ANALYSIS OF SEASONAL AND DAY-OF-WEEK TRAFFIC PATTERNS AT NATIONAL PARKS

A Thesis

by

LINDSAY ELIZABETH LIGGETT

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2008

Major Subject: Civil Engineering

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Approved by:

Chair of Committee,	Mark Burris
Committee Members,	Yunlong Zhang
	Scott Shafer
Head of Department,	David Rosowsky

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ABSTRACT

Analysis of Seasonal and Day-of-Week Traffic Patterns at National Parks. (May 2008)

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Chair of Advisory Committee: Dr. Mark Burris

The National Park Service (NPS) is currently contemplating the implementation of a system-wide traffic monitoring program. While several of the national parks within this network collect continuous vehicle data at multiple stations within each park, these programs have not been examined for their efficiency and cost effectiveness. Therefore, as the NPS looks to expand their count program, this thesis investigates potential improvements using a sample set of five parks.

To determine whether the national park seasonal and day-of-week traffic patterns exhibit consistency from one year to the next, the seasonal and day-of-week factors were compared across all five years. Using the Kruskal-Wallis test, it was determined that the seasonal and day-of-week factors were not statistically different from 2002 to 2006 for all five national parks. Therefore, it is recommended that the NPS consider reducing the amount of data that they collect by using short-duration counts in conjunction with a modest number of permanent counts.

To determine whether data collection efforts can be shared amongst various entities, the national park traffic counts for 2002 to 2006 were compared to those of nearby state highway automatic traffic recorder (ATR) locations using correlation analyses. While the correlation values ranged from "high" to "negligible", the distance between the park and ATR location had a direct effect on the magnitude of the value. Therefore, in order to achieve the greatest probability that the correlation will be "high", it is suggested that the NPS share data collection efforts using ATR locations within 20 miles of the park.

To determine which design volume calculation method was most appropriate for the parks, design volumes were computed using two methods. Using the traditional K-factor plot, it was determined that the 30th highest hourly volumes should be used for urban parks as this is where the "knee" occurs. Although this is not the case for rural parks, there is no compelling evidence to suggest a more appropriate design hour. Additionally, the method recommended by AASHTO for recreational roadways resulted in volumes that were frequently exceeded. Therefore, the K-factor plot method is most appropriate for both the urban and rural parks.

DEDICATION

To my husband and best friend, Ben --

Thank you for always loving and believing in me. I love you with all of my heart.

ACKNOWLEDGEMENTS

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Additionally, the author would like to extend her gratitude to the National Park Service and the various state departments of transportation for providing the traffic data and to Mr. Nathaniel Litton and Dr. Eun Sug Park for their help with the statistical analysis portion of this thesis.

Finally, the author would like to thank her family and friends for their love and support.

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CHAPTER I

INTRODUCTION

Traffic data provide guidance when vital transportation decisions need to be made. They form the foundation upon which the nation's transportation system was built and support the decisions that are made when preparing for the future. Traffic data are collected across the country, but traffic counting needs, budgets, and geographic constraints vary from one location to the next. Therefore, before data collection begins, it is important for an area to create a traffic monitoring program to make best use of all available resources. Development of such a program assists in capturing the relevant data while preparing to properly maintain it in an archived fashion for future use in a cost-effective manner.

Various agencies nationwide are required to develop traffic monitoring programs and collect traffic data with the intent of using it to develop and improve their infrastructure systems. The National Park Service, which is a network of 391 natural, recreational, and cultural areas covering over 84 million acres, is one agency that is contemplating the implementation of such a program. Although the National Park Service does not currently require that traffic to be monitored in all 391 areas, several of the national parks within this network collect continuous vehicle and visitation data.

This thesis follows the style of *Journal of Transportation Engineering*.

These parks use a counting method governed by the data collection policy and procedures set by the National Park Service. After collecting such data, these parks submit summaries of the continuous counts to be published in an annual report so that this information can be used to monitor the traffic in these particular parks and plan for future adjustments/construction as necessary. However, these programs have not been examined for their efficiency and cost effectiveness. Therefore, a careful examination of these programs may result in increased efficiencies. This is particularly important as the National Park Service looks to expand their count program to additional parks.

PROBLEM STATEMENT

This thesis investigates the method in which national park traffic is currently monitored and searches for potential improvements. Although the Federal Highway Administration recommends using only a limited number of continuous counts in conjunction with a large number of short-duration counts to best utilize the available resources when monitoring traffic, several of the national parks collect only continuous traffic data at multiple stations within each park in order to monitor these roadways. If this method of data collection were to be applied to all 391 areas that make up the National Park Service, traffic monitoring would be both costly and require a significant time commitment in terms of data collection, reduction, and organization. However, it has recently been suggested that improvements could be made to the current traffic monitoring program. Therefore, in an effort to reduce the amount of time and money spent on data collection within these recreational areas, research into potential improvements to data collection was undertaken. One potential source of efficiency may stem from determining whether the traffic within each park follows the same seasonal pattern from one year to the next. The existence of such a pattern would enable the parks to implement a sampling approach to reduce the volume and cost of data collection. It may also allow the parks to integrate the traffic data collected within the parks with that of other nearby transportation agencies. If seasonal trends do not exist when comparing the park traffic from one year to the next, then traffic must be continuously collected in several locations in order to maintain accuracy.

OBJECTIVES

The goal of this research is to examine traffic patterns at national parks in an effort to reduce the amount of time and money that is spent on traffic data collection in these recreational areas while maintaining the quality and accuracy of the counts. To accomplish this goal, traffic data from national parks will be examined for patterns. The specific objectives of this research were as follows:

- Determine whether the national park seasonal and day-of-week traffic patterns exhibit consistency from one year to the next for each particular park using traffic volumes provided by the National Park Service for the past five years.
- Compare national park traffic data to that of other nearby state highway routes to determine whether the data collection efforts can be reduced and shared amongst these various entities.

- Determine the most appropriate design hourly volume calculation method for national parks and compare the K-factors of urban national parks to those of rural parks.
- Develop improved traffic data collection methods and guidelines for the national parks.

THESIS OVERVIEW

The following chapters of this thesis present the information that was used to achieve the previously stated objectives and are in the order of introduction, literature review, methodology, data analysis and results, and conclusions and recommendations. The literature review examines past studies related to traffic data collection design methods with a focus on short-count data. Although little research has been performed in the area of traffic variability within national parks or the development of a traffic monitoring program specific to these recreational areas, literature concerning the importance of monitoring traffic and the data collection methodologies which are currently utilized by each national park were reviewed. The data collection chapter outlines the process by which the vehicle data were gathered from the National Park Service and state departments of transportation. The data analysis and results section focuses on identifying seasonal patterns in the traffic volumes at national parks, comparing park traffic data to that of other nearby roadways, and comparing urban national park design hourly volumes to those of rural parks. The results are then summarized, and conclusions and recommendations are gathered from the research findings.

CHAPTER II

LITERATURE REVIEW

Measurement of traffic volumes is one of the most basic components of transportation planning and management. Collection of these volumes is the most common measure of roadway use throughout the nation. Most agencies focus on the average annual daily traffic (AADT) when monitoring a roadway network. AADT represents the average daily number of vehicles that traverse a specific point on a roadway; however, this vehicle count is not evenly distributed. Instead, traffic varies by time of day, day of week, and month (or season), and it is important to account for these fluctuations when measuring the use of a particular roadway.

TRAFFIC DATA COLLECTION DESIGN

A successful data collection program accounts for traffic variability and also identifies changes in traffic patterns as they occur over time. It is comprised of "a modest number of permanent, continuously operating, data collection sites and a large number of short-duration collection efforts" and includes adjustment factors that are used to better approximate traffic conditions (FHWA 2001). While short-duration counts provide vast geographic coverage and contribute to the understanding of traffic characteristics on individual roadways, permanent locations assist in determining the seasonal and day-of-week trends. Because permanent counters are expensive to install, operate, and maintain, they cannot be utilized on every roadway. Instead, the limited data that is collected at the permanent locations are used to develop adjustment factors, which are then used to convert short-duration data into AADT estimates (FHWA 2001).

To apply the appropriate factor to the correct sites, the roadways must first be grouped together using one of three techniques: cluster analysis, geographic/functional assignment, or application of the same roadway factor. Cluster analysis groups roadways using a least-squares minimum distance algorithm to determine which sets of factors are the most similar. Geographic/functional assignment uses existing data summaries and professional traffic pattern experience to form similar roadway groups. The simplest of these techniques establishes a factor for each continuous counter in a particular area and then assigns that factor to the roadways within the influence of each counter location (FHWA 2001). This is termed the "same roadway factor".

No matter which grouping method is utilized, it must be assumed that the roadways within each group behave similarly. Additionally, whatever grouping approach is adopted, the issues of variability and implementation must be addressed. As a general rule, the variability within groups should be minimized while the variability between groups should be maximized. In terms of implementation, roadway groupings must be continuously reviewed to ensure that the grouped data conforms to the functional classification of that roadway (AASHTO 1992). After these issues are addressed, and the roadways are divided into groups, traffic data are collected at a sample of locations within each group. Average traffic conditions are then calculated for the sample with the assumption that these mean values best represent the traffic behavior on all roadways within the group. Finally, these adjustment factors are applied to the short-term traffic counts, and the annual averages are approximated (FHWA 2001).

The Texas Department of Transportation (TxDOT) is one example of an agency that monitors traffic using a method similar to that which is described above. Permanent traffic data are collected at approximately 160 automatic traffic recorder (ATR) locations, which are selected by TxDOT districts in accordance with the Federal Highway Administration (FHWA) *Traffic Monitoring Guide*. While the ATR equipment continuously collects the traffic volumes in each lane and records them as directional totals, the data are retrieved via modem on a daily basis to develop seasonal factors. In terms of short-duration data, TxDOT conducts between 60,000 and 80,000 counts each year. Short-duration counts are performed on the Highway Performance Monitoring System (HPMS) samples (or on-system roads) and the off-system roads. While the short-duration counts are collected annually on the on-system roadways according to the methods set forth in the FHWA *Traffic Monitoring Guide*, the off-system counts are collected every five years throughout Texas' 26 urbanized areas in with the number of counts ranging from 10,000 to 30,000 annually. Using these short-duration counts and the seasonal factors that are developed using the permanent counts, the AADT is then approximated (TxDOT 2001).

COMPUTATION OF SEASONAL FACTORS

Seasonal factors are used to account for temporal bias when estimating the AADT using short-duration counts. External factors such as weather and the availability of both staff and equipment affect the time in which an agency can conduct short-duration counts. Therefore, adjustment factors must be developed for all times of the year. Seasonal factors can be based on the day of the week, month of the year, or any other time period. The combination of monthly and day-of-week factors is most commonly used in practice (FHWA 2001). To compute seasonal factors for a particular site, the AADT is divided by a factor that depends on the factoring approach that was used.

The AADT, or numerator, can be determined with either a simple average of all 365 days in a given year or with an averaging technique. Although the first of these techniques is advantageous in that it is simple and easy to program, one downside to this simple method is that it is subject to significant bias when data are missing. The averaging technique, on the other hand, accounts for missing data (FHWA 2001). All complete daily traffic volumes are averaged for each day of the week and month of year, yielding seven values for each of the 12 months, or 84 monthly average days of the week (MADW) values. The annual average days of the week (AADW) values are then calculated for each day of the week as the average of the 12 MADW values for that particular day. These seven AADW values are then averaged to yield the AADT. Therefore, this method accounts for missing data by weighting each day of the week the same and each month the same no matter how many days are actually present within that year. This method for computing the AADT is preferred by AASHTO over the simple average, and Eq. (1) is used to calculate the AADT for the averaging method (FHWA 2001).

$$AADT = \frac{1}{7}\sum_{i=1}^{7}\left[\frac{1}{12}\sum_{j=1}^{12}\left(\frac{1}{n}\sum_{k=1}^{n}VOL_{ijk}\right)\right] \quad (1)$$

where

VOL_{ijk} = daily traffic volume for day "k", day-of-week "i", and month "j",

i = day of the week,

j = month of the year,

k = 1 when the day is the first occurrence of that day of the week in a month, 4 when it is the fourth day of the week, and

n = the number of days of that day of the week during that month.

In a study conducted by the Texas Transportation Institute, researchers examined the two AADT calculation methods mentioned above, as well as several other techniques, to test the effects of various missing data patterns. Although the averaging technique is preferred by AASHTO and allows for missing days of data when computing the 84 MADW values, this method does require all 84 MADW values when calculating the AADT due to the effect that a missing value will have on the accuracy of the estimate. After a thorough analysis of the traffic data, the researchers at the Texas Transportation

Institute concluded that missing data are tolerable for AADT calculations although the limitations vary depending upon location type. For urban locations with weekday commuter traffic, the authors found that systematically missing data for up to 8 months (50 to 75 percent of all days) are tolerable for the purposes of calculating annual average traffic statistics. However, for rural locations with pronounced seasonality patterns, missing data are tolerable only up to 1 to 2 months (6 to 15 percent). Therefore, although missing data are acceptable when calculating the AADT, one must be careful to not use data that results in error rates greater than that which is acceptable (Turner and Park 2008).

As mentioned previously, the denominator used to calculate a seasonal factor varies depending upon the factoring approach used. Some agencies choose to use an adjustment factor that only converts the average daily traffic of certain weekdays into an AADT estimate. These agencies do not use every day of the week and instead use only those that represent a typical weekday for a given month. This requires the agency to use the monthly average weekday traffic (MAWDT) as the denominator. The MAWDT for a given day of week and month is calculated as shown in Eq. (2).

$$MADWT_j = \frac{1}{m}\sum_{i=1}^{m}\left(\frac{1}{n}\sum_{k=1}^{n}VOL_{ijk}\right) \qquad (2)$$

where

VOL_{ijk} = daily traffic volume for day "*k*", day-of-week "*i*", and month "*j*",

i = day of the week,

j = month of the year,

k = 1 when the day is the first occurrence of that day of the week in a month, 4 when it is the fourth day of the week,

m = the number of days of that represent a typical weekday, and

n = the number of days of that day of the week during that month.

When the MAWDT is used as the denominator, the days that the short-count data are collected should coincide with the days that are used to develop the seasonal factor. Therefore, if short-duration data are not collected on Fridays, Saturday, and Sundays, the denominator should only include Mondays to Thursdays. However, other agencies prefer to use all seven days of the week. They develop an adjustment factor that converts any weekday average daily traffic into an AADT estimate, and therefore, the denominator is assumed to be the monthly average daily traffic (MADT), which is calculated using Eq. (3).

$$MADT_j = \frac{1}{7}\sum_{i=1}^{7}\left(\frac{1}{n}\sum_{k=1}^{n} VOL_{ijk}\right) \tag{3}$$

where

VOL_{ijk} = daily traffic volume for day "*k*", day-of-week "*i*", and month "*j*",

i = day of the week,

j = month of the year

k = 1 when the day is the first occurrence of that day of the week in a month, 4 when it is the fourth day of the week, and

n = the number of days of that day of the week during that month.

When computing the MADT or MAWDT, the same two techniques that exist for the AADT computation may be used. Again, a simple average is easy to use but leads to bias when data are missing. Therefore, the averaging technique is again recommended and is computed similar to that of the AADT (FHWA 2001).

After determining both the numerator and denominator, seasonal factors for a specific site are computed by the ratio of AADT to MADT or AADT to MAWDT. These factors are then applied to an appropriate 24-hour count along with several other adjustment factors as seen in Eq. (4) (FHWA 2001).

$$AADT_{hi} = VOL_{hi} \times M_h \times D_h \times A_i \times G_h \tag{4}$$

where

$AADT_{hi}$ = annual average daily travel at location "*i*" of factor group "*h*"

VOL_{hi} = 24-hour axle volume at location "*i*" of factor group "*h*"

M_h = applicable seasonal (or monthly) factor for factor group "*h*"

D_h = applicable day-of-week factor for factor group "*h*" (if needed)

A_i = applicable axle-correction factor for location "*i*" (if needed)

G_h = applicable growth factor for factor group "*h*" (if needed)

Eq. (4) can be used to convert short-duration counts to AADT estimates using the seasonal adjustment factors developed in this thesis. However, instead of using separate adjustment factors for the applicable month and day of the week, the factors developed in this thesis were combined to yield a single adjustment factor for each day-of-week and month-of-year combination. Additionally, axle-correction factors were not needed because the short-duration volumes were vehicle counts and not axle counts. Growth factors were also not necessary because the short-duration volumes did not need to be projected into the future. Therefore, with the use of Eq. (4) and the applicable adjustment factors, the 24-hour vehicle count collected on Monday, May 1, 2006 in Yosemite National Park can be converted to an AADT estimate for 2006 as follows.

$$AADT_{2006,Yosemite} = (VOL_{2006,Yosemite}) \times (MD_{May,Monday}) = (811veh)(0.74) = 599veh$$

ACCURACY OF AADT ESTIMATES USING SHORT-COUNT DATA

Over the past few years, numerous studies have been conducted to assess the accuracy of AADT estimates found by expanding short-term traffic counts. While the FHWA suggests collecting short-count data with a single 48-hour count every three years, other count durations have been studied to determine the effect that they have on the accuracy of the estimated value. A recent study in Canada examined AADT estimates that used either adjustment factors or regression analysis to expand the short-term traffic counts. For both of these expansion methods, it was determined that a minimum eight-day sample over three seasons is required to estimate AADT values within ±10 percent. It was also found that the more commonly used factor method of expanding one 48-hour count has an accuracy that ranges from ±13 to ±25 percent, 9 times out of 10 (Robichaud and Gordon 2003).

Another study in Canada grouped roadways prior to analysis using three different types of routes: commuter, rural, and recreational. While the commuter and rural routes were associated with low and moderate variation in monthly traffic, respectively, the recreational routes were characterized by high seasonal variation and moderate to high weekend volumes. As a result of this variability, recreational routes experienced greater AADT estimation error than either commuter or rural routes for the same duration of short-term counts. Additionally, it was determined that longer and more frequent counts are required for recreational roadways where more accurate estimations are expected (Sharma and Allipuram 1993). Further research on this topic found AADT estimation errors to be even more sensitive to the correctness of the assignment of the sample site to an automatic traffic recorder than to the duration of the count. Results showed that "even a 6-hour count when assigned correctly can provide a much better AADT estimate than an incorrectly assigned 72-hour count" (Sharma et al. 1996). Therefore, in order to ensure that the assignment is reliable, it is recommended that seasonal counts consist of at least two one-week counts made in different months when assigning a site to a factor group (Davis 1997).

Although this thesis does not aim to define the exact time period in which the national parks should collect short-duration counts, it is important to recognize that accurate AADT estimates can be achieved when the short-count data are collected for an appropriate duration and when the roadway is correctly assigned to an adjustment factor group. In order to accurately assign a site to an adjustment factor group and estimate the AADT, it is suggested that several days of short-duration counts be made in different months. This recommendation supports the need for adjustment factors for all times of the year and reinforces the use of both monthly and day-of-week factors.

CURRENT NATIONAL PARK TRAFFIC MONITORING PRACTICES

National park visitation and traffic volumes are currently collected under the policies and procedures found in Director's Order 82 (DO82): Public Use Data Collecting and Reporting Program. A copy of this document is included in *Appendix A*. Since as early as 1904, information concerning the public use of national parks has been collected while informally monitoring the visitation levels, trip origins, and transportation modes used to access the parks. The National Park Service developed a formal system for gathering and reporting such information in the late 1960s, which is documented in DO82 (NPS 2007b).

While the purpose of DO82 is to set forth rules for collecting and reporting national park public use data, the main objectives of this director's order are to:

- "Design a statistically valid, reliable, and uniform method of collecting and reporting public use data for each independent unit administered by the NPS;
- Enact a variety of quality control checks to eliminate errors;
- Provide analysis and to verify measurements of the data;
- Ensure consistency of data collection; and
- Support the continuous collection and timely publication of such data (NPS 2007b)".

DO82 requires that visitation and traffic data be collected, analyzed and reported in a consistent manner throughout the National Park Service and that the parks submit accurate data to the Servicewide Public Use Data Collecting and Reporting Program in a timely manner. To assist in this effort, the Public Use Statistics Office (PUSO) issues a set of Counting and Reporting Instructions that contain the procedures for measuring, assembling, and reporting the visitation and traffic data at each park (NPS 2007b). Under these procedures, several of the national parks collect continuous traffic data at each park via inductive loop traffic counters. The traffic counts are then converted to both recreational and non-recreational visitation counts using the approach documented in the Public Use Counting and Reporting Instructions. However, each park slightly modifies the conversion method to best fit the conditions at that particular park.

When determining the number of recreational visitors, vehicle counts are converted to visitation volumes using a vehicle expansion multiplier and a persons-per-vehicle multiplier that vary based on the month to determine the number of vehicles and visitors, respectively. Additionally, some of the national parks include the number of persons that enter on bus, bicycle, foot, cross-country skis, snowmobile, snow coach, ferry, and/or train depending upon the location of the park. When determining the number of non-recreational visitors, the national parks first estimate the number of non-recreational vehicles using a predetermined proportion and then multiply this count by a persons-per-vehicle multiplier to yield the number of non-recreational visitors. However, some parks instead use a simple count that remains constant each month when estimating the number of non-recreational visitors (NPS 2006).

The Public Use Counting and Reporting Instructions specific to each of the national parks analyzed in this thesis can be found in *Appendix B*. However, those specific to Acadia National Park (see Fig. 1) are provided in this section as an example of how the national parks measure the number of recreational and non-recreational visitors.

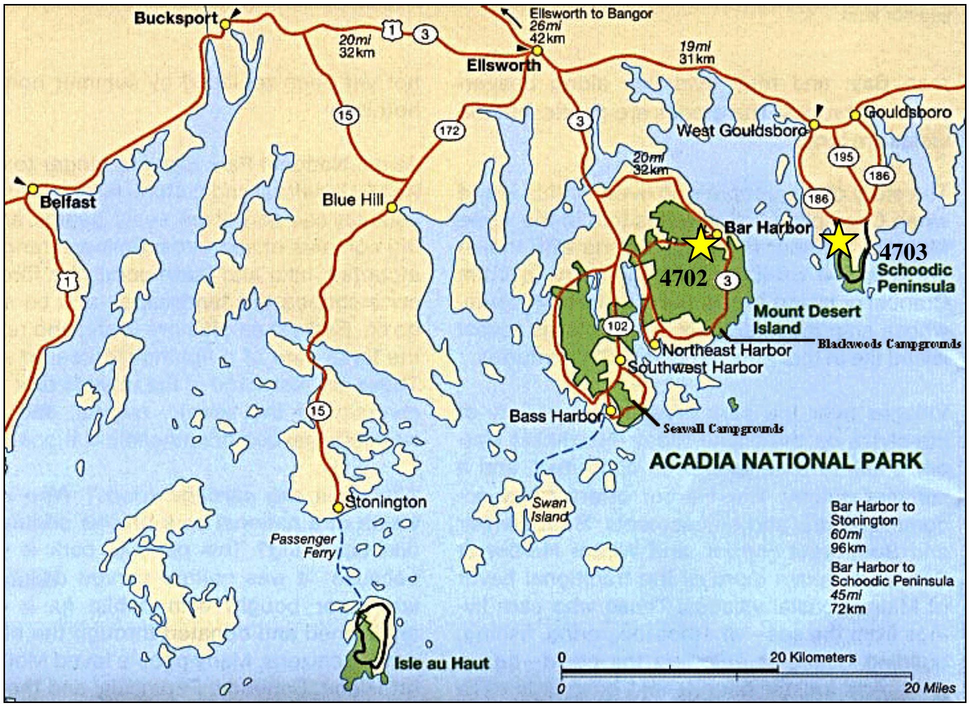

Fig. 1. Map of Acadia National Park (Uhler 2007)

In Acadia National Park, recreational visitors are counted on Mount Desert Island, Isle au Haut, and Schoodic Peninsula. The recreational counts on Mount Desert Island include the number of visitors observed snowmobiling and cross-country skiing, the number of bus passengers, and the counts collected at Station 4702, which is an inductive loop traffic counter located on Loop Road, just 20 feet north of Sand Beach Road (see Fig. 1). The number of bus passengers is determined by multiplying the number of buses by the persons per bus multiplier of 45. The vehicle counts collected at Station 4702 are multiplied by the vehicle expansion multipliers shown in Table 1 to estimate the number of vehicles using all of the recreational areas within the park although some of these vehicles do not cross this particular counter. These adjusted vehicle counts are then multiplied by the person-per-vehicle multipliers for recreation use shown in Table 2 (NPS 2003).

Table 1. Vehicle Expansion Multipliers for Acadia National Park (NPS 2003)

Month	Multiplier
January	1.8
February	1.8
March	2.2
April	2.5
May	2.6
June	2.7
July	2.7
August	2.7
September	2.6
October	2.5
November	2.4
December	1.8

Table 2. Persons-Per-Vehicle Multipliers for Acadia National Park (NPS 2003)

Month	Recreational Use PPV	Nonrecreational Use PPV
January	2.0	1.5
February	2.0	1.5
March	2.0	1.5
April	2.8	2.0
May	3.0	2.0
June	3.0	2.0
July	3.0	2.0
August	3.0	2.0
September	3.0	2.0
October	3.0	1.5
November	2.8	1.5
December	2.0	1.5

Recreational visitor counts on Isle au Haut include the number of visitors arriving by ferry from Stonington while Schoodic Peninsula counts the number of non-recreational visitors using the collection of traffic counts at Station 4703, which is located 0.15 mile north of the park boundary on the access highway to Schoodic Peninsula (see Fig. 1). Again, the traffic counts collected at this station are multiplied by the person-per-vehicle multipliers for recreation use found in Table 2 (NPS 2003).

Non-recreational visitor counts are collected exclusively on Mount Desert Island. During the months of May through October, the non-recreational vehicles are estimated to be one hundred vehicles per day. However, because Acadia National Park is closed each year from November 1st to April 15th, the number of non-recreational vehicles during these months is at a minimum. Using the non-recreational person-per-vehicle multipliers found in Table 2, monthly traffic counts are then converted to the number of non-recreational visits (NPS 2003).

Although public use counting and reporting instructions are slightly different for each national park, the PUSO periodically reviews both the recreational and non-recreational counting practices employed by each park to ensure that the data being collected are reliable and consistent from one park to the next. The visitation data are then published and used for a variety of park planning and operational efforts (NPS 2007b).

COORDINATION OF TRAFFIC MONITORING EFFORTS

Traffic data collection is costly and is frequently constrained by a predetermined budget. Agencies are frequently unable to single-handedly collect enough data to meet all of their needs, and as a result, Federal Highway Administration (FHWA) suggests that public and private agencies coordinate such data collection efforts in an attempt to stretch available budgets and share resulting databases. While it is recommended that this coordination begin at the state level, FHWA proposes that organizations outside of the state highway agency also participate in this joint effort (FHWA 2001). A significant number of jurisdictions other than state agencies operate roadways throughout the nation, and the traffic information collected by these agencies is another excellent source of data. Therefore, it is recommended that a means of communication be established within each state, other governmental agencies, and the private sector to exchange traffic counts and summary statistics (AASHTO 1992). Successful data collection coordination requires a continuing effort and commitment between all agencies involved along with the adoption of efficient data transfer methods. Additionally, shared traffic data must be carefully described to all users to ensure that the counts are used correctly. Through traffic data collection coordination, each agency would have access to more data with little to no increase in cost. Additionally, duplication of traffic counts would be reduced or eliminated, and the resources that are available within each agency would be more efficiently distributed to better utilize each agency's capabilities (FHWA 2001).

The National Park Service is one agency potentially capable of assisting state highway agencies with the collection of traffic data. While several of the national parks collect continuous traffic data at the main entrances, many state departments of transportation collect these same counts on the state highways located directly outside of the park boundaries. Therefore, according to FHWA recommendations, these agencies should coordinate traffic monitoring efforts in order to reduce or eliminate the duplication of traffic counts. Such coordination would enable the National Park Service and each state department of transportation to stretch available budgets and make better use of each agency's capabilities.

ESTIMATING DESIGN HOURLY VOLUMES

When planning the construction or expansion of a roadway, traffic demands are often estimated using traffic volume data collected at nearby permanent counters. While an hourly traffic volume is the most appropriate unit of volume for planning roadway capactiy, traffic volumes display significant variation from one hour to the next throughout the year. Therefore, it is important to determine which hourly volume should be used to most appropriately base predictions of future demand. While it is unreasonable to design a roadway to accommodate the maximum peak-hour traffic, averaging the traffic volumes across all hours of the day would result in an insufficient design due to the large number of off-peak hours. Therefore, the design hourly volume should not be so high that traffic rarely makes full use of the facility, but it should also not be so low that it is exceeded frequently or by a significant amount (AASHTO 2004).

Traditionally, design hourly volumes are determined by plotting the hourly traffic volumes as percentages of the AADT (the K-factors) for the highest hourly volumes of the year. Using this plot, the particular hour used for design is then chosen within the range that encompasses the "knee" of the curve, or the area in which the slope of the curve changes most rapidly (see Fig. 2). It is in this region of the curve that the compromise between economic efficiency and the level of service is most appropriate. Since 1941, highway engineers have generally used the 30th highest hourly volume as the design volume in standard practice (Sharma and Oh 1988). AASHTO recommends that this particular hourly volume of the year be used based on the assumption that the knee of the curve occurs at or near the 30th highest hour, which can be seen Exhibit 2-28 of AAHSTO's *A Policy on Geometric Design of Highways and Streets* (AAHSTO 2004). A plot similar to that of Exhibit 2-28 can be seen in Fig. 2.

Fig. 2 displays the relationship between the highest hourly volumes and their K-factors on rural arterials while the curve in the middle represents a highway with average fluctuation in traffic flow. The slope of the curve to the left of the point representing the 30th highest hour volume is very steep, but to the right of this point, the curve flattens. Therefore, while many hours exist where the volume is not much less than the 30th highest hourly volume, there are only a few hours with higher volumes (AASHTO 2004).

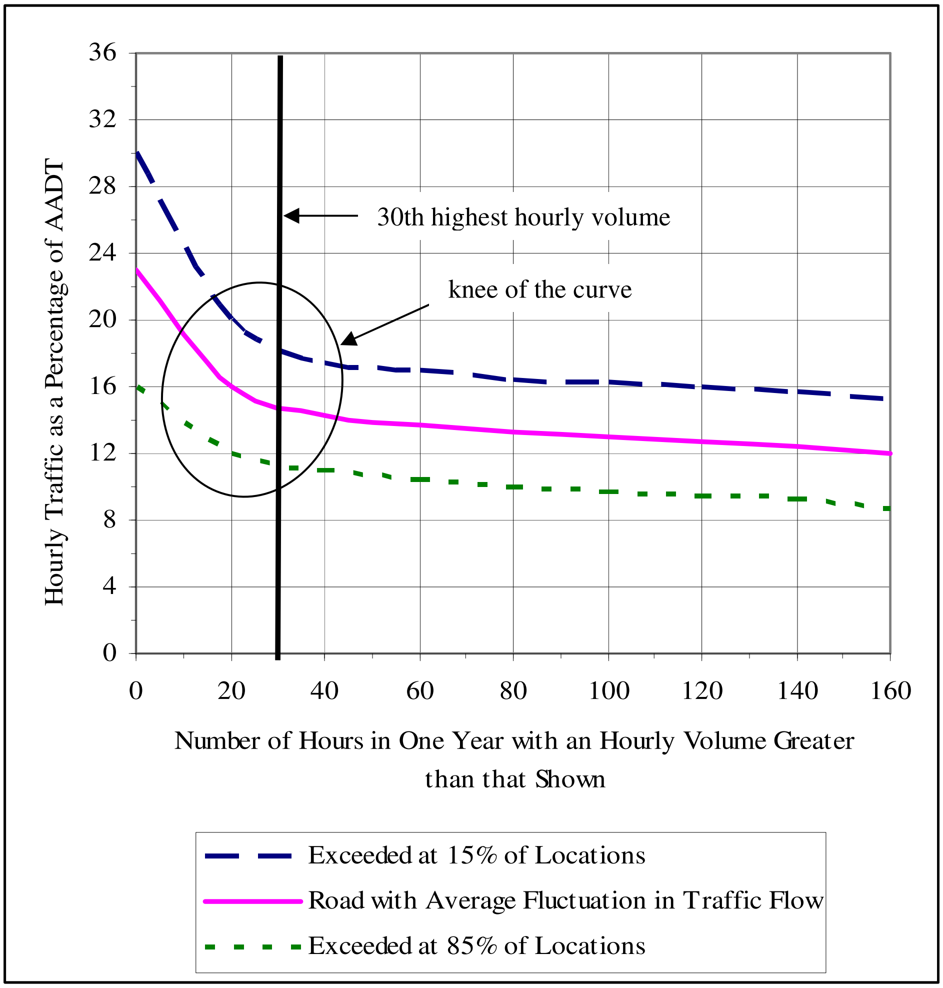

Fig. 2. Relation between Peak-Hour and AADT Volumes on Rural Arterials

According to AAHSTO's *A Policy on Geometric Design of Highways and Streets*, the 30th highest hourly volume is approximately 15 percent of the AADT on a typical rural arterial and 10 percent of the AADT for urban areas. A study in Canada found that the type of road use has a significant influence on the value of the K-factor. While the lowest K-factors occur on urban commuter routes, the highest K-factors are found on routes near popular recreational areas. K-factors found between these two extremes are seen on rural routes (Sharma and Oh 1988). To test this theory, a study was conducted in Vermont where roadways were classified on the basis of annual traffic patterns. The average K-factor was computed for each roadway group, and the results supported the theory. The K-factors for urban, rural, and recreational routes were found to be low, moderate, and high, respectively. While the average K-factor for the urban roadways was 0.1040, the K-factors for the rural primary and secondary routes and the rural Interstate system were 0.1127 and 0.1243, respectively. Additionally, the K-factors for the summer recreational routes and the summer and winter U.S. and Vermont routes were 0.1326 and 0.1436, respectively (Byrne 2007).

Because K-factors vary based on the type of the road, transportation professionals must consider the type of the facility before a design volume is arbitrarily chosen. While, these typical K-factors noted above hold true for most highways, there are roads that experience traffic flows with significant seasonal fluctuations (AASHTO 2004).
Such recreational roadways experience significantly high peak-hour volumes relative to the AADT. Therefore, the 30th highest hourly volume criterion may not always be the most appropriate design volume. Although slight delays are expected on recreational roadways during seasonal peaks, the design should not be so conservative that it causes severe congestion during peak times. Therefore, instead of using the 30th highest hourly volume, AASHTO recommends that an hourly volume, which is about 50 percent of the volumes experienced during the highest hours, be used. AASHTO also states that "a check should be made to ensure that the expected maximum hourly traffic does not

exceed the capacity [although] some congestion would be experienced by traffic during peak hours (AASHTO 2004)". However, it is recognized that traffic congestion is experienced when the capacity of the roadway is exceeded. Therefore, it is assumed that the check suggested by AASHTO intends to verify that a design volume of this magnitude does not result in a significant amount of congestion although traffic volumes are expected to exceed the capacity of the recreation roadway during the highest of the peak hours.

SUMMARY

Although little to no research has been performed in the development of a traffic monitoring program specific to the National Park Service, this literature review assists in understanding the basics of traffic monitoring for such recreational areas and the effect that significant traffic variability has on the development of such a program. Literature that relates to the traditional method of traffic monitoring and the computation of seasonal factors provides the fundamentals needed to determine whether the National Park Service can use both continuous and short-duration counts when monitoring traffic. Additionally, literature that encourages the coordination of such traffic monitoring efforts provides reasons to determine whether the National Park Service could coordinate traffic monitoring efforts with nearby state departments of transportation. Finally, the literature that relates to the various design volume calculation methods assists in establishing the technique that is most appropriate for these recreational roadways.

CHAPTER III

DATA COLLECTION

Prior to the collection of any traffic data, it was necessary to determine which national parks were to be included in the study. Therefore, the first part of this chapter describes the technique that was used to select the national park sample set. Subsequent parts of this chapter detail the ways in which the national park traffic and nearby state highway traffic data were gathered for the national park sample set.

SELECTION OF THE NATIONAL PARK SAMPLE SET

The National Park Service consists of 391 parks and covers more than 84 million acres. Therefore, not all of the national parks were included in this study. To narrow this to a manageable number of datasets, the 30 parks included in the NPS Annual Traffic Data Report were examined for potential research candidates. Because these 30 national parks accounted for approximately 30 percent of the total NPS annual visitation, it was assumed that these particular parks were areas where traffic was an issue and where the most money was spent in monitoring the traffic (NPS 2006).

When determining which of the 30 parks to include in the national park sample set, the primary goal was to select national parks located in both rural and urban settings where traffic monitoring improvements were most needed. Therefore, this study examined parks that had an extremely high number of annual visitors or were large in size. The following five parks were chosen as the national park sample set (see Fig. 3 as well):

- Acadia National Park, which is located in Maine, along the rocky shores of the Atlantic Ocean. While most of the park is situated on Mount Desert Island, a portion of the park is also located on Isle au Haut and Schoodic Peninsula.
- Big Bend National Park, which is located in southwest Texas. Southerly bounded by the Rio Grande, the river's flow to the southeast suddenly changes to the northeast and forms the "big bend" of the Rio Grande.
- George Washington Memorial Parkway, which serves as a memorial to George Washington. It is located in Maryland, Virginia, and the District of Columbia and was originally designed as the gateway to the Nation's Capital.
- Yellowstone National Park, which was established in 1872 and is America's first national park. The majority of the park is found in the northwest corner of Wyoming. However, park grounds also stretch into Idaho and Montana.
- Yosemite National Park, which is located in central California and primarily lies in Tuolumne and Mariposa Counties.

While George Washington Memorial Parkway was chosen to represent an urban national park, the other four parks were seen as rural. In terms of visitation, Acadia National Park, Yellowstone National Park, and Yosemite National Park were three of the top 10 most visited national parks in the country. George Washington Memorial Parkway was one of the 10 most visited units of the National Park Service (NPCA 2007).

Additionally, in terms of acreage, Yellowstone and Yosemite National Parks were two of the top 30 largest national parks, and Acadia National Park was one of the top 100. Although Big Bend National Park is not one of the most highly visited parks, in terms of size, it is in the top 30 (NPS 2006). Therefore, Big Bend National Park was included in the sample set with the assumption that traffic monitoring improvements are needed in a park that covers such a large area. A map detailing the location of these five national parks within the United States can be seen in Fig. 3.

Fig. 3. Map of the United States and National Parks (NPS 2007a)

While many of the parks that make up the National Park Service had several traffic data collection stations throughout the park, only one data collection station was used for each park due to limitations on data access. Big Bend National Park had only one data collection station, and therefore, this particular station was used to represent the traffic at that national park. For the other four parks that contained more than one station, both geography and archived data were analyzed to determine which station was the most appropriate. Stations that were located at the main entrances were assumed to most appropriately represent the parks. However, all four national parks had data collection stations at more than one main entrance. Therefore, the data collection stations at the main entrances that had consistently collected the most traffic data from 2002 to 2006 were selected as the most representative sub-sample. This was determined through analysis of the traffic data summaries found in the NPS Annual Traffic Data Reports for 2002 to 2006. Using this technique along with the national park sample set criteria, the following parks and stations were chosen as the sample set to be used in this study:

- Acadia National Park – Station 4701, which collected traffic data on Mount Desert Island and is located on Paradise Road, one-fourth of a mile north of the Loop Road intersection and just south of the State Highway 233 underpass (see Fig. 4). Vehicle counts were collected using dual loops in both the northbound and southbound lanes although only the southbound, or incoming, vehicles were used in this analysis. Additionally, it should be noted that Park Loop Road and most of the park facilities were closed every November 1st through April 14th although the park was technically open all year.

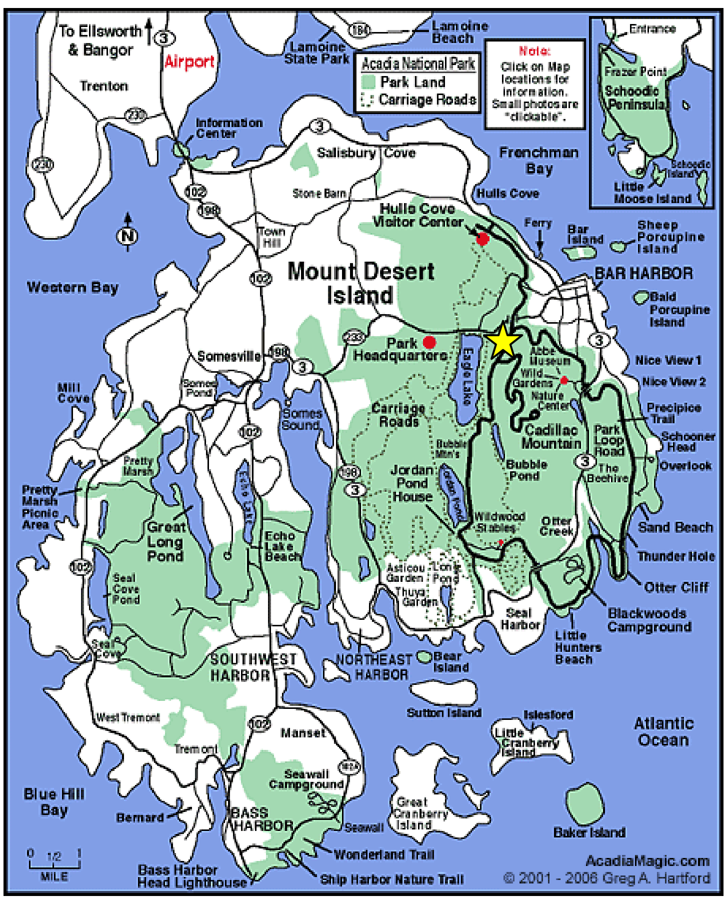

Fig. 4. Map of Acadia National Park and Station 4701 (Hartford 2007)

- Big Bend National Park – Station 5601, located near the Persimmon Gap Entrance, just 200 feet north of the ranger station (see Fig. 5). This was the only data collection station in the park and was therefore chosen to represent the park by default. Vehicle counts were collected using loop detectors in both the northbound and southbound lanes although only the southbound, or incoming, vehicles were used in the analysis.

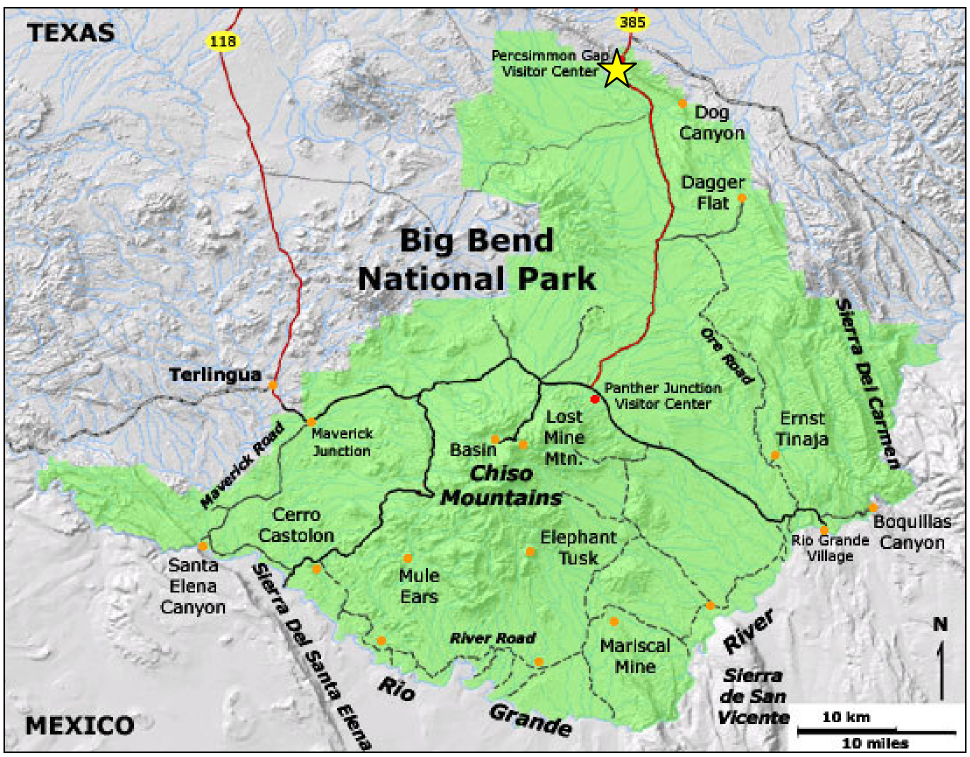

Fig. 5. Big Bend National Park and Station 5601 (USGS 2008)

- George Washington Memorial Parkway – Station 6009, which collected data in Virginia near Theodore Roosevelt Island and was 250 feet north of the footbridge (see Fig. 6). This station was centrally located, and vehicle data were collected in both the northbound and southbound lanes although only the southbound lanes were used in this study.

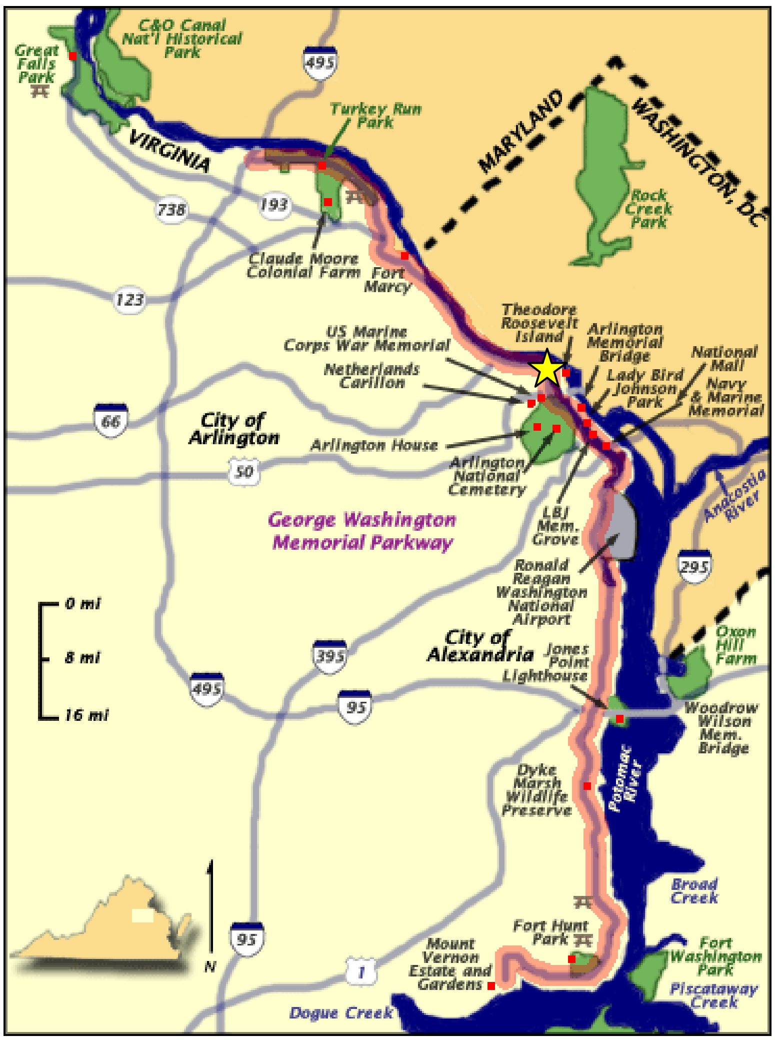

Fig. 6. George Washington Memorial Parkway and Station 6009 (NSBP 2007)

- Yellowstone National Park – Station 2701, which collected data at Madison Junction, a main point of access, which is located 14 miles east of the West Entrance (see Fig. 7). At this junction, data were collected for vehicles traveling in the northbound, southbound, and westbound directions although only the eastbound, or incoming, lanes were used in this study. Additionally, it should be noted that the North Entrance was the only park area that remained open to wheeled-vehicle use year-round. Therefore, Madison Junction was closed to all wheeled vehicles every mid-December through mid-March.

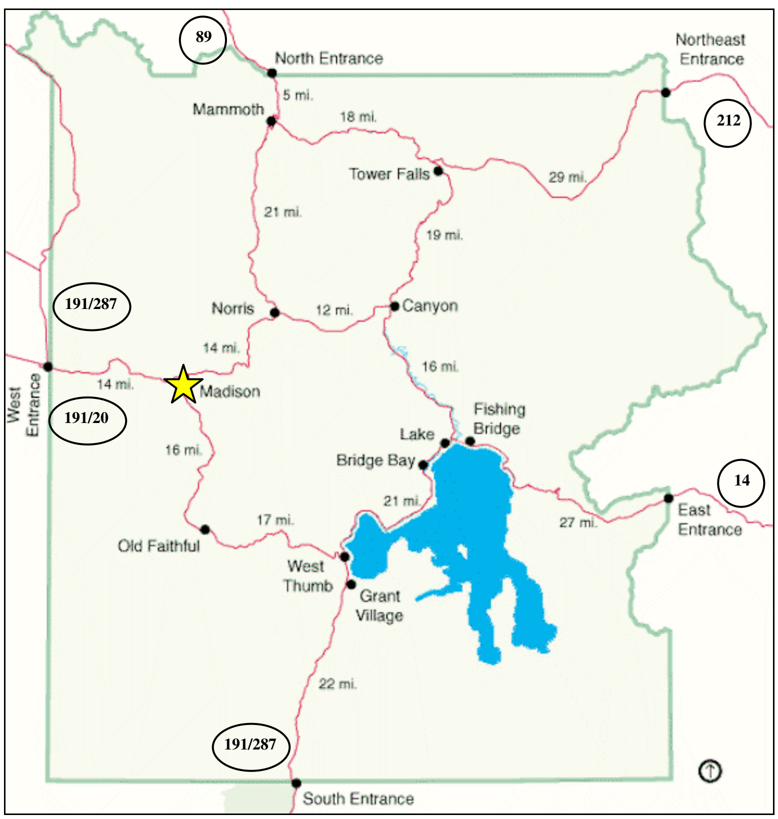

Fig. 7. Yellowstone National Park and Station 2701 (NPS 2007a)

- Yosemite National Park – Station 4808, which collected data 450 feet east of the kiosks at Big Oak Flat Entrance (see Fig. 8). Vehicle data were collected in both the eastbound and westbound lanes using loop detectors; however, only the eastbound, or incoming, counts were used in this study.

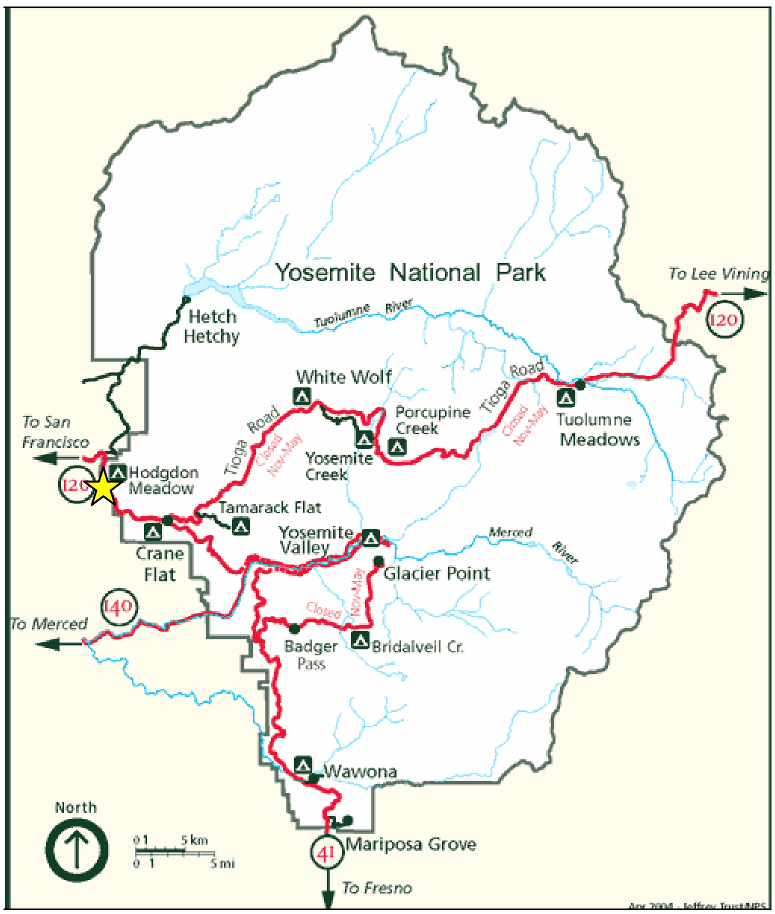

Fig. 8. Yosemite National Park and Station 4808 (NPS 2007a)

NATIONAL PARK TRAFFIC DATA

After determining the most appropriate national park sample set, hourly traffic data were obtained directly from the National Park Service. An internal source to the National Park Service provided electronic data files containing the hourly counts for 2002 to 2006 for the five data collection stations representing the national parks. In addition to the 24 hourly counts, the electronic files also included the park name, the station name, and the number and orientation of the lanes in which the data were continuously collected. Hand-drawn aerial views of the data collection stations found in the NPS Annual Traffic Data Report were also consulted to determine the exact location of the inductive loop detectors with respect to the other components of each data collection station. While the majority of the data collection stations were located near main entrances, the detectors were typically installed directly after the toll booths. Therefore, it is recognized that the traffic volumes entering the parks were possibly a function of the capacity of the entrance stations and not constrained by the design of the roadway itself. Copies of the hand-drawn aerial views are included in *Appendix C*.

It should be noted that Grand Canyon National Park was originally included in the national park sample set but was later removed due to the lack of traffic data. The data collection station that had been chosen to represent Grand Canyon National Park was located north of the North Rim on the north entrance roadway. Although this station consistently collected more traffic data from 2002 to 2006 than the other data collection stations located in the park, the amount of missing data was still significant. The North

Rim of Grand Canyon National Park was closed every mid-October through May 14th. Therefore, data were only available for the months that the entrance was open, and many of these months also contained a considerable amount of missing data. Additionally, the only state highway ATR location found near the park was located south of the South Rim. Because this area of the park was open all year, it was expected that the traffic patterns experienced at the ATR location during the months of October through May would not be the same as those experienced at the station representing the park. Therefore, Grand Canyon National Park was removed from the analysis.

STATE HIGHWAY TRAFFIC DATA

After gathering traffic data for the national park study sample, archived traffic data collected on nearby state highways were also obtained from the states surrounding these five national parks. Before directly contacting each of the state departments of transportation, the department websites were first visited to determine the locations where traffic data were collected continuously. While some states posted all of their hourly traffic counts online, others provided only a map of the automated traffic recorder (ATR) locations in their state. For the states that did not post the counts online, the departments of transportation were directly contacted to obtain the hourly counts for specific ATR locations. Because the hourly state highway counts were to be compared to those of the data collection station representing each national park, it was determined that the ATR located nearest to the national park data collection station was of the most interest. Therefore, continuous traffic data for the following ATR locations were requested:

- The ATR located in Maine on State Route 3 at the north end of Thomson Island Bridge. This bridge provides access to Mount Desert Island, which is where most of Acadia National Park is situated, and is located approximately eight miles northwest of the data collection station representing this national park. A map detailing the location of this permanent count station with respect to that of Station 4701 can be seen in Fig. 9.

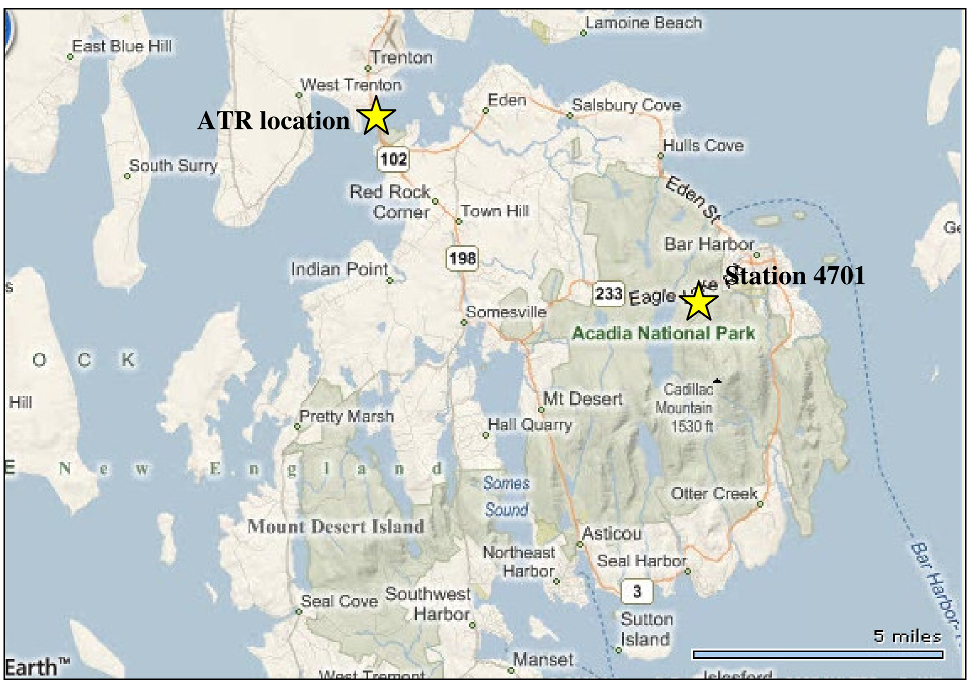

Fig. 9. Map of Station 4701 and Nearby ATR Location (Microsoft 2007)

- The ATR located in Texas on Interstate 90 just west of the town of Marfa. This location was approximately 60 miles northwest of the data collection station representing Big Bend National Park. A map detailing the location of this permanent count station with respect to that of Station 5601 can be seen in Fig. 10.

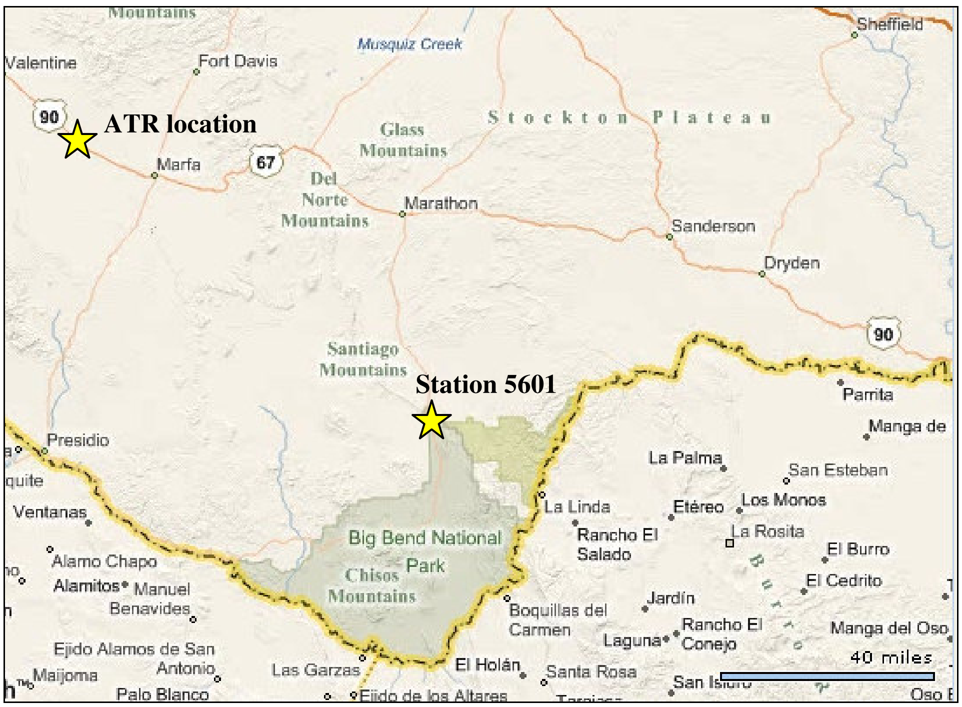

Fig. 10. Map of Station 5601 and Nearby ATR Location (Microsoft 2007)

- The ATR located in Virginia on Interstate 66 between Interstate 29 and State Route 120. Although this location was not on George Washington Memorial Parkway, it was on a nearby roadway and was no more than five miles west of the data collection station representing George Washington Memorial Parkway. A map detailing the location of this permanent count station with respect to that of Station 6009 can be seen in Fig. 11.

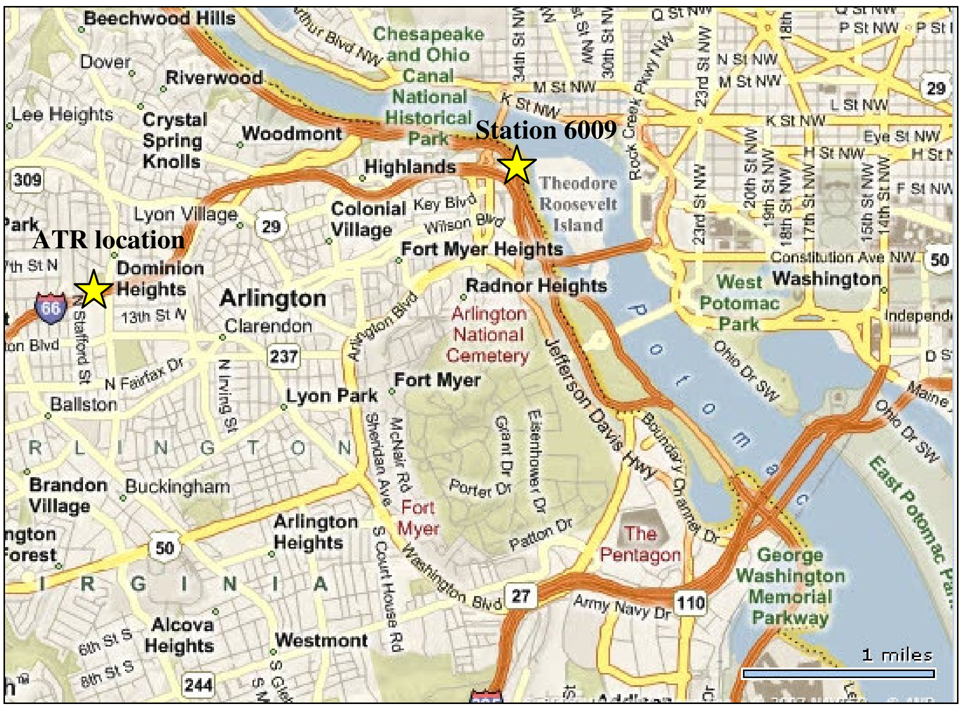

Fig. 11. Map of Station 6009 and Nearby ATR Location (Microsoft 2007)

- Two ATR locations were used in Montana. One (Station A-18) was on Interstate 20 and 15 miles west of the data collection station representing Yellowstone National Park while the other (Station A-19) was on Interstate 191/287 and 20 miles northwest of the data collection station representing Yellowstone National Park. A map detailing the location of these permanent count stations with respect to that of Station 2701 can be seen in Fig. 12.

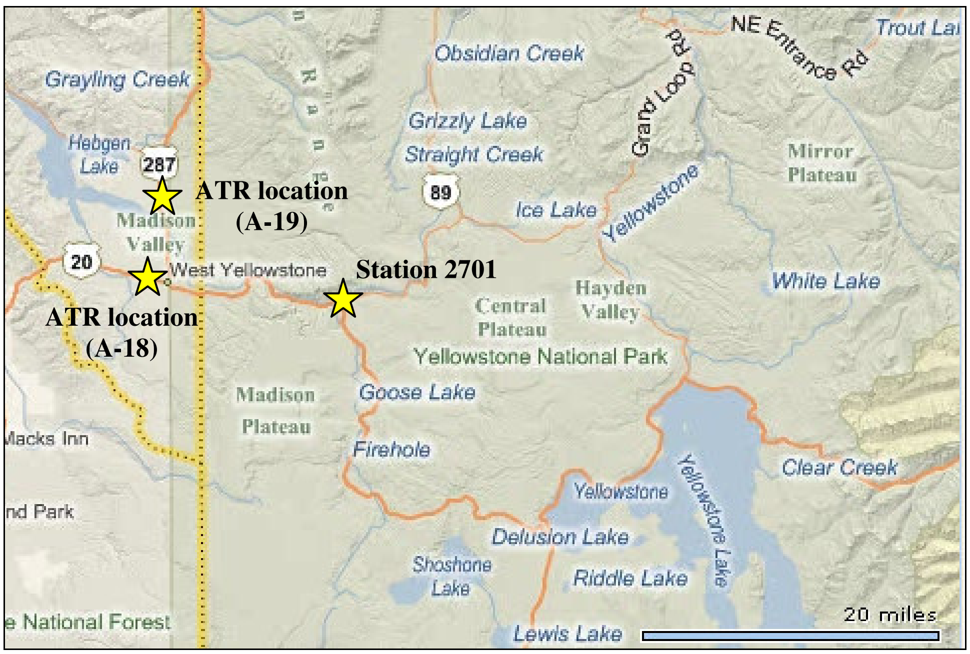

Fig. 12. Map of Station 2701 and Nearby ATR Locations (Microsoft 2007)

- The ATR located in California on State Route 120 at Kistler Ranch Under Crossing. This location was approximately 40 miles west of the data collection station representing Yosemite National Park. A map detailing the location of this permanent count station with respect to that of Station 4808 can be seen in Fig. 13.

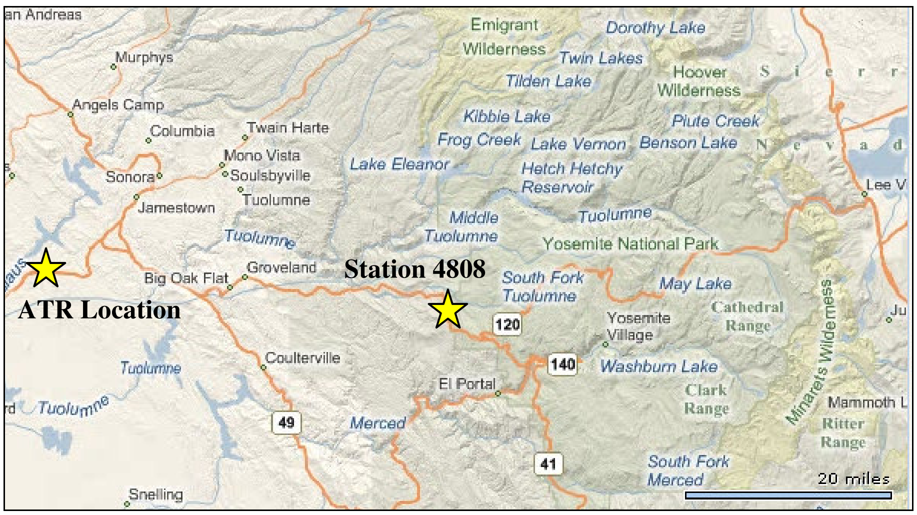

Fig. 13. Map of Station 4808 and Nearby ATR Location (Microsoft 2007)

Although the ATR locations listed above include only those that were located nearest to the national parks, some of these locations were much farther from the parks than others. For instance, the ATR locations corresponding to Acadia National Park, George Washington Memorial Parkway, and Yellowstone were much closer than those of Big Bend National Park and Yosemite National Park. However, the data for each of these ATR locations were equally significant. Upon determining whether the National Park Service could coordinate such data collection efforts using nearby ATR locations, the wide range of distances was necessary in determining how close the ATR location needs to be to the park in order to be useful.

Although each requested ATR data file included similar information for the locations listed above, it was evident that each state uses a different format when archiving continuous traffic data. Therefore, before the traffic data were analyzed, the data files were reformatted to establish consistency. Reformatted files included the description of the ATR location and name of the county in which the data were collected along with the 24 hourly counts and total count for that ATR. While the hourly counts for Virginia, Texas, and California were collected for 2002 to 2006, Maine and Montana were only able to provide continuous counts for 2003 to 2006. Additionally, it was noted that the dataset provided by Maine Department of Transportation for 2006 included a traffic volume for the 31st day of November, which is a date that does not exist. Therefore, this year was not used. In the reformatted data files, it was also noted that the counts for Maine and Montana were a combination of the counts in both directions while Virginia, Texas, and California reported the hourly count for each direction separately. Additionally, it was noted in each file that all of the above state highways were two-lane roads with one lane in each direction except for the highway in Virginia, which was a four-lane road with two lanes in each direction.

SUMMARY

Because it was not feasible to include all 391 parks in this study, a national park sample set was created to include national parks located in both rural and urban settings where traffic monitoring improvements were most needed. Therefore, this study examined parks that had an extremely high number of annual visitors or were large in size, and the sample set included Acadia National Park, Big Bend National Park, George Washington Memorial Parkway, Yellowstone National Park and Yosemite National Park. While most of these parks contained multiple traffic data collection stations, only one station was used for each park due to limitations on data access. Big Bend National Park had only one data collection station, and therefore, this particular station was used to represent the park. For the other four parks, the data collection stations at the main entrances that consistently collected the most traffic data from 2002 to 2006 were selected to represent the parks. After determining the most appropriate national park sample set, hourly traffic data for 2002 to 2006 were obtained directly from the National Park Service for the five data collection stations representing the parks. Additionally, hourly traffic counts for the nearby state highways were collected for 2002 to 2006. These archived data were accessed either directly from the appropriate state departments of transportation or via the department websites. Because the hourly state highway counts were to be compared to those of the data collection station representing each national park, continuous traffic data were requested for the ATR located nearest to each national park data collection station.

CHAPTER IV

DATA ANALYSIS AND RESULTS

This chapter is divided into three parts and provides a detailed description of the analyses completed in this study and the results. The seasonal and day-of-week factor analysis involves the comparison of national park traffic patterns from one year to the next while the nearby state highway traffic analysis includes the analysis and comparison of the national park traffic to that of adjacent state highways. Additionally, this chapter details the procedures used to compare the design hourly volume experienced on these recreational routes to that which is found on traditional highways.

SEASONAL AND DAY-OF-WEEK FACTOR ANALYSIS AND RESULTS

To determine whether the national park traffic exhibits consistent seasonal patterns, traffic was compared from one year to the next for each particular park using the national park traffic data obtained for 2002 to 2006. As a means of quantifying the seasonal patterns for each park, a set of seasonal factors were computed for each of the five years. Although seasonal adjustment procedures can be based on any predefined time period, seasonal factors for this analysis were calculated as a ratio of annual average daily traffic (AADT) to the monthly average day-of-week (MADW) values, yielding a value for each day-of-week and month-of-year combination for 2002 to 2006.

The method used to calculate the 84 seasonal factors (one value for each of the seven days of each of the 12 months) followed that which was described in the *Literature Review* portion of this thesis. Daily traffic volumes were first computed for all five national parks with the summation of the hourly traffic counts across all 24 hours. However, because AASHTO recommends that missing traffic data not be imputed, or estimated using a current traffic editing program, only days that were 100 percent complete were used (AASHTO 1992). Therefore, days that included even a single hour of missing data were omitted from the dataset prior to analysis. All complete daily traffic volumes were then averaged for each day-of-week and month-of-year combination to yield seven values for each of the 12 months, or 84 monthly average day-of-week (MADW) values (see Eq. (5)).

$$MADW_{ij} = \frac{1}{n}\sum_{k=1}^{n} VOL_{ijk} \tag{5}$$

where

- i = day of the week,
- j = month of the year,
- k = 1 when the day is the first occurrence of that day of the week in a month, 4 when it is the fourth day of the week, and
- n = the number of days of that day of the week during that month.

The annual average day-of-week (AADW) values were then calculated with an average of the MADW values. The conventional AASHTO averaging procedure states that the MADW values should be averaged across all 12 months to yield seven AADW values. However, a slight modification was made to this conventional approach to allow for missing MADW values in this analysis. Instead of requiring that all 12 MADW values be present to calculate an AADW value, a value that was missing could be omitted from this average. This adjustment followed that which was suggested by research at the Texas Transportation Institute when calculating annual average traffic statistics with the use of archived ITS data (Turner and Park 2008). Therefore, in this study, the AADW values were calculated using Eq. (6).

$$AADW = \frac{1}{m}\sum_{j=1}^{m} MADW_{ij} \tag{6}$$

where

i = day of the week,

j = month of the year, and

m = the number of months where MADW values are available.

A similar modification was made to allow for missing AADW values when calculating the AADT. Although the conventional AASHTO method recommends averaging the

AADW values across all seven days of the week, missing values were simply omitted from the average. Therefore, the AADT values were calculated using Eq. (7).

$$AADT = \frac{1}{d}\sum_{i=1}^{d} AADW \qquad (7)$$

where

i = day of the week, and

d = the number of days of the week where AADW values are available.

Finally, a seasonal factor was developed for each day-of-week and month-of-year combination for 2002 to 2006 as shown in Eq. (8).

$$F_{ij} = \frac{AADT}{MADW_{ij}} \qquad (8)$$

where

i = day of the week, and

j = month of the year.

Using these steps, a table of seasonal and day-of-week factors was developed for each of the five national parks and each of the five years. While an example of such a table can be seen in Table 3 for Big Bend National Park in 2002, all 25 of the tables are included in *Appendix D*.

Table 3. Seasonal and Day-of-Week Factors for Big Bend National Park in 2002

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	1.1	1.2	1.1	1.1	1.1	1.0	1.1
February	0.9	0.8	1.0	0.9	0.8	0.7	0.7
March	0.4	0.4	0.5	0.5	0.5	0.5	0.4
April	0.8	0.8	0.9	0.9	0.6	0.7	0.7
May	1.0	1.2	1.2	1.3	1.2	0.9	0.9
June	1.3	1.2	1.5	1.5	1.7	1.5	1.5
July	1.8	1.5	1.6	1.6	1.4	1.4	1.7
August	1.9	1.9	2.0	2.0	1.6	1.4	1.4
September	1.7	1.7	2.4	1.9	1.8	1.8	1.8
October	1.2	1.2	1.3	1.3	1.1	0.9	1.1
November	1.0	1.1	1.2	0.8	0.7	0.9	0.9
December	1.0	1.0	1.3	1.5	1.0	0.9	0.9

The tables for Big Bend National Park, George Washington Memorial Parkway, and Yosemite National Park include seasonal and day-of-week factors for all 12 months of the year. However, because Acadia National Park and Yellowstone National Park experienced seasonal park closures, factors were not created for the months that the parks were closed. National park traffic during park closures is unstable. Therefore, there is no need for adjustment factors for these months as traffic data should not be collecting during these months when approximating the AADT. As mentioned in the *Data Collection* portion of this thesis, most of Acadia National Park was closed each year from November 1st through April 14th, and Madison Junction of Yellowstone National Park, which was where the data collection station representing this national park was located, was closed to all wheeled vehicles every mid-December through mid-March. Therefore, seasonal and day-of-week factors were only developed for the months of May through October and April through November for Acadia National Park and Yellowstone National Park, respectively.

In order to determine whether the traffic patterns were consistent from one year to the next for each of the five national parks, the Kruskal-Wallis test was used to compare the seasonal and day-of-week factors across all five years. Each complete daily traffic volume was expressed as a percentage of the AADT for that particular year, and the ratios were grouped according to the day of week, month, and year. While the average of the ratios within a particular group represented the seasonal factor for that given day of the week, month, and year, the Kruskal-Wallis test was used to compare the ratios across all five years or groups. The Kruskal-Wallis test is a non-parametric method of testing the equality of population medians among groups with the use of the following null and alternative hypotheses.

H_0: All of the groups have populations with the same median.

H_1: At least two of the groups have populations with different medians.

Although the Kruskal-Wallis test does not assume that the data are normally distributed, it does assume that the observations within each group come from populations with the same shape of distribution. Therefore, because the groups are assumed to have the same shape, the comparison of medians is similar to the comparison of the means. In order to assess the validity of this assumption, the groups of ratios were plotted on the same histogram for each particular day-of-week and month combination across all five years, and the shapes of the distributions were compared visually. A sample of these plots can be seen in Fig. 14, Fig. 15, Fig. 16, Fig. 17, and Fig. 18 for the ratios representing Sundays in May for Acadia National Park, Big Bend National Park, George Washington Memorial Parkway, Yellowstone National Park, and Yosemite National Park, respectively.

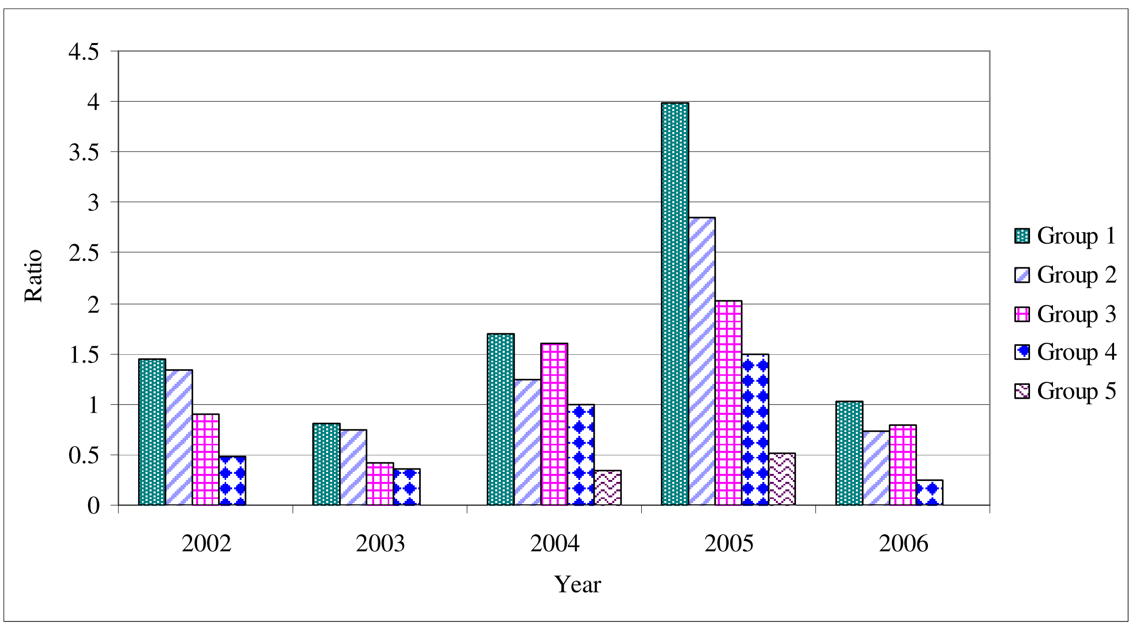

Fig. 14. Ratios Representing Sundays in May in Acadia National Park

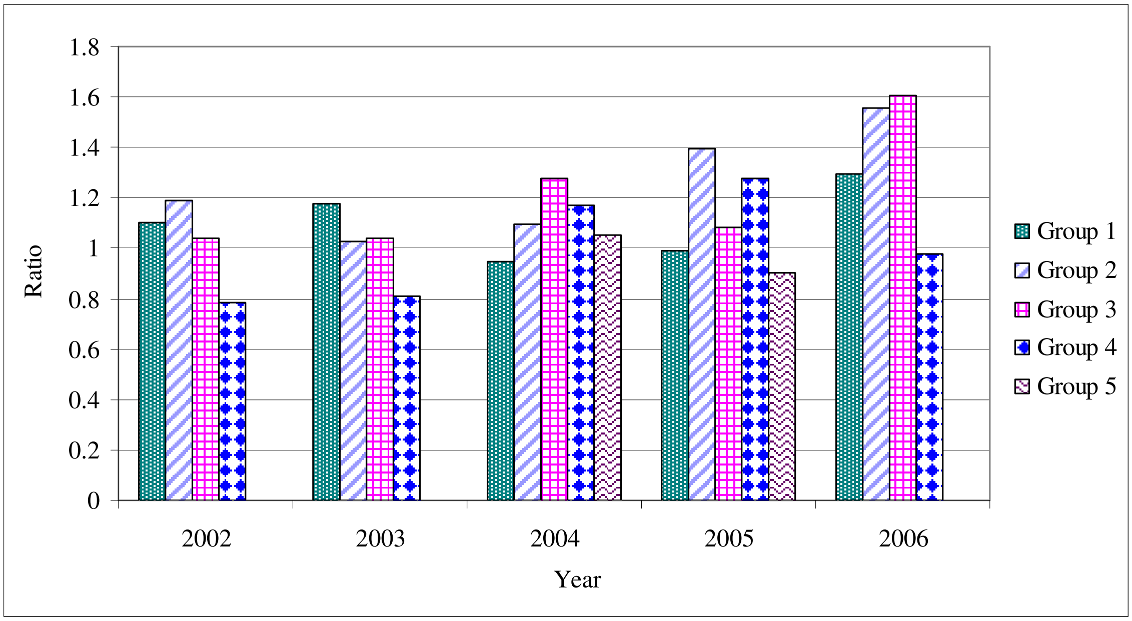

Fig. 15. Ratios Representing Sundays in May in Big Bend National Park

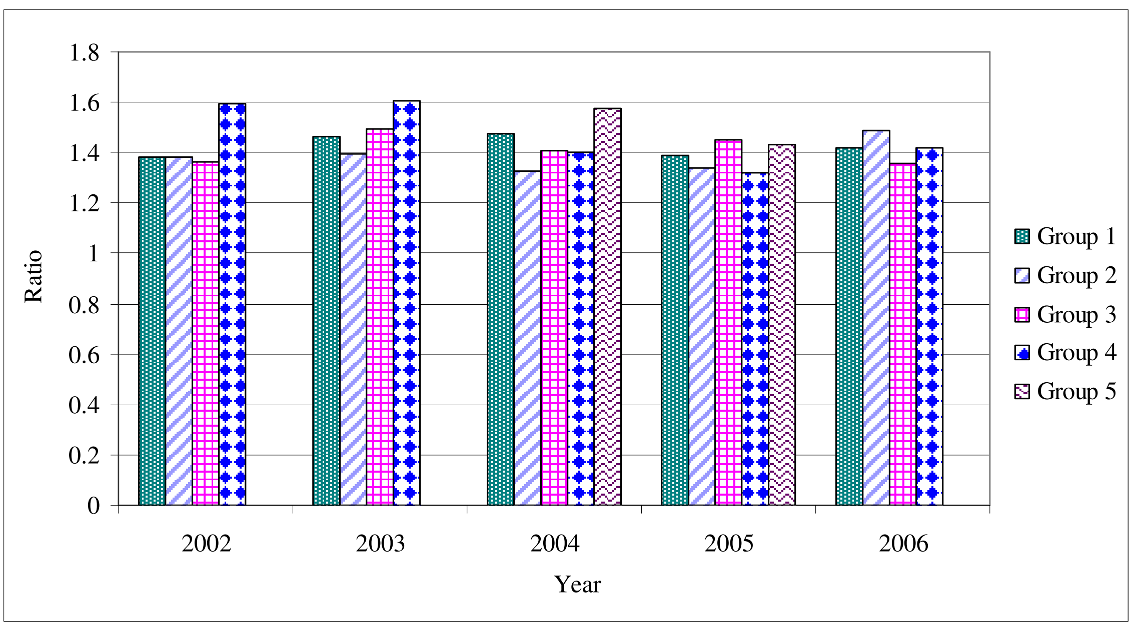

Fig. 16. Ratios Representing Sundays in May on George Washington Memorial Parkway

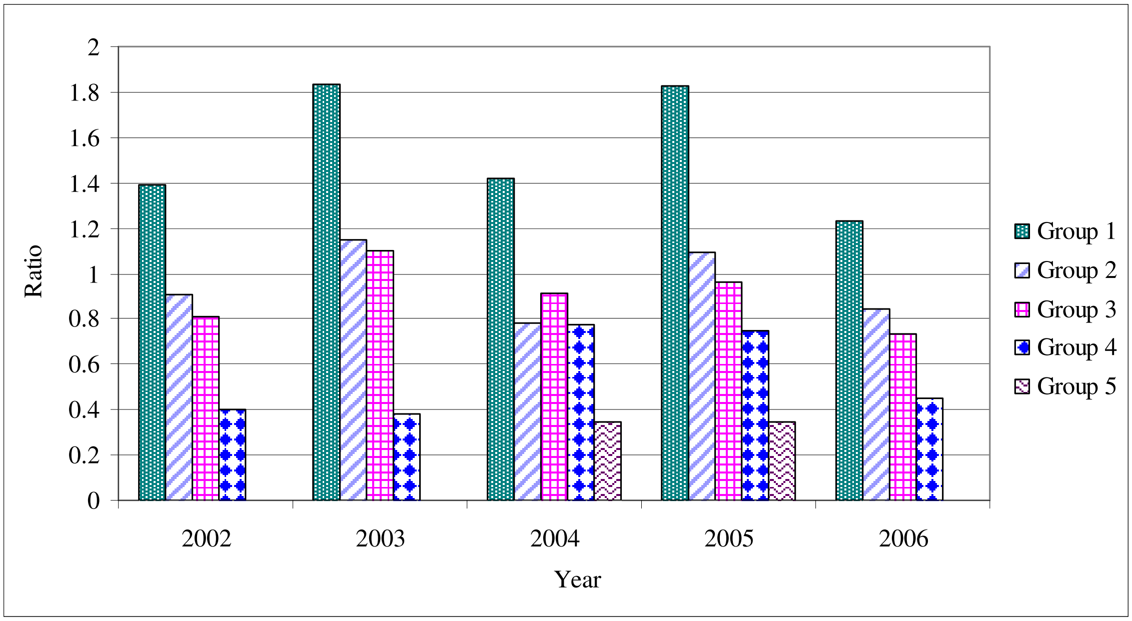

Fig. 17. Ratios Representing Sundays in May in Yellowstone National Park

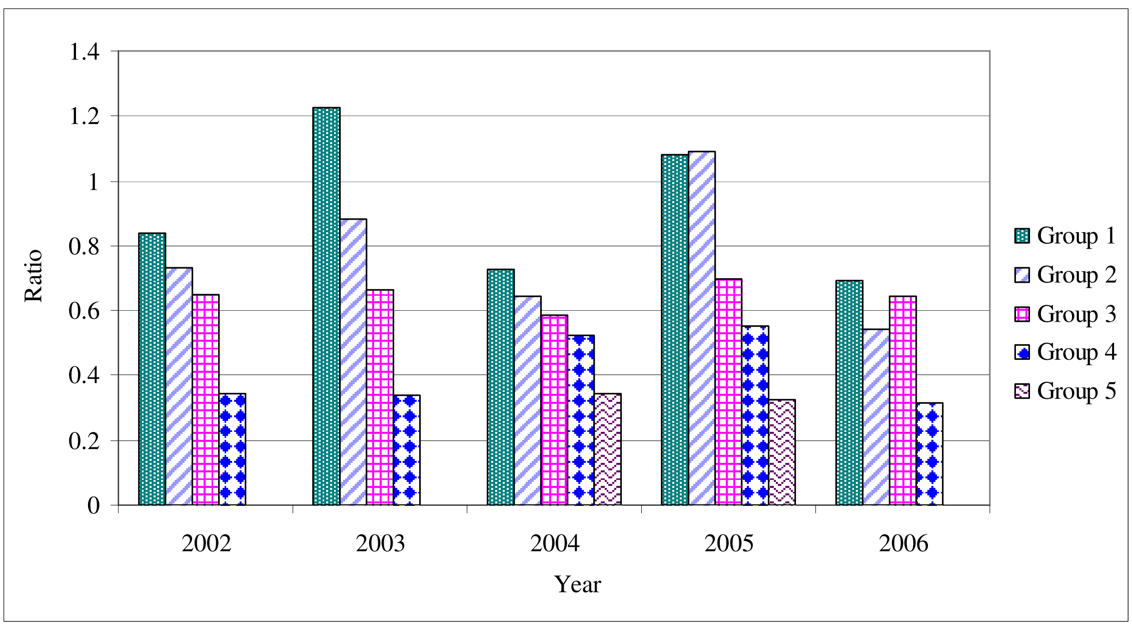

Fig. 18. Ratios Representing Sundays in May in Yosemite National Park

Using these plots, it was determined that the distribution of the ratios within each group is fairly consistent from one group to the next for all five national parks. The distribution of the ratios representing Group 1, or the first Sunday in May for all five years, has the same shape as those representing the other four groups for each of the five parks. Although these plots are specific to Sundays in May, similar plots were developed for the other possible day-of-week and month combinations, and these histograms also appeared to have the same shape. Therefore, it is valid to assume that the ratios within each group come from populations with the same shape of distribution.

Intuitively, the Kruskal-Wallis test is identical to a one-way analysis of variance (ANOVA) where the statistic is calculated using the ranks of the data rather than the raw data values. Therefore, for this analysis, the five years or groups of ratios were combined for each of the five national parks, and the pooled data were ranked from 1 to *N*, where *N* represented the total number of ratios across all of the groups. It should be noted that ratios of equal magnitude were given an average rank. Therefore, if four identical ratios occupied the second, third, fourth, and fifth smallest places, all four values were given a rank of 3.5. After ranking all of the ratios, the test statistic was computed for each day-of-week and month-of-year combination for all five national parks as shown in Eq. (9), Eq. (10), and Eq. (11).

$$H = \frac{12}{N(N+1)} \sum_{i=1}^{y} n_i \left(\overline{R}_{i\bullet} - \overline{R}_{\bullet\bullet} \right)^2 \qquad (9)$$

$$\overline{R}_{i\bullet} = \frac{\sum_{j=1}^{n_i} R_{ij}}{n_i} \tag{10}$$

$$\overline{R}_{\bullet\bullet} = \frac{N+1}{2} \tag{11}$$

where

R_{ij} = rank of ratio "*j*" from year (or group) "*i*",

n_i = number of ratios in year (or group) "*i*",

N = total number of ratios across all years (or groups), and

y = number of years (or groups).

After computing the test statistic for each day-of-week and month-of-year combination for all five national parks, the p-values were determined using the chi-square table where the degrees of freedom were equal to the number of groups minus one. Using the p-values and the significance level of 0.25, the null hypothesis was then tested for each day-of-week and month-of-year combination. However, because the Kruskal-Wallis test had to be performed 84 times for each national park, the p-value threshold was adjusted using the Bonferroni correction. The Bonferroni correction is a multiple-comparison adjustment that is used to reduce falsely significant results when several statistical tests are performed on a set of data simultaneously. In statistics, one out of every four hypothesis tests will appear to be significant purely due to chance when a significance level of 0.25 is used. Therefore, according to the Bonferroni correction, if an experiment is testing *n* hypotheses on a dataset, the significance level that should be used to test each hypothesis separately is 1/*n* times what is would be if only one hypothesis were being tested. While all 84 individual hypotheses (12 months and 7 days) were tested for Big Bend National Park, George Washington Memorial Parkway, and Yosemite National Park, only 42 (6 months and 7 days) and 56 individual hypotheses (8 months and 7 days) were tested for Acadia National Park and Yellowstone National Park, respectively, due to seasonal park closures. Therefore, instead of using a significance level of 0.25 to test each individual hypothesis, the following p-value thresholds were used.

$$threshold_{Big\ Bend,GW\ MP,Yosemite} = \frac{1}{n}(0.25) = \frac{1}{84}(0.25) = 0.0030$$

$$threshold_{Acadia} = \frac{1}{n}(0.25) = \frac{1}{42}(0.25) = 0.0060$$

$$threshold_{Yellowstone} = \frac{1}{n}(0.25) = \frac{1}{56}(0.25) = 0.0045$$

Using these thresholds and the Kruskal-Wallis test, the null hypothesis was either accepted or rejected for each day-of-week and month-of-year combination for all five national parks. For example, the median of the ratios that make up the seasonal factor representing Tuesdays in May for Yellowstone National Park were compared across all five years using the following steps.

First, the null and alternative hypotheses were stated as shown below.

H_0: All of the groups have populations with the same median.

H_1: At least two of the groups have populations with different medians.

Second, the ratios were ranked from lowest to highest across all five groups as shown in Table 4.

Table 4. Rank of Ratios for Tuesdays in May for Yellowstone National Park

Year	Ratio	Rank
2002	1.76	19
2002	1.13	13
2002	0.89	9
2002	0.72	4
2003	2.12	21
2003	1.54	18
2003	1.02	10
2003	0.76	5
2004	1.53	17
2004	1.35	14
2004	0.87	8
2004	0.68	2
2005	2.06	20
2005	1.53	16
2005	1.10	12
2005	0.78	6
2005	0.64	1
2006	2.16	22
2006	1.47	15
2006	1.10	11
2006	0.84	7
2006	0.69	3

Next, the ratios were averaged for each of the five years as shown below.

$$\overline{R}_{2002,\bullet} = \frac{\sum_{j=1}^{n_i} R_{ij}}{n_i} = \frac{19+13+9+4}{4} = 11.25$$

$$\overline{R}_{2003,\bullet} = \frac{\sum_{j=1}^{n_i} R_{ij}}{n_i} = \frac{21+18+10+5}{4} = 13.50$$

$$\overline{R}_{2004,\bullet} = \frac{\sum_{j=1}^{n_i} R_{ij}}{n_i} = \frac{17+14+8+2}{4} = 10.25$$

$$\overline{R}_{2005,\bullet} = \frac{\sum_{j=1}^{n_i} R_{ij}}{n_i} = \frac{20+16+12+6+1}{5} = 11.00$$

$$\overline{R}_{2006,\bullet} = \frac{\sum_{j=1}^{n_i} R_{ij}}{n_i} = \frac{22+15+11+7+3}{5} = 11.60$$

The ratios were also averaged across all five years or groups with the equation below.

$$\overline{R}_{\bullet\bullet} = \frac{N+1}{2} = \frac{22+1}{2} = 11.50$$

Using these averages, the test statistic was then computed as follows.

$$H = \frac{12}{N(N+1)} \sum_{i=1}^{y} n_i \left(\overline{R}_{i\bullet} - \overline{R}_{\bullet\bullet}\right)^2 =$$

$$\frac{12}{22(22+1)} \begin{bmatrix} 4(11.25-11.50)^2 + 4(13.50-11.50)^2 + 4(10.25-11.50)^2 + \\ 5(11.0-11.50)^2 + 5(11.60-11.50)^2 \end{bmatrix} = 0.5644$$

Finally, the p-value was found on the chi-square table for the test statistic shown above and the degrees of freedom calculated below.

$$df = y - 1 = 5 - 1 = 4$$

According to the chi-square table, the p-value was greater than 0.05. However, in order to calculate a more precise p-value, the statistical software package *R* was utilized, and the p-value was determined to be 0.9631. Because this p-value was greater than the p-value threshold of 0.0045 that was calculated using the Bonferroni correction, the null hypothesis was not rejected. Therefore, it was determined that the medians were not statistically different across all five years, which also implies that the traffic patterns observed during Tuesdays in May were not significantly different from one year to the next in Yellowstone National Park.

Using these steps, the median was compared across all five years for each of the 84 day-of-week and month-of-year combinations and for each of the five national parks, theoretically yielding a total of 504 hypotheses tests. However, due to seasonal park closures in both Acadia National Park and Yellowstone National Park, comparisons were only performed for the months of May through October and April through November for Acadia National Park and Yellowstone National Park, respectively. Additional omissions were made as a result of the nature of the Kruskal-Wallis test. In order to compare the medians for each day-of-week and month-of-year combination, at least two ratios were needed for every year. Years that included only a single ratio for that particular day-of-week and month-of-year combination were omitted from the dataset prior to analysis. Therefore, the traffic patterns for the years shown below were not included when comparing the ratio distribution from one year to the next for the specified day-of-week and month-of-year combination:

- Acadia National Park: 2006, July, Tuesday
- Acadia National Park: 2006, July, Wednesday
- Acadia National Park: 2006, July, Thursday
- Acadia National Park: 2006, July, Friday
- Acadia National Park: 2006, September, Wednesday
- Acadia National Park: 2006, September, Thursday
- Acadia National Park: 2006, September, Friday
- Acadia National Park: 2006, September, Saturday
- Big Bend National Park: 2003, June, Tuesday

- Big Bend National Park: 2003, June, Friday
- Big Bend National Park: 2003, June, Saturday
- George Washington Memorial Parkway: 2004, January, Saturday

Using the Kruskal-Wallis test and the statistical software package *R*, a p-value was calculated for all applicable day-of-week and month-of-year combinations and for all five national parks. These p-values can be found in *Appendix E*. While the p-values ranged from 0.9966 to 0.0033 for all five national parks, each one was greater than the p-value threshold that was appropriate for that park. Therefore, the null hypothesis could not be rejected for any of the five park's applicable day-of-week and month-of-year combinations. It was determined that the medians were not statistically different for any of the day-of-week and month-of-year combinations, which also implies that the seasonal and day-of-week traffic patterns were not significantly different from one year to the next for all five national parks.

NEARBY STATE HIGHWAY TRAFFIC ANALYSIS AND RESULTS

To determine whether the National Park Service could potentially share traffic monitoring efforts with various state departments of transportation, the traffic counts collected in the five national parks for 2002 to 2006 were compared to those of the nearby ATR locations. When comparing the traffic at a particular park to that of the adjacent state highway, the researcher aimed to contrast only the counts of the vehicles traveling in the same direction. Therefore, because the national park datasets included only the vehicles entering the park, except for that of the centrally located station representing George Washington Memorial Parkway, the researcher used only the counts collected for the vehicles traveling in the direction of the park. However, this was not possible for all five national parks. While three of the five ATR locations collected separate traffic volumes for each of the two directions of travel, both Maine Department of Transportation and Montana Department of Transportation were only able to provide traffic volumes as a combination of both directions. Therefore, the researcher was forced to use these combination counts when comparing the state highway traffic to that which was collected at both Acadia National Park and Yellowstone National Park. However, it was assumed that the volumes collected at the ATR location were simply twice the number of the incoming vehicles based on the theory that the vehicles traveling into the park eventually traveled out using the same roads. However, because the purpose of the analysis was to simply examine the linear relationship between the two sets of traffic data, dividing the ATR volumes by a constant of two would not yield different results. Therefore, the combination counts were not divided by a constant of two before they were compared to the traffic volumes at Acadia National Park and Yellowstone National Park. Using this assumption and the researcher's desire to compare only the vehicles traveling in the same direction, the following comparisons were made:

- The southbound traffic entering Acadia National Park via Paradise Road was compared to that which was traveling both northbound and southbound on State

Route 3, approximately eight miles northwest of the data collection station representing the park.

- The southbound vehicles entering Big Bend National Park at the Persimmon Gap Entrance were compared to those traveling southbound on Interstate 90, approximately 60 miles northwest of the data collection station representing the park.
- The vehicles traveling southbound on George Washington Memorial Parkway were contrasted to those which were traveling eastbound on Interstate 66, about five miles west of the data collection station representing the park.
- The eastbound traffic at Madison Junction, which is 14 miles east of Yellowstone National Park's West Entrance, was contrasted to the traffic counts collected at two state highway locations. Station A-18 includes the eastbound and westbound traffic on Interstate 20, which is 15 miles west of the data collection station representing the park, and Station A-19 consists of the northbound and southbound traffic on Interstate 191/287, which is 20 miles northwest of the data collection station representing the park.
- The eastbound vehicles entering Yosemite National Park at Big Oak Flat Entrance were compared to those traveling eastbound on State Route 20, approximately 40 miles west of the data collection station representing the park.

In order to compare the park traffic to that of the nearby state highways, the daily traffic volumes were first computed for both datasets with the summation of the hourly traffic counts across all 24 hours. Similar to the seasonal factor calculations, only the days that were 100 percent complete were used in this analysis. Days that included even a single hour of missing data were omitted. The state highway traffic datasets provided by both Virginia Department of Transportation and California Department of Transportation included multiple missing hourly volumes. Therefore, the particular days in which these missing volumes occurred were removed from the dataset prior to comparing the state highway traffic to that of Acadia National Park and Yosemite National Park. Guidelines provided by AASHTO were used to further edit the state highway traffic data prior to performing the correlation analysis. AASHTO states that "a traffic volume of 0 for all lanes must not occur for 8 consecutive hours or 32 consecutive quarter hours (AASHTO 1992)". Texas Department of Transportation and California Department of Transportation provided datasets that contained at least one occurrence of eight or more consecutive hours of where traffic volumes were zero. Therefore, these days were removed from the datasets before the state highway traffic was compared to that of Big Bend National Park and Yosemite National Park. Additionally, all five national park datasets included multiple missing hourly volumes. Therefore, due to missing data in both the national park and state highway datasets, the following numbers of days were not included in the analysis:

- Acadia National Park – 863 days out of 1,096 days (3 years)
- Big Bend National Park – 93 days out of 1,826 days (5 years)
- George Washington Memorial Parkway – 133 days out of 1,826 days (5 years)
- Yellowstone National Park – 791 days and 841 days out of 1,461 days (4 years)

- Yosemite National Park – 60 days out of 1,826 days (5 years)

After computing the daily traffic volumes for all five national parks and the corresponding state highways, correlation analyses were used to contrast the park traffic to that which was collected at nearby ATR locations. Such analyses examined the linear relationship between the traffic and quantified the strength of the relationship with a correlation coefficient. Daily national park traffic volumes were compared to those collected at the adjacent ATR location for each of the five years, and correlation values were calculated using Eq. (12), Eq. (13), Eq. (14), and Eq. (15) (Rosenkrantz 1997).

$$r_{PH,Y} = \frac{S_{PH,Y}}{\sqrt{S_{PP,Y}}\sqrt{S_{HH,Y}}} \tag{12}$$

$$S_{PH,Y} = \sum\left(P_{Y,D} - \overline{P}_Y\right)\left(H_{Y,D} - \overline{H}_Y\right) = \sum\left(P_{Y,D}H_{Y,D}\right) - n_Y\overline{P}_Y\overline{H}_Y \tag{13}$$

$$S_{PP,Y} = \sum\left(P_{Y,D} - \overline{P}_Y\right)^2 = \sum P_{Y,D}^2 - n_Y\overline{P}_Y^2 \tag{14}$$

$$S_{HH,Y} = \sum\left(H_{Y,D} - \overline{H}_Y\right)^2 = \sum H_{Y,D}^2 - n_Y\overline{H}_Y^2 \tag{15}$$

where

$r_{PH,Y}$ = correlation coefficient for the traffic in national park "*P*" and that of state highway "*H*" in year "*Y*",

$S_{PH,Y}$ = covariance of the traffic in national park "*P*" and that of state highway "*H*" in year "*Y*",

$S_{PP,Y}$ = variance of the traffic in national park "*P*" in year "*Y*",

$S_{HH,Y}$ = variance of the traffic on state highway "*H*" in year "*Y*",

$P_{Y,D}$ = national park traffic volume for year "*Y*" and day "*D*",

$H_{Y,D}$ = state highway traffic volume for year "*Y*" and day "*D*",

n_Y = number of traffic volumes for year "*Y*",

$\overline{P}_Y$ = average of national park traffic volumes for year "*Y*", and

$\overline{H}_Y$ = average of state highway traffic volumes for year "*Y*".

Using the equations above, a correlation coefficient was developed for each pair of locations and for each of the five years. For example, the correlation between the traffic at Acadia National Park and that of the nearby ATR location for 2005 was quantified using the following four steps.

First, the variance of the traffic in Acadia National Park in 2005 was calculated.

$$S_{Acadia,2005} = \sum\left(P_{2005,D} - \overline{P}_{2005}\right)^2 = \sum P^2_{2005,D} - n_{2005}\overline{P}^2_{2005} =$$

$$674{,}108{,}325 - (182)\left(1{,}694^2\right) = 152{,}136{,}061$$

Second, the variance of the nearby state highway traffic in 2005 was computed.

$$S_{ATR,2005} = \sum \left(H_{2005,D} - \overline{H}_{2005}\right)^2 = \sum H^2_{2005,D} - n_{2005}\overline{H}^2_{2005}$$

$$57{,}478{,}957{,}514 - (182)\left(17{,}391^2\right) = 2{,}430{,}912{,}143$$

Third, the covariance of the traffic in Acadia National Park and that of the nearby state highway in 2005 was calculated.

$$S_{Acadia,ATR,2005} = \sum \left(P_{2005,D} - \overline{P}_{2005}\right)\left(H_{2005,D} - \overline{H}_{2005}\right) = \sum \left(P_{2005,D} H_{2005,D}\right) - n_{2005}\overline{P}_{2005}\overline{H}_{2005}$$

$$(5{,}853{,}765{,}279) - (182)(1{,}694)(17{,}391) = 493{,}396{,}556$$

Finally, a correlation coefficient was developed for the traffic in Acadia National Park and that of the nearby state highway in 2005.

$$r_{Acadia,ATR,2005} = \frac{S_{Acadia,ATR,2005}}{\sqrt{S_{Acadia,2005}}\sqrt{S_{ATR,2005}}} = \frac{493{,}396{,}556}{\sqrt{152{,}136{,}061}\sqrt{2{,}430{,}912{,}143}} = 0.811$$

Using these steps, a correlation value was developed for each of the five national parks and each of the five years, theoretically yielding a total of 25 correlation values. However, because Maine Department of Transportation and Montana Department of Transportation were only able to provide traffic counts for 2003 to 2006, correlation values could not be developed for Acadia National Park and Yellowstone National Park for the year 2002. Due to additional daily volume that was provided by Maine Department of Transportation for the year 2006, a correlation value was also not developed for this particular year. Additionally, Montana Department of Transportation provided traffic counts for two ATR locations, and the traffic at Yellowstone National Park was compared to that which was collected on both state highways. Therefore, correlation analyses were carried out based on the availability of the data, and 26 correlation coefficients were developed. Table 5 summarizes the results from the analyses.

Table 5. Correlation Values

		Year				
		2002	2003	2004	2005	2006
Acadia National Park		N/A	0.834	0.781	0.811	N/A
Big Bend National Park		0.110	0.133	0.328	0.260	0.258
George Washington Memorial Parkway		0.928	0.922	0.901	0.920	0.934
Yellowstone National Park	Station A-18	N/A	0.967	0.958	0.965	0.963
	Station A-19	N/A	0.970	0.972	0.973	0.964
Yosemite National Park		0.770	0.687	0.726	0.753	0.687

As shown in the table, the correlation coefficients range from 0.973 to 0.110. Although the values are fairly consistent for a particular park across all five years, the coefficients significantly vary in magnitude from one national park to the next. Therefore, as a means of describing the degree of relation between the national park and state highway traffic for each particular location, the guidelines or rules of thumb provided by a classic piece of literature and shown in Table 6 were used.

Table 6. Correlation Rules-of Thumb (adapted from Franzblau 1958)

Correlation Coefficient	Degree of Relation
0.0-0.2	None or Negligible
0.2-0.4	Low
0.4-0.6	Moderate
0.6-0.8	Marked
0.8-1.0	High

While correlation values ranging from 0.8 to 1.0 were labeled as “high”, values ranging from 0.6 to 0.8 also symbolized a significant correlation and were labeled “marked”. Additionally, correlation values ranging from 0.4 to 0.6 were seen as “moderate”, and values ranging from 0.2 to 0.4 and 0.0 to 0.2 signified “low” and “negligible” relations, respectively. Using these rules-of-thumb, the following observations were made:

- The correlation values for Acadia National Park ranged from “high” to “marked”. While the park traffic was “highly” correlated with that which was collected about eight miles away on State Route 3 for the years of 2003 and 2005, the correlation coefficient for 2004 only signified a “marked” relationship.
- The correlation coefficients for Big Bend National Park ranged from “low” to “negligible”. The correlation between the park traffic and that which was collected approximately 60 miles away on Interstate 90 was “negligible” for 2002 to 2003 and “low” for 2004 to 2006.

- The traffic volumes at George Washington Memorial Parkway were “highly” correlated with those which were collected about five miles away on Interstate 66 for all five years.
- The traffic volumes at Yellowstone National Park were “highly” correlated with those which were collected on both Interstate 20, which was 15 miles from of the park, and Interstate 191/287, which was 20 miles from the park, for all five years.
- The correlation between the traffic at Yosemite National Park and that which was collected approximately 40 miles away on State Route 20 exemplified a “marked” relationship for all five years.

To visualize these relationships, the daily traffic volumes of each national park were plotted against those of the nearby state highway for each of the five years. A sample of these plots can be seen in Fig. 19, Fig. 20, Fig. 21, Fig. 22, Fig. 23, and Fig. 24 for Acadia National Park, Big Bend National Park, George Washington Memorial Parkway, Yellowstone National Park (Station A-18), Yellowstone National Park (Station A-19), and Yosemite National Park, respectively. Although these six plots are specific to the year 2004, the plots for the other four years follow these same trends and can be found in *Appendix G*.

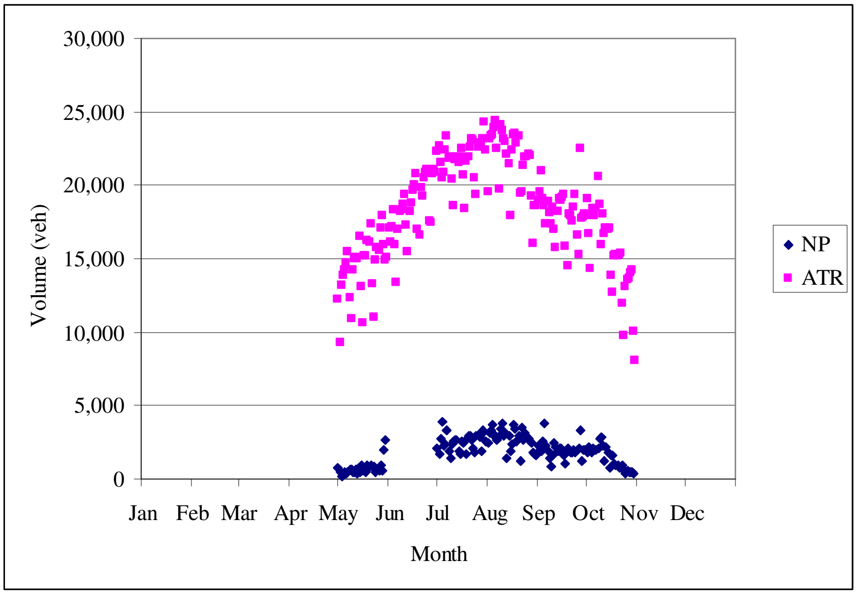

Fig. 19. Daily Traffic Volumes for Acadia National Park and Nearby ATR in 2004

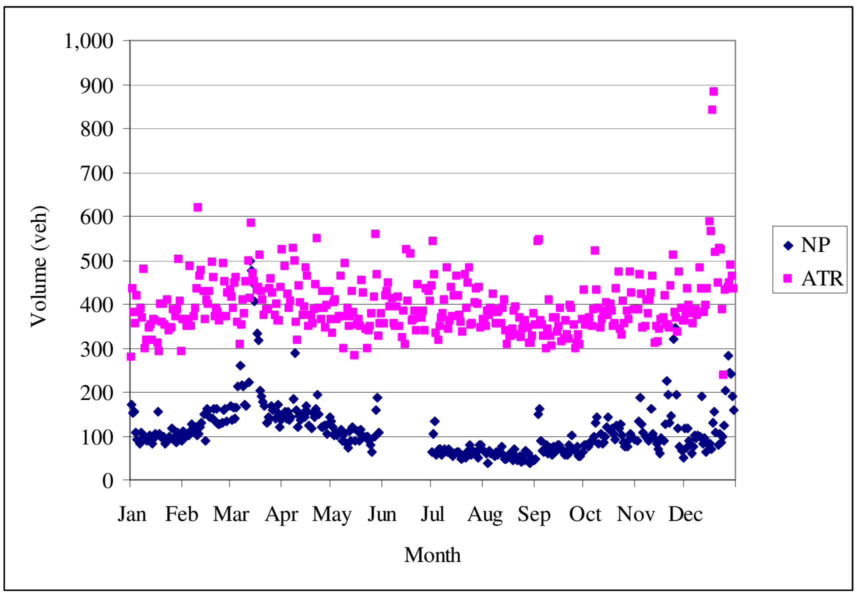

Fig. 20. Daily Traffic Volumes for Big Bend National Park and Nearby ATR in 2004

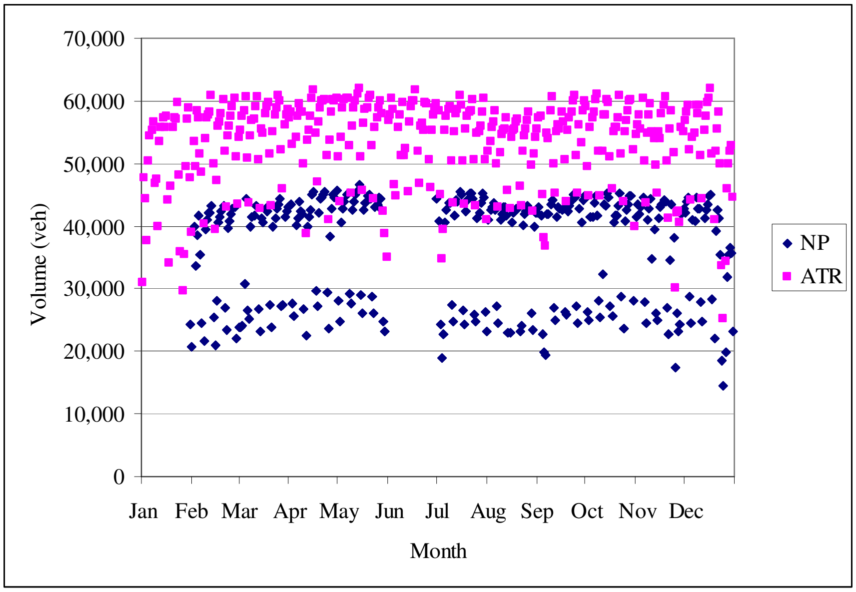

Fig. 21. Daily Traffic Volumes for George Washington Memorial Parkway and Nearby ATR in 2004

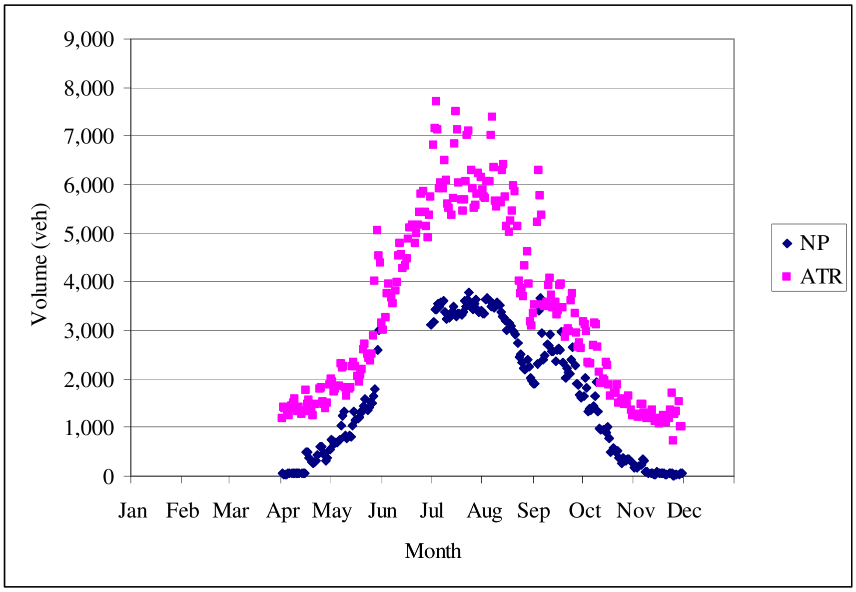

Fig. 22. Daily Traffic Volumes for Yellowstone National Park (Station A-18) and Nearby ATR in 2004

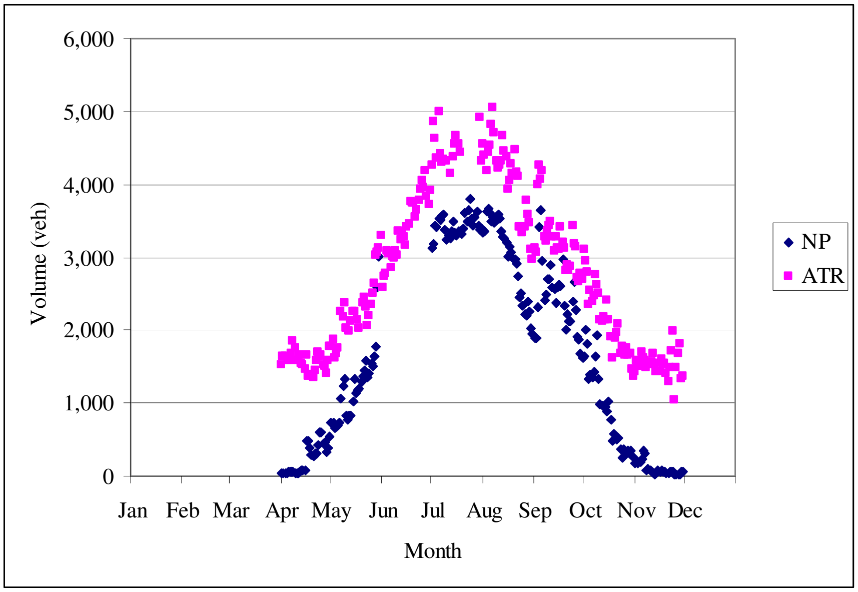

Fig. 23. Daily Traffic Volumes for Yellowstone National Park (Station A-19) and Nearby ATR in 2004

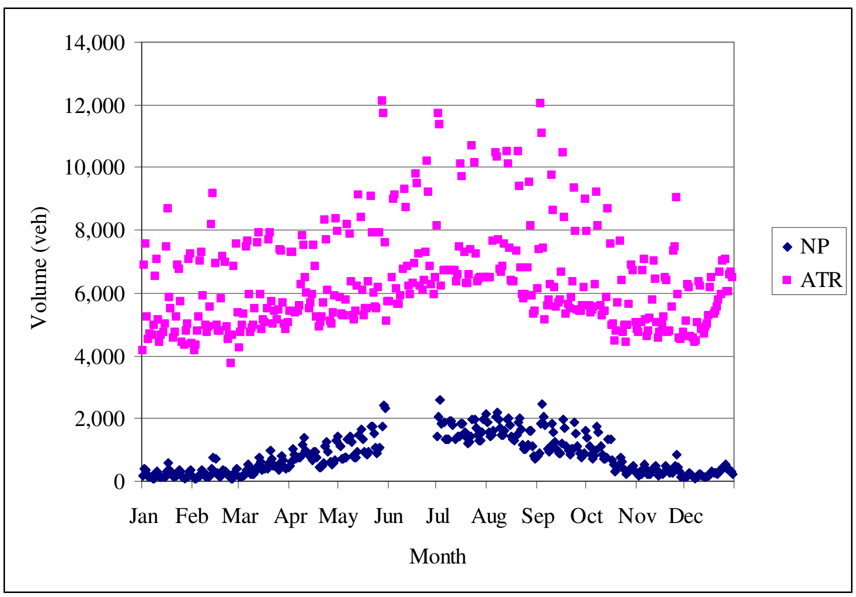

Fig. 24. Daily Traffic Volumes for Yosemite National Park and Nearby ATR in 2004

The figures above confirm the observations that were previously made using the rules-of-thumb:

- The correlation between the traffic in Acadia National Park and that of the nearby state highway ranged from high to marked. While the plots shown in Fig. 19 follow a similar trend, the park's summer peak was more severe than that which was experienced on the nearby state highway.
- The correlation between the traffic at Big Bend National Park and that of the nearby state highway ranged from low to negligible. The park traffic shown in Fig. 20 follows a distinct trend with peaks during the week of Spring Break and in the fall, but the traffic on the nearby state highway remained fairly consistent throughout the entire year.
- The traffic on George Washington Memorial Parkway was highly correlated with that which appeared on the nearby highway. As it is shown in Fig. 21, both of the roadways experienced heavy commuter volumes that were consistent throughout the year and weekend volumes that were slightly less.
- The traffic in Yellowstone National Park was highly correlated with that of both state highways. The plots in Fig. 22 and Fig. 23 follow the same pattern with peaks during the both the summer and the fall.
- The correlation between the traffic at Yosemite National Park and that which appeared on the nearby state highway was marked. While the plots shown in Fig. 24 peak during the summer and follow a similar trend, the state highway traffic pattern is not as clear as that of the park.

After thoroughly examining the correlation values and the characteristics of each location, it was determined that the distance between the national park and the ATR location had a direct effect on the magnitude of the correlation value. State highway locations that were within close proximity to the national parks resulted in a high correlation values while ATR locations that were far from the parks resulted in significantly lower coefficients. Using these research findings, Table 3 was developed to display the effect that distance had on the magnitude of the corresponding correlation value.

Table 7. Correlation Values as a Function of Distance

Distance Range (miles)	Number of Samples	Correlation Value	
		Maximum	Minimum
1-20	4	0.973	0.781
21-40	1	0.770	0.687
41-60	1	0.328	0.110

According to the five locations examined in this study, distances of 1 to 20 miles resulted in relatively "high" correlation values, distances of 21 to 40 miles revealed a rather "marked" relationship, and distances of 41 to 60 miles resulted in correlations that ranged from "low" to "negligible". As the ATR location moved further away from the national park, the correlation coefficient significantly decreased. The traffic patterns of state highway locations that are within close proximity to the national parks are most representative as those which are found in the parks. Although the distances ranging from 21 to 40 miles and 41 to 60 miles contained only one sample each, it is assumed that samples of similar distances would result in correlation coefficients comparable to those seen in Table 7. Therefore, in order to achieve the greatest probability that the traffic will be highly correlated, it is suggested that the National Park Service share data collection efforts with the state departments of transportation using only those ATR locations that are within 20 miles of the national park.

DESIGN HOURLY VOLUME ANALYSIS AND RESULTS

Using the hourly volumes for 2002 to 2006, design volumes for each national park were determined using a variety of suggested methods, and the K-factors of urban parks were compared to those of rural parks to determine the effect that location type has on the magnitude of the K-factor. For this analysis, George Washington Memorial Parkway represented an urban national park, and Acadia National Park, Big Bend National Park, Yellowstone National Park, and Yosemite National Park were classified as rural. Additionally, all hourly volumes were used for each year and for each park as this analysis did not require that each day be 100 percent complete.

The design volumes for each of the five national parks were first determined using the 30th highest hourly volume, which is the method recommended by AASHTO and used in standard practice for both urban and rural arterials. All hourly traffic volumes were arranged in descending order of magnitude for each of the five years. The 30th highest hour was labeled as the design hour, and the corresponding volume was chosen as the design volume. After determining the hourly design volume for all five years and for each national park, the volumes were then expressed as a percentage of the AADT with the calculation of the K-factors using Eq. (16).

$$K - factor_{P,Y} = \frac{DHV_{P,Y}}{AADT_{P,Y}} \times 100 \qquad (16)$$

where

$DHV_{P,Y}$ = design hourly volume for national park "P" and year "Y", and

$AADT_{P,Y}$ = average annual daily traffic national park "P" and year "Y".

Using Eq. (16), a K-factor was determined for each of the five national parks and each of the five years, yielding a total of 25 K-factors. Table 8 summarizes the results from these analyses.

Table 8. Design Hourly Volumes and K-Factors Using the 30th Highest Hour

		DHV (veh)	K-factor
Acadia National Park	2002	474	0.23
	2003	338	0.20
	2004	437	0.23
	2005	430	0.25
	2006	326	0.19
Big Bend National Park	2002	42	0.35
	2003	39	0.34
	2004	38	0.33
	2005	34	0.32
	2006	39	0.39
George Washington Memorial Parkway	2002	4351	0.12
	2003	4124	0.11
	2004	4192	0.11
	2005	4161	0.11
	2006	4031	0.11
Yellowstone National Park	2002	533	0.30
	2003	521	0.29
	2004	498	0.31
	2005	532	0.30
	2006	528	0.29
Yosemite National Park	2002	270	0.31
	2003	260	0.31
	2004	250	0.31
	2005	289	0.31
	2006	292	0.31

While the design volumes and K-factors in Table 8 are fairly consistent across all five years for each particular park, they significantly vary from one park to the next. It is stated in the *Literature Review* that the lowest K-factors occur on urban commuter routes while the highest K-factors are found on routes near popular recreational areas. The results shown in Table 8 confirm this statement. While the lowest K-factors are those of

George Washington Memorial Parkway, the urban national park, for 2002 to 2006, the higher values are those of the rural national parks.

In terms of "typical" K-factors, George Washington Memorial Parkway is the only national park with values consistent to those mentioned in the *Literature Review*. While the *Literature Review* states that the appropriate hourly design volume is approximately 10 percent of the AADT on a typical urban arterial, the K-factors for this urban national park range from 0.11 to 0.12. Therefore, the 30^{th} highest hourly volume seems to be an appropriate design volume for George Washington Memorial Parkway. To confirm this, the K-factors and hourly volumes for the highest ordinal hours of 2003 were plotted to determine where the "knee" of the curve occurs. Although the plot seen in Fig. 25 is specific to the year 2003, the plots for the other four years followed this same trend. All five of these plots can be found in *Appendix F*.

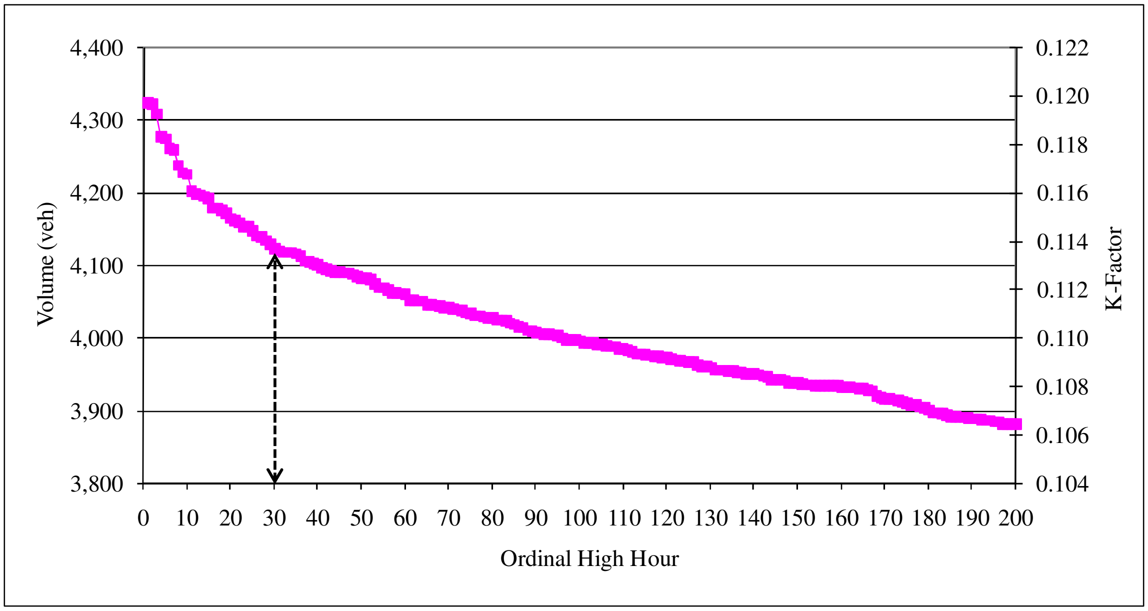

Fig. 25. Peak-Hour and AADT Relationship on George Washington Memorial Parkway in 2003

As stated in the *Literature Review*, AASHTO recommends that the 30th highest hourly volume be used as the design volume based on the assumption that the "knee" of the curve, or the area in which the slope of the curve changes most rapidly, occurs at or near the 30th highest hour. This assumption was verified for George Washington Memorial Parkway with the plot seen in Fig. 25. While many hours exist where the volume is not much less than the 30th highest hourly volume, there are only 29 hours with higher volumes. Therefore, it is confirmed that the 30th highest hourly volume be used as the design volume for George Washington Memorial Parkway.

The K-factors for the rural parks were not consistent with those mentioned as “typical” in the *Literature Review*. While the *Literature Review* states that the appropriate hourly design volume is approximately 15 percent of the AADT on a typical rural arterial, the K-factors shown in Table 8 are much greater than 0.15. However, this alone does not prove that the 30th highest hour is not an appropriate method. Therefore, plots similar to that seen Fig. 25 were developed for each of the four rural parks to determine where the “knee” of each curve occurs for each of the five years. A sample of these plots can be seen in Fig. 26, Fig. 27, Fig. 28, and Fig. 29 for Acadia National Park, Big Bend National Park, Yellowstone National Park, and Yosemite National Park, respectively. All 20 plots (one plot for each of the four rural national parks and each of the five years) are included in *Appendix F*. It should be noted that the plots found in *Appendix F* for the other four years follow the same general trend that is shown for 2003 in each of the figures below.

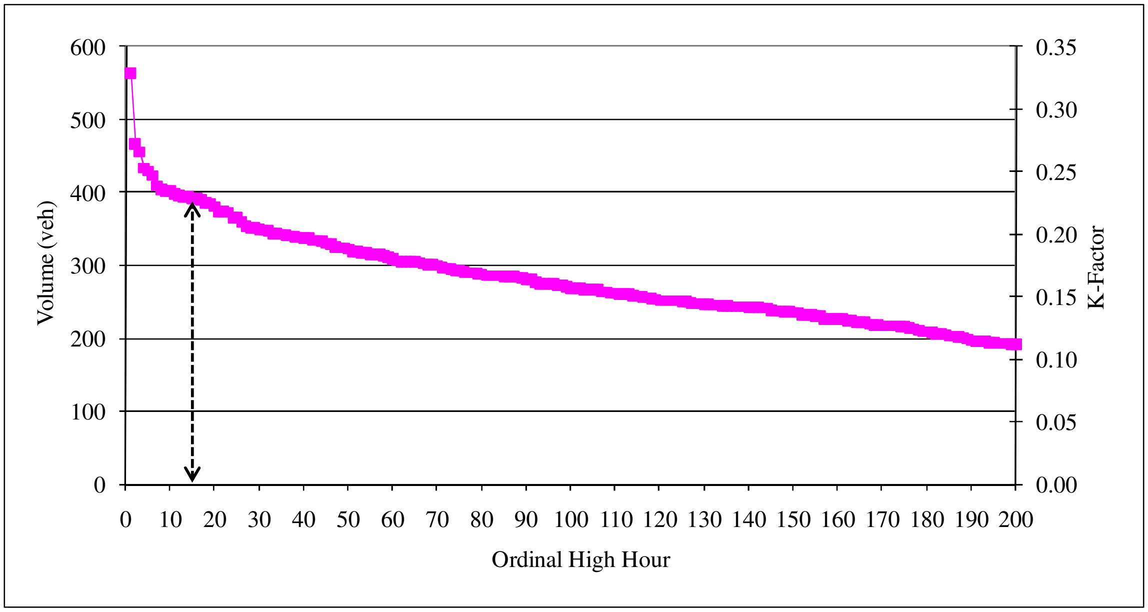

Fig. 26. Peak-Hour and AADT Relationship in Acadia National Park in 2003

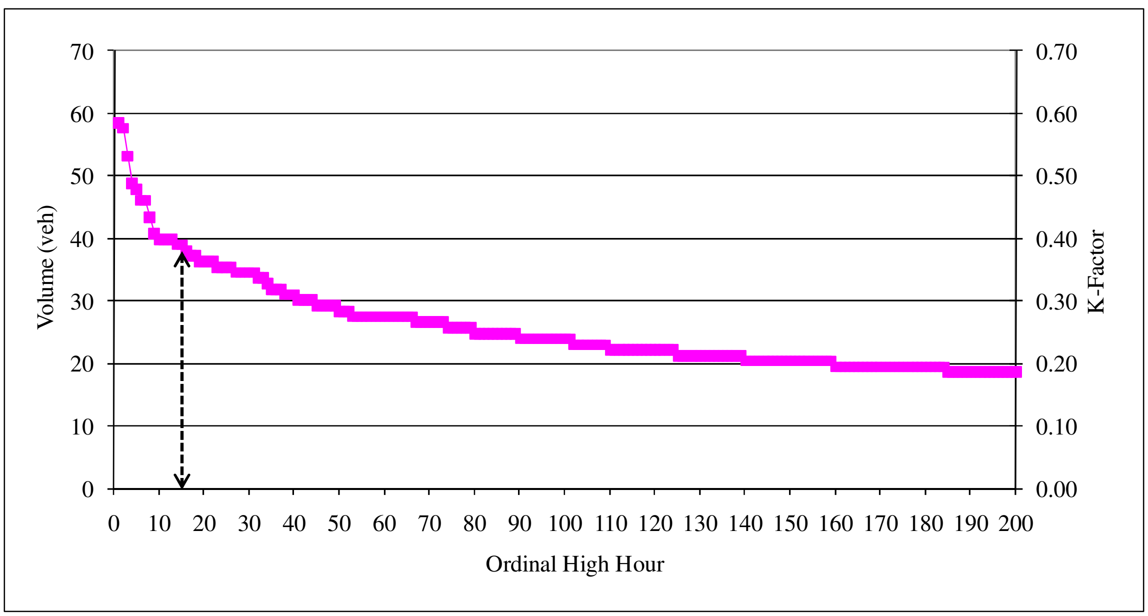

Fig. 27. Peak-Hour and AADT Relationship in Big Bend National Park in 2003

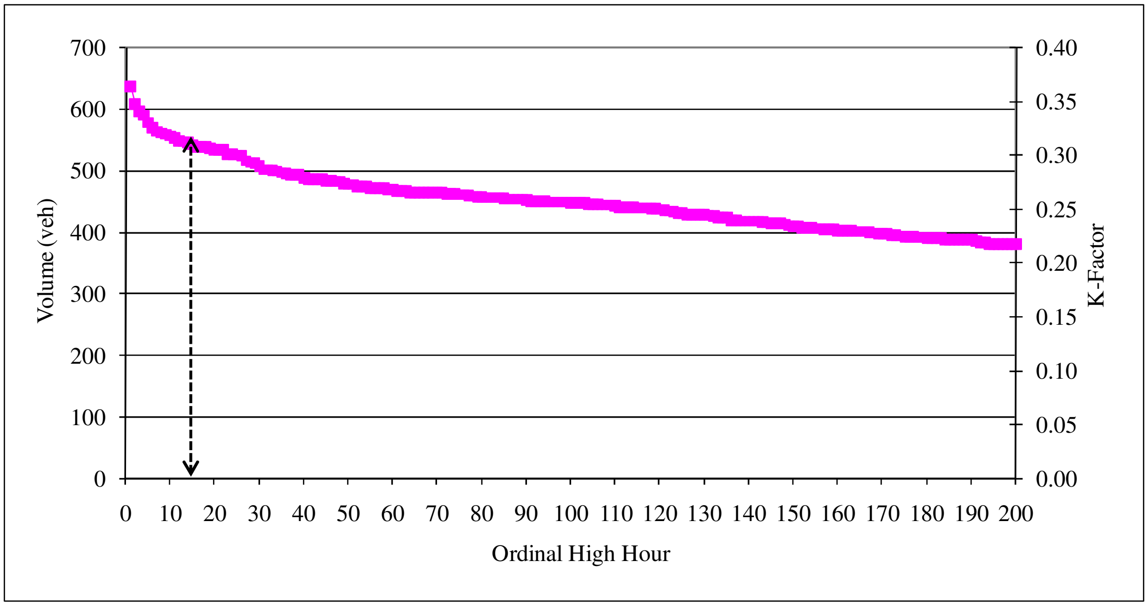

Fig. 28. Peak-Hour and AADT Relationship in Yellowstone National Park in 2003

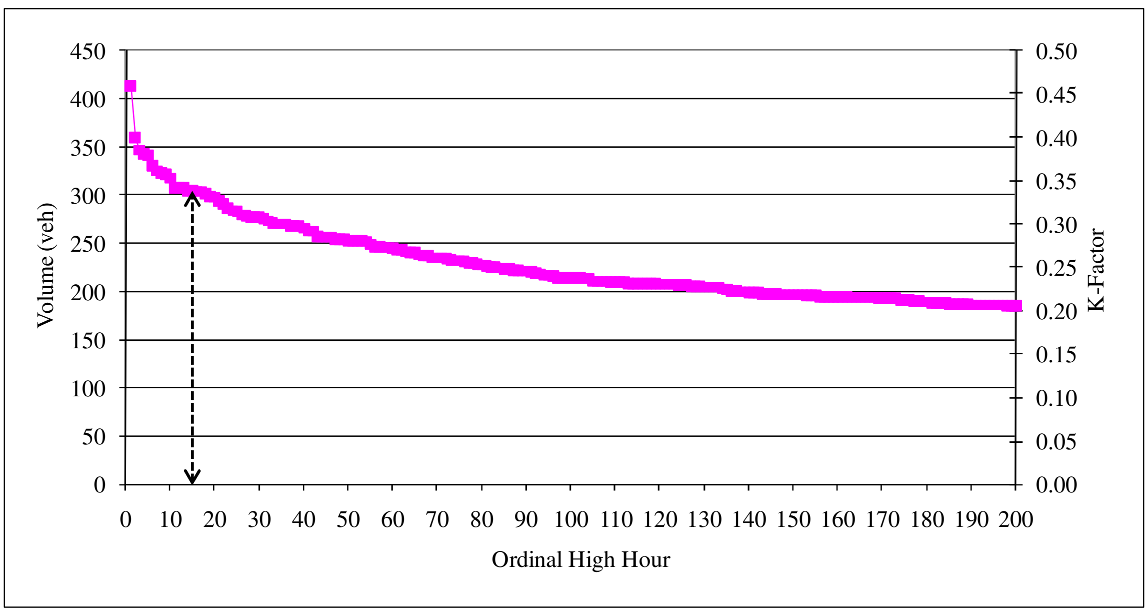

Fig. 29. Peak-Hour and AADT Relationship in Yosemite National Park in 2003

Although AASHTO recommends that the 30th highest hour be used as the design hour, it does not appear that this is where the "knee" occurs on the plots seen in the four figures above. Instead, the slope of each curve seems to change most rapidly at the 15th highest hour. If the design hour were to be chosen based on the knee of the curve, the 15th highest hourly volume should be used for the rural parks. However, a design standard stricter than that which is used in urban locations cannot be justified. Therefore, it is suggested that the design hour for rural parks be either equal to the 30th highest hour or lie to the right of this particular hour on the K-factor plot. Because George Washington Memorial Parkway plot levels off to the right of the 30th highest hour, this design volume is able to capture many hours within a certain range. However, a long flat section does not exist to the right of the 30th highest hour on the rural park plots. Therefore, because there is no compelling evidence to suggest a design hour other than the 30th highest hour, it is suggested that this particular hour also be used for Acadia National Park, Big Bend National Park, Yellowstone National Park, and Yosemite National Park.

The design volumes for the rural parks were also calculated using the method recommended by AASHTO for recreational roadways to determine whether this technique was more appropriate. Instead of arbitrarily labeling one particular hour as the design hour using the knee of the curve, this method entails the use of about 50 percent of the volumes experienced during the highest hours. Similar to the previous method, all hourly traffic volumes were arranged in descending order of magnitude for each of the five years. The volumes corresponding to the highest ten hours were averaged, and the volume equal to 50 percent of this average was labeled as the hourly design volume. Using Eq. (16), a K-factor was determined for each of the four rural parks and each of the five years, yielding a total of 20 K-factors. Table 9 summarizes the results from these analyses.

Table 9. Design Hourly Volumes and K-Factors using 50% of the 10 Highest Hours

		DHV (veh)	K-factor
Acadia National Park	2002	289	0.14
	2003	212	0.13
	2004	266	0.14
	2005	259	0.15
	2006	226	0.13
Big Bend National Park	2002	36	0.30
	2003	27	0.24
	2004	29	0.26
	2005	26	0.25
	2006	31	0.31
Yellowstone National Park	2002	296	0.17
	2003	299	0.17
	2004	287	0.18
	2005	292	0.16
	2006	293	0.16
Yosemite National Park	2002	165	0.19
	2003	160	0.19
	2004	152	0.19
	2005	190	0.21
	2006	181	0.19

Similar to the results shown in Table 8, the design volumes and K-factors in Table 9 significantly vary from one national park to the next but are fairly consistent across all five years for each particular park. In comparison to the values in Table 8, the design volumes and corresponding K-factors in Table 9 are about half as large. However, because roads cannot be designed with capacities as low as those which are seen in Table 9, slightly larger volumes would be used, and the design would be very similar to that which would result from using the 30th highest hourly volume. It should be noted however that this would not be the case for parks that experience heavier traffic. In terms of K-factors, the values shown in Table 9 for the rural parks are still greater than those of George Washington Memorial Parkway, which remains consistent with what is stated in the *Literature Review*. However, it is noted that the K-factors of the rural national parks remain slightly higher than the typical rural arterial value of 15 percent. Additionally, it is noted that design volumes as low as those shown in Table 9 will result in a roadway capacities that are frequently exceeded. Table 10 displays the number of hours that exceed the design volume for each of the five years and for each of the four rural parks.

Table 10. Number of Hours That Exceed the Design Volume

		No. of Hours
Acadia National Park	2002	303
	2003	166
	2004	278
	2005	257
	2006	108
Big Bend National Park	2002	49
	2003	89
	2004	62
	2005	79
	2006	52
Yellowstone National Park	2002	361
	2003	354
	2004	306
	2005	398
	2006	425
Yosemite National Park	2002	243
	2003	267
	2004	287
	2005	236
	2006	298

The numbers of hours shown in Table 10 are all significantly greater than 30. Therefore, while the percent of AADT traveling on the roadway during the design hour is not consistent with that which is "typical", the roadway is also often congested. As it was previously mentioned, roads cannot be designed using capacities as low as those which are seen in Table 9, and design volumes closer to those seen in Table 8 would instead be used as the minimum. Therefore, the capacity of the facility would not be exceeded as often as what is shown in Table 10. However, this is not the case for rural parks that experience heavier traffic volumes. Using 50 percent of the volumes experienced during the highest hours to design roadways in rural parks with heavy volumes could be a problem. As it is stated in the *Literature Review*, slight delays are expected on recreational roadways during seasonal peaks, but the design should not be so conservative that it causes severe congestion during peak times. When 50 percent of the highest hourly volumes is used in design, AASHTO recommends that "a check should be made to ensure that the expected maximum hourly traffic does not exceed the capacity (AASHTO 2004)." However, if this design method is used in rural parks that experience heavy traffic volumes, it is possible that the capacity of the roadways will frequently be surpassed.

When planning roadways in the national parks, design volumes should result in a roadway that appropriately satisfies traffic demands and that is in support of the national park experience. Therefore, if the traditional K-factor plot is to be used when determining the design volume, it is recommended that the volume corresponding to the 30th highest ordinal hour be used as the design hour for both the urban and rural national parks. Because the "knee" of the curve occurs at this particular hour on the George Washington Memorial Parkway plot, this design hour is where the compromise between economic efficiency and the level of service is most appropriate. Although this is not where the "knee" lies on the rural park plots, there is no compelling evidence to suggest a design hour other than the typical 30th highest ordinal hour. Therefore, the design volumes shown in Table 11 are suggested for each of the five national parks.

Table 11. Recommended Design Hourly Volumes and K-Factors

		DHV (veh)	K-factor
Acadia National Park	2002	474	0.23
	2003	338	0.20
	2004	437	0.23
	2005	430	0.25
	2006	326	0.19
Big Bend National Park	2002	42	0.35
	2003	39	0.34
	2004	38	0.33
	2005	34	0.32
	2006	39	0.39
George Washington Memorial Parkway	2002	4351	0.12
	2003	4124	0.11
	2004	4192	0.11
	2005	4161	0.11
	2006	4031	0.11
Yellowstone National Park	2002	533	0.30
	2003	521	0.29
	2004	498	0.31
	2005	532	0.30
	2006	528	0.29
Yosemite National Park	2002	270	0.31
	2003	260	0.31
	2004	250	0.31
	2005	289	0.31
	2006	292	0.31

As it was previously mentioned, the design volumes and K-factors shown above significantly vary from one national park to the next but are fairly consistent across all five years for each particular park. In terms of "typical" K-factors, George Washington Memorial Parkway is the only national park with values consistent to those mentioned in the *Literature Review*. The plot for George Washington Memorial Parkway that was previously shown in Fig. 25 levels off to the right of the 30th highest hour, which signifies that this design hour is the most appropriate. Although the K-factors for the rural parks are not consistent with that which is stated as "typical", there is no compelling evidence to suggest a design hour that is more appropriate than the typical 30th highest hour. Therefore, of the two methods investigated in this thesis, the traditional K-factor plot method is the most appropriate for both the urban and rural national parks.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Conclusions drawn from these analyses are provided in this chapter. Additionally, recommendations are made with respect to the potential application of these findings within the National Park Service.

CONCLUSIONS

The goal of this research was to examine traffic patterns at national parks in an effort to reduce the amount of time and money that is spent on traffic data collection in these recreational areas while maintaining the quality and accuracy of the counts.

To determine whether the national park seasonal and day-of-week traffic patterns exhibit consistency from one year to the next, the seasonal and day-of-week factors were compared across all five years. Using the Kruskal-Wallis test, it was determined that the seasonal and day-of-week factors were not statistically different from 2002 to 2006. Therefore, the traffic patterns observed during each day-of-week and month-of-year combination were not statistically different from one year to the next in each of the five national parks.

To determine whether data collection efforts can be reduced and shared amongst various entities, the traffic counts collected in the five national parks for 2002 to 2006 were compared to those of the nearby state highway ATR locations. The linear relationship was examined, and a correlation value was developed for each of the five national parks and each of the five years. While the correlation values ranged from "high" to "negligible", the distances between the national parks and the ATR locations also widely varied. It was determined that this distance had a direct effect on the magnitude of the correlation value. According to the five locations examined in this study, distances of 1 to 20 miles resulted in relatively "high" correlation values, distances of 21 to 40 miles revealed a rather "marked" relationship, and distances of 41 to 60 miles resulted in correlations that ranged from "low" to "negligible".

To determine which design hourly volume calculation method was most appropriate for the national parks, design volumes were computed using a variety of suggested methods. Using the traditional K-factor plot, it was determined that the volume corresponding to the 30^{th} highest ordinal hour should be used as the design hour for George Washington Memorial Parkway (an urban park) as this is where the knee of the curve lies. Although this is not where the "knee" occurs on the rural park plots, there is no compelling evidence to suggest a design hour that is more appropriate than the typical 30^{th} highest hour. The method recommended by AASHTO for recreational roadways was also used to calculate design volumes for the rural parks. However, this method resulted in volumes that were frequently exceeded throughout the year, and therefore, it was determined that this method should not be used. In terms of "typical" K-factors, George Washington Memorial Parkway was the only national park with values consistent to those mentioned in the *Literature Review*. However, the relationship between urban and rural K-factors was confirmed in that the lowest K-factors occurred on the urban commuter route while the highest K-factors were found on the rural recreational routes.

RECOMMENDATIONS

Based on these findings, it is recommended that the National Park Service take the following actions when improving their traffic data collection methods and guidelines:

- It is recommended that the National Park Service consider reducing the amount of data that they collect by using short-duration counts in conjunction with a modest number of permanent counts. Because the seasonal and day-of-week traffic patterns are consistent from one year to the next, short-duration counts can be collected and converted into AADT estimates using the previous year's table of adjustment factors without having a significant impact on the accuracy of the data.
- It is recommended that the National Park Service investigate potential data collection integration with nearby state highway locations as a means of reducing the amount of time and money spent. However, in order to achieve the greatest probability that the traffic will be highly correlated, it is suggested that the National Park Service share data collection efforts using only those ATR locations that are within 20 miles of the national park.
- When the traditional K-factor plot method is used to design roadways in the national parks, it is recommended that the volume corresponding to the 30^{th}

highest ordinal hour be used as the design hour for both the urban and rural locations. However, the National Park Service should determine whether the 30th highest hourly volume appropriately satisfies traffic demands, supports the national park experience, and is financially feasible. This is especially important in areas with heavy traffic as the rural park volumes studied in this thesis were fairly low.

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APPENDIX A

DIRECTOR'S ORDER 82 (DO82): PUBLIC USE DATA COLLECTING AND REPORTING PROGRAM

(Send comments to Brian Forist by February 16, 2004)

DIRECTOR'S ORDER #82: PUBLIC USE DATA COLLECTING AND REPORTING PROGRAM

Approved:

Effective Date:

Sunset Date:

This Director's Order supersedes NPS-82 (Public Use Reporting) and Staff Directive 76-8 (Revised) on the Public Reporting Program. This Director's Order, in conjunction with the Counting and Reporting Instructions and the Summary of Survey Findings, outlines and identifies acceptable approved practices and requirements.

Table of Contents

I. Purpose and Background

Information about visitation and public use of units of the National Park System is in constant demand. The National Park Service (NPS) Public Use Data Collecting and Reporting Program is managed by the Public Use Statistics Office (PUSO) under direction of the Visiting Chief Social Scientist (VCSS) and the Associate Director for Natural Resource Stewardship and Science (ADNRSS).

Information about public use of national parks has been collected since 1904, before the NPS was established. Since the early days of informally monitoring visitation levels, trip origin of visitors, and transportation modes used to get to the parks, the NPS has developed a formal system for collecting, compiling, and reporting public use data. Although the system has changed little in emphasis and operation since the late 1960s, careful attention is needed to keep the data collection consistent and reliable.

The purpose of this Director's Order is to set forth policies and procedures for collecting and reporting public use data at units of the National Park System. This Director's Order describes the Servicewide Public Use Data Collecting and Reporting Program, establishes policies and procedures for counting and reporting visitation by the public, and defines the roles and responsibilities of park, regional, Public Use Statistics Office (PUSO) and Washington office personnel in implementing the program.

As is the case with all components of the NPS directives system, this Director's Order is intended only to improve the internal management of the NPS, and is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or equity by a party against the United States, its departments, agencies, instrumentalities or entities, its officers or employees, or any other person.

II. Authorities

Authority to issue this Director's Order is contained in the NPS Organic Act (16 USC 1 through 4). Part 245 of the Department of the Interior (DOI) Manual delegates to the Director of the NPS the Secretary of the Interior's authority to supervise, manage, and operate the National Park System.

The National Parks Omnibus Management Act of 1998 (P.L. 105-391, Sec. 202; 16 U.S.C. 5932) requires that the management of units of the National Park System be enhanced by the availability and utilization of a broad program of the highest quality science and information.

In addition, all federal recreation land managing agencies measure and report public use in accordance with standards set forth in a 1965 Interagency Agreement between the Department of the Interior (National Park Service and Fish and Wildlife Service), Department of Agriculture (U.S. Forest Service), and the U.S. Army Corps of Engineers: A Uniform Method of Measuring and Reporting Public Use on the Public Lands and Waters of the United States. Other requirements for reporting include Coordination Memorandum No. 1 dated April 15, 1969, covering use reporting at all federal recreation land areas where fees are collected as required by Public Law 88-29.

III. Policies and Procedures

The following guidance is specified for the Public Use Data Collecting and Reporting Program:

A. Governing Concepts
Public use data will be collected, analyzed and reported in a consistent manner throughout all units of the National Park System. Park units will contribute timely, accurate data to the Servicewide Public Use Data Collecting and Reporting Program. This data will document monthly workload requirements and the annual history of park use relative to seasonality, budget, and staff. The public use data developed and published by the NPS will be accurate and reliable. It will be useful for a variety of park and recreation planning and operational functions for the benefit of the American public.

The objectives of the Public Use Data Collecting and Reporting Program are to:
· design a statistically valid, reliable, and uniform method of collecting and reporting public use data for each independent unit administered by the NPS;
· enact a variety of quality control checks to eliminate errors;
· provide analysis and to verify measurements of the public use data;
· ensure consistency of data collection within areas of the NPS; and
· support the continuous collection and timely publication of public use data.

Public use data will be collected and reported at all areas either administered or managed by the NPS, whether solely or in partnership or association with other entities (i.e., states, counties, other federal agencies, private groups, individuals, or foreign governments). The NPS, through the PUSO, will analyze and categorize the data in order to maintain and ensure statistical validity and accuracy of the program. The PUSO will distinguish between those units that are under the sole administration of the NPS and other units that are classified as "miscellaneous areas." The data collected in miscellaneous areas where the NPS has partial administrative responsibility or limited presence will be maintained as a source for identifying internal comparisons but will not be reported in the combined total statistics of those areas directly administered by the NPS. The data from the miscellaneous areas will be maintained and displayed separately in the Annual Statistical Abstract.

B. Documentation
The Public Use Data Collecting and Reporting Program will prepare a variety of occasional, monthly and annual documents. The PUSO will maintain electronic copies of all data submitted by parks and all documents generated. This data will be made available to the public and to all NPS personnel by being posted to the World Wide Web. Reports will also

be available on the World Wide Web. The various documents are described below.

1. **Counting and Reporting Instructions**

The PUSO will conduct periodic reviews of the public use counting instructions for each park and verify and issue the specific counting instructions to keep the data consistent and reliable. It will issue a set of Counting and Reporting Instructions (CI) that contain the procedures for measuring, compiling, and recording public use at each park, including unique counting instructions. A simple desk audit review may consist of an examination of the current set of CI for that park, and telephone verification of procedures and placement of traffic counters. A more complex review may require an on-site visit to the park to review park records, verify park procedures, examine placement of traffic counters and consult with the park staff about changing visitor use patterns.

2. **Summary of Survey Findings**

The Summary of Survey Findings is the report of an individual park's public use surveys and will contain conversion and correction factors needed by the park for valid and accurate reporting. Most parks will require various conversion factors to convert readings from counters (traffic trail, or electric eye) to visits. The conversion factors are established by surveys of public use.

a) Visitor Surveys.

Certain public use characteristics must be provided directly from visitors, e.g., how long they stay in the park, if they are visiting the park or just passing through, and park exit and re-entry factors during a visit. Visitor surveys will collect such data and will be used to produce person-per-vehicle multipliers or conversion factors, which will be employed to improve the accuracy of public use reporting. The park will conduct surveys according to a sampling protocol designed to represent the general visiting public. The exact form of the questionnaire will depend on the specific information needed by the park.

It is the park's responsibility to maintain current and accurate conversion factors. The PUSO will provide assistance, as available, to parks in such areas by obtaining the necessary clearance from the Visiting Chief Social Scientist and the Office of Management and Budget (in compliance with the Paperwork Reduction Act of 1995), providing sampling plans for person-per-vehicle surveys, designing a survey form, entering the data, analyzing the results, and compiling and issuing the Summary of Survey Findings.

3. **Monthly Public Use Report**

All independent units administered by the NPS will submit a Monthly Public Use Report by the 15th of each month for the previous monthly reporting period. This report will be submitted for all months even if the park is closed for the season or on a temporary basis. It is the responsibility of the superintendent to work with the PUSO to ensure that an approved set of counting instructions is being used.

The contents of the Monthly Public Use Report will contain the following applicable data:

o Visits (recreation and nonrecreation),

o Hours of use (recreation and nonrecreation) which is converted into visitor days, and

o Overnight stays (concessioner lodges and campgrounds, tents and recreational vehicles in NPS campgrounds, backcountry, group or miscellaneous, and nonrecreation).

4. Annual Statistical Abstract

The PUSO will publish the Annual Statistical Abstract containing data from the previous calendar year. Included in the Annual Statistical Abstract will be information on:

o Recreation and non-recreation visits to units of the National Park System, reported systemwide, by state, region, population center and park,

o Recreation visits and visitor days spent in units of the National Park System, reported systemwide, by state, region and park,

o Overnight stays in units of the National Park System, reported by park,

o Forecasts of recreation visits for next two calendar years reported by park, and

o Acreage in the National Park System.

C. Starting a Public Use Counting Program at a New Park Unit

A new park area should initiate with the PUSO a public use counting program when the park is staffed on a full-time basis and when NPS-administered property or facilities are open to the public and in use on a regular basis. Initiation of a counting program by a park involves notifying the PUSO of the need for assistance and providing a brief description of current public services and activities and any services and activities expected in the immediate future. The PUSO will follow-up to clarify details. Upon completion of basic background work, PUSO will prepare, for park review, public use counting instructions compatible with the standards and conditions of these guidelines.

D. Temporary Modifications

The counting instructions are considered the official statement of how visitation data is collected and compiled and may not be changed or deviated from without the review and concurrence of the PUSO. Emergencies (e.g., forest fires, floods, and other disasters) may require temporary modifications to the counting instructions. Parks should consult and work with the PUSO in coordinating the implementation of any changes to the counting and data gathering process.

E. Difficulties or Problems
Any difficulties or problems in reporting public use at the park should be conveyed to the PUSO for pursuit of appropriate remedies. Remedies may include actions such as the modification of the counting instructions or providing direct assistance to the park.

F. Noting Reasons for Anomalies
Conditions that influence public use will be identified in footnotes in the Annual Statistical Abstract to alert all data users to the apparent anomalies. The park is expected to inform the PUSO of such conditions including road detours, full or partial closing of the park, dates of opening and closing for short season areas, or other factors that may be of significance.

G. Duplicate Reporting
The applicable rule is that one entrance per individual per day is reportable. A visitor going from park to park is reported separately as long as the areas visited are independently authorized units of the National Park System, not separate portions of the same park. The complexity of the physical layouts of parks and the diversity of their surrounding environments may result in conditions that could involve duplicate counts. Extra care must be taken to eliminate any duplicate counting.

Below are common situations that can lead to duplicate reporting and must be avoided:

o Commuter traffic going to and from work through the park.

o Visitor traffic going to and from outside locations (campers in need of additional supplies or in search of goods and services outside the park).

o Visits to different areas of the same park that involve crossing non-park lands.

o Visitors staying outside the park and making multiple daily visits.

o Visitors counted once upon entry to the park and again as overnight stays.

H. Definitions
The following definitions will be used in the Public Use Data Collecting and Reporting Program:

o <u>Miscellaneous area</u>: A property that is neither solely federally owned nor directly administered by the NPS, but which utilizes NPS assistance.

o <u>Overnight stay</u>: One night within a park by a visitor (a party of two visitors staying over for three nights yields six overnight stays). Overnight stays by inholders will not be recorded, as they are not on parkland.

The seven categories of overnight stays are described below:

o *Concessioner lodging*: Persons staying overnight in concessioner operated lodges, cabins, motels, and hotels (including youth or elder hostels).

o *Concessioner campground*: Persons staying overnight in concessioner operated trailer courts, recreational vehicle parks, and tent campgrounds.

o *Tent*: Campers in sleeping bags or soft-sided tents attached to a vehicle or erected in a NPS operated campground.

o *Recreational vehicle*: Campers in recreational vehicles including tent trailers at NPS operated campground.

o *Backcountry*: Campers in sleeping bags or soft-sided tents erected at undeveloped walk-in campsites not accessible by road.

o *Miscellaneous*: Campers in group camping areas, on boats, in undeveloped overflow areas, or in other areas not otherwise described above (except inholders).

o *Nonrecreation*: Overnight stays associated with nonrecreation visits (e.g., nights on board commercial fishing vessels off shore but within boundaries of NPS areas, or researchers on non-legislated NPS business).

o Visit: The entry of any person onto lands or waters administered by the NPS. A visitor is an individual who may generate one or more visits. The three categories of visits (recreation visit, non-recreation visit and non-reportable visit) are described in depth below.

o *Recreation visits*: Entries of persons onto lands or waters administered by the NPS, except non-recreation and nonreportable visits.

o *Non-recreation visits* include the following:

o Commuter and other through traffic.

o Persons going to and from inholdings across significant parts of parkland, including subsistence users.

o Trades-people with business in the park.

o Any civilian activity as a part of or incidental to the pursuit of a gainful occupation.

o Government personnel (other than NPS employees) with business in the park.

o Citizens using NPS buildings for civic or local government business, or attending public hearings. And

o Research activities independent of the legislated interests of the NPS and conducted on behalf of the NPS.

o *Nonreportable visits* include the following:

o Brief incidental entries into a park by passing traffic (vehicular or pedestrian) using NPS administered grounds, roads, or walkways.

o Employees of the NPS who are assigned to the park or are visiting the park in connection with their duty assignments.

o NPS contractors, concessionaires, Cooperating Associations and their employees.

o Temporary or permanent members in households of personnel otherwise included in this definition whose residence is within the park.

o Private tenants within NPS boundaries (inholders) if not crossing significant NPS territory for access.

o Any other persons whose presence in the park is to help the NPS fulfill its mission (e.g., Volunteers in the Parks, research activities associated with the NPS legislated mission, etc.). And

o People engaged in illegal activity.

o <u>Visitor day</u>: Twelve visitor hours.

o <u>Visitor hour</u>: The presence of one or more persons in a park for continuous, intermittent, or simultaneous periods of time aggregating one hour (one person for one hour or two persons for one-half hour each).

IV. Roles and Responsibilities

The responsibility for ensuring a reliable and accurate statistical reporting program lies with each park and the PUSO under the supervision of the Visiting Chief Social Scientist.

A. Superintendents

Park superintendents and their staffs are responsible for collecting, compiling, and reporting monthly public use data by the 15th of each month for the previous monthly reporting period directly to the Public Use Statistics Office. The park, using the approved database management software, will enter the data electronically. The park will save all backup or supplementary information designed to document or assist in the collection of his or her data, e.g., separate district reports. This information should be retained for three years in order to assist examination during audits and to trace errors when they occur.

B. Regional and Support Offices
Regional and Support offices are responsible for ensuring, if necessary, the timely submission of public use information by park areas in their jurisdiction.

C. Associate Director for Natural Resource Stewardship and Science (ADNRSS)
The ADNRSS will appoint the Visiting Chief Social Scientist and provide oversight and guidance for the Social Science Program, including the Public Use Data Collecting and Reporting Program.

D. Visiting Chief Social Scientist (VCSS)
The VCSS will report to the Associate Director for Natural Resource Stewardship and Science. The VCSS will:

o Provide leadership and direction to the social science activities of the NPS.

o Manage the NPS Social Science Program, which conducts and promotes state-of-the-art social science related to the mission of the National Park Service for the purpose of delivering usable knowledge to NPS managers and the public, including public use data collection and reporting.

o Act as a liaison with the USGS, the Department of the Interior, and other federal agencies on social science activities, including public use data collection and reporting.

o Perform other tasks as assigned by the ADNRSS. And,

o Advise the Director and National Leadership Council on social science issues, including those related to public use.

E. Public Use Statistics Office (PUSO)
The PUSO is responsible for Service wide quality control of public use collecting and reporting. It has the authority to determine the need for change regarding public use reporting and to issue specific directions to accomplish the necessary tasks. Through the ADNRSS, the PUSO will identify inappropriate practices at specific park areas and may exclude from publication any park statistical information that is unacceptable (in terms of nonconformity with definitions) or unverifiable (in terms of failure to verify conversion factors). The PUSO is responsible for the development of counting instructions and data

validity. It is also responsible for collecting and maintaining public use information and will publish the annual NPS Statistical Abstract.

The PUSO will provide and maintain the monthly reporting software and provide technical support to the park's staff on the software's proper use.

----------------- *End of Director's Order* ---------------

APPENDIX B

PUBLIC USE COUNTING AND REPORTING INSTRUCTIONS

Acadia National Park

PUBLIC USE COUNTING AND REPORTING INSTRUCTIONS

Following are detailed instructions for collecting and reporting data to be entered on Form 10-157, Revised, Monthly Public Use Report by Acadia National Park. These instructions are effective the date of issuance and will continue in effect unless changed by amendment or by memorandum from the Socio-Economic Studies Division to the superintendent approving a requested change.

Each item below describes the procedures to be followed in collecting public use data and summarizing the various elements of those data for entry on the corresponding line on the 10-157, Monthly Public Use Report.

Recreation Visits

Mount Desert Island Area

1. An inductive loop traffic counter (Station 4702)** is located on both southbound lanes of Loop Road, 20 feet north of Sand Beach Road. The traffic count at station 4702*** is multiplied by the vehicle expansion multiplier (Table 1)* to estimate the number of vehicles using all other recreation areas of the park but which do not cross this counter. The adjusted vehicle count is multiplied by the persons-per-vehicle (PPV) multiplier for recreation use (Table 2)*.

2. The number of visitors observed snowmobiling.

3. The number of visitors observed cross-country skiing.

4. The number of bus passengers is determined by multiplying the number of buses by the persons per bus multiplier of 45.

Isle au Haut

The number of visitors arriving by ferry from Stonington.

Schoodic Peninsula

An inductive loop traffic counter (station 4703)** is located 0.15 mile north of the park boundary on the access highway to Schoodic Peninsula. The traffic count is multiplied by the seasonal PPV multiplier for Recreation Use (Table 2).

* Source: Acadia National Park, 1990-1991 Visitor Survey, University of Vermont.
** Source: National Park Service, Professional Support Division B4ranch of Transportation.
***(If Stations 4702 or 4703 are inoperative, Table 4 estimates the number of vehicles that would have crossed the counter. Multiply the daily traffic count in Table 4 by the number of days the counter was inoperative. Add this count to the traffic count obtained for the days the counter was operative.)

Nonrecreation Visits

Mount Desert Island

Nonrecreation vehicles are estimated as one hundred vehicles per day May through October. There are a minimal number of nonrecreation vehicles the remaining months. The vehicle count is multiplied by the nonrecreation PPV multiplier (Table 2)

Recreation Visitor Hours

Mount Desert Island

1. Total recreation visits are multiplied by the length-of-stay (LOS) multiplier for recreation day use (Table 3)*.

2. Total overnight stays are multiplied by the appropriate LOS multiplier for recreation overnights (Table 3)*.

Isle au Haut

1. Total recreation visits are multiplied by the LOS multiplier for recreation day use (Table 3)*.

2. Total overnight stays are multiplied by the LOS multiplier for recreation overnights (Table 3)*.

Schoodic Peninsula

1. Total recreation visits are multiplied by the LOS multiplier for recreation day use (Table 3)*.

2. Total overnight stays are multiplied by the LOS multiplier for recreation overnights (Table 3)*.

Nonrecreation Visitor Hours

The total nonrecreation visits are multiplied by 1 hour.

Overnight Stays

NPS Campgrounds - Blackwoods Campground, Seawall Campground, Isle au Haut (tents only)

The actual number of tent or RV sites occupied are multiplied by the persons-per-site multiplier of 3.0.

NPS Miscellaneous - Blackwoods Group Camping, Seawall Group Camping.
The actual number of group campers are multiplied by the number of nights stayed.

Table 1
VEHICLE EXPANSION MULTIPLIERS BY MONTH*

MONTH	MULTIPLIER
January	1.8
February	1.8
March	2.2
April	2.5
May	2.6
June	2.7
July	2.7
August	2.7
September	2.6
October	2.5
November	2.4
December	1.8

* Source: Acadia National Park, 1990-1991 Visitor Survey, University of Vermont. Figures are rounded.

Table 2

PERSONS-PER-VEHICLE MULTIPLIERS FOR
RECREATION AND NONRECREATION USE BY MONTH*

MONTH	RECREATION USE PPV	NONREC USE PPV
January	2.0	1.5
February	2.0	1.5
March	2.0	1.5
April	2.8	2.0
May	3.0	2.0
June	3.0	2.0
July	3.0	2.0
August	3.0	2.0
September	3.0	2.0
October	3.0	1.5
November	2.8	1.5
December	2.0	1.5

Table 3

LENGTH-OF-STAY MULTIPLIERS BY SEASON*

SEASON	MONTH	Recreation Day Use	Recreation Overnights
SUMMER	January	5 HOURS	26.5 HOURS
	February		
	March		
FALL	April	6 HOURS	27 HOURS
	May		
	June		
WINTER	July	6.6 HOURS	28 HOURS
	August		
	September		
SPRING	October	5.8 HOURS	27.3 HOURS
	November		
	December		

Table 4

AVERAGE DAILY TRAFFIC COUNTS BY MONTH AND TRAFFIC COUNTER*

MONTH	4702 Sand Beach	4703 Schoodic Peninsula
January	75	50
February	86	75
March	115	100
April	245	125
May	491	200
June	969	275
July	1,961	450
August	2,224	500
September	1,345	350
October	558	200
November	162	100
December	65	50

*Source: National Park Service, Professional Support Division, Transportation Department, Denver, Colorado. Averages are derived from 1987 through 1990 data.

BIG BEND NATIONAL PARK

PUBLIC USE COUNTING AND REPORTING INSTRUCTIONS

Following are detailed instructions for collecting and reporting data to be entered on Form 10-157, Revised, Monthly Public Use Report by Big Bend National Park. These instructions are effective the date of issuance and will continue in effect unless changed by amendment or by memorandum from the Socio-Economic Studies Division to the superintendent approving a requested change.

Each item below describes the procedures to be followed in collecting public use data and summarizing the various elements of those data for entry on the corresponding line on the 10-157, Monthly Public Use Report.

Recreation Visits

1. An inductive loop traffic counter is located on Route 13 at the Maverick entrance.
2. An inductive loop traffic counter is located on Route 11 at the Persimmons Gap entrance.

The traffic counts in 1 and 2 are summed and reduced for the number of buses, nonrecreation vehicles (197 per month), and nonreportable vehicles (156 per month). The reduced traffic count is multiplied by the persons-per-vehicle multiplier of 2.9.

3. The number of bus passengers as recorded at the Lodge and the Front Desk.

Nonrecreation Visits

Nonrecreation visitors are estimated as 197 per month.

Recreation Visitor Hours

1. The total number of recreation visitors is multiplied by twelve hours.
2. The number of overnight stays is multiplied by twenty four hours.

Nonrecreation Visitor Hours

The number of nonrecreation visitors is multiplied by three hours.

Overnight Stays

Concessioner Lodging - The Lodge

The actual number of visitors staying overnight as reported by the concessioner.

Concessioner Campgrounds - RGV Trailer Park

The actual number of visitors staying overnight as reported by the concessioner.

NPS Campgrounds - Rio Grande Village, Basin, and Castolon Campgrounds

The number of overnight stays by tent and RV campers.

NPS Backcountry - River Use, Backcountry Roads, and Backcountry Miscellaneous Sites

The number of overnight stays by backcountry campers.

NPS Miscellaneous - Rio Grande Village, Basin, Castolon Group Campgrounds

The number of nights stayed by group campers.

Special Use Data

Line a. The number of vehicles on Route 13
Line b. The number of vehicles on Route 11
Line c. The number of river users
Line d. The number of other backcountry users
Line e. The number of backcountry road users
Line f. The number of visitors by horse
Line g. The number of bus passengers
Line n. The number of buses

GEORGE WASHINGTON MEMORIAL PARKWAY

PUBLIC USE COUNTING AND REPORTING INSTRUCTIONS

Following are detailed instructions for collecting and reporting data to be entered on Form 10-157, Revised, Monthly Public Use Report by George Washington Memorial Parkway. These instructions are effective the date of issuance and will continue in effect unless changed by amendment or by memorandum from the Socio-Economic Studies Division to the superintendent approving a requested change.

Each item below describes the procedures to be followed in collecting public use data and summarizing the various elements of those data for entry on the corresponding line on the 10-157, Monthly Public Use Report.

Recreation Visits

1. An inductive loop vehicle counter is located on the entrance lane of the access road leading to the Belle Haven unit. The vehicle count is multiplied by a persons-per-vehicle (PPV) multiplier of 1.45.

2. An inductive loop vehicle counter is located on the entrance lane of the access road leading to the Daingerfield Island unit. The vehicle count is multiplied by a PPV multiplier of 1.64.

3. An inductive loop vehicle counter is located on the entrance lane of the access road leading to the Fort Hunt Park unit. The vehicle count is multiplied by a PPV multiplier of 1.68.

4. An inductive loop vehicle counter is located on the entrance lane of the access road leading to the Fort Marcy unit. The vehicle count is multiplied by a PPV multiplier of 1.76.

5. An inductive loop vehicle counter is located on the entrance lane of the access road leading to the Gravelly Point unit. The vehicle count is multiplied by a PPV multiplier of 2.5.

6. An inductive loop vehicle counter is located on the entrance lane of the access road leading to the Riverside Park unit. The vehicle count is multiplied by a PPV multiplier of 2.5.

7. An inductive loop vehicle counter is located on the entrance lane of the access road leading to the Turkey Run Park unit (Picnic Area). The vehicle count is multiplied by a PPV multiplier of 1.24.

8. .An inductive loop vehicle counter is located on the entrance lane of the access road leading to the United States Marine Corps War Memorial unit. The vehicle count is reduced for buses (see Table 1) and the reduced vehicle count is multiplied by a PPV multiplier of 2.18.

9. An inductive loop vehicle counter is located on the entrance lane of the access road leading to the Great Falls Park unit. The vehicle count is multiplied by a PPV multiplier of 2.58.

10. The number of persons attending programs at Glen Echo Park.

11. The number of admissions to the Mount Vernon Estate reported by Mount Vernon Ladies Association.

12. The number of visitors to Claude Moore Colonial Farm from concessionaire.

13. The number of bicyclist at Crystal City, Bellehaven, and Daingerfield Island.

Non-recreation Visits

1. A Branch of Transportation (BRTR) inductive loop traffic counter (Station 60010 Lanes 3 and 4) is located south of I-495 west of the intersection to Turkey Run Park Headquarters. The vehicle count is multiplied by the PPV multiplier of 1.2[1].

2. A Branch of Transportation (BRTR) inductive loop traffic counter (Station 6005 Lanes 1 and 2) is located north of Chain Bridge adjacent to the Little Falls Pumping Station. The vehicle count is divided by two to compensate for vehicles crossing the counters on the same day. The adjusted vehicle count is multiplied by the PPV multiplier of 1.2[1].

3. A Branch of Transportation (BRTR) inductive loop traffic counter (Station 60021 Lane 1) is located north of the intersection to National Airport. The vehicle count is multiplied by the PPV multiplier of 1.2[1].

4. A Branch of Transportation (BRTR) inductive loop traffic counter (Station 60023 Lane 2,3,4,5) is located north of the intersection to National Airport. The vehicle count is divided by two to estimate the number of vehicles on lanes 2 and 3 only. The adjusted vehicle count is multiplied by the PPV multiplier of 1.2[1].

If any of the traffic counters are inoperative, use Table 3 to estimate the daily traffic counts. Multiply the daily traffic counts by the number of days the counter was inoperative and add it to the monthly traffic count.

Recreation Visitor Hours

Recreation visitor hours are the sum of the subtotals of each of the categories listed in Table 2. Each subtotal is the results of multiplying the number of visitors associated with that category by its length-of-stay multiplier.

Special Use Data

Line a. Bellehaven visitors
Line b. Daingerfield visitors
Line c. Fort Hunt visitors
Line d. Fort Marcy visitors
Line e. Gravelly Point visitors
Line f. Riverside Park visitors
Line g. Turkey Run Park visitors
Line h. USMC Memorial visitors
Line i. Great Falls Park visitors
Line j. Glen Echo Park visitors
Line k. Mount Vernon visitors
Line l. Claude Moore Farm visitors

Table 1
Vehicle Reduction Factors for Buses (U.S. Marine Corp Memorial)

MONTH	REDUCTION FACTOR
January	9%
February	8%
March	12%
April	13%
May	13%
June	13%
July	17%
August	14%
September	10%
October	10%
November	10%
December	9%

Table 2
Average Length-of-Stay Multipliers by Category

CATEGORY	AVERAGE LENGTH-OF-STAY (in Hours)
Belle Haven	1.00
Daingerfield Island	1.00
Fort Hunt Park	3.00
Fort Marcy	.50
Gravelly Point	.25
Riverside Park	1.00
Turkey Run Park (Picnic Area)	2.00
Bicyclist	1.00
U.S. Marine War Memorial	.25
Great Falls Park	3.00
Glen Echo Park	4.00
Mount Vernon Estate	2.00
Claude Moore Colonial Farm	2.00

NPS Backcountry - Bright Angel, Cottonwood, Indian Gardens, River Users, and Miscellaneous locations.

The number of visitors is multiplied by the number of nights stayed as determined by permits issued.

NPS Miscellaneous - Mather, North Rim

The number of group campers is multiplied by the number of nights stayed.

Special Use Data

Line a. Visitors entering at Desert View
Line b. Visitors entering at South Entrance
Line c. Visitors entering at North Rim
Line n. The number of tour buses

YELLOWSTONE NATIONAL PARK

PUBLIC USE REPORTING AND COUNTING INSTRUCTIONS

Following are detailed instructions for collecting and reporting data to be entered on Form 10-157, Revised, Monthly Public Use Report by Yellowstone National Park. These instructions are effective the date of issuance and will continue in effect unless changed by amendment or by memorandum from the Socio-Economic Studies Division to the superintendent approving a requested change.

Each item below describes the procedures to be followed in collecting public use data and summarizing the various elements of those data for entry on the corresponding line on the 10-157, Monthly Public Use Report.

Recreation Visits

North Gate

1. An inductive loop traffic counter is located on the entrance lane at the North Gate. The traffic count is reduced for the number of non-recreation vehicles and non-reportable vehicles. The reduced traffic count is multiplied by the persons-per-vehicle (PPV) multiplier in Table 1.

2. The number of visitors arriving by bus.

3. The number of visitors arriving by bicycle, foot, or cross-country skis.

West Gate

1. An inductive loop traffic counter is located on the entrance lane at the West Gate. The traffic count is reduced for the number of non-recreation vehicles and non-reportable vehicles. The reduced traffic count is multiplied by the PPV multiplier in Table 1.

2. The number of visitors arriving by bus.

3. The number of visitors arriving by bicycle, foot, or cross-country skis.

4. The number of visitors arriving by snowmobile.

5. The number of visitors arriving by snow coach.

January 27, 1995

South Gate

1. An inductive loop traffic counter is located on the entrance lane at the South Gate. The traffic count is reduced for the number of non-recreation vehicles and non-reportable vehicles. The reduced traffic count is multiplied by the PPV multiplier in Table 1.

2. The number of visitors arriving by bus.

3. The number of visitors arriving by bicycle, foot, or cross-country skis.

4. The number of visitors arriving by snowmobile.

5. The number of visitors arriving by snow coach.

East Gate

1. An inductive loop traffic counter is located on the entrance lane at the East Gate. The traffic count is reduced for the number of non-recreation vehicles and non-reportable vehicles. The reduced traffic count is multiplied by the PPV multiplier in Table 1.

2. The number of visitors arriving by bus.

3. The number of visitors arriving by bicycle, foot, or cross-country skis.

4. The number of visitors arriving by snowmobile.

5. The number of visitors arriving by snow coach.

Northeast Gate

1. An inductive loop traffic counter is located on the entrance lane at the Northeast Gate. The traffic count is reduced for the number of non-recreation vehicles and non-reportable vehicles. The reduced traffic count is multiplied by the PPV multiplier in Table 1.

2. The number of visitors arriving by bus.

3. The number of visitors arriving by bicycle, foot, or cross-country skis.

Table 1
Persons-Per-Vehicle Multipliers by Month and Location

MONTH	LOCATION				
	NORTH GATE	WEST GATE	SOUTH GATE	EAST GATE	NORTHEAST GATE
JANUARY	2.75	N/A	N/A	N/A	N/A
FEBRUARY	2.75	N/A	N/A	N/A	N/A
MARCH	2.75	N/A	N/A	N/A	N/A
APRIL	2.75	2.7	2.5	2.3	2.2
MAY	2.75	2.7	2.5	2.3	2.5
JUNE	3.0	3.1	2.9	2.8	2.75
JULY	3.0	3.1	2.9	2.8	2.75
AUGUST	3.0	3.1	2.9	2.8	2.75
SEPTEMBER	2.6	2.4	2.5	2.3	2.5
OCTOBER	2.3	2.4	2.5	2.3	2.5
NOVEMBER	2.3	2.4	2.4	2.3	N/A
DECEMBER	2.3	N/A	N/A	N/A	N/A

Non-recreation Visits

1. The number of non-recreation vehicles entering the park from the North, South, East, West, and Northeast entrances is multiplied by the non-recreation PPV multiplier of 1.2.

2. The traffic count on Highway 191 is multiplied by 0.93 to estimate the number of non-recreation vehicles entering the park. The vehicle count is multiplied by the PPV multiplier of 1.2.

Recreation Visitor Hours

Recreation visitor hours are the sum of the subtotals of each of the categories listed in Table 2. Each subtotal is the result of multiplying the number of visitors associated with that category by its length-of-stay multiplier.

January 27, 1995

Table 2
Average Length of Stay Multipliers by Category

CATEGORY	AVERAGE LENGTH-OF-STAY
Day Use	12.0 Hours Per Visit
Overnight Stays	24.0 Hours Per Overnight Stay

Non-recreation Visitor Hours

The total number of non-recreation visitors is multiplied by four hours.

Overnight Stays

Concessioner Lodging - Old Faithful Inn, Old Faithful Lodge, Old Faithful Snowlodge, Grant Village Lodge, Lake Hotel, Lake Lodge, Canyon Lodge, Roosevelt Lodge, and Mammoth Hotel

The number of overnight stays at concessioner managed lodges.

Concessioner Campgrounds - Fishing Bridge RV Park

The number of overnight stays at concessioner managed campground.

NPS Campgrounds - Bridge Bay, Mammoth, Canyon, Norris, Grant Village, Pebble Creek, Indian Creek, Slough Creek, Lewis Lake, Tower Fall, and Madison

The number of tent of RV sites occupied is multiplied by the persons-per-site multiplier of 2.3.

NPS Backcountry - Miscellaneous backcountry sites.

The number of backcountry overnight stays as determined by permits issued.

NPS Miscellaneous - Bridge Bay and Grant Village

The number of overnight stays at group camping areas.

Special Use Data

Line a. North Gate Visits
Line b. West Gate Visits
Line c. South Gate Visits
Line d. East Gate Visits
Line e. Northeast Gate Visits
Line f. Snowmobile Visits
Line g. Snow coach Visits
Line n. The number of tour buses

YOSEMITE NATIONAL PARK

PUBLIC USE COUNTING AND REPORTING INSTRUCTIONS

Following are detailed instructions for collecting and reporting data to be entered on Form 10-157, Revised, Monthly Public Use Report by Yosemite National park. These instructions are effective the date of issuance and will continue in effect unless changed by amendment or by memorandum from the Socio-Economic Studies Division to the superintendent approving a requested change.

Each item below describes the procedures to be followed in collecting public use data and summarizing the various elements of those data for entry on the corresponding line on the 10-157, Monthly Public Use Report.

Recreation Visits

1. An inductive loop traffic counter (Lane 1, station 4802) is located on the entrance lane at the Arch Rock Entrance. The traffic count is reduced for non-reportable vehicles (14 percent), non-recreation vehicles (14 percent), and buses. The reduced traffic count is multiplied by the persons-per-vehicle (PPV) multiplier of 2.9.

2. An inductive loop traffic counter (Lane 1, station 4801) is located on the entrance lane at the South Entrance. The traffic count is reduced for non-reportable vehicles (7 percent), non-recreation vehicles (7 percent), and buses. The reduced traffic count is multiplied by the PPV multiplier of 2.9.

3. An inductive loop traffic counter is located on the entrance lane at the Big Oak Entrance. The traffic count is reduced for non-reportable vehicles (7 percent) and buses. The reduced traffic count is multiplied by the PPV multiplier of 2.9.

   Currently this counter is broken and the park is using the traffic count from Crane Flat (Lane 6, station 4805). The traffic count is used in the multiple regression factor of 4600 + (0.6874 * traffic count). This factor was developed by park staff and is a temporary factor.

4. An inductive loop traffic counter (Lane 2, station 4806) is located on the entrance lane at Tioga Pass Entrance. The traffic count is reduced for non-recreation vehicles (4 percent) and buses. The reduced traffic count is multiplied by the PPV multiplier of 2.9.

5. An inductive loop traffic counter (Lane 1, station 4807) is located on the entrance lane at Hetch Hetchy Entrance. The traffic count is reduced for non-reportable vehicles 23 percent), non-recreation vehicles (4 percent), and buses. The reduced traffic count is multiplied by the PPV multiplier of 2.9.

6. The number of visitors that enter the park by bus.

Non-recreation Visits

1. The traffic count at Arch Rock Entrance is reduced for buses. The reduced traffic count is multiplied by four percent to estimate the number of non-recreation vehicles. The vehicle count is multiplied by the PPV multiplier of 2.0.

2. The traffic count at the South Entrance is reduced for buses. The reduced traffic count is multiplied by seven percent to estimate the number of non-recreation vehicles. The vehicle count is multiplied by the PPV multiplier of 2.0.

3. The traffic count at Big Oaks Entrance is reduced for buses. The reduced traffic count is multiplied by four percent to estimate the number of non-recreation vehicles. The vehicle count is multiplied by the PPV multiplier of 2.0.

4. The traffic count at Tioga Pass Entrance is reduced for buses. The reduced traffic count is multiplied by four percent to estimate the number of non-recreation vehicles. The vehicle count is multiplied by the PPV multiplier of 2.0.

5. The traffic count at Hetch Hetchy Entrance is reduced for buses. The reduced traffic count is multiplied by four percent to estimate the number of non-recreation vehicles. The vehicle count is multiplied by the PPV multiplier of 2.0.

Recreation Visitor Hours

1. The number of recreation visitors is multiplied by 5.0 hours.

2. The number of overnight stays is multiplied by 28.0 hours.

Non-recreation Visitor Hours

1. The number of non-recreation visitors entering at Arch Rock is multiplied by 31.34 hours.

2. The number of non-recreation visitors entering at the South Entrance is multiplied by 29.77 hours.

3. The number of non-recreation visitors entering at Big Oak Flat is multiplied by 16.64 hours.

4. The number of non-recreation visitors entering at Tioga Pass is multiplied by 16.64 hours.

5. The number of non-recreation visitors entering at Hetch Hetchy is multiplied by 16.64 hours.

Overnight Stays

Concessioner Lodging - Hotel Wawona, Housekeeping Camp, Tuolumne Meadows Lodge, and White Wolf Lodge

The number of visitors staying overnight as reported by the concessioner.

NPS Campgrounds - Wawona, Bridalveil Creek, Hodgdon Meadow, Crane Meadow, Tamarack Flat, White Wolf, Yosemite Creek, Porcupine Flat, Tuolumne Meadows, HH Backpackers, Sunnyside, YV Backpackers, Upper River, Lower River, Upper Pines, Lower Pines, and North Pines

The number of sites occupied by tent and RV campers is multiplied by the persons per site multiplier of 4.0 except Sunnyside and YV Backpackers which is the actual number of overnight stays.

NPS Backcountry - Miscellaneous sites

The number of overnight stays by backcountry campers as determined from backcountry permits.

NPS Miscellaneous - Wawona, Bridalveil Creek, Tuolumne Meadows, and Yosemite Valley Group Campgrounds and Wawona, Bridalveil Creek, and Tuolumne Meadows Horse Camps

The number of nights stayed by group campers and visitors at Horse Camps.

Special Use Data

Line a. The number of vehicles entering at Arch Rock
Line b. The number of vehicles entering at South Entrance
Line c. The number of vehicles entering at Big Oak Flat
Line d. The number of vehicles entering at Tioga Pass
Line e. The number of vehicles entering at Hetch Hetchy
Line f. The number of campers at Valley camping areas
Line g. The number of campers outside of Valley camping areas
Line h. The number of group campers
Line i. The number of vehicles at Glacier Point
Line j. The number of vehicles at Big Trees
Line k. The number of bus passengers
Line n. The number of buses

APPENDIX C

AERIAL VIEWS OF THE DATA COLLECTION STATIONS

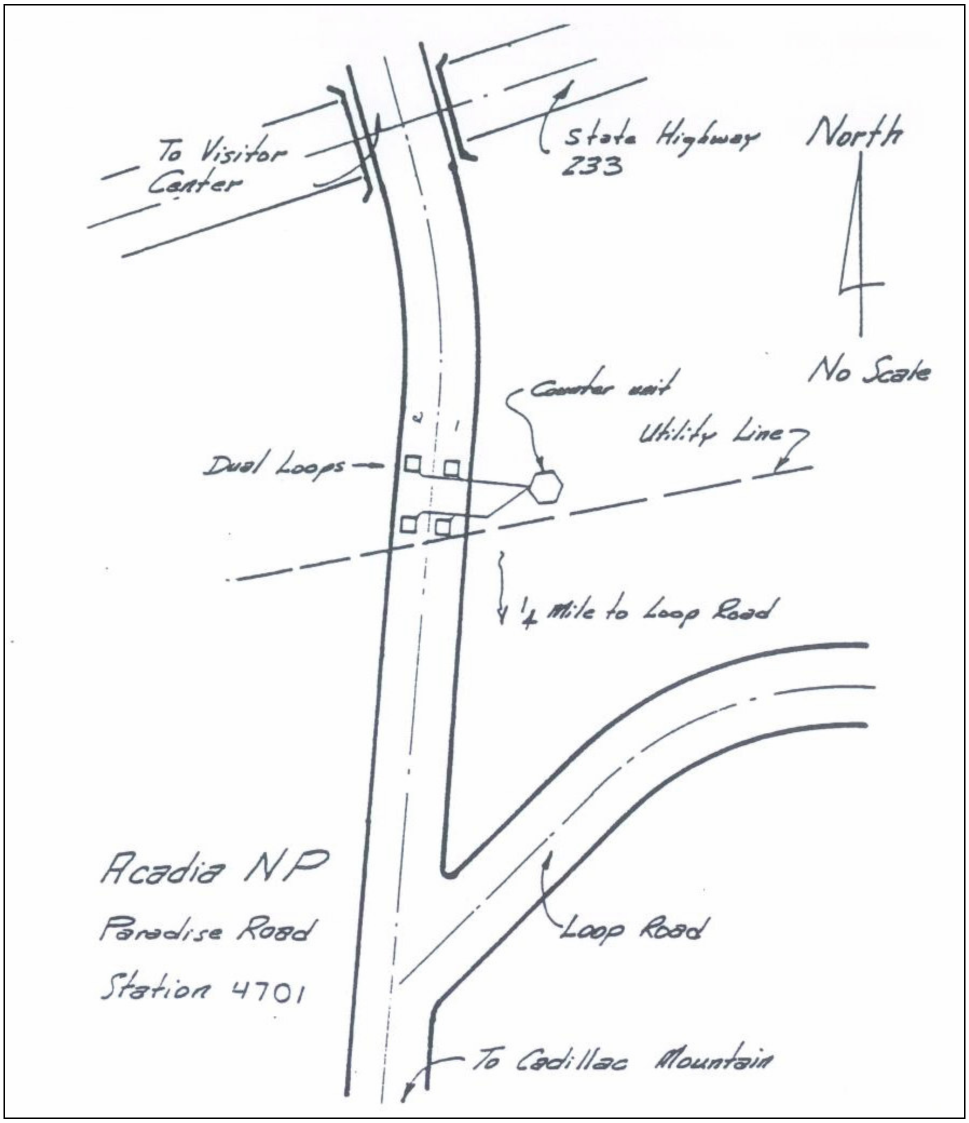


Fig. 30. Aerial View of Station 4701 in Acadia National Park (NPS 2003)

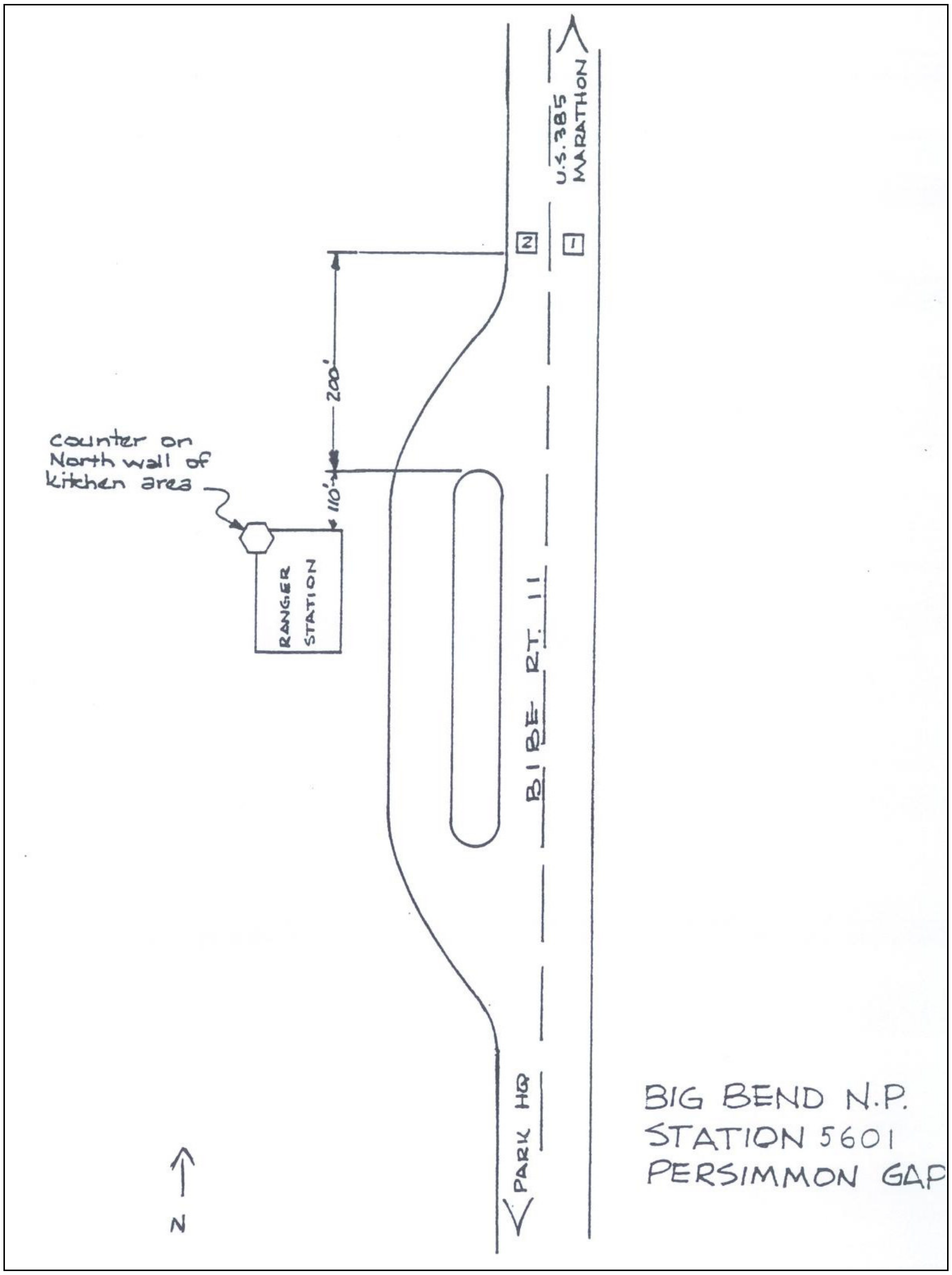


Fig. 31. Aerial View of Station 5601 in Big Bend National Park (NPS 1993a)

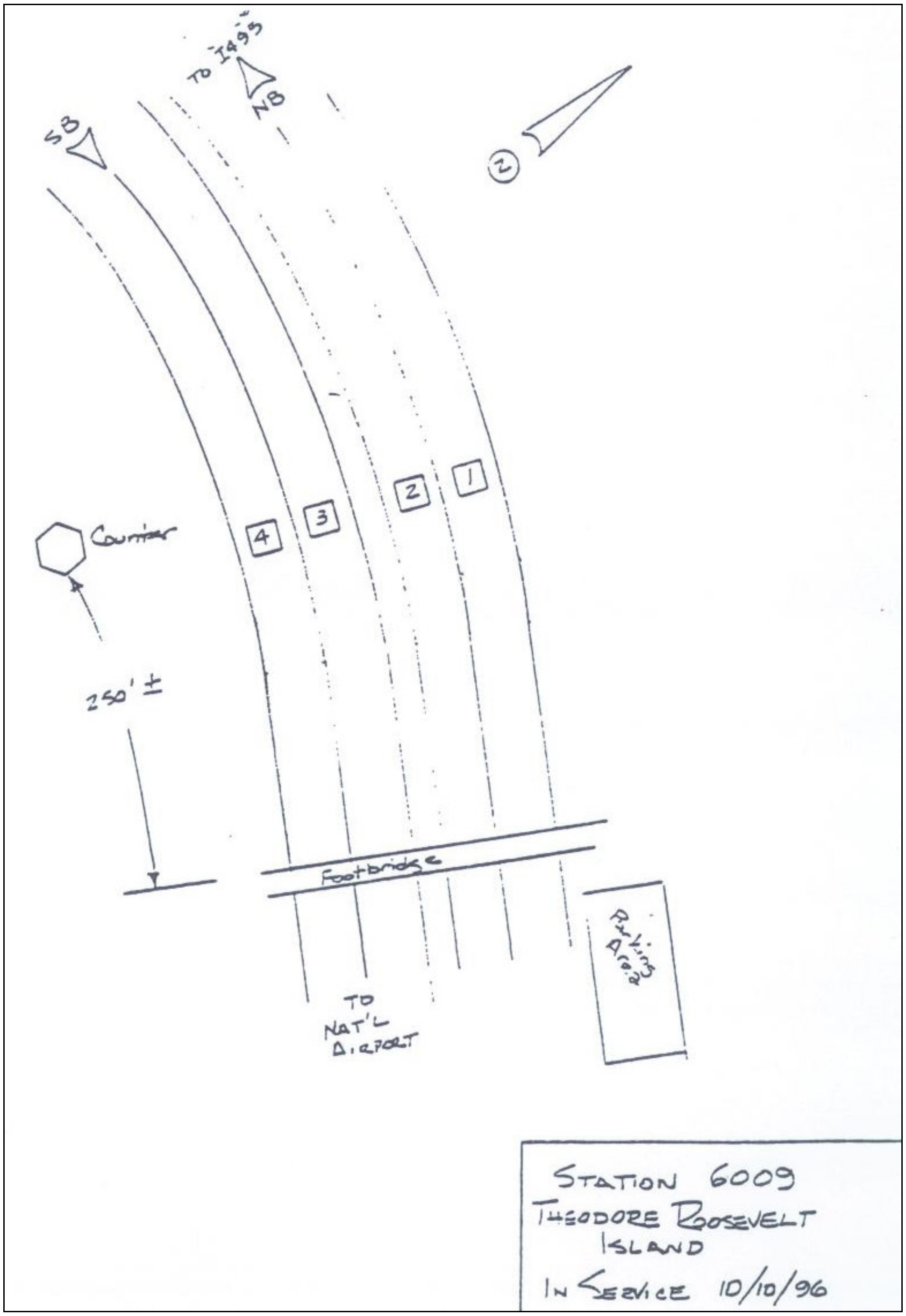


Fig. 32. Aerial View of Station 6009 on George Washington Memorial Parkway (NPS 2002)

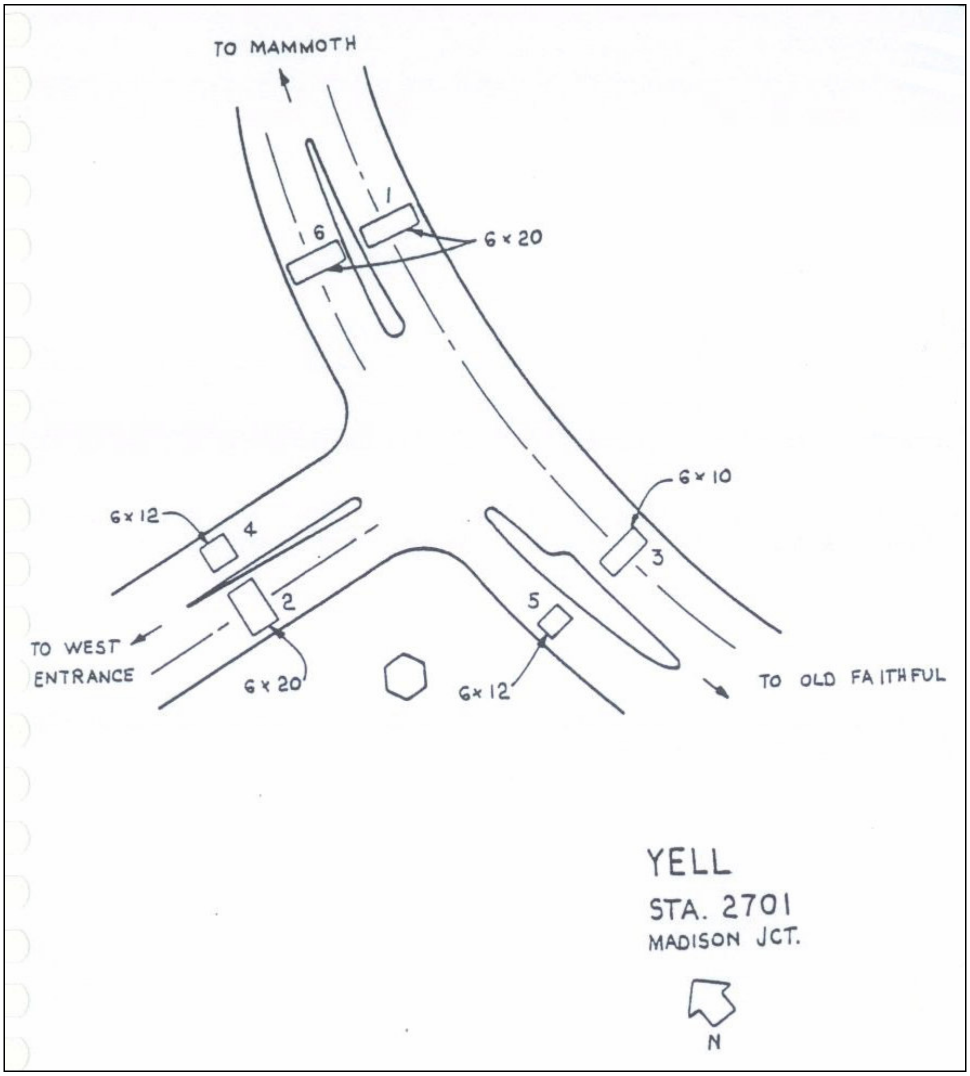
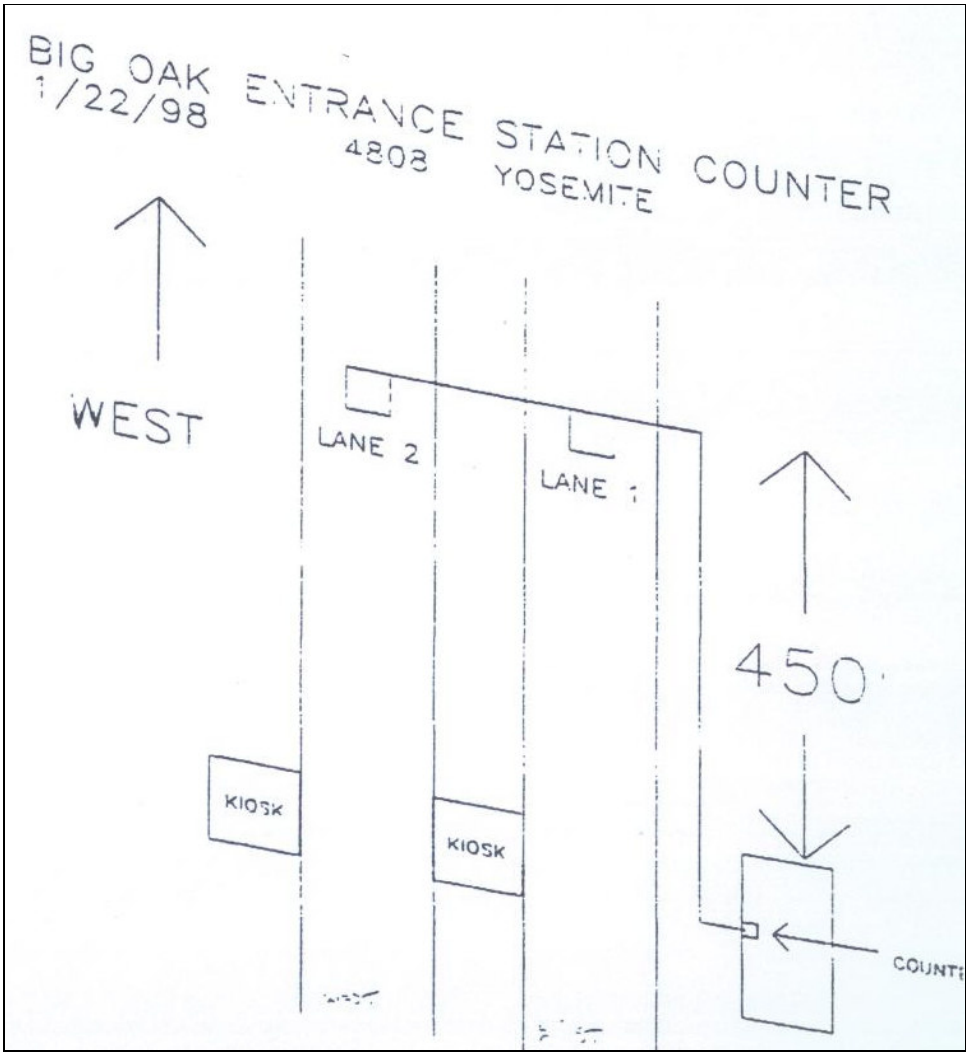


Fig. 33. Aerial View of Station 2701 in Yellowstone National Park (NPS 1995)



NOTE: The arrow labeled “west” actually points in the east direction.

Fig. 34. Aerial View of Station 4808 in Yosemite National Park (NPS 1993b)

APPENDIX D

SEASONAL AND DAY-OF-WEEK FACTORS

Table 12. Seasonal and Day-of-Week Factors for Acadia National Park in 2002

Day of Week and Month[1]	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
May	1.7	2.2	3.3	3.1	3.5	3.0	1.7
June	1.4	1.2	1.3	1.4	1.1	1.2	1.1
July	0.7	0.8	0.7	0.6	0.6	0.7	0.8
August	0.6	0.6	0.6	0.6	0.6	0.7	0.7
September	0.9	1.2	1.0	1.0	0.9	1.1	0.9
October	1.1	1.6	1.4	1.7	1.7	1.4	1.2

[1] Data are not available for November through April due to park closure.

Table 13. Seasonal and Day-of-Week Factors for Acadia National Park in 2003

Day of Week and Month[1]	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
May	1.5	2.4	2.8	2.9	3.4	3.1	1.8
June	1.1	1.0	0.9	1.1	1.2	1.0	1.0
July	0.6	0.7	0.6	0.6	0.6	0.7	0.6
August	N/A[2]	N/A	N/A	N/A	N/A	N/A	N/A
September	N/A	N/A	N/A	N/A	N/A	N/A	N/A
October	N/A	N/A	N/A	N/A	N/A	N/A	N/A

[1] Data are not available for November through April due to park closure.
[2] An "N/A" means that data are not available for that particular day of week and month of year.

Table 14. Seasonal and Day-of-Week Factors for Acadia National Park in 2004

Day of Week and Month[1]	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
May	1.8	3.9	3.7	2.9	2.8	3.1	1.8
June	N/A[2]	N/A	N/A	N/A	N/A	N/A	N/A
July	0.6	0.8	0.7	0.7	0.8	0.9	0.8
August	0.7	0.7	0.6	0.6	0.7	0.8	0.8
September	0.7	0.8	1.1	1.0	1.1	1.1	0.9
October	1.1	1.3	1.6	1.3	1.5	1.6	1.2

[1] Data are not available for November through April due to park closure.
[2] An "N/A" means that data are not available for that particular day of week and month of year.

Table 15. Seasonal and Day-of-Week Factors for Acadia National Park in 2005

Day of Week and Month[1]	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
May	2.6	3.7	3.2	3.9	4.0	2.7	2.0
June	1.0	1.1	1.1	1.2	1.3	1.4	1.0
July	0.6	0.7	0.6	0.7	0.7	0.8	0.7
August	0.7	0.7	0.6	0.6	0.5	0.6	0.6
September	0.8	0.9	1.1	0.9	1.1	1.1	0.9
October	1.6	1.5	1.5	1.3	1.6	1.6	1.5

[1] Data are not available for November through April due to park closure.

Table 16. Seasonal and Day-of-Week Factors for Acadia National Park in 2006

Day of Week and Month[1]	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
May	1.2	2.4	3.2	3.1	3.5	3.5	1.6
June	1.1	1.2	0.9	1.1	1.4	1.2	1.5
July	0.5	0.5	0.7	0.6	0.6	0.6	0.6
August	N/A[2]	N/A	N/A	N/A	N/A	N/A	N/A
September	N/A	N/A	N/A	0.8	0.9	1.7	0.6
October	0.9	1.3	1.3	1.3	1.4	1.2	0.9

[1] Data are not available for November through April due to park closure.

[2] An "N/A" means that data are not available for that particular day of week and month of year.

Table 17. Seasonal and Day-of-Week Factors for Big Bend National Park in 2002

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	1.1	1.2	1.1	1.1	1.1	1.0	1.1
February	0.9	0.8	1.0	0.9	0.8	0.7	0.7
March	0.4	0.4	0.5	0.5	0.5	0.5	0.4
April	0.8	0.8	0.9	0.9	0.6	0.7	0.7
May	1.0	1.2	1.2	1.3	1.2	0.9	0.9
June	1.3	1.2	1.5	1.5	1.7	1.5	1.5
July	1.8	1.5	1.6	1.6	1.4	1.4	1.7
August	1.9	1.9	2.0	2.0	1.6	1.4	1.4
September	1.7	1.7	2.4	1.9	1.8	1.8	1.8
October	1.2	1.2	1.3	1.3	1.1	0.9	1.1
November	1.0	1.1	1.2	0.8	0.7	0.9	0.9
December	1.0	1.0	1.3	1.5	1.0	0.9	0.9

Table 18. Seasonal and Day-of-Week Factors for Big Bend National Park in 2003

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	1.2	1.1	1.2	1.1	1.0	1.0	0.9
February	0.9	0.9	1.0	0.9	0.9	0.8	0.9
March	0.5	0.4	0.5	0.5	0.5	0.6	0.5
April	0.8	0.8	0.9	0.8	0.7	0.6	0.7
May	1.0	1.1	1.2	1.2	1.1	0.9	1.1
June	1.7	1.2	1.2	N/A[1]	N/A	1.6	1.4
July	1.8	1.6	1.7	1.7	1.5	1.2	1.3
August	2.2	1.8	2.1	2.1	1.8	1.5	1.5
September	1.7	1.6	1.8	1.7	1.5	1.4	1.5
October	1.2	1.0	1.2	1.3	0.9	0.9	0.9
November	1.0	1.0	1.1	0.8	0.7	0.8	0.8
December	0.9	1.0	1.0	1.1	1.3	0.9	0.8

[1] An "N/A" means that data are not available for that particular day of week and month of year.

Table 19. Seasonal and Day-of-Week Factors for Big Bend National Park in 2004

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	1.1	1.1	1.2	1.2	1.0	1.1	0.9
February	1.0	0.9	0.9	0.9	0.9	0.8	0.8
March	0.4	0.5	0.5	0.6	0.6	0.6	0.4
April	0.9	0.8	0.8	0.8	0.8	0.6	0.7
May	1.1	1.2	1.3	1.2	1.1	0.9	0.9
June	N/A[1]	N/A	N/A	N/A	N/A	N/A	N/A
July	1.9	1.8	1.9	2.0	1.9	1.5	1.4
August	2.3	2.0	2.1	2.1	2.0	1.8	2.1
September	1.7	1.6	1.9	1.7	1.8	1.2	1.2
October	1.2	1.2	1.3	1.3	1.1	1.0	1.0
November	1.0	1.3	1.3	0.7	0.6	0.8	0.8
December	0.9	0.8	0.9	0.9	1.1	1.0	0.9

[1] An "N/A" means that data are not available for that particular day of week and month of year.

Table 20. Seasonal and Day-of-Week Factors for Big Bend National Park in 2005

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	1.4	1.1	1.1	1.0	1.1	0.9	1.0
February	0.9	0.7	1.0	0.9	0.8	0.7	0.8
March	0.4	0.4	0.5	0.5	0.5	0.5	0.4
April	0.7	0.8	0.8	0.8	0.7	0.6	0.7
May	1.1	1.1	1.2	1.1	1.0	0.9	0.9
June	1.5	1.3	1.6	1.3	1.6	1.4	1.5
July	1.6	1.6	1.6	1.7	1.9	1.5	1.4
August	2.2	1.6	2.1	2.0	1.9	1.8	2.2
September	1.9	1.9	1.8	2.3	1.7	1.2	1.2
October	1.4	1.2	1.4	1.4	1.2	1.0	1.3
November	1.0	1.1	1.2	0.9	0.7	0.7	0.8
December	1.6	1.0	0.9	1.0	1.1	1.1	1.1

Table 21. Seasonal and Day-of-Week Factors for Big Bend National Park in 2006

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	1.4	1.0	1.2	1.1	1.0	1.0	0.9
February	1.0	0.7	0.9	0.9	0.8	0.7	0.8
March	0.4	0.4	0.5	0.6	0.5	0.6	0.4
April	0.8	0.7	0.8	0.9	0.7	0.6	0.8
May	1.3	1.2	1.3	1.4	1.3	1.0	0.9
June	1.7	1.7	1.9	2.0	1.7	1.5	1.8
July	1.5	1.6	1.8	1.5	2.0	1.9	1.4
August	2.2	2.2	2.2	2.5	2.2	1.9	2.0
September	1.5	1.7	1.9	1.8	1.7	1.3	1.3
October	1.1	1.1	1.2	1.2	0.9	0.8	1.0
November	1.0	0.9	1.1	0.8	0.6	0.6	0.8
December	1.3	1.3	0.9	0.7	0.8	1.1	1.0

Table 22. Seasonal and Day-of-Week Factors for George Washington Memorial Parkway in 2002

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	1.9	1.1	1.0	0.9	0.9	0.9	1.7
February	1.7	1.0	0.9	0.9	0.9	0.9	1.4
March	1.6	0.9	0.9	0.9	0.9	0.9	1.4
April	1.5	0.9	0.9	0.9	0.8	0.8	1.3
May	1.4	1.0	0.9	0.8	0.8	0.8	1.4
June	1.4	0.9	0.8	0.8	0.8	0.8	1.3
July	1.5	0.9	0.9	0.8	1.0	0.9	1.4
August	1.6	0.9	0.9	0.9	0.9	0.9	1.5
September	1.6	1.0	0.9	0.9	0.8	0.9	1.3
October	1.5	1.0	0.9	0.9	0.8	0.8	1.4
November	1.6	1.0	0.9	0.9	1.0	0.9	1.4
December	1.5	0.9	1.0	1.2	1.1	0.9	1.4

Table 23. Seasonal and Day-of-Week Factors for George Washington Memorial Parkway in 2003

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	1.9	1.0	0.9	1.0	0.9	0.9	1.5
February	2.1	1.2	1.1	1.0	1.0	1.1	1.7
March	1.6	0.9	0.9	0.9	0.9	0.9	1.3
April	1.3	0.9	0.9	0.8	0.8	0.8	1.3
May	1.5	1.0	0.8	0.8	0.8	0.8	1.4
June	1.3	0.8	0.8	0.8	0.8	0.8	1.3
July	1.4	0.9	0.8	0.8	0.8	0.9	1.3
August	1.5	0.9	0.9	0.8	0.8	0.8	1.5
September	1.5	1.0	0.9	0.9	1.0	1.0	1.4
October	1.4	0.9	0.8	0.8	0.8	0.8	1.3
November	1.5	0.9	0.9	0.9	1.0	0.9	1.3
December	1.8	0.9	0.9	0.9	0.8	0.9	1.4

Table 24. Seasonal and Day-of-Week Factors for George Washington Memorial Parkway in 2004

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	N/A[1]	N/A	N/A	N/A	N/A	N/A	1.5
February	1.6	1.0	0.9	0.9	0.8	0.9	1.4
March	1.4	1.0	0.9	0.9	0.9	0.8	1.3
April	1.4	0.9	0.8	0.8	0.8	0.8	1.3
May	1.4	0.8	0.8	0.8	0.8	0.8	1.3
June	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July	1.5	1.0	0.8	0.8	0.8	0.8	1.4
August	1.5	0.9	0.8	0.8	0.8	0.8	1.4
September	1.5	1.0	0.8	0.8	0.8	0.8	1.4
October	1.4	0.9	0.8	0.8	0.8	0.8	1.3
November	1.5	0.9	0.8	0.8	1.0	0.9	1.4
December	1.6	0.9	0.9	0.9	0.9	1.0	1.4

[1] An "N/A" means that data are not available for that particular day of week and month of year.

Table 25. Seasonal and Day-of-Week Factors for George Washington Memorial Parkway in 2005

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	2.1	1.0	0.9	0.9	1.0	0.9	1.8
February	1.7	1.1	0.9	0.9	0.9	0.9	1.5
March	1.6	0.9	0.9	0.9	0.9	0.9	1.4
April	N/A[1]	N/A	N/A	N/A	N/A	N/A	N/A
May	1.4	1.0	0.9	0.8	0.8	0.8	1.3
June	1.4	0.9	0.8	0.8	0.8	0.8	1.3
July	1.5	1.0	0.9	0.8	0.8	0.9	1.4
August	1.5	0.9	0.9	0.9	0.8	0.9	1.4
September	1.6	1.0	0.9	0.9	0.8	0.9	1.4
October	1.5	1.0	0.9	0.9	0.8	0.9	1.4
November	1.5	0.9	0.9	0.9	1.0	1.0	1.4
December	1.8	1.0	0.9	0.9	0.9	1.0	1.5

[1] An "N/A" means that data are not available for that particular day of week and month of year.

Table 26. Seasonal and Day-of-Week Factors for George Washington Memorial Parkway in 2006

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	1.8	1.1	0.9	0.9	0.9	0.9	1.5
February	2.0	1.0	0.9	0.9	0.9	0.9	1.7
March	1.5	0.9	0.9	0.9	0.9	0.8	1.4
April	1.4	0.9	0.9	0.9	0.8	0.9	1.4
May	1.4	1.0	0.9	0.9	0.9	0.9	1.3
June	1.4	0.9	0.9	0.8	0.8	0.8	1.3
July	1.5	1.0	1.0	0.9	0.8	0.8	1.4
August	1.6	0.9	0.9	0.9	0.9	0.9	1.5
September	1.6	1.0	0.9	0.9	0.9	0.9	1.5
October	1.5	0.9	0.9	0.8	0.8	0.9	1.4
November	1.6	0.9	0.9	0.9	1.0	1.0	1.4
December	1.7	1.1	0.9	0.9	0.9	0.9	1.4

Table 27. Seasonal and Day-of-Week Factors for Yellowstone National Park in 2002

Day of Week and Month[1]	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
April	6.9	7.5	8.7	10.4	11.0	7.5	6.7
May	1.1	1.3	1.5	1.7	1.6	1.4	1.1
June	0.7	0.7	0.7	0.6	0.6	0.6	0.7
July	0.5	0.5	0.5	0.5	0.5	0.5	0.5
August	0.6	0.6	0.6	0.6	0.6	0.6	0.6
September	0.7	0.8	0.7	0.8	0.8	0.8	0.7
October	1.6	2.0	2.0	2.2	2.3	1.9	1.4
November	19.1	36.2	32.4	33.2	35.8	23.3	22.3

[1] Data are not available for December through March due to park closure.

Table 28. Seasonal and Day-of-Week Factors for Yellowstone National Park in 2003

Day of Week and Month[1]	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
April	6.2	7.0	9.3	9.2	12.1	6.6	6.4
May	1.2	1.5	1.7	1.6	1.8	1.5	1.2
June	0.7	0.7	0.7	0.7	0.6	0.6	0.6
July	0.5	0.5	0.5	0.5	0.5	0.5	0.5
August	0.6	0.6	0.6	0.6	0.6	0.6	0.6
September	0.7	0.8	0.8	0.8	0.8	0.8	0.7
October	1.4	2.1	2.2	2.0	1.9	1.6	1.1
November	18.4	36.8	40.5	41.5	49.7	54.6	22.2

[1] Data are not available for December through March due to park closure.

Table 29. Seasonal and Day-of-Week Factors for Yellowstone National Park in 2004

Day of Week and Month[1]	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
April	6.1	7.5	7.4	8.7	9.3	5.3	5.6
May	1.1	1.6	1.5	1.5	1.4	1.2	1.1
June	N/A[2]	N/A	N/A	N/A	N/A	N/A	N/A
July	0.5	0.5	0.5	0.5	0.5	0.5	0.5
August	0.5	0.6	0.5	0.5	0.5	0.5	0.5
September	0.6	0.7	0.7	0.8	0.7	0.6	0.5
October	1.6	2.0	2.0	2.1	2.0	1.6	1.4
November	16.4	18.0	16.7	17.4	19.2	18.6	15.2

[1] Data are not available for December through March due to park closure.

[2] An "N/A" means that data are not available for that particular day of week and month of year.

Table 30. Seasonal and Day-of-Week Factors for Yellowstone National Park in 2005

Day of Week and Month[1]	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
April	8.4	9.5	10.1	11.3	11.8	7.5	6.2
May	1.1	1.4	1.5	1.7	1.7	1.4	1.0
June	0.7	0.6	0.6	0.6	0.6	0.7	0.6
July	0.5	0.5	0.5	0.5	0.5	0.5	0.5
August	0.6	0.6	0.6	0.6	0.5	0.6	0.6
September	0.7	0.8	0.8	0.8	0.8	0.8	0.7
October	1.9	2.2	2.4	2.5	2.3	2.0	1.5
November	27.4	33.6	21.5	21.1	28.9	27.8	21.8

[1] Data are not available for December through March due to park closure.

Table 31. Seasonal and Day-of-Week Factors for Yellowstone National Park in 2006

Day of Week and Month[1]	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
April	12.0	12.6	12.0	12.3	12.5	5.6	5.8
May	1.1	1.5	1.6	1.5	1.6	1.4	1.1
June	0.7	0.7	0.6	0.6	0.7	0.7	0.7
July	0.5	0.5	0.5	0.5	0.5	0.5	0.5
August	0.6	0.6	0.6	0.6	0.6	0.6	0.6
September	0.6	0.7	0.7	0.8	0.8	0.8	0.6
October	1.5	2.4	2.6	2.3	2.0	1.7	1.5
November	20.4	69.0	59.8	28.7	27.5	25.1	17.4

[1] Data are not available for December through March due to park closure.

Table 32. Seasonal and Day-of-Week Factors for Yosemite National Park in 2002

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	3.0	5.6	5.2	5.0	4.5	2.5	1.9
February	2.3	3.5	5.3	4.8	4.0	2.3	1.5
March	2.3	2.7	2.9	2.9	2.6	1.6	1.4
April	1.1	1.6	1.7	1.7	1.5	0.9	0.8
May	0.6	0.8	1.0	1.0	0.9	0.5	0.5
June	0.6	0.7	0.8	0.8	0.7	0.5	0.5
July	0.5	0.7	0.7	0.6	0.5	0.4	0.4
August	0.5	0.6	0.7	0.7	0.6	0.4	0.4
September	0.6	0.8	1.0	1.0	0.8	0.4	0.5
October	0.9	1.2	1.4	1.4	1.2	0.6	0.6
November	1.9	2.7	3.1	2.7	2.6	1.3	1.3
December	3.1	3.7	4.5	4.5	4.2	3.2	2.9

Table 33. Seasonal and Day-of-Week Factors for Yosemite National Park in 2003

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	2.9	5.5	5.5	3.6	4.0	2.5	1.8
February	2.0	3.7	5.0	4.6	4.6	2.0	1.6
March	1.9	2.8	2.8	2.8	2.5	1.7	1.3
April	1.4	1.7	1.9	1.8	1.8	1.1	1.0
May	0.6	0.8	1.0	1.1	1.0	0.7	0.6
June	0.5	0.7	0.7	0.7	0.7	0.4	0.4
July	0.5	0.6	0.7	0.6	0.5	0.4	0.4
August	0.5	0.6	0.7	0.7	0.6	0.4	0.4
September	0.7	0.8	1.0	1.0	0.8	0.4	0.5
October	0.8	1.2	1.4	1.3	1.2	0.6	0.6
November	2.2	3.3	3.1	2.7	2.6	1.6	1.6
December	2.9	4.1	4.1	4.5	5.4	3.0	2.5

Table 34. Seasonal and Day-of-Week Factors for Yosemite National Park in 2004

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	2.8	5.3	5.9	5.8	5.4	2.5	2.1
February	2.2	4.7	5.5	6.8	4.9	2.6	1.7
March	1.3	2.4	2.5	2.4	2.5	1.6	1.0
April	0.9	1.2	1.2	1.2	1.3	0.8	0.7
May	0.5	0.9	1.0	0.9	0.8	0.5	0.5
June	N/A[1]	N/A	N/A	N/A	N/A	N/A	N/A
July	0.5	0.5	0.6	0.6	0.6	0.4	0.4
August	0.5	0.6	0.7	0.6	0.5	0.4	0.4
September	0.6	0.7	0.9	0.9	0.8	0.4	0.4
October	1.0	1.2	1.6	1.5	1.2	0.7	0.7
November	2.2	3.6	3.5	3.0	2.4	1.5	1.7
December	2.6	3.3	3.7	3.6	3.6	3.3	2.6

[1] An "N/A" means that data are not available for that particular day of week and month of year.

Table 35. Seasonal and Day-of-Week Factors for Yosemite National Park in 2005

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	3.4	6.5	8.0	7.7	6.7	4.1	2.4
February	2.9	4.5	6.3	5.9	4.6	2.6	1.9
March	1.9	2.6	3.1	2.8	2.4	1.9	1.5
April	1.4	1.8	1.9	2.0	1.8	1.1	1.0
May	0.6	0.8	1.0	1.1	1.1	0.6	0.5
June	0.4	0.5	0.6	0.6	0.6	0.5	0.4
July	0.4	0.6	0.6	0.6	0.6	0.4	0.4
August	0.5	0.6	0.7	0.7	0.6	0.4	0.4
September	0.6	0.8	1.0	1.0	0.9	0.5	0.5
October	0.9	1.2	1.4	1.4	1.2	0.7	0.7
November	1.7	3.1	3.2	2.6	1.9	1.2	1.1
December	3.5	3.6	3.5	4.3	3.8	3.4	3.3

Table 36. Seasonal and Day-of-Week Factors for Yosemite National Park in 2006

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	2.8	5.7	6.3	7.4	6.5	3.3	2.8
February	2.6	3.5	5.2	5.6	5.1	2.3	1.8
March	2.6	4.3	5.8	4.9	4.2	3.1	2.6
April	1.9	2.3	2.3	2.2	1.8	1.3	1.2
May	0.5	0.7	0.9	0.9	0.9	0.5	0.4
June	0.5	0.6	0.7	0.6	0.6	0.5	0.4
July	0.4	0.5	0.6	0.6	0.5	0.4	0.4
August	0.5	0.6	0.7	0.6	0.6	0.4	0.4
September	0.6	0.7	1.0	1.0	0.8	0.5	0.5
October	0.9	1.3	1.6	1.4	1.2	0.7	0.7
November	1.8	3.1	3.2	2.3	2.2	1.1	1.3
December	3.9	4.4	4.4	4.2	3.5	3.1	2.5

APPENDIX E

P-VALUES FOUND USING THE STATISTICAL SOFTWARE PACKAGE *R*

Table 37. P-Values for Acadia National Park

Day of Week and Month[1]	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
May	0.08258	0.49165	0.74506	0.44710	0.45652	0.80843	0.51516
June	0.49913	0.26552	0.09878	0.31296	0.64123	0.04309	0.42804
July	0.03403	0.03926	0.02209	0.14957	0.05312	0.52248	0.02930
August	0.82596	0.97963	0.54753	0.84627	0.19665	0.78840	0.98352
September	0.17656	0.02746	0.30371	0.76363	0.44391	0.50821	0.83599
October	0.33491	0.96150	0.96899	0.60306	0.82398	0.94024	0.63576

[1] Data are not available for November through April due to park closure.

Table 38. P-Values for Big Bend National Park

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	0.22352	0.25674	0.54372	0.31048	0.62984	0.72415	0.82539
February	0.97094	0.43701	0.62205	0.92170	0.56812	0.78082	0.82941
March	0.91686	0.65804	0.72752	0.64161	0.50800	0.62818	0.65368
April	0.71321	0.81320	0.52754	0.81688	0.49316	0.88249	0.30922
May	0.40153	0.70612	0.78198	0.43275	0.28539	0.84237	0.74110
June	0.62739	0.13115	0.02593	0.04406	0.67720	0.95269	0.31638
July	0.66195	0.35819	0.77261	0.31035	0.06628	0.55232	0.61756
August	0.51648	0.12388	0.69386	0.41463	0.25329	0.57002	0.21077
September	0.77126	0.14326	0.09947	0.33871	0.82950	0.65087	0.48363
October	0.06623	0.41876	0.56625	0.77457	0.16570	0.13298	0.32697
November	0.91054	0.55401	0.93465	0.93674	0.91351	0.53432	0.89208
December	0.57008	0.93270	0.78241	0.44474	0.84054	0.90795	0.87655

Table 39. P-Values for George Washington Memorial Parkway

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	0.64666	0.93717	0.51088	0.70640	0.18304	0.14271	0.59105
February	0.82075	0.73505	0.01362	0.07821	0.07532	0.01259	0.04822
March	0.35552	0.37422	0.87094	0.07647	0.49150	0.84363	0.82108
April	0.23498	0.87936	0.38071	0.31027	0.86618	0.16501	0.79366
May	0.38627	0.13759	0.09114	0.09048	0.01610	0.35990	0.47807
June	0.09838	0.03568	0.19133	0.50162	0.07023	0.08770	0.19725
July	0.45553	0.08457	0.04933	0.54069	0.26230	0.64685	0.35547
August	0.09913	0.00914	0.32475	0.11948	0.01760	0.16551	0.90607
September	0.81915	0.64530	0.75596	0.96795	0.36981	0.54585	0.21589
October	0.74375	0.99658	0.26145	0.81066	0.08223	0.02072	0.72691
November	0.46535	0.20636	0.69963	0.81496	0.81323	0.49853	0.53082
December	0.27850	0.70840	0.37508	0.83470	0.59847	0.65898	0.45242

Table 40. P-Values for Yellowstone National Park

Day of Week and Month[1]	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
April	0.91238	0.94621	0.90018	0.98127	0.98384	0.83813	0.96643
May	0.89168	0.88895	0.96309	0.91154	0.76493	0.80240	0.95242
June	0.88313	0.77550	0.66424	0.83635	0.98401	0.99475	0.92457
July	0.08796	0.05040	0.00509	0.01802	0.01518	0.04930	0.06800
August	0.64312	0.82047	0.71037	0.48135	0.51631	0.59902	0.68005
September	0.16967	0.65366	0.43902	0.67258	0.75842	0.05405	0.06532
October	0.95427	0.94460	0.92302	0.98295	0.95462	0.92423	0.91591
November	0.54556	0.00669	0.03116	0.10179	0.74555	0.34424	0.31683

[1] Data are not available for December through March due to park closure.

Table 41. P-Values for Yosemite National Park

Day of Week and Month	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	0.82238	0.70712	0.19226	0.05018	0.08927	0.03830	0.19477
February	0.59889	0.96498	0.80879	0.17592	0.77771	0.45938	0.68274
March	0.07231	0.38719	0.09747	0.13652	0.27438	0.07768	0.07125
April	0.00903	0.12684	0.15503	0.10972	0.17506	0.20268	0.11022
May	0.57290	0.84844	0.93893	0.46357	0.58771	0.09660	0.66274
June	0.01552	0.01807	0.02948	0.07799	0.09996	0.33806	0.22855
July	0.36659	0.00334	0.00737	0.13320	0.68608	0.31973	0.87029
August	0.88884	0.89080	0.83363	0.83262	0.78080	0.72948	0.93980
September	0.73269	0.58382	0.72798	0.18853	0.46143	0.02836	0.34251
October	0.72621	0.97874	0.92295	0.98592	0.99253	0.87956	0.76368
November	0.40794	0.42860	0.98765	0.89730	0.63599	0.32845	0.15072
December	0.81617	0.93052	0.98181	0.98412	0.92165	0.90457	0.88202

APPENDIX F

RELATION BETWEEN THE NATIONAL PARK AND NEARBY ATR TRAFFIC VOLUMES

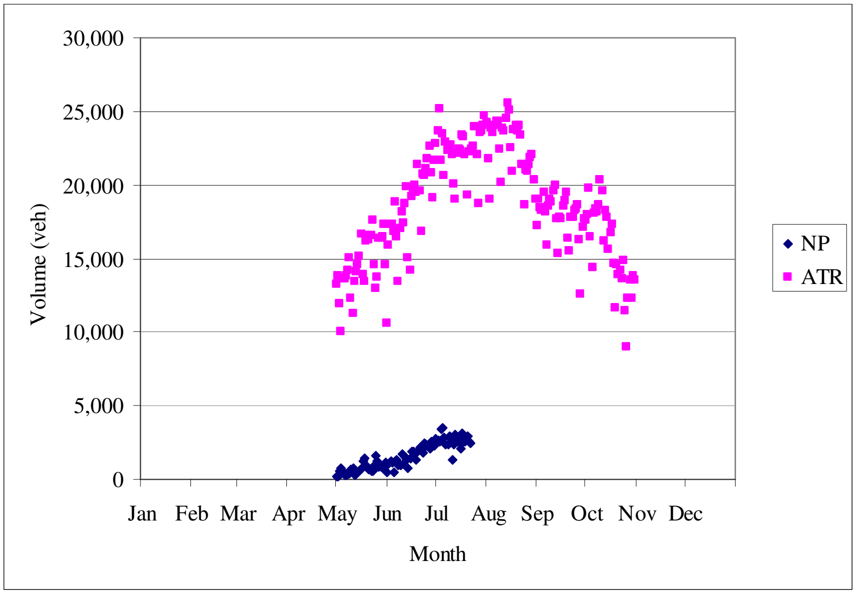


Fig. 35. Daily Traffic Volumes for Acadia National Park and Nearby ATR in 2003

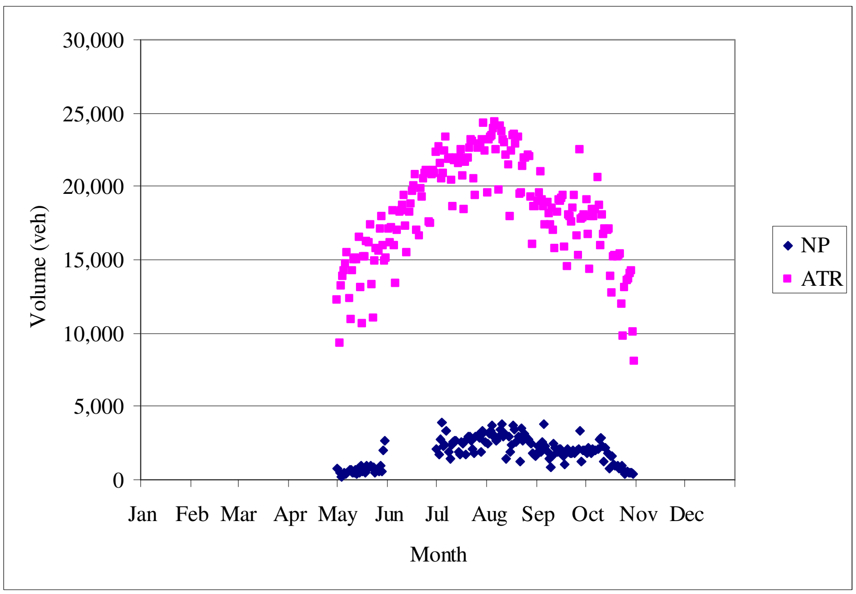


Fig. 36. Daily Traffic Volumes for Acadia National Park and Nearby ATR in 2004

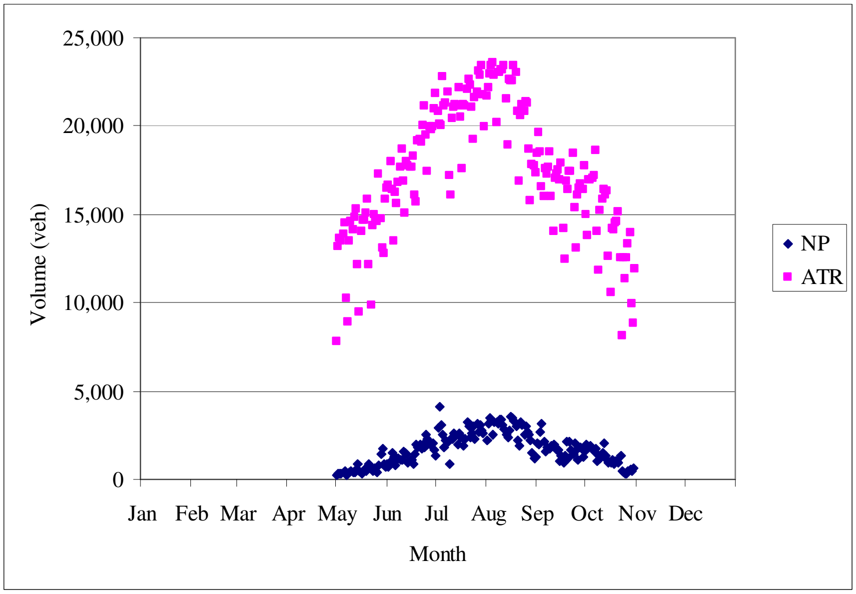


Fig. 37. Daily Traffic Volumes for Acadia National Park and Nearby ATR in 2005

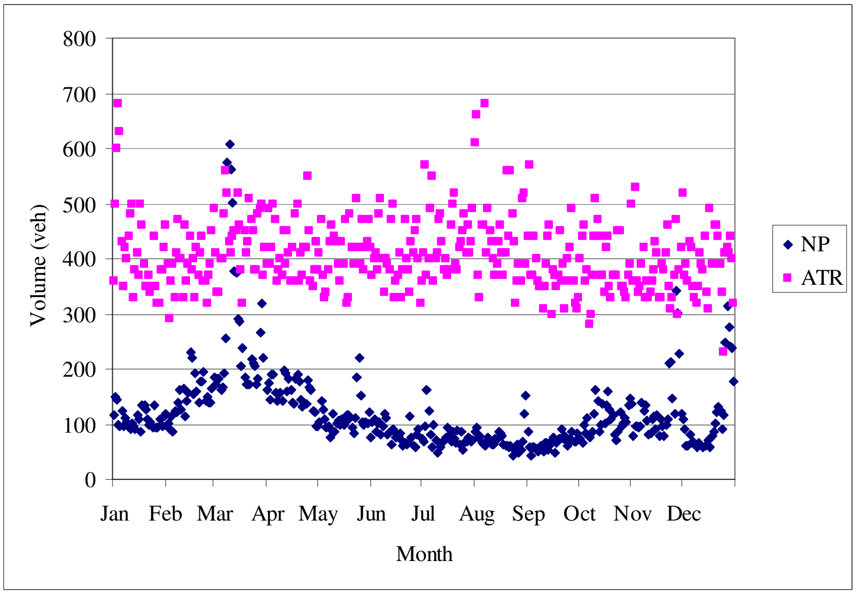


Fig. 38. Daily Traffic Volumes for Big Bend National Park and Nearby ATR in 2002

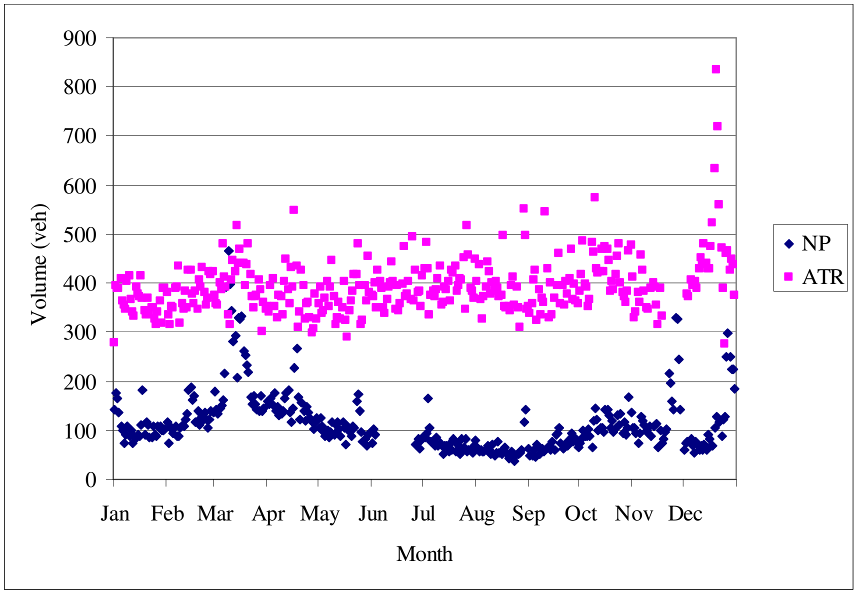


Fig. 39. Daily Traffic Volumes for Big Bend National Park and Nearby ATR in 2003

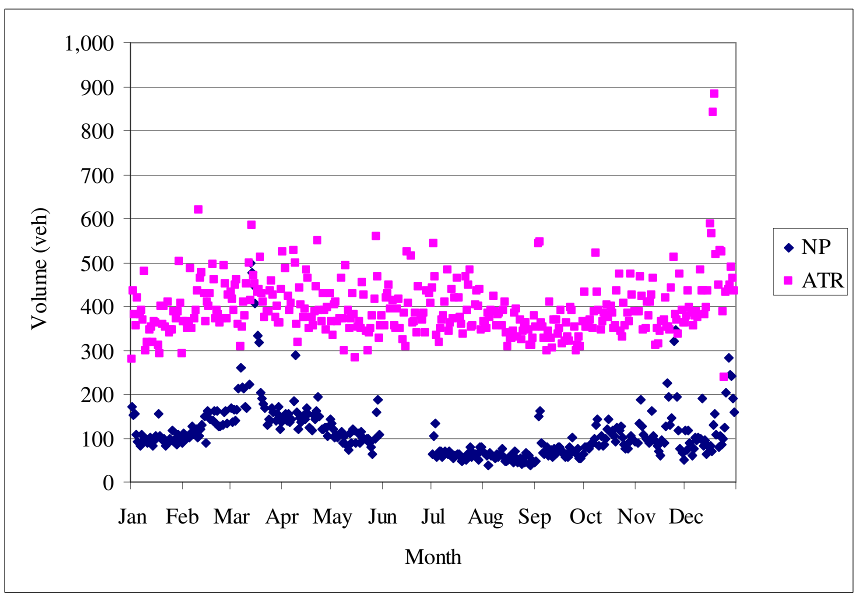


Fig. 40. Daily Traffic Volumes for Big Bend National Park and Nearby ATR in 2004

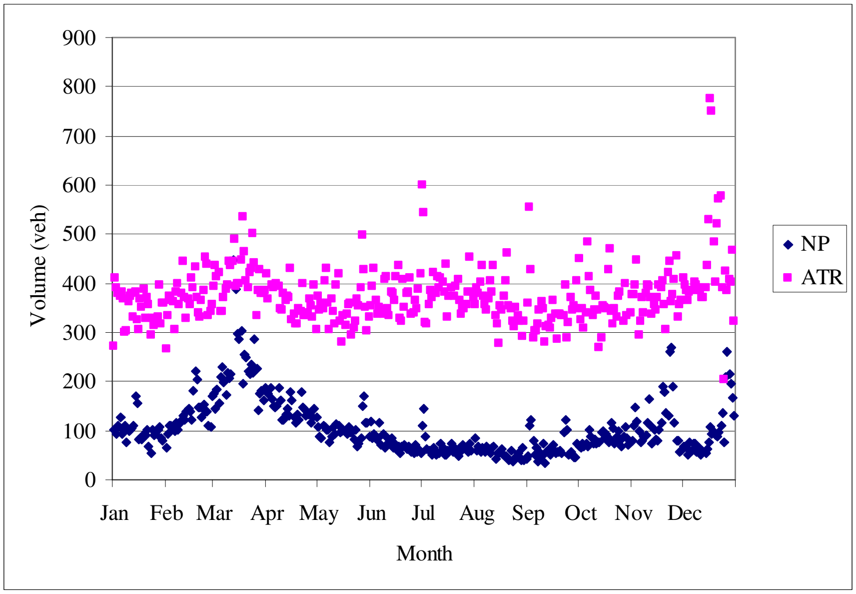


Fig. 41. Daily Traffic Volumes for Big Bend National Park and Nearby ATR in 2005

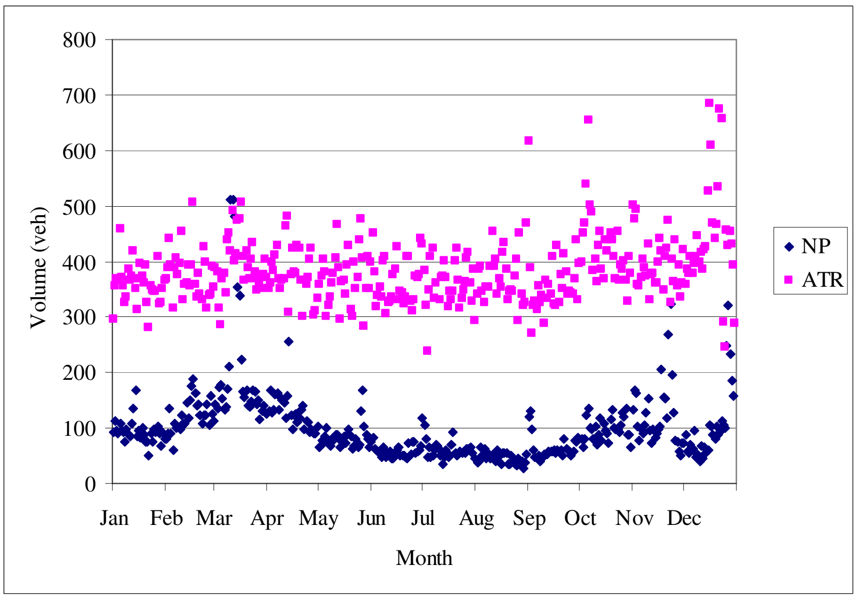


Fig. 42. Daily Traffic Volumes for Big Bend National Park and Nearby ATR in 2006

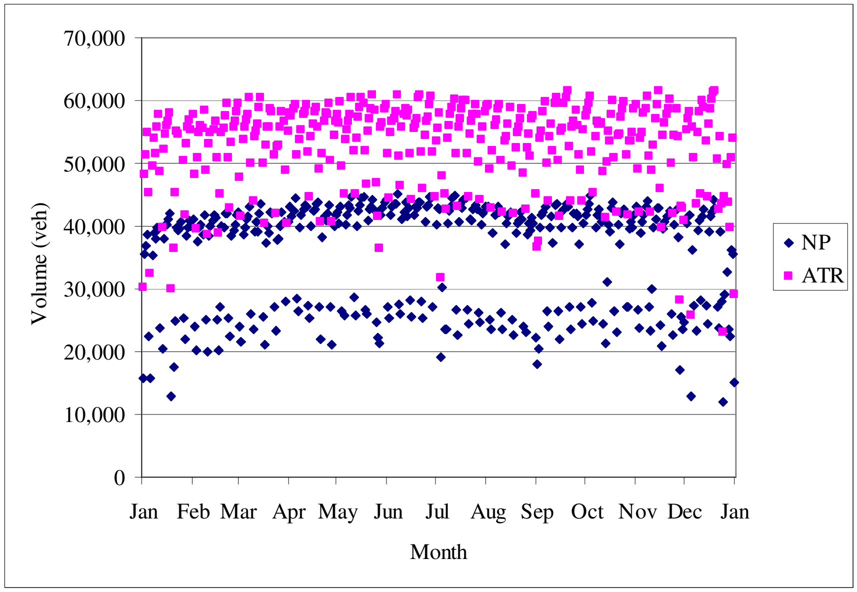


Fig. 43. Daily Traffic Volumes for George Washington Memorial Parkway and Nearby ATR in 2002

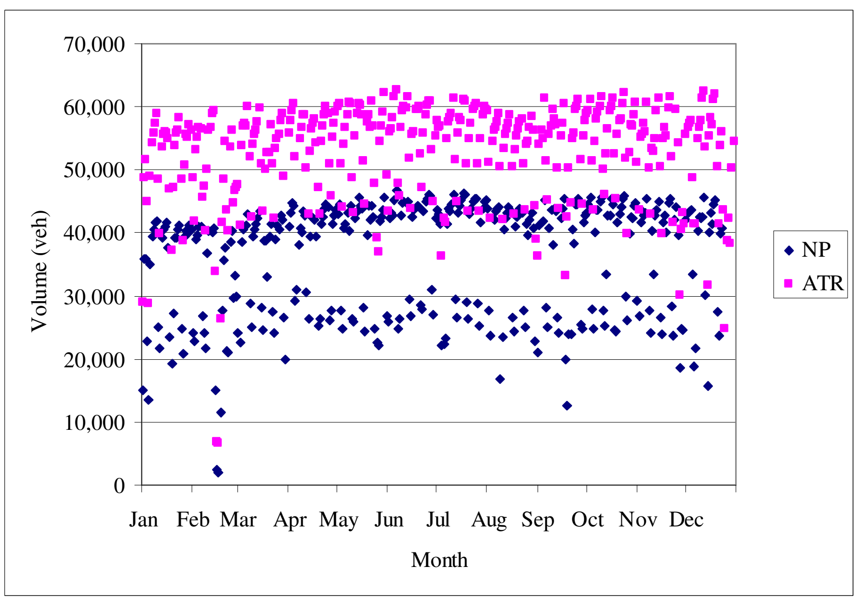


Fig. 44. Daily Traffic Volumes for George Washington Memorial Parkway and Nearby ATR in 2003

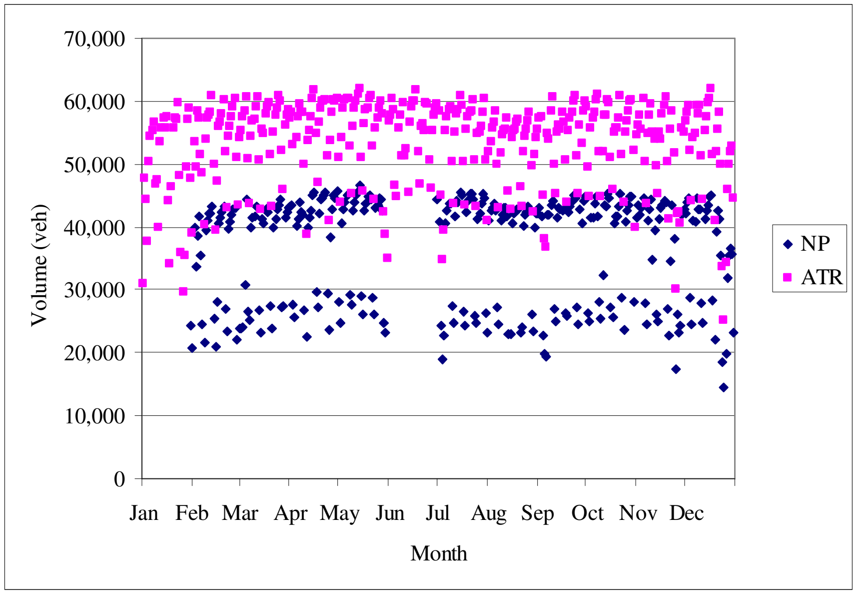


Fig. 45. Daily Traffic Volumes for George Washington Memorial Parkway and Nearby ATR in 2004

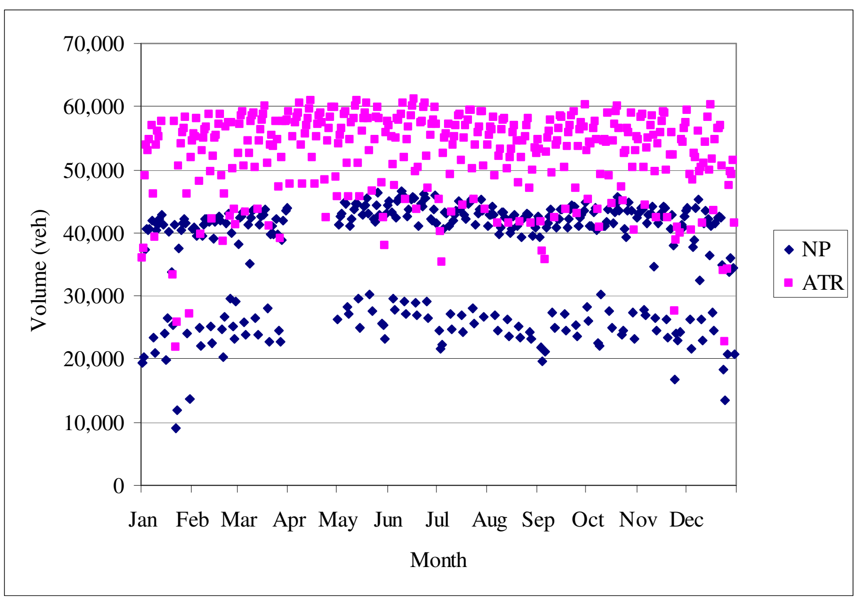


Fig. 46. Daily Traffic Volumes for George Washington Memorial Parkway and Nearby ATR in 2005

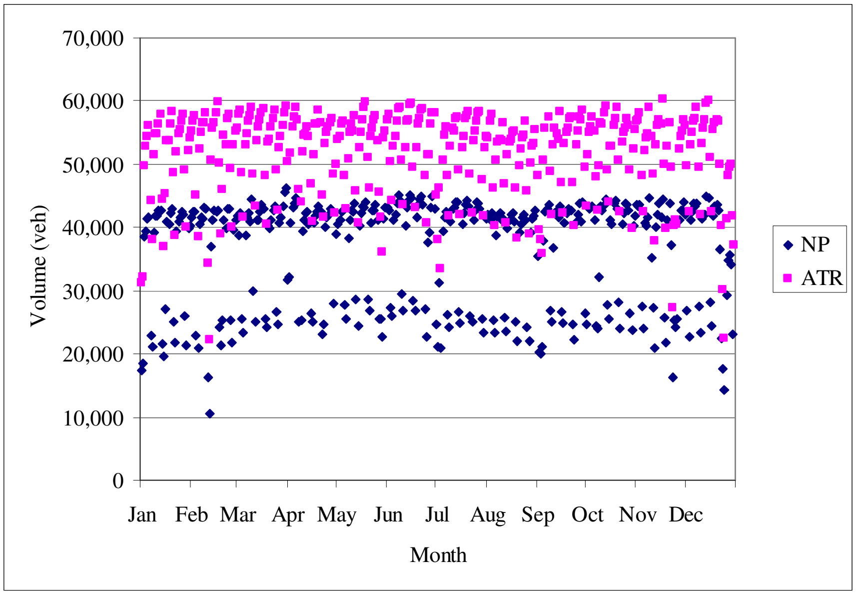


Fig. 47. Daily Traffic Volumes for George Washington Memorial Parkway and Nearby ATR in 2006

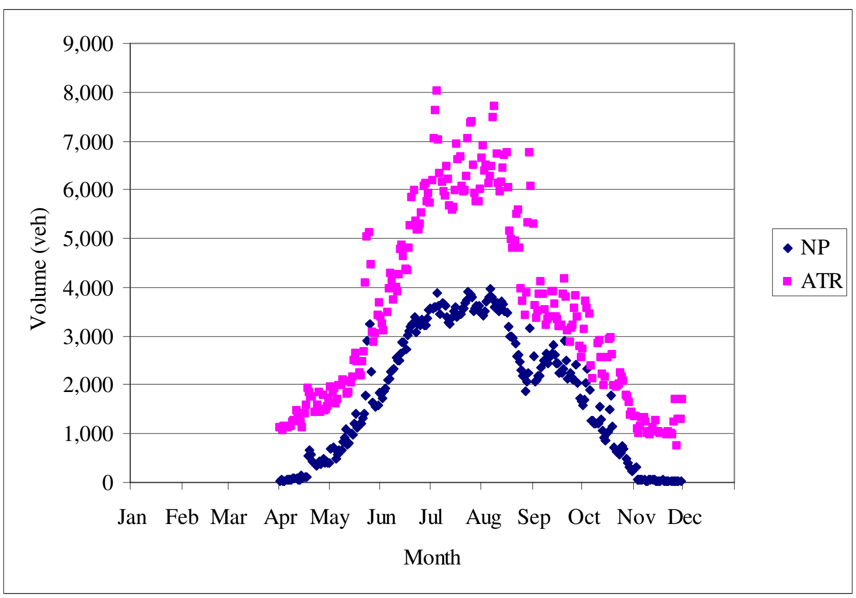


Fig. 48. Daily Traffic Volumes for Yellowstone National Park (Station A-18) and Nearby ATR in 2003

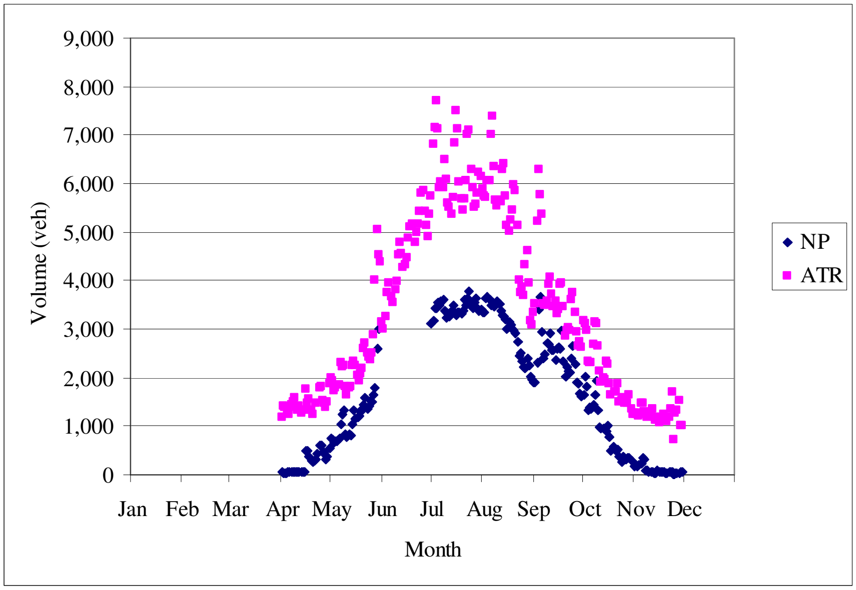


Fig. 49. Daily Traffic Volumes for Yellowstone National Park (Station A-18) and Nearby ATR in 2004

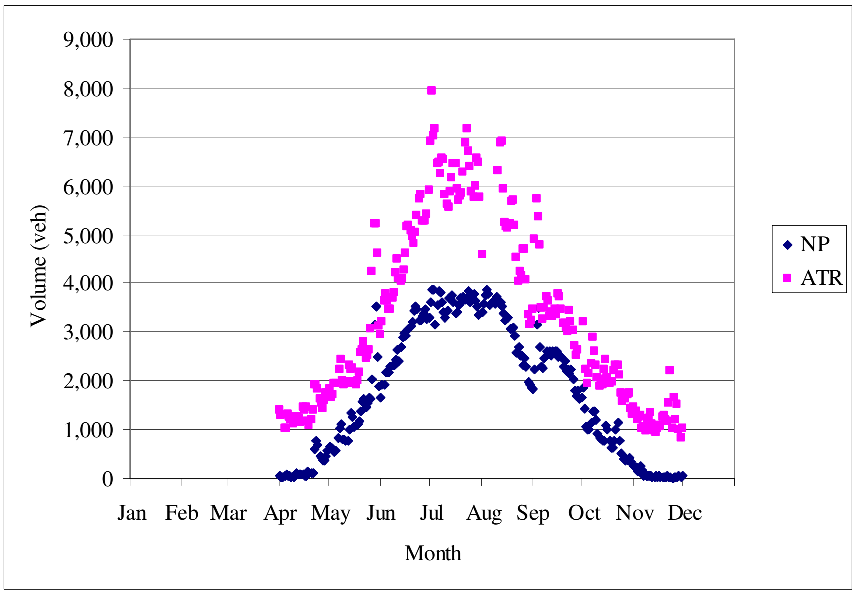


Fig. 50. Daily Traffic Volumes for Yellowstone National Park (Station A-18) and Nearby ATR in 2005

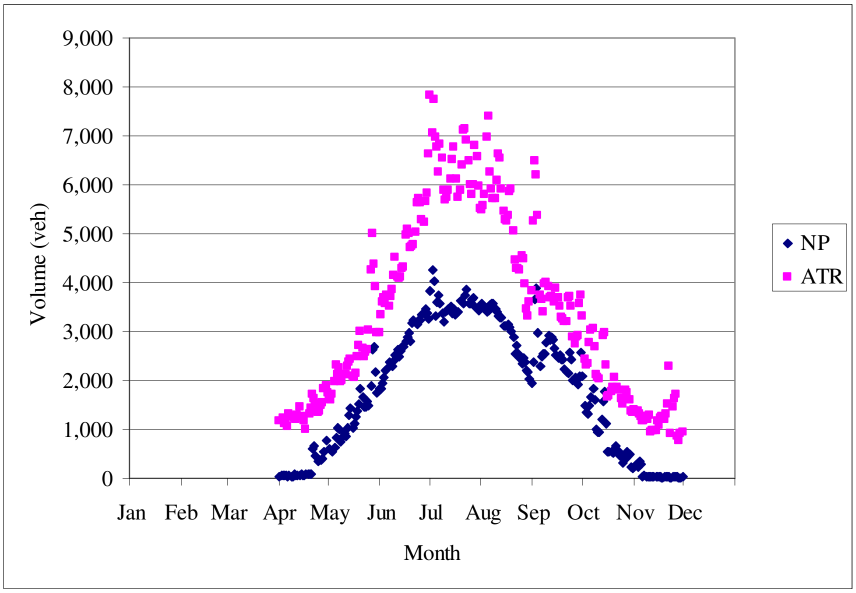


Fig. 51. Daily Traffic Volumes for Yellowstone National Park (Station A-18) and Nearby ATR in 2006

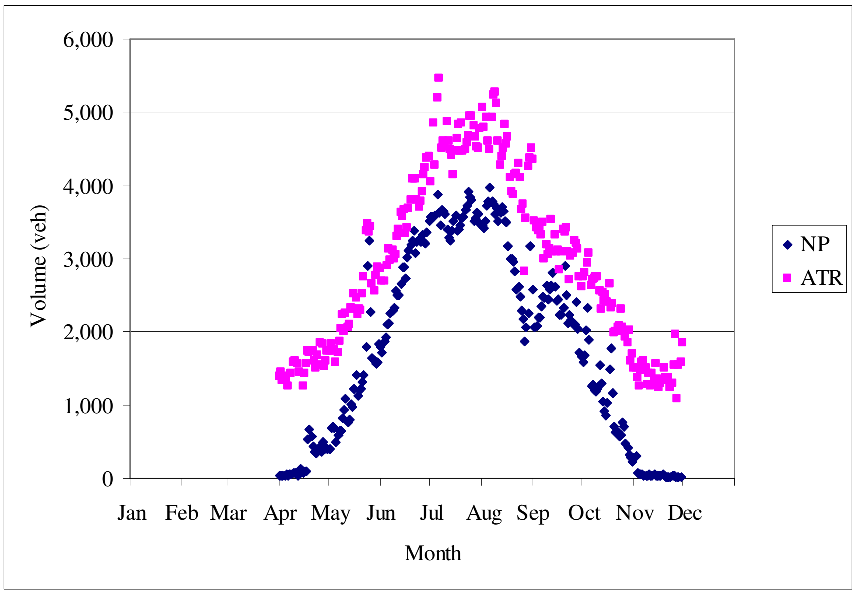


Fig. 52. Daily Traffic Volumes for Yellowstone National Park (Station A-19) and Nearby ATR in 2003

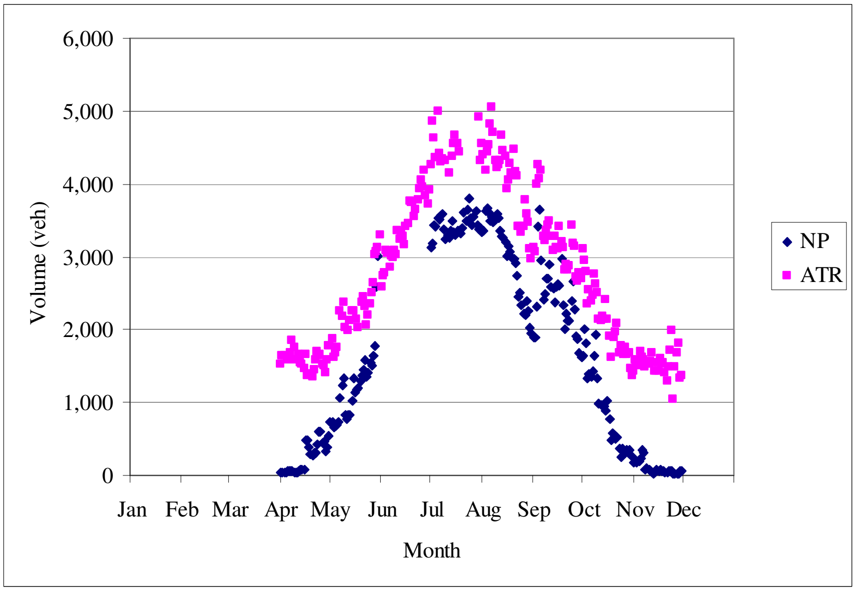


Fig. 53. Daily Traffic Volumes for Yellowstone National Park (Station A-19) and Nearby ATR in 2004

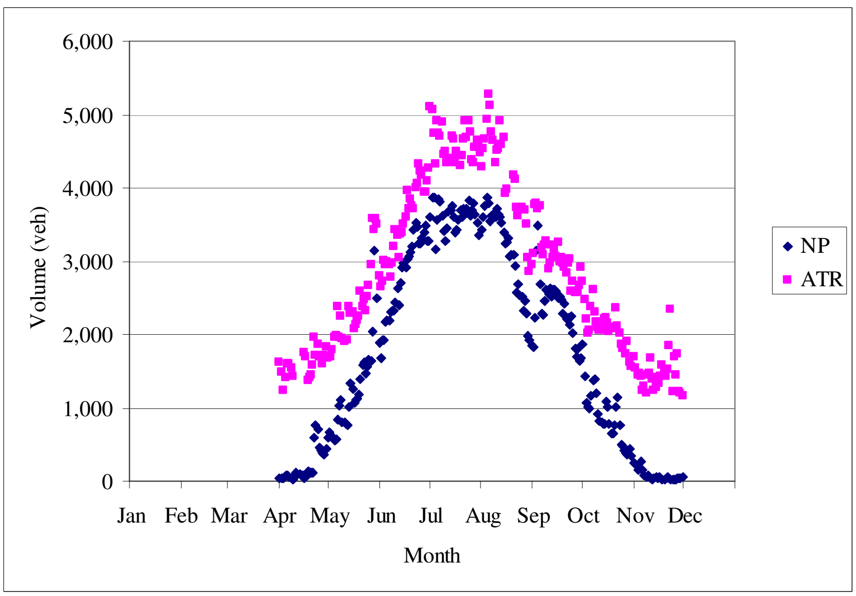


Fig. 54. Daily Traffic Volumes for Yellowstone National Park (Station A-19) and Nearby ATR in 2005

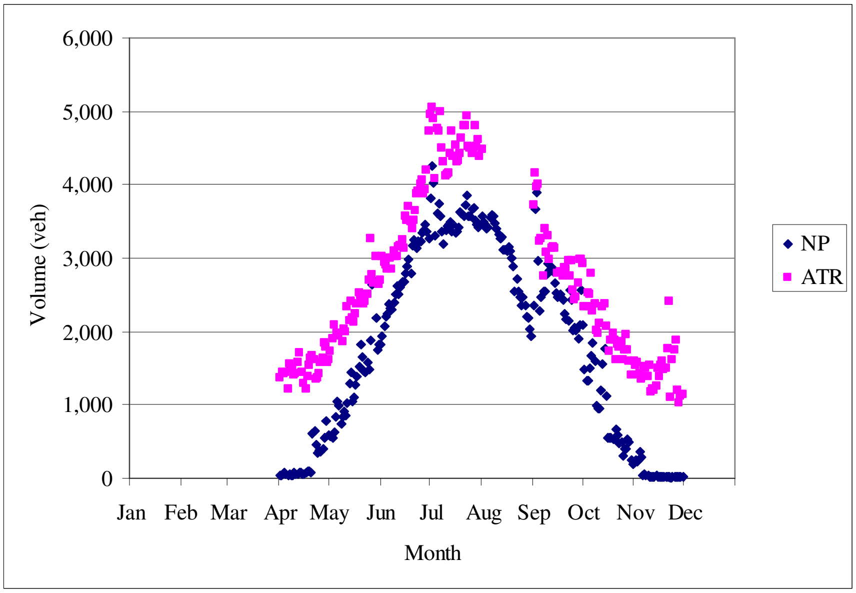


Fig. 55. Daily Traffic Volumes for Yellowstone National Park (Station A-19) and Nearby ATR in 2006

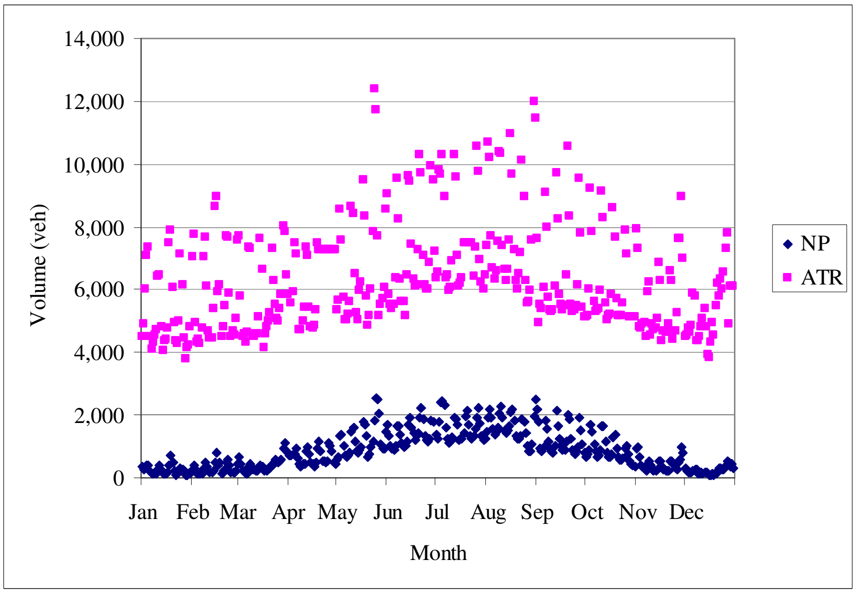


Fig. 56. Daily Traffic Volumes for Yosemite National Park and Nearby ATR in 2002

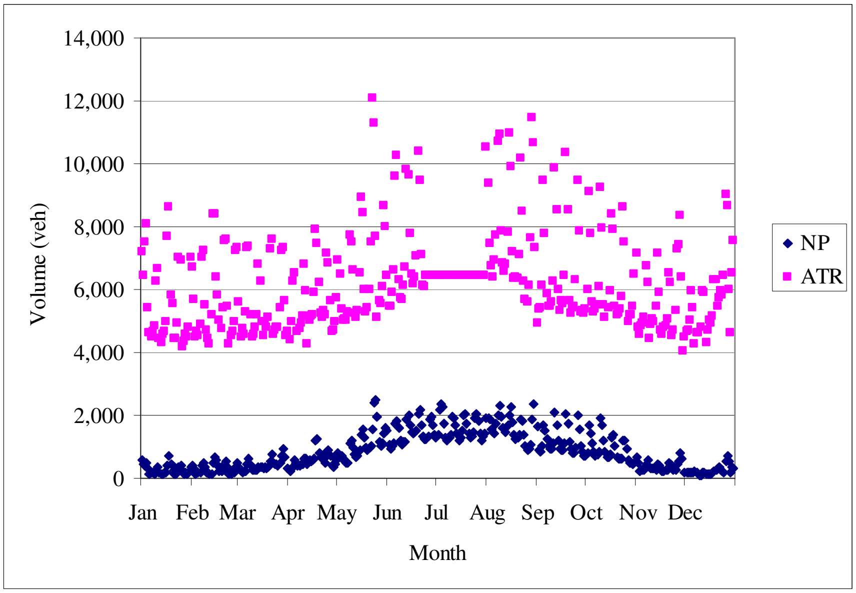


Fig. 57. Daily Traffic Volumes for Yosemite National Park and Nearby ATR in 2003

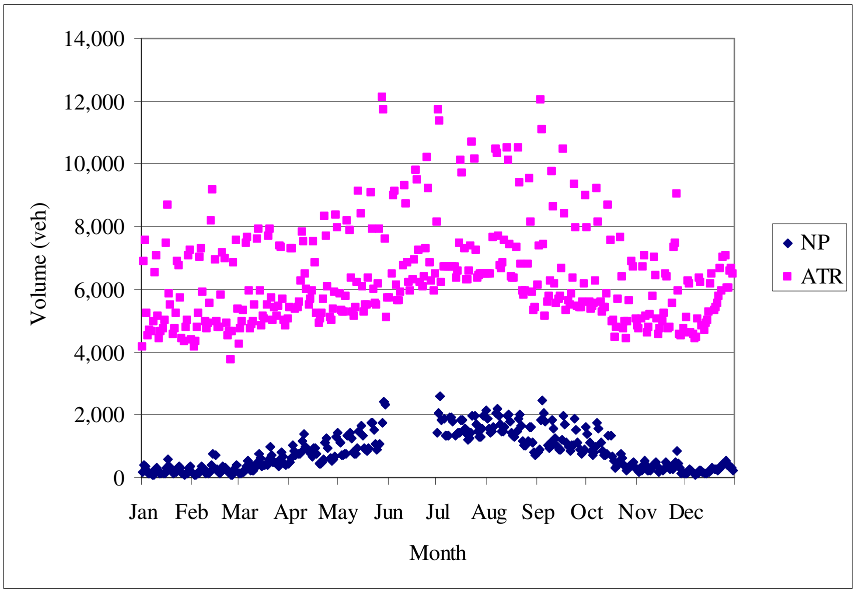


Fig. 58. Daily Traffic Volumes for Yosemite National Park and Nearby ATR in 2004

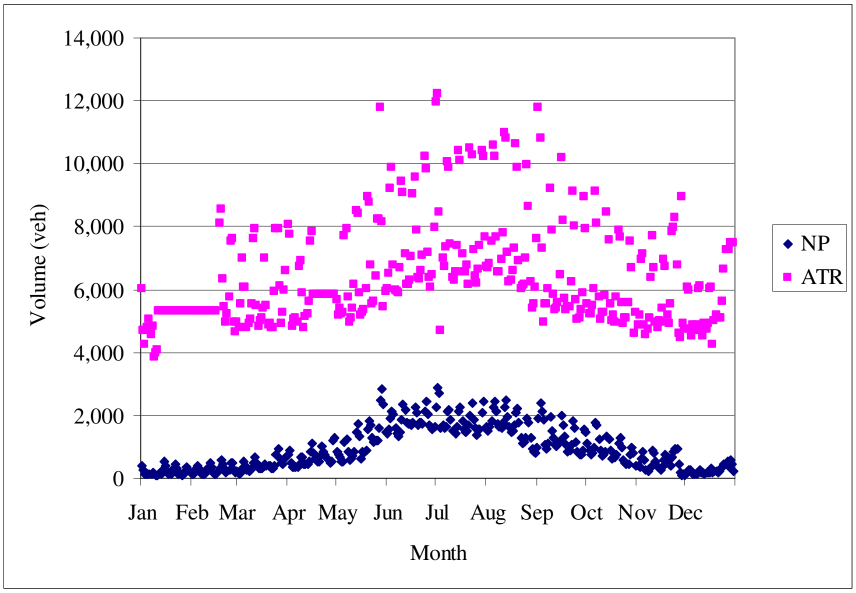


Fig. 59. Daily Traffic Volumes for Yosemite National Park and Nearby ATR in 2005

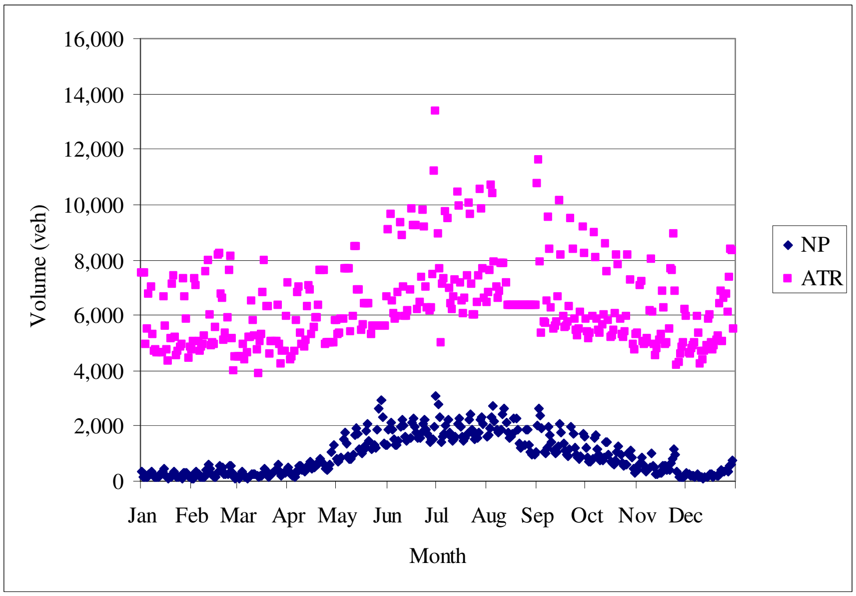


Fig. 60. Daily Traffic Volumes for Yosemite National Park and Nearby ATR in 2006

APPENDIX G

RELATION BETWEEN THE PEAK-HOUR AND AADT VOLUMES

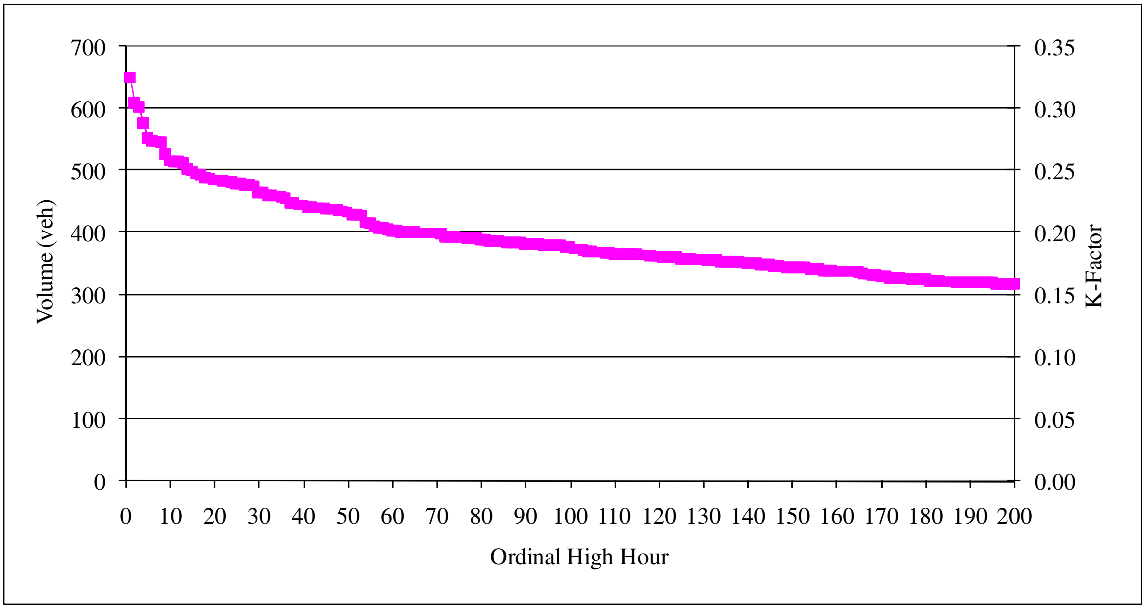


Fig. 61. Peak-Hour and AADT Relationship in Acadia National Park in 2002

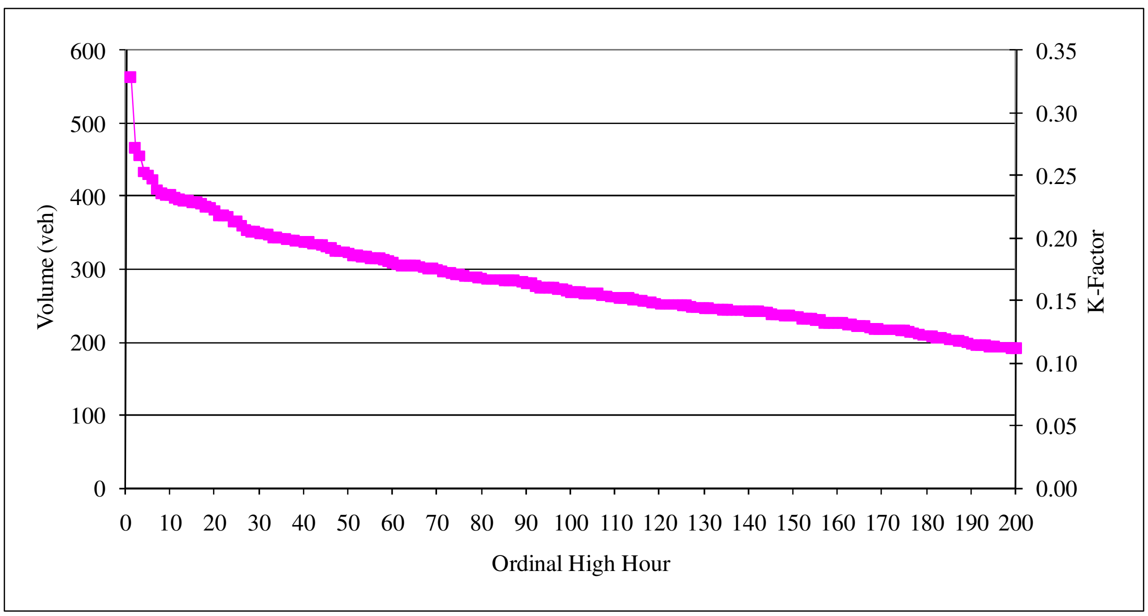


Fig. 62. Peak-Hour and AADT Relationship in Acadia National Park in 2003

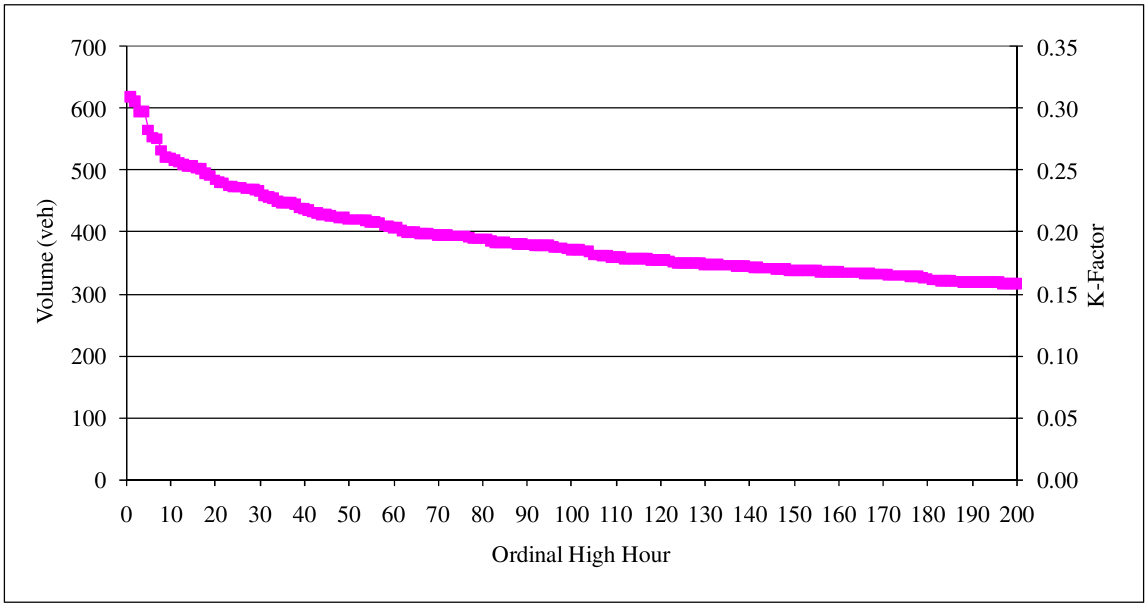


Fig. 63. Peak-Hour and AADT Relationship in Acadia National Park in 2004

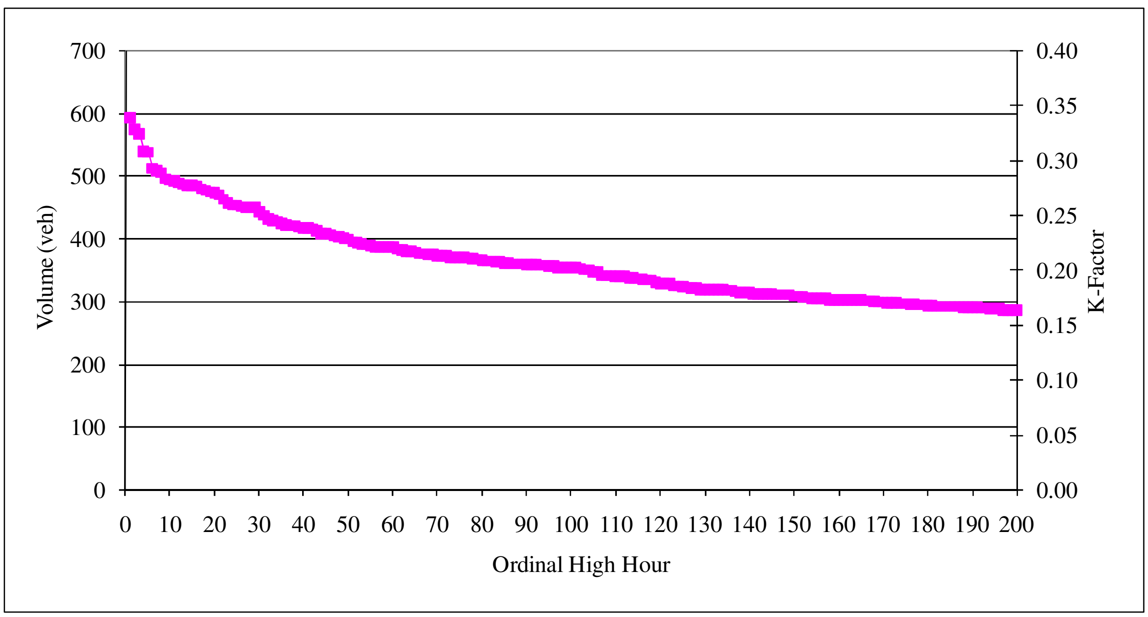


Fig. 64. Peak-Hour and AADT Relationship in Acadia National Park in 2005

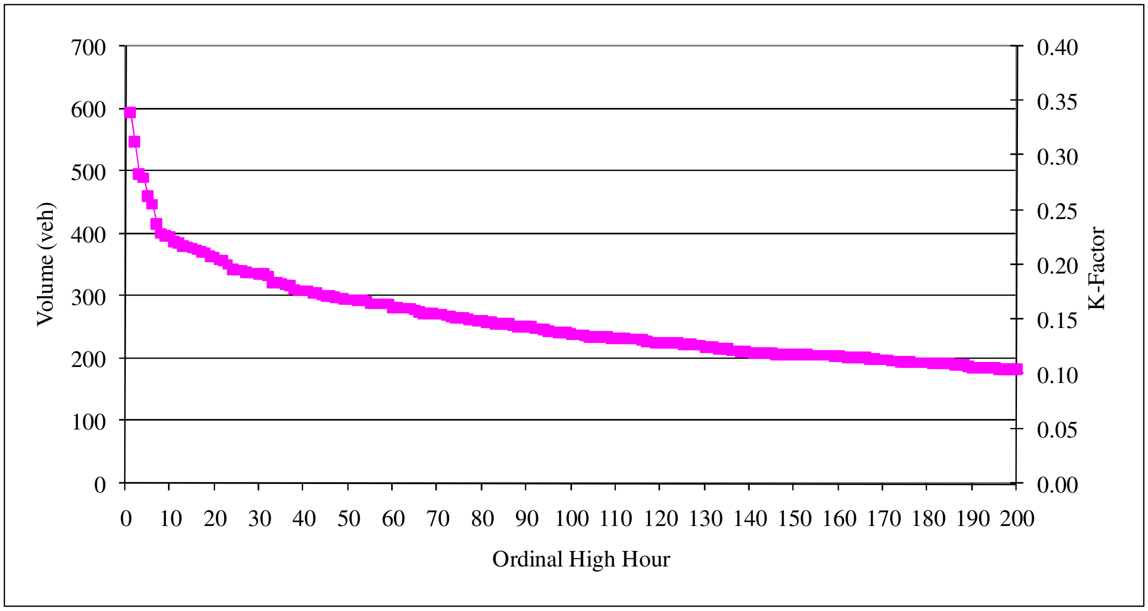


Fig. 65. Peak-Hour and AADT Relationship in Acadia National Park in 2006

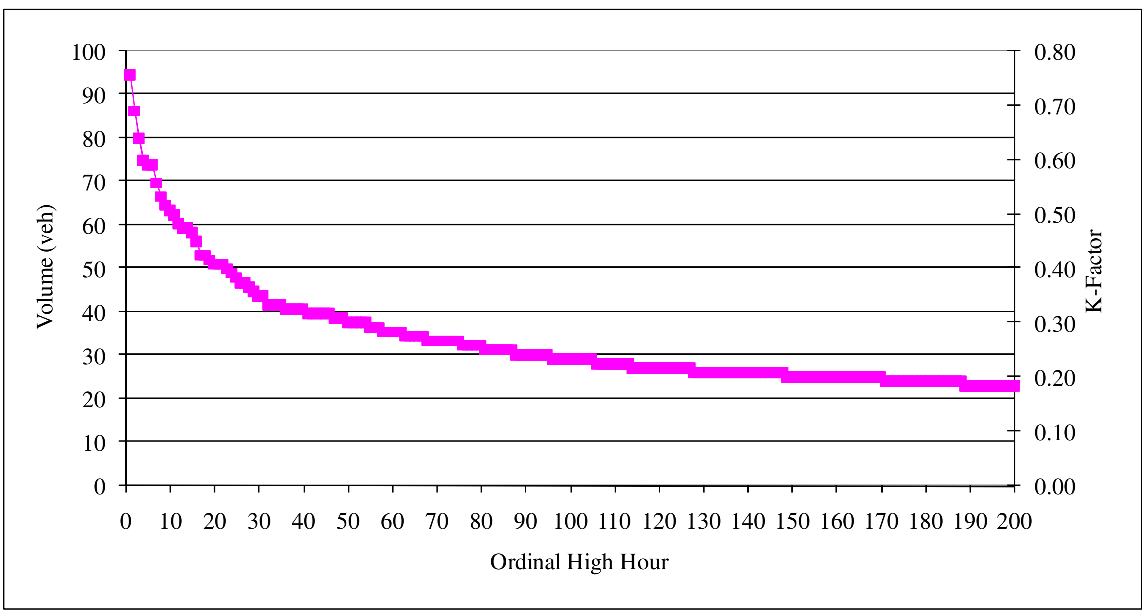


Fig. 66. Peak-Hour and AADT Relationship in Big Bend National Park in 2002

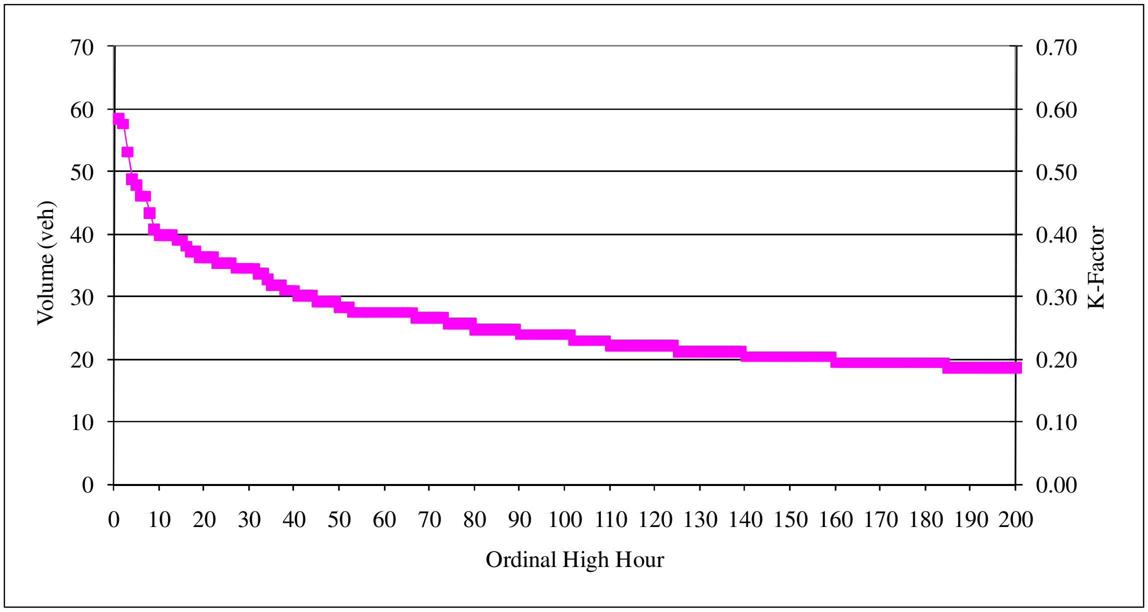


Fig. 67. Peak-Hour and AADT Relationship in Big Bend National Park in 2003

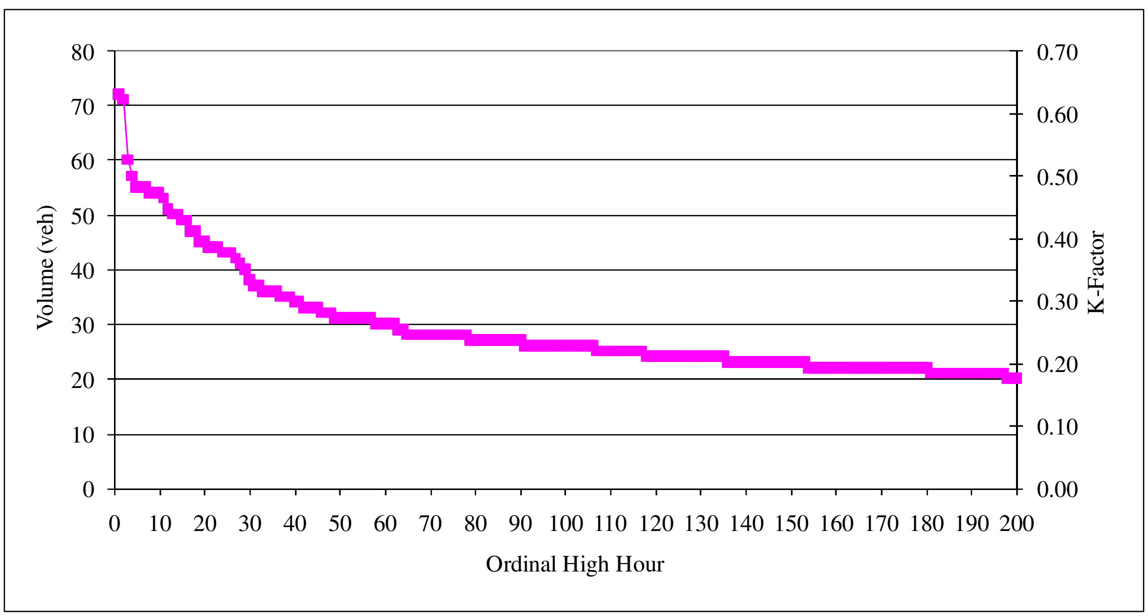


Fig. 68. Peak-Hour and AADT Relationship in Big Bend National Park in 2004

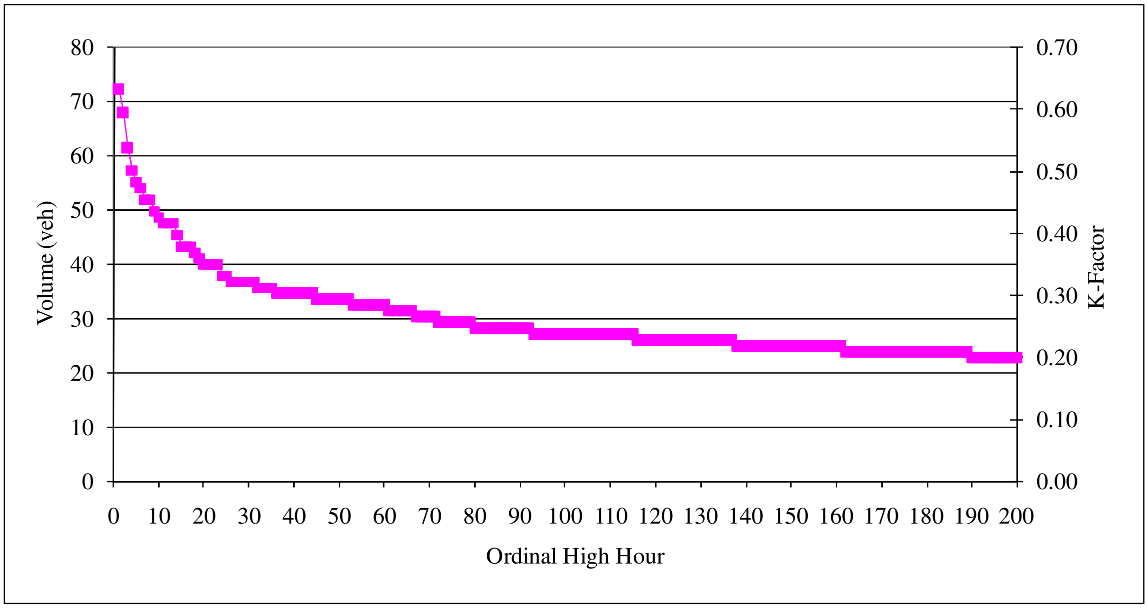


Fig. 69. Peak-Hour and AADT Relationship in Big Bend National Park in 2005

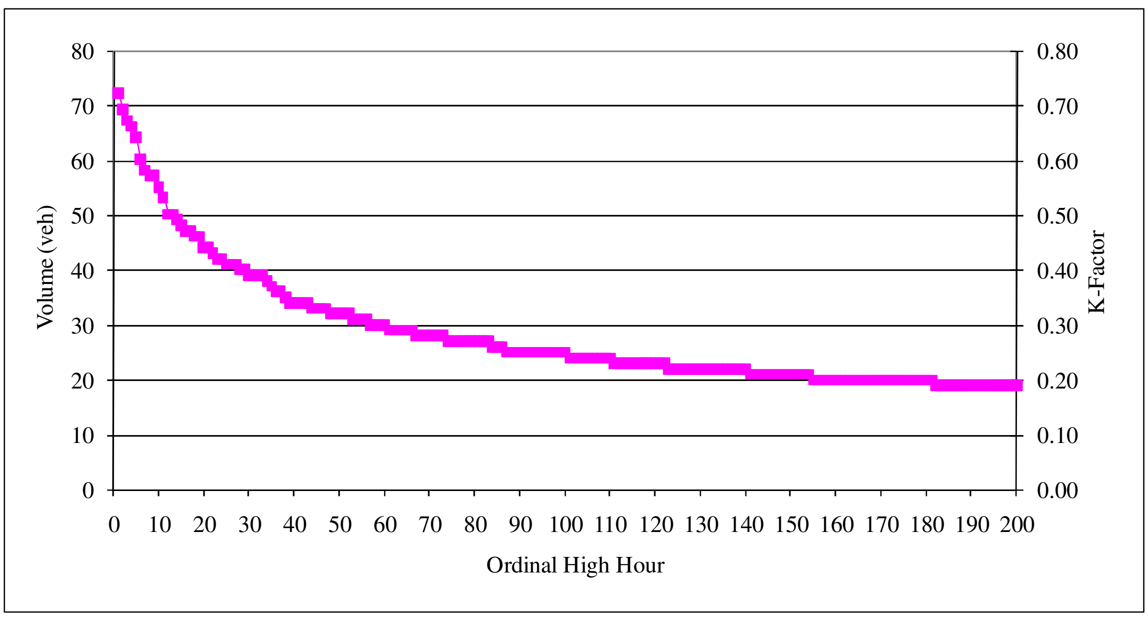


Fig. 70. Peak-Hour and AADT Relationship in Big Bend National Park in 2006

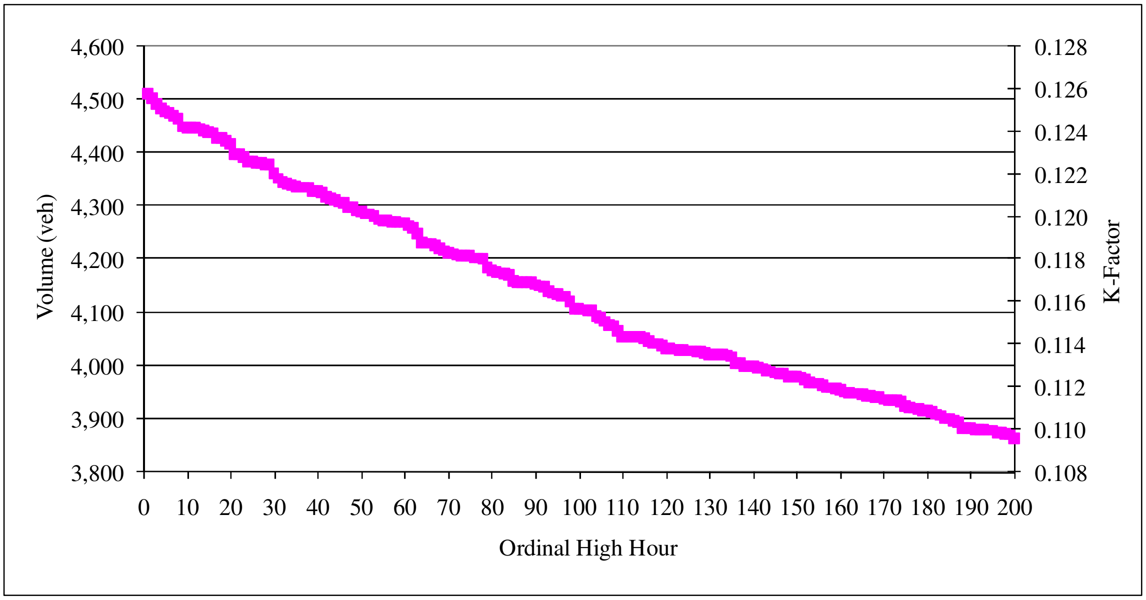


Fig. 71. Peak-Hour and AADT Relationship on George Washington Memorial Parkway in 2002

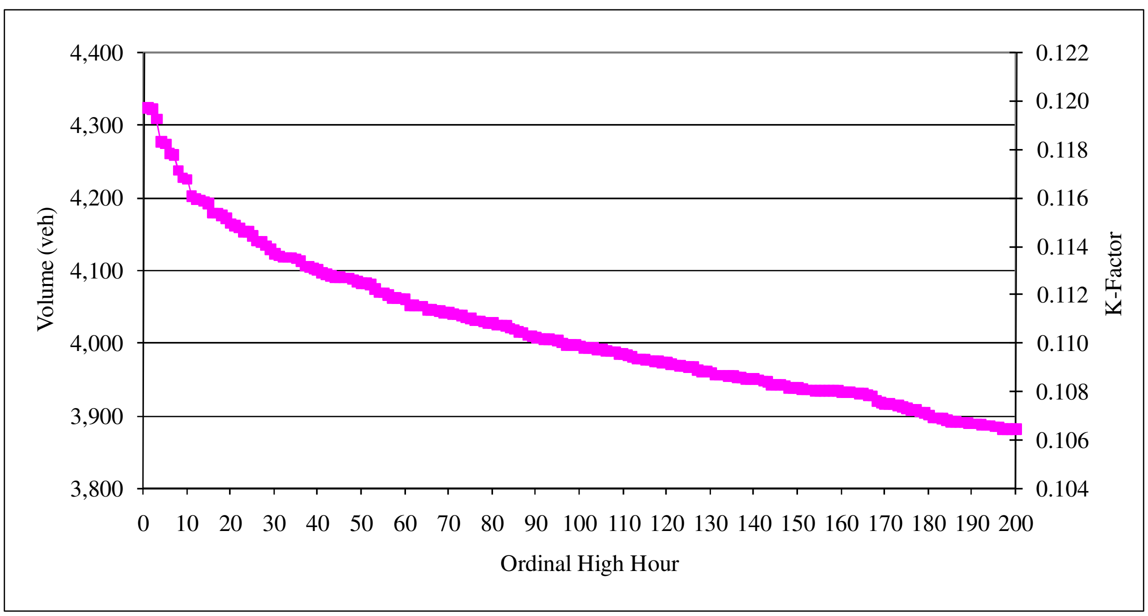


Fig. 72. Peak-Hour and AADT Relationship on George Washington Memorial Parkway in 2003

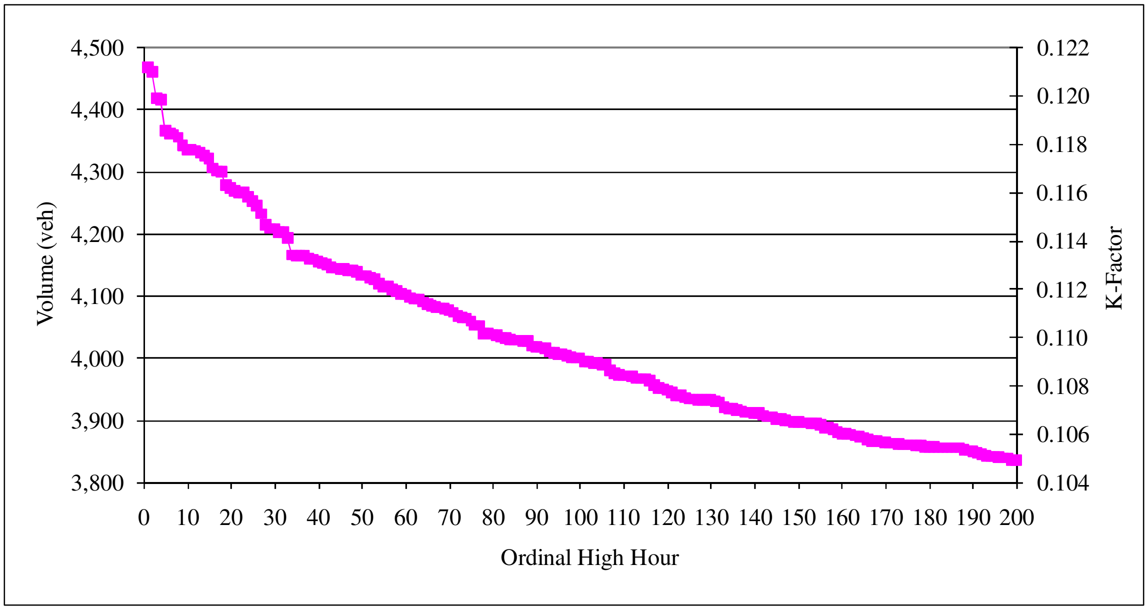


Fig. 73. Peak-Hour and AADT Relationship on George Washington Memorial Parkway in 2004

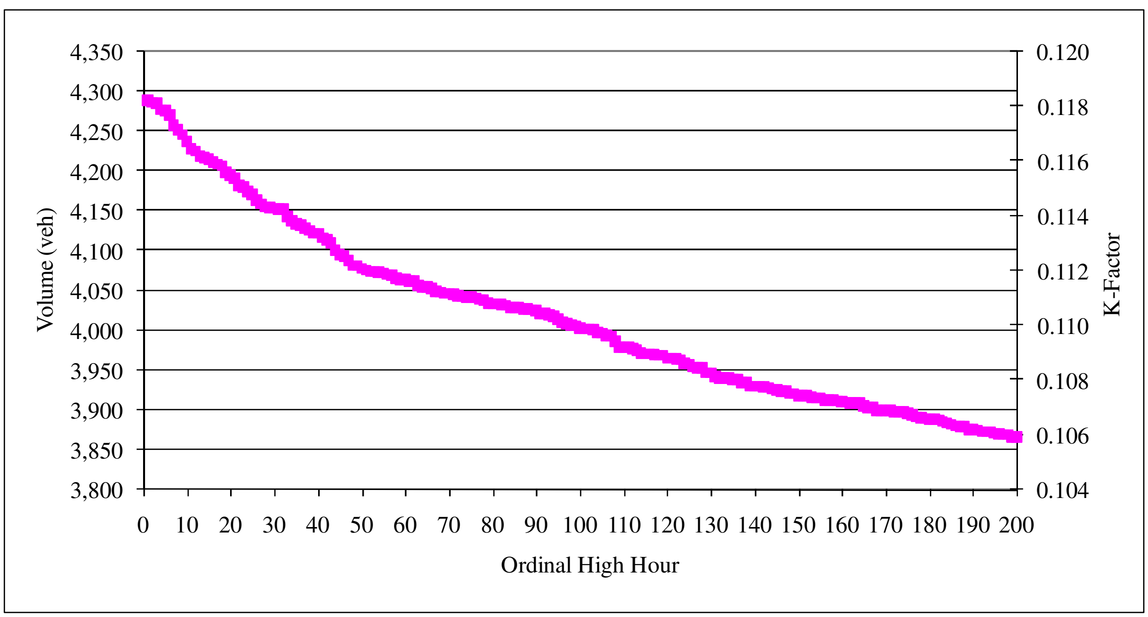


Fig. 74. Peak-Hour and AADT Relationship on George Washington Memorial Parkway in 2005

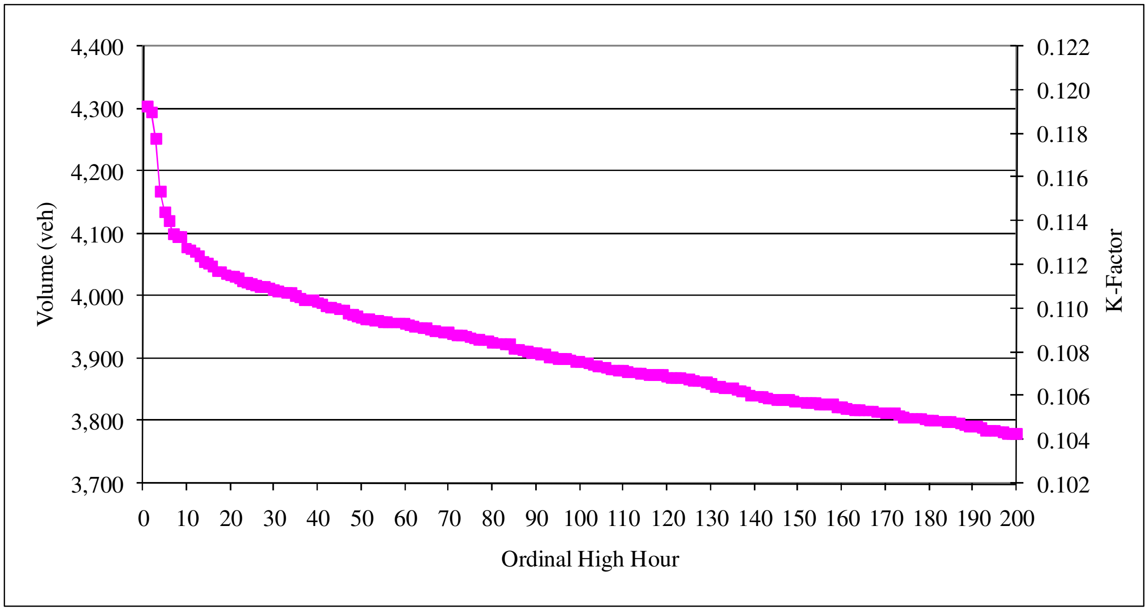


Fig. 75. Peak-Hour and AADT Relationship on George Washington Memorial Parkway in 2006

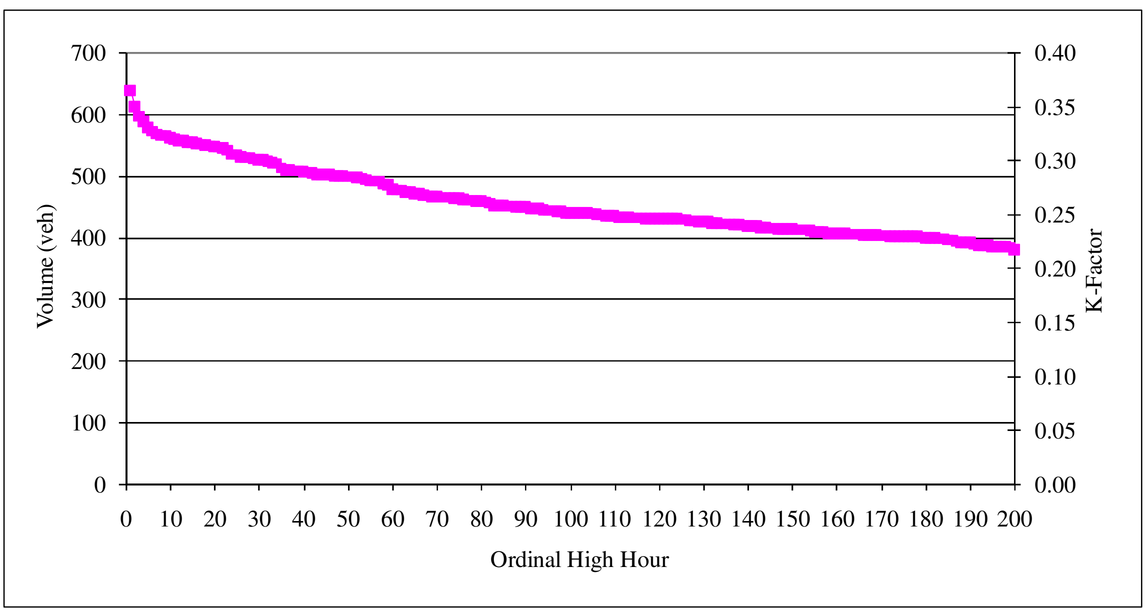


Fig. 76. Peak-Hour and AADT Relationship in Yellowstone National Park in 2002

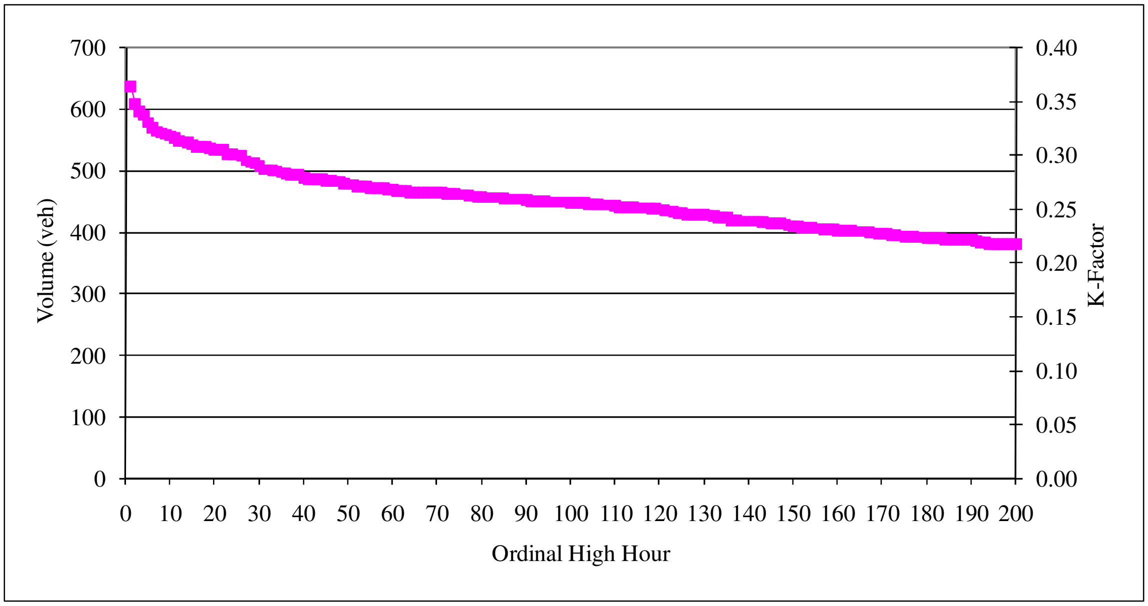


Fig. 77. Peak-Hour and AADT Relationship in Yellowstone National Park in 2003

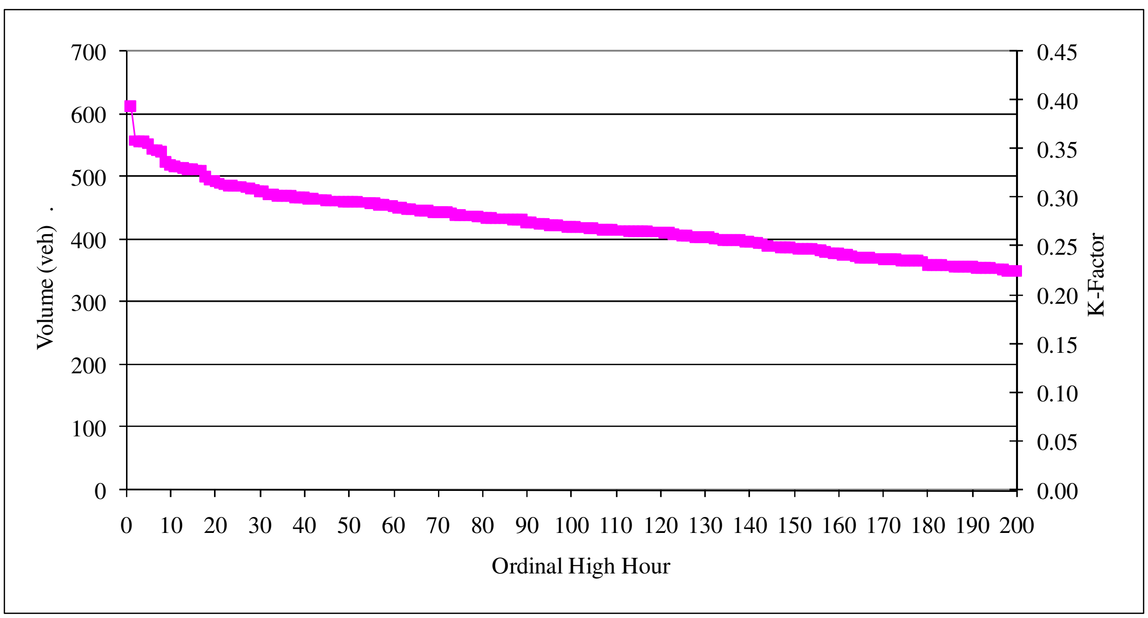


Fig. 78. Peak-Hour and AADT Relationship in Yellowstone National Park in 2004

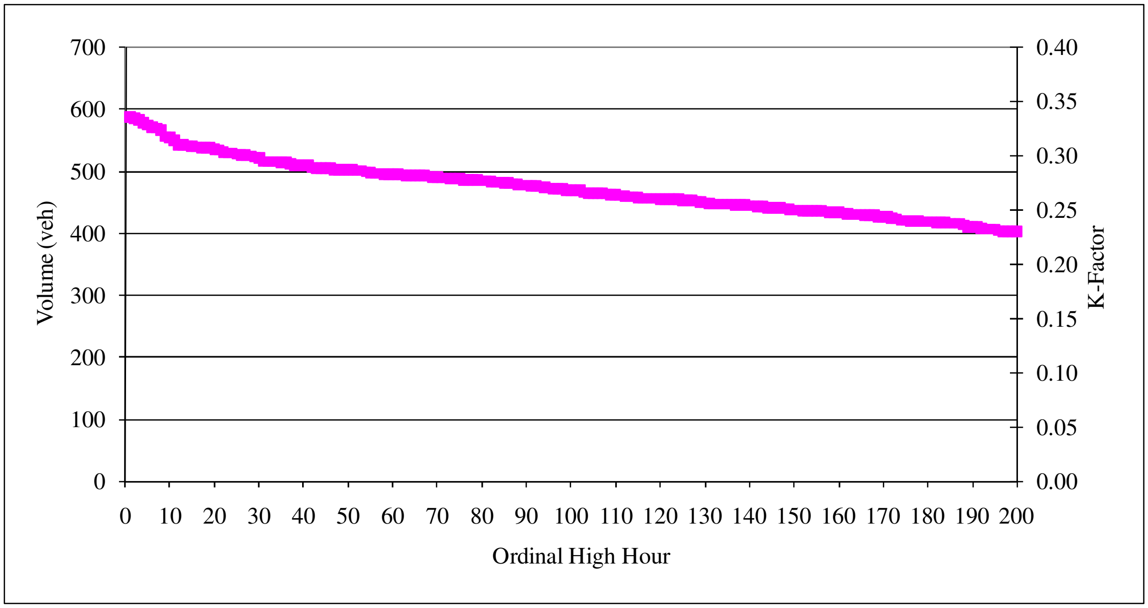


Fig. 79. Peak-Hour and AADT Relationship in Yellowstone National Park in 2005

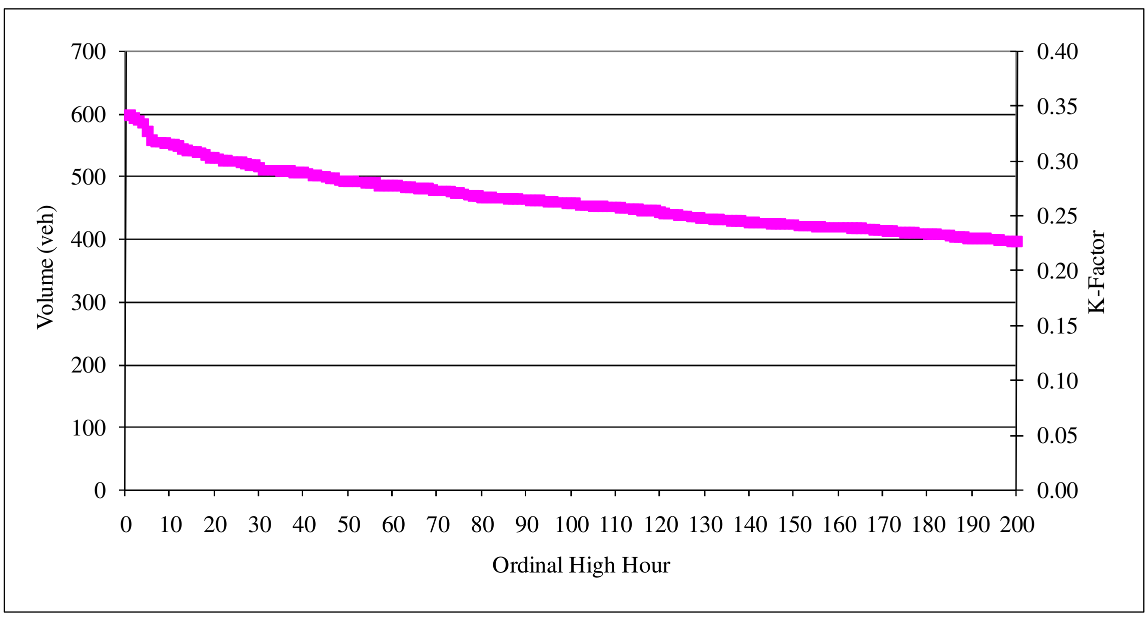


Fig. 80. Peak-Hour and AADT Relationship in Yellowstone National Park in 2006

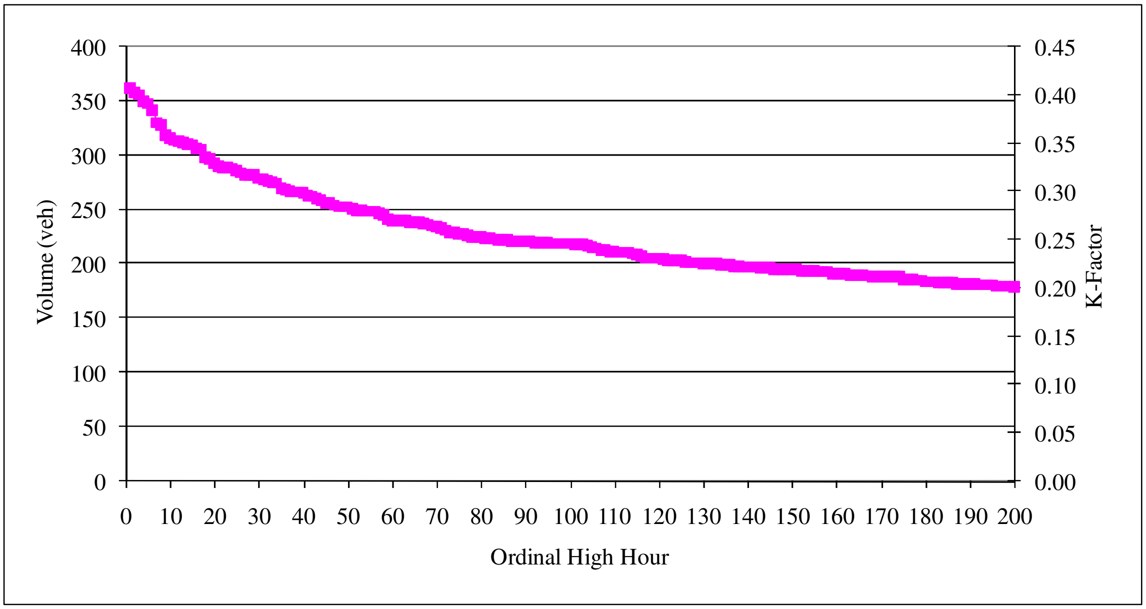


Fig. 81. Peak-Hour and AADT Relationship in Yosemite National Park in 2002

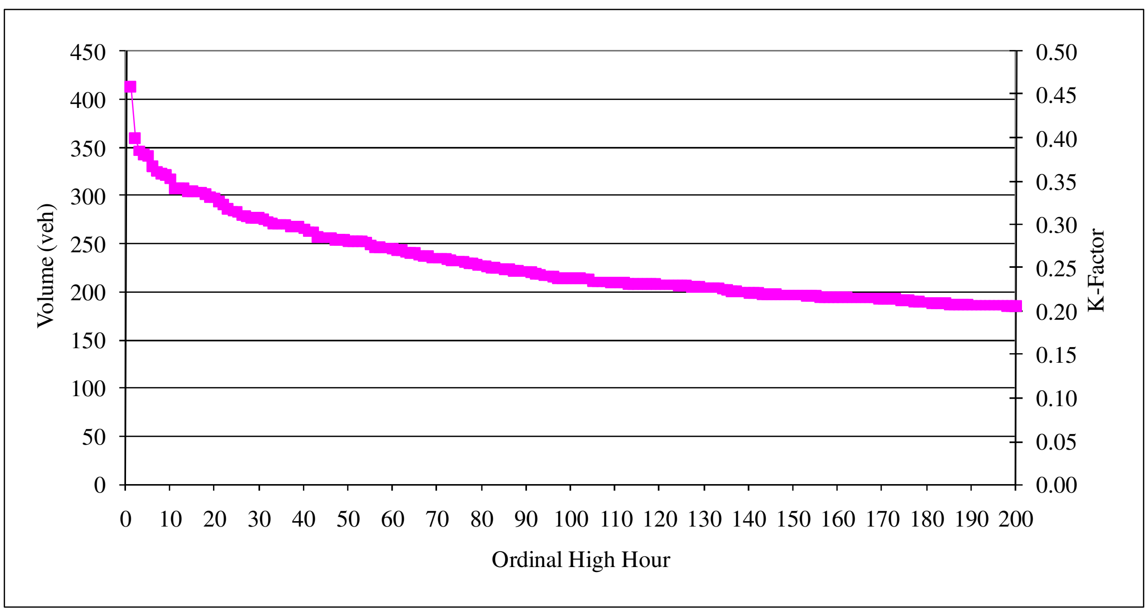


Fig. 82. Peak-Hour and AADT Relationship in Yosemite National Park in 2003

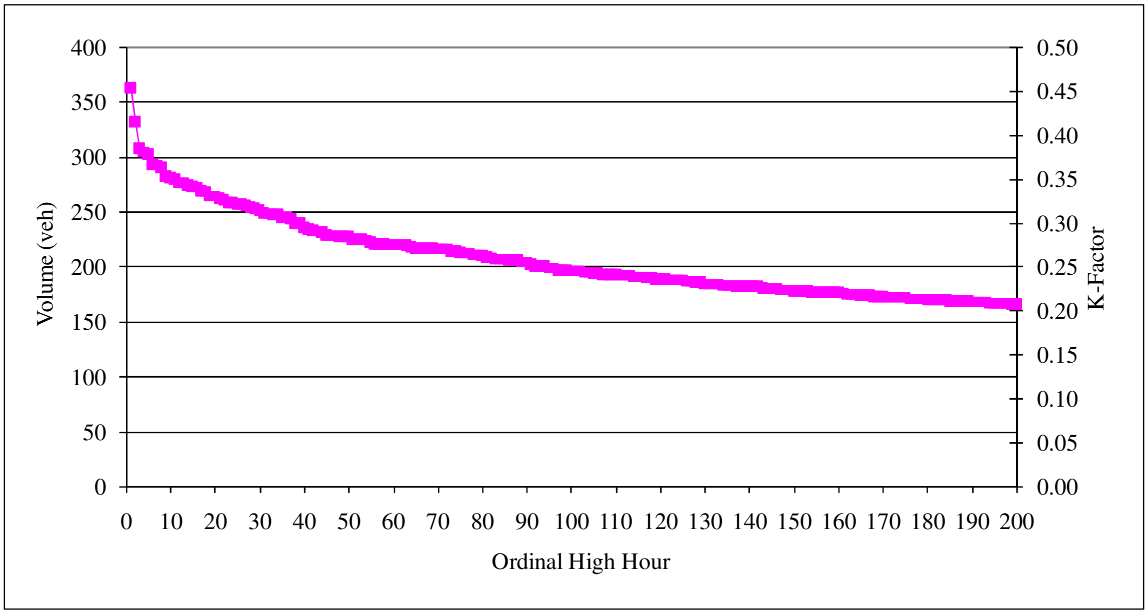


Fig. 83. Peak-Hour and AADT Relationship in Yosemite National Park in 2004

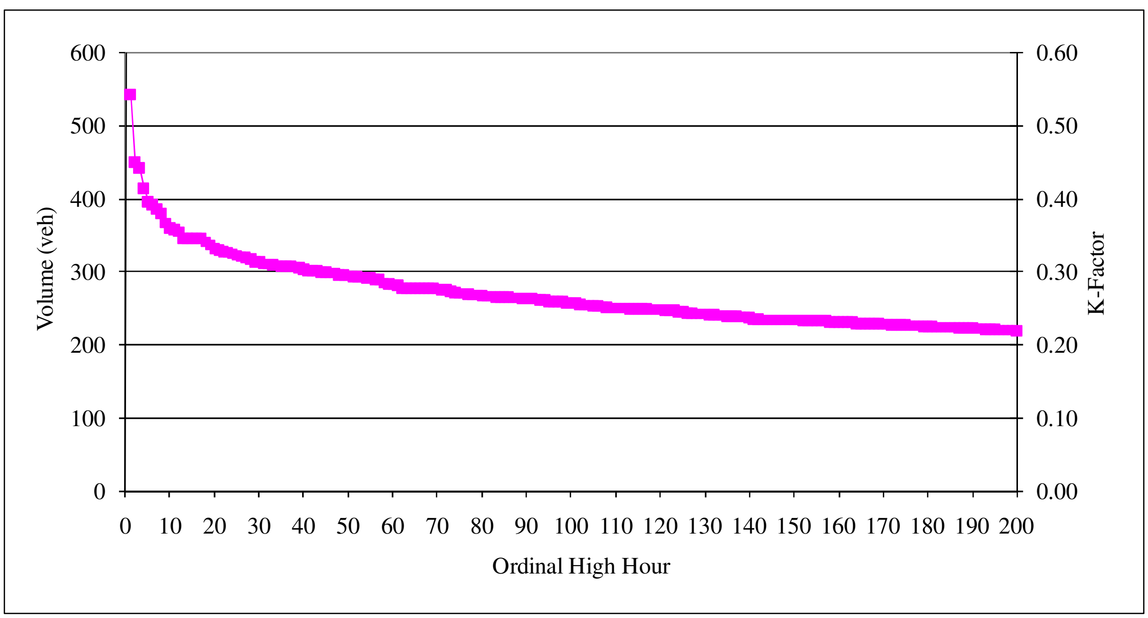


Fig. 84. Peak-Hour and AADT Relationship in Yosemite National Park in 2005

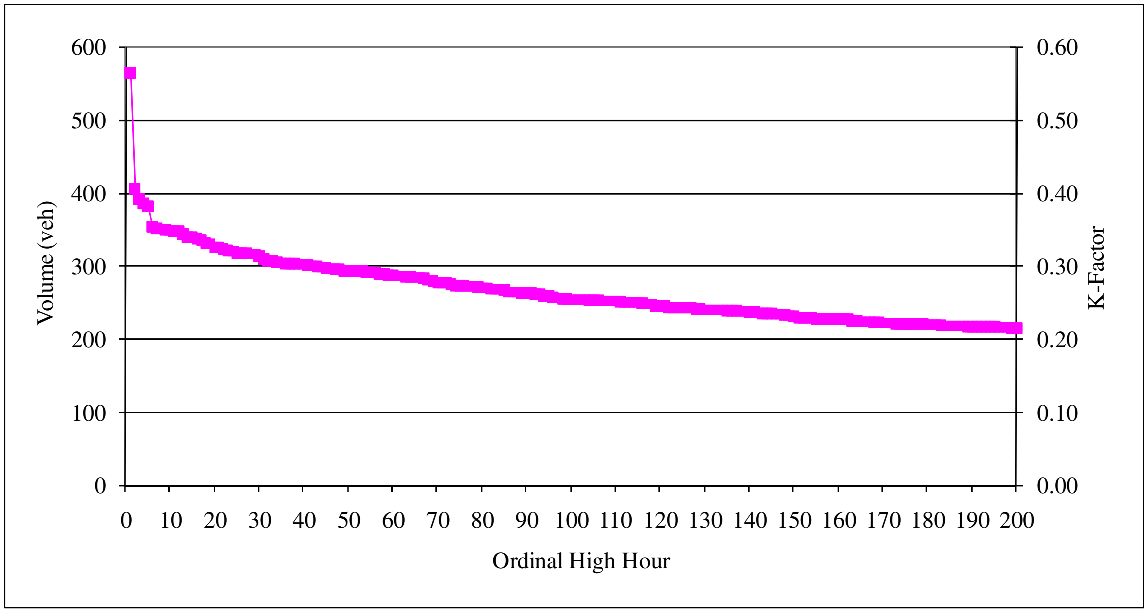


Fig. 85. Peak-Hour and AADT Relationship in Yosemite National Park in 2006

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