Great Smoky Mountains
National Park

Cades Cove Opportunities Plan

Appendix B
Visitation and
Transportation Forecast Report

October 2004

United States Department
Of the Interior
National Park Service

Table of Contents

List of Figures

List of Tables

Introduction

Great Smoky Mountains National Park

Located in the eastern United States, the park lies in both Tennessee and North Carolina. Famous for its size and temperate climate, the Park receives just over nine million visitors annually. These visitors arrive in approximately 4.3 million motorized vehicles, an increase of 50 percent during the last 15 years. Several distinctive features within the Park focus around natural resources, historical sites, and outdoor activities. Many of these features are located within a small area on the western edge of the park named Cades Cove.

Cades Cove

Cades Cove represents a relatively small portion of the land area of the Park, but it attracts nearly one-fourth of the 9 million annual visitors that come to the National Park. The two primary attractions of Cades Cove are the collection of settlement era structures found there (the largest collection in the United States) and the diversity of wildlife that can be viewed while touring the Loop Road. As Figure 1 shows, historical structures can be viewed at ten sites along the Loop Road. Wildlife in the Cove ranges from a variety of birds to small mammals to black bears and deer.

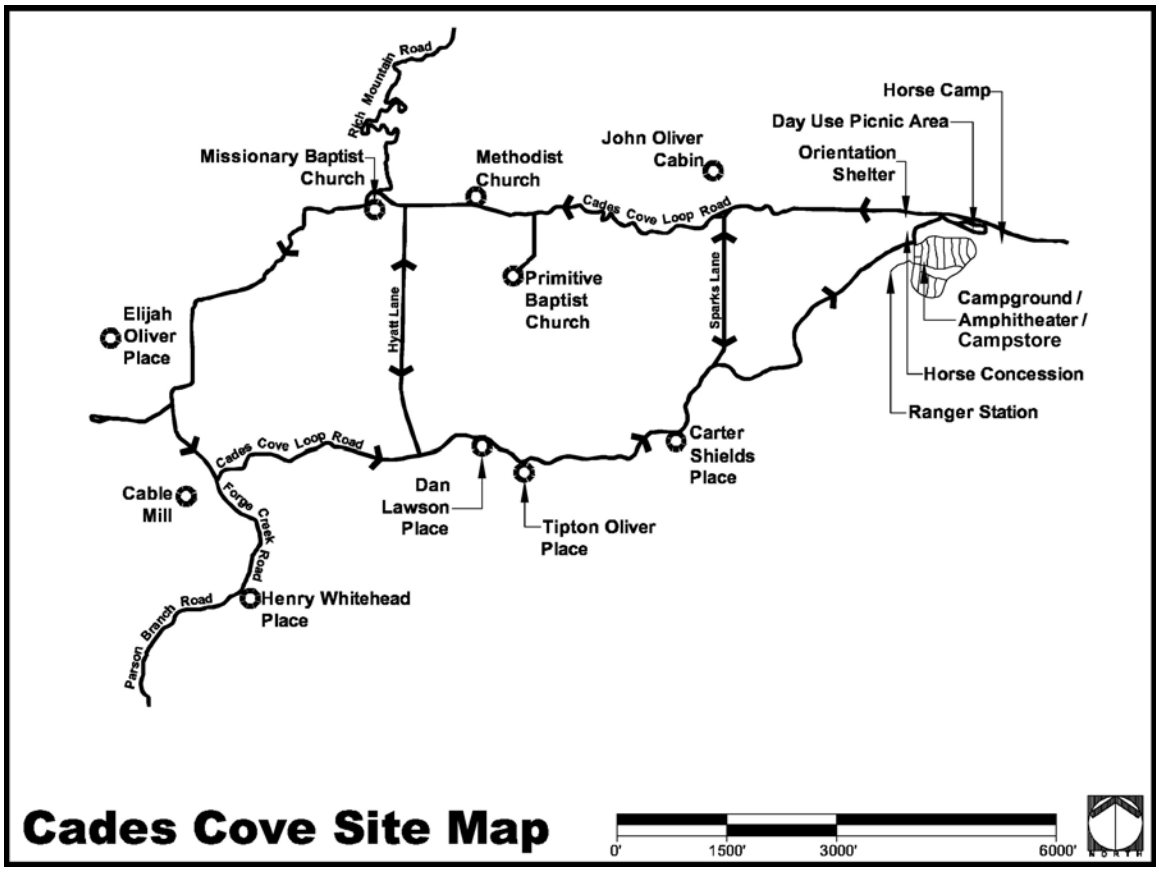
Another attraction to Cades Cove relates to the people who inhabited it. The Cove was continuously inhabited from the early 1800's through 1999 when the last permanent resident passed away. For some nearby residents, the Cove is more than a place to view log cabins - it is the place they go to visit the gravesites of their ancestors. Information collected from the Cades Cove Opportunities Plan public input meetings (held in Townsend, Maryville, and Knoxville, Tennessee and in Cherokee, North Carolina) indicates that many visitors who live in the surrounding region visit the Cove 12 or more times in a year.

Access to Cades Cove is provided via Laurel Creek Road - a two-way, two-lane road. The Loop Road is a narrow, 11-mile, one-way road that traverses the Cove's valley floor and provides access to cultural sites and trailheads. Rich Mountain and Parson's Branch provide one-way exit routes from the Cove. Both of these unpaved secondary roads are lightly traveled, wind through surrounding mountains, and are closed to traffic November through March.

Although it is paved, the Loop Road is too narrow in most places to allow vehicles to pass one another. Following former wagon tracks, portions of the road are steep,

with sharp turns. The road follows the edge of the forested lands that surround the open fields in the center of the Cove. Excellent views of wildlife result in visitors stopping in the travel lane, creating "wildlife jams" when the vehicles behind cannot pass. Visitation peaks during July and August, and again in October. During the busy season, many visitors to the Cove find themselves in long traffic queues, with only those visitors in the first few vehicles in the queues being able to enjoy the wildlife and scenic vistas.

Figure 1: Cades Cove Site Map



Report Purpose

A wide range of recreational activities and historic sites as well as wildlife viewing attract close to 2 million visitors each year, resulting in congestion along the Loop Road, over-crowded parking areas, and heavily used visitor facilities and services during peak visitation periods. During these times, the Cove functions at capacity or over-capacity conditions. Capacity here is defined in terms of vehicles on the Loop Road and in the parking areas, which is a vehicular capacity and not a carrying

capacity which incorporates protection and preservation of the resources. Planning efforts for managing this condition require estimates of future demand. The carrying capacity volume might actually be less than the calculated Loop Road capacity.

This report documents existing vehicle and visitor patterns, volumes, and trends along with projected visitation characteristics for the Cove in 2007, 2012 and 2022. A discussion on the Loop Road's physical characteristics and the factors that affect the visitation capacity of the road and the features along the road follows the presentation of the projected visitation characteristics. An estimate of the practical capacity of the Loop Road, given its current physical characteristics and patterns of visitor use, is provided for use in developing alternative transportation strategies to improve visitor experience and protect park resources.

Cades Cove Traffic

Traffic Trends

Traffic volume at Great Smoky Mountains National Park increased at an average rate of 2.1% per year for the 17-year period from 1986 to 2002. In four of these years, visitation declined from the previous year. The most notable visitation drop occurred in 2001, when visits declined by nearly 11%. Visitation rebounded and increased by over 1% in 2002. The yearly average vehicle occupancy dropped from 3.3 to 2.4 people per vehicle over the 1986 - 2002 time period. Traffic to the Cades Cove area has been less variable, increasing at an average rate of 1.9% from 1986 – 2002. With the exception of 2002, the Cove saw visitation decline during the same years in which overall Park visitation declined. 2002 Cove visitation declined one-half percent from 2001. The yearly average vehicle occupancy at the Cove paralleled the decreasing trend for the whole park. Average vehicle occupancy was 3.3 in 1986 and reached a low of 2.4 in 1989, where it remained through 2002. The average vehicle occupancy tends to vary between peak and non-peak visitation periods.

Cades Cove attracted a total volume of 643,400 vehicles in 2002. Since the Cove is a recreational destination, the daily traffic volumes tend to vary by season and day of week. During July 2000, the weekend daily traffic averaged about 4,100 vehicles while the fall peak period averaged about 4,450 vehicles daily on the weekends. During the week, the daily traffic averaged about 3,100 vehicles in the summer peak. Weekday traffic during October was much lower.

The one-lane narrow road can not accommodate such high volumes of traffic when frequent wildlife sightings cause motorists to stop in the road. As a result, high

percentages of visitors are trapped in queues of vehicles during much of the day during peak visitation periods. Visitor parking in non-designated parking areas along the sides of the road also contributes to traffic congestion, as well as resource damage. Congestion also occurs at the Loop Road entrance on Wednesday and Saturday mornings as vehicles queue up to 400 feet while waiting for the end of bicycle/pedestrian-only hours. Adding to this congestion is the fact that bicyclists and hikers typically park in the parking lot at the entrance – leaving few open spaces for later arriving visitors.

A 1998 survey effort concluded the following is the average vehicle mix along the Loop Road:

- 95.0% automobiles
- 0.8% recreation vehicles (RVs)
- 0.3% motorcycles and
- 4.0% bicycles

In 1998, the National Park Service initiated a study of visitor use during peak visitation seasons in order to document actual traffic and visitation conditions at Cades Cove. Prior to this time, traffic counts were the only source of actual data. The congestion and visitor use conditions were based on anecdotal information. The information gathered was intended to provide a benchmark of peak season traffic and visitation conditions which could be used to measure future trends and their impacts. This was the first effort of its kind at Cades Cove. Operations Research Consulting Associates conducted the surveys during the summer and fall peak visitation periods in 1998. Following are the major components of the survey:

- Instantaneous counts of parked vehicles at the major Cades Cove destinations
- Instantaneous counts of vehicles traveling on the Loop Road and other major roadways within Cades Cove, vehicles stopped at roadside pull-offs and by the side to the roads, and vehicles stopped in traffic backups
- Hourly counts of traffic volumes for the major roadways at Cades Cove
- Instantaneous counts of visitors at the major Cades Cove destinations
- Visitor surveys to obtain key demographic information, visitation demographics, and visitors' impressions of their Cades Cove experience
- Average vehicle mix along the Loop Road

The instantaneous counts were used to determine the distribution of vehicles and visitors among the major Cades Cove destinations and on the roadways at one point in time. The distribution is the percent of the total vehicles/visitors in the Cove which were at a particular destination or on a particular roadway at the time of the survey. This report references the vehicular distribution, parking occupancy, visitor distribution at major destinations, and vehicular mix information gathered in this 1998 survey to depict the vehicular and visitor use in Cades Cove. Although vehicular and visitor volumes have fluctuated since 1998, the distribution, or percentage, of visitors among the major locations will likely remain the same in the future.

Design Volume

Design volumes represent the baseline condition from which projections are made. The growth factors are applied to the design volume to calculate future volume. The average daily traffic volume for the year is not typically used as the design volume since it smoothes out variations and tends to understate the peak volume conditions. Thus, a design volume is one that is representative of the days that experience higher volume conditions.

Design Day Volume - The highest traffic volume day of the year is not used as the design volume because it occurs infrequently enough that the system would be over designed the majority of the year. This leads to unnecessary construction and operating/maintenance expenses. Typical conditions on weekends during the busy visitation periods in the summer and in October are appropriate for analyzing transportation needs and planning alternative forms of transportation. For the analysis of alternative transportation systems, the average weekend days in July and October were analyzed, along with the average week days in July and August.

Design Hour Volume - Roadway capacity is based on the number of vehicles that can traverse a segment of roadway in one hour. Thus, the capacity of the Cades Cove Loop Road is controlled by the number of vehicles that can travel past a given location in one hour. It is important to note that Park roads serve a different function than non-Park roads. Park roads are intended to showcase Park resources and are to be enjoyed at a leisurely pace. Conversely, most non-Park roads are designed for fast and convenient travel. Because of this and the Loop Road's unique physical characteristics, traditional traffic engineering techniques are generally not useful for analysis of the Loop Road. The practical capacity of the Loop Road can be compared to the highest volume of traffic to assess the severity of congestion. The design hour volume is the highest hourly volume during the design day. Table 1 shows the hourly

volumes for an average weekend day in October. The design hour occurs in the late morning from 12:00 PM – 1:00 PM when 652 vehicles entered the Cove. The analysis uses 650 vehicles.

Table 1: Vehicles Entering Cades Cove on Average Weekend Day October 2000

Hour	Vehicles
8am – 9am	115
9am – 10am	198
10am – 11am	302
11am – 12pm	438
12pm – 1pm	652
1pm – 2pm	547
2pm – 3pm	407
3pm – 4pm	391
4pm – 5pm	401
5pm – 6pm	412
6pm – 7pm	386

Volume Distribution and Parking

The traffic volumes in the Cove disperse to eight primary locations. The summer/fall 1998 survey effort collected visitor and traffic count data in addition to surveying visitors about their activities in the Cove. The traffic counts were taken simultaneously throughout the Cove on each day in the study period in order to provide a snapshot of the distribution of vehicles in the Cove at any given point in time. The counts were taken when the Cove experienced average vehicular volumes of 2,500 on summer weekend days and 3,675 on fall weekend days during the study period.

The following describes the transportation characteristics of these primary locations. Each of the following percentages refers to the distribution of vehicles, as determined by the survey, around the Cove at one time during the day during both the summer and fall peak visitation periods. This includes the Loop Road itself and parking areas. The visitor use section of this report contains more detail about specific activities in these locations.

Cades Cove provides approximately 350 paved parking spaces. These are in the major areas such as the camp store, picnic area, maintenance facility, resource education building, riding stable, and areas adjacent to the Loop Road. Gravel parking areas are available at some of the historic sites along the Loop Road such as

the Primitive Baptist Church. The Cable Mill area has an overflow lot which is gravel. Unpaved parking areas provide approximately 280 more parking spaces.

Roads - The Loop Road, a one-way, 11-mile paved road, encompasses most of the Cades Cove area. Almost all Cove activities are accessed via this one-lane road. Two, bi-directional gravel roads bisect the Loop – Sparks Lane and Hyatt Lane. These can be used to shorten a visit around the Cove or return to the first half of the loop without going to the end. The combined length of these three roadways is 13 miles. The Loop Road has a total of 125 parking spaces and 250 pull-off spaces adjacent to it. These serve the historic sites, horse and pedestrian trailheads and scenic overlooks. The main visitor parking area is located at the entrance and offers 63 parking spaces, one of which is a designated ADA accessible space. Some visitors leave their vehicles parked here while bicycling the Loop. The survey during the summer peak determined that 43% of the vehicles during the survey were on the road or by the roadside in pull-offs and undesignated areas while the remainder were parked at various designated parking lots and pull-offs off of the Loop Road. This percentage increased to 61 in the fall.

Cable Mill Area - This location is halfway around the Loop. It offers the largest collection of historic sites in the Cove including a functioning gristmill, small bookstore and the only restroom facilities along the Loop. It is also the location for Old Timers Day activities. This site has two (2) parking lots for a total of 61 motor vehicle spaces including one (1) handicapped space, two (2) spaces reserved for National Park Service vehicles and eight (8) bus/RV spaces. The survey captured 8% of the vehicles during the summer peak and 9% during the fall peak period in these lots.

Historic Sites - Each of the 10 sites provides parking spaces. Of the spaces available, 65 are paved and striped. Additionally, two sites, the Primitive Baptist Church and Methodist Church, have gravel parking areas which are not striped. The survey captured 13% of the vehicles in the Cove in these 10 lots during the summer and fall peak periods. The heaviest visitor use occurs on the front half – primarily at the John Oliver homestead and barn area and the Primitive Baptist Church Area. Two cabins along the backside of the Loop – the Tipton Place and Carter Shields Cabin – also receive numerous visitors.

Camp Store and Parking Area - This 51-space parking area is in the developed area of the Cove adjacent to the ranger's station and functions as a multi-purpose lot serving the camp store and bicycle rental concessionaire, overflow parking demand from the campground, ranger-led programs at the amphitheater, the restroom

facilities, and ranger station. The survey captured 6% of the summer peak vehicles and 5% of the fall peak vehicles in this lot.

Day Use Picnic Area - This facility offers 57 parking spaces adjacent to the picnic sites off of a paved road which loops through the facility. The horse camp is also accessed via this road. During bicycle and pedestrian-only hours on Wednesday and Saturday mornings, it is not unusual for cyclists to park their motor vehicles in the picnic area when other parking areas are full (camp store and entrance parking area). During the summer peak, 6% of the vehicles at the Cove were parked at the picnic area. This percent dropped to four during the fall peak period.

Riding Stables - This facility offers parking at the stables. The lot has recently been paved to provide 22 parking spaces, one (1) of which is a handicapped space. A gravel area provides parking for approximately seven (7) horse trailers. Three percent of the summer and 2% of the fall peak period visitors used this lot.

Other - Other areas which attract vehicles include the campground, horse camp and ranger station. The campground offers one parking space per campsite. This analysis assumes the remaining 13% of the summer peak period vehicles and 3% of the fall peak period vehicles are at these locations.

Table 2 summarizes the vehicular volume distribution in the Cove.

Table 2: 1998 Peak Period Vehicle Distribution in Cades Cove

Location	Percentage of Vehicles in Area	
	Summer	Fall
Loop Road & By Roadside	42.5%	60.5%
Entrance Parking Lot	2.3%	3.5%
Cades Cove Overlook	2.0%	.7%
Wildlife Overlook	.8%	.2%
Pine Oak Nature Trailhead	.4%	.2%
Cable Mill	7.9%	8.0%
John Oliver Cabin	2.1%	1.7%
Primitive Baptist Church	1.4%	1.2%
Methodist Church	.5%	.7%
Missionary Baptist Church	.8%	.4%
Oliver Barn Area	2.1%	2.0%
Abrams Falls & Elijah Oliver Cabin	5.4%	6.0%
Cable Cemetery	.2%	.2%
Dan Lawson Place	.5%	.1%
Tipton Oliver Cabin	.1%	.4%

Location	Percentage of Vehicles in Area Summer	Fall
Carter Shields Cabin	.2%	.2%
Camp Store and Parking Area	7.0%	5.0%
Day Use Picnic Area	7.0%	4.0%
Riding Stables	4.0%	2.0%
Other	12.8%	3.0%

Table 3 compares the occupancy to capacity for several of the paved parking areas adjacent to the Loop Road. The 1998 survey collected the occupancy volumes. The riding stable lot was not paved at this time and, therefore, is not included in the table.

Table 3: 1998 Loop Road Paved Parking Lot Capacity and Occupancy

Location	Parking Spaces	Vehicles Parked Summer	Fall
Entrance Parking Area	70	18	45
Cable Mill Main Lot	55	47	52
John Oliver Cabin	9	16	23
Missionary Baptist Church	8	6	5
Cades Cove Overlook	15	10	9
Cooper Road Trail Lot	5	Not Counted	Not Counted
Abrams Falls & Elijah Oliver Cabin	26	42	77
Pine Oak Nature Trail	6	3	3
Wildlife Overlook	8	6	2
Dan Lawson Place	7	4	3
Tipton Place	5	3	4
Carter Shields Cabin	4	2	2
Camp Store Parking Area	51	49	62
Day Use Picnic Area	57	43	51

As Table 3 shows, the parking area at the entrance of the Cove generally operates at near capacity conditions, especially during the pedestrian and bicycle only time periods, when the Loop Road is closed to motorized vehicles. The demand is greater than the capacity for the Camp store and both the John and Elijah Oliver home sites. When parking areas are full, visitors tend to park wherever space allows – typically in undesignated areas. Parking in these undesignated areas impacts natural resources and impairs the cultural landscape within the Cove. The picnic area provides one parking space per picnic table and generally operates within existing capacity. However when the entrance parking area is full, parking in the picnic area is often used as an overflow lot for cyclists, pedestrians, and hikers. Many of the

remaining paved parking areas located around the Loop Road had enough capacity to meet peak demand periods during the 1998 surveys.

Cades Cove Visitation

Visitor Trends

The number of people visiting Great Smoky Mountains National Park decreased at an average rate of 0.5% per year for the 17-year period from 1986 to 2002. Visitation increased from the previous year during most of these years. However, significant declines in three of these years (1988, 1994 and 2001) cause the average to be negative. The visitation drop from 2000 to 2001 was nearly 11%. This decline may be, in part, related to the change in travel habits across America after the September 11th terrorist attacks. Visitation trends to Cades Cove during this period parallel those of the Park; however, the Cove experienced less of a decline when compared to the Park overall. The average visitation decreased 0.14% per year. Again, this negative growth rate is due to significant visitation declines in 1988, 1994 and 2001. Approximately 1.6 million people visited the Cove in 2000 and 1.5 million people visited the Cove in 2002.

The peak season for Cades Cove runs from June through October. Within this five-month span, here are two distinctive peak visitation periods – the summer vacation season (mid June through August) and the fall color season (mid September through late October). During these peak visitation seasons, the highest visitation volumes occur on the weekends. However, during July and August, weekday visitation levels are high and often reach capacity. The peak visitation times during these periods range from mid morning to early afternoon.

Daily visitation volumes during off peak season (late October through late June and early August through mid September) are considerably less than peak season volumes. The weekday visitation tends to peak during late morning to mid-afternoon hours while weekend visitation tends to peak from mid morning to mid afternoon.

Visitation numbers and patterns change and peak visitation periods in the future may be different from what is seen now. Over the ten-year period from 1990 to 2000, visitation to the park, as a whole, grew significantly during the off-peak months of November through March. In 1990, approximately 1.51 million visitors came to the Park during these winter months. By 2000, this number had grown to over 2.36 million visitors. This trend is likely to continue as more visitors elect to come to the Park during less busy periods or are attracted to gateway community events planned

to bolster visitation as well as changes such as the implementation of year round schools.

The 1998 survey derived an average vehicle occupancy rate of 2.3 from the fall data. This rate is less than the yearly average of 2.4, which indicates smaller group sizes in the fall peak period. The summer survey calculated an average vehicle occupancy of 2.8. This may be related to a larger share of families visiting the Cove during the peak period.

Visitor Activities

Simply knowing the number of visitors is not enough information upon which to base decisions since Cove management deals with more than just capacity versus visitor demand i.e., resource protection, interpretation, enforcement, visitation experience, etc. Therefore, understanding why visitors come to the Cove and what they do when they are at the Cove is an important component of the planning process.

Cades Cove visitors participate in a variety of activities. Table 4 lists the typical visitor activities. Of these, the primary appropriate visitor activities include wildlife viewing, auto touring and visiting historic sites along the Loop Road. These sites include cabins, churches, cemeteries, and a gristmill. Biking, picnicking, camping, hiking, and horseback riding are other popular activities within Cades Cove. These activities allow visitors to view the natural beauty of Cades Cove as well as the historical sites.

Table 4: Visitor Activities in Cades Cove

Appropriate	Inappropriate
Visiting historic structures/sites	Organized sports
Hayrides	Creating unauthorized trails
Ranger-led programs	
Viewing wildlife	**Illegal**
Enjoying scenic beauty	Harassing/feeding wildlife
Picnicking	Plant/animal poaching
Bicycling	Parking in fields
Camping	Underage driving
Day and back country hiking	Drunk driving
Horseback riding	Obstructing traffic
Fishing	Using firearms
Permitted special events	Vandalism of historic structures
Descendant access and events	Graffiti/Littering
	Urinating/defecating outside or within historic structures

An analysis of visitor use data from 1990 – 2001 determined average levels of visitation per activity. The specific activity types include auto touring the Loop Road, visiting the Cable Mill area, bicycling on the Loop Road, camping and other overnight activities, hiking, hayrides, and horseback riding. The analysis compared visitor participation in each activity for the same month over the twelve year span in order to determine the average monthly participation per activity. This analysis allows for the identification of peak periods of activity on a monthly basis as well as providing a comparison of the type of activities visitors tend to prefer. Figure 2 shows these monthly averages for the more popular activities.

Figure 2: Historic Average Monthly Visitation Per Activity

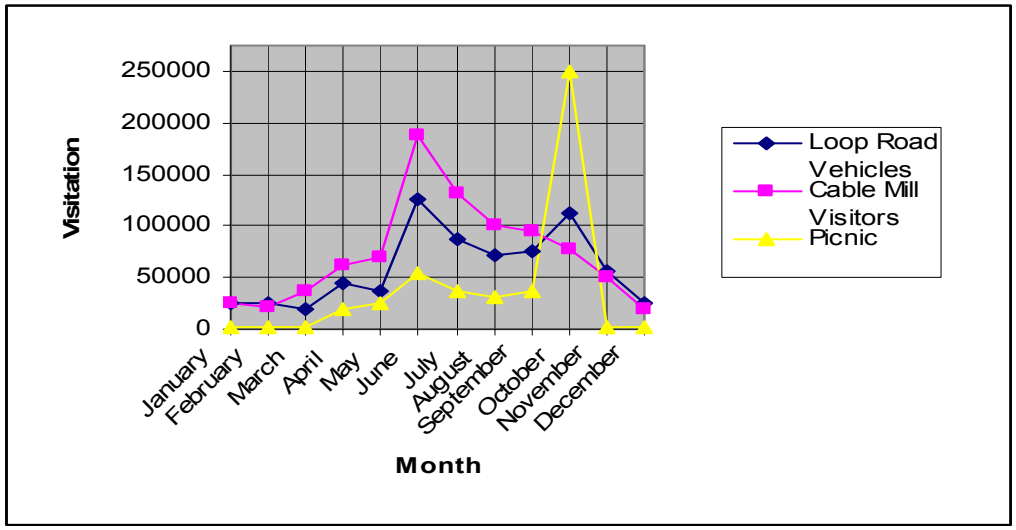


Figure 2 depicts three trends. First is the relationship between visitors to the Cable Mill area and visitors driving the Loop Road. During the winter and early spring months, the ratio of visitors at the Cable Mill area to the number of vehicles traveling on the Loop Road is close to the same. This indicator that vehicle occupancy is low shows individual visitors rather than families visit during this period. During the summer peak period, the ratio of visitors at Cable Mill to vehicles traveling on the Loop Road increases. This is consistent with higher vehicle occupancy during this period. The second trend is the clear peaks that relate to the summer months (June/July) and fall months (mainly October). These are periods where monthly visitation typically peaks anywhere from 120,000 to 200,000 visitor range.

The third trend occurs in the fall months. Fewer visitors to the Cable Mill area in the fall than vehicles on the Loop Road indicates fall visitors are primarily in the Cove to

view fall colors/wildlife and to picnic, not to visit historic sites. During this time, mild weather, fall colors and active wildlife combine to create an ideal setting for weekend picnicking.

The activities previously mentioned take place in eight common areas. A description of each area along with the visitor use percentages follows. The percentages are from the 1998 survey when visitors voluntarily completed exit surveys about their experience in the Cove.

Loop Road - Historical sites, resource facilities, and hiking and horse trailheads can be accessed via the Loop Road. Although not sanctioned with designated areas or facilities, picnicking is a popular activity which takes place within the Cove. Wildlife viewing and bicycling are two popular visitor activities, which take place on and adjacent to the Loop Road. The Loop is open only to bicyclists and pedestrians on Wednesday and Saturday mornings from sunrise to 10:00 AM from Old Timers day in May through the last Wednesday before Old Timers Day in September. Visitors can obtain a guidebook at an open-sided shelter at the Loop entrance. Rangers and VIPs occasionally staff this shelter to talk with visitors.

The survey calculated the following visitor use percentages for activities along the Loop Road during the summer and fall peak periods:

- Sparks Lane - 16% (summer) and 12% (fall)
- Hyatt Lane – 25% (summer) and 19% percent (fall)
- Pull off and Parking Areas – 78% (summer) and 91% (fall)
- Wildlife Viewing – 87% (summer) and 93% (fall)
- Hiking – 40% (summer and fall)
- Bicycling – 23% (summer) and 8% (fall)

Cable Mill Area - This area is located halfway around the Loop Road. It offers restrooms, a bookstore, a functioning gristmill, and several historical buildings that can be accessed via a self-guided walking tour. Outdoor ranger-led education programs are often held in this area, as well as Old Timers Day festivities. Great Smoky Mountains Association, a cooperating partner to the park, operates a small bookstore providing interpretative, historical and educational items. Seventy-seven percent of the summer visitors stopped here while only 63% of the fall visitors stopped.

Campground - The campground is located adjacent to the ranger station within the developed area at Cades Cove. It offers 159 sites, including two handicapped accessible sites. Four group campsites are also available. The sites offer a fire ring, table and designated tent pad. There are five restroom facilities, none of which provide hot water or showers. Electricity is not offered at any of the sites. The maximum stay is two weeks. Twenty-seven percent of the summer visitors camped here while only 1% percent of the fall visitors utilized this facility.

Horse Camp - An overnight horse camp facility located near the entrance to Cades Cove Loop Road operates from April through October. The camp has three (3) sites. Each site can accommodate up to four (4) horses and six (6) riders. It is accessed through the day use picnic area. Several hiking trails in the Cades Cove District - separate from those used by the horse concessionaire - are designated for horse use. Ten percent of the summer and 4% of the fall visitors rode horses. This statistic is combined with riders that used the horse concessionaire and riders that brought their own horses for the day and did not use the horse camp.

Day Use Picnic Area - There is one picnic facility located at the beginning of the Cades Cove Loop Road. It offers 60 sites, complete with tables and grills. There are two restroom facilities. All sites are accessed via a paved road through the site. Forty-eight percent of the summer and 36% of the fall visitors stopped at this facility. However, the survey shows 33% of the summer and 48% of the fall visitors actually picnicked at the Cove. These statistics indicate fall picnicking is more likely to take place along the Loop Road.

Concession Operations - There are two concession operations located in Cades Cove. The first is the camp store/bicycle rental concession, located at the campground. It provides basic food and camping items along with bicycle rentals. Adjacent to the camp store are visitor restroom facilities and an amphitheater that is used for ranger-led activities and programs. The statistic of 23% of summer and 8% of fall visitors riding bicycles combines riders using rentals from this concession and riders using their own equipment. Forty-nine percent of the summer and fall visitors stopped at the camp store. The second concessionaire offers day and overnight horseback riding trips and seasonal hayrides around the Loop Road. The horse concession operation uses trails in the Cades Cove district which are separate from those designated for day use and hiking. Fourteen percent of the summer and 5% of the fall visitors stopped at the stables, but only 10% in the summer and 4% in the fall actually rode horses. This statistic is combined with riders that used their own horses. This is also the staging area for day-use horseback riders who bring their own horses to the Cove.

In addition to the two concessions, the Great Smoky Mountain Association, a cooperating association to the Park, operates a bookstore in the Cable Mill area providing interpretative materials, park maps, and other items.

Historic Building Sites - There are ten historical building sites located around the Loop Road. Several churches, cabins, barns, and a mill are contained within these sites. Most can be viewed from the Loop Road, but visitors may pull off into parking lots or pull-out areas to visit these sites. Seventy-eight percent of the summer and fall visitors stopped and visited at least one building.

Ranger Station - The ranger station is located at the entrance to Cades Cove Loop Road across from the Campground. Information, ranger services, and emergency services may be accessed at the station.

Table 5 summarizes the percent of Cove visitors participating in various activities according to the 1998 survey effort.

Table 5: Percent of Visitors Participating in Cades Cove Activities in 1998

	Participation	
Activity	**Summer**	**Fall**
Loop Road	100%	100%
Sparks Lane	16%	12%
Hyatt Lane	25%	19%
Pull-off and Parking Areas	78%	91%
Wildlife Viewing	87%	93%
Hiking	40%	40%
Bicycling	23%	8%
Cable Mill	77%	63%
Camping	27%	1%
Horseback Riding	10%	4%
Historic Sites	78%	78%
Camp Store	49%	49%
Picnicking	33%	48%

Visitation Projections

Long-range management of Cades Cove requires an understanding of current visitation levels and the ability to forecast future levels of visitation. Visitation volumes typically vary by season and by day of week. During five months of the year

(November through March), Cades Cove does not experience a high level of visitation when compared to peak periods and generally does not require increased or additional management effort to accommodate the level of visitation experienced. Visitation during the shoulder months requires a higher level of management effort on weekends but not on weekdays. Peak visitation periods when the Cove experiences high volumes require increased management efforts every day. This analysis defines which months and which days of the week during the year will require management effort based on forecast volume.

Projection Methodology

The future volumes for visitors and vehicles are projected using growth rates based on the historical visitation trends. The projections utilize three growth rates ranging from a low to high growth rate per year to provide a range of anticipated visitor volumes to Cades Cove. As previously mentioned, data was analyzed over a seventeen year period from 1986 to 2002. This data was from the Townsend Entrance counter. Year 2000 data from counters at the Townsend Wye provided volumes of vehicles traveling to and from Cades Cove itself. This data was compared to the Loop Road entrance data to develop a ratio by which to factor the Townsend Entrance data down to Cades Cove vehicles only.

October and July are the months used for determining growth rates. October typically has the top five or ten daily visitor volumes of the year and the design day volume for this analysis is an average weekend in October. July typically has the highest monthly visitation because there are more visitors to the Cove on weekdays in the summer.

October and July also represent the two types of visitation patterns at the Cove. July has larger group sizes and a more even split between the weekday and weekend volumes. October visitation occurs in smaller group sizes and is more concentrated on the weekends. A regression equation was fit to the Townsend Entrance volume data to determine a low, medium and high growth rate for October and July. The low was fit with data from 1992 – 2002, the median with the full range of data from 1986 – 2002 and the high with data from 1986 – 1992. These periods were chosen because they represent a range of visitation growth characteristics that have been experienced in Cades Cove over the past 17 years. Table 6 shows the resulting growth rates in terms of vehicles per month after factoring the Townsend Entrance rates to Cades Cove vehicles.

Table 6: Increase in Vehicles Entering Cove per Month

	Growth Rate		
Month	**Low**	**Median**	**High**
July	272	1,269	1,948
October	873	1,575	2,085

The methodology used the growth rates in Table 6 to calculate the vehicular growth expected during July and October between 2000 and the years 2007, 2012 and 2022. The resulting vehicle volume growth is added to the volume in 2000 to obtain the forecast vehicular demand for July and October in each of these future years.

The methodology analyzed each month individually to determine when transportation management changes would be required to avoid congestion on the Loop Road. The average monthly visitation over the seventeen year period was calculated and compared to that of October since this month experiences the peak volume days and frequently operates at near or over capacity conditions. Table 7 shows the percent of visitation for each month compared to October.

January, February, March, November, and December have low visitation rates compared to October. Therefore, transportation management is not likely to be needed and future volumes have not been estimated for these months. Visitation forecasts have been prepared for all the other months. In this report, the determination of whether or not transportation management is needed is based on transportation-related parameters such as number of vehicles and Loop Road capacity. Management efforts necessary to protect and preserve the natural and cultural resources and quality of visitor experience are not included in this analysis. For purposes of this analysis, April, May and September visitation is assumed have similar characteristics to October in that weekend volume is assumed to be higher than weekday and group sizes are assumed to be smaller. June and August characteristics are assumed to be similar to July in that weekday volume is assumed to be closer to the weekend volume and group sizes are assumed to be larger.

Table 7: Average Monthly Visitation as a Percent of October Visitation

Month	Rate
January	23%
February	27%
March	38%
April	54%
May	68%
June	86%
July	114%
August	95%
September	71%
October	100%
November	43%
December	29%

The 2007, 2012 and 2022 volumes for April, May and September were estimated by applying the percentage in Table 7 to the forecasted October volumes. Likewise, the 2007, 2012 and 2022 volumes for June and August were estimated by applying the percentage in Table 7 to the forecasted July volumes. Table 8 shows these monthly volumes.

Table 8: Forecasted Monthly Vehicular Volumes

		Number of Vehicles Entering Cades Cove		
Year	Month	Low	Median	High
2007	April	47,015	49,685	51,620
	May	58,660	61,990	64,410
	June	82,855	88,840	92,920
	July	96,635	103,615	108,370
	August	91,910	98,950	103,075
	September	61,585	65,085	67,625
	October	86,595	91,515	95,085
2012	April	49,385	53,960	57,280
	May	61,615	67,330	71,475
	June	84,020	94,280	101,270
	July	97,995	109,960	118,115
	August	93,205	104,580	112,340
	September	64,690	70,690	75,040
	October	90,960	99,390	105,510
2022	April	54,120	62,515	68,605
	May	67,530	78,000	85,600

Year	Month	Number of Vehicles Entering Cades Cove Low	Median	High
2022	June	86,350	105,155	117,980
	July	100,715	122,645	137,600
	August	95,790	116,650	130,870
	September	70,900	81,890	89,870
	October	99,685	115,145	126,370

Average Weekend Day by Month

The average weekend day volume for the month of October, 2000 is 4.49% of the total monthly volume. The corresponding July percentage is 4.00%. Applying these percentages to the other monthly volumes in Table 8 yields the forecasted average weekend day per month for 2007, 2012 and 2022. Table 9 shows these volumes.

Table 9: Forecasted Average Weekend Day Vehicular Volume Per Month

Year	Month	Forecast Volume Low	Median	High
2007	April	2,110	2,230	2,320
	May	2,635	2,785	2,890
	June	3,315	3,555	3,720
	July	3,865	4,145	4,335
	August	3,675	3,940	4,125
	September	3,230	3410	3,545
	October	4,540	4,795	4,980
2012	April	2,220	2,425	2,570
	May	2,770	3,025	3,210
	June	3,360	3,770	4,050
	July	3,920	4,400	4,725
	August	3,730	4,185	4,495
	September	3,390	3,705	3,930
	October	4,765	5,210	5,530
2022	April	2,430	2,810	3,080
	May	3,030	3,500	3,845
	June	3,455	4,200	4,720
	July	4,030	4,905	5,505
	August	3,830	4,665	5,235
	September	3,715	4,290	4,710
	October	5,225	6,035	6,620

Average Weekday by Month

The average weekday volume for the month of October, 2000 is 2.89% of the total monthly volume. The corresponding July percentage is 3.04%. Applying these percentages to the monthly volumes in Table 8 yields the forecasted average weekday per month for 2007, 2012 and 2022. Table 10 shows these volumes.

Table 10: Forecasted Average Weekday Vehicular Volume Per Month

Year	Month	Forecast Volume Low	Median	High
2007	April	1,345	1,420	1,475
	May	1,680	1,775	1,840
	June	2,520	2,700	2,825
	July	2,940	3,150	3,295
	August	2,795	2,995	3,135
	September	1,760	1,860	1,935
	October	2,480	2,620	2,720
2012	April	1,410	1,545	1,640
	May	1,760	1,925	2,045
	June	2,555	2,865	3,080
	July	2,980	3,345	3,590
	August	2,835	3,180	3,415
	September	1,850	2,020	2,145
	October	2,600	2,845	3,020
2022	April	1,550	1,790	1,960
	May	1,930	2,230	2,450
	June	2,625	3,200	3,590
	July	3,060	3,730	4,185
	August	2,910	3,545	3,980
	September	2,030	2,340	2,570
	October	2,850	3,295	3,615

Design Hour

The design hour is the hour during the day which experiences the highest volume demand. For planning purposes, the design hour is of importance during the higher demand days –July and August weekdays and weekend days and June, September and October weekend days. The design hour was determined by analyzing hourly traffic counts entering the Cove recorded at the Townsend Wye. The historical percentages of traffic entering the Cove by hour of the day were applied to the daily traffic forecasts to estimate future design hour conditions. When applied to the average weekday and weekend volumes for these months as shown in Tables 9 and 10, this design hour factor yields the vehicular design hour volume. Table 11 shows the forecasted weekend day design hour volumes for July and October while Table 12 shows the weekday design hour volumes for the busiest months of July and August. For simplicity, only the medium growth rate forecasts of design hour traffic are provided.

Table 11: Forecasted Weekend Day Design Hour Vehicular Volume

Year	Month	Design Hour Volume
2007	July	464
	October	701
2012	July	490
	October	760
2022	July	549
	October	882

Table 12: Forecasted Weekday Design Hour Vehicular Volume

Year	Month	Design Hour Volume
2007	July	355
	August	340
2012	July	375
	August	355
2022	July	415
	August	400

Peak Demand Period

The peak demand period is the time during the day which experiences the highest visitor demand. It includes the design hour. According to 2000 data, summer peak period demand on the weekends ran from 10:00 am until 5:00 pm on the weekend days and from 10:00 am until 3:00 pm. The fall weekend day peak period occurred between 10:00 am and 4:00 pm. A peak demand period is typically only a few hours a day. But, the popularity of the Cove attracts significant vehicular demand for most of the day, causing the peak demand period to extend beyond the normal few hours. This further suggests a need for transportation management.

Loop Road Capacity

This section discusses the existing roadway conditions and a projected capacity for the Loop Road. It also compares projected demand to existing capacity to determine if any capacity issues will arise in the future.

Existing Roadway Conditions

Roadway capacity is basically a measure of the number of vehicles that can traverse a segment of roadway in one hour. Many features influence capacity, such as average travel speed, geometry (lanes, shoulders, grade, alignment), conflict points, and vehicle mix. If these features compromise the free flow speed, fewer vehicles can traverse the segment on an hourly basis and a lower roadway capacity results. Based on the 1998 survey, the average visitor travel time over the length of the Loop Road is three (3) hours in summer and 3.1 hours in fall peak periods. Accounting for stops, this equates to an average travel speed of five (5) MPH. The posted speed limit is 20 MPH.

The characteristics of the Loop Road as well as the drivers themselves influence the slow average travel speed. These features are:

- Geometry – The typical road cross-section is one, eleven-foot lane wide with narrow, two-foot wide shoulders in some locations and no shoulders in other locations. The road is narrower in a few locations. The alignment has many curves with very few lengthy tangent sections. Several of the curves are sharp and require a slow speed to safely negotiate. At two locations toward the middle of the Loop, the alignment consists of reverse curves on a steep downgrade. Signing suggests bicyclists dismount and walk in order to safely navigate these two sections. These sections are the reason RV use is not recommended on the Loop Road. The grade for the rest of the Loop is gently rolling with very few flat sections. Since there are narrow or non-existent shoulders, there are no adequate vehicle refuges to get out of the traffic flow in the event of breakdown or a desire to stop in a non-designated area. Thus, vehicles that pullover are still partially in the travel-way and require slow, careful navigation by subsequent vehicles. Also, the vegetation along side the road deteriorates as a result of this practice.
- Conflict Points – There are several designated parking and pull off areas along the Loop Road. There are no acceleration or deceleration lanes to transition between the Loop Road and these areas. Thus, drivers must reduce speed or stop for vehicles which are slowing to pull into these areas or to avoid vehicles leaving these areas. In addition, there are four intersections at the termini of each of the cut-off lanes. Through traffic on the Loop Road does not stop, but may have to slow for vehicles turning onto and off of these lanes because there are no turn lanes or acceleration lanes.
- Vehicle Mix – The majority of the Loop Road vehicles are automobiles. However, even the small presence of RV's decreases the average travel speed because of the curvy alignment and rolling grades. Since the shoulders are narrow or non-

existent, bicyclists and pedestrians share the one travel lane with motorized vehicles. Consequently, average travel speed slows if drivers slow down to maneuver around the bicycles and pedestrians. This mix also poses a safety issue for the bicyclists and pedestrians due to their close proximity to the motor vehicles.

- Driver Characteristics – The typical Loop Road driver behaves differently in this setting than they do in the usual day-to-day driving routine. Many drive slowly in order to scan for wildlife and frequently stop in the road to observe wildlife more closely. This behavior causes traffic to come to a standstill until the first driver moves. Many also drive slowly to observe the views along the sections which are not flanked by forest right next to the road. Slowing down to check the availability of parking at designated parking and pull-off areas or to view structures is another practice which contributes to the slow average travel speed.

Capacity

Because of the unique road features and driver behaviors, the Loop Road vehicular capacity cannot be calculated using traditional methods. Therefore, an alternate methodology is used to determine the vehicular capacity of the Loop Road. The 1998 survey effort counted the number of vehicles involved in each traffic backup, or jam, throughout the length of the survey effort. Based on the survey results, the percentage of vehicles involved in traffic back-ups at any one time increased dramatically when the total number of vehicles on the Loop Road exceeded 800. The hourly volume of traffic entering the Cove during periods when the road had about 800 vehicles was 300 to 330 vehicles. The ratio of 800 total vehicles to 330 entering vehicles per hour suggests that a desirable travel time around the loop without the influence of long traffic queues is about 2 ½ hours.

The total vehicle use level of 800 vehicles that can be accommodated without a major increase in vehicles caught in queues, and the corresponding entering volume of 330 vehicles per hour have been identified as the practical capacity of the Cove road. When the use of the road rises above these levels, visitor experience is compromised and visitor behavior that damages resources (such as roadside parking) is likely to increase.

Another factor that may limit the desirable capacity of Cades Cove is the impact of visitors on natural and cultural resources. Additional study is needed to define the resource carrying capacity of the Cove, based on the impacts that different levels of visitor use have on sensitive resources, including the historic structures. Crowding of visitors at features may also have an impact on the overall capacity of the Cove.

Level of Service

Level of service is a term used to qualitatively describe the operations of a roadway. It ranges from "A" which is the best to "F" which is the worst in terms of operations. The level of service is determined by the free flow speed of the average vehicle and the density of vehicles on a segment of roadway. The highest levels of service allow drivers to travel at or close to the posted speed and unimpeded by other vehicles. Thus, improving the level of service under this methodology tends to involve geometric or structural improvements to add capacity and does not account for transportation demand management practices which may be able to reduce roadway density. This methodology also assumes vehicles are on the roadway segment solely for the purpose of traversing it as quickly and safely as possible. Thus, the traditional level of service concept can not be applied directly to roads such as the Loop Road which service scenic areas and are driven by those seeking a leisurely drive.

Demand to Capacity Comparison

Comparing the projected volumes to capacity determines if the Cove can accommodate the anticipated future visitation demand. The analysis compares peak hour volume to capacity for three factors – baseline vehicular volume on the Loop Road, projected vehicular volume on the Loop Road, and paved parking lot capacity. A carrying capacity analysis will determine if projected visitor demand exceeds resource capacity.

The baseline vehicular design hour volume comparison shows what is currently happening within the Cades Cove area in regards to how much of the existing facility capacity is being used. This comparison also provides a starting point from which to consider future growth comparisons. The average weekend day design hour volume of 650 vehicles in October exceeds the recommended hourly entrance capacity of 330 vehicles per hour by a wide margin. Thus, the Cove is currently operating well over the estimated vehicular capacity and will in the future with the projected increases in visitation.

Per Table 3, most of the paved parking lots currently operate with excess capacity under peak period conditions. Demand currently is very near capacity or exceeds capacity for a few of the paved lots and is likely to do so under future volume conditions:

- Abrams Falls & Elijah Oliver Cabin
- John Oliver Cabin

- Camp Store Parking Area
- Cable Mill – the gravel overflow lot can accommodate excess demand for the paved parking spaces

Conclusion

Cades Cove is a popular destination within Great Smoky Mountains National Park. Its various activities and sites attract close to 2 million visitors each year. During peak visitation periods, the Cove functions at capacity or over-capacity conditions and is expected to do so in the future. This analysis determined that these peak visitation periods occur seven months of the year – April, May, June, July, August, September, and October. Additional effort is required during these months to manage the vehicular demand.

The analysis identified 800 vehicles as the practical capacity of the Cades Cove Loop Road. This is the number of vehicles that can be accommodated without a major increase in vehicles caught in queues. The recommended hourly entrance volume is 330 vehicles. This allows for a 2 ½ hour travel time to complete the Loop. When the use of the road rises above these levels, visitor experience is compromised and visitor behavior that damages resources (such as roadside parking) is likely to increase.

References

Great Smoky Mountains National Park: Cades Cove Visitor Use Study, Operations Research Consulting Association, Inc., April 1999.

Cades Cove Technology Assessment Report, Wilbur Smith Associates, August 2001.

The Road Inventory for Great Smoky Mountains National Park, Federal Highway Administration, June 1999.

Great Smoky Mountains National Park: Visitor Studies Report 92, Margaret Littlejohn, July 1997.

Internet Explorer, www.nps.gov, 2003.

Brochure, Great Smoky Mountains, National Park Service.

Brochure, Great Smoky Mountains Trail Map, National Park Service.

Brochure, Cades Cove Tour, Carson Brewer, Tennessee, 1999.