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Standards in the Denali Park Road Vehicle Management Plan — How Current Conditions Measure Up

A Summary Report 2013

Natural Resource Technical Report NPS/DENA/NRTR—2014/915



ON THE COVER
Passengers on a Tundra Wilderness Tour bus enjoy seeing a grizzly bear near Sable Pass.
Photo courtesy of Denali National Park and Preserve.

Standards in the Denali Park Road Vehicle Management Plan—How Current Conditions Measure Up

A Summary Report 2013

Natural Resource Technical Report NPS/DENA/NRTR—2014/915

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Abstract

This report summarizes data collected during the 2013 regulatory season to monitor six of the seven Denali Park Road Vehicle Management Plan (VMP) tier one indicators: 1) number of vehicles stopped to view wildlife at one time (wildlife stops); 2) number of vehicles at rest stops; 3) number of vehicles visible in viewscapes; 4) maintenance of hourly ten-minute gaps in traffic at sheep crossing locations (sheep gaps); 5) number of vehicles per hour between 10 p.m. and 6 a.m. (night-time traffic); and 6) amount of time a hiker waits for a bus.

The primary objective of this report is to compare the conditions of VMP indicators during the 2013 regulatory season to the standards. The monitoring results will be used to develop strategies for managing vehicle traffic on the park road in a manner that meets the goals and standards established by the VMP. Results include:

- The standards for the number of vehicles at wildlife stops were met in Subzones 1 and 2. Two of the three standards for Subzone 3 (Eielson Visitor Center to Wonder Lake) were exceeded.
- The standards for the number of buses and vehicles parked at one time at the Toklat and Teklanika Rest Stops and the Eielson Visitor Center were met.
- The standards for the numbers of vehicles visible in each of the four viewscapes at any one time were met.
- The standards for maintaining at least one ten-minute gap in traffic ninety percent (90%) of the time were met for four of the five sheep gaps. Mile 60.6 achieved a gap 89.3% of the hours monitored.
- The standards for night-time traffic were met.
- The most restrictive standard for hiker wait time was not met for hikers at the Eielson Visitor Center. The remaining standards were met at Eielson Visitor Center. Data were not available for analysis of hiker wait time along the rest of the park road.

Our results suggest that traffic scheduling, volumes, and driver behavior during the 2013 regulatory season enabled the park meet most of the VMP standards. The results also highlighted: 1) areas where conditions could be improved through vehicle management; and 2) areas where our monitoring efforts could be improved.

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Introduction

For over seventy years, the Denali Park Road has provided the primary access to Denali National Park and Preserve, and concessioners have offered tours along the park road (Bryant 2011). Beginning at the park entrance, the narrow ribbon of road winds 92 miles west, following a beautiful valley that separates the Alaska Range to the south from the Outer Range to the north. While traveling the park road, visitors can observe wildlife species in their natural habitats, as well as enjoy the magnificent wilderness landscape, including views of the continent's highest peak.

Most of the park road is one lane and sections of it hang precipitously high above the valley, posing challenges for drivers and managers to ensure the safety of travelers. In 1958, the National Park Service (NPS) began a project that would have drastically altered the character of the road. The intent was to widen and pave the entire road and to add guard rails and striping. Conservationists, including Adolph Murie, fought to protect the "wilderness atmosphere" of the road. Because of their efforts, the road is only paved as far as the Savage River Bridge (Mile 15) and it is only widened to the Teklanika River (Mile 31). Westbound visitors cross the Teklanika River Bridge, and are welcomed on the other side by the rustic character of road that has persisted for over seventy years.

The road improvement story is an example of one of the biggest challenges faced by national parks, balancing the need to protect park resources while making them available for people to enjoy. The challenge is particularly great in Denali, where park managers must balance the growing demand for visitor opportunities to tour the park road with the need to ensure that park resources are protected and visitors continue to have a safe, high-quality experience. To balance these sometimes conflicting responsibilities, park managers have restricted private vehicle travel beyond the Savage River since 1972. Traffic on the road was restricted from approximately Memorial Day through Labor Day. In 1986 park managers instituted a vehicle limit of 10,512 round trips during the regulatory season for all users combined (NPS 1986). Vehicle use was allocated among user groups which include concessioner-operated buses, NPS and park partners, and private vehicles including special permit holders, Teklanika campers, Kantishna property owners, and subsistence users.

The 1972 restrictions were implemented by park mangers to address the anticipated substantial increase in motor vehicle access to the park resulting from the opening of the George Parks Highway. The vehicle restrictions were further refined in the 1997 Entrance Area and Road Corridor Development Concept Plan (NPS 1997) and promulgated in special park regulation (36 CFR § 13.930 et seq.) in 2000. The 1997 plan also refined the regulatory season so that it started the Saturday before Memorial Day until ended the second Thursday after Labor Day or September 15, whichever came first.

Denali Park Road Capacity Study

Between 1986 and 2006, visitation to the park and demand to travel the park road increased steadily. In 2006 park managers, faced with increasing visitation and pressure to defend or increase the annual vehicle limit, initiated a process to comprehensively evaluate the strategy for transporting people on the park road. The road capacity study addressed concerns for protecting important park resources and values by evaluating the transportation systems and determining the carrying capacity of the road

(Phillips et al. 2010a, Phillips et al. 2012). The study was conducted by an interdisciplinary team of NPS scientists and managers and academic scientists over several years. They assessed the effects of traffic volumes and patterns on the park's social, biological, and physical environment. The results of the study were used to inform development of the Denali Park Road Vehicle Management Plan and Environmental Impact Statement (VMP; NPS 2012), including establishing seven indicators of desired resource and visitor experience conditions, and developing quantitative standards to ensure those conditions are maintained.

The study included three primary components: 1) an assessment of the relationship between vehicle traffic and wildlife movements and sightings (Phillips et al. 2010b); 2) visitor surveys to identify and quantify key indicators of a high-quality visitor experience on the park road (Manning and Hallo 2010); and 3) the development of a spatially explicit traffic model that integrated the results from the first two components with Global Positioning Systems (GPS) data collected from vehicles traveling the park road to predict the effects of changes in traffic volume and patterns on wildlife movements and visitor experience (Morris et al. 2010).

To identify possible links between vehicle traffic and wildlife behavior, 20 grizzly bears (*Ursus arctos horribilis*) and 20 Dall's sheep (*Ovis dalli dalli*) were collared and tracked using GPS. Data were also collected to determine the number and distribution of the "big five" large mammals: caribou (*Rangifer tarandus*), grizzly bears, Dall's sheep, moose (*Alces alces*), and wolves (*Canis lupus*) sighted from the park road. Traffic data were collected using traffic counters placed at six locations along the park road and wildlife sightings were recorded by bus drivers using touch-panel interfaces installed in 20 buses (Phillips et al. 2010b, Phillips et al. 2012).

The results suggested that the volume and patterns of vehicle traffic might affect the distribution and movements of wildlife, although the effects were not statistically significant. The clearest indication of negative impacts from vehicle traffic on wildlife included findings that Dall's sheep increased their movement rates when approaching the road and they were located further from the road during higher traffic volumes. Some bands of sheep migrate between habitats in the Outer Range (primarily winter habitat) and the Alaska Range (primarily summer habitat). Other bands may use habitats on both sides of the road throughout the summer. During migration, these sheep must cross the road. Therefore, understanding and mitigating the impacts to sheep movements is important for maintaining healthy sheep populations. This study also found a reduction in the number of early morning sightings of the big five wildlife following high levels of night-time traffic. The night-time traffic considered in this study often included large construction vehicles which may have a greater impact on wildlife due to the nature and behavior of these vehicles—they produce more noise and dust and likely move more quickly when passing wildlife than do visitor buses that stop to view the wildlife. One of the uncertainties relating to the relationship between night-time traffic and morning wildlife sightings is the specific impact of large vehicles, including contractor vehicles and NPS vehicles, and there is concern that large vehicles will have a similar impact at any time of day.

The results of the wildlife studies enabled park managers to identify three indicators and establish standards directly related to the volume and timing of vehicle traffic to protect wildlife and visitor

experience: 1) the spacing of traffic at five sheep crossings; 2) the amount of night-time (10 p.m. to 6 a.m.) traffic; and 3) the hourly amount of large (>80,000 gross pounds) vehicle traffic.

Visitor surveys were used to identify the fourth through seventh indicators. In 2006, qualitative surveys identified the fourth through sixth indicators to capture the effects of vehicle crowding conditions on visitor experience: 4) the numbers of vehicles stopped at the same location to view wildlife; 5) the number of vehicles visible in four iconic viewscapes at one time; and 6) the number of vehicles parked at rest stops at one time. In 2007, researchers conducted quantitative visitor surveys to determine how varying levels of vehicle traffic affected visitor satisfaction. Survey participants were shown a series of simulated photographs depicting a range of vehicles at wildlife stops, rest stops, and within iconic viewscapes. The results were used to assess the reaction of visitors to increasing levels of crowding to provide management with guidance on establishing standards (Manning and Hallo 2010). Additionally, the concessioner operates buses that provide interpretive tours and buses that are used to transit the road. People using the transit buses can get on and off anywhere along the road to hike or backpack. The overarching goal for setting these standards was to maintain or improve current crowding conditions or to maintain numbers of vehicles at these locations similar to or less than what they are currently.

The effectiveness of the transportation system in serving the needs of visitors can be measured by looking at two domains; the ability of visitors entering the park to acquire a seat on a bus and the wait time for hikers reboarding buses to exit the park. Thus, the seventh indicator, 7) the amount of time a hiker waits for a bus to pick them up, was developed to ensure that transit buses are adequately scheduled along the length of the park road and that these buses have enough space on them to pick up additional passengers.

Results from the wildlife and visitor experience studies, along with GPS data collected from vehicles traveling the park road were integrated into a traffic simulation model to test the effects of different traffic scenarios (VMP alternatives) on the indicators and standards.

A Long-term Plan for Managing the Park Road

The VMP was developed to improve management of vehicle traffic during the regulatory period for the next 15 to 20 years (NPS 2012). The goal is to ensure that visitors would have a high-quality experience, wildlife and other park resources would be protected, and the unique character of the park road is maintained. The VMP uses an adaptive management approach to ensure that desired resource and visitor experience conditions are being met as traffic volumes and schedules are adjusted to optimize the transportation system. Adaptive management is a process that promotes flexible decision making that can be adjusted as results of management actions are monitored and better understood. Adaptive management is necessary because there is some level of uncertainty and unpredictability in the outcomes of most management actions due to environmental variability or incomplete knowledge of how the system functions.

The adaptive management strategy includes a four-tiered approach to monitor for impacts to visitor satisfaction and natural resources resulting from changes in the transportation system, such as increases in traffic volume or modifications to scheduling (e.g., clustering vehicles). The four tiers

include: 1) monitoring the indicators and standards of desired conditions; 2) monitoring changes in wildlife observations; 3) monitoring changes in wildlife populations (using data from long-term monitoring programs); and 4) conducting Before-After-Control-Impact (BACI) studies. The tier one indicators are monitored throughout the regulatory season. Some of the standards are based on absolute maximums (e.g., Toklat rest stop will not exceed 12 buses at one time) while other standards are based on one-year and five-year averages (e.g., hikers won't have to wait more than 30 minutes for a bus at least 70% of the time in any one year and 75% of the time averaged over five years). The five-year average allows for aberrant years. Monitoring results will be reported to the public on an annual basis, and the results will be used to adjust the traffic schedule to optimize the system while protecting the values that make transiting the park road a special and unique experience for visitors from around the globe. The results from the comprehensive monitoring program and the BACI study will enable park managers to make informed decisions regarding changes to the transportation system while protecting important park resources and maintaining a high-quality visitor experience.

The VMP also replaces the regulatory season vehicle limit (10,512) with a daily limit of 160 vehicles and it modifies the Wildlife Viewing Subzones to clarify the management objectives necessary for achieving the desired conditions within specific segments of the park road. Crowding standards (number of vehicles at wildlife stops, number of vehicles at rest stops, and number of vehicles in viewscapes) are established for each subzone to preserve the character-defining qualities and attributes of the different road segments in relation to visitor experience. Managers expect subzone 1 to have the greatest amount of traffic and consequently, the greatest crowding conditions. As visitors travel further out on the park road, the volume of traffic decreases and the standards become more stringent to reflect visitor's expectations for lower crowding conditions further out into the park. The VMP was approved in September 2012, and park managers anticipate full implementation of the plan, when a new concessions contract to operate the park's public transportation system is in place and the special park regulations have been updated in the U.S. Code of Federal Regulations with the 160 vehicle daily limit.

During the 2013 regulatory season park staff and volunteers collected monitoring data to assess the current state of the indicators in relation to VMP standards and to refine monitoring techniques and protocols. The primary objective of this report is to compare the current conditions of the VMP indicators to set standards. The results will help inform adaptive management of vehicle travel (e.g., traffic scheduling, management of different user groups, driver behavior) on the park road.

This report summarizes data for six of the seven Denali Park Road Vehicle Management Plan (VMP) tier one indicators: 1) number of vehicles at wildlife stops; 2) number of vehicles at rest stops; 3) number of vehicles visible in viewscapes, 4) hourly ten-minute gaps in traffic at sheep crossing locations, 5) average hourly night-time vehicle traffic, and 6) hiker wait time. The secondary objective of this report is to assess traffic patterns within shorter periods (daily or subseason) that indicate potential sources of future problems if crowding increases to the point where standards are not being met, and areas where management could improve existing conditions to ensure that the goals of the VMP are achieved.

Indicators and Standards

See Appendix A for a table of the tier 1 indicators and their associated standards.

Number of Vehicles at Wildlife Stops

Wildlife stops are random events that can occur at any point along the park road when one or more vehicles stop to observe wildlife. One or more individual animals, representing one or more species may be present at a given wildlife stop. The most frequent wildlife stops involve sightings of the "big five" large mammal species: caribou, grizzly bears, Dall's sheep, moose, and wolves, although vehicles will stop for other species as well. The VMP manages for crowding at wildlife stops by establishing standards for the maximum number of vehicles stopped at the same location to view wildlife at the same time. The VMP also established wildlife viewing subzones with different management objectives for crowding conditions. The wildlife stop crowding standards vary depending on the wildlife viewing subzone (Figure 1).

Number of Vehicles at Rest Stops

The VMP manages for crowding at the Teklanika and Toklat Rest Areas and the Eielson Visitor Center, collectively called "Rest Stops", by establishing standards for the number of vehicles parked at a rest stop at any one time (Figure 1). The design standards for each facility's parking lot were used to set the standard for the maximum number of buses and vehicles parked at one time.

Number of Vehicles in Viewscapes

VMP identified four iconic viewscapes—mile 26 (Teklanika Flats), mile 55 (west of Toklat), mile 62 (Stony Overlook), and mile 68 (Grassy Pass). The standard for each viewscape is based on the social normative curves developed from the 2007 visitor surveys (Manning and Hallo 2010) and the desired conditions for visitor experience established for the wildlife viewing subzone where the viewscape occurs (NPS 2012). The VMP viewscapes were established to provide reference points for monitoring conditions along the park road. Traffic is managed based on data collected from these reference points with the intent that crowding conditions within each subzone are represented by what is observed at the four viewscapes.

Sheep Gap Spacing

The VMP identified five locations that are important for movement by sheep and other wildlife (Figure 1)—mile 21.6 (Hogan Creek), mile 37.6 (Igloo Creek), mile 52.8 (Porcupine Forest), mile 60.6 (Highway Pass), and mile 68.5 (Grassy). These crossing locations may be used for seasonal migrations and/or for within season movements between adjacent habitats. Research suggests that movement patterns of sheep and other wildlife species between habitats bisected by roads may be affected by the volume and type of vehicle traffic. The VMP includes a standard requiring the maintenance of at least one 10-minute gap in traffic per hour at five locations along the park road. The indicator and its standard were established to balance the need to not disrupt the migratory patterns of less habituated sheep groups with the desire to not unnecessarily restrict traffic and consequently displace visitors. The VMP sheep gap monitoring locations were also established to ensure breaks in traffic along the entire length of the controlled section of the park road by providing reference points for monitoring conditions along the park road. Traffic is managed based on data

collected from these reference points with the intent that traffic spacing along the entire length of the park road is represented by what is observed at the sheep gaps.

Night-time Traffic

The VMP includes an indicator to reduce the impact of night-time traffic on the following morning's wildlife sightings. The standard for this indicator is for an average of three or fewer vehicles per hour (total westbound and eastbound) per night (10:00 p.m. to 6:00 a.m.) as counted at traffic counters placed along the road corridor; and no more than six vehicles in any one hour. Both standards are to be met at least 95% of the time. This standard will continue to be refined during the first two years of implementation of the VMP through experimentation with night-time traffic including experimentation with night-time construction traffic (both NPS and contractor).

Hiker Wait Time

Hiker wait times that begin to consistently approach or exceed the standard are an indication that there is not adequate transit service and additional buses need to be added to the schedule to address the need. The VMP does not specify an allocation of concessioner buses between tour and transit. The purpose of not defining this allocation was to maintain flexibility in the system to respond to changing visitor demands. The VMP expressly states that transit needs will be prioritized over tours and that transit service will be maintained to a level that meets the standard for hiker wait time. If an increase in transit service is necessary it may be balanced by a decrease in tour services if that is required for compliance with the standards controlling the number of buses on the road.

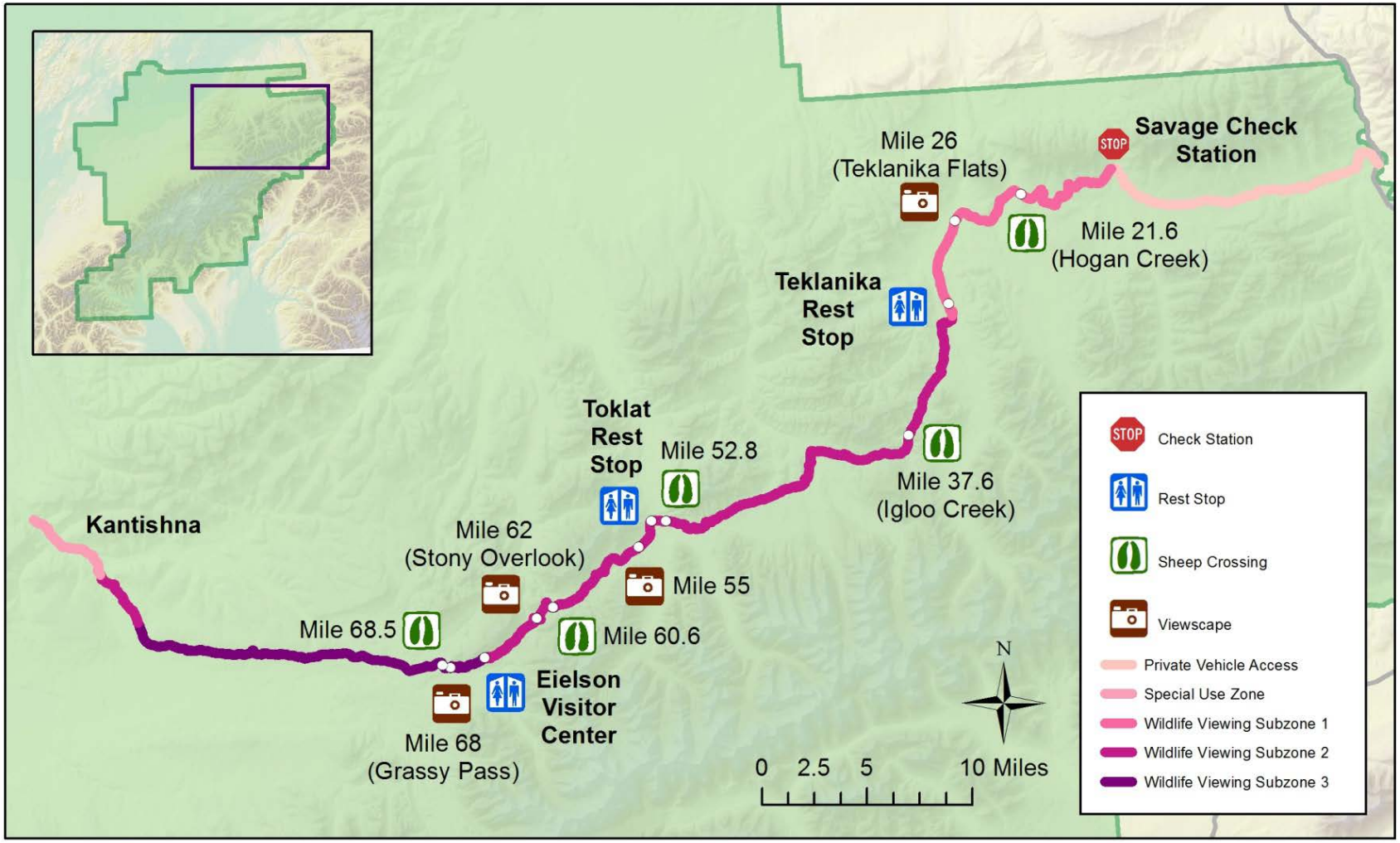


Figure 1. The Vehicle Management Plan established indicators (rest stops, sheep crossings, and viewscapes) that would be monitored for maintenance of desired conditions. The standard which must be met for each indicator depends on the Wildlife Viewing Subzone.

Methods

Study Area

Denali is located in interior Alaska between Anchorage and Fairbanks. Most visitors to Denali access the park's 2.4 million hectares via the 92-mile road that connects George Parks Highway to the former mining community of Kantishna. The Denali Park Road follows a 1 to 10 km wide valley between the Alaska Range to the south and the foothills to the north commonly referred to as the Outer Range. Habitat along the road includes boreal forests dominated by spruce (*Picea* spp.), scrub shrub dominated by dwarf birch (*Betula* spp.) and willow (*Salix* spp.), and high-elevation tundra characterized by *Dryas* spp. or graminoids and sedges (*Carex* spp. and *Eriophorum* spp.). The climate in Denali is subarctic. Summers are short and cool with average minimum and maximum temperatures of 0º and 24ºC, respectively (Western Regional Climate Center 2007). Annual precipitation averages 38 cm with over half occurring during the summer months. Snow cover is generally present from October through early May. Daylight varies during the year from more than 20 hours in June to four hours in December.

Data Collection

NPS Staff Observations

NPS staff collected data at designated locations along the controlled portion of the park road at least once every two weeks during the regulatory period in 2013. For sampling purposes, the monitoring period was divided into "early", "peak", and "late" subseasons to ensure adequate sampling across the regulatory period. The subseasons were defined by changes in the Visitor Transportation Systems (VTS) bus schedules (Table 1), with peak season coinciding with the highest level of park visitation and park road transit. During each subseason, NPS staff collected data at rest stops, viewscapes, and sheep gap locations during early morning (0600–0900), late morning (0900–1200), afternoon (1200–1500), late afternoon (1500–1800), and evening (1800–2200) time periods. Sampling occurred during bus operating hours (0600–2200). This sampling scheme enables us to collect data to determine where the indicators may be stressed, and where potential windows of opportunity exist for shifting future bus schedules to address stresses in the system.

Table 1. The summer regulatory season is broken up into three subseasons. The subseasons are based on the transit bus schedule.

	Early Season	Peak Season	Late Season
2013	5/25 - 6/19	6/20 - 8/7	8/8 - 9/12

Although scheduling logistics prohibited randomized sampling, each observation site was sampled at least once during each time period, within each subseason. For rest stops and viewscapes, the maximum number of vehicles, by vehicle type was recorded in two-minute intervals for a period of at least 20 minutes. For sheep gaps, NPS staff recorded vehicle inter-arrival times until a ten-minute gap in traffic was achieved or an hour had passed, whichever came first. The number and type of vehicles at wildlife stops were recorded opportunistically while traveling to and from the observation sites. Vehicles were defined as tour bus, transit bus, lodge bus, government vehicle, or private vehicle. When possible, we recorded the type of permit on private vehicles.

Ride, Observe, and Record (ROAR)

Ride, Observe, And Record (ROAR) observers (NPS staff and volunteers) recorded data at wildlife stops, rest stops, and hiker pickups while either riding Visitor Transit System (VTS) buses as scheduling permitted or traveling in a government vehicle. Data were collected during 91 trips that took place between May 29 and September 12, 2013. Trip destinations included Igloo Campground (1.1%), Polychrome (1.1%), Toklat (2.2%), Stony (2.2%), Eielson Visitor Center (68.1%), Wonder Lake (18.7%), and Kantishna (6.6%). ROAR participants recorded their observations in a data dictionary installed on Trimble JUNO^{TM} Series Handheld GPS Devices (Trimble, Sunnyvale, CA). Wildlife observations included time, date, GPS coordinates, species, number of individuals, sex and age when possible, and distance from the road. Distance was determined using calibrated range finders. Rest stop data included the rest stop name, time, date, and maximum number of vehicles parked at one time by vehicle category (tour bus, transit bus, lodge bus, government vehicle, and private vehicle).

Satellite-based Global Positioning System (GPS)

Real-time data on the position of concessioner buses and NPS vehicles was recoded using a satellite-based GPS. This technology enables us to collect real-time data on the movement of vehicles along the park road remotely and to access the data via the internet. During development of the VMP, the NPS identified (GPS) technology as the best way to monitor VMP indicators to ensure compliance with the viewscape, rest stop, wildlife stop (crowding) and sheep gap standards. The VMP calls for installing GPS units on all buses, NPS vehicles, and professional photographers traveling the controlled portion of the park road.

Our GPS system is operated by Fleet Management Solutions (FMS, http://www.fmsgps.com). These data are transferred from GPS units to a central database managed by FMS via the Iridium Satellite Network and we download the data via an internet-accessible user interface. The FMS system also supports the use of a Message Display Terminal (MDT) that is integrated with the GPS system. The MDT has a preprogrammed set of messages that enables us to get accurate times and locations of wildlife sightings (wildlife stops) made by buses. When bus drivers stop to view wildlife, they push a button on the MDT that sends a time stamped, georeferenced (latitude and longitude) message indicating that wildlife were observed and can include species. The FMS system records positional information (latitude and longitude) during the following events: ignition on/off, begin/end idle (prompted when the vehicle travels for two or more minutes at speeds less than seven miles per hour), wildlife quick messages, breadcrumbs (generated at 15-minute intervals with the interval clock starting after an ignition on, end idle, or previous breadcrumb event), and boundary alerts. The system also sends data when a vehicle enters or exits a georeferenced boundary placed at the start and end of viewscapes (approximately 1 mile in road length), around rest stops, and across the road at sheep gaps. From these data, we are able to determine how many vehicles are at a rest stop or within a viewscape during any given time interval and the frequency by which vehicles pass through sheep gaps (inter-arrival rate).

During 2011 and 2012, we field tested the FMS system to assess its ability to accurately track vehicle movements on the park road with positive results (Zitzow et al. 2013). As of 2013, there were 100

GPS/MDT units installed in the concessioner-operated buses and 48 GPS units installed in NPS vehicles. These vehicles represent approximately 70 percent (70%) of the total traffic on the controlled portion of the park road during the regulatory period. The remaining 30 percent (30%) of traffic is not currently monitored by GPS and this traffic is not captured in the results. Thus, the 2013 GPS data can be used to assess traffic patterns, but these data do not provide the accuracy necessary for assessing standards.

Traffic Counters

Data on night-time and large-vehicle traffic levels were collecting using seven traffic counters located just west of the Savage Check Station (Savage), at Mile 28 (Tek28), at the Teklanika gate (Tek Gate), near Sable Pass (Sable Pass); west of Toklat Rest Area (Toklat), west of Stony Overlook (Stony), and near Grassy Pass (Grassy Pass; Figure 2). Large vehicle traffic levels were monitored using the Savage traffic counter. The Savage traffic counter used two parallel pneumatic tubes installed on top of the road surface. This technology enabled us to collect data on the volume of traffic, direction of travel, number of axles, and length—the number of axles and vehicle length are used to classify the vehicles by size class. Count data were recorded individually and in 15-minute bins. The remaining traffic counters used two parallel inductive loops installed below the road surface to monitor the volume and direction of traffic. The data from these traffic counters was recorded in ten-minute bins.

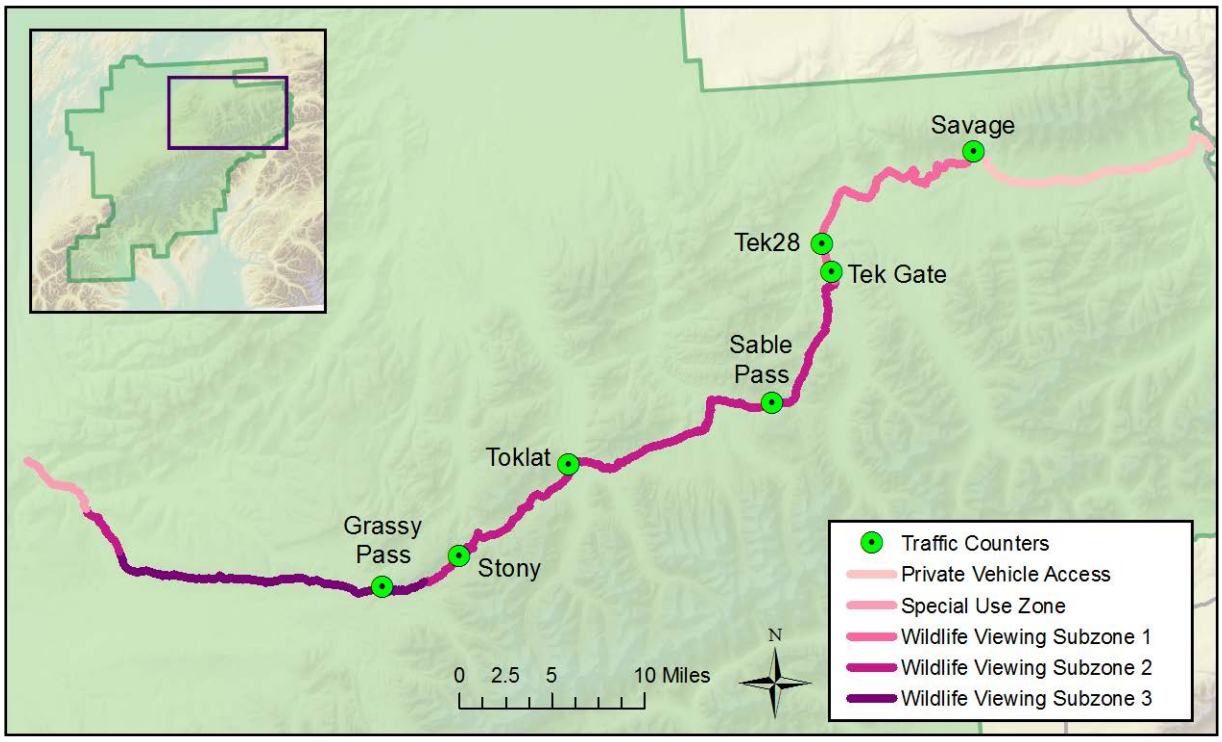


Figure 2. Names and locations of seven traffic counters installed along the Denali Park Road to monitor traffic.

Savage Check Station

The NPS staffed the Savage Check Station, located at Mile 15 on the Denali Park Road, from 6:00 a.m. to 7:00 p.m. during the 2013 regulatory season. Data collected by staff include: trip type, trip purpose, destination, time, date, number of passengers, and type of permit. Vehicles passing through the check station after hours are required to log in and fill out a data sheet with the above information. The data is entered into the Savage Database. We used these data to estimate the amount of bus traffic we missed by not having GPS units installed in lodge buses. We also used these data to adjust Savage traffic counter data on large vehicle traffic. Large vehicles traveling in tandem during September were under-counted; some of these vehicles were lumped together and the data estimated vehicle length up to 189 feet. We were able to correct these data using the Savage database.

Concessioner Dispatch Staff and Bus Drivers

The concessioner has dispatch staff at the Eielson Visitor Center during normal operating hours. Most visitors take the same bus east to the park entrance area as that which brought them westbound to the visitor center and beyond. Visitors who choose to spend a longer time at the visitor center, or who are returning from backpacking, request eastbound transit through the dispatcher. The dispatcher records the time the request is made and the number of individuals in their group, coordinates with bus drivers to find empty seats on buses, and records the time the hikers new bus departs from the visitor center. Hiker wait time is calculated from these data.

Transit bus drivers operating the concessioner-owned transit buses pick up hikers at designated stops (e.g., Wonder Lake Campground) and at any point along the road beyond mile 17. During 2013, bus drivers asked hikers if they had been waiting more or less than one hour for a bus. Additionally, bus drivers collect information at campground locations and other set stops, including their first stop of the day (e.g., Wonder Lake Campground). Because these data do not adequately answer the question of hiker wait time they were not analyzed for this report.

Indicators and Standards

Number of Vehicles at Wildlife Stops

We used ROAR data to compare 2013 conditions for the number of vehicles at wildlife stops to the VMP standards. ROAR observers recorded the type and maximum number of each class of vehicle at each stop (Figure 3). They also recorded when they observed any of the "Big Five" wildlife (caribou, brown bear, Dall's sheep, moose, and wolves) but there weren't any vehicles stopped or when the recording vehicle (for non-bus trips) was the only vehicle at the stop. Data collected from a government vehicle when there weren't any other vehicles present was not considered a wildlife stop for the purpose of monitoring the VMP crowding standards and these data were not included in the analysis. ROAR data were collected beginning at each trip's initiation



Figure 3. A Visitor Transit bus, a Tundra Wilderness Tour bus, and two professional photography vehicles stop to view a grizzly bear near Polychrome Pass.

point at the Wilderness Access Center or the park headquarters. Data collected east of the Savage River, outside of the controlled portion of the road, and data that were missing location information (unknown stop location), were not used to assess wildlife stop crowding conditions.

During 2013, NPS and ROAR observers that were traveling in a government vehicle (i.e., a vehicle dedicated to collecting road use data) counted that vehicle. ROAR observers also included their bus when traveling by public transportation. Inclusion of the government observer vehicle increased the number of vehicles at a wildlife stop above the number that were present as a result of the VMP (i.e., the research vehicle was not part of the normal traffic volume). To address the concern regarding this bias, we returned to the original (2011) methodology that excluded the government observer vehicle from the data starting in 2014. The 2013 data were adjusted by subtracting the government observer vehicles from the wildlife stop data.

Wildlife stops are captured by the FMS system two different ways: bus drivers push a button on the MDT indicating they saw wildlife, or we can infer wildlife stops from vehicle behavior (vehicle slows down or stops for more than two minutes). We are still developing the methodology for analyzing crowding conditions at wildlife stops using the FMS data. Therefore, this report does not include results from monitoring wildlife stops using the FMS data.

Number of Vehicles at Rest Stops

We used data from the ROAR program and NPS staff observations to compare the number of buses and vehicles stopped at rest stops at one time to the VMP standards. ROAR observers recorded the maximum number of vehicles, by vehicle type, at the rest stop during the time they were stopped (Figure 4). NPS staff recorded the maximum number of vehicles (by vehicle type) during two-minute intervals for a period of 20 minutes (or longer). Each of the two-minute sampling intervals was treated as a separate observation for this analysis.

As with the wildlife stops, data collected at rest stop protocol included the government monitoring vehicle in the counts, which biased these counts as described above. Consistent to the changes in the stop methodology, we chose to return to the original (2011) methodology that excluded the government observer vehicle starting in 2014. The 2013 data were adjusted by subtracting the government observer vehicles from the rest stop data.



Figure 4. The number of buses and vehicles at the Teklanika Rest Stop (A) and Toklat Rest Stop (B) and the Eielson Visitor Center (C) are monitored as indicators of visitor experience under the VMP.

We used FMS data to estimate crowding conditions at rest stops to compare current conditions to the VMP standards and to compare the findings to ROAR and NPS observational data. First we determined the maximum number of vehicles present in a given rest stop during each two-minute time interval (bin) during bus operating hours (6:00 a.m. to 10:00 p.m.). To do this, we extracted all records with enter or exit records and combine the 'enter' records with their corresponding 'exit' records. We used the enter/exit time stamp to determine which bins the vehicle was present in and to calculate the maximum number of vehicles in each time bin. Due to a systematic error with the FMS system that resulted in faulty boundary enter/exit data we excluded data collected from July 15 through July 24. We used these results to assess the patterns of vehicle crowding resulting from concessioner buses and NPS vehicles and compared these results to conditions reported by NPS and ROAR observers.

Number of Vehicles in Viewscapes

We used data from NPS staff observations to compare the number of vehicles visible at one time in designated viewscapes to the VMP standards (Figure 5). NPS staff recorded observations at all four viewscapes (mile 26, mile 55, mile 62, and mile 68).



Figure 5. Four viewscapes are monitored to determine if the number of vehicles visible at one time in each viewscape is meeting the standards established in the VMP.

As with rest stop observations, the maximum number of vehicles by type was recorded during each two-minute interval for at least twenty minutes and each two-minute observation was treated as a separate observation for analysis. Data are collected during bus operating hours.

Sheep Gap Spacing

NPS staff observations were used to estimate how much time there was between consecutive vehicles (inter-arrival time) passing through sheep crossing locations (sheep gaps). The results were compared to the VMP standards to determine whether current conditions are meeting the standards. NPS staff recorded observations at mile 21.6, 37.6, 52.8, 60.6, and 68.5 (Figure 6). A gap was considered to be present if ten minutes passed between vehicles at least once during a 60-minute time interval. During each sampling period, observers recorded the times (rounded to the minute) when a vehicle crossed the sheep crossing location until there was either a ten-minute traffic gap or until an hour passed, whichever came first. An observation period of 60 minutes that did not have a break in traffic of at least ten minutes was considered an observation without a gap. The number of hours monitored that included a minimum of a ten-minute break in traffic at sheep gaps were divided by the total number of hours monitored to determine the percent of hours meeting the standard for gaps in traffic at sheep crossing locations.

We also used FMS data to estimate inter-arrival time of vehicles with GPS units passing through sheep gaps and compared the results to the VMP standards. To calculate the standards for each of the five sheep gaps, we extract all FMS records with sheep gap entry records. The sheep gap boundaries are a narrow polygon and are treated in our analysis as if it was a line across the road. We used entry records to calculate the inter-arrival time between vehicles during the full 24 hours of each day. Due to a systematic error with the FMS system that resulted in faulty boundary enter/exit data we excluded data collected from July 15 through July 24.Gap times were calculated between successive records, regardless of the hour the record occurred. For example, a ten-minute gap could occur if the first vehicle crossed at 7:55 a.m. and the second vehicle crossed at 8:06 a.m. The results include the number of days when 23 out of 24 hours had a ten-minute gap in traffic and the number of days when 22 of 24 hours had a ten-minute gap in traffic. We used these results to assess the patterns of vehicle inter-arrival rates resulting from concessioner buses and NPS vehicles and compared these results to conditions reported by NPS and ROAR observers.



Figure 6. The spacing of traffic at five sheep crossing locations is monitored to ensure that there are adequate gaps in traffic throughout the day to enable wildlife to move between adjacent habitats.

Night-time Traffic

We used the data collected by seven traffic counters set up along the park road to determine night-time traffic volumes. We experienced a high rate of malfunctions at the start of the year which were probably due to battery failures resulting from improper winter storage; the batteries experienced sub-zero temperatures and were not charged during the nearly eight months they were in storage (Table 2). Additionally, the solar panels may not have had good sun exposure and may not have been charging properly.

Table 2. The location and monitoring dates of seven traffic counters were used to monitor night-time traffic (10:00 p.m. to 6:00 a.m.) along the Denali Park Road during the summer 2013 regulatory season. Some dates were excluded due to malfunctions.

Counter	2013 Monitoring Dates
Savage	5/25-8/29, 9/6-12
Tek28	5/25, 5/30-6/1, 6/6-9, 6/18-6/20, 6/28-9/12
Tek Gate	5/30-6/3, 6/6-6/10, 6/18-6/21, 6/28-9/12
Sable Pass	5/25-6/9, 6/18-6/24, 6/29-9/12
Toklat	6/01-9/12
Stony	6/01-9/12
Grassy Pass	6/18-6/21, 6/28-6/30, 7/4-9/12

Hiker Wait Time

ROAR observers record hiker wait time when they are traveling the park road on concessioner-operated buses. The observer records the number of hikers, whether the bus driver asked them how long they had been waiting for a bus, and how long they had been waiting for a bus. If the driver does not ask the hiker, then the ROAR observer will ask if possible. Wait time is recorded as 0-15 min, 15-30 min, 30-45 min, 45-60 min, 60-90 min, and over 90 min.

The concessioner maintains dispatch staff at the Eielson Visitor Center during normal operating hours. Most visitors take the same bus east to the park entrance area as that which brought them westbound to the visitor center and beyond. Visitors who choose to spend a longer time at the visitor center, or who are returning from backpacking, request transit through the dispatch. The dispatch records the time the request is made and the number of individuals in their group, coordinates getting them on a bus, and records the time their new bus leaves. Hiker wait time at the Eielson Visitor Center is calculated from these data.

Results

Number of Vehicles at Wildlife Stops

ROAR observers recorded data at 888 wildlife stops in 2013. Eighty-six percent (86%) of wildlife stops were recorded in Wildlife Viewing Subzone 2, which is also the longest subzone (Table 3). Approximately 11% of wildlife stops were recorded in Wildlife Viewing Subzone 1 and the remaining stops were recorded in Wildlife Viewing Subzone 3. The average (± SD) number of vehicles observed at all wildlife stops combined was 1.7 (±1.1, n=887).

Table 3. Number of observations used for analyzing compliance with the Vehicle Management Plan indicator for the number of vehicles at wildlife stops along the Denali Park Road.

	Wildlife Subzone 1	Wildlife Subzone 2	Wildlife Subzone 3
2013	n=83	n=767	n=37

Wildlife Viewing Subzone 1 and 2 met all three crowding standards for the number of vehicles at a wildlife stop. Wildlife Viewing Subzone 3 met the most restrictive crowding standard (≤1 vehicle), but the standards for the percentage of stops with ≤2 and ≤3 vehicles at one time were exceeded by a small percentage, 1.2% and 0.8% respectively (Table 4).

Table 4. The minimum standards for the number of vehicles at wildlife stops were met in Wildlife Viewing Subzone 1 and 2. Two of the three categorizes for the Wildlife Viewing Subzone 3 standards were exceeded (bolded text).

	Wildlife Subzone 1			Wildlife Subzone 2			Wildlife Subzone 3		
	% ≤3 Vehicles	% ≤4 Vehicles	% ≤5 Vehicles	% ≤2 Vehicles	% ≤3 Vehicles	% ≤4 Vehicles	% ≤1 Vehicles	% ≤2 Vehicles	% ≤3 Vehicles
Standard (minimum)	70	85	90	70	85	90	70	85	90
ROAR	91.6	98.8	100	82.1	93.0	95.8	70.3	**83.8**	**89.2**

Number of Vehicles at Rest Stops

During 2013, ROAR observers recorded 393 observations, and NPS staff recorded 887 observations of crowding conditions at the rest stops. The GPS data were continuous. We binned the GPS data into 48,000 two-minute bins to be consistent with our observations which are collected in two-minute intervals. Due to a system malfunction that resulted in a high number of boundary reporting errors, the GPS data generated between July 14 and 24 were excluded from analysis.

Based on analysis of these data, all rest stop indicators met the VMP standards for the maximum number of buses and the maximum number of vehicles parked at one time. ROAR and NPS staff observations were consistent in recording the highest maximum number of buses and average number of buses at the Eielson Visitor Center (Table 5, Table 6). Eielson also had the highest maximum and average number of vehicles (Table 7). While the maximum number of buses observed at Eielson was at the maximum for the standard, the total number of vehicles parked at one time was well within the standard.

Table 5. Maximum number of buses and vehicles parked at one time at the Teklanika and Toklat rest stops and the Eielson Visitor Center during the summer 2013 regulatory season.

	Teklanika			Toklat			Eielson		
Standard (maximum)	12 buses/16 total vehicles			11 buses/16 total vehicles			10 buses/19 total vehicles		
	Bus Max	Vehicle Max	*n*	Bus Max	Vehicle Max	*n*	Bus Max	Vehicle Max	*n*
Staff Observations	6	6	295	10	10	306	10	12	286
ROAR	8	9	149	9	9	151	10	14	93

Table 6. Mean (standard deviation) number of buses parked at one time at the Teklanika and Toklat rest stops and the Eielson Visitor Center during the summer 2013 regulatory season.

	Teklanika		Toklat		Eielson	
	Mean (SD)	***n***	**Mean (SD)**	***n***	**Mean (SD)**	***n***
Staff Observations	1.8 (±1.4)	295	2.5 (±2.3)	306	3.1 (±2.4)	286
ROAR	2.9 (±1.7)	149	3.4 (±1.8)	151	3.8 (±2.1)	93

Table 7. Mean (standard deviation) number of vehicles parked at one time at the Teklanika and Toklat rest stops and the Eielson Visitor Center during the summer 2013 regulatory season.

	Teklanika		Toklat		Eielson	
	Mean (SD)	***n***	**Mean (SD)**	***n***	**Mean (SD)**	***n***
Staff Observations	2.4 (±1.4)	295	2.7 (±2.2)	306	4.7 (±3.2)	286
ROAR	3.0 (±1.8)	149	3.5 (±1.9)	151	4.7 (±3.0)	93

The VMP standard for the maximum number of buses and the maximum number of vehicles was not exceeded at the Teklanika Rest Stop during the 2013 regulatory season (Table 5). NPS staff observers reported the lowest average number of buses followed while ROAR observers recorded the highest average number of buses (Table 6). The average total number of vehicles followed the same pattern (Table 7). The average number of buses ranged from 0.4 (±0.81) buses at 6:00 p.m. to 4.1 (±1.38) at 10:00 a.m. (Figure 7). The greatest number of buses was observed during 10:00 a.m. (n=149). ROAR observers recorded similar pattern with the maximum number of buses being reported during the 9:00 and 10:00 a.m. hours. The GPS data showed the maximum number of concessioner buses during the 2:00 p.m. hour.

The VMP standard for the maximum number of buses and the maximum number of vehicles was not exceeded at the Toklat Rest Stop during the 2013 regulatory season (Table 5). The NPS staff observers reported the lowest average number of buses followed while ROAR observers recorded the highest average number of buses (Table 6). The average total number of vehicles followed the same pattern (Table 7). The average number of buses observed by NPS staff at the Toklat Rest Stop ranged from 0.0 buses during the 6:00 and 7:00 a.m. hours to 5.4 (±2.86) at 10:00 a.m. (Figure 8). No observations were recorded during the 2:00 p.m. and 5:00 p.m. hours. The greatest number of buses

was observed by NPS staff during 10:00 a.m. and by ROAR observers during 11:00 a.m. The GPS data show the maximum number of concessioner buses during 1:00 p.m. with another high during 5:00 p.m.

The VMP standard for the maximum number of buses and the maximum number of vehicles was not exceeded at the Eielson Visitor Center during the 2013 regulatory season (Table 5). The average total number of vehicles followed the same pattern (Table 7). The average number of buses (n=286) observed by NPS staff at the Eielson Visitor Center ranged from 1.5 (±0.53) buses at 7:00 p.m. to 7.1 (±2.19) at 10:00 a.m. (Figure 9). The greatest number of buses was observed during 10:00 a.m. hour. The maximum number of buses (10) was observed on Wednesday July 3 and again on Wednesday September 4 when four lodge buses and six concessioner buses were at the visitor center at the same time. Eielson Visitor Center had the highest average number of buses and total number of vehicles of any of the three rest stops. ROAR data shows a similar pattern, although these data show the highest average number of buses during the 11:00 a.m. hour. The GPS data shows the average number of transit buses as being relatively constant at this site between the hours of 11:00 a.m. and 3:00 p.m.

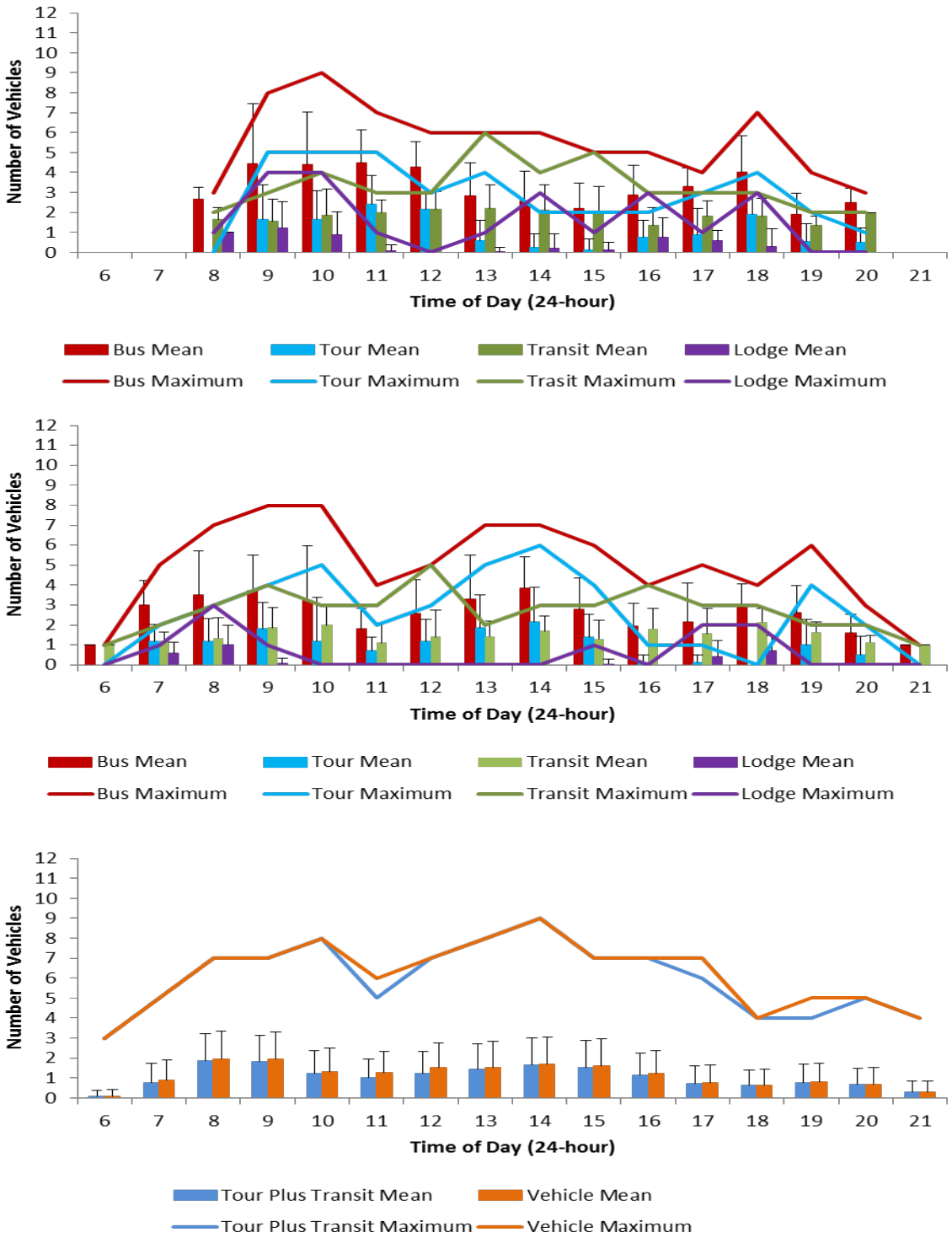


Figure 7. The mean (+1 standard deviation) and maximum number of buses at the Teklanika Rest Stop by time of day during bus operating hours for the summer 2013 regulatory season. Data were collected via NPS observations (top), ROAR observers riding transit buses (middle) and satellite-based GPS units installed in concessioner buses and NPS fleet vehicles (bottom). The bottom graph also includes the mean and maximum number of vehicles.

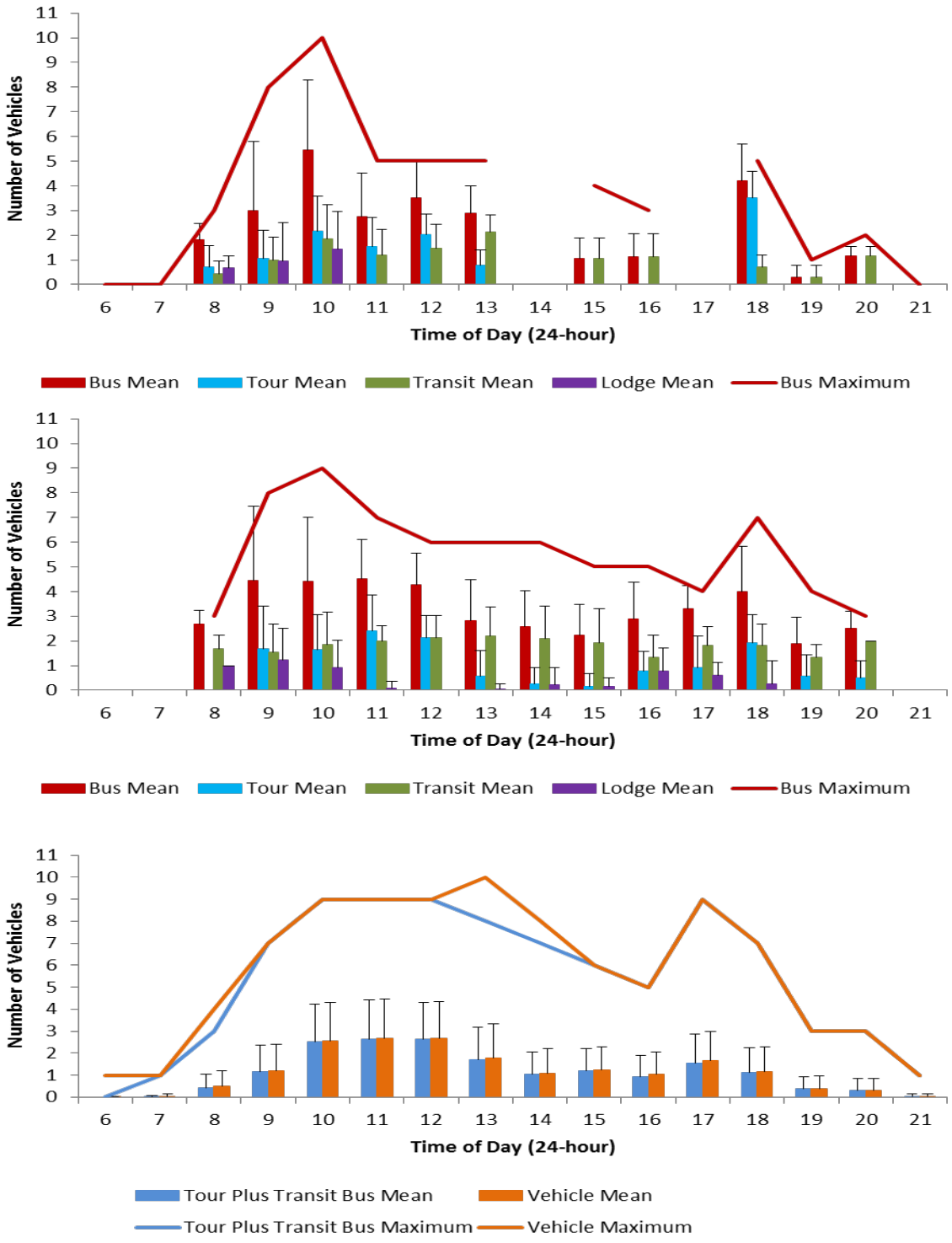


Figure 8. The mean (+1 standard deviation) and maximum number of buses at the Toklat Rest Stop by time of day during bus operating hours for the summer 2013 regulatory season. Data were collected via NPS observations (top), ROAR observers riding transit buses (middle) and satellite-based GPS units installed in concessioner buses and NPS fleet vehicles (bottom). The bottom graph also includes the mean and maximum number of vehicles.

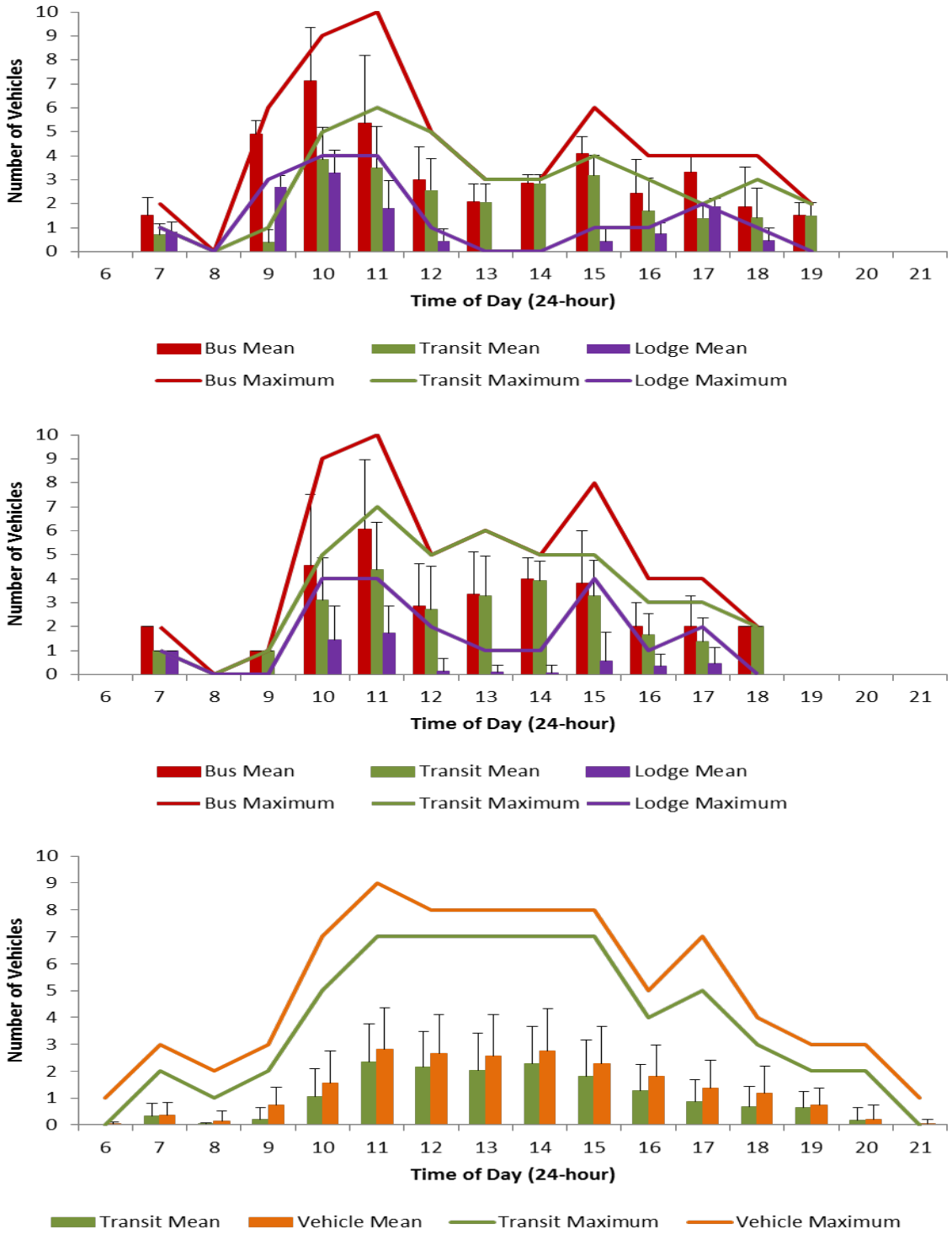


Figure 9. The mean (+1 standard deviation) and maximum number of buses at the Eielson Visitor Center by time of day during bus operating hours for the summer 2013 regulatory season. Data were collected via NPS observations (top), ROAR observers riding transit buses (middle) and satellite-based GPS units installed in concessioner buses and NPS fleet vehicles (bottom). The bottom graph also includes the mean and maximum number of vehicles.

Number of Vehicles in Viewscapes

The VMP standards for the percentage of time vehicles are visible in each of the four viewscapes were met at all four sites during the 2013 regulatory season (Table 8). During 2013, NPS staff recorded the number of vehicles visible in the mile 26 (n=276), mile 55 (n=361), mile 62 (n=246), and mile 68 (n=295) viewscapes (Table 9).

Table 8. A summary of NPS observational data showing the average number of vehicles visible at one time in each of the four viewscapes. These results include data when no vehicle was present. The VMP minimum annual standard is provided for comparison.

	Mile 26		Mile 55		Mile 62		Mile 68	
	% ≤3 vehicles	% ≤4 vehicles	% ≤2 vehicles	% ≤3 vehicles	% ≤2 vehicles	% ≤3 vehicles	% ≤1 vehicles	% ≤2 vehicles
Standard (minimum)	80	90	80	90	80	90	80	90
NPS Observations	94.2	97.1	94.5	98.9	95.9	98.0	95.3	99.3

Based on NPS observations, Mile 26 had the highest average number of vehicles visible at one time and the greatest variation (Table 9). Mile 62 had the next highest average and variation followed by Mile 55 with Mile 68 having the lowest average and variation.

Table 9. Mean (±1 standard deviation) and number of observations made by NPS staff at each of the four viewscapes during the summer 2013 regulatory season.

	Mile 26		Mile 55		Mile 62		Mile 68	
	Mean (SD)	*n*	Mean (SD)	*n*	Mean (SD)	*n*	Mean (SD)	*n*
NPS Observations	1.2 (±1.38)	276	0.7 (±0.95)	361	0.8 (±1.03)	246	0.3 (±0.60)	295

Miles 26, 55, and 68 had the highest average number of vehicles during the late subseason. Mile 62 had the highest average number of vehicles during the early and peak subseason (Table 10).

Table 10. Mean (±1 standard deviation) and number of observations made by NPS staff at each of the four viewscapes during the summer 2013 regulatory season. The data is summarized by subseason.

	Mile 26		Mile 55		Mile 62		Mile 68	
	Mean (SD)	*n*	Mean (SD)	*n*	Mean (SD)	*n*	Mean (SD)	*n*
Early	0.5 (±0.50)	52	0.6 (±0.69)	88	1.1 (±0.97)	35	0.1 (±0.32)	35
Peak	0.8 (±0.97)	108	0.7 (±0.89)	121	1.1 (±1.22)	108	0.3 (±0.55)	132
Late	1.9 (±1.60)	116	0.9 (±1.90)	152	0.5 (±0.67)	103	0.4 (±0.69)	128

Sheep Gap Spacing

NPS staff recorded data at sheep gaps during 134 observation hours. Analysis of these data found that the VMP standard for spacing of vehicle traffic was met at the Mile 21.6, Mile 37.6, Mile 52.8, and Mile 68.5 sheep gap locations (Table 11). The standard was exceeded at the Mile 60.6 Sheep

Gap. Subseason analysis found that Mile 60.6 had the lowest level of success during the early season, and had minimal success during the peak and late season. Mile 37.6 and Mile 52.8 achieved high levels of success during the early and peak season, but much lower success during the late season. Mile 21.6 had high success during the early season and minimal success during the peak and late season. Mile 68.5 had high success throughout the regulatory season.

Table 11. During the hours observed by NPS staff, four of the five sheep gaps met the annual standard for maintaining an hourly ten-minute gap in traffic during the 2013 regulatory season. Mile 60.6 did not meet the standard (bold text). The standard is the minimum percent of time that at least 22 of each 24-hour period has a ten-minute gap in traffic at sheep gaps.

	Mile 21.6 % success	**Mile 37.6 % success**	**Mile 52.8 % success**	**Mile 60.6 % success**	**Mile 68.5 % success**
Standard	90	90	90	90	90
Early	100 (*n*=5)	100 (*n*=6)	100 (*n*=7)	75.0 (*n*=4)	100 (*n*=3)
Peak	90.9 (*n*=11)	100 (*n*=9)	100 (*n*=10)	91.7 (*n*=12)	100 (*n*=11)
Late	90.9 (*n*=11)	81.8 (*n*=11)	80.0 (*n*=10)	91.7 (*n*=12)	100 (*n*=11)
Total	92.6 (*n*=27)	92.6 (*n*=27)	92.6 (*n*=27)	**89.3 (*n*=28)**	100 (*n*=25)

Night-time Traffic

The VMP standards for the maximum average number of vehicles per hour between 10:00 p.m. and 6:00 a.m. were met at all seven of the traffic counter locations (Table 13). The Savage traffic counter had the highest maximum nightly average (4.00 vehicles per hour) and the fewest number of nights with three or fewer vehicles (95%). The lowest average number of vehicles per hour was recorded at the Toklat and Stony traffic counters which are located between the Toklat Rest Stop and the Eielson Visitor Center. Sable and Grassy had the next lowest average.

Table 12. A summary of the mean number of vehicles per hour during night-time hours (10:00 p.m.–6:00 a.m.). These data were based on traffic counter data collected during the 2013 regulatory season. Shown are the maximum and minimum mean number of vehicles per hour per night, percent of night-time averages less than or equal to three vehicles per hour (% ≤3), percent of hours less than or equal to six vehicles per hour (% ≤6), total number of nights monitored (n), and the total number of hours monitored (H).

	Maximum mean # vehicles per hour	**Minimum mean # vehicles per hour**	**% nights ≤3 vehicle per hour**	***n***	**% hours ≤6 vehicles per hour**	**H**
Standard (minimum)			95% of time		95% of time	
Savage	4.00	0.13	95%	104	99%	832
Tek 28	2.38	0.13	100%	90	99%	720
Tek Gate	1.88	0.00	100%	91	100%	728
Sable	1.75	0.00	100%	99	100%	790
Toklat	1.25	0.00	100%	111	100%	888
Stony	1.25	0.00	100%	111	100%	888
Grassy	1.75	0.00	100%	82	100%	625

The amount of night-time traffic crossing the Savage Check station increased August 21, 2013 as a result of a culvert replacement project in the Hogan Creek area (milepost 20–21; Figure 11). An average of three vehicles per hour per night was exceeded on five of the 12 nights monitored between August 21 and September 8, 2013.

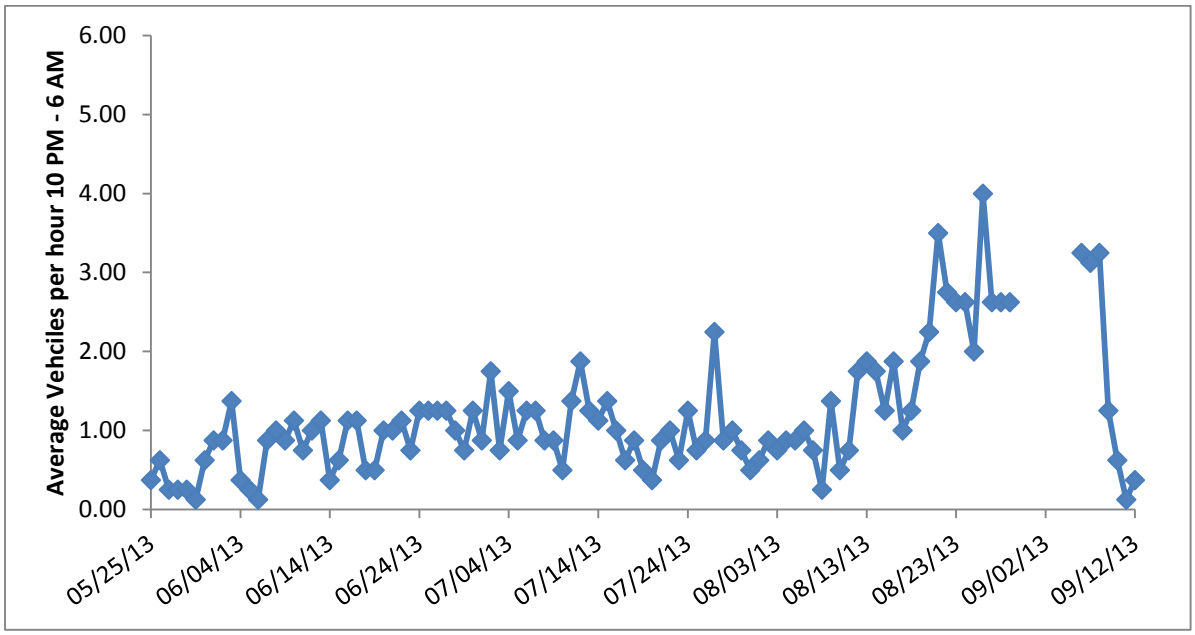


Figure 10. The average number of vehicles per hour per night at the Savage Check Station based on traffic counter data collected between May 25 and September 12, 2013. Data were not collected between August 30 and September 5 due to an equipment malfunction.

The total number of night-time vehicles remained high through this time period (Figure 11), ranging between 16 and 32 vehicles per night with an average of 23.33 vehicles per night. No data were recorded between August 30 and September 5 due to an equipment malfunction.

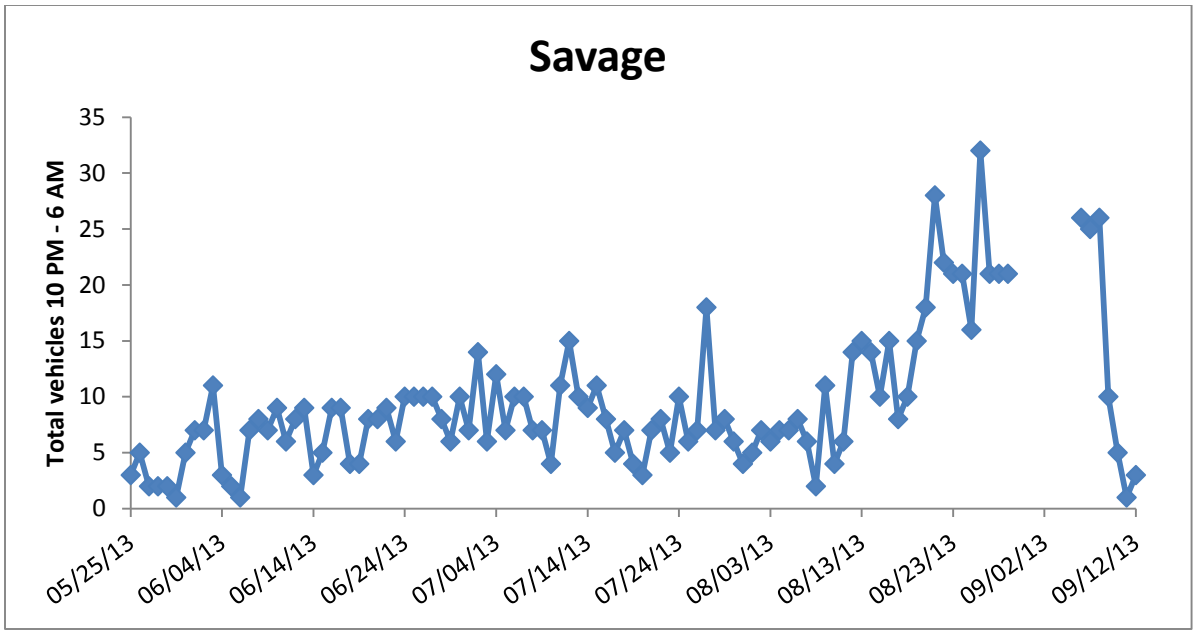


Figure 11. Total number of vehicles per night (10 p.m.–6 a.m.) recorded at the Savage Check Station traffic counter between May 25 and September 12, 2013. Data were not collected between August 30 and September 5 due to an equipment malfunction.

Hiker Wait Time

Eielson Visitor Center

Hiker wait time standard for the percent of hikers waiting less than 30 minutes was not met at the Eielson Visitor Center during 2013 (Table 13). Wait times for the remaining categories were met.

Table 13. Comparison of hiker wait times recorded at the Eielson Visitor Center to the VMP standards. Presented are the % of hikers in each hiker wait time category (%), the number of hikers (n), and the one-year VMP standard for each category. Exceeded standards are in bold text.

Wait time	Percent of Hikers	*n*	VMP Standard
<30 min wait	**68%**	10,217	70%
<60 min wait	95%	4,020	93%
<90 min wait	99%	554	98%
>90 min wait	1%	186	

Discussion

The impacts from the full suite of user groups were captured by data collected during NPS staff observations, ROAR observations, and traffic counters and are reflected in the analysis of these data. During 2013, GPS units were installed in approximately 70% of the vehicles traveling the controlled portion of the park road during the regulatory period. The GPS units were only installed in concessioner and NPS vehicles. The remaining approximately 30% of vehicles constituted all other road users, and thus the impacts of these vehicles/user groups on the indicators were not adequately captured by the GPS data. We compared crowding conditions captured by NPS and ROAR observers to the GPS data to assess the efficacy of the different methods and to look at patterns. Based on this analysis, the three methods do a good job capturing the patterns of crowding conditions, although there is a time shift between NPS and ROAR observers. The park has excellent GPS data from the concessioner buses and NPS vehicles. Adding GPS units to lodge buses will provide the park with data to more accurately assess the indicators in relation to their standards remotely. Additionally, these data will also enable us to establish "rules of behavior" for the different vehicle types (e.g., travel speed, amount of time spent at rest stops) so that we can integrate this information into our traffic model. The traffic model will enable us to test various schedule modifications to meet the goals and objectives of the VMP.

Number of Vehicles at Wildlife Stops

Although the park was in compliance with the VMP standards in Wildlife Viewing Subzone 1 and 2, Subzone 3 exceeded the standards for the percentage of stops with ≤2 and ≤3 vehicles at one time by small amounts. Because most of our wildlife stop data comes from ROAR observers traveling on transit buses, these results could be slightly biased. Additionally, the fewest number of ROAR trips in 2013 included this portion of the park road. Bus schedules for both day and overnight lodge trips and a few of the transit buses (e.g., camper bus) overlap to some degree. The overlaps along with wildlife events along the road likely contribute to conditions where buses start out individually, but wind up traveling as a group on occasion.

Number of Vehicles at Rest Stops

The park was in compliance for the total number of buses and vehicles parked at one time at the Teklanika and Toklat Rest Stops and the Eielson Visitor Center. All rest areas showed the greatest crowding in the morning followed by another peak in the afternoon. The results illustrated crowding conditions during mid-morning hours that are close to, but do not exceed standards. For example, Eielson Visitor Center reached the maximum number of buses allowed. The mid-morning crowding conditions reflect the morning pulse of tour, transit, and lodge day tour buses that go out between 6:30 a.m. and 7:30 a.m. Shifts in scheduling of the concessioner buses to offset them slightly from Lodge Day tours should alleviate some of the crowding conditions. There is a second pulse of traffic in the afternoon that includes roundtrip vehicles heading back east and vehicles heading west for afternoon tours and overnights in the Wonder Lake/Kantishna area. This pulse doesn't reach the same magnitude as the morning pulse, but park managers will want to watch these time periods to ensure that standards are not exceeded.

Number of Vehicles at Viewscapes

The park was in compliance for the number of vehicles visible in a viewscape at one time. The regulatory season average number of vehicles visible in a viewscape at one time ranged from 0.3 (±0.60) vehicles at Mile 68 to 1.2 (±1.38) vehicles at Mile 26. Analysis of data by subseason did not illustrate any time periods where viewscape crowding conditions could be problematic.

Sheep Gap Spacing

The Mile 60.6 sheep gap (east of Stony Overlook) was the only sheep gap found out of standard in 2013. Tour buses turn around at the Stony Overlook (Mile 62) after a brief stay to enjoy the scenery, including Mt. McKinley on clear days. This poses a challenge for meeting vehicle spacing requirements at this location. Subseason analysis found a reduction in the maintenance of hourly ten-minute gaps in traffic at Mile 37.6 and 52.8 during late season. Mile 60.6 had the lowest percent success in meeting the gap times during the early season. The peak and late season had the lowest percent success at the Mile 21.6 sheep gap. These results were an improvement over results from 2011 and 2012 (McKenny et al. 2014) in which sheep gap spacing standards were only met at the Mile 37.6 and Mile 68.5 sheep gap locations in 2011 and Mile 52.8 and Mile 68.5 sheep gap locations in 2012. During the summer 2013 there was road construction at Mile 3 that created pulses of traffic; vehicles were held by flaggers or a traffic light for short periods of time. These short duration holds may have been enough to improve gap times along the regulated portion of the road. Construction will continue during the 2014 regulatory season providing a second season of data for analysis.

Night-time Traffic

Night-time vehicle traffic was within standards during the 2013 regulatory season. The Savage traffic counter recorded the lowest percent of nights with three or fewer vehicles (95%), but was still within standard based on recorded data. There was a substantial increase in traffic at Savage starting August 21 through August 29 and September 6 through 8. Due to a malfunction, the Savage counter did not record data between August 30 and September 5, however, night-time construction traffic continued through this period of time. Had data been collected during these six days, it is possible that the seasonal average nights with three or fewer vehicles would have been lowered and the standard would have been exceeded at the Savage traffic counter.

Hiker Wait Time

Hiker wait time exceeded the most restrictive standard that requires a wait time of 30 minutes or less for at least 70 percent (70%) of hikers. The remaining standards for wait times were met. These data, however, were based solely on data from the Eielson Visitor Center. Data collected by bus drivers for hikers waiting along the road was not collected in a manner that allows for the standards to be assessed, therefore, how well the transit system performed for roadside hikers is unknown.

Future Monitoring and Data Collection

Continuing to expand our use of GPS for tracking vehicles will improve our ability to monitor and ultimately manage for conditions on the park road. For example, lodge buses contribute about 11% of the vehicle traffic on the park road. Having GPS data from these vehicles will greatly improve our monitoring. Stochastic or unscheduled vehicle behavior may result in a greater impact on indicators.

For example, professional photographer and commercial film crew trips are not scheduled and do not have a specific destination or turn around point. Additionally, this user group behaves more stochastically as they patrol the road for wildlife sightings and scenic opportunities. This behavior can lead to greater crowding at wildlife stops and it can impact vehicle spacing at sheep crossing locations. Due to their potential impact on the indicators, professional photographers and commercial film crews should carry GPS units as a Term and Condition of their road access permit. This will enable us to better understand their impact and develop management strategies for reducing their impacts. Although GPS systems will improve monitoring, it is not practical to install GPS units in every vehicle traveling the park road (e.g., Teklanika campers). Therefore, other monitoring techniques need to be refined to improve our remote monitoring capabilities. For example, traffic counters may be a good tool for monitoring the time between vehicle arrivals at sheep gaps. Currently, the park has one traffic counter (Grassy) that is well placed to monitor sheep gaps. This counter should be reprogrammed to collect data in one-minute bins to determine the feasibility of monitoring sheep gap spacing using this technology.

The ROAR observations and NPS staff observations will remain an important tool for validating the GPS and traffic counter data and for collecting data on wildlife observations along the park road. During 2014 and 2015, we will continue to refine and improve ROAR and NPS observational protocols and analysis methods including completing the methodology for analyzing the GPS data for wildlife stops.

In 2013, we began developing a traffic simulation model to test different traffic scenarios (schedules). This model differs from the traffic model used to develop the VMP in that it uses a more intuitive and affordable software program that can be used by park staff. The traffic model will use monitoring data to establish vehicle behaviors. For example, we will use GPS data to determine average travel speeds along various road segments for different user groups, average lengths of stay at rest stops for different user groups. The results from simulations will be used to determine which scenarios allow for the greatest access to the park while ensuring that VMP goals and standards are being met. The model should be completed by summer 2015.

Management Recommendations

The following management recommendations are based on the goals and objectives of the VMP and the results presented in this report:

- Continue to educate road users about the goals and objects of the VMP and how they can modify their behavior to assist the park in meeting standards.
- Develop terms and conditions for road access permits that manage for the desired resource and visitor experience conditions established by the VMP.
- Modify how bus drivers collect hiker wait times to correspond with the VMP standards.
- Install GPS units in lodge buses and professional photographer vehicles.
- Test the use of traffic counters for monitoring sheep gaps.

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Appendix A. Denali Park Road Final Vehicle Management Plan: Tier 1 Indicators and Standards

Number of vehicles stopped at the same location to view wildlife at one time (Number of vehicles at a wildlife stop)	
Wildlife Viewing Subzone 1	75% of wildlife stops will have 3 or fewer vehicles (5-year average) No one year will have less than 70% of wildlife stops with 3 or fewer vehicles 90% of wildlife stops will have 4 or fewer vehicles (5-year average) No one year will have less than 85% of wildlife stops with 4 or fewer vehicles 95% of wildlife stops will have 5 or fewer vehicles (5-year average) No one year will have less than 90% of wildlife stops with 5 or fewer vehicles
Wildlife Viewing Subzone 2	75% of wildlife stops will have 2 or fewer vehicles (5-year average) No one year will have less than 70% of wildlife stops with 2 or fewer vehicles 90% of wildlife stops will have 3 or fewer vehicles (5-year average) No one year will have less than 85% of wildlife stops with 3 or fewer vehicles 95% of wildlife stops will have 4 or fewer vehicles (5-year average) No one year will have less than 90% of wildlife stops with 4 or fewer vehicles
Wildlife Viewing Subzone 3	75% of wildlife stops will have 1 or fewer vehicles (5-year average) No one year will have less than 70% of wildlife stops with 1 or fewer vehicles 90% of wildlife stops will have 2 or fewer vehicles (5-year average) No one year will have less than 85% of wildlife stops with 2 or fewer vehicles 95% of wildlife stops will have 3 or fewer vehicles (5-year average) No one year will have less than 90% of wildlife stops with 3 or fewer vehicles
Number of vehicles parked at one time at the Teklanika and Toklat Rest Stops and Eielson Visitor Center (Number of vehicles at a rest stop)	
Teklanika Rest Stop	No more than 12 buses at one time with a total of no more than 16 vehicles
Toklat Rest Stop	No more than 11 buses at one time with a total of no more than 16 vehicles
Eielson Visitor Center	No more than 10 buses at one time with a total of no more than 19 vehicles
Number of vehicles visible at one time in four scenic viewscapes during bus operating hours (Number of vehicles in a viewscape)	
Mile 26 **Wildlife Viewing Subzone 1**	85% of the time there will be 3 or fewer vehicles visible in the viewscape (5-year average) No one year will have less than 80% of the time with 3 or fewer vehicles visible in the viewscape 95% of the time there will be 4 or fewer vehicles visible in the viewscape (5-year average) No one year will have less than 90% of the time with 4 or fewer vehicles visible in the viewscape

Miles 55 and 62 **Wildlife Viewing Subzone 2**	85% of the time there will be 2 or fewer vehicles visible in the viewscape (5-year average) No one year will have less than 80% of the time with 2 or fewer vehicles visible in the viewscape 95% of the time there will be 3 or fewer vehicles visible in the viewscape (5-year average) No one year will have less than 90% of the time with 3 or fewer vehicles visible in the viewscape
Mile 68 **Wildlife Viewing Subzone 3**	85% of the time there will be 1 or fewer vehicles visible in the viewscape (5-year average) No one year will have less than 80% of the time with 1 or fewer vehicles visible in the viewscape 95% of the time there will be 2 or fewer vehicles visible in the viewscape (5-year average) No one year will have less than 90% of the time with 2 or fewer vehicles visible in the viewscape
Maintenance of a one 10-minute gap in traffic per hour at designated sheep crossing locations (Sheep Gap Spacing)	
Milepoint 21.6, 37.6, 52.8, 60.6, and 68.5	There will be at least one 10-minute gap in traffic every hour with a 95% success rate (23 of 24 hours with gaps at each crossing) averaged over 5 years No one year will have less than 90% success rate (22 of 24 hours with gaps at each crossing)
Average number of vehicles per hour per night passing any of the traffic counters west of Savage between 10 pm and 6 am (Night-time Traffic Levels)	
	There will be an average of 3 or fewer vehicles per hour per night (total westbound and eastbound) passing any of the traffic counters between 10 pm and 6 am, with never more than six vehicles in any one hour. Both standards must be achieved at least 95% of the time. This standard will undergo further analysis and development.
Total number of large (>80,000 pounds) vehicles crossing any of the traffic counters west of Savage in any one hour (Large Vehicle Traffic)	
	There will never be more than 4 large vehicles in any one hour crossing any of the traffic counters west of Savage. This standard will undergo further analysis and development.
The amount of time a hiker spends waiting to be picked up by a bus (Hiker wait time)	
Less than 30 minutes	At least 75% of hikers will have wait times of less than 30 minutes for pick-up by a bus, averaged over 5 years. No one year will have less than 70% of hikers with wait times of less than 30 minutes.
Less than 60 minutes	At least 95% of hikers will have wait times of less than 60 minutes for pick-up by a bus, averaged over 5 years. No one year will have less than 93% of hikers with wait times of less than 60 minutes.
Less than 90 minutes	At least 99% of hikers will have wait times of less than 90 minutes for pick-up by a bus, averaged over 5 years. No one year will have less than 98% of hikers with wait times of less than 90 minutes.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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