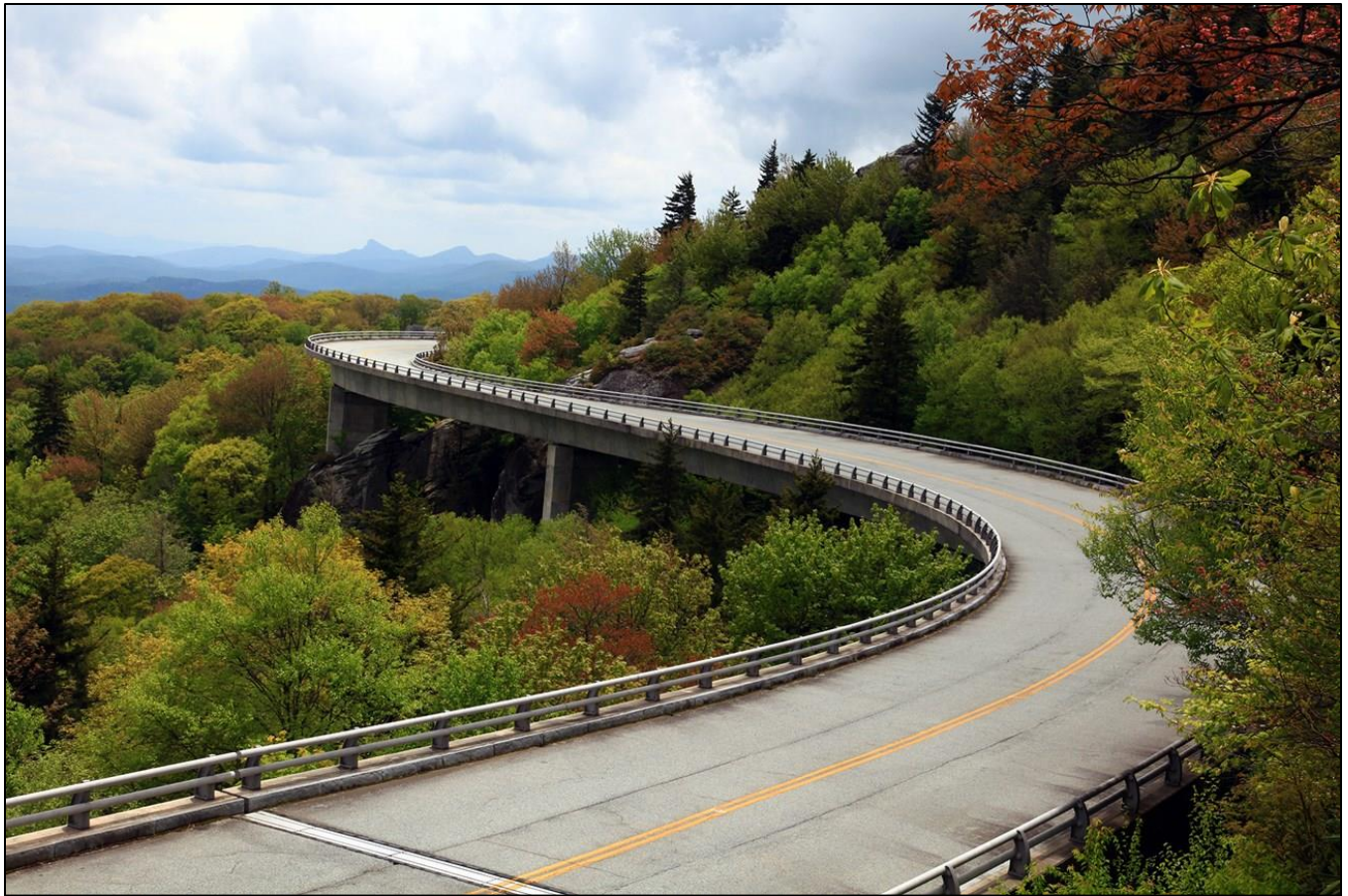




Blue Ridge Parkway

2023 Visitor Use Counting Study



ON THE COVER

Linn Cove Viaduct on the Blue Ridge Parkway
Photo by NPS

Blue Ridge Parkway

2023 Visitor Use Counting Study

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with:

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Prepared for:
Blue Ridge Parkway



June 2024

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado



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Introduction

The Blue Ridge Parkway (BLRI) stretches 469 miles through the region, connecting Great Smoky Mountains National Park with Shenandoah National Park. BLRI is a series of parks providing visitors access to high mountain passes, a continuous series of panoramic views, the boundaries of its limited right-of-way rarely apparent, and miles of the adjacent countryside seemingly a part of the protected scene. The park protects various plants and animals and provides diverse recreation opportunities for park visitors. Visitors come to BLRI to experience a variety of activities including hiking, biking, wildlife watching, scenic driving, and more. The Parkway, stretching 469 miles in total, represents one of the most visited sites in the nation due to its geographic reach and popularity as being “America’s Favorite Drive”.

Parks across the National Park Service (NPS) have an obligation to estimate visitor use when feasible. For parkways, visitor use estimation has been an ongoing effort. The size and nature of parkways make measuring visitor use challenging.



Source: www.nps.gov

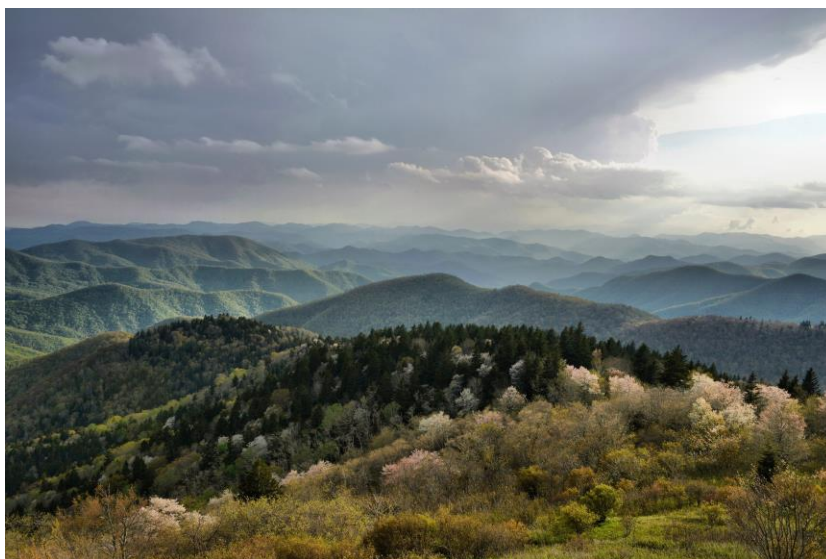


Background and Methods

This report section outlines the historical background and new counting system for the BLRI visitor use counting model. Additionally, the section explains the methods and analysis to analyze mobile location and Federal Highway Administration counter data to update the BLRI counting procedures.

Project purpose and approach

The Blue Ridge Parkway (BLRI) Visitor Use Counting Study has been ongoing since the project's start in July 2023. Units across the National Park Service (NPS) are mandated to provide monthly updates of visitation estimates, if feasible. For some parks, this process is straightforward, but BLRI has unique challenges due to the length, complexity, and number of access points. Parkways, along with rivers and trails, are some of the most difficult locations to accurately estimate visitation



Source: www.NPS.gov

because of their geographic reach

and uncontrolled access. For decades, BLRI has provided counts of both recreation and non-recreation visits and hours; however, the count system procedures have not been updated since 2002. Since then, the region has changed significantly. Asheville, NC, and Roanoke, VA, the two primary metropolitan areas near BLRI, have grown substantially, and recreational use in the Appalachians has changed over time.

BLRI is a challenging park to estimate use because of its miles of boundary and numerous access points via public and private roads and communities. Currently, BLRI is estimating its visitor use from protocols established in 2002 based on 15 vehicle counters deployed across its 469 miles of roadway. These counters are used as inputs into regression formulas that estimate use in areas that do not have equipment installed. The overall visitor counting system and protocol need to be reevaluated for current accuracy. Previous studies have shown that vehicle counter placement can affect a counter's accuracy. Currently, the park use estimation protocol assumes 15 operational counters across the 469 miles of the Parkway. However, the operational status of some counters is unknown and the NPS is evaluating its counters. Ultimately, the NPS needs to reevaluate the public use estimates developed in 2002 and update its methodology.



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Scoping Trip

To provide context to assist in updating the current count procedures, the research team traveled the parkway in person during August 2023, gaining insight into major components of the parkway including:

- 1) Visitor/traffic flow
- 2) Differences between recreation and urban/commuting areas
- 3) Relative differences between segments on the Parkway
- 4) Major roadway intersections and area attractions
- 5) Opportunities and challenges for maintaining current physical counters

The scoping trip allowed for an in-depth evaluation of how best to adjust the count system. From the scoping trip, a few major considerations came to the forefront of the project:

- 1) The current system relies on many counters that are either not functional or difficult to reach.
- 2) Some stretches of the parkway are more remote and see much less traffic volume than the urban centers of Roanoke, Asheville, and near Great Smoky Mountains National Park.
- 3) Creating a logistically and administratively feasible system will benefit the parkway in the long run.

With these considerations in mind, the research team began creating a methodology that could be used to address each point of issue. Between specific discussions on the count procedures and internal brainstorming on current best practices and the feasibility of a system overhaul, the research team has developed a promising strategy to update BLRI's count procedures and streamline the update and monitoring process over time. The following sections detail the current system, the potential changes, and the next steps within the project.

Study area

The study area we focused on for BLRI included the entire 469 miles of parkway. BLRI is characterized by its porous boundaries, featuring hundreds of access points distributed across the parkway (Figure 1). As discussed, this extensive network of entry and exit points poses challenges for accurately counting visitor use and estimating overall visitation. Moreover, BLRI is closely connected to many gateway communities, ranging from urban centers like Asheville and Roanoke to smaller communities like Boone, Mount Airy, and Waynesboro. These communities act as entry points and central hubs for visitors exploring the parkway. The numerous gateways add complexity to how visitors move within and around the park, as many often get on and off the parkway to travel between the park and these communities. These factors suggest that the visitor use count procedures for BLRI would benefit from refinements to enhance the accuracy and reliability of visitor use estimates.



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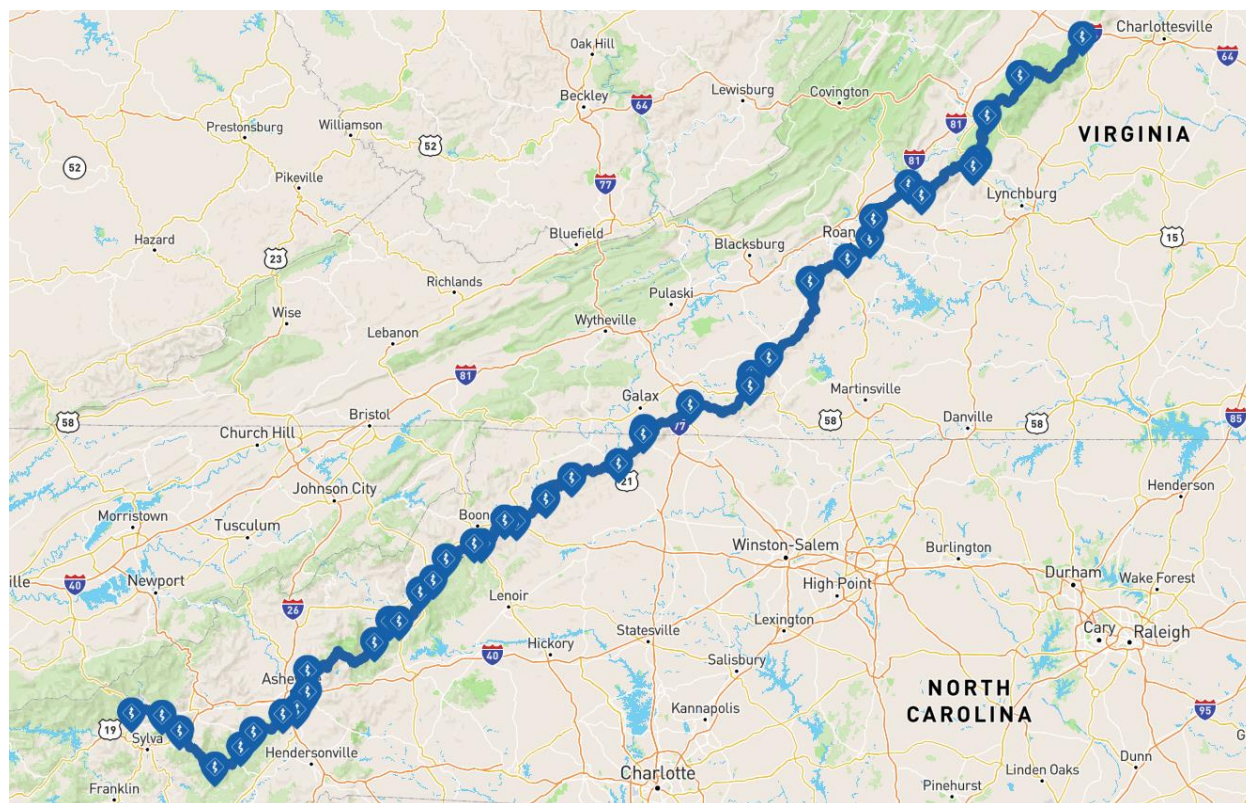


Figure 1: Numerous access points along BLRI (source: Blue Ridge Parkway Association)

Fifty-six physical counters owned and operated by BLRI were the main source of data for the visitor use counting model.

In 2002, the counting model transitioned from the 56 counters installed down to 15 with the remaining locations being estimated using regression formulas. The current formulas were developed using statistical relationships from the original set of counters. However, there are gaps in documentation that make retaining these models in full challenging and/or impossible. Replicating the models is no longer possible as the counter data from the original dataset was not retained.

As developed (Obremski 2002), the present procedures utilized vehicle counter data from January 1996 to December 2001 to estimate a series of regression models that allowed the number of counters to be reduced from 56 to 15. The remaining counters were maintained given either their predictive power or their inability to be predicted within an acceptable margin of error. All established regressions were developed on a seasonal basis (May-November and December-April), contained only a single independent count (variable), and

Counter	Dec-April	May-Nov
F6	.451*F4 + 1994	.221*F4 + 5902
F7	.221*F4 + 997	.216*F4 + 325
F8	.171*F4 + 601	.250*F4 + 314
F10	1.024*F9 + 227	.392*F9 + 8017
F15	.441*F14 + 464	.327*F14 + 2413
F16	.742*F14 + 4197	.209*F14 + 11248
F17	.599*F14 + 3963	.444*F14 + 6515
F22	2.529*F9 + 2477	.570*F25 + 8520
F23	.189*F25 + 1780	.257*F25 + 2321
F26	.102*F25 + 2625	.188*F25 + 2192
F29	.400*F33 + 1318	.486*F33 + 1386
F30	.408*F33 + 705	.490*F33 + 281
F31	.655*F33 + 1353	.495*F33 + 3332
F32	1.077*F33 + 173	.941*F33 + 2311
F34	.336*F33 + 1136	.195*F33 + 4575
F40	.460*F42 + 234	.368*F42 + 1596
F41	1.160*F42 + 66	.989*F42 + 1282
F43	.558*F42 + 747	.500*F42 + 1677
F44	.656*F42 + 532	.578*F42 + 1940
F45	.518*F42 + 1051	.465*F42 + 1989
F46	.461*F42 + 731	.550*F42 + 748
F51	.198*F53 + 326	.165*F53 + 1043
F52	.390*F53 + 6242	.308*F53 + 14176
F54	.345*F53 + 261	.292*F53 + 8873
F55	.233*F53 + 2005	.075*F53 + 3340
F59	.318*F63 + 704	.709*F63 + 3842
F60	.161*F63 + 732	.224*F63 + 803
F61	.675*F63 + 1688	.814*F63 + 1220
F62	.143*F63 + 1809	.072*F63 + 3619
F64	.791*F63 + 531	.787*F63 + 2039
F65	.195*F63 + 150	.254*F63 + 220
F71	.105*F76 + 3601	.0878*F76 + 7990
F72	.466*F75 + 4781	.618*F76 + 558
F74	.404*F77 + 6835	.616*F77 + 519
F78	.226*F76 + 9416	.380*F76 + 8045
F79	.0865*F77 + 1132	.041*F76 + 248
F81	.657*F83 + 2573	.541*F83 + 8661
F82	.628*F83 + 545	.349*F83 + 663
F84	.610*F83 + 1455	.785*F83 + 1716
F85	.733*F83 + 1250	.919*F83 + 1834
F86	1.384*F83 + 401	1.587*F83 + 669

RI



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were significant at or below the $p=0.05$ level. Under conditions of low volumes recorded on any of the remaining counters, the estimated counter location volume will be assigned a zero if the regression would have otherwise resulted in a negative volume number (in Excel, this is achieved by the following formula: =maximum(formula,0)).

Based on the current system, the physical count locations have served the park well over the past two decades. When the full system is up and running, it provides a comprehensive view of traffic patterns across the parkway. However, many of the current counters are nonfunctional and difficult to maintain. Counter issues and malfunctions are frequently cited resulting in a need to utilize 5-year averages in many months of reporting. For example, in a recent entry (3/1/2022) the following is noted: “5 Year estimates used for the following inoperable counters: MP 2.2, 61.6, 199.4, 330.9, 382.5, 384.7, 388.7, 388.9, 443.2”¹ While utilizing multi-year averages is fine when necessary, they should only be used sparingly as they do not reflect many of the changes in recent years due to issues such as COVID-19. Because of the challenge to maintain, operate, and have confidence in the current system, the research team investigated other options to set up the count procedures for BLRI moving into the future.

Current Visitor Estimates

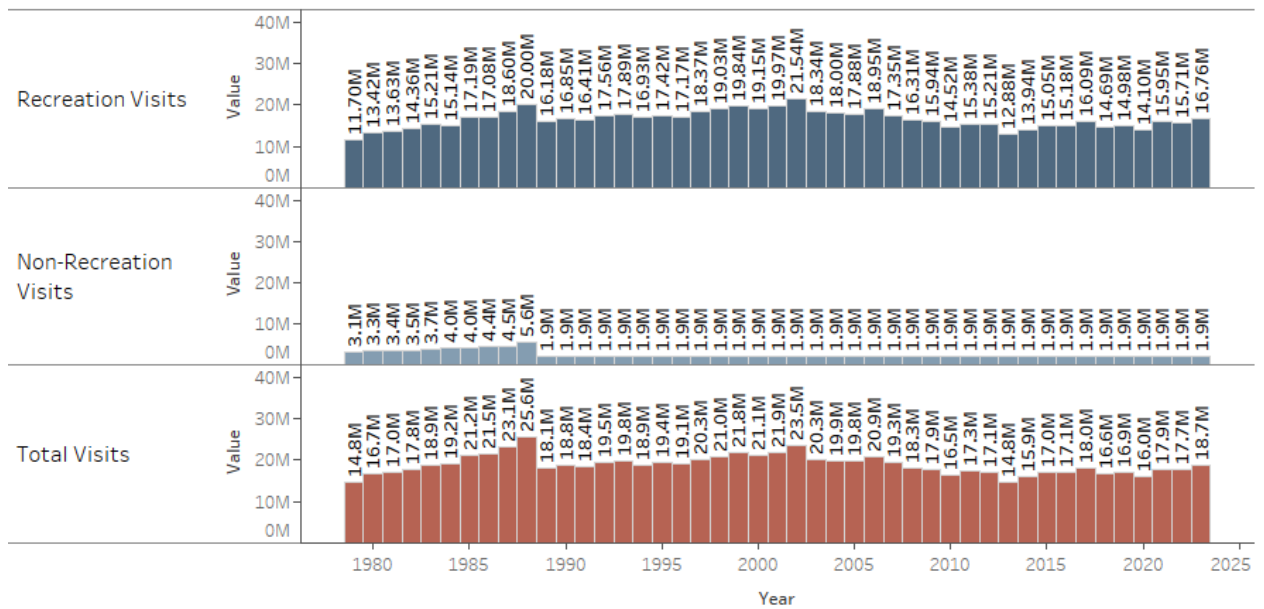
The following figure presents visitor estimates to the Blue Ridge Parkway (BLRI) from 1979 to 2023, categorizing them into recreation visits, non-recreation visits, and total visits (the sum of recreation and non-recreation visits). Based on current counting procedures, recreation visits saw significant growth from 11.7 million annual visits in 1979 to a peak of 21.5 million in 1999, but steadily declined afterward, reaching a low of 13.8 million in 2013. In subsequent years, recreation visits showed signs of recovery, fluctuating between 14.1 million and 16.7 million. Methods for calculating non-recreation visits have remained constant since 1989 at 1.9 million annual visits.

¹<https://irma.nps.gov/Stats/SSRSReports/Park%20Specific%20Reports/Monthly%20Visitation%20Comments%20By%20Park?Park=BLRI>

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BLRI Visits by Year, 1979 - 2023



*2023 data may be subject to change.

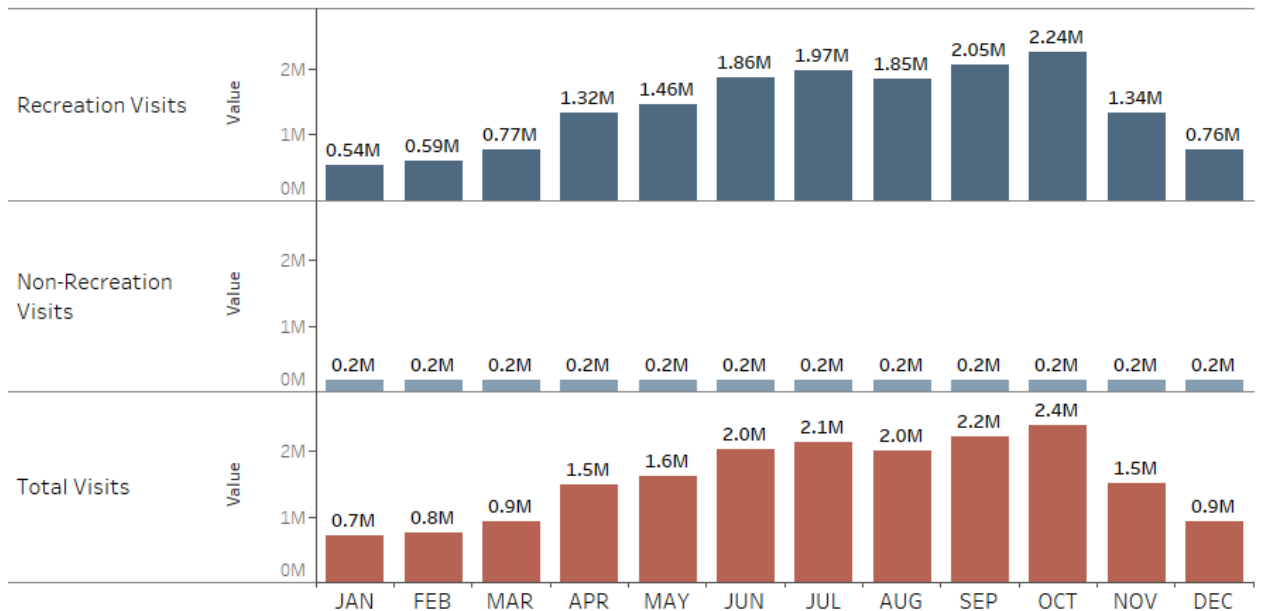
Figure 2: BLRI Visits by Year 1979-2023

To understand seasonal patterns of visitation, the following figure presents 2023 visitor estimates by month. Recreation visits display a clear seasonal pattern with 0.54 million in January and steadily increasing to a peak of 2.24 million in October before tapering off towards the end of the year. Non-recreation visits remained constant across all months at 0.2 million due to a consistent method for estimating non-recreation visits.

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BLRI Visits by Month, 2023



*2023 data may be subject to change.

Figure 3: BLRI Visits by Month 2023

Based on current counting procedures since 2013, recreation visits have increased significantly over the last decade. Every month displays an upward trajectory, with the most substantial increases occurring in October and September, which have reached over 2 million visits in recent years compared to less than 1.5 million in 2013. Growth has been more moderate during the winter months (December to February) when visitation remains relatively low but still demonstrates an upward trend. This seasonal pattern reflects the popularity of the BLRI in warmer months and fall, particularly in October when fall foliage attracts high visitor numbers.

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BLRI Recreation Visits by Month and Year, 2013 - 2023

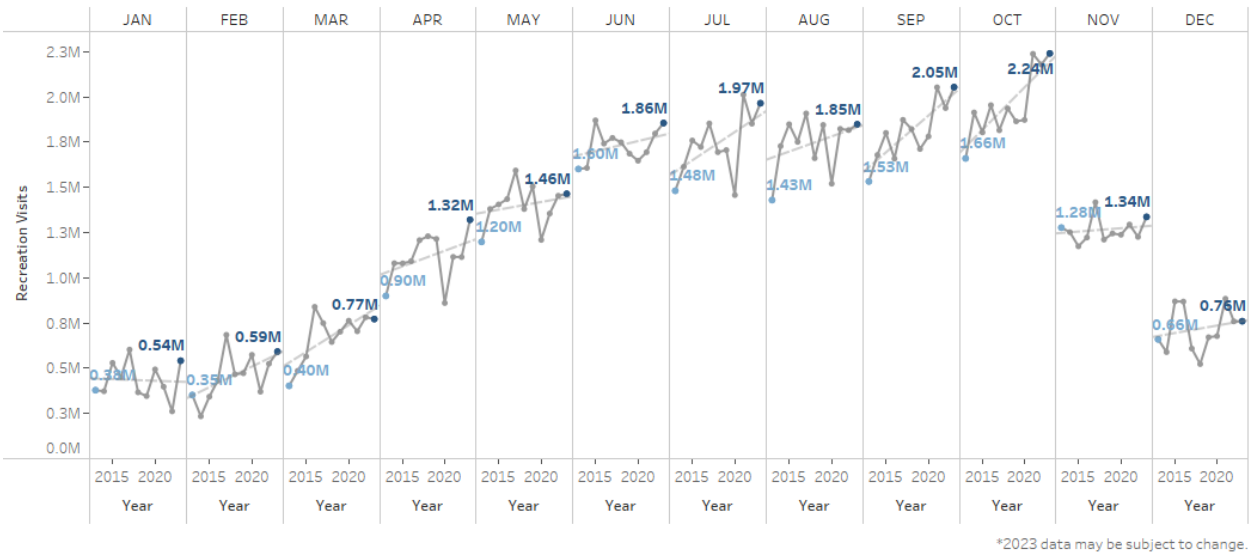


Figure 4: BLRI Recreation Visits by Month and Year 2013 – 2023

In addition to total BLRI visits, current counting procedures enable an understanding of the share of use by state. Overall, in 2022, North Carolina received three-quarters of total recreation visits (75%) while Virginia received 25%. Data from January through September in 2023 shows North Carolina received 72% of total recreation visits.

Viewed by month, North Carolina consistently accounts for the majority of recreation visits, ranging from 63% (in February 2023) to 80% (in March 2022), while Virginia made up between 20% to 37%. The distribution of use by state does not display a clear seasonal pattern; however, data suggests that Virginia's share of use appears to peak during the spring and fall months.

Percent of BLRI Recreation Visits by State, 2022 & 2023 (Partial)

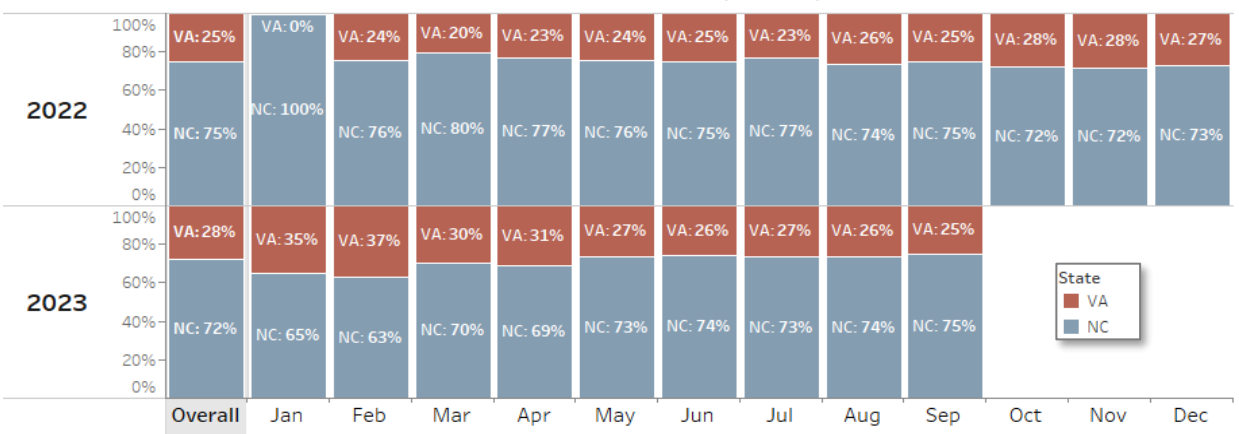


Figure 5: Percent of BLRI Recreation Visits by State, 2022 and 2023 (partial)



New Counter System

In lieu of using the current BLRI counters, the research team met with the Federal Highway Administration (FHA) to understand their installed counters. The FHA has ten counters, also defined as Field Operations Technical Support Center (FOTSC) counters, installed along the entirety of the parkway. These counters are placed along the actual parkway and not on the exit and off-ramp locations. The figures on the next page display the exact locations of all counters on the parkway.

Given the challenges with the old physical counting equipment, the research team and NPS staff instead chose to utilize the newer, more advanced FHA-managed traffic counters for the new BLRI counting procedure system.

There are a variety of pros and cons to using these FOTSC counters described below.

Pros:

- 1) FOTSC counter equipment is more advanced and newer than most current BLRI counters and they are subject to data quality checks to ensure accuracy.
- 2) BLRI does not need to maintain the equipment as it is the FOTSC's responsibility to keep them updated and running.
- 3) Counts are uploaded online at the end of the month to www.geocounts.com.
- 4) Data is required for FOTSC monitoring purposes already, meaning that collecting the data is already a required agreement between the NPS and FOTSC.
- 5) Counters are installed directly on the parkway and are not limited to a small set of on/off ramp locations.

Cons:

- 1) Data must still be physically collected from the counter equipment every month, even though it is a smaller number of units.
- 2) The park must continue to hold agreements with FOTSC to support one another's data collection needs.
- 3) FOTSC will dictate the timing of any maintenance and updates to the counter equipment.

Despite some drawbacks of relying on the FOTSC counter equipment, the research team decided that the FOTSC counters were more reliable and a better system to design for the future of the parkway. Therefore, the analysis and subsequent results use the ten counters along the parkway installed and maintained by the FOTSC.

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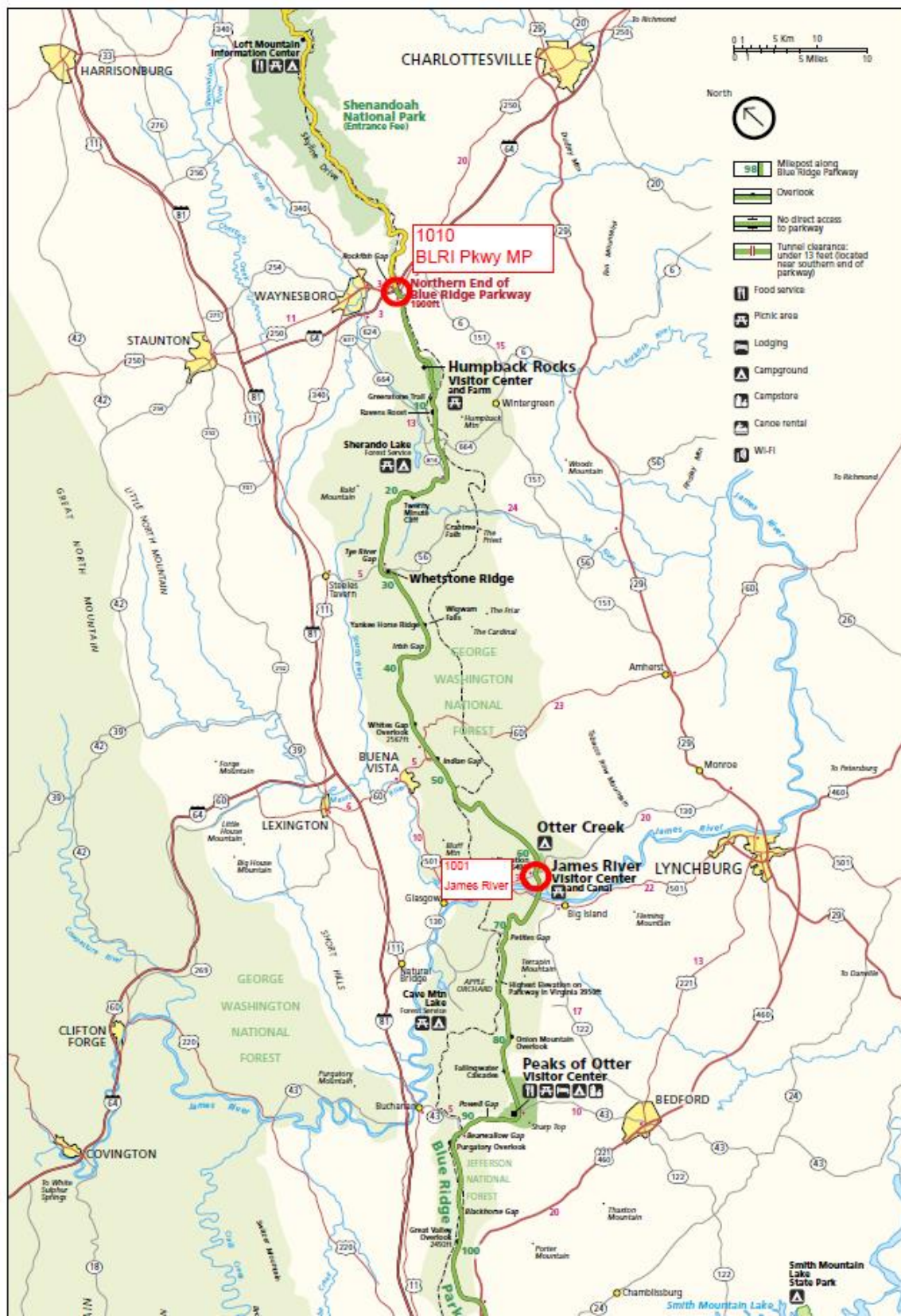


Figure 6: Northern FOTSC Counters on BLRI

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Figure 7: Central FOTSC Counters on BLRI

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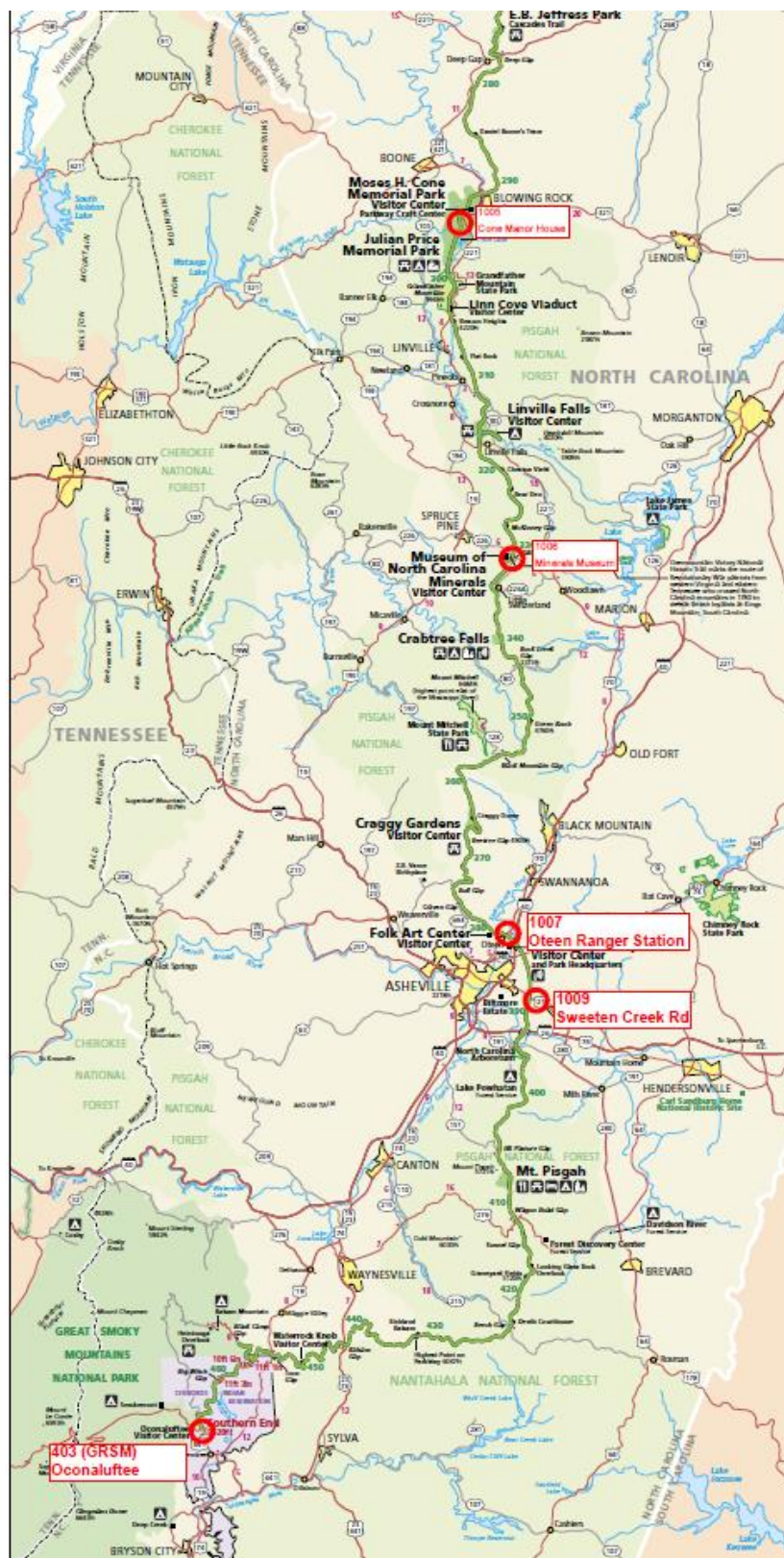


Figure 8: Southern FOTSC Counters on BLRI



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Table 1: FOTSC Counter Locations

FOTSC Location	Longitude	Latitude
1010	-78.8572916	38.0297259
1001	-79.4113992	37.5581767
1002	-79.8528064	37.2893007
1003	-79.9541581	37.2112003
1004	-80.3498556	36.8114499
1005	-81.6911111	36.1504937
1006	-82.0513785	35.8540387
1007	-82.4789632	35.5891522
1009	-82.5193228	35.5243528
403	-83.3008296	35.5055687

Table 1 displays the FOTSC counter locations along BLRI. All ten counters are recommended to be used in the modeling process for updating the parkway's count procedures. However, counter 1006's data from 2023 was not able to be extracted by those at FOTSC. The counter box to download data was not accessible during the time of collection in April of 2023. Future count procedures will need to integrate this counter's data into the model for accurate counting estimates.

Mobile Location Data Background

The research team selected mobility data for this project to identify and understand individual trip patterns. Applying trip patterns in the mobility data to on-the-ground vehicle counts can provide more detail for new visitation count procedures. Mobile location data consists of passively collected information from cellular devices over a given study area and predefined time span. Mobile device applications installed on consumer cellular devices are granted voluntary permission to collect device location data. Data warehouses have access to over 250,000 individual apps ranging from weather forecasts to navigation that passively collect location information. The data for this study was acquired from Azira (formerly Near), one of the largest providers of raw mobile location data. Azira follows strict privacy regulations to ensure the data meets all applicable laws and policies required for mobile data collection. For more privacy information related to raw data collection, please reference Azira's comprehensive privacy policy (<https://near.com/privacy-policy/>). To collect data, the available apps collect small pieces of information periodically from the device. This information shows up in the forms of "pings" or breadcrumbs of data that occur at varying frequencies and includes the following information:

- 1) Exact time stamp from devices within the study area
 - a. Date
 - b. Exact time stamp
- 2) Latitude and Longitude of the device in the study area
- 3) A randomized device ID



Some devices may “ping” 10 times within a study area while others may see over 1,000 pings. The frequency (and, therefore, quality) of the data collected is very dependent on the individual apps used and collected by the 3rd party data vendor. In addition to the three fields of data available, while the device is within the area of interest, data is continuously collected from devices, enabling the common evening and common daytime locations (commonly defined as home and work locations) of the devices to be inferred. If a device’s regular evening pings are in one location for 3+ months a year, that location is inferred as the device’s home location. Similarly, the work location is inferred in the same manner but for the common daytime location observed. In the interest of user privacy, exact home/work locations are not revealed; rather the location is jittered (error forced into the measurement) prior to being provided to any researcher. Jittering remains accurate to the Census Block Group of the device.

This data was used in BLRI to understand and correlate to existing traffic counters. Since this data has become available, opportunities exist to use big data sources to help inform large landscape-level decisions for places like the parkway. Because most of the original 56 counters do not exist anymore, it is not possible to recalculate the share of trips that are passing any given counter. Instead, the research team employed mobile location data to help understand and provide results for the following concepts:

- 1) Calculating the share of BLRI trips passing counters on a single day and throughout their trip.
 - a. Modeling visitation using traffic counters requires knowing how many vehicles are being represented in the current counter arrangement.
- 2) Understanding whether vehicles are being counted multiple times by existing counters.
 - a. In addition to whether a vehicle passed a counter at all, knowing whether a vehicle is being picked up on counters multiple times is necessary to calibrate data. Mobile location data can be used to help understand the percentage of trips likely passing multiple counters.
- 3) Explore the potential for a realistic recreation vs. non-recreation split in visitation.
 - a. The urban areas around BLRI have grown substantially since the original count procedure was conducted. Mobile data was used to help understand commuting patterns from visitors who live in the local area and use the parkway as a means for navigating the area and visitors who are there for recreation/leisure purposes. Because survey data does not exist on this topic, assumptions are needed and outlined in the results.



Source: www.nps.gov



Results

Data Acquisition, Cleaning, and Understanding the Sample

Initially, the research team acquired a month of test data, from which we performed a series of analyses that proved that existing data within BLRI was sufficiently large for our desired approach to updating the BLRI visitation estimate. Following our analysis of this trial data, we acquired a dataset consisting of all observations within a buffered area of the BLRI boundary from January to December 2023. To determine the boundary of our data purchase polygon, the research team identified all census block groups that intersect BLRI and acquired data within the perimeter of these 152 census block groups. The figure below shows the boundaries of BLRI and the data purchase boundary.

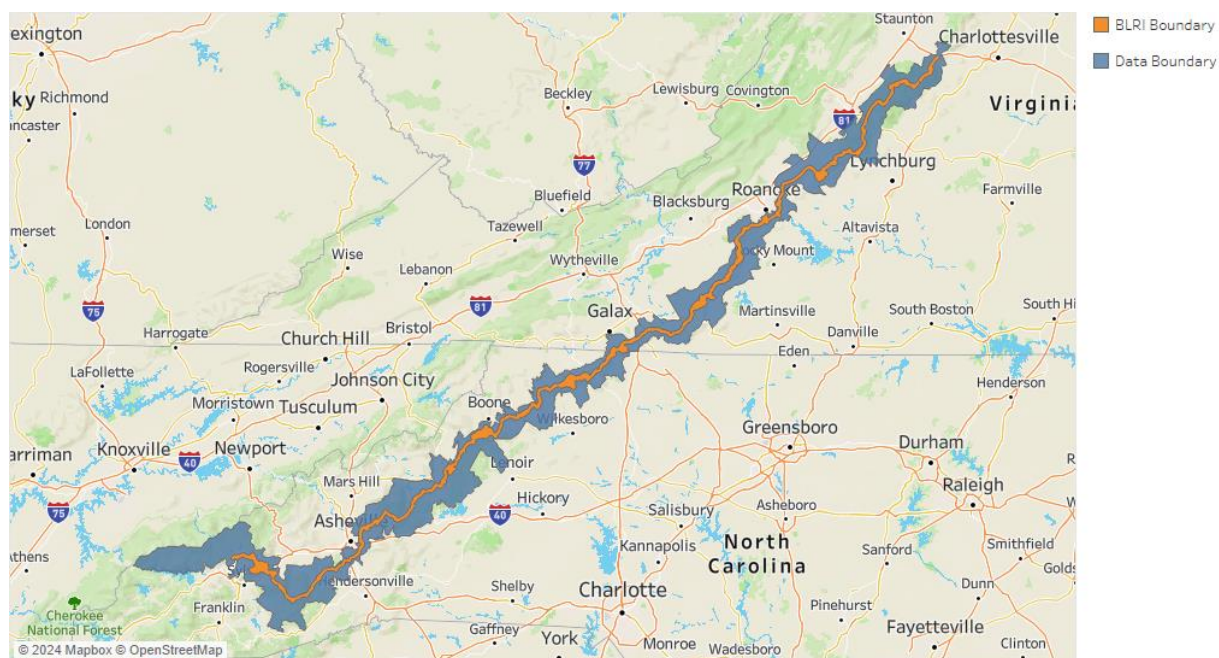


Figure 9: BLRI Mobile Data Purchase Boundary

This boundary resulted in a vast dataset comprising 2,337,343,551 individual records of data; however, raw mobile location data is not immediately suitable for analysis due to inherent issues such as duplicate observations, where the same device appears in two different locations simultaneously. To address these issues, we developed a rigorous data-cleaning process.

Our cleaning protocol includes a de-duplication step that selects the most plausible point for each observation based on adjacent data points, considering their spatial and temporal proximity. This process refined the dataset to 1,673,134,469 individual records, which formed the basis for subsequent data processing steps.

Purchasing data only for complete Census Block Groups ensures that we receive observations from devices prior to and after their park visit, which helps determine park entry and exit locations as well



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as more accurately estimate dwell time per visit. Additionally, because mobile location data provides a device's inferred Census Block group of origin (based on where that device is most commonly observed during evening hours), the purchase of complete block group boundaries allows us to compare the count of residents of each Census Block Group from our mobility data sample to US Census population estimates. If we assume that a resident local of a Census Block Group is as likely as a visitor to be captured within our sample, we can estimate the share of total visitation that our mobility data sample represents.

This ratio (the Census population vs. mobility sample size by Census Block Group) also enables us to estimate total park visitation absent traffic counter data. However, this is not our preferred method of estimating total park visitation. It not only serves as rough validation of subsequent modeling that utilizes traffic counter data, but it also informs how our mobility data sample capture rate fluctuates over time, which is a known issue with utilizing mobility data for total use estimates (as the pool of participating apps and data sources changes over time). To perform this analysis, we first determined a daily count of all device IDs local to our purchase boundary. Dividing these counts by the known census population results in a daily weighting variable that, when multiplied by the daily count of all devices observed within BLRI boundaries results in an estimate of total visitation.

Data Transformation and Analysis

Transforming raw "ping" data into actionable insights involves several steps, starting with identifying potential trips along the parkway. First, we sourced spatial files consisting of roadway centerlines from the Virginia and North Carolina Department of Transportation Open Data portals. We determined where the parkway overlapped with the BLRI boundary, and also segmented the roadway by 1/10th of a mile increments, utilizing point data provided by park staff. Next, we computed the straight-line distance from each mobility data observation to the roadway centerline. Consecutive observations within 150 feet of the road centerline were assumed to be "on the road." While a 150-foot buffer may be generous, it helps to account for potential device GPS error and is merely a first step in the data transformation process. The use of 1/10th of a mile roadway segments allowed us to ascertain the direction of travel, which was used to distinguish a northbound vs. southbound trip. The average speed between all observations was also computed, utilizing the straight-line distance and time elapsed between observations.

Identifying the origin and destination points of trips required a nuanced approach, given the intermittent nature of mobile location data. For example, if a mobile device is first detected at segment 20 and next at segment 30, it cannot be conclusively determined that the device did not travel beyond these points, say from segment 10 to 40. Such gaps in data necessitate the consideration of observations immediately before and after the parkway journey. To these ends, we first utilized multiple data sources, Google Earth, and the team's site visit to identify plausible origin and destination points along the parkway, incorporating intersections, viewpoints, pullouts, campgrounds, and other significant locations. This resulted in a database of N possible origin and destination locations. While no dataset can be comprehensive of all possible origin and destination points, we believe our effort resulted in a database sufficiently large for our modeling objectives.



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Then, for each point immediately preceding the first detected point along the parkway and immediately following the last detected point, we identified the nearest origin/destination point. This approach allowed us to infer with greater precision the actual origins and destinations of trips along the parkway. Scenario A in Figure 10 illustrates how utilizing only points along the roadway (orange dots) could lead one to conclude this trip went from origin B to destination C. Considering points prior to and after the journey results in the conclusion that this trip went from origin A to destination D.

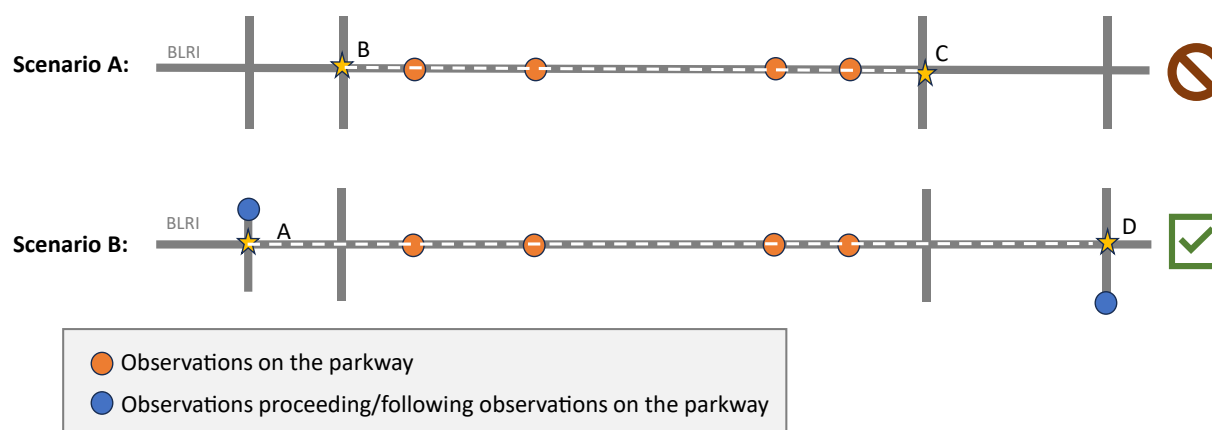


Figure 10: Trip Scenarios for BLRI Data Observations

To validate the identified origins and destinations, we implemented a drive-time analysis comparing the expected travel time (from, say, a preceding point to an origin point to the first observation on the parkway) against the actual time elapsed between the two observations. This comparison was necessary to differentiate between plausible travel behavior and anomalies that could indicate incorrect data interpretation or the presence of non-travel-related activity. We retained trip records where the elapsed time and expected drive time were within a reasonable estimate, ensuring that the data accurately represented genuine travel behavior within the park. Additionally, to counteract the issue of intermittent data capture, we inferred that the device traversed all roadway segments lying between the confirmed origin and destination points.

This process culminated in the generation of a dataset comprising 141,113,801 observations from 194,699 unique devices, which represent 335,849 individual trips and 299,767 visitor days. This dataset serves as a foundational element for modeling total visitation and facilitating informed decision-making and strategic planning.

Table 2: Sample Sizes of Mobile Location Data for BLRI

Observations	Trips	Device Days	Unique Devices
141,113,801	335,849	299,767	194,699



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Traffic Count Data Cleaning and Analysis

Simultaneous to cleaning and processing traffic mobile location data, we gathered traffic count data from existing counters along the Blue Ridge Parkway. Figure 11 displays the map of FOTSC counters managed by the FOTSC on the parkway. A total of ten counters are located along the entire route.

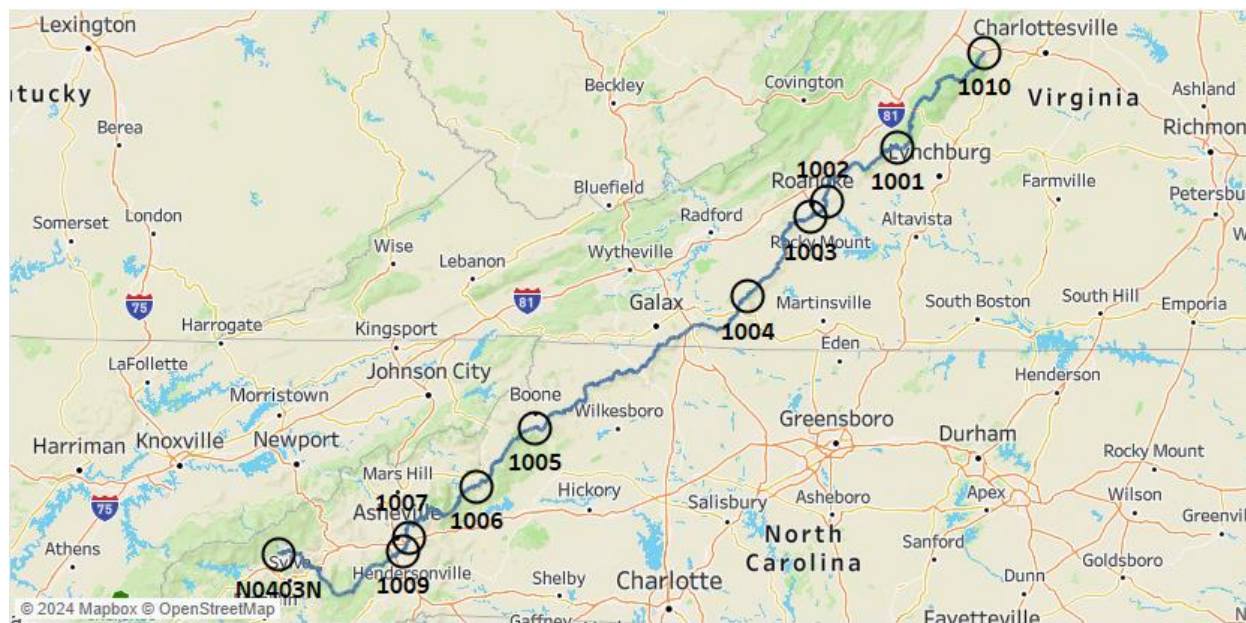


Figure 11: Map of Current FOTSC Counters on BLRI

After working with FOTSC and BLRI on capturing the data from the ten FOTSC counters on BLRI, the research team analyzed the data to determine the number of complete and incomplete months of data available for 2023. Because of anomalies in the data, some months have data removed and/or cleaned for use in the analysis with mobile location data. Figure 12 displays each traffic counter and the number of months that have either complete or incomplete data on BLRI in 2023. Furthermore, we specified which counters had at least 14 or more days or less than 14 days, a common cutoff within the NPS Visitor Use Statistics program. In general, most counters have rather complete data in 2023 except FOTSC counters 1001, 1002, and some within 1006.



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		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Complete
VA	1010	17	8	22	30	31	30	31	31	30	31	29	19	Complete
	1001	0	0	21	30	0	0	0	0	0	0	0	0	14 Days or More
	1002	0	0	0	0	0	0	0	21	24	31	30	30	14 Days or More
	1003	20	23	28	30	30	28	31	31	30	31	30	31	14 Days or More
	1004	0	0	22	30	30	30	31	31	30	31	30	30	14 Days or More
NC	1005	15	11	8	17	26	30	31	31	30	31	30	20	14 Days or More
	1006	9	21	21	30	31	30	31	0	0	0	0	0	14 Days or More
	1007	31	28	31	30	30	30	31	31	30	31	30	31	14 Days or More
	1009	17	28	27	30	30	30	31	31	30	31	30	27	14 Days or More
	403	0	6	10	25	31	29	2	0	29	31	0	0	14 Days or More

Figure 12: Number of Days of Usable FOTSC Traffic Counter Data by Location and Month, 2023

Average daily vehicles were computed for each location by month as well (Figure 13). Counter 1009 in NC sees the highest average daily vehicles, hovering at an average of 5,842 vehicles per day. The FOTSC counters in NC tend to see higher daily vehicle traffic compared to most locations in VA.

Average Daily Vehicles by Location & Month, 2023

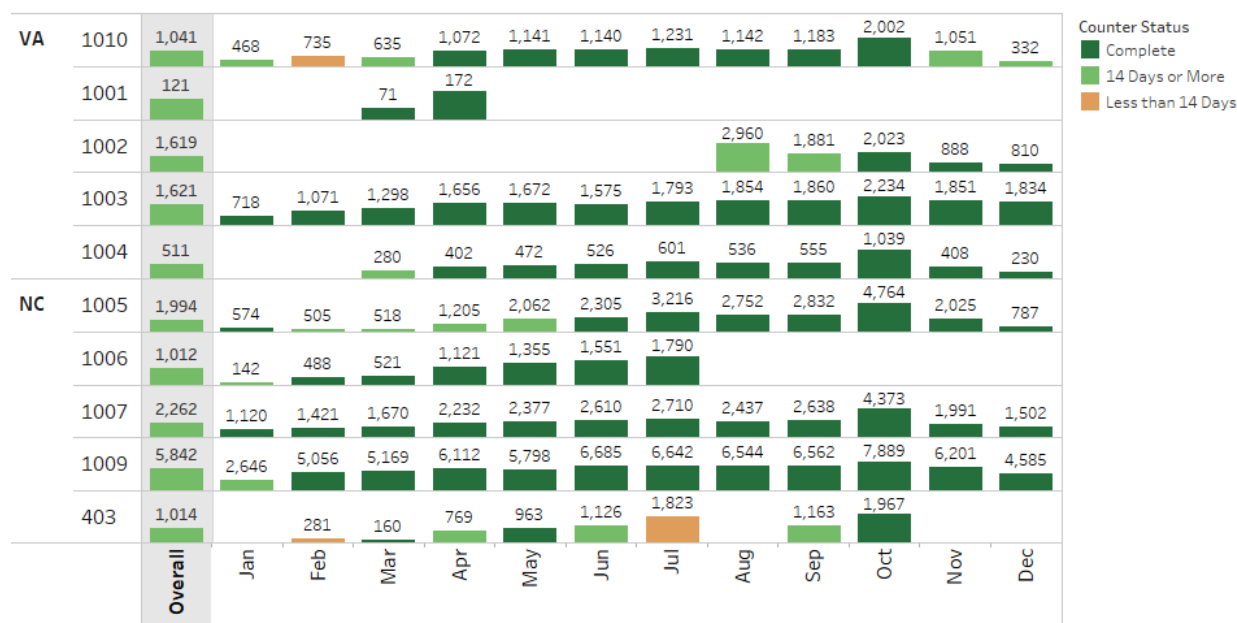


Figure 13: Average Daily Vehicles by Location and Month by FOTSC Counter, 2023

Analyzed by location and day of the week, some counters see a spike in traffic on the weekends while others see weekdays as more consistent in traffic. For instance, counter 1009 in NC has higher average daily vehicles on Monday-Friday than on the weekends. Locals commuting or on the roadway for non-recreation reasons likely contribute to this increase. Counters such as 1005, 1006, and 1007 see their peaks on weekends compared to weekdays.

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Average Daily Vehicles by Location & Day of Week, 2023

		Overall	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Day of Week
VA	1010	1,049	1,423	878	778	810	882	1,038	1,518	Sun
	1001	121	198	104	97	80	94	87	179	Mon
	1002	1,619	1,520	1,582	1,585	1,673	1,684	1,663	1,625	Tue
	1003	1,621	1,457	1,558	1,550	1,541	1,676	1,818	1,752	Wed
	1004	511	661	393	407	409	451	505	742	Thu
NC	1005	1,994	2,183	1,644	1,507	1,679	1,882	2,214	2,808	Fri
	1006	1,012	1,074	980	930	921	980	1,054	1,140	Sat
	1007	2,262	2,592	2,035	1,972	2,008	2,074	2,173	2,975	Overall
	1009	5,842	4,139	5,905	6,187	6,611	6,633	6,559	4,897	
	403	1,029	1,165	940	929	920	956	1,017	1,283	

Figure 14: Average Daily Vehicles by Location and Day of Week by FOTSC Counter, 2023

The following figure highlights the differences in average daily vehicles by FOTSC counter and part of the week (weekend/weekday). The three locations in the following figure are negative by a percent difference which indicates higher use mid-week than on weekends. Counters 1002 (-4.0%), 1003 (-1.6%), and 1009 (-29.3%) see a higher weekday figure while all other counters have an overall increase on weekends. The largest difference is observed on counter 1001 (+104.6%) with strong weekend differences also observed on counters 1010 (+67.7%) and 1004 (+61.9%). Therefore, this further confirms that counters 1009, 1002, and 1003 are most likely to have a higher share of locals using it for non-recreation purposes.

Average Daily Vehicles by Location & Part of Week, 2023

		Weekday	Weekend
VA	1010	877	1,470 (+67.7%)
	1001	92	188 (+104.6%)
	1002	1,638	1,572 (-4.0%)
	1003	1,628	1,603 (-1.6%)
	1004	433	702 (+61.9%)
NC	1005	1,787	2,496 (+39.7%)
	1006	973	1,107 (+13.7%)
	1007	2,053	2,782 (+35.5%)
	1009	6,382	4,514 (-29.3%)
	403	953	1,224 (+28.5%)

Figure 15: Average Daily Vehicles by Location and Part of Week by FOTSC Counter, 2023

Throughout the day, most counters tend to see their peaks during the middle of the day, approximately from 1:00-2:00 PM. In terms of total volume, all counters, except 1009, have a peak average vehicles per hour of approximately 200 vehicles or below. Counter 1009 sees a much higher peak at 1009. Because of this counter's location near Asheville, NC, vehicle volumes are significantly higher than other count locations.



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Average Vehicles by Location & Hour of Day, 2023

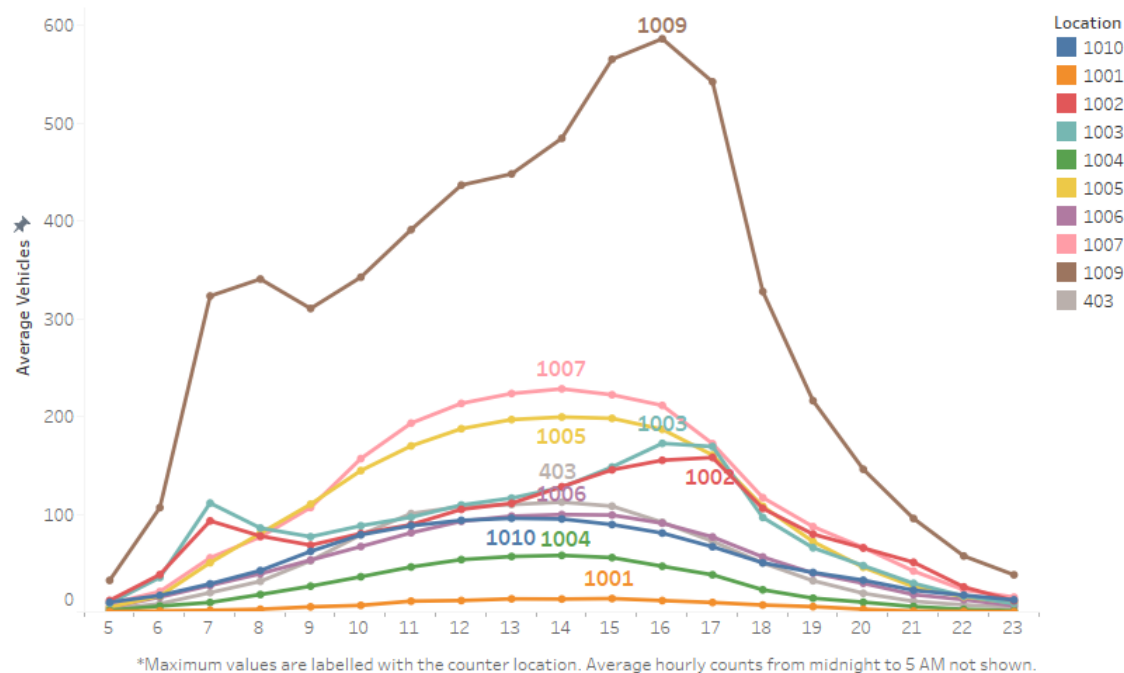


Figure 16: Average Vehicles by Location & Hour of Day by FOTSC Counter, 2023

Figure 17 and Figure 18 both single out two sets of the FOTSC counters: those that see their peaks during commuting hours compared to those that peak during the middle of the day. Consistent with increased weekday traffic, counters 1002, 1003, and 1009 all have their peak average vehicle during the 5:00-6:00 PM hour. Counter 1009 sees the largest increase during this time as it slowly rises from approximately 300-400 vehicles in the mid-morning to over 500 by the late afternoon. Furthermore, these count locations also see a more minor increase in vehicle traffic during the morning between 7-9 AM. Again, these results further reinforce the likelihood that these counters experience more local traffic commuting than other areas. All other counters see their peak daily vehicle traffic during the mid-afternoon, approximately 2:00 PM. Traffic during this time of the day is more likely to be recreation visits from those using the parkway for true leisure purposes.



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Average Vehicles by Location & Hour of Day, 2023

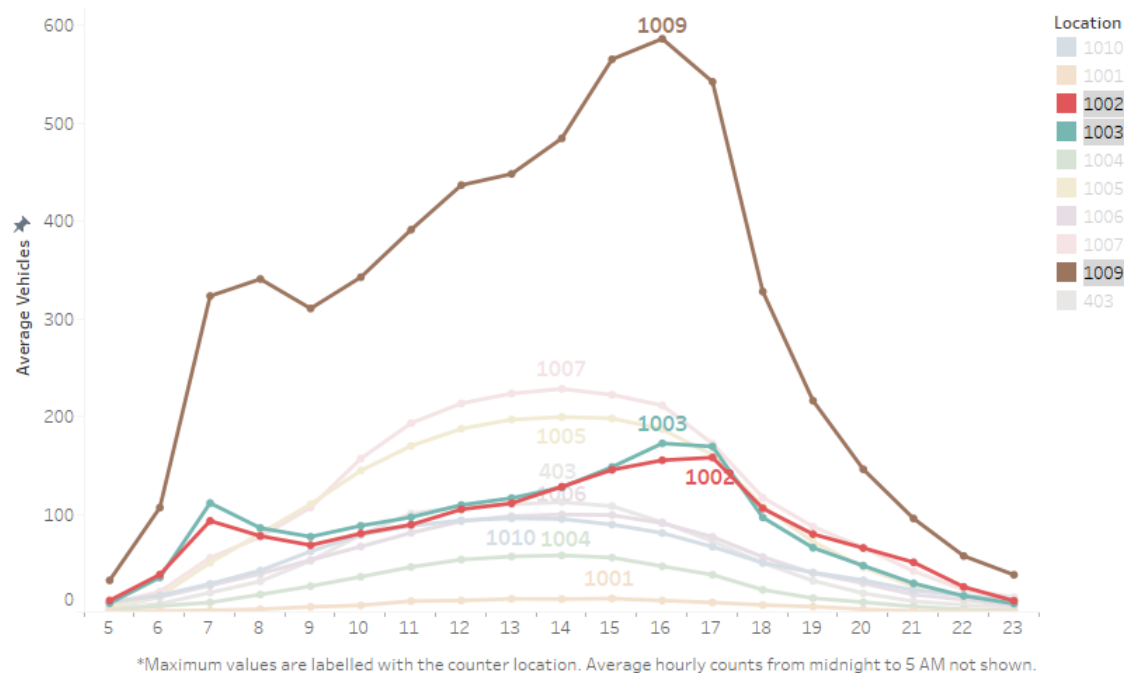


Figure 17: Average Vehicles by Location and Hour of Day by Counter

Average Vehicles by Location & Hour of Day, 2023

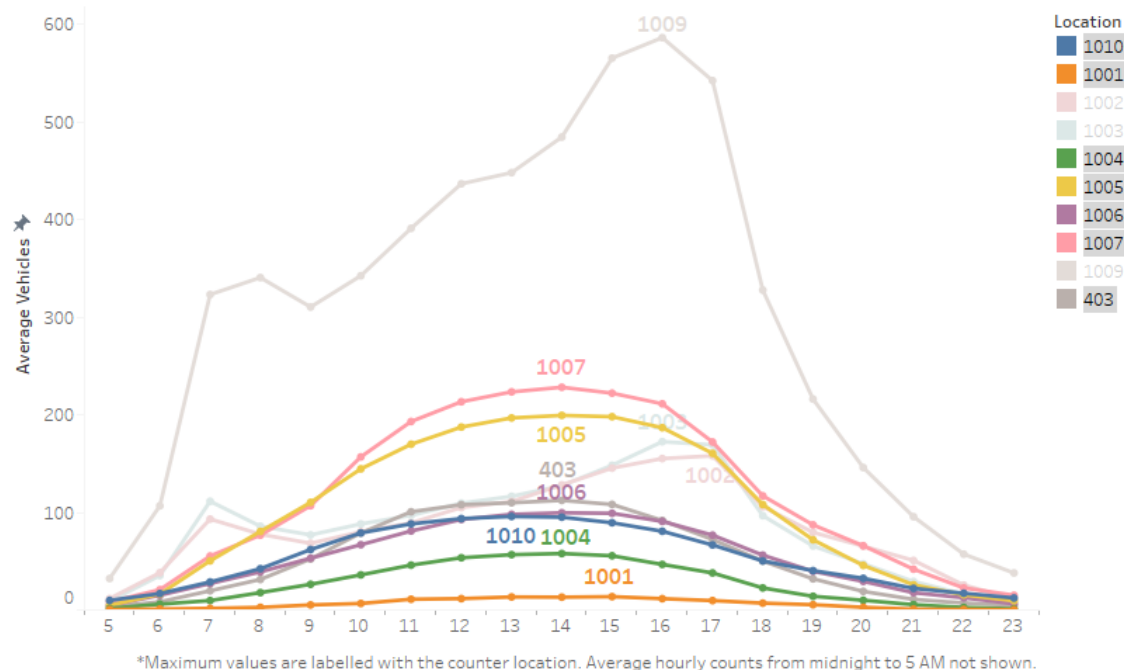


Figure 18: Average Vehicles by Location and Hour of Day by Counter



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Data Visualization and Interactive Dashboards for Analysis

Before delving into the complexities of modeling visitor data along with the FOTSC counters, the research team placed significant emphasis on the visualization of the cleaned and processed mobility and traffic count data. Visualizing this dataset before modeling served several critical functions. Interactive dashboards provided a means to validate the effectiveness of our data cleaning process, ensuring that the refined dataset accurately reflects real-world conditions and behaviors. The ability to visually explore the dataset enabled our analysts to identify patterns and trends that may not be immediately apparent through traditional data analysis methods. By exploring the data in a visual context, we were able to generate hypotheses about visitor behaviors, which could then be tested and refined through more formal modeling processes. This informed approach ensured that our modeling efforts were reflective of the complex dynamics at play within BLRI.

Understanding the inherent patterns and behaviors within such a large and complicated dataset is crucial for accurate analysis and modeling. To this end, we developed interactive dashboards that serve as an essential tool for both validating the data cleaning processes and exploring the intricacies of visitor patterns to BLRI. Images of these dashboards are below to provide context for how in-depth the analysis needed to be for BLRI's system. The dashboards allowed the research team to build scenarios and monitor individual trip routes from BLRI devices not possible via other tools.

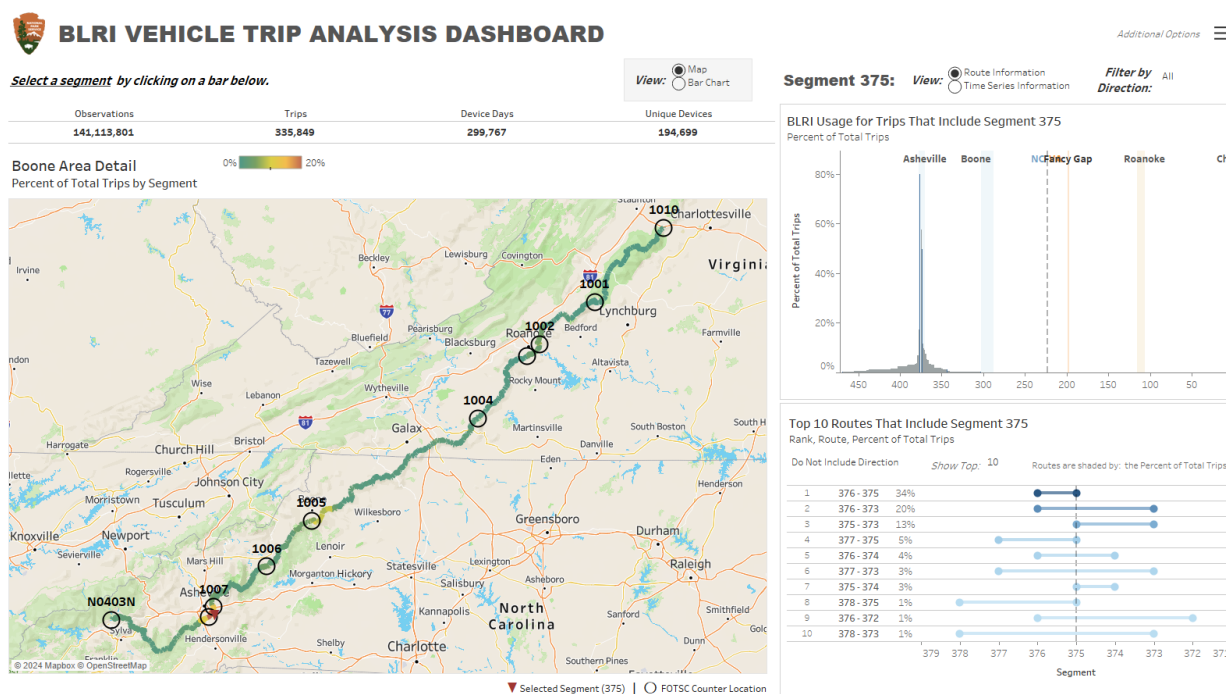


Figure 19: Image of Interactive Dashboard Displaying Route Information

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BLRI VEHICLE TRIP ANALYSIS DASHBOARD

Select a segment by clicking on a bar below.

View: ☐ Map ☒ Bar Chart

Additional Options

Segment 375: View: ☐ Route Information ☒ Time Series Information

Filter by All Direction

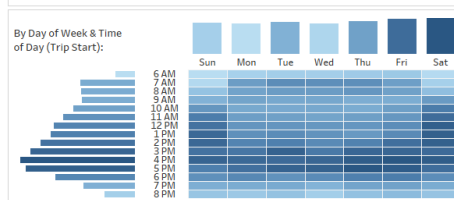
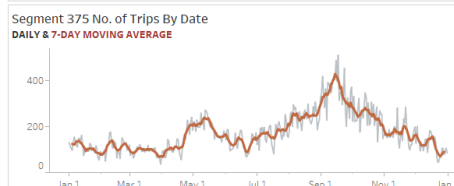
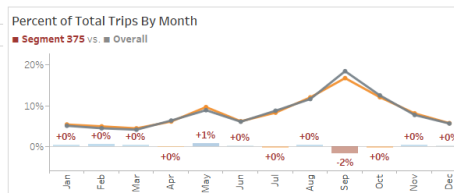
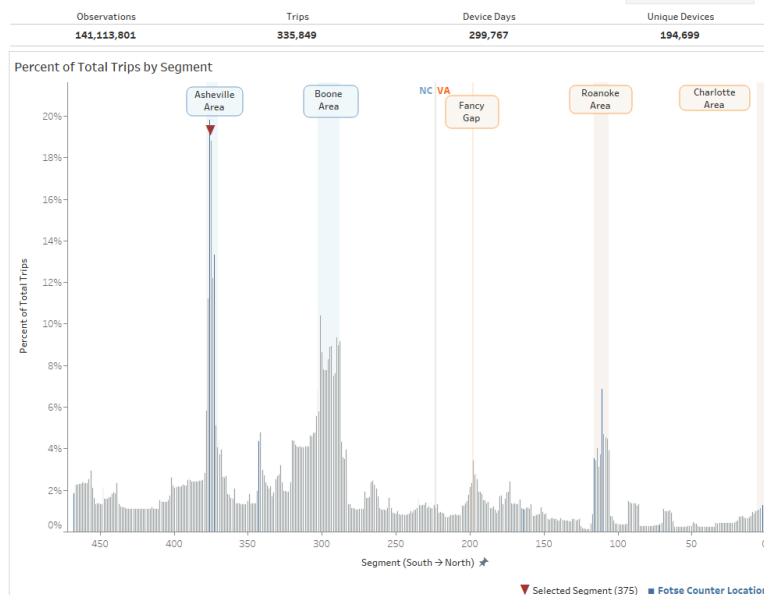


Figure 20: Image of Interactive Dashboard Displaying Time Series Information

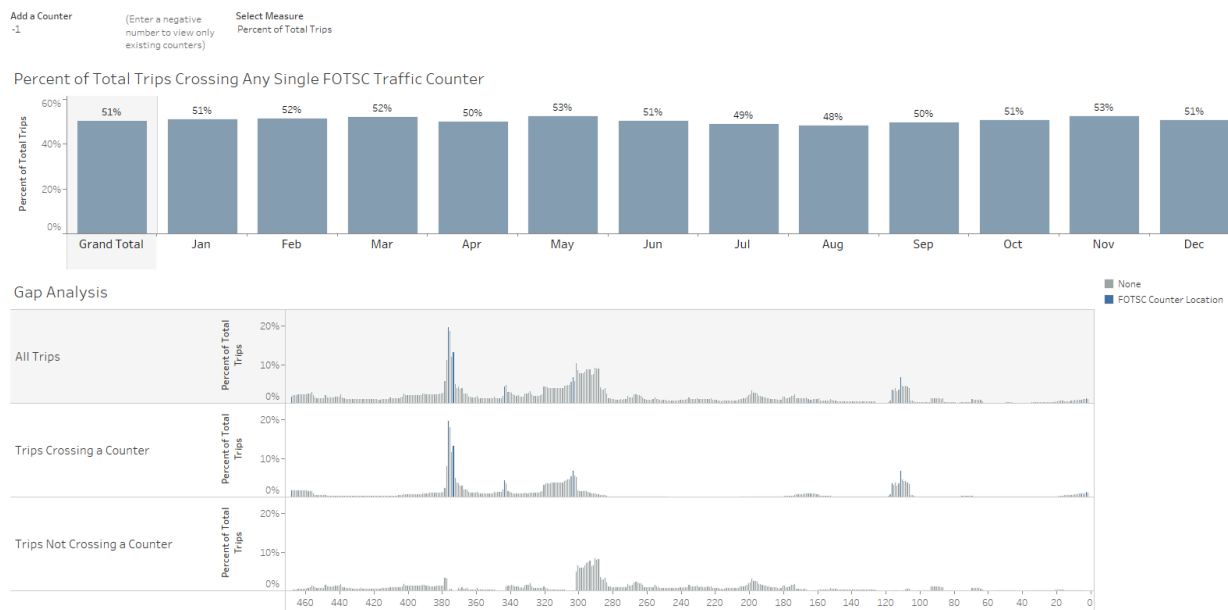


Figure 21: Image of Interactive Dashboard Displaying Information About the Share of Total Trips Crossing FOTSC Counters



Underlying Components of Visitation Model Update

Whereas traffic counters offer a complete census of vehicle counts at specific points but cannot capture the entirety of a trip or visitor day, the cleaned mobile location data represents only a sample of all trips but offers insights into origins, destinations, and travel patterns not available from traffic counter data alone. Taken together, these datasets plus person-per-vehicle estimates can be used to model total visitation by state for both recreational and non-recreation users from traffic counts alone. The visitation model utilizes inputs derived from point-in-time estimations, and significant changes to use patterns or significant population changes that are not evenly distributed geographically may necessitate updates to the model. Before describing the functions of the model, it is first necessary to understand the underlying components of the model.

Percent of Trips Crossing Multiple Counters

One challenge with using traffic count data to estimate total visitation is determining the share of trips crossing multiple counters. Because of the NPS's definition of visits, only one visit is allowed per vehicle, per day. Therefore, calculating a "re-entry" rate is important to avoid double-counting. Figure 22 displays the percent of trips crossing one counter that cross all other counters. For instance, 31.5 percent of all trips crossing counter 1009 also are observed crossing counter 1007. Most counters have a very low rate of being crossed multiple times; however, those near each other are observed crossing more commonly.

	N0403N	1009	1007	1006	1005	1004	1003	1002	1001	1010
N0403N	100.0%	0.4%	0.3%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1009	4.0%	100.0%	50.4%	3.7%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%
1007	2.0%	31.5%	100.0%	9.8%	1.0%	0.2%	0.0%	0.0%	0.0%	0.0%
1006	0.5%	0.8%	3.4%	100.0%	4.1%	0.4%	0.0%	0.0%	0.0%	0.0%
1005	0.1%	0.1%	0.6%	6.6%	100.0%	1.2%	0.1%	0.0%	0.0%	0.0%
1004	0.0%	0.0%	0.0%	0.1%	0.2%	100.0%	0.8%	0.2%	0.4%	0.0%
1003	0.0%	0.0%	0.0%	0.0%	0.0%	2.1%	100.0%	30.1%	5.6%	0.5%
1002	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%	60.1%	100.0%	18.0%	2.0%
1001	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.7%	1.2%	100.0%	6.1%
1010	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.4%	19.6%	100.0%

Figure 22: Percent of Trips per FOTSC Counter Crossing Additional Counter Locations

Displayed in Figure 23, total trips on BLRI by segment peak near the urban areas. More specifically, the Asheville, NC area sees the highest percentage of trips with about 20% of all trips in the area. Boone, NC, and Roanoke, VA saw the second-highest percentage of trips per segment, ranging between 5-10%. The more remote/rural areas of the parkway see a much lower percentage of total trips with most hovering under 3% of all trips allocated to that segment.



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Percent of Total Trips by Segment

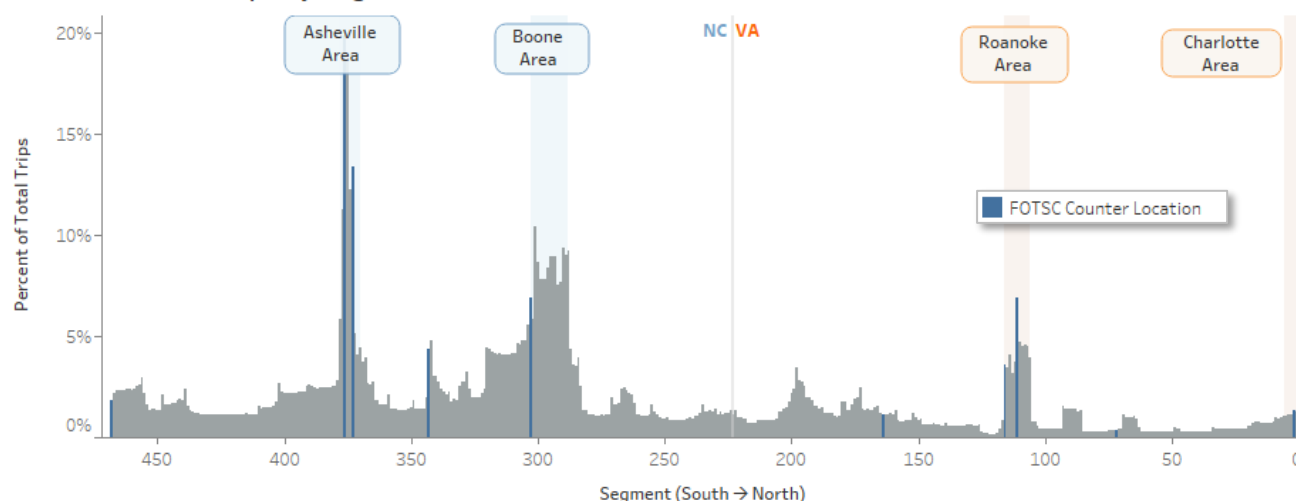


Figure 23: Total Trips on BLRI by Segment, 2023

A key strength of using mobility data is that it enables the researchers to understand the portion of total park visits that cross a traffic counter. Just over half (51%) of total parkway trips cross at least one traffic counter. This number varies from a low of 48% in August to a high of 53% in May and November. This model is a key input to the visitation estimation model as it allows the model to “gross up” traffic counts at the sample locations to total park estimates.

Percent of Total Trips Crossing Any Single FOTSC Traffic Counter

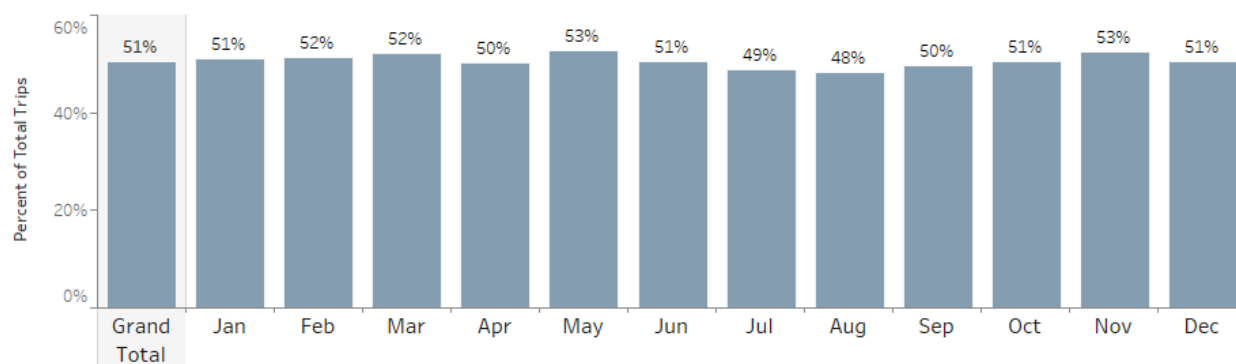


Figure 24: Percent of Total Trips Crossing Any Single FOTSC Traffic Counter, 2023

The following figure, where each point represents a date, illustrates that the number of trips that cross a counter is highly correlated with trips that do not cross a counter ($r^2=.93$ p value $< .0001$). In other words, with current use patterns, there is little indication that additional counters would lead to substantively different visitor estimations. These findings should instill confidence in new measures as providing relevant and accurate data even with limiting the number of physical counters on the parkway.



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Daily Correlation of Visits That Cross a Counter
& Visits That Do Not Cross a Counter

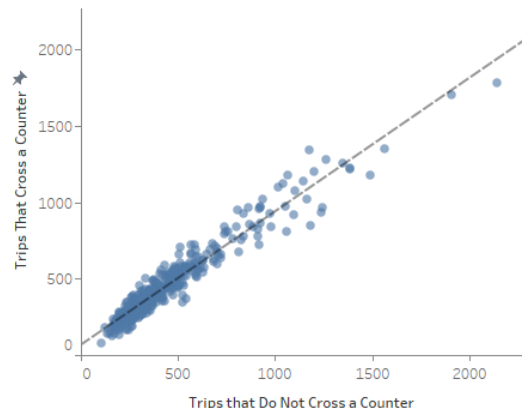


Figure 25: Correlation of BLRI Trips That Cross and Do Not Cross FOTSC Counters

Additionally, mobility data enables us to evaluate current counter placement and understand where trips are occurring that are not captured by any counters. The following figure (Figure 26) illustrates use patterns across the length of the parkway for trips that cross a traffic counter versus trips that do not cross a counter. While counter 1005 is located near the Boone area, it is located south (or east) of the most heavily used section portion of the parkway near Boone. A second notable area where visitors are not currently being captured by a traffic counter is around segment 198 near Fancy Gap.

Percent of Total Trips by Segment

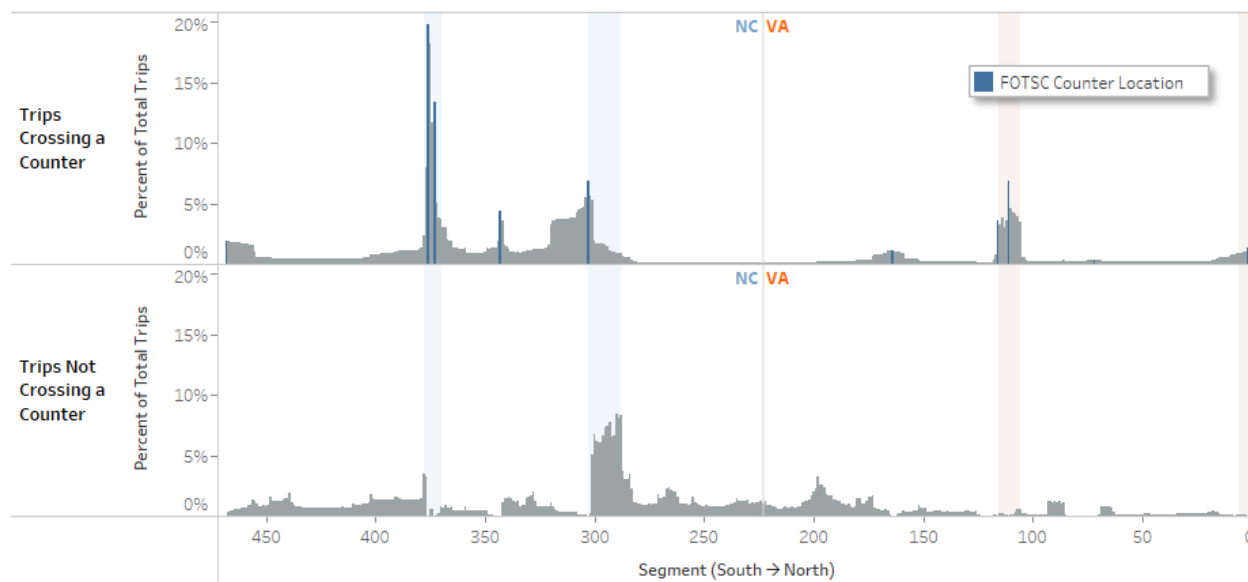


Figure 26: Percent of Total BLRI Trips by Segment of Road, Crossing and Not Crossing FOTSC Counters

Figure 27 displays the heat map of total trips along the area near Boone, NC where an additional counter might be useful to consider installing in the future. This location sees a fair volume of trips,



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but many are not currently being accounted for with counter 1005 alone. While this is not a major issue for current updates, it could be a future improvement if the park deems it necessary.

Boone Area Detail

Percent of Total Trips by Segment

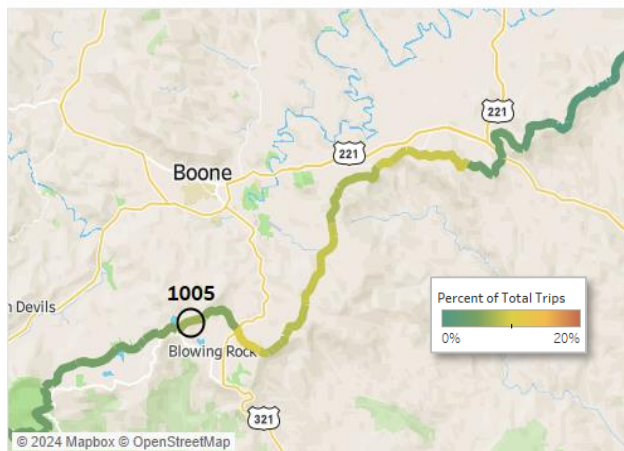


Figure 27: Percent of Total Trips by Segment, Boone, NC Area

Figure 28 displays the total trips by segment with a hypothetical counter placed at mile marker 288, capturing the traffic that is not being picked up by counter 1005. The cleaned mobility dataset enables us to place a hypothetical counter at segment 288 (between the Deep Gap Campsite and Grandview Overlook), which would result in a total capture rate of 59% (as opposed to 51%). While this additional capture rate could be important, it is still considered a long-term decision for the park to decide if it is necessary to potentially implement it.

Percent of Total Trips by Segment

With Hypothetical Counter Placed at Segment 288

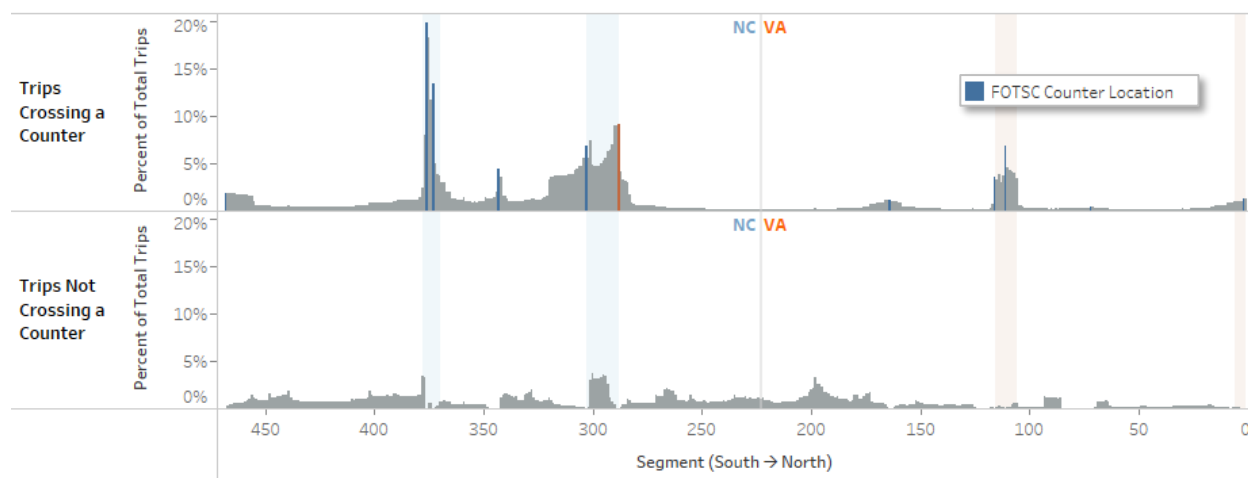


Figure 28: Percent of Total Trips by Segment with Hypothetical Counter Placed at Segment 288



Recreation Visits and Non-Recreation Visits

In addition to calculating the share of trips passing counters, calculating the recreation and non-recreation visits to BLRI is an important component of the visitor use count system. Currently, BLRI uses a fixed non-recreation visit estimate that has been in place since 1990. Because the local area around the parkway has changed significantly, a major focus to estimate true recreation visits more accurately on the parkway was to better calibrate the ratio of these visits. Recreation visits along the parkway can be hard to define. Because driving is a main activity for many visiting the area, creating a distinction of who is driving for recreation vs. commuting purposes is difficult. In most cases, a visitor survey would be needed to understand the trip purpose of visitors. However, the approach used for this study aimed to use a conservative estimate based on the likely commuting times of local residents along the parkway.

To calculate the ratio of recreation and non-recreation visits, the research team used two methods to calculate the potential share of non-recreation visits in the area. Because of the difficult nature of this calculation, two alternatives were created using slightly different definitions. In both approaches, the team focused on commuters along the parkway for the basis behind non-recreation visits. Commuters are the primary source of non-recreation visits that can be defined through this process. To calculate commuters, a radius of locals was used as one of the primary aspects of a non-recreation visit. In addition to home location, the research team utilized the time of day and day of week of visit in defining recreation vs. non-recreation visits. The research team, with approval from the NPS Social Science Program, assumed that local trips (people living 15 miles from the parkway in Alternative #1 or living within 15 miles of a counter in Alternative #2) occurring on weekdays (Monday – Friday) between 7-9 AM and 4-6 PM were eligible for non-recreation trips. Below are the definitions for both approaches (named Alternative #1 and Alternative #2).

Alternative #1: Alternative #1 focused on a larger geography where those living generically across a 15-mile radius from the parkway could be considered a local eligible to be classified as a commuter. Those who could be eligible for a non-recreation visit must fit the following categories:

- 1) Live within 15 miles from **any** point on the parkway.
- 2) Travel on weekdays between 7-9 AM or 4-6 PM.

Alternative #2: Alternative #2 focused on a narrower definition using each counter as a smaller area to define locals who could be classified as a commuter. Those who could be eligible for a non-recreation visit must fit the following categories:

- 1) Live within 15 miles of their respective counter location (e.g., each counter has a 15-mile buffer around itself.
- 2) Travel on weekdays between 7-9 AM or 4-6 PM across the local's home counter location.
 - a. Locals who are observed at another counter are counted as a recreation visit.



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In both alternatives, non-recreation visits are limited to local visitors only. The research team acknowledges that some locals will be considered non-recreation at times; however, non-recreation visits on weekends or outside of the times of 6-8 AM or 4-6 PM are not being considered for purposes of this analysis. Because of the challenging conditions of assuming non-recreation visits, this number can be updated at a future date if other methods become available for analysis.

The research team worked with both the park and the Visitor Use Statistics Program to provide the best information for the group to move forward with to finalize a non-recreation figure on a per-counter basis. These totals are included in the model as a fixed number. The following figures use Alternative #2 as a basis for display; however, we recognize that the park and VU Stats program will need to work to best identify the best non-recreation estimate going forward. Alternative #2 is a more logical definition based on capturing commuters on the parkway.

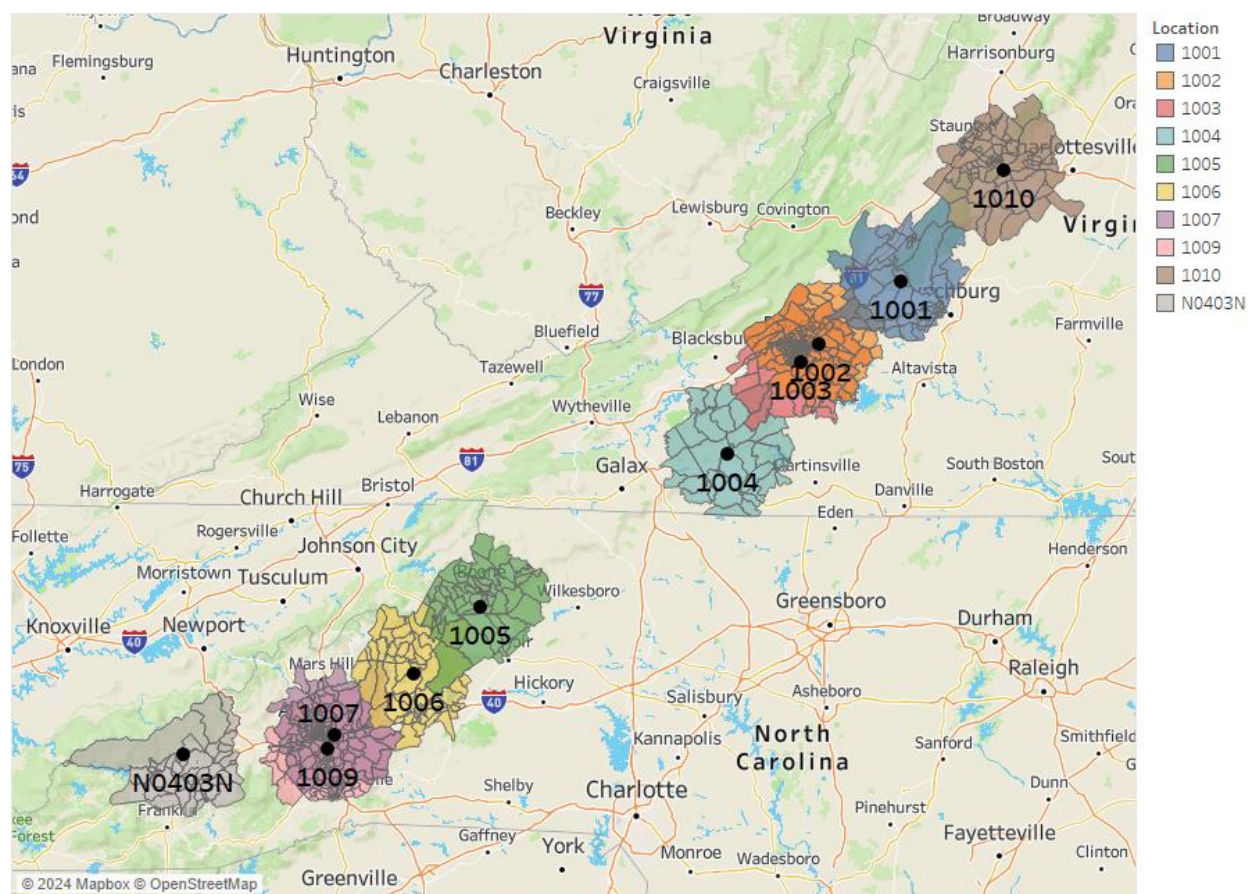


Figure 29: Map of "Local" Geography of BLRI - Calculated for Non-Recreation Purposes (Alternative #2)

Figure 30 displays the ratio of recreation and non-recreation visits using this calculation. Overall, 91% of visits are recreation visits while 9% percent are non-recreational. By counter, the largest share of recreation visits is on counters 1005 (96%), 1004 (96%), 1010 (60%), and 1001 (96%). The largest share of non-recreation visits is on counters 1002, (14%), 1009 (14%), 1003 (13%), and 1007



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(13%). Because of the large variation in the recreation/non-recreation split, the research team built the new count procedure model with a separate non-recreation adjustment on a per-counter basis.

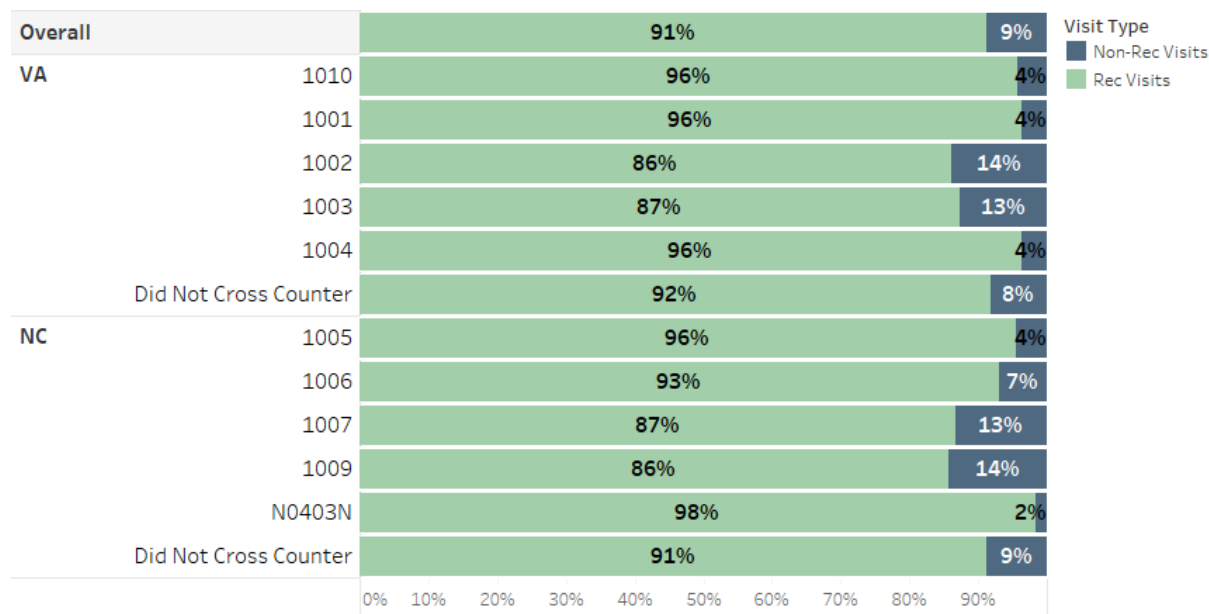


Figure 30: Percent of Recreation vs. Non-Recreation Visits on BLRI by Counter Location

Figure 31 breaks down the share of local vs. non-local visitors to BLRI, both overall and by FOTSC counter location. Local devices are the Census Block Groups within a 15-mile radius of BLRI's counters. Overall, 63% of visitors are non-local while 37% are local. However, a wide variation is observed across the counter locations. The counters in NC tend to have a higher proportion of non-local use compared to those in VA.

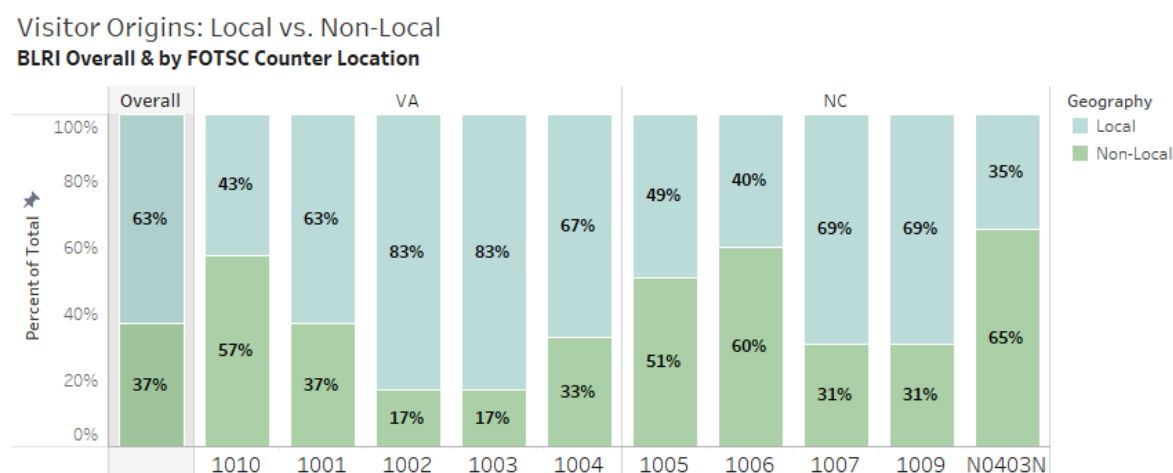


Figure 31: Visitor Origins of Devices at BLRI - Local vs. Non-Local by Counter



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By month, the local and non-local split tends to stay relatively steady. The main difference is within September which has higher proportions of non-local visitation (45%). Potentially due to non-local visitors wanting to view autumn foliage. All other months range from 30-38%. Overall, the variation is not significant and tends to be consistent across months.

Visitor Origins: Local vs. Non-Local
BLRI Overall & by FOTSC Counter Location

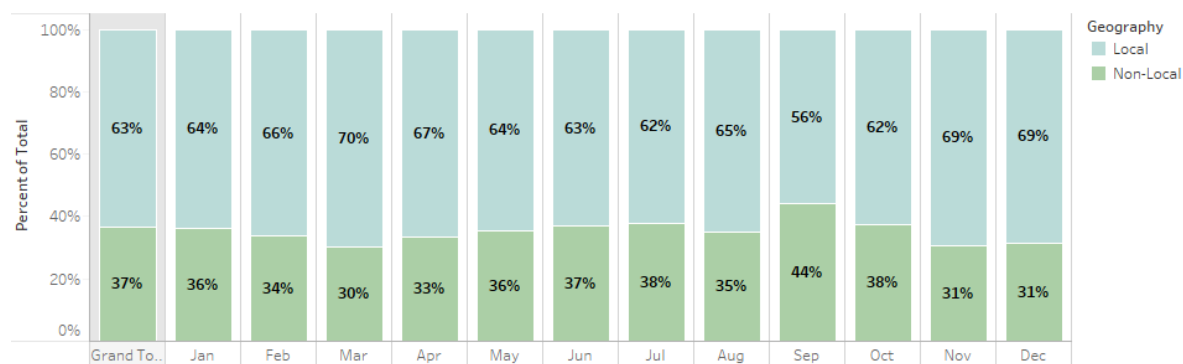


Figure 32: Visitor Origins of BLRI Devices - Local vs. Non-Local by Month

Figure 33 displays the in-state and out-of-state mix of visitor use on BLRI by FOTSC counter location. As expected, the counters in their respective states have the majority of use by residents of those states. The locations in NC tend to have a higher proportion of use from out-of-state visitors ranging from 15-61% of use by counter. Counters in VA range from 4%-18% out-of-state visitation. Overall, approximately 63% of all use is from NC residents, 21% from VA, and 16% from out-of-state.

Visitor Origins: In vs. Out-of-State
BLRI Overall & by FOTSC Counter Location

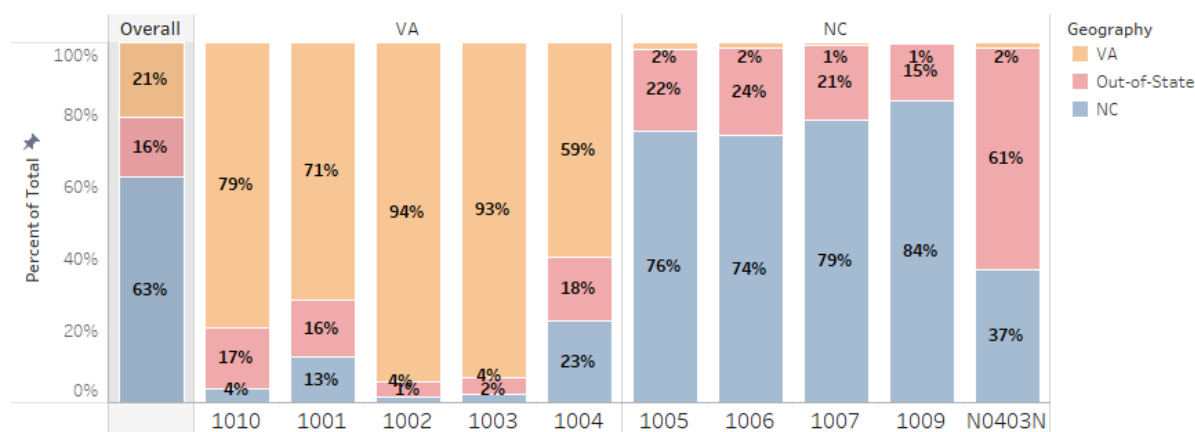


Figure 33: Visitor Origins of Devices at BLRI - In-state vs. Out-of-State

Visitor origins don't vary too much between months on BLRI (Figure 34). Visitor use from NC residents ranges from a low of 57% in December to a high of 67% in August. Residents in VA range



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from a high of 28% in December to a low of 18% in July and August. Out-of-state use remains almost flat and ranges from 14-19% across the year.

Visitor Origins: In vs. Out-of-State

BLRI Overall & by Month

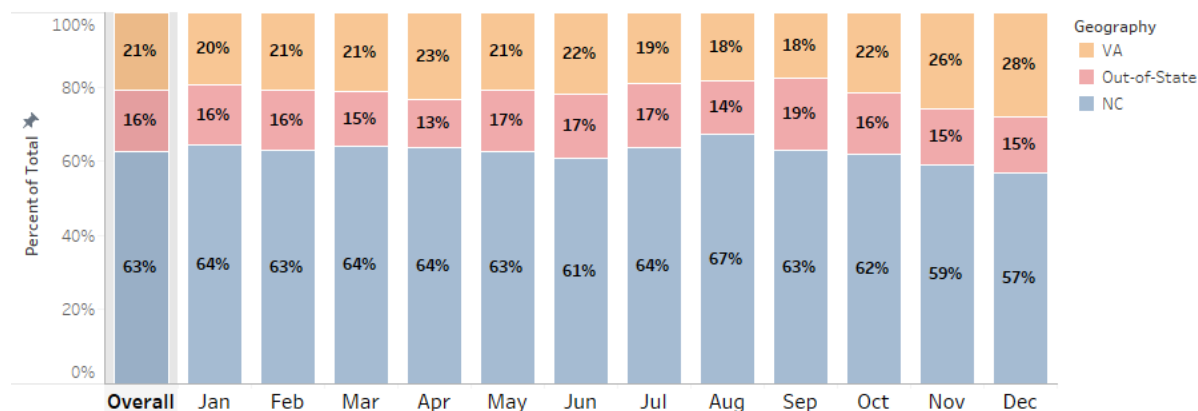


Figure 34: Visitor Origins of BLRI Devices by Month - In-state vs. Out-of-State

Overall, most visitors to BLRI originate from North Carolina (63%) and Virginia (21%), with smaller percentages coming from South Carolina (4%), Florida (3%), Tennessee (2%), and other states. Not surprisingly, trips passing through counter locations in Virginia have a higher share of Virginia residents while trips at counter locations in North Carolina have a higher share of North Carolina residents. Counter N0403N stands out with a higher proportion of visitors from Florida (13%) and South Carolina (10%) compared to other locations, indicating that this site attracts a broader mix of out-of-state visitors. This is most likely because of the counter's proximity to Great Smoky Mountains National Park. Overall, there are strong regional visitation trends at most counters, with nearby states supplying the majority of visitors.

Visitor Origins: by State (Top 10 + "Other")

BLRI Overall & by FOTSC Counter Location

	Overall	1010	1001	1002	1003	1004	1005	1006	1007	1009	N0403N
NC	63%	4%	13%	1%	2%	23%	76%	74%	79%	84%	37%
VA	21%	79%	71%	94%	93%	59%	2%	2%	1%	1%	2%
SC	4%	1%	2%	0%	1%	2%	5%	5%	6%	5%	13%
FL	3%	1%	4%	0%	1%	2%	5%	5%	4%	3%	10%
TN	2%	1%	2%	0%	1%	2%	5%	4%	2%	2%	12%
GA	2%	1%	1%	0%	0%	2%	2%	3%	2%	2%	8%
AL	1%	1%	1%	0%	0%	1%	1%	1%	1%	1%	4%
OH	1%	1%	3%	0%	0%	1%	1%	1%	1%	0%	2%
TX	0%	1%	0%	0%	0%	0%	0%	0%	1%	0%	1%
KY	0%	0%	1%	0%	0%	1%	1%	0%	1%	0%	1%
Other US	3%	11%	4%	2%	2%	7%	3%	5%	4%	2%	10%

Figure 35: Visitors Origins of BLRI Devices by State and by Counter



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Figure 36 displays similar information about profiles of use by state; however, this particular graph shows it on a sliding scale of the entire parkway. Similar to patterns of traffic, the bulk of use from all other states except for those who live in VA is within the NC side of the parkway. Those in VA are much more likely to use the segments in their state, which makes sense for the patterns of use.

Profile of Use by State (Top 10 + "Other")

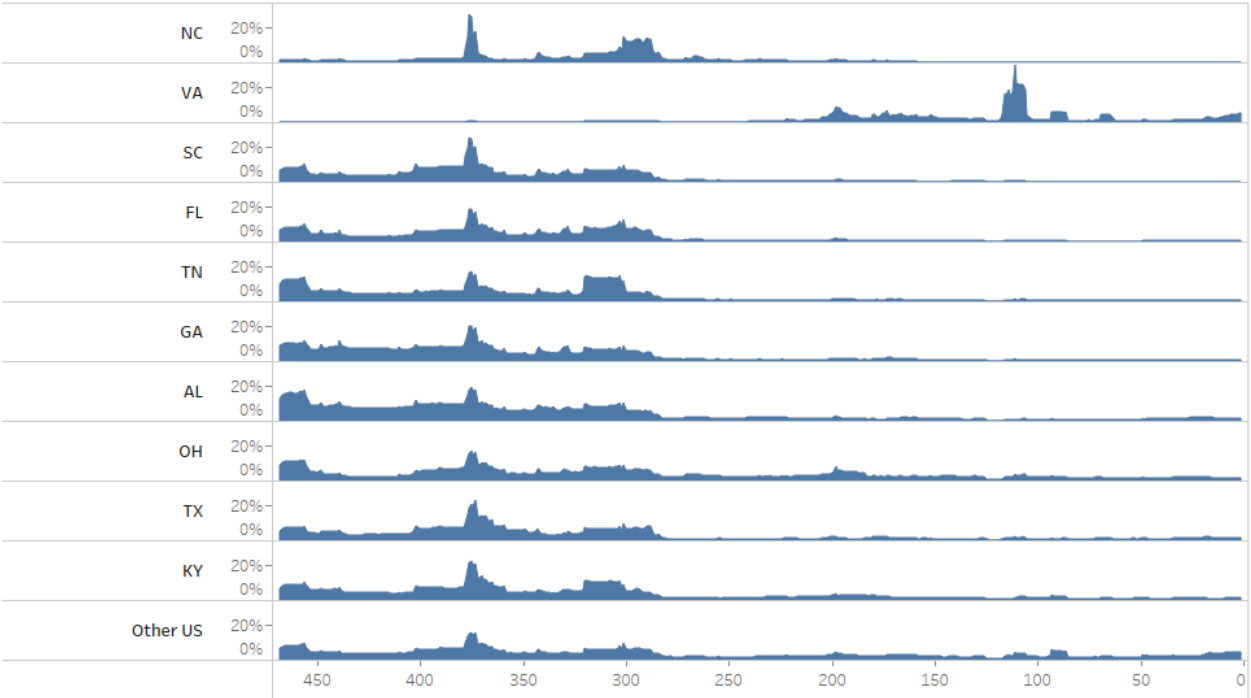


Figure 36: BLRI Profiles of Use by State and Mile Segment

Figure 37 and Figure 38 display the same type of analysis except on a county-wide scale. Buncombe County, NC, and Watauga County, NC have the most overall use at the individual county level. Most counties see the use of the parkway highest in their immediate area, further validating the mobile location data.



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Visitor Origins: by County (Top 10 + "Other")

BLRI Overall & by FOTSC Counter Location

	Overall	1010	1001	VA			1005	1006	NC		
				1002	1003	1004			1007	1009	N0403N
Buncombe County, NC	19%	0%	1%	0%	0%	0%	1%	3%	55%	64%	3%
Watauga County, NC	8%	0%	1%	0%	0%	0%	23%	1%	0%	0%	0%
Roanoke County, VA	4%	0%	2%	35%	44%	3%	0%	0%	0%	0%	0%
Bedford County, VA	3%	1%	12%	30%	21%	1%	0%	0%	0%	0%	0%
Ashe County, NC	3%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%
Henderson County, NC	3%	0%	0%	0%	0%	0%	0%	1%	6%	8%	1%
Carroll County, VA	3%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%
Wilkes County, NC	2%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%
Mitchell County, NC	2%	0%	0%	0%	0%	0%	1%	30%	0%	0%	0%
Botetourt County, VA	2%	0%	0%	15%	4%	1%	0%	0%	0%	0%	0%
Other NC	26%	4%	11%	1%	2%	22%	48%	38%	16%	12%	33%
Other US	16%	17%	16%	4%	4%	18%	22%	24%	21%	15%	61%
Other VA	10%	78%	57%	15%	24%	47%	2%	1%	1%	1%	1%

Figure 37: Visitor Origins of BLRI Devices by County by Counter

Profile of Use by County (Top 10 + "Other")

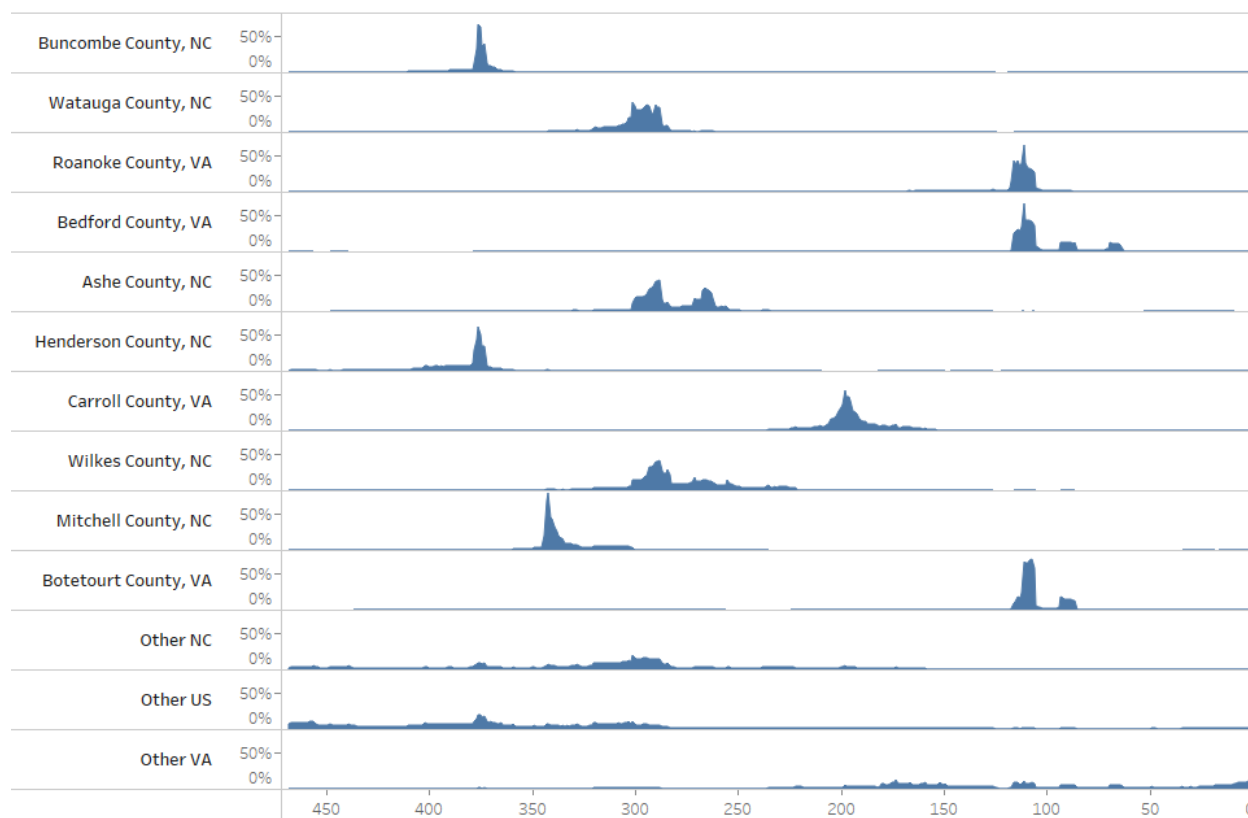


Figure 38: BLRI Profiles of Use by County and Mile Segment



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Figure 39 displays the percentage of entrances occurring along various mile markers of the parkway. The top 10 entrances are highlighted with blue dots on the graph. The spikes are all near most of the major urban areas. Asheville, NC represents the highest spikes between mile markers 350-400. Similar spikes are seen in areas such as Boone, NC (near mile marker 300) and Roanoke, VA (near mile marker 110).

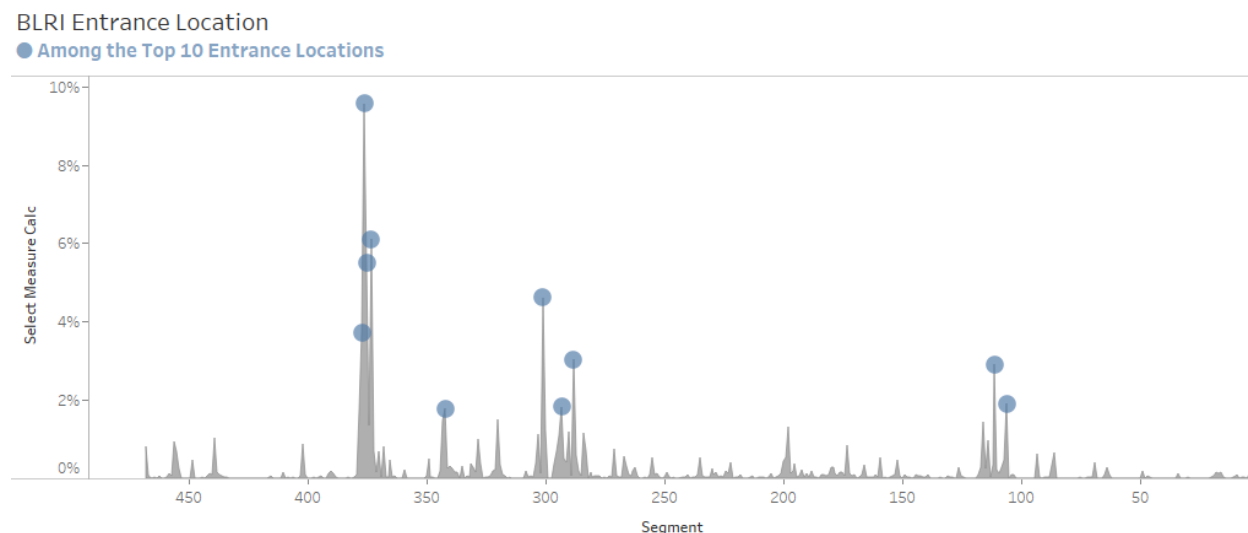


Figure 39: BLRI Entrance Location

Device-level data enabled the research team to understand how long visitors traveled along the parkway during the day of their visit. Non-recreation visitors tend to travel about the same distance with 48% of non-recreation visits traveled less than 10 miles on the BLRI compared to 46% of the recreation visits. By averages and medians, recreation visits have a slightly higher distance traveled on the parkway with an average of 16.7 miles and 11.5 miles as a median. Non-recreation visits are slightly lower at 14.7 miles on average and 10.8 miles as a median.

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Distance Travelled on Parkway by Type (Miles)

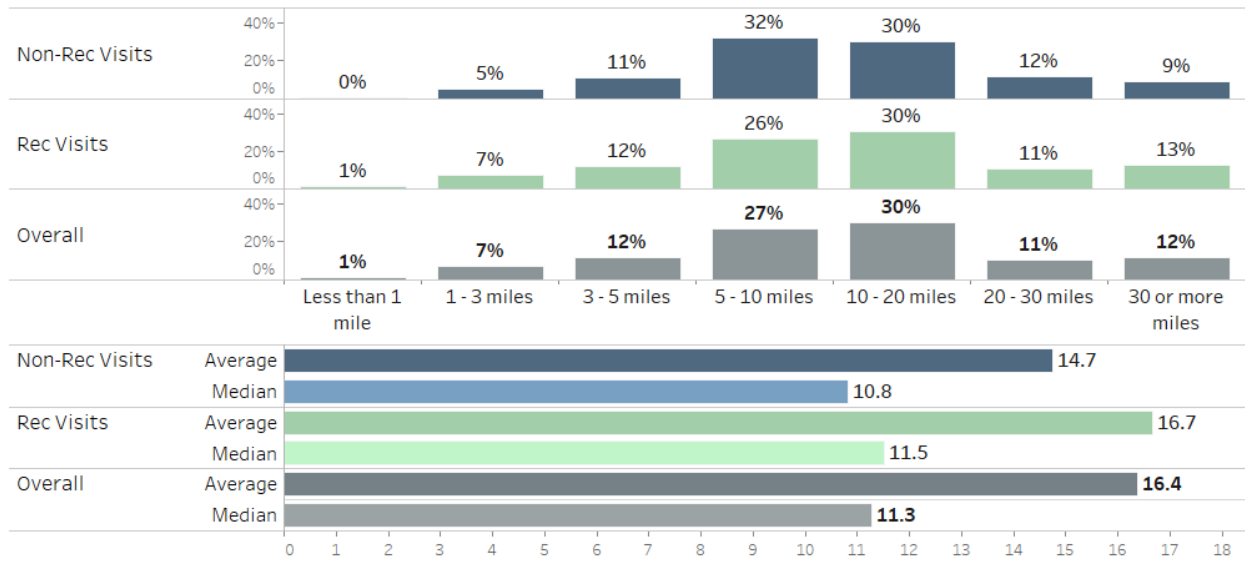


Figure 40: Distance Travelled on Parkway

Figure 41 further shows how the parkway is utilized based on the number of miles driven on the parkway based on mile markers. As the number of miles driven increases, the pattern of visitation starts to stretch out. Shorter trips, such as those between 3-5 miles, mostly take place near the urban zones of Asheville, Boone, and Roanoke.

Profile of Use by Miles Travelled on Parkway On Day of Visit

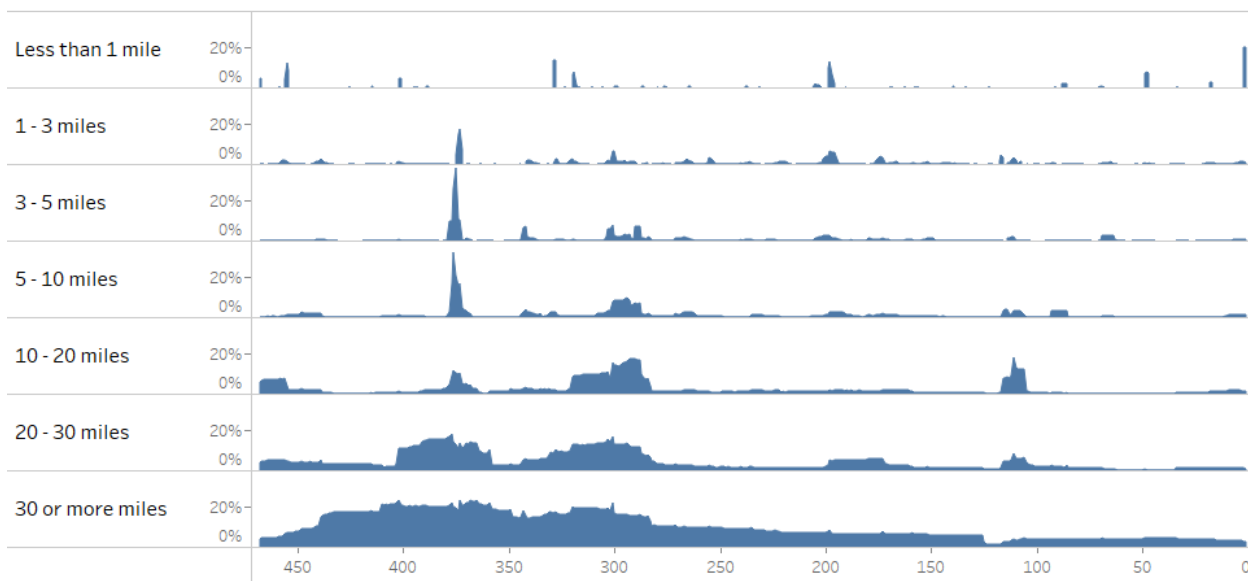


Figure 41: Profiles of Use by Distance Travelled and Mile Segment



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The following map shows the Blue Ridge Parkway (BLRI) segments used in this analysis by state to provide a geographic context for the subsequent figures that will reference these roadway segments along the x-axis. The Parkway starts at segment 468 in North Carolina and extends north to segment 0 in Virginia. Each segment is shaded based on the percentage of trips that occur within that state, ranging from 1% to 27% in Virginia and 1% to 26% in North Carolina.

BLRI Roadway Segments: Virginia

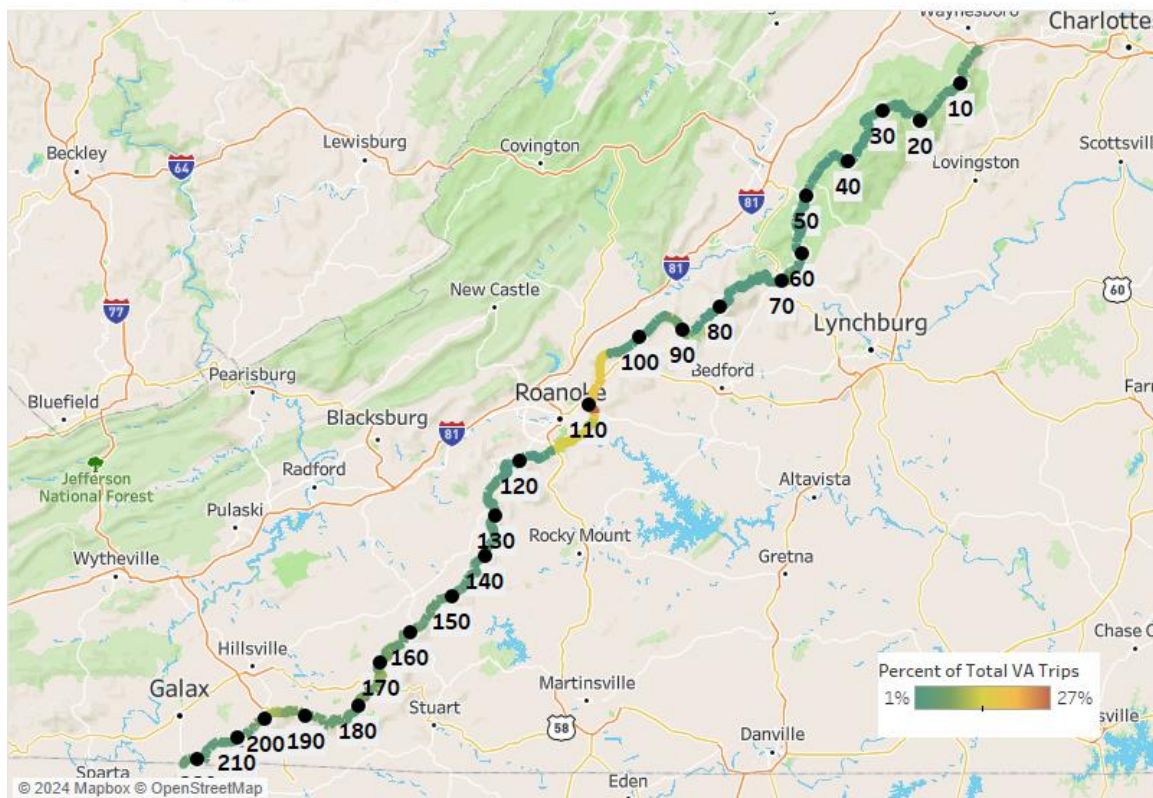


Figure 42: BLRI Roadway Segments in VA



BLRI Roadway Segments: North Carolina

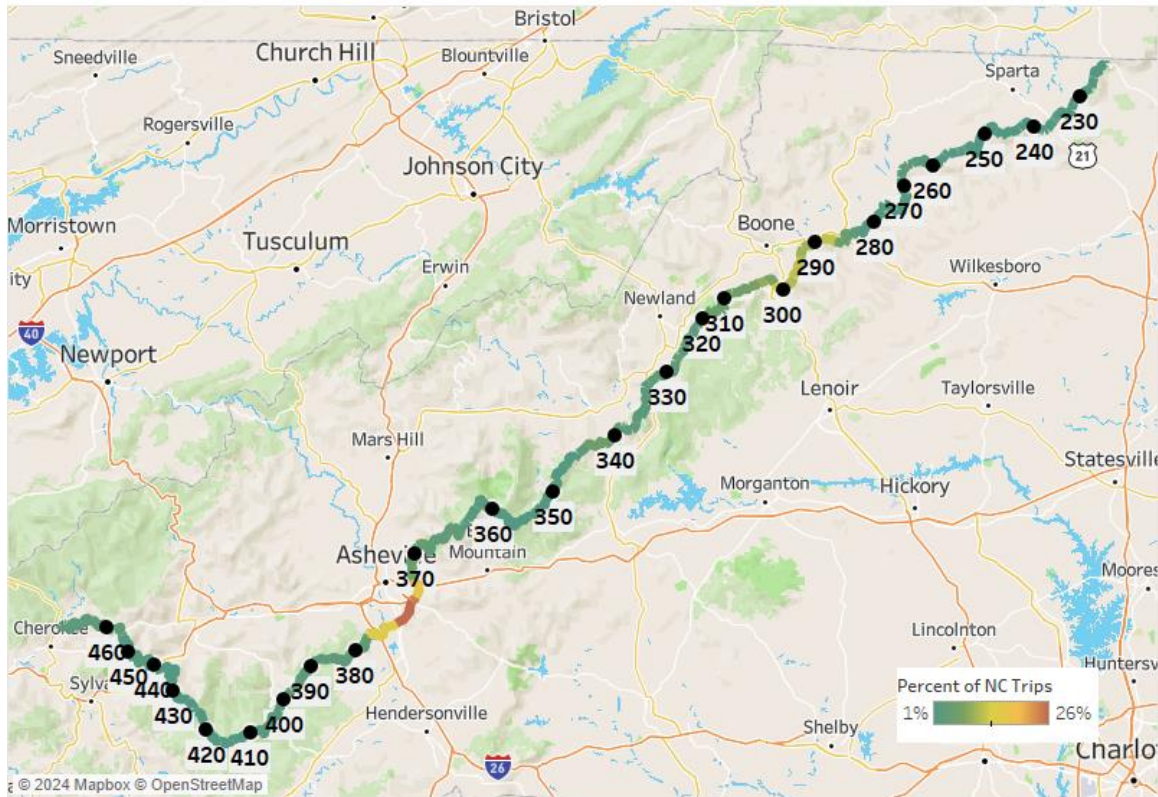


Figure 43: BLRI Roadway Segments in NC



Calculating a New Visitor Use Statistics Model

To build the new visitor-use counting model, all the previous analyses were taken into account and helped provide the inputs for the new model. From the mobile location data analysis, several key metrics were used to help create the new visitor use model for BLRI moving forward. At its core, the visitor use counting model requires inputting traffic counts from the ten FOTSC counters used in this analysis at a monthly level. From there, several adjustments are made from the previous analyses to scale these counters to a total visitor use metric. Below is a summary of the key metrics needed for the new model:

Table 3: BLRI Model Inputs

Metric	Purpose	Frequency of needing to be updated
Monthly traffic counts from 10 FOTSC counters on BLRI	Used as the real inputs of vehicle traffic along the parkway. This represents the only data that is being collected monthly for the model.	Monthly updates required
Average counters cross per trip per counter	For each counter, an average number of counters crossed per trip is calculated to account for duplicate reporting	Constant from the mobility data
Total share of trips passing a FOTSC counter	Used to estimate the ratio of trips that are being accounted for on FOTSC counters vs. those that are not passing a counter.	Constant from the mobility data
Persons Per Vehicle (PPV) – Rec Visits	The number of people per vehicle for recreation visits.	Constant from past studies
Person Per Vehicle (PPV) – Non-recreation visits	The number of people per vehicle for non-recreation visits.	Constant from past studies
Re-entry rate	A re-entry rate for those who leave the parkway and re-enter on the same day is used to correct for duplicate reporting.	Constant from the mobility data
Fixed Non-Recreation Counts Applied	A fixed count of non-recreation visits by counter is applied to the model. This figure is a constant and was calculated through the mobility analysis.	Constant from the mobility data

The metrics needed for the model moving forward are outlined in the above table and are included in an accompanying Excel model document. For BLRI, the only data that will need to be updated regularly is the monthly traffic counts from the ten FOTSC counters installed along the parkway. These inputs are the basis for all visitation estimates and are required for the model. Because of the



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parkway's total mileage and distance, on-the-ground counts are necessary to accurately update visitation moving forward. However, all other metrics are constant and should not need to be updated except with major count procedure updates through future studies.

All metrics have been calibrated and vetted by the research team along with the NPS Visitor Use Statistics coordinator. The process for calculating one month of data is described below for Virginia. A formula for the process is described below:

1. **X**: Traffic count input from n traffic counters.
2. **y**: Mean number of counters crossed per trip for all n traffic counters.
3. **z**: Person per vehicle count.
4. **a**: Share of trips crossing any counter.
5. **b**: Re-entry rate.

X_i as the traffic count from the i -th traffic counter, where i ranges from 1 to n .

1. **Divide each traffic count by the mean number of counters crossed per trip (y):**
2. **Sum these values for all n traffic counters:**
3. **Multiply the summed count by the person per vehicle count (recreation and non-recreation) (z):**
4. **Divide this product by the share of trips crossing any counter (a):**
5. **Divide this result by the re-entry rate (b):**

$$\frac{z}{ab} \sum_{i=1}^n (X_i/y_i)$$

Non-recreation totals are added as a fixed number per counter after the above formula is calculated.

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BLRI Visitation Model Overview – VA Example

INPUT DATA: Traffic Counts

Counts from each counter location are entered for the month.

	FOTSC Location	Count
Virginia	1010	35,070
	1001	6,327
	1002	70,000
	1003	38,283
	1004	16,562
	Admin. Visits	760

*Numbers are hypothetical

Counts are Deduped

Counts are divided by the mean number of counters crossed by vehicles in that location. This number is specific to each counter location and season (summer/winter).

E.G.

FOTSC Location	Count	Avg. Counters Crossed Per Trip	Step Result
1010	35,070	1.09	32,174

Counts are Summed

Deduped counts are summed by state.

Deduped Count						Step Result
32,174	4,394	53,030	23,631	15,773	(583)	128,420

Counts Are Multiplied by Persons Per Vehicle

Recreation visits are multiplied by 2.5. Non-recreation visits are multiplied by 1.5.

Total	PPV	Step Result
128,420	2.5	321,050

Counts Are Divided by the Share of Trips that Cross any Counter

This accounts for BLRI trips that do not cross a counter location. This number is specific to each counter location and season (summer/winter) and visit type (recreation vs. non-recreation).

Product	Share Crossing Any VA Counter	Step Result
321,050	45%	713,445

Counts Are Divided by a Re-Entry Rate

This accounts for visitors that make multiple visits to BLRI within a day.

Quotient	Re-Entry Rate	Step Result
713,445	1.4	509,603

Fixed non-recreation counts are recorded

On a per-counter basis, fixed non-recreation numbers are reported each month. This figure does not change based on traffic counts.

OUTPUT DATA: Visitor Estimates

Final recreation and non-recreation visits are determined by State



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To provide a sense of how the new model functions, the figure below highlights the monthly recreation and non-recreation visits by both non-recreation alternatives. As displayed, the difference is not major; however, there are some nuances to the approach.

To estimate visitation using these two models, traffic counter data from 2023 was used; however, missing data necessitated interpolation. For months where counters worked on 14 or more days, the average daily traffic was computed, multiplied by the number of missing days, and added to the sum traffic volume in both directions on usable days. For months where the counters worked on fewer than 14 days, the mode value by month and counter location were utilized for all months except for January, which used the minimum value.

Based on input from NPS staff, the alternative two model utilizes static numbers to estimate non-recreation visits (in addition to administrative visits). These numbers do not change based on traffic counter volume. To estimate these non-recreation values, the alternative two model was used in conjunction with interpolated traffic counts to predict monthly visitation. The mean value by month, 59,444, was then apportioned by the traffic counter based on the share of non-recreation visits by the counter.

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
VA	Non-Rec Visits	Alternative 1	27K	28K	32K	36K	42K	41K	44K	75K	58K	74K	38K	34K
		Alternative 2	10K	10K	12K	13K	14K	14K	15K	25K	19K	25K	14K	13K
	Rec Visits	Alternative 1	240K	245K	300K	357K	428K	419K	459K	635K	529K	758K	364K	288K
		Alternative 2	278K	284K	346K	410K	440K	431K	472K	660K	547K	778K	419K	336K
	Total	Alternative 1	268K	273K	332K	393K	470K	460K	504K	710K	587K	832K	402K	323K
		Alternative 2	288K	294K	358K	423K	454K	444K	487K	685K	566K	803K	433K	348K
NC	Non-Rec Visits	Alternative 1	66K	67K	86K	94K	102K	109K	118K	105K	105K	145K	90K	76K
		Alternative 2	30K	31K	39K	44K	46K	50K	53K	48K	47K	66K	42K	35K
	Rec Visits	Alternative 1	665K	676K	816K	955K	1,055K	1,131K	1,251K	1,066K	1,097K	1,634K	897K	740K
		Alternative 2	713K	725K	876K	1,023K	1,113K	1,193K	1,319K	1,129K	1,160K	1,725K	964K	795K
	Total	Alternative 1	731K	743K	902K	1,049K	1,157K	1,241K	1,369K	1,171K	1,202K	1,779K	987K	817K
		Alternative 2	744K	756K	916K	1,066K	1,159K	1,242K	1,373K	1,177K	1,208K	1,791K	1,005K	830K
Grand Total		Alternative 1	999K	1,016K	1,234K	1,442K	1,627K	1,700K	1,873K	1,881K	1,788K	2,611K	1,389K	1,139K
		Alternative 2	1,032K	1,049K	1,273K	1,489K	1,613K	1,686K	1,860K	1,862K	1,774K	2,594K	1,438K	1,178K

Figure 44: BLRI Visits with New Model - By Non-Recreation Alternative #1 and Alternative #2



Conclusions and Recommendations for Future Studies

The 2023 BLRI Visitor Counting Study was an ambitious effort to best document, update, and refine the visitor use counting procedures at one of the busiest sites in the NPS. With over twenty years since the last real update of the counting procedures, the time was right to utilize new methodologies for updating the count procedures at the parkway. Mobile location data is still an emerging method for refining visitor use procedures, but there is strong evidence for its benefits through this study.

Overall, BLRI's counting procedures have been simplified and updated to allow for easy changes in the future. The total visitation metrics have not changed significantly; however, the split of recreation vs. non-recreation visits has not been updated to account for the rise in urban traffic in the Asheville, NC, Boone, NC, and Roanoke, VA areas specifically. This new model provides a more accurate picture of this ratio at the individual counter level.

One benefit of this study is that all of the metrics that were used to extrapolate from the traffic counts are updatable over time. The person-per-vehicle metrics, re-entry rates, and all metrics from the mobile location data could be updated over time to account for changes in visitation and traffic patterns. The old system was much more difficult to update as it relied on dozens of regression models that were not updatable with new counter data. For the parkway, this new procedure should set them up for long-term implementation with the ability to conduct surveys or other studies to refine numbers over time.

A major change for these new visitor-use counting procedures is the use of FHA's FOTSC counters along the parkway. With the previous model, only BLRI's 15 counters were used. While that setup had its advantages such as controlling the ability to replace the counters by the parkway, the disadvantages were much greater. By relying on the FOTSC counters the parkway does not need to maintain the existing counters and they are much more accurate. However, the parkway must make efforts to collect monthly data from these counters moving forward. The parkway's previous model relied on many dysfunctional or inoperable counters. While the visitation estimates may have been close to reality, there was no way to tell whether real change was occurring because of these limitations. Now, the parkway has an easier count procedure to update but FOTSC is also relying on these counters being updated every month as well.

Overall, the research team's goal was to provide a more accurate visitor use counting procedure for BLRI while also reducing the complexity of calculating and collecting data. By moving from 15 counters to 10 that are not required to be maintained by the parkway, the counting procedure should be an easier process moving forward. Plus, there is the added flexibility of having an updatable process to use well into the future as the parkway continues to evolve. Further validation could occur for improvements in the model in non-recreation and recreation visits through survey work; however, capturing commuters is very difficult in survey research. A survey could help further refine re-entry rates as well as metrics such as distance traveled on the parkway. There are limitations with this method as well, but having multiple data sources could be useful.