Montana Three City Parking Generation/ Land Use Pattern Correlation Study

by

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ABSTRACT

Parking facilities are costly and space intensive. Regulatory parking requirements are often set by local governments in reference to the size and type of land use (eg., cinema, laundromat), but the compactness and pattern of land use (ie., the urban form) may also have influence on the need for parking. Different land use forms may have different actual parking efficiencies, that is, greater numbers of destinations arising from single parking event. If such differences exist, but are not embodied in local parking requirements, then unnecessary costs may be imposed on areas that are more parking efficient. This study aims to identify and quantify differences in parking efficiencies of common land use forms by surveying parking events in central business districts, commercial corridors, and power centers in Montana's four largest cities; Bozeman, Missoula, Great Falls, and Billings.

The hypothesis to be examined is that some commercial land use development patterns appear to be more vehicle trip generation/parking efficient than others are. It is expected that the difference can be quantified by personal questionnaire survey of vehicle users. It is expected that a more densely developed with highly connected travel routes land use pattern following the Central Business District pattern provides the most parking efficiency. At this time no other study is known to have examined this type of correlation.

The results of this survey will provide a formula for which to determine the allowable percent reduction in the number of parking spaces provided by land use development pattern. These numbers will be taken into consideration in the land development regulation in the cities of Great Falls, Billings, and Bozeman.

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1. INTRODUCTION

Parking lots are a vital element in the success of a business. Patrons of a business have to be able to access the store, and in most cases, they arrive there by car. This means that the business must provide adequate parking facilities to accommodate their customers, since a lack of parking spots can be a direct deterrent to frequenting a business. Every city has regulations outlining the minimum and maximum amount of parking spaces that business must provide. The amount of parking spaces required is dependent on the type of business, and include factors such as square footage of a business, or the number of chairs that a business contains. Shown below is an excerpt from the City of Bozeman's Land Development Regulations Title 18 Chapter 46 "Parking", which outlines the requirements of parking facilities for various retail operations.

Table 1: Non-residential Uses Minimum Parking Requirements[1]

Uses Type	**Off-Street or Off-Road Parking Spaces Required**
Bank, financial institutions	1 space per 300 square feet of floor area
Bowling Alley	4 spaces per alley; plus 2 spaces per billiard table; plus 1 space per each 5 visitor gallery seats
Restaurants, cafes, bars, and similar uses	1 space per 50 square feet of indoor public serving area; plus 1 space per 100 square feet of outdoor (patio) area
Retail store and service establishment	1 space per 300 square feet of floor area

Besides setting a minimum parking requirement, a maximum parking requirement is also outlined in Bozeman's Land Development Regulation, stating that "provision of parking spaces in excess of 125 percent of the minimum number of spaces required… is not permitted".[2]

But how much is too much? Parking facilities are costly and space intensive. The regulatory parking requirements set by local governments are in reference to the size and type of land uses, but the compactness and pattern of land uses may also have influence on the need for parking. Different land use forms may have different actual parking efficiencies, that is, greater numbers of destinations arising from a single parking event. This is taken into consideration by the City of Bozeman in a clause built into the parking regulations that allows adjustments to the minimum parking requirements, shown in Table 2 and Table 3 below.

[1] City of Bozeman, Bozeman Land Development Regulations, Title 18, Chapter 46, Table 46-3 (2004)

[2] City of Bozeman, Bozeman Land Development Regulations, Title 18, Chapter 46, pg 5 (2004)

Table 2: Adjustments to Minimum Requirements – Neighborhood Commercial[3]

Use	**Maximum Allowable Reduction**
Retail	20 percent
Restaurant	25 percent
Office	10 percent
All Others	15 percent
Transit Availability	An additional 5 percent reductions may be taken in circumstances where the development is within 400 feet of a developed and serviced transit stop.

Table 2 shows the percent reduction of parking spaces that is allowed, categorized by business type, in the zoning district defined as "neighborhood commercial". *Neighborhood commercial* is defined as:

"The smallest scale of the commercial land use designation is, as its name implies, oriented at serving the needs of neighborhoods. This category is typified by smaller scale shops and services and a high level of pedestrian, bicycle, and transit opportunities. Neighborhood Commercial centers are intended to support and help give identity to individual neighborhoods by providing a visible and distinctive focal point. High density residential areas are in close proximity to facilitate the provision of services and opportunities to persons without requiring the use of an automobile. Activities commonly expected in this classification are daycares, smaller scale grocery, bakeries, retail stores, offices, small restaurants, and residences above other activities."[4]

Neighborhood commercial areas mainly include the central business district of a city.

[3] City of Bozeman, Bozeman Land Development Regulations, Title 18, Chapter 46, Table 46-4 (2004)

[4] City of Bozeman, Bozeman 2020 Community Plan, Chapter 6 "Land Use", pg 24 (2001)

Table 3: Adjustments to Minimum Requirements – Community Commercial [5]

Use	Maximum Allowable Reduction
Retail	10 percent
Restaurant	20 percent
Office	10 percent
All Others	10 percent
Transit Availability	An additional 5 percent reduction may be taken in circumstances where the development is within 400 feet of a developed and serviced transit stop

Table 3 shows the percent reduction of parking spaces that is allowed, categorized by business type, in the zoning district defined as "community commercial". *Community commercial* is defined as:

"Activities within this land use category are the basic employment and services necessary for a vibrant community. Establishments located within these categories draw from the community as a whole for their employee and customer base and are sized accordingly. A broad range of functions including retail, education, professional and personal activities, offices, residences, and general service activities typify this designation. Community Commercial areas are generally 120 to 140 acres in size and are activity centers for an area of several square miles surrounding them. The density of development is expected to be higher than currently seen in most commercial areas in Bozeman and should include multi-story buildings."[6]

These two tables are already included in the Bozeman Land Development Regulations, indicating that there can exist a correlation between the type of land use and the number of businesses that are frequented in that category. The percent reductions in Table 2 are greater than the percent reductions in Table 3 (except for the Office and Transit reductions). This signifies that the neighborhood commercial land use development pattern is more parking efficient than the community commercial land use development pattern.

This project is closely related to these minimum parking adjustments based on land use. The land use development patterns that are explored in this project are the central business district, commercial corridors, and power centers. Following is a definition for each of the three land use development patterns under investigation in this study.

A *central business district* has the following development characteristics:

[5] City of Bozeman, Bozeman Land Development Regulations, Title 18, Chapter 46, Table 46-5 (2004)

[6] City of Bozeman, Bozeman 2020 Community Plan, Chapter 6 "Land Use", pg 24 (2001)

1. A wide variety of commercial activities such as retail, offices, goods repairs, governmental services, eating establishments, and may contain recreational activities such as movie houses.
2. Commercial development is more than one building deep along major streets (collector or arterial).
3. A high level of street interconnectedness (intersection spacing typically 300-450 feet) which may or may not include alleys.
4. Buildings typically located close to the street and often sharing common side walls or boundaries.
5. Parking is generally located along the street or in centralized parking lots or garages, often to the rear of buildings.

The following picture was taken by the researcher from a plane that her mentor, David, flew over Bozeman. The picture is an aerial shot of the central business district in Bozeman.

A *power center* has the following developmental characteristics:

1. Commercial activities primarily dominated by multiple large, anchor tenants, including discount department stores, off-price stores, warehouse stores, or “category killers” (i.e. stores that offer tremendous election in a particular merchandise category at low prices).
2. Large parking areas placed in front of the anchor store(s) with high ratios of parking stalls to building area.

3. A minimal number of additional smaller tenants who do not generally compete with the anchor stores.
4. Access to the power center is often centralized to provide for traffic signalization and may be a public street but often appears as an oversized driveway.
5. Location is typically adjacent to arterial streets.

The following picture was taken by the researcher from a plane that her mentor, David, flew over Bozeman. The picture is an aerial shot of a power center in Bozeman.

A *commercial corridor development* area has the following development characteristics:

1. Commercial activities primarily dominated by small to medium sized single user buildings or small single-story linear multi-user buildings
2. Commercial development is usually only one building deep and fronting onto a major street (collector or arterial).
3. Buildings are generally set back from the street with parking in front.
4. Buildings are generally separated by open areas from adjacent buildings.
5. Frequent vehicle access points onto streets.
6. Moderate levels of street interconnections (intersection spacing 400-600 feet or greater).
7. A variety of commercial activities such as retail, offices, goods repair, eating establishments, and may contain recreational activities such as arcades.

The following picture was taken by the researcher from a plane that her mentor, David, flew over Bozeman. The picture is an aerial shot of a commercial corridor in Bozeman.

In this project, these three land use development patterns were examined to verify or disprove the anecdotal evidence that some commercial land use development patterns are more trip generation/parking efficient than others, and to quantify the differences, if any. It is expected that the difference can be quantified by personal questionnaire survey of vehicle users. It is expected that a more densely developed with highly connected travel routes land use pattern following the Central Business District pattern provides the most parking efficiency. The scope of the study involves a parking survey that was conducted in these three categories in the cities of Bozeman, Billings, and Great Falls, Montana.

The objective of this project is two fold:

1. The research will provide increased accuracy in parking and trip generation data utilized for review of development and urban planning and provide increased and publicly available knowledge in the area of urban development.
2. Creation of a method, which can be used by local regulatory agencies to adjust projected parking and vehicle trip demand generation, based upon patterns of land use development.

This study would provide increased accuracy in data regarding the amount of parking required by different land use development patterns. Many parking standards in existing zoning ordinances are based on collections of studies which have no local connection and may be influenced by factors that are not locally relevant. The study will examine each participating city and will provide locally relevant information as well as summary data from across the state. Having more accurate data is expected to benefit local governments by:

1. Strengthening legal defensibility of adopted ordinances since there is a strong logical and proportional connection between the standards for development and empirical evidence of actual demand. An ordinance which is strongly supported by empirical evidence is less likely to be challenged, which saves financial and staff time resources, and when challenged, to be upheld.
2. Help ensure adequate mitigation of development impacts relating to parking, thereby avoiding street congestion or commercial parking spill over into residential areas. Correct mitigation avoids community opposition to development and helps support a healthy development environment.
3. Help prevent excessive exactions for traffic signalization or other off-site work or development standards, which lead to conflict with the development industry. Excessive exactions are often a source of litigation and opposition from developmental interests who find the financial burdens of the exactions a limitation on development
4. Public relations and community good will.
5. Supports correctly sized parking facilities so that land is not used for non-revenue generating parking unless actually needed. Development that is land efficient reduces public and private costs for installation and maintenance for water, sewer, and street infrastructure; increases the use of non-motorized travel with accompanying reductions in air pollution. This can directly benefit the bottom line of operational departments in the city.
6. Supports infill development by avoiding excessive parking requirements, which can make a development cost prohibitive since most of the site must be dedicated to parking rather than revenue generating building area.
7. Reduce development costs by avoiding excess parking which is land intensive. Parking for offices or restaurants often consumes more land than the building itself. The paving, stormwater management, and other accompanying costs and area requirements of parking areas are often significant constraints on development.
8. Provide a rational and demonstrable basis for revisions to development standards consistent with community priorities. For example, in 2002 Bozeman adopted parking requirement modifiers for the downtown area. Bozeman city officials had observed that many persons park one time then visit multiple destinations when they go downtown. Unfortunately they had to make a best estimate of appropriate change on a non-empirical basis. This study will help better define those estimates with the empirical evidence.

2. LITERATURE REVIEW

The motivation for this study came from the City of Bozeman's Department of Planning and Community Development. The Bozeman 2020 Community Plan was developed by Bozeman's Department of Planning and Community Development in 2001. In Chapter 10, entitled "Transportation", the City outlines its plans for the future of transportation in Bozeman. One of the main principles of that plan addresses "the need for adequate transportation means, coupled with efficient land use policy, to meet future transportation demand"[7]. It is this goal of the City that hatched the idea for this study.

To date, there is no literature available on this study. It is a unique endeavor by the researcher and her mentors. Extensive research has failed to locate any information pertaining to the topic of this study.

It has been found that there exists a need for this study, considering that "land development codes nearly everywhere still set minimum parking requirements for new developments far in excess of normal needs"[8].

[7] City of Bozeman, Bozeman 2020 Community Plan, Chapter 10 "Transportation", pg 1 (2001)

[8] Ewing, Reid. "Transportation & Land Use Innovations: When You Can't Pave Your Way Out of Congestion". Chicago, Ill.: Planners Press, 1997.

3. METHODOLOGY

There are several main tasks that were necessary for the project.

3.1 Develop Survey Tool

This study requires knowing how many places a person visits after they park once at different land use development patterns. In order to obtain the data for this study, on-site interviews at each land use development pattern was necessary. A survey tool was required to conduct the interviews. The survey tool that was developed is contained in Appendix 1. The survey has eleven objective questions and took about one minute to fill out. The main objective of the survey was to determine how many places a person visits after parking in a specific location. Secondary demographic information was also included on the survey. This information was used to determine bias in the survey. It can also be useful to look at patterns in the results in light of the demographic information.

3.2 Data Collection

The data was collected over a one month period in three towns in Montana: Great Falls, Billings, and Bozeman. The researcher traveled to Great Falls from June 28 through July 1, 2004 to administer her surveys. The researcher traveled to Billings from July 11 through July 14, 2004 to administer her surveys. The researcher administered surveys in Bozeman during multiple days in July, 2004. The surveys were taken in the three locations of study, the central business district, the power center, and the commercial corridor.

3.3 Data Entry

The completed surveys were given to the City of Bozeman for processing. The researcher created a database in MS Access in which the data was entered. The researcher was given the completed database for analysis.

3.4 Analysis of Data

The data required a statistical analysis, which was done in MINITAB. In the “Findings” section of the report there is a description of the tests run on the database.

4. FINDINGS

After the surveys were administered, the results were inputted into a database by the staff of the City of Bozeman. Below is a breakdown showing the total number of surveys administered, separated by city and land use development pattern.

Table 4: Breakdown of Number of Surveys Administered by City and Location

City	Location 1	Location 2	Location 3	Total
Great Falls	122	83	49	254
Billings	124	114	83	321
Bozeman	120	79	79	278

The total number of surveys administered is 853 between all cities and locations. The survey database was created in MS Excel, and imported into MINITAB for statistical analysis.

4.1 Statistical Analysis in MINITAB

The researcher chose to run a statistical analysis on the data set in MINITAB. Statistics is an appropriate method of analysis when it is not possible to directly observe or measure all of the values possible. In the case of this project, the survey that was administered was on a finite sample of an (effectively) infinite population. That is, it was not possible to get every single person entering or leaving a business in the location of study to participate in the survey. What was gathered was a fair representation of the population of users. This data is assumed to be representative of the population as a whole for statistical analysis.

4.1.1 Histogram Analysis

The researcher is primarily interested in the values for the "number of places visited". Histograms were used to analyze the distribution of these values, for both the "number of places visited today" and the "number of places visited when you normally park here" or the average number of places usually visited at a specific location. A histogram is viewed as a distribution of the data values, showing the "value entered" on the x-axis and the frequency that the value is entered on the y-axis. A histogram is assumed to follow a normal distribution curve, and these bell-shaped curves are shown on the graph, fitting the shape of the histogram. The mean and standard deviation values are calculated from the histogram.

In a few cases, the histogram created contained obvious outliers of the data set that could possibly be skewing the whole data set, such as a very high value or a zero value. When this was observed, the histogram was re-created, excluding the outlying values. There are a variety of reasons that these outliers may have occurred, such as exaggerated responses to the survey or human error in the transfer of the data from the surveys to the database.

4.1.2 Confidence Intervals

Using the results from each histogram, confidence intervals were determined with a 95% degree of confidence. A 95% confidence interval means that the probability of any random variable being within 1.96 standard deviations of the mean value is 0.95, or 95%, if the data set is normally distributed. This means that after collecting n survey samples, the researcher can be 95% sure that the true mean of the data set being examined (for this report, the "number of places visited") is found between the bounds of the confidence interval.

4.1.3 Correlation Analysis: Fit Trend Line

For further analysis, the researcher wanted to investigate possible correlations between the "number of places visited" and the "duration of stay", and between the "number of places visited" and the "number of stores in a location". The two data values for each set were plotted against each other, and a trend line was fit to the points. The trend line shows whether there is any correlation between the two data sets being examined, that is, seeing whether a dependency exists between the data sets. For example, if the trend line is shown to have a positive slope, that indicates a positive dependency and a negative slope indicates a negative dependency. The degree of correlation is then assessed by the slope of the trend line.

4.2 Great Falls Data Analysis

The database for Great Falls was the first data set collected, and the first data set analyzed. Histograms were created for the three locations of study, and the corresponding confidence intervals were calculated. The results are shown below.

4.2.1 Great Falls – Location 1 Central Business District

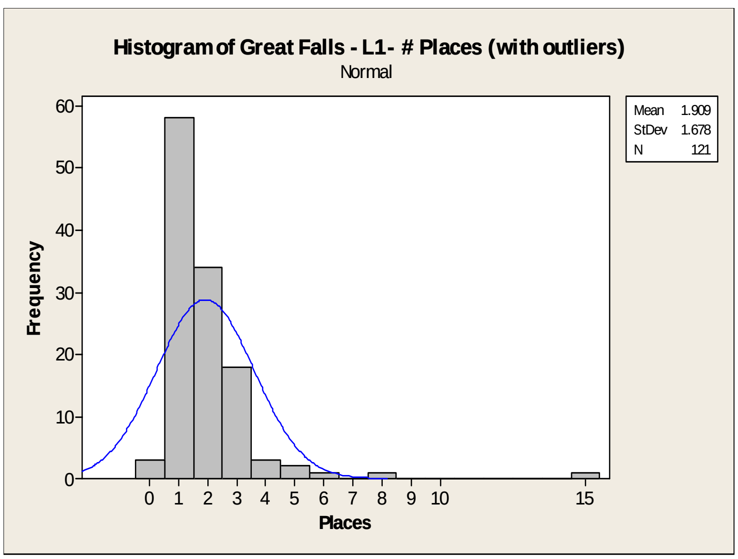

Figure 1: Histogram of Great Falls – L1 - # of Places Visited (with outliers)

The figure to the left shows the histogram of the "number of places visited" for location 1 in Great Falls. The graph shows that there are outliers to the data set, the value of 15 and the zero values. The histogram was run again, this time excluding the outliers.

For Figure 1:

Mean = 1.909

Standard deviation = 1.678

N = 121

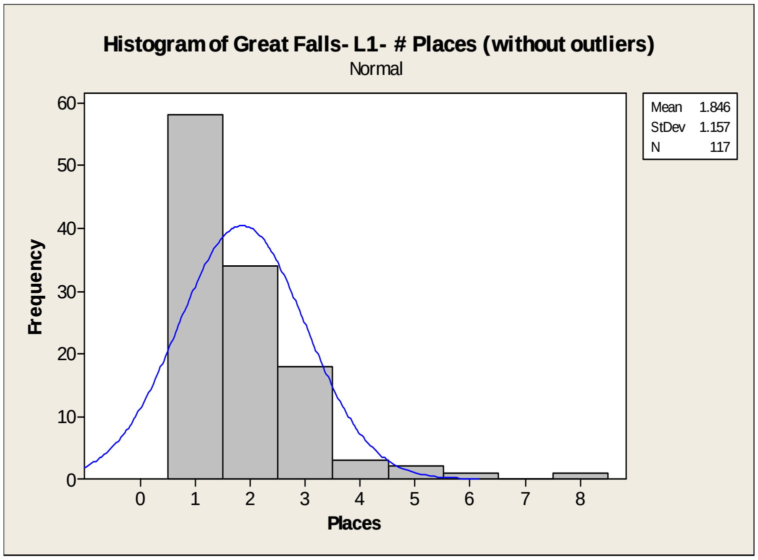

Figure 2: Histogram of Great Falls – L1 - # of Places Visited (without outliers)

The figure to the left shows the histogram of the "number of places visited", this time without the outliers.

For FigureFigure 2:

Mean = 1.846

Standard deviation = 1.157

N = 117

The mean for the histogram run without the outliers is less than the one run with the outliers, and the standard deviation value also dropped. The values of the standard deviations for both figures leave a high variation around the mean in the results, since the standard deviations are only slightly less than the values for the means.

Confidence Intervals were then calculated using the resulting mean and standard deviation from the histogram without outliers. The resulting output is shown below.

```
 N    Mean       SE Mean         95% CI
117  1.84600  0.10696  (1.63635, 2.05565)
```

For this initial section, the researcher has included a comparison of the histogram with the outliers to the histogram without the outliers. She has concluded that the data sets are less skewed if the outlying data points are excluded from the analysis. For the remaining sections of the data analysis, only the histograms without the outliers will be included (and noted if there were outliers excluded). Only the results from the histograms without outliers will be used for the remaining analysis.

4.2.2 Great Falls – Location 2 Power Center

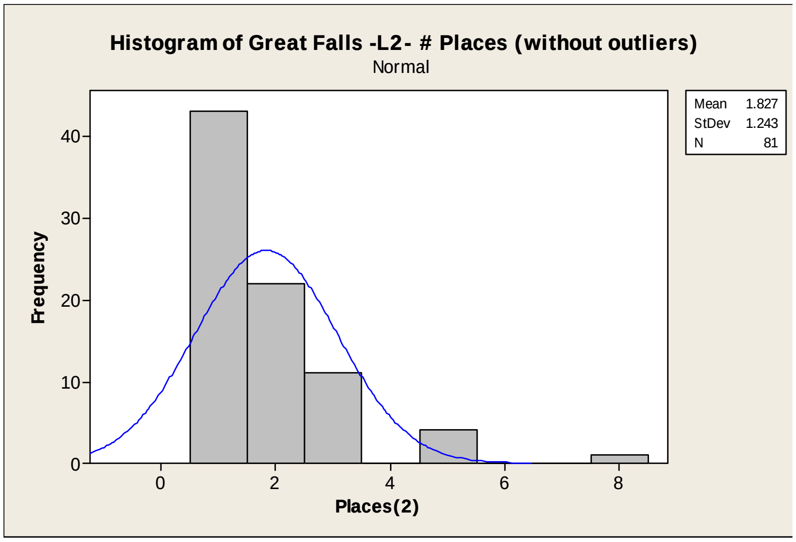

Figure 3:Histogram of Great Falls – L1 - # of Places Visited (without outliers)

The figure to the left shows the histogram of the "number of places visited" for location 2 in Great Falls, without the outliers.

For Figure:

Mean = 1.827

Standard deviation = 1.243

N = 81

The standard deviation value is very high compared to the mean value, which shows the high variation around the mean value.

Confidence Intervals were then calculated using the resulting mean and standard deviation from the histogram without outliers. The resulting output is shown below.

N	Mean	SE Mean	95% CI
81	1.87700	0.13811	(1.60631, 2.14769)

4.2.3 Great Falls – Location 3 Commercial Corridor

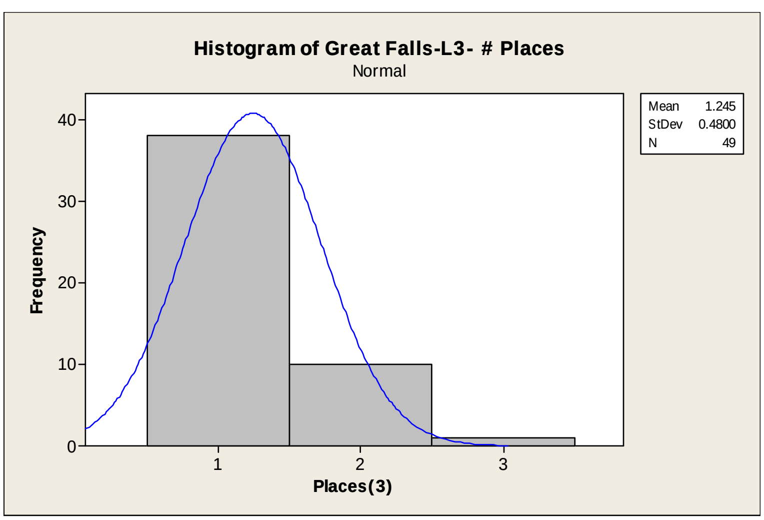

Figure 4: Histogram of Great Falls – L3 - # of Places Visited

The figure to the left shows the histogram of the "number of places visited" for Great Falls in location 3. This data set did not have any outliers to remove.

For Figure 4:

Mean = 1.245

Standard deviation = 0.48

N = 49

The value for the standard deviation shows the high variation around the mean value.

Confidence Intervals were then calculated using the resulting mean and standard deviation from the histogram. The resulting output is shown below.

N	Mean	SE Mean	95% CI
49	1.24490	0.06857	(1.11050, 1.37930)

4.3 Billings Data Analysis

The database for Billings was the second data set collected, and the second data set analyzed. Histograms were created for the three locations of study, and the corresponding confidence intervals were calculated. The results are shown below.

4.3.1 Billings – Location 1 Central Business District

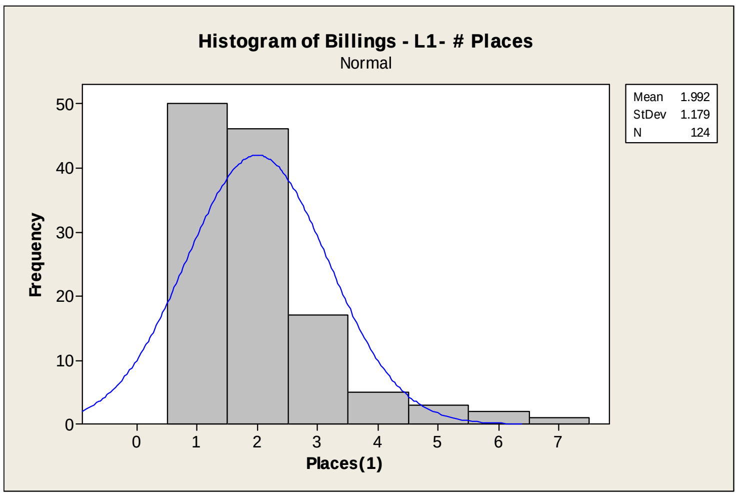

Figure 5: Histogram of Billings – L1 - # of Places Visited

The figure to the left shows the histogram for the "number of places visited" for Billings in location 1. This data set did not have any outliers to remove.

For Figure 5:

Mean = 1.992

Standard deviation = 1.179

N = 124

The value for the standard deviation shows the high variation around the mean value.

Confidence Intervals were then calculated using the resulting mean and standard deviation from the histogram. The resulting output is shown below.

N	Mean	SE Mean	95% CI
124	1.99200	0.10588	(1.78448, 2.19952)

4.3.2 Billings – Location 2 Power Center

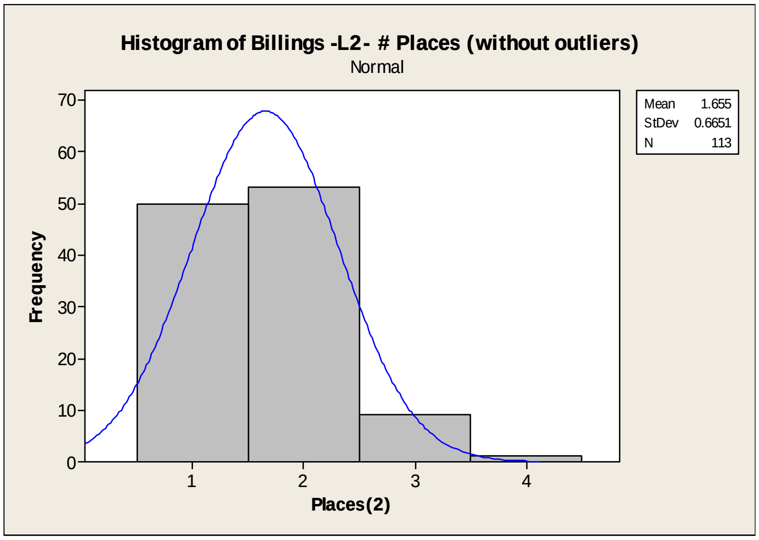

Figure 6: Histogram of Billings – L2 - # of Places Visited (without outliers)

The figure to the left shows the "number of places visited" for Billings in location 2, without outliers.

For Figure 6:

Mean = 1.655

Standard deviation = 0.6651

N = 113

The value for the standard deviation shows the high variation around the mean value.

Confidence Intervals were then calculated using the resulting mean and standard deviation from the histogram without outliers. The resulting output is shown below.

```
N      Mean   SE Mean        95% CI
113  1.65500  0.06257  (1.53237, 1.77763)
```

4.3.3 Billings – Location 3 Commercial Corridor

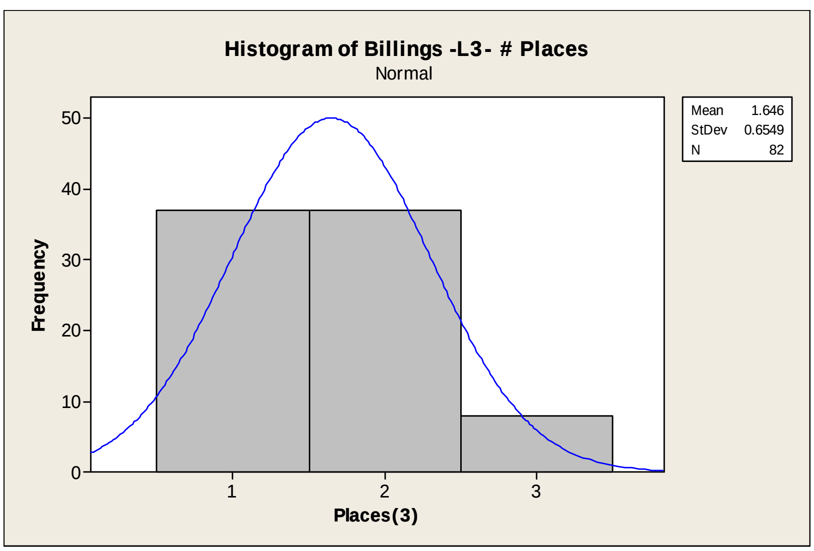

Figure 7: Histogram of Billings – L3 - # of Places Visited

The figure to the left shows the histogram for "number of places visited" in Billings for location 3.

For Figure 7:

Mean = 1.646

Standard deviation= 0.6549

N = 82

The value for the standard deviation shows the high variation around the mean value.

Confidence Intervals were then calculated using the resulting mean and standard deviation from the histogram. The resulting output is shown below.

N	Mean	SE Mean	95% CI
82	1.64600	0.07232	(1.50425, 1.78775)

4.4 Bozeman Data Analysis

The database for Bozeman was the last data set collected, and the last data set analyzed. Histograms were created for the three locations of study, and the corresponding confidence intervals were calculated. The results are shown below.

4.4.1 Bozeman – Location 1 Central Business District

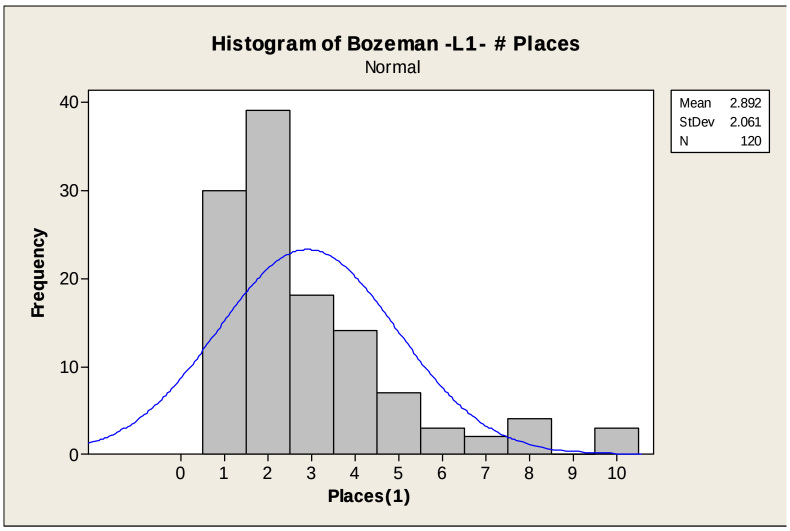

Figure 8: Histogram of Bozeman – L1 - # of Places Visited

The figure to the left shows the histogram for "number of places visited" in Bozeman for location 1.

For Figure 8:

Mean = 2.892

Standard deviation= 2.061

N = 120

The value for the standard deviation shows the high variation around the mean value.

Confidence Intervals were then calculated using the resulting mean and standard deviation from the histogram. The resulting output is shown below.

N	Mean	SE Mean	95% CI
120	2.89200	0.18814	(2.52325, 3.26075)

4.4.2 Bozeman – Location 2 Power Corridor

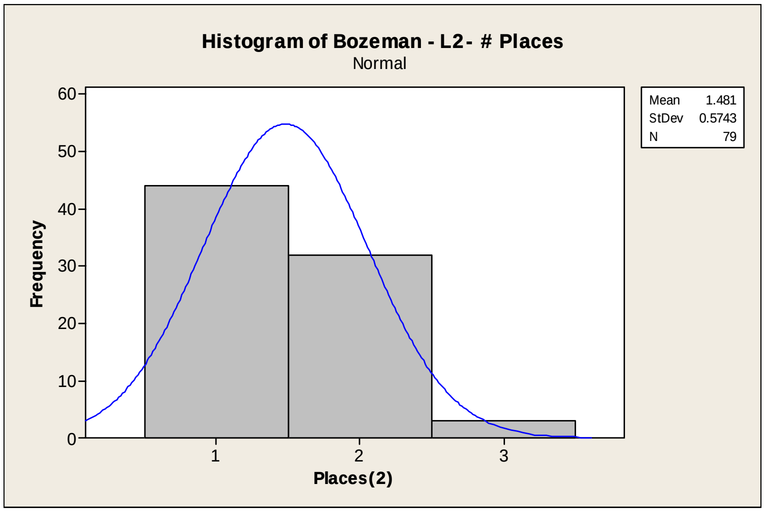

Figure 9: Histogram of Bozeman – L2 - # of Places Visited

The figure to the left shows the histogram for "number of places visited" in Bozeman for location 2.

For Figure 9:

Mean = 1.481

Standard deviation= 0.5743

N = 79

The value for the standard deviation shows the high variation around the mean value.

Confidence Intervals were then calculated using the resulting mean and standard deviation from the histogram. The resulting output is shown below.

N	Mean	SE Mean	95% CI
79	1.48100	0.06461	(1.35436, 1.60764)

4.4.2 Bozeman – Location 3 Commercial Corridor

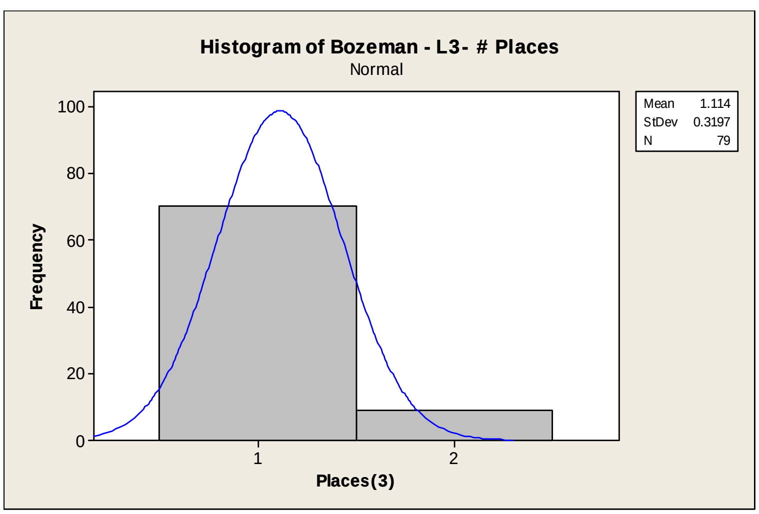

Figure 10: Histogram of Bozeman – L3 - # of Places Visited

The figure to the left shows the histogram for "number of places visited" in Bozeman for location 3.

For Figure 10:

Mean = 1.114

Standard deviation= 0.3197

N = 79

The value for the standard deviation shows the slightly high variation around the mean value.

Confidence Intervals were then calculated using the resulting mean and standard deviation from the histogram. The resulting output is shown below.

N	Mean	SE Mean	95% CI
79	1.11400	0.03597	(1.04350, 1.18450)

4.5 Interpretation of Great Falls, Billings, and Bozeman Data Analysis

The standard deviations from the histograms resulting from the data set all showed significant variations from the mean value. The values for the standard deviations were anywhere from 30% of the mean value to over 50%. This shows that the mean value estimated has a high amount of variability, which was an anticipated result due to the nature of the data sets. This project dealt with collecting data on number of stores visited in a location. The number of stores visited is a value that should fall between certain intervals, depending on the number of stores available to visit in a location. It is also restricted to whole integer numbers only, and for most cases shown those integers were either 1 or 2. It is acceptable to have these high standard deviation values due to the nature of the project.

4.6 Correlation Analysis – Fit Trend Line

Correlation analysis was done in order to check for dependencies between data sets. Two separate analyses were done to check for correlation.

4.6.1 Location 1 – Correlation between Number of Places Visited and Duration of Stay

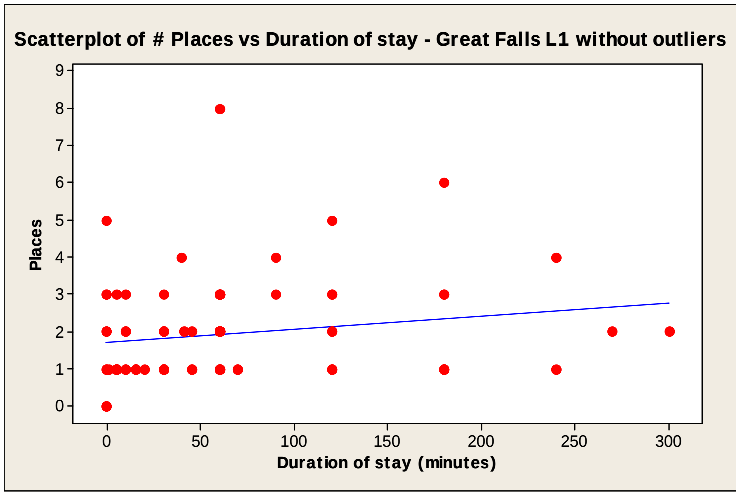

Figure 11: Great Falls L1 - Plot of # of Places Visited vs. Duration of Stay

The figure to the left shows the plot of "number of places visited" against the "duration of stay". The data set used excluded outliers. The graph shows a slightly positive relationship between the number of places visited and the duration of stay, as shown by the fit trend line. The correlation is not very strong, and there is a large scatter of points concentrated in the 0-50 minute range.

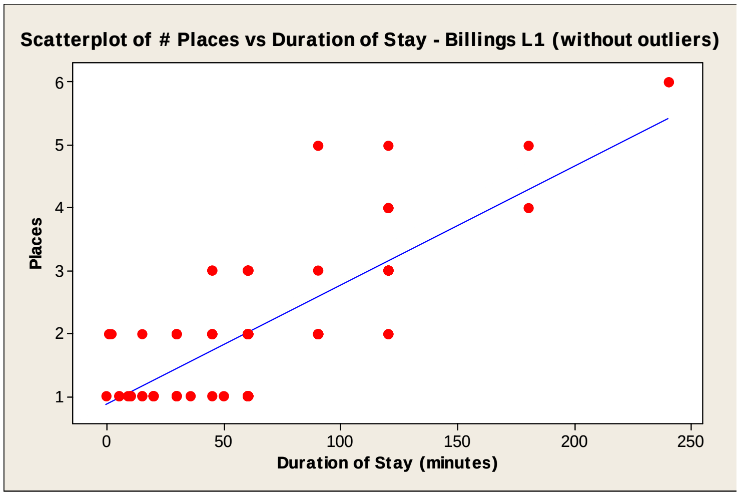

Figure 12: Billings L1 – Plot of # of Places Visited vs. Duration of Stay

The figure to the left shows the plot of "number of places visited" against the "duration of stay". The data set used excluded outliers. The graph shows a strong positive relationship between the number of places visited and the duration of stay, as shown by the fit trend line.

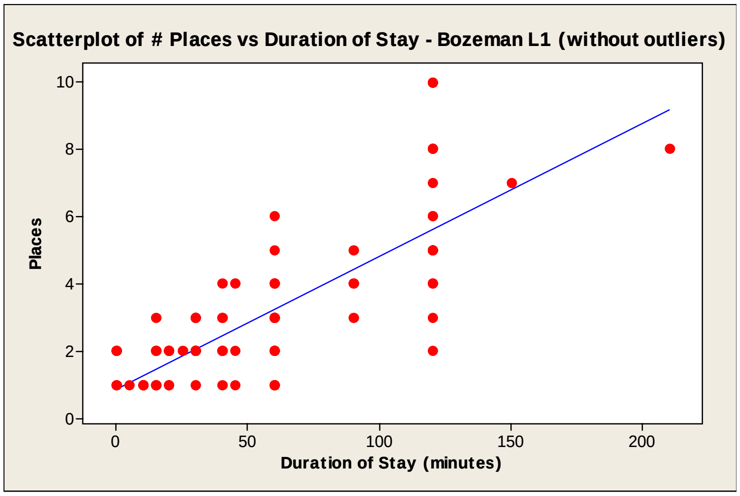

Figure 13: Bozeman L1 – Plot of # of Places Visited vs. Duration of Stay

The figure to the left shows the plot of "number of places visited" against the "duration of stay". The data set used excluded outliers. The graph shows a strong positive relationship between the number of places visited and the duration of stay, as shown by the fit trend line.

4.6.2 Location 2 – Correlation between Number of Places Visited and Duration of Stay

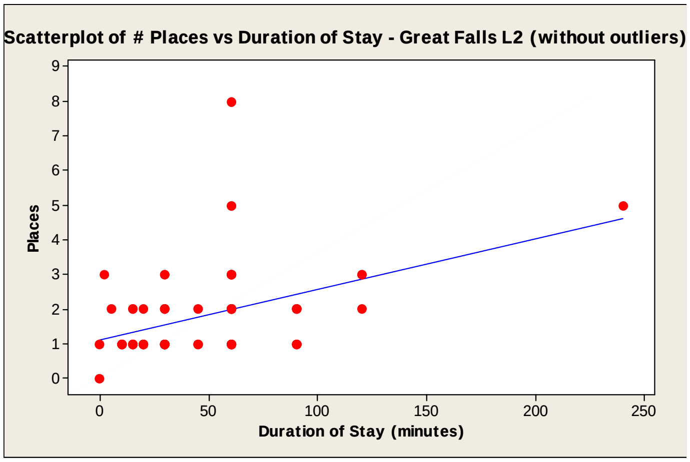

Figure 14: Great Falls L2 – Plot of # of Places Visited vs. Duration of Stay

The figure to the left shows the plot of "number of places visited" against the "duration of stay". The data set used excluded outliers. The graph shows a positive relationship between the number of places visited and the duration of stay, as shown by the fit trend line.

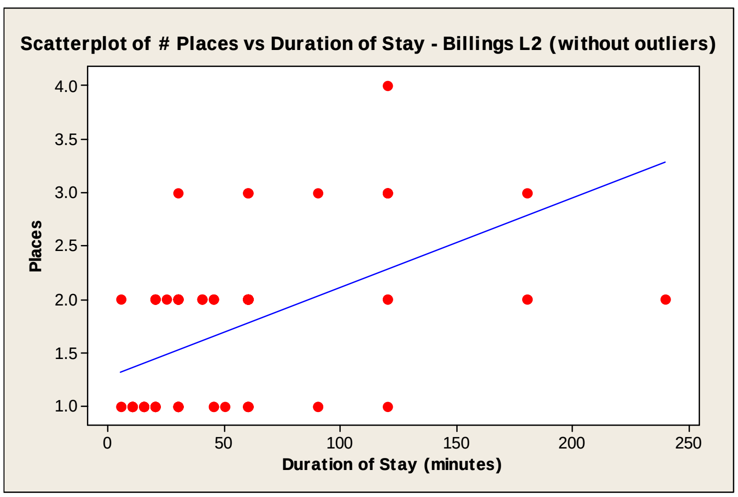

Figure 15: Billings L2 – Plot of # of Places Visited vs. Duration of Stay

The figure to the left shows the plot of "number of places visited" against the "duration of stay". The data set used excluded outliers. The graph shows a strong positive relationship between the number of places visited and the duration of stay, as shown by the fit trend line.

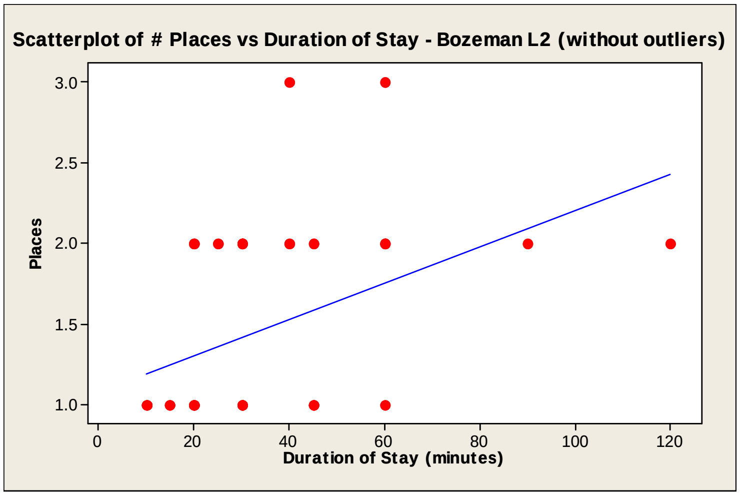

Figure 16: Bozeman L2 – Plot of # of Places Visited vs. Duration of Stay

The figure to the left shows the plot of "number of places visited" against the "duration of stay". The data set used excluded outliers. The graph shows a strong positive relationship between the number of places visited and the duration of stay, as shown by the fit trend line.

4.6.3 Location 3 – Correlation between Number of Places Visited and Duration of Stay

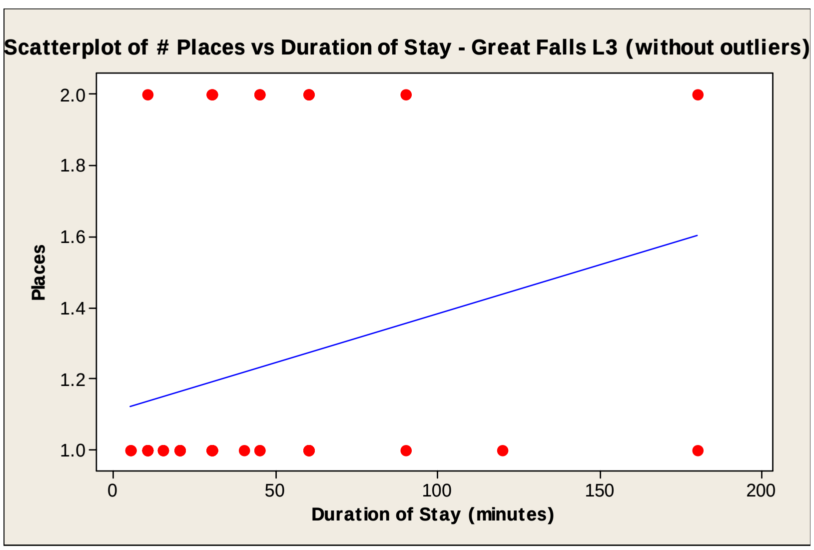

Figure 17: Great Falls L3 – Plot of # of Places Visited vs. Duration of Stay

The figure to the left shows the plot of "number of places visited" against the "duration of stay". The data set used excluded outliers. The graph shows a strong positive relationship between the number of places visited and the duration of stay, as shown by the fit trend line.

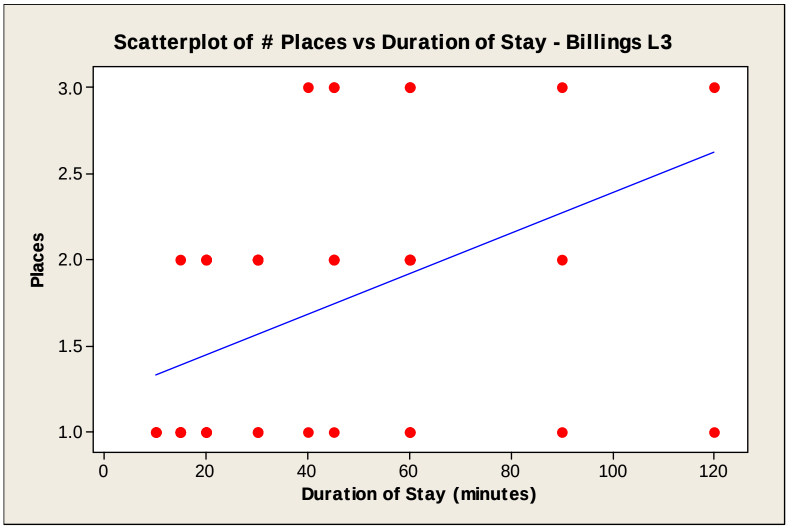

Figure 18: Billings L3 – Plot of # of Places Visited vs. Duration of Stay

The figure to the left shows the plot of "number of places visited" against the "duration of stay". The graph shows a strong positive relationship between the number of places visited and the duration of stay, as shown by the fit trend line.

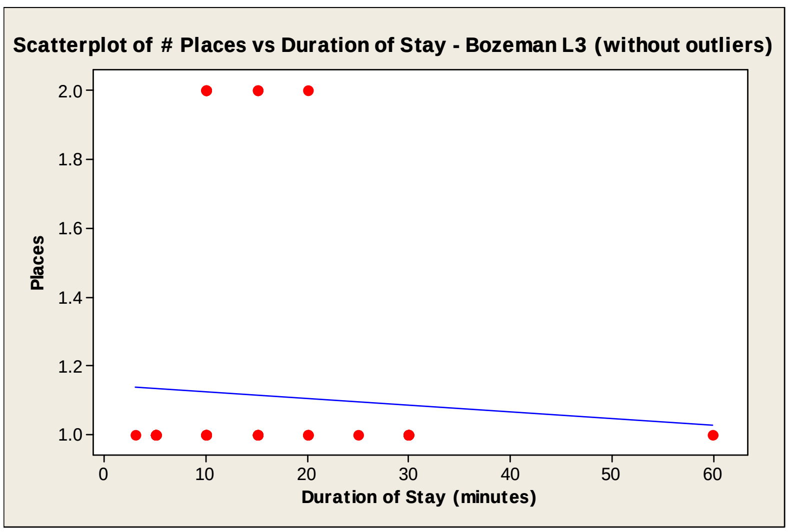

Figure 19: Bozeman L3 – Plot of # of Places Visited vs. Duration of Stay

The figure to the left shows the plot of "number of places visited" against the "duration of stay". The data set used excluded outliers. The graph shows a negative relationship between the number of places visited and the duration of stay, as shown by the fit trend line.

4.6.4 Interpretation – Correlation between Number of Places Visited and Duration of Stay

All of the figures in section 4.6.1 through 4.6.3 showed a positive fit trend line, except for location 3 in Bozeman. Even though the correlation is positive and shows dependencies, further investigation of the scatter plots of each graph reveals such variable data points that the researcher is not able to conclude that a positive dependency exists between the number of places visited and the duration of stay.

4.6.5 Location 1 – Correlation between Number of Places Visited and Number of Stores in Location

This correlation was not able to be tested. It is possible to have various definitions of the boundaries of a downtown, and so the number of stores in the central business district of each city is not known. Also, downtowns cover more area than the other locations studied, and a person could potentially move their car throughout a downtown area to shop at multiple stores within the downtown. This study will not cover the correlation between the number of places visited and the number of stores in the location for the central business district.

4.6.6 Location 2 – Correlation between Number of Places Visited and Number of Stores in Location

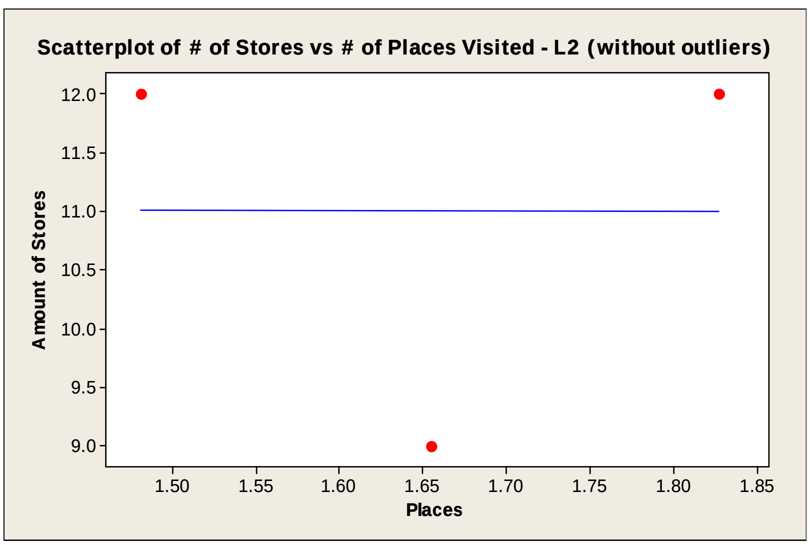

Figure 20: L2 – Plot of # of Stores in Location vs. # of Places Visited

The figure to the left shows that there is not correlation between the number of stores in a location and the number of places visited. The values for the number of places visited represent the mean values for the number of places visited at location 2 for all three towns.

4.6.7 Location 3 – Correlation between Number of Places Visited and Number of Stores in Location

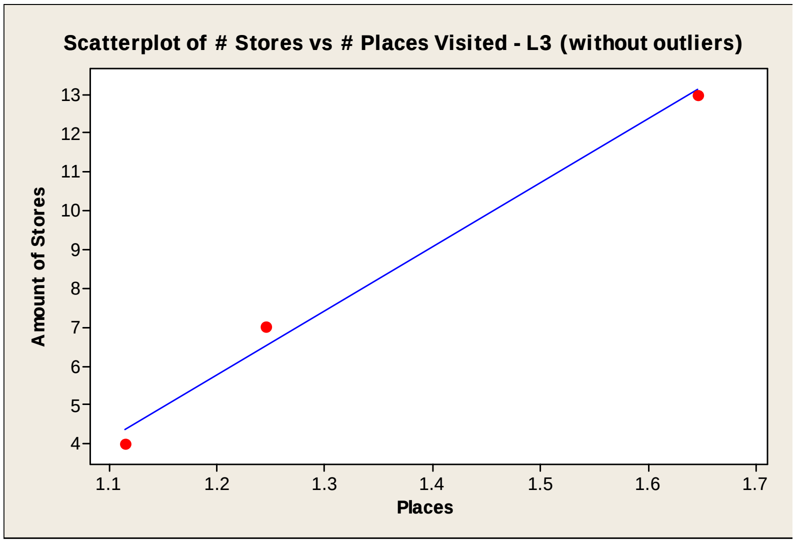

Figure 21: L3 – Plot of # of Stores in Location vs. # of Places Visited

The figure to the left shows the fit mean line having a positive slope and a positive correlation between the number of stores in a location and the number of places visited. The values for the number of places visited represent the mean values for the number of places visited at location 3 for all three towns.

4.6.8 Interpretation – Correlation between Number of Places Visited and Number of Stores in Location

The results from location 2 are not significant. The values for amount of stores do not vary drastically nor do they have an impact on the number of places visited. The results from location 3 do show a positive dependency between the amount of stores in a commercial corridor and the number of places visited. There is a wider gap between the amounts of stores in the commercial corridors studied. The increase in the amount of stores offered has a direct relationship to the amount of places people visited. Intuitively, this would be expected since the more places that are offered to shop at provide the opportunity to visit more stores.

4.7 Demographic Information from Surveys

The researcher decided to look at the characteristics of the people that were surveyed. This helps check whether any bias exists in the survey and helps get an idea of what kind of people participated in the survey. The following table shows the breakdown.

Table 5: Demographics – Percent of Total

Category	**% of Total**
Purpose	
Work	11.4%
Visit/Shop	73.2%
Both	2.6%
Other	12.8%
Mode	
Walk	6.9%
Bike	6.1%
Automobile	86.9%
Bus	0.1%
Age	
Under 15	0.83%
15-24	13.93%
25-44	48.2%
45-64	24.44%
65+	12.6%
Gender	
Male	47.6%
Female	52.4%

4.8 Summary of Data Analysis

The following table summarizes the average number of places visited, separated by location. The numbers for the average number of places visited was derived by averaging the results from each individual city by location.

Table 6: Average # of Places Visited by Location

Location	Average # of Places Visited
1	2.243
2	1.654
3	1.335

5. CONCLUSIONS

The aim of this project is to determine if some land use development pattern are more parking efficient than others. From the data analysis done in MINITAB, it is determined that the three land use development patterns under consideration, the central business district, the power center, and the linear corridor, are all parking efficient (refer to Table 6). The most efficient land use development pattern is found to be the central business district. The second most efficient land use development pattern is the power center. The third most efficient land use development pattern is the linear corridor.

From the data analysis done in MINITAB, the average number of places visited, defined by location, was calculated. These numbers are used to determine the allowable percent reduction of parking spaces. Two equations for the percent reduction of parking spaces were determined.

5.1 Formula – Percent Reduction Based on Number of Businesses in Study Area

Since each business has to provide its own parking spaces, the reduction in the total amount of parking provided in a land use development pattern is dependent on the number of businesses that are providing parking in that location. A formula was developed for the allowable percent reduction based on the number of business in a study area.

$$\% \text{ Reduction} = 100 * \frac{\text{Mean \# of Places Visited} - 1}{\text{\# of Business in the Study Area}}$$

Table 7: Percent Reduction Based on Number of Business in Study Area

Location	**Av. # of Places Visited**	**Av. # of Stores in Location**	**% Reduction**
1	2.243	n/a	n/a
2	1.654	11	~ 6%
3	1.335	8	~ 4.2%

5.2 Formula – Percent Reduction Based on Number of Parking Spaces Provided

The required amount of parking spaces that a business must provide is dependent on the type and size of the business. Businesses within a certain land use development pattern differ in the amount of spaces they must provide, some having to provide more than others. With this in mind, the researcher concluded that instead of only looking at the total number of businesses in a location, it would prove to be beneficial and more accurate to base the parking reduction percents on the spaces provided by the individual business. A formula was developed for the allowable percent reduction based on the number of spaces provided by each business in a study area.

$$\% \text{ Reduction} = 100 * \frac{\text{Mean \# of Places Visited} - 1}{\text{\# of Spaces Provided (unique to each business)}}$$

The percent reduction is unique to each business. The number of spaces provided is dependent on the type and size of business. The land use development pattern that the business fits in determines the mean number of places visited. Once these variables are determined, then they are plugged into the equation in order to determine the percent reduction.

5.3 Study Recommendations

This study was limited by the scope of time available to collect data. The researcher was only able to visit one of each location type in each town. Further research should include surveying at more than one of each location type in each town for comparison purposes. The researcher was also only able to survey during the week and spanning the hours from 9am – 6pm. Further research should include weekend survey gathering and nighttime survey gathering. It is thought that more people tend to do their shopping on the weekend or after work, which could affect the results of this project.

In conclusion, certain land use development patterns are more parking efficient than others. Because of this, it is possible to reduce the amount of parking spaces provided by a business if they fall into one of the land use development patterns covered in this study.

6. REFERENCES

City of Bozeman, Bozeman 2020 Community Plan, Chapter 6 “Land Use”, 2001.

City of Bozeman, Bozeman 2020 Community Plan, Chapter 10 “Transportation”, 2001.

City of Bozeman, Bozeman Land Development Regulations, Title 18, Chapter 46, 2004.

Ewing, Reid. “Transportation & Land Use Innovations: When You Can’t Pave Your Way Out of Congestion”. Chicago, Ill.: Planners Press, 1997.