclists	Std. Dev.
Wkend	Sunny	14	145.4	60.9
	Cloudy	3	52.3	26.5
	Rainy	2	84	16.3

Table 14. 10 AM-3 PM Counts - Spokane

Type	Weather	No. Counts	Mean No. Obs. Cyclists	Std. Dev.
Wkend	Sunny	7	455	176.2
	Cloudy	2	403	482.9
	Rainy	1	248	NA

As can be seen on figure 24, a steep decline in volumes during cloudy conditions is visible. There is a fair degree of variability in the sunny counts with volumes ranging from a low of seven to a high of 240. These counts appear to be approximately normally distributed.

Seasonal Trends. Figure 25 provides a limited basis for evaluating weekend seasonal trends at this location. As can be seen, there appears to be a substantial increase in volumes during the month of May followed by a decrease in June. This may be due to anomalies in count periods or it may reflect weather patterns at the time. At any rate, the data are simply insufficient in number to analyze results properly.

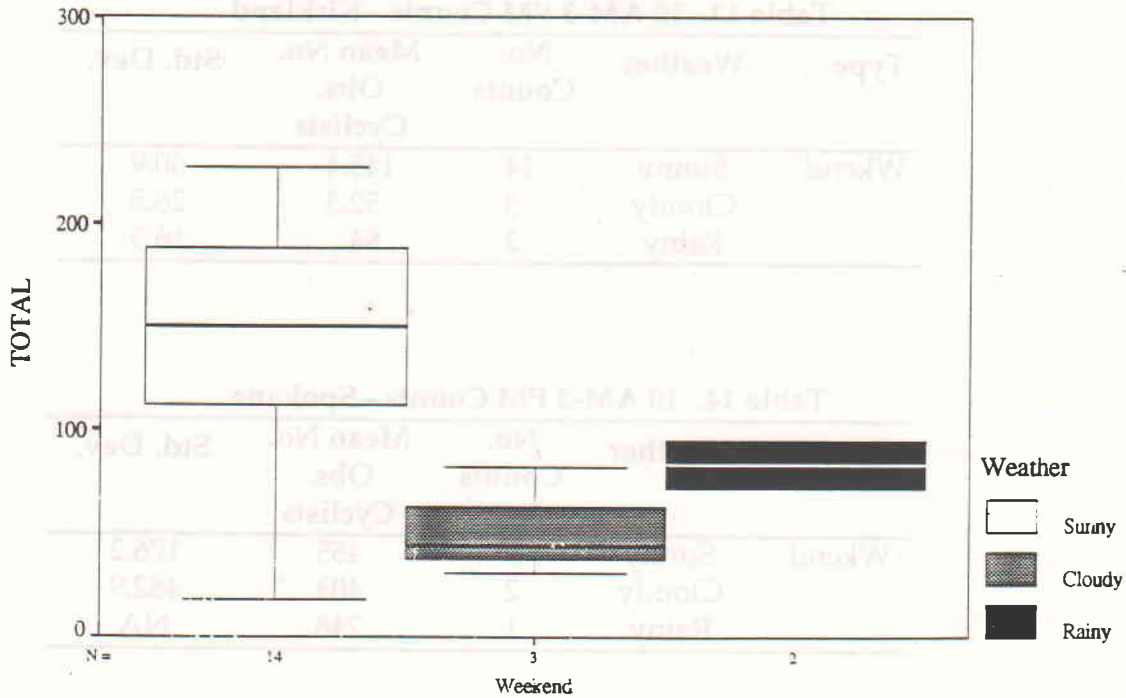
Spokane

Daily Trends. Ten weekend counts were made at this location, with more sunny than cloudy or rainy counts (Table 14). Count volumes declined by roughly 11 percent when comparing cloudy to sunny conditions. As with earlier sites, the limited number of rainy counts precludes anything more than a brief comment.

Seasonal Trends. Figure 26 suggests a clear trend of increasing volumes as the summer months approach. Based on the available data, whether counts begin to level off in June or whether they continue to rise is difficult to determine.

Figure 24. Weekend Distributions

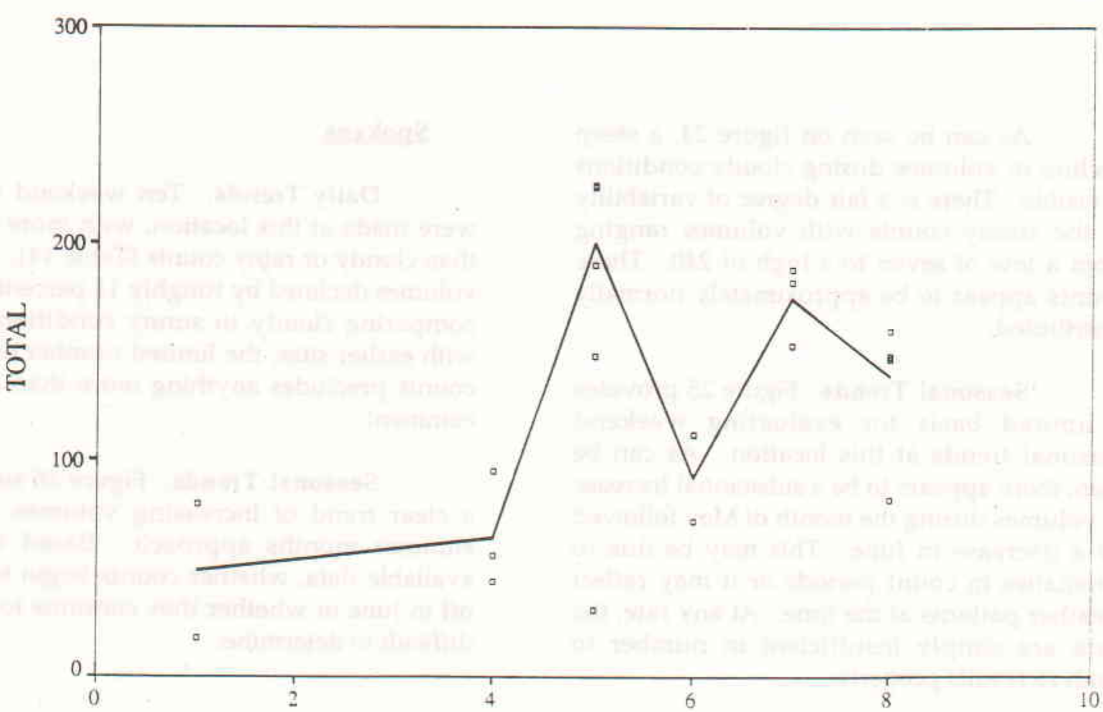
Kirkland - 10 AM - 3 PM Count Period



Type of Count

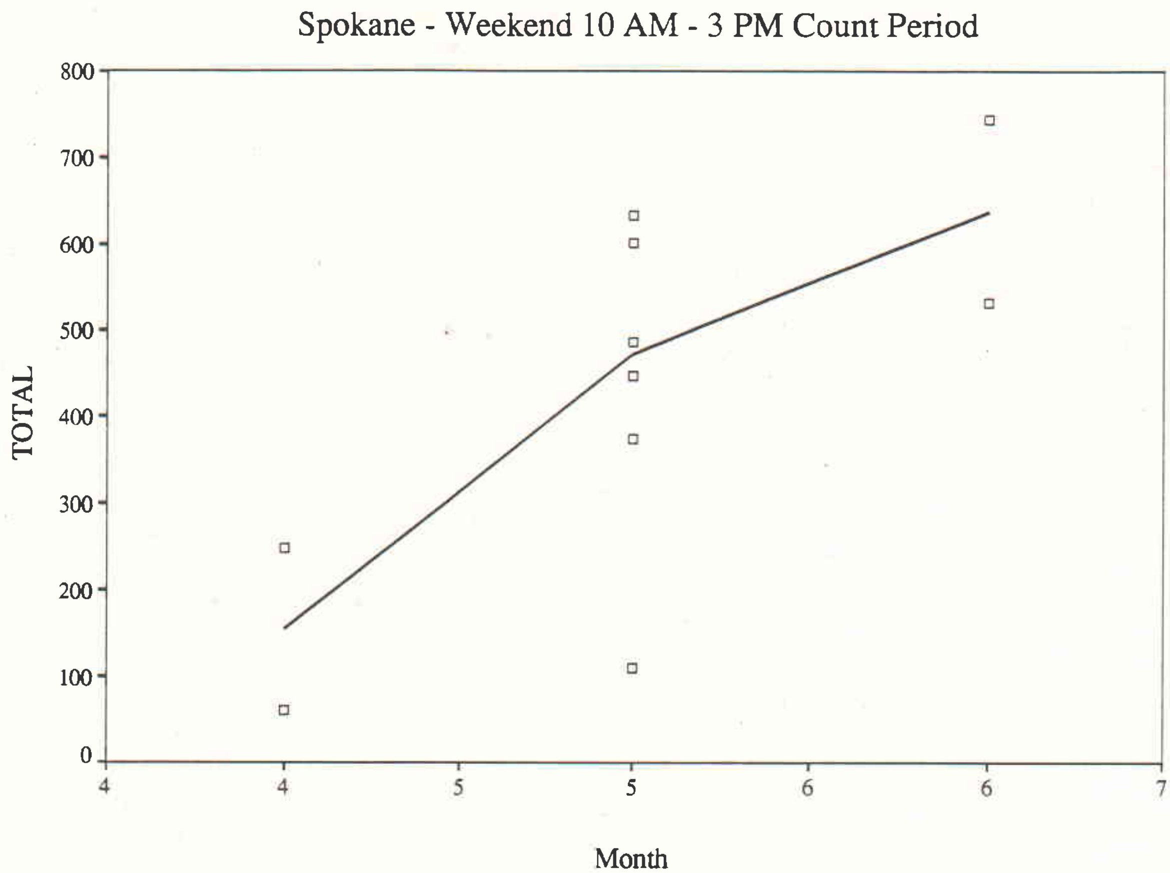
Figure 25. Seasonal Trends

Kirkland - Weekend 10 AM - 3 PM Count Period



MONTH

Figure 26. Seasonal Trends



3.0 Travel By Time of Day

In addition to peak-period counts, a very limited number of all-day counts were conducted, in May of 1993, at each location. As will be seen, the purpose of these counts is to provide the basic information necessary to estimate average daily volumes from peak-period volumes. Figures 27a through 27d illustrate the count by hour. As with vehicle counts, there is a clear peaking pattern in the PM, with slight peaks noticeable in both the AM peak-period and around noontime. The NE 65th and Burke-Gilman location shows a steady increase in riders throughout the day; this is probably due to the flow of students destined for the University of Washington. As might be expected, the weekend pattern is decidedly different; counts at all locations peak in late afternoon. Figures 28a through 28d provide a time-of-day trend for the weekend all-day counts. Some caution should be exercised when reviewing these figures, insofar as each location was counted only once.

The purpose of the all-day counts was primarily for use in estimating average daily volume for all locations based on the peak-period counts. Essentially, the proportion of the daily volume occurring in the peak-period volume can be used (after adjusting for weather conditions) to estimate the average daily volume. As Table 15 illustrates, the proportion of volume during the AM and PM peak-periods is slightly different, ranging from 11 percent to 27 percent in the AM and from 23 to 33 percent in the PM. It is also interesting that the proportion of the daily volume allocated to the peak-period seems to increase as the weather becomes less favorable.

Figure 27. Weekday Travel by Time of Day

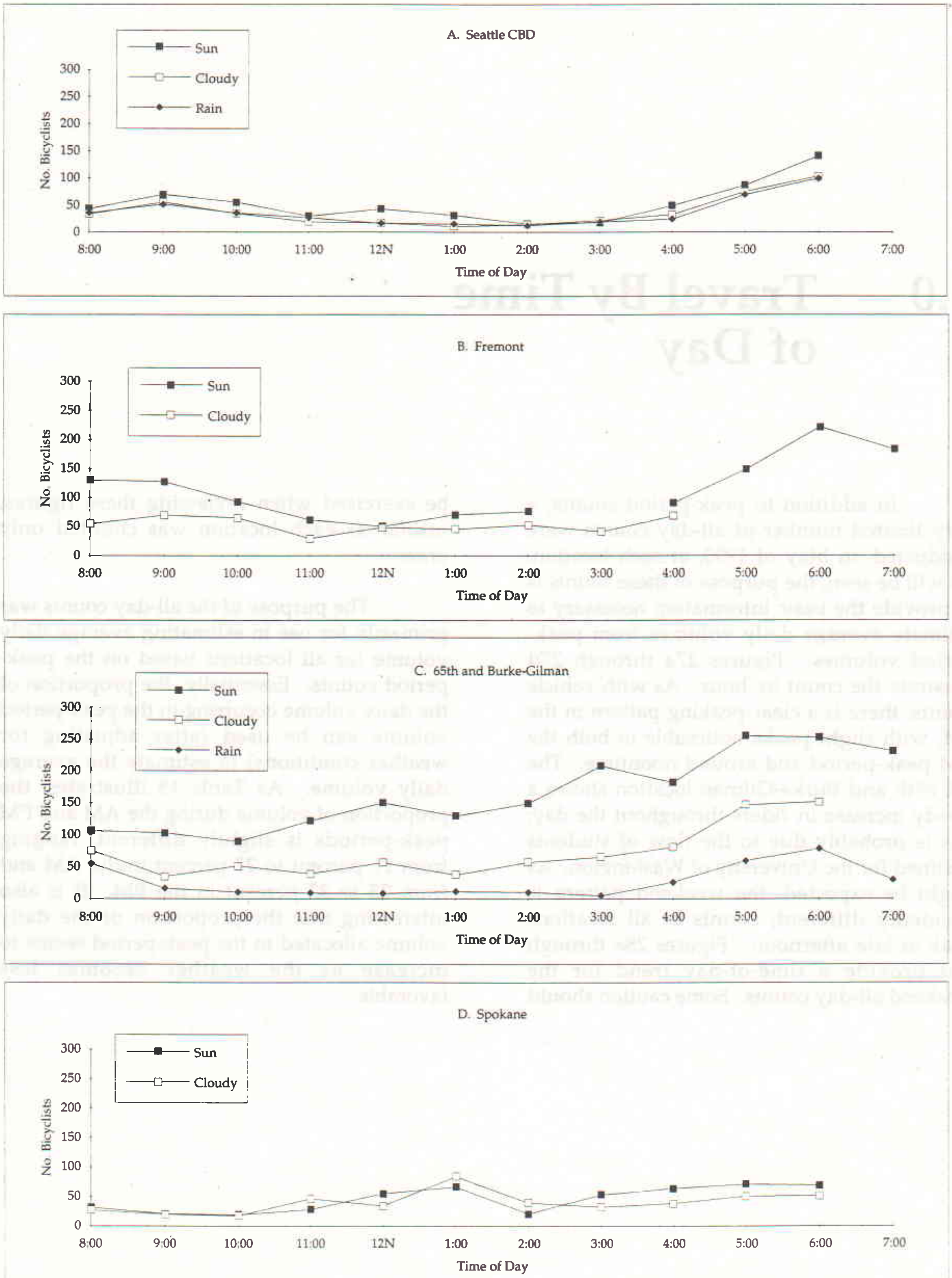


Figure 28. Weekend Travel by Time of Day

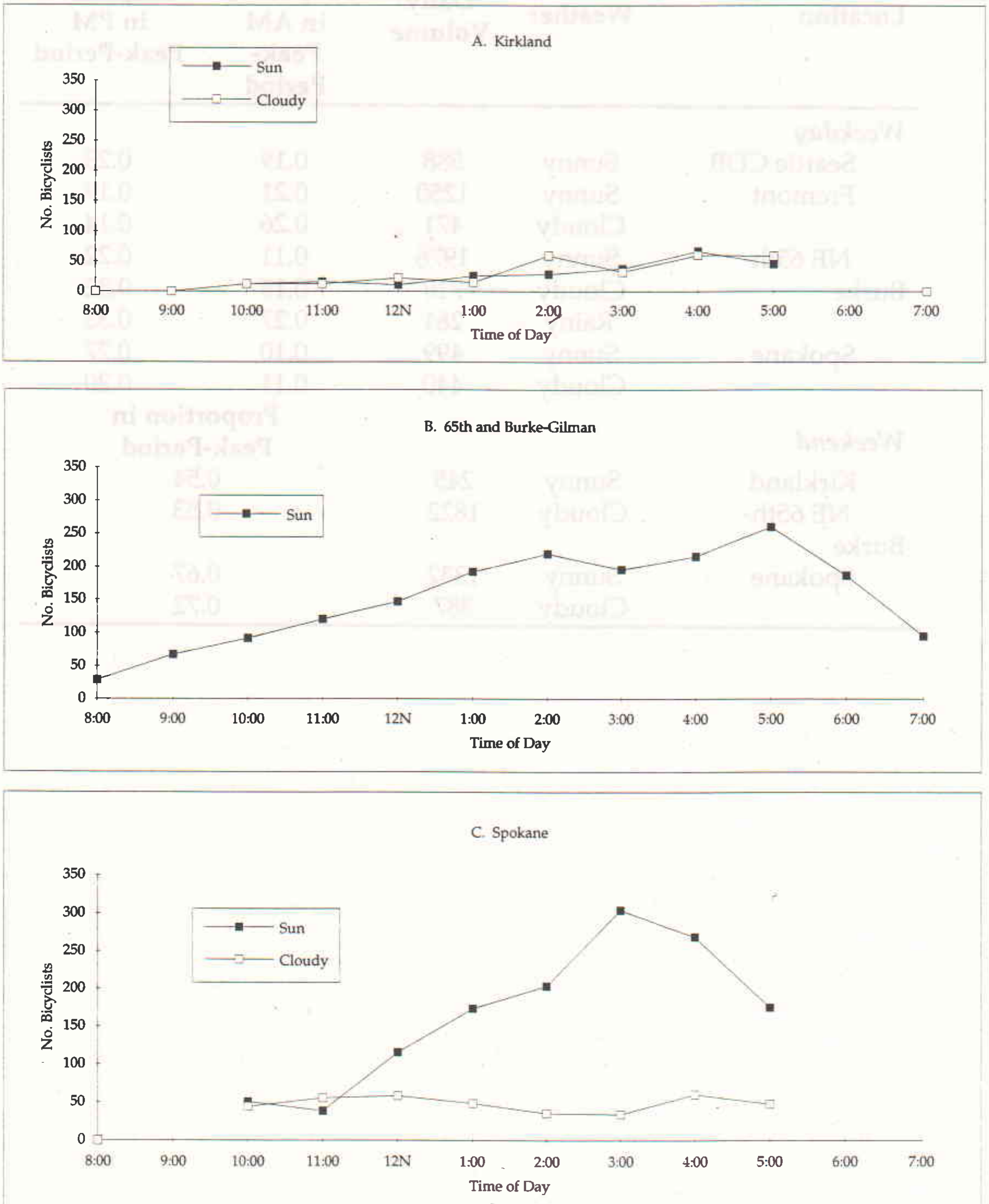


Table 15. Summary Statistics From All Day Counts

Location	Weather	Daily Volume	Proportion in AM Peak-Period	Proportion in PM Peak-Period
Weekday				
Seattle CDB	Sunny	588	0.19	0.23
Fremont	Sunny	1250	0.21	0.19
	Cloudy	471	0.26	0.14
NE 65th-Burke	Sunny	1976	0.11	0.22
	Cloudy	719	0.15	0.32
	Rainy	261	0.27	0.33
Spokane	Sunny	499	0.10	0.27
	Cloudy	440	0.11	0.20
Weekend			**Proportion in Peak-Period**	
Kirkland	Sunny	245	0.54	
NE 65th-Burke	Cloudy	1822	0.53	
Spokane	Sunny	1332	0.67	
	Cloudy	387	0.72	

4.0 Estimates of Average Daily Volumes

Estimates of average daily volumes were constructed from the peak period and weekend counts. However, because of the nature of the counts, these estimates could not simply be derived by averaging peak counts and then extrapolating daily counts. Table 16 lists the proportion of counts made at each location during various weather conditions. The data in Table 16 suggest that sunny day counts may be over-represented; although count days were randomly selected each week, counters were allowed to sign up for any of the randomly selected days. Therefore, if weather patterns had been poor during the previous week or were forecasted to be poor during the count week, it is likely that fewer count days were actually selected to be counted.

From earlier analysis it is clear that sunny days produce very high volumes relative to cloudy or rainy days; for this reason, simple averages of peak-period count volume counts cannot be used to estimate daily volumes. In addition, it is also apparent from earlier analysis that the count data are not always normally distributed; there are generally greater numbers of lower volume counts with a few very high volume counts. Consequently, a simple average would pro–duce a mean higher than might actually be expected.

An alternative approach to estimating the average daily volume by the peak-period volume requires a resampling method known as bootstrapping. Bootstrapping allows estimation of the average peak hour volumes without assuming normality of the data. Bootstrapping is accomplished by resampling, with replacement, from the data and calculating the desired statistic (Efron and Tibshirani 1986, pp. 54-55). This procedure is repeated many times. Thus, even though each of the individual resamples of the data will include the same number of observations, one or more of the observations may be repeated or, may not even be included, in any given resampling.

Table 16. Average Proportion (Number) of Counts

		NE 65th-Burke	Fremont	Seattle-CBD	Kirkland	Spokane
AM	Sunny	0.42 (22)	0.47 (20)	0.29 (9)	0.26 (9)	0.44 (7)
	Cloudy	0.40 (20)	0.41 (14)	0.59 (12)	0.57 (16)	0.50 (8)
	Rainy	0.18 (9)	0.13 (5)	0.12 (2)	0.17 (4)	0.05 (1)
PM	Sunny	0.51 (29)	0.45 (16)	0.54 (12)	0.50 (14)	0.63 (10)
	Cloudy	0.32 (16)	0.45 (13)	0.38 (5)	0.45 (9)	0.31 (5)
	Rainy	0.17 (9)	0.10 (3)	0.08 (1)	0.05 (1)	0.06 (1)
Weekend	Sunny	0.50 (18)	N/A	N/A	0.66 (14)	0.70 (7)
	Cloudy	0.45 (10)			0.17 (3)	0.20 (2)
	Rainy	0.05 (1)			0.17 (2)	0.10 (1)

The theoretical justification for bootstrapping is based on the parallelism between using a data sample as a best estimate of the population distribution and using resampling to simulate the random component of the data sampling process (Rao 1987, pp. 162-166). Simply put, the sample is treated as the population, and a series of resamples is generated. Each of the individual resamples is thought of as an independent sample from the original population distribution, and a sampling distribution of a test statistic q, is estimated by calculating that statistic for each of the individual samples (Mooney and Duval 1993, pp. 10-11).

Essentially the procedure is undertaken in the following manner:

- A peak period for each location is selected for resampling.
- A resampling procedure is undertaken for sunny, cloudy, and rainy counts separately, with an average for each type of count calculated.
- A weighted average of the three separate averages is then calculated.

This procedure is repeated 1,000 times, generating a distribution of average peak-period volumes. From this distribution, a point estimate of the average peak-period volume can be calculated, along with a standard error and confidence intervals. These estimates can then be used in conjunction with the percentage of volume occurring in the peak-period to estimate daily volumes. However, adjustments for time of year are also appropriate.

Earlier analysis demonstrated that volumes were considerably higher in the late spring, summer, and early fall months. Examination of weather data provided by the National Weather Service indicates clear trends during these months. As can be seen on Table 17, weather patterns based on long-term averages indicate a far greater proportion of sunny days during the months of July, August, and September. The proportion of cloudy days remains relatively stable during the entire year. This suggests that the cloudy days may also include what is known as fair weather days. These are days in which rain is not imminent, and which may actually include a fair amount of sun time. As noted in the first section, the weather conditions for the actual counts were recorded assuming a cloudy day meant rain was imminent. Using data available through the weather service, a breakdown of the proportion of sunny, cloudy, and rainy days based on fair weather days can be derived. These proportions are included in the second column of Table 17.

As can be seen from these data, there are strong seasonal patterns of sunny, cloudy, and rainy days. In fact, as seen in Table 18, seasonal trends can be arbitrarily divided into two categories for the purposes of this study: (1) winter months and (2) summer, late spring, and early fall months. The data could also be subdivided again, into summer months; however, there are an insufficient number of counts to warrant any greater increase in accuracy that might be gained from this subsetting. The second set of information included in Table 18 consists of averages used to estimate the weighted average for the peak-period volume. In the winter months sunny day volumes (which are generally the highest counts) are weighted much less than rainy day volumes; the reverse is true for the summer months.

Using the weights, averages were bootstrapped; the results are shown in Table 19. These results indicate that, on average, we can be 95 percent certain that the AM two-hour peak-period winter volume at the Burke-NE 65th location will fall between 65 and 78. Using this estimate we can then construct a confidence interval for daily volumes (column 4). For example, we can be 95 percent confident that the average daily winter volume on the Burke-Gilman will be between 365 and 437 cyclists. At the Fremont location, we can be 95 percent confident that average daily volumes will fall between 385 and 525 during winter months and between 726 and 923 during summer months (roughly twice that found at the Burke-NE 65th location). Average daily downtown volumes were also calculated for summer months and are consistent with the Fremont location. This is notable insofar as it seems to confirm the importance of the Fremont location for commuting purposes. Finally, eastside Kirkland volumes during the summer months are noticeably lower than the remaining locations, with a 95 percent confidence interval for average daily volumes of between 80 and 123.

Using the bootstrap method in conjunction with the above weather information, average daily weekend volumes can also be estimated. As Table 20 indicates, we can be 95 percent confident that average daily weekend summer volumes will fall between 1,745 and 2094 at the Burke-NE 65th location and that winter volumes will fall between 743 and 1081. It should also be noted, as discussed earlier, that these volumes primarily represent daily volumes associated with recreational and exercise cyclists. Again, the Kirkland daily volumes are lowest in the summer months with a 95 percent confidence interval between 170 and 260. One limitation to this estimate is that weekend daily volumes may be uderestimated because of the time of count (see figures 25a through 25c).

Table 17. Average Weather Conditions

Based on Recorded Patterns	Sunny	Cloudy	Rainy	Based On "Fair Weather" Days	Sunny	Cloudy	Rainy
Jan	0.04	0.54	0.41	Jan	0.15	0.43	0.41
Feb	0.08	0.53	0.40	Feb	0.18	0.42	0.40
Mar	0.07	0.52	0.40	Mar	0.18	0.42	0.40
Apr	0.13	0.51	0.36	Apr	0.46	0.18	0.36
May	0.13	0.56	0.31	May	0.49	0.20	0.31
Jun	0.16	0.55	0.29	Jun	0.52	0.19	0.29
Jul	0.41	0.41	0.19	Jul	0.67	0.14	0.19
Aug	0.33	0.44	0.22	Aug	0.62	0.16	0.22
Sep	0.27	0.43	0.30	Sep	0.55	0.15	0.30
Oct	0.11	0.54	0.35	Oct	0.46	0.19	0.35
Nov	0.05	0.53	0.42	Nov	0.15	0.43	0.42
Dec	0.04	0.54	0.41	Dec	0.15	0.43	0.41

Source: National Weather Service

Table 18. Weather Trends Used for Daily Volume Estimates

	Sunny	Cloudy	Rainy			Sunny	Cloudy	Rainy
Winter Months								
Jan	0.15	0.43	0.41					
Feb	0.18	0.42	0.40	*Model*		0.16	0.43	0.41
Mar	0.18	0.42	0.40	*Averages*				
Nov	0.15	0.43	0.42					
Dec	0.15	0.43	0.41					
Summer/Late Spring/Early Fall Months								
Apr	0.46	0.18	0.36		Apr			
May	0.49	0.20	0.31		May			
Jun	0.52	0.19	0.29	*Model*	Jun	0.54	0.17	0.29
Jul	0.67	0.14	0.19	*Averages*	Jul			
Aug	0.62	0.16	0.22		Aug			
Sep	0.55	0.15	0.30		Sep			
Oct	0.46	0.19	0.35		Oct			

Table 19. Weekday - Average 2 Hr. Peak-Period and Daily Volumes

	Peak-Period Mean (S.E.) (Time)	95 Percent Confidence Int.	Average Daily Estimate (K)[1]	95 Percent Confidence Int.
NE 65th-Burke				
Winter	72.3 (0.13) (AM)	65.8-78.8	401.7 (0.18)	365.6-437.8
Spr/Sum/Fall	194.5 (0.54) (PM)	164.6-222.5	670.7 (0.29)	567.6-767.2
Fremont				
Winter	110.4 (0.32) (AM)	92.3-126.1	460.0 (0.24)	384.6-525.4
Spr/Sum/Fall	197.7 (0.46) (PM)	174.3-221.4	823.8 (0.24)	726.3-922.5
Seattle CBD				
Winter	N/A	N/A	N/A	N/A
Spr/Sum/Fall	155.6 (0.25) (AM)	142.1-168.5	778.0 (0.20)	710.5-842.5
Kirkland				
Winter	N/A	N/A	N/A	N/A
Spr/Sum/Fall	20.0 (0.08) (Both)	16.0-24.6	100.0 (0.20)[2]	80.0-123.0
Spokane				
Winter	N/A	N/A	N/A	N/A
Spr/Sum/Fall	85.4 (0.19) (PM)	75.4-94.5	355.8 (0.24)	314.2-393.8

1 Different peak-periods were used in the bootstrapping depending upon the availability of data. K represents the proportion of the daily volume occurring in the peak-period.

2 This peak hour factor is only an estimate (i.e., not based on a full day count).

Table 20. Weekend - Average 10 AM to 3 PM and Daily Volumes

	Peak-period Mean (S.E.)	95 Percent Confidence Int.	Average Daily Estimate (K)[1]	95 Percent Confidence Int.
NE 65th-Burke				
Winter	485.9 (1.72)	393.9-572.9	916.8 (0.53)	743.2-1080.9
Spr/Sum/Fall	1147.8 (2.01)	1047.5-1256.6	1911.7 (0.60)	1745.8-2094.3
Spokane				
Spr/Sum/Fall	358.3 (1.63)	274.4-442.8	514.1 (0.70)	392.0-632.6
Kirkland				
Spr/Sum/Fall	116.2 (0.46)	91.6-140.3	214.8 (0.54)	169.7-259.81

5.0 Conclusion

The findings presented in this report indicate that both daily and peak-period volumes differ much among locations. Nonetheless, the findings also reveal important similarities between locations. Beginning with weather, all count volumes decline when weather conditions worsen; this by itself is not particularly surprising. However, if the percent decline between sunny and cloudy and sunny and rainy weather conditions is examined, it is seen that volumes at all locations tend to decrease by relatively similar amounts. For example, consider the AM peak period volumes. In the Puget Sound region, volumes recorded on cloudy days were approximately 10 to 20 percent less than volumes recorded on sunny days. For rainy day counts, volumes were roughly 45 to 60 percent less than those observed on sunny days. In the PM peak period, cloudy day counts declined, on average, by approximately 25 to 41 percent compared to sunny day counts and by 55 to 68 percent when comparing rainy day volumes to sunny day volumes.

Further, at all locations except Kirkland and Spokane, the number of cloudy day utility cyclists was only 15 to 23 percent less than sunny day utility cyclists. On average, counts of training and social recreational cyclists ranged 35 to 75 percent less on cloudy days when compared to counts made on sunny days. The same pattern of bigger drops in the number of recreational and training cyclists, compared to utility cyclists, persists when comparing rainy day volumes to sunny day volumes.

These trends suggests several important implications for any type of bicycle count program. All other things being equal, a single sunny weekday peak period count will naturally result in the highest observed volumes. However, based on these findings, cloudy or rainy day volumes may be estimable by proportioning, suggesting that declines in volumes, as weather worsens, are relatively consistent and fall within a reasonably narrow band. The data suggest that utility cyclists tend to cycle in greater proportions during bad weather conditions. Reductions in volumes are, to a large extent, generally related to decreases in the number of social-recreational and training-exercise cyclists during this weekday period.

Finally, it was noted that AM peak period volumes tended to vary less than PM peak period volumes, and the distribution of the data exhibited skewing. This indicates that simple means of counts may not be the most precise estimate of average volumes. A technique known as bootstrapping, which does not rely on the assumption of normality, was introduced as a method for estimating average peak- period and daily volumes.