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

A Summary Report 2014

Natural Resource Report NPS/DENA/NRR—2015/905



ON THE COVER
A private lodge bus stops to view three bull caribou west of Toklat on the Denali Park Road.
Photograph courtesy of the Denali National Park and Preserve.

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

A Summary Report 2014

Natural Resource Report NPS/DENA/NRR—2015/905

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Abstract

This report summarizes data collected from May 24 through September 11, 2014 during the 2014 regulatory season. The data were used 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 methodology used to monitor the seventh standard (large vehicle traffic) did not produce reliable results, therefore, this report does not include those data, but it does provide recommendations to improve monitoring of this indicator. The objectives of this report are to 1) compare current conditions of the VMP indicators to the standards, 2) assess the efficacy of the current monitoring techniques and make recommendations for improvement, and 3) make recommendations for improving the condition of the resources as measured by the indicators. Results include:

- The standards for the number of vehicles at wildlife stops were met in all three subzones.
- The standards for the number of buses and vehicles parked at one time at rest stops were met based on ROAR and NPS observational data. The GPS data showed at least one occasion at each of the three rest stops where standards were exceeded.
- 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 at least 90 percent (90%) of the time were met at two of the five sheep gaps. Traffic counters were effective for monitoring sheep gaps and should be installed at additional locations to provide accurate assessments of current conditions and to inform scheduling.
- The standards for night-time traffic were exceeded at four of the six traffic counter locations.
- The standards for hiker wait time were met.

Efforts to increase compliance with the standards should be made through a combination of continued education for road users, traffic scheduling, and the integration of Terms and Conditions into contracts and road use permits that are designed to maintain or improve the condition of VMP indicators.

Based on our assessment of the Fleet Management Solutions GPS, we determined that the current technology is not reliable; the system had a high rate of malfunctions and there were concerns regarding data quality. Based on these results, we recommended that park mangers discontinue use of the GPS system and redirect the available resources to improve monitoring using observations and traffic counters.

Acknowledgments

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Introduction

For over seventy years, the Denali Park Road has provided the primary access to Denali National Park and Preserve (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, and 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 accessible 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 in 1972 began annually restricting private vehicle travel beyond the Savage River during the period from approximately Memorial Day through Labor Day (hereafter referred to as the regulatory season). In 1986 park managers instituted a vehicle limit of 10,512 round trips during the regulatory season (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 managers 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 maintain 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 radio 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 observations that Dall's sheep increased their movement rates when approaching the road and they were located further from the road during periods of 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. In both cases, these sheep must cross the road. Therefore, understanding and mitigating the impacts to sheep movements is important for maintaining the natural movement and habitat use patterns of the park's sheep populations. The road capacity 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 the 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 have a high-quality experience, wildlife and other park resources are 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 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 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 also replaces the regulatory season vehicle limit (10,512) with a daily limit of 160 vehicles. The VMP was approved in September 2012. 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 U.S. Code of Federal Regulations have been updated to include the 160 vehicle daily limit.

During the 2014 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 methodology used to monitoring the seventh standard (large vehicle traffic) did not produce reliable results. Therefore, this report does not include these data, but it does provide recommendations to improve monitoring of this indicator.

The secondary objective of this report is to provide an assessment of the GPS system as a monitoring tool given the current technology available and the challenges posed by occasional road users such as

NPS staff access pass holders, Teklanika campers, and private in-holders. This report provides recommendations to managers regarding the use of current GPS technology as a monitoring tool.

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 (Figure 1). One or more individual animals, representing one or more species may be present at a given stop. The most frequent stops are to view 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 minimum percentage of time there is a maximum number of vehicles stopped to view wildlife at the same time and the same location. The VMP also established wildlife viewing subzones with different management objectives for crowding conditions. The wildlife stop crowding standards are the desired conditions for each wildlife viewing subzone (Figure 2).



Figure 1. Two lodge buses and one tour bus stop to view a grizzly bear on Stony Dome. The number of vehicles stopped to view wildlife at one time is an indicator of visitor experience

A *wildlife event* includes the entire length of time a wildlife species is being observed from the road by vehicles. The event begins when the first vehicle stops, continues as long as at least one vehicle is present, and it ends when the last vehicle exits (zero vehicles present). The animal(s) may be at the same location for some or all of the day, and thus there may be multiple wildlife events at the same location over the course of that day. The standard for the wildlife stop indicator is evaluated based on what each vehicle experiences—a *wildlife stop* captures the stop duration and crowding conditions experienced by a particular vehicle present at the wildlife event.

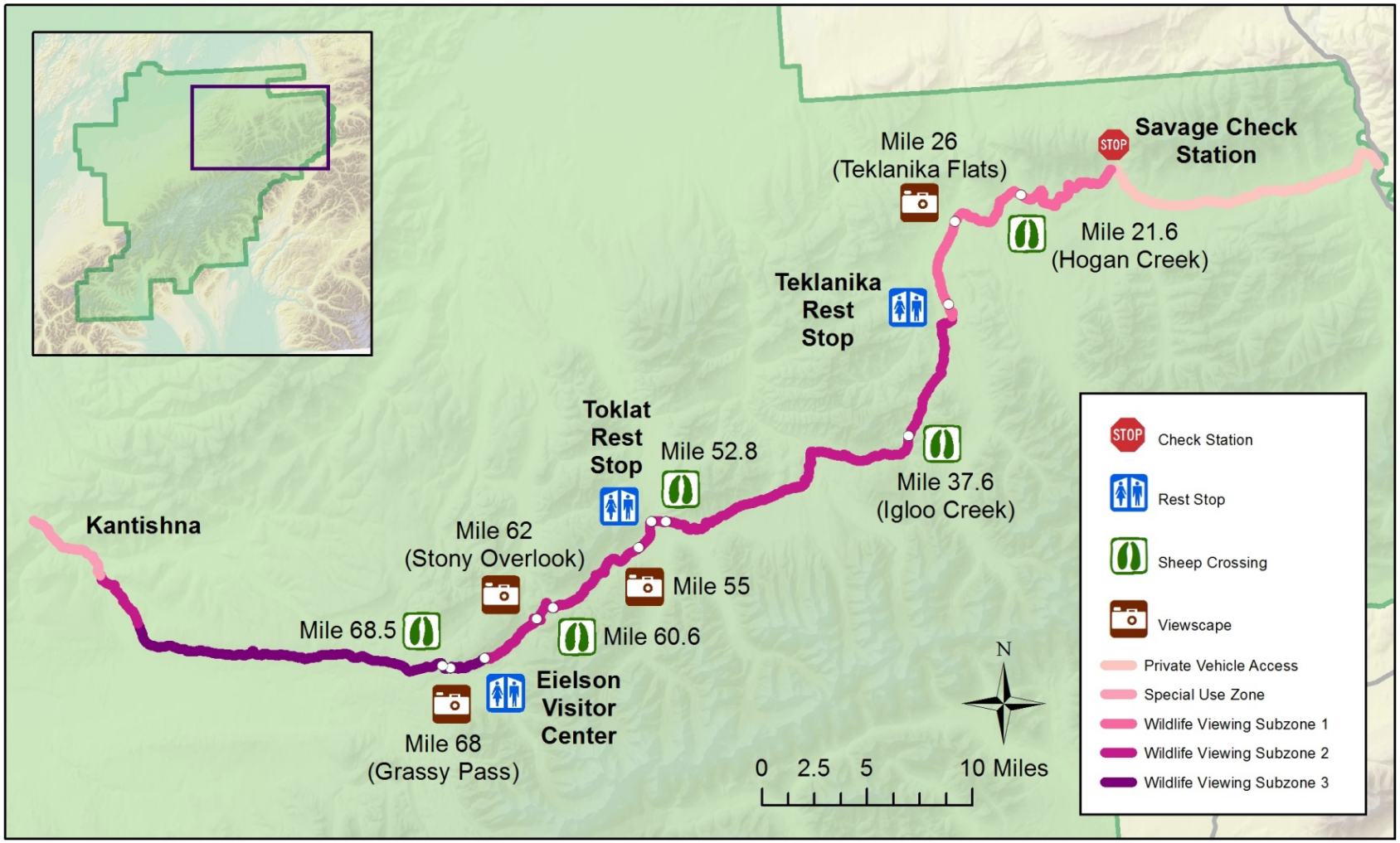


Figure 2. This map shows the location of three of the Vehicle Management Plan (VMP) indicators of desired resource and visitor experience conditions and the three Wildlife Viewing Subzones. Some VMP standards (wildlife stops, viewscapes) vary by Wildlife Viewing Subzone.

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 3, Figure 2). 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.



Figure 3. The number of buses and total vehicles parked at one time at the Teklanika Rest Stop (A), the Toklat Rest Stop (B), and the Eielson Visitor Center (C) is used as an indicator of visitor experience. The standard varies by location and is a maximum number of buses and a maximum number of vehicles parked at one time.

Number of Vehicles in Viewscapes

VMP identified four iconic viewscapes (Figure 4, Figure 2)—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 with the intent that crowding conditions within each subzone are represented by what is observed at the four viewscapes.

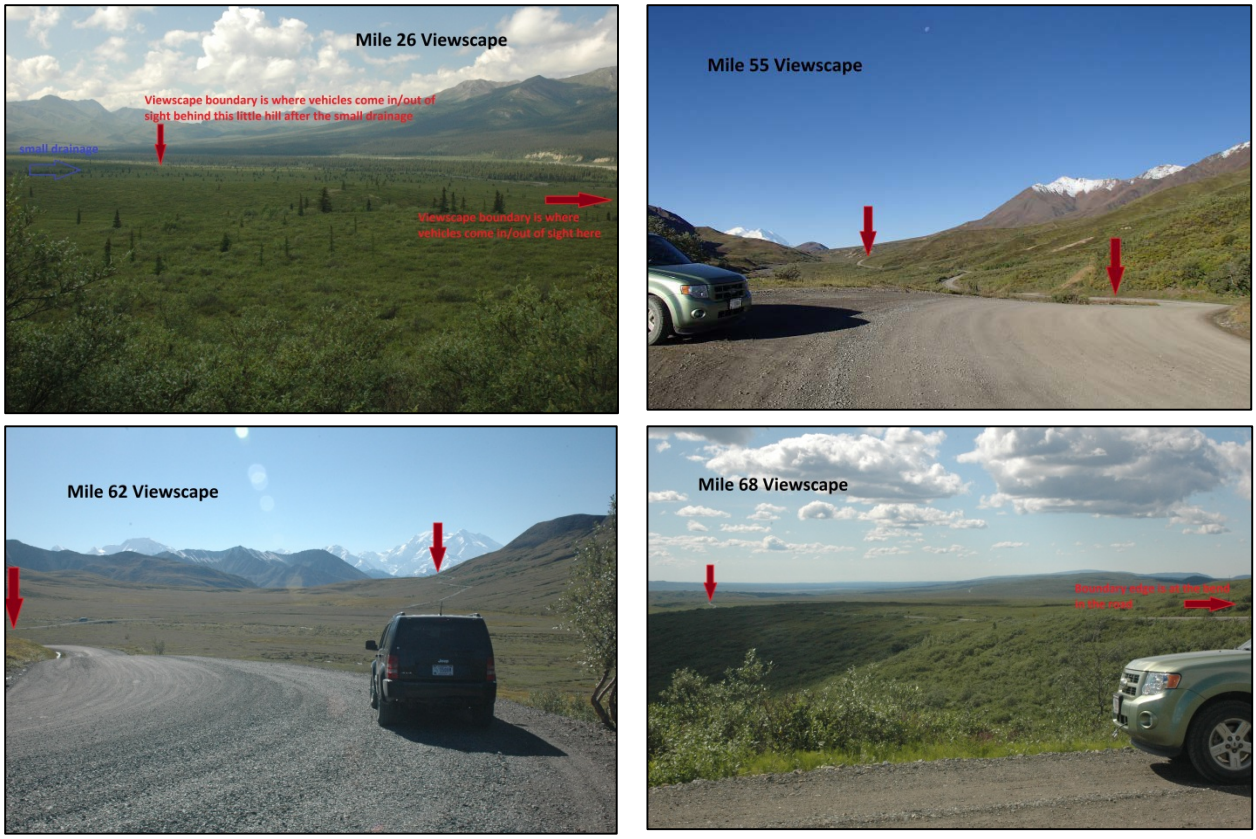


Figure 4. The number of vehicles visible in each of four viewscapes is an indicator of visitor experience. Red arrows indicate the end points of the viewscapes. The standard varies by viewscape and is a minimum percentage of time there are a specified number of vehicles or fewer visible at one time in each of the four viewscapes.

Sheep Gap Spacing

The VMP identified five locations that are important for movement by sheep and other wildlife (Figure 5, Figure 2)—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 during 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 establishes a standard requiring 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 minimize disruption to migratory patterns of less habituated sheep groups with the desire to minimize unnecessary restriction of vehicle traffic and consequently displace visitors. The VMP sheep gap monitoring locations were 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.



Figure 5. The spacing of traffic at five sheep crossing locations (sheep gaps) is an indicator of desired resource conditions. Red arrows indicate the monitoring locations. The standard is a minimum percentage of hours that contain at least one ten-minute gap in traffic.

Night-Time Traffic

The VMP includes an indicator designed to reduce the impact of night-time traffic on the following morning's wildlife sightings. The indicator is the number of vehicles traveling on the park road during night-time hours (10:00 p.m. to 6:00 a.m.) and the standard is an average of three or fewer vehicles per hour (total westbound and eastbound) per night as counted at traffic counters placed along the road corridor, with no more than six vehicles in any one hour. Both standards are to be met

at least 95% of the time. Due to the uncertainty of the effect of night-time and large vehicle traffic on wildlife sightings, this standard will continue to be refined during the first two years the VMP is fully implemented using experimentation with night-time traffic including experimentation with night-time construction traffic (both NPS and contractor).

Large Vehicle Traffic

The VMP includes an indicator to reduce the impacts of large vehicle traffic on wildlife sightings. The indicator is the number of large vehicles during any one hour and the standard is no more than four large (>80,000 pounds) vehicles crossing any of the traffic counters west of Savage in any one hour. This standard will continue to be refined during the first two years of implementation of the VMP through experimentation large vehicle traffic.

Hiker Wait Time

The amount of time hikers wait to be picked up by a bus is an indicator of how well the transit service is meeting demand. The VMP standards for hiker wait time are a percentage of hikers waiting less than 30 minutes, less than 60 minutes and less than 90 minutes to be picked up by a bus. If the transit system is not meeting demand and the number of concessioner buses (tour, transit, charter) is at the daily limit, then meeting the demand for transit services is the priority according to the VMP.

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

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 during trips along the park road. ROAR observers traveled the road on Visitor Transit System (VTS) buses and in a government vehicle. During 2014, ROAR observers collected data during 163 trips that took place between May 24 and September 11, 2014. Trip destinations included Toklat (6.1%), Eielson Visitor Center (60.7%), Wonder Lake (15.3%), and Kantishna (17.8%). Observations were recorded in a data dictionary installed on Trimble JUNO™ 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). Hiker wait times included time, date, GPS coordinates, number of hikers picked up, and their wait times.

NPS Staff Observations

NPS staff collected data on viewscape and rest stop crowding and sheep gap spacing at designated locations along the controlled portion of the park road at least once every two weeks during the regulatory period in 2014. 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). Although scheduling logistics prohibited randomized sampling, each observation site was sampled at least once during each time period, within each subseason.

Table 1. The regulatory season includes three subseasons which are based on the transit bus schedule.

	Early Season	Peak Season	Late Season
2014	5/24 - 6/18	6/19 - 8/6	8/7 - 9/11

Fleet-Based GPS

Real-time data on the position of concessioner buses and NPS vehicles were recoded using a satellite-based GPS. This technology enabled collection of real-time data on the movement of vehicles along the park road remotely and access to 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 called for installing GPS units on all buses, NPS vehicles, and professional photographers traveling the controlled portion of the park road.

The GPS system installed in vehicle traveling the park road was operated by Fleet Management Solutions (FMS, http://www.fmsgps.com). These data were transferred from GPS units to a central database managed by FMS via the Iridium Satellite Network. We downloaded the data via an internet-accessible user interface. The FMS system recorded spatial information (latitude and longitude) during the following events: ignition on/off, begin/end idle (prompted when the vehicle speed is seven miles per hour or less for two or more minutes), wildlife quick messages (see below), breadcrumbs (a sequence of locations recorded at 15-minute intervals with the interval clock re-starting after each ignition on, end idle, or previous breadcrumb event), and boundary alerts when a vehicle enters or exits a rest stop, viewscape, or sheep gap. These data provided continuous monitoring of most road traffic so that we could determine vehicle crowding conditions during any given time interval and the frequency by which vehicles passed through sheep gaps (inter-arrival rates). The FMS system also supported the use of a Message Display Terminal (MDT) integrated with the GPS system. The MDT has a set of custom quick messages (CQMs) that were programmed with the message “Wildlife” or a specific species (e.g., caribou, moose, sheep, bear, and wolf). This provided a mechanism for recording accurate times and locations of wildlife sightings (wildlife stops) made by buses. When bus drivers stopped to view wildlife, they pushed a button on the MDT that sends a time-stamped, georeferenced (latitude and longitude) message indicating that the bus stopped to view wildlife, and the message could include the species observed. During 2014, there were 100 GPS/MDT units installed in the concessioner-operated buses, 47 GPS units installed in NPS vehicles, and 18 units installed in privately owned lodge (in-holder) vehicles. These vehicles only represented about 81 percent (81%) of the total vehicles traveling the controlled portion of the park road. Therefore, we did not use this information to assess the condition of the indicators. Ninety percent (90%) or more of the vehicles would need to have functioning GPS to complete an accurate assessment.

For this report, we assessed the technical performance of this system. We conducted a course-scale assessment by determining the overall extent and severity of technical issues, and we conducted a fine-scale assessment of the rest stop data to determine the quality of the data, to determine the level of effort necessary to use the data for monitoring the indicators, and to look at the patterns of crowding at rest stops compared to the other data collection methods. The method for conducting the

fine-scale assessment is presented below under the “Number of Vehicles at Wildlife Stops” and the “Number of Vehicles at Rest Stops” section.

The course-scale methods for determining functionality of the FMS GPS technology differed by fleet (Concessioner, NPS, Lodge) due to differences in tracking methods by fleet managers and readily accessible to NPS staff. For the concessioner fleet, we obtained Daily Dispatch sheets from the concessioner that indicated which vehicles were dispatched, their schedule, and their route. We compared these data to the GPS data to determine which buses were not producing data consistent with their schedules. We then examined the GPS data of each potential problem bus and looked for records that indicated the bus had moved. A log of the issues by asset and troubleshooting actions were entered into a database for future reference. At the end of the season, we created a document that charted the history of issues for each asset from 2012 through 2014.

Unlike the concessioner fleet, the NPS and lodge fleets did not have set schedules or Daily Dispatch logs for use in determining the functionality of the GPS. Instead, NPS staff downloaded and reviewed two weeks of GPS data at a time to determine 1) which vehicles had transited the controlled portion of the road and 2) what data those vehicles were collecting. We created a log to track which units were having problems, troubleshooting efforts, and outcomes of those efforts. At the end of the season, we created a document that charted the history of issues for each asset from 2012 through 2014. All vehicles that were operational during 2014, and were traveling on the Denali Park Road past Savage were included in our 2014 analysis. Vehicles were placed in one of four categories: 1) collected data all season, 2) corrected problems with minimal loss of data, 3) corrected problems with major loss of data, and 4) unresolved problems.

Traffic Counters

Traffic counters were set up along the park road 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 west of Grassy Pass (Grassy Pass; Figure 6). The Savage traffic counter used two parallel pneumatic tubes installed on top of the road surface. This technology is designed 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 establish size classes of vehicles so that we can monitor large-vehicle traffic. Count data were recorded individually and were consolidated into 15-minute bins. The other traffic counters used two parallel inductive loops installed below the road surface to monitor the volume and direction of traffic. Data from Tek28, Tek Gate, Sable Pass, Toklat, and Stony were recorded in ten-minute bins and these data were only used to monitor night-time traffic. The Grassy Pass counter was set up to record data in one-minute bins to test the ability of this technology to monitor the timing between vehicles at sheep gaps.

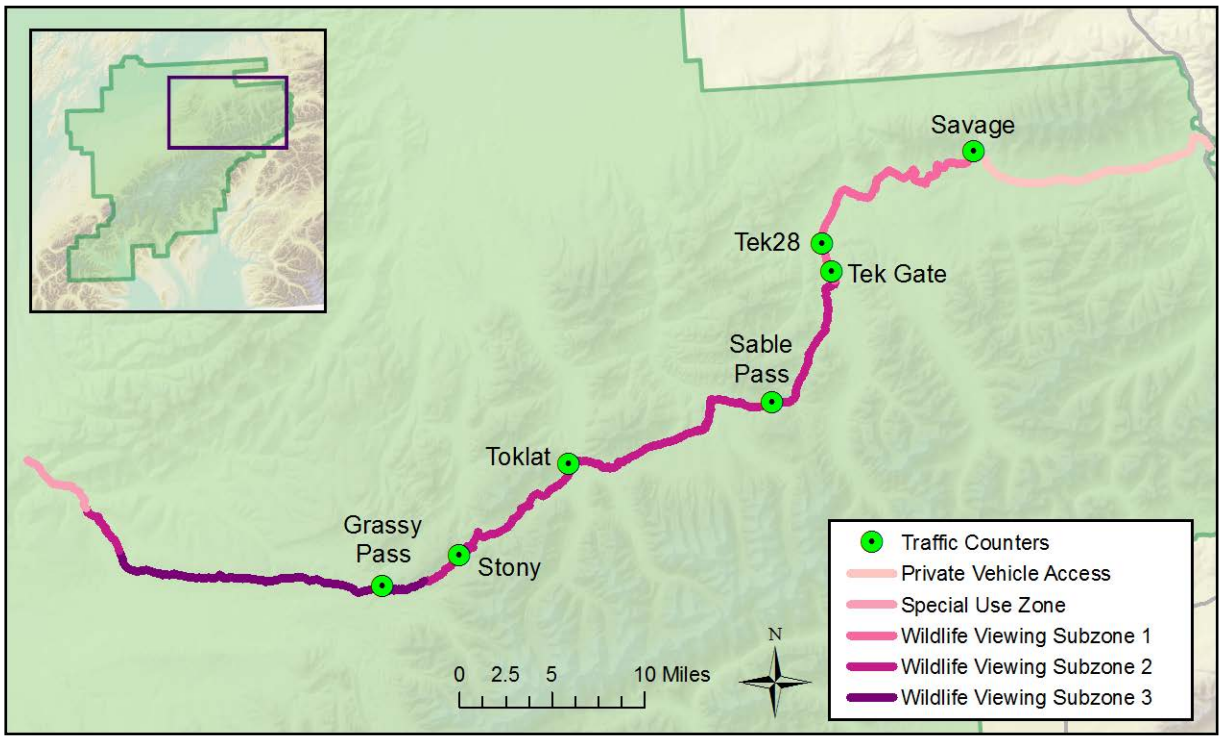


Figure 6. Seven traffic counters are installed along the Denali Park Road to monitor traffic for compliance with VMP indicators and standards.

Concessioner Dispatch Staff and Bus Drivers

The concessioner maintains a dispatch operation at the Eielson Visitor Center during operating hours. Most visitors return to the park entrance on the same bus which brought them westbound to the visitor center and beyond. Visitors who choose to spend a longer time at the visitor center, or are returning from backpacking, request eastbound transit through the dispatcher. 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. Bus drivers maintain a manifest of passengers. They record how many get on, how many get off, and the how long hikers have waited for a bus to pick them up along the road.

Indicators and Standards

Number of Vehicles at Wildlife Stops

We used ROAR data to compare 2014 crowding conditions at wildlife stops to the VMP standards. ROAR observers recorded the maximum number of vehicle at each stop by vehicle type. Data collected from a government vehicle when there were no other vehicles present were 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 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. ROAR observers traveling on

buses included their bus in the count while observers traveling in a government vehicle solely for the purpose of monitoring crowding conditions did not include their vehicle in the count.

We used FMS data to assess the use of the current GPS system for monitoring crowding conditions at wildlife stops. Because only ~81% of the vehicles traveling the park road had GPS units installed, and many of the units were working sporadically, we could not use these data to evaluate compliance with the standards. We identified wildlife stops from FMS data using four types of records or a combinations of records: 1) CQMs that were sent by bus driver from the MDT without associated end idle or ignition on/off records, 2) idle end records with no CQMs, 3) ignition on/off records with no CQMs, and 4) CQMs with associated end idle or ignition on/off records. In cases where an ignition or idle record accompanied a CQM, we used information from the ignition/idle record to improve the accuracy of the event start and end time and removed the duplicate ignition/idle records. We collected the following attributes for each unique wildlife stop for the reporting vehicle: date, vehicle ID, wildlife species (if identified by CQM), event start time, and event end time. We used the start and end time to calculate the event duration. We used adjustable parameters of time (in seconds) and distance (in road miles) between records to determine when vehicles were at the same wildlife stop as the reporting vehicle. For this analysis, we set the time parameter to include all vehicles within the wildlife stop duration plus a buffer of 120 seconds (2 minutes) to compensate for the time lag in the GPS system. The maximum number of vehicles at the wildlife stop for each vehicle was determined by calculating the maximum number of vehicles during each minute of the stop that were within 0.25 miles of the reporting vehicle and taking the maximum.

Number of Vehicles at Rest Stops

We used ROAR and NPS staff observations to determine if crowding conditions (maximum buses and maximum vehicles) at rest stops were meeting VMP standards (Figure 3). ROAR observers recorded the number of vehicles, by vehicle type, at rest stop when they first arrived, and again when they were ready to depart. NPS staff recorded the maximum number of vehicles (by vehicle type) during two-minute intervals for a period of 20 minutes (n = 10 observations). ROAR observers traveling on buses included their bus in the count while observers traveling in a government vehicle for the purpose of monitoring crowding conditions did not include their vehicle in the count.

The FMS GPS units captured vehicles at rest stops by sending a time-stamped, georeferenced boundary alert when the vehicle entered a rest stop and again when it exited the rest stop. Quality control efforts identified three re-occurring problems with the FMS dataset: 1) the location of georeferenced boundary data was often wrong (e.g., data points for Eielson were not at (or near) the Eielson boundary); 2) boundary data were often mislabeled (e.g., an alert labeled as Eielson but the latitude and longitude placed it within the 500-meter buffer for Toklat); and 3) entrance and exit alerts were often repeated within seconds of the original alert several times (echo data). Due to location inaccuracies, all boundary data were imported into ArcMap to cross reference their locations. Boundary alert data outside of a 500-meter buffer from the edge of the boundary was considered inaccurate and was not considered in analysis. Mislabeled boundary alerts were considered in analysis for the boundary location as verified by ArcMap, not as labeled by the FMS system. Echo data were identified and removed using a series of Microsoft Excel equations that

identified same-day, same-vehicle events reported from the same location that were within a 20-second threshold of one another. If an exit record was less than 1 minute after the enter record, it was assumed to be either a vehicle passing by the rest stop, or an echo (>8,400 instances) in the GPS. These records were excluded from analysis. Following this process, all boundary enter and corresponding boundary exit records were combined to a boundary pair. The duration the vehicle was at the rest stop was equal to the difference in the timestamps. The maximum number of vehicles present at a given rest stop during each one-minute time interval during bus operating hours (6:00 a.m. to 10:00 p.m.) for each day of the regulatory season (May 24 – September 11). We used these estimates of current conditions to assess the patterns of vehicle crowding resulting from concessioner buses, lodge-owned buses, and NPS vehicles compared to VMP standards. These results were also compared to conditions reported by NPS and ROAR observers.

Number of Vehicles in Viewscapes

We used NPS staff observations to determine if crowding conditions (average number of vehicles) in viewscapes were meeting VMP standards NPS staff recorded the maximum number of vehicles (by vehicle type) during two-minute intervals for a period of 20 minutes (n = 10 observations).

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 2, Figure 5). A gap was considered to be achieved if ten minutes passed between vehicles at least once during a 60-minute period. During each sampling period, observers recorded the times (to the second) 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 greater than 50 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 one ten-minute break in traffic at sheep gaps were divided by the total number of hours monitored to determine the percentage of hours meeting the standard for gaps in traffic at sheep crossing locations.

During 2014, we configured the Grassy Pass traffic counter to collect data in one-minute bins. Our goal was to test whether this technology could be used to effectively monitor the timing between vehicles at sheep gaps. A gap was determined to be present if there were at least ten one-minute bins without any traffic within a one-hour period.

Night-Time Traffic

We used the data collected by six of the seven traffic counters to determine the volume of night-time traffic. Data from the Savage traffic counter were excluded from 2014 analysis due to system malfunctions throughout the summer and some data from the other traffic counters were excluded due to sporadic system malfunctions and operator error that occurred in September (Table 2).

Table 2. Presented are the dates in 2014 when data from traffic counters installed along the Denali Park Road were used to determine hourly night-time traffic volumes (10:00 p.m. to 6:00 a.m.). The Grassy Pass counter was also used to determine the timing between vehicles at Sheep Gaps. Data was not collected during some date ranges due to system errors.

Counter	Dates included in analysis
Tek28	5/24-8/23, 9/04-9/11
Tek Gate	5/24-8/23, 9/04-9/11
Sable Pass	5/24-9/11
Toklat	6/01-9/11
Stony	6/01-9/11
Grassy Pass	6/01-7/5, 7/16-8/23, 9/4-9/11

Hiker Wait Time

We used data from the Eielson Visitor Center dispatch, bus driver manifests and ROAR observers to evaluate the hiker wait time standards. The dispatcher recorded the time the request was made and the number of individuals in the group, coordinated with bus drivers to find empty seats on buses, and recorded the time the hiker's new bus departed from the visitor center. During 2014, bus drivers asked hikers how long they had been waiting to be picked up by a bus. They recorded the number of hikers picked up, the road segment, and the amount of time they were waiting (<30 min, <60 min, <90 min, and ≤90 min). These data included designated campground, rest area stops, and pickups at any location along the road beyond Savage. ROAR observers recorded hiker wait time when they were traveling the park road on concessioner-operated buses. The observer recorded 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 did not ask the hiker, then the ROAR observer would try to ask the hikers if possible. ROAR observers recorded wait times as 0–15 min, 15–30 min, 30–45 min, 45–60 min, 60–90 min, and over 90 min.

Results

Number of Vehicles at Wildlife Stops

ROAR observers recorded data at 1878 wildlife stops in 2014. The majority of these sightings (86%) occurred in Wildlife Viewing Subzone 2 (Table 3), approximately 8% occurred in Wildlife Viewing Subzone 1, and the remaining 6% occurred in Wildlife Viewing Subzone 3. Based on these data, all Wildlife Viewing Subzones were within standard during the 2014 regulatory season (Table 4).

Table 3. The number of ROAR observations recorded in each of three Wildlife Viewing Subzones during the summer 2014 regulatory period.

	Wildlife Subzone 1	Wildlife Subzone 2	Wildlife Subzone 3
2014	143	1,624	111

Table 4. Crowding conditions measured as a percent of time *X* or fewer vehicles were observed at a wildlife stop. The standard was the minimum proportion of observations required to meet desired conditions.

	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	70	85	90	70	85	90	70	85	90
ROAR	96.5	98.6	98.6	83.1	92.9	97.5	77.5	96.4	97.3

From the GPS data, we were able to identify 58,578 wildlife stops (or suspected stops), with 81% occurring in Wildlife Viewing Subzone 2, 10% occurring in Wildlife Viewing Subzone 1, and the remaining 9% occurring in Wildlife Subzone 3. In all but one case, analysis of the GPS data found less crowding at wildlife stops as compared to ROAR (Table 5).

Table 5. Presented is a comparison of crowding conditions at wildlife stops along the Denali Park Road in 2014 as measured by ROAR versus GPS.

	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
ROAR	96.5	98.6	98.6	83.1	92.9	97.5	77.5	96.4	97.3
GPS	97.5	99.4	99.8	80.2	93.5	98.1	78.6	96.8	99.5

Number of Vehicles at Rest Stops

During 2014, ROAR observers recorded 1,529 observations of the number of vehicles at rest stops. NPS staff recorded 870 observations. Based on these data, all rest stops were within standard during the 2014 regulatory season (Figure 7, Figure 8, Figure 9). The greatest number of buses at one time was observed at Toklat. Eielson had the highest average number of buses observed (Table 6, Table 7) and the highest maximum and average number of all vehicles combined (Table 6, Table 8).

Table 6. 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 2014 regulatory season. The standard was the maximum number of buses and vehicles that could be parked at one time to meet desired conditions.

	Teklanika			Toklat			Eielson		
	Bus Max	Vehicle Max	*n*	Bus Max	Vehicle Max	*N*	Bus Max	Vehicle Max	*n*
Standard	12	16		11	16		10	19	
NPS Staff	6	7	250	10	10	300	8	10	320
ROAR	10	10	571	11	11	563	9	13	395

Table 7. Mean (standard deviation) number of buses parked at one time at the Teklanika and Toklat rest stops and the Eielson Visitor Center during the 2014 regulatory season. The standard was the maximum number of buses and vehicles that could be parked at one time to meet desired conditions.

	Teklanika		Toklat		Eielson	
	Mean (SD)	*n*	Mean (SD)	*n*	Mean (SD)	*n*
Staff Observations	1.8 (±1.5)	250	2.2 (±2.2)	300	2.6 (±1.9)	320
ROAR	2.7 (±1.5)	571	3.2 (±1.9)	563	3.3 (±1.7)	395

Table 8. Mean (standard deviation) number of vehicles parked at one time at the Teklanika and Toklat rest stops and the Eielson Visitor Center during the 2014 regulatory season.

	Teklanika		Toklat		Eielson	
	Mean (SD)	*n*	Mean (SD)	*n*	Mean (SD)	*n*
Staff Observations	2.0 (±1.7)	250	2.4 (±2.2)	300	4.2 (±2.4)	320
ROAR	2.8 (±1.6)	571	3.2 (±1.9)	563	4.5 (±2.1)	395

The GPS recorded 582,313 non-zero observations at the rest stops. Based on the GPS data, the VMP standard for the maximum number of buses and the maximum number of vehicles was exceeded at the Teklanika Rest Stop in 2014 with one instance of 19 buses (and 19 total vehicles) (Figure 7). This occurred on Tuesday September 2. The VMP standard for the maximum number of buses was exceeded at Toklat twice (Friday June 27 with 14 buses and Wednesday August 27 with 13 buses (Figure 8) and Eielson once on Wednesday August 6 with 11 buses (Figure 9). Based on the ROAR data, neither of these stops exceeded the VMP standard for maximum number of vehicles during the 2014 regulatory season. Overall, the ROAR and GPS data show similar patterns for the mean number of vehicles recorded at the Teklanika and Toklat rest stops while the pattern illustrated by the NPS observations does not (Figure 8, Figure 9). All three methods show similar patterns for crowding conditions at the Eielson Visitor Center.

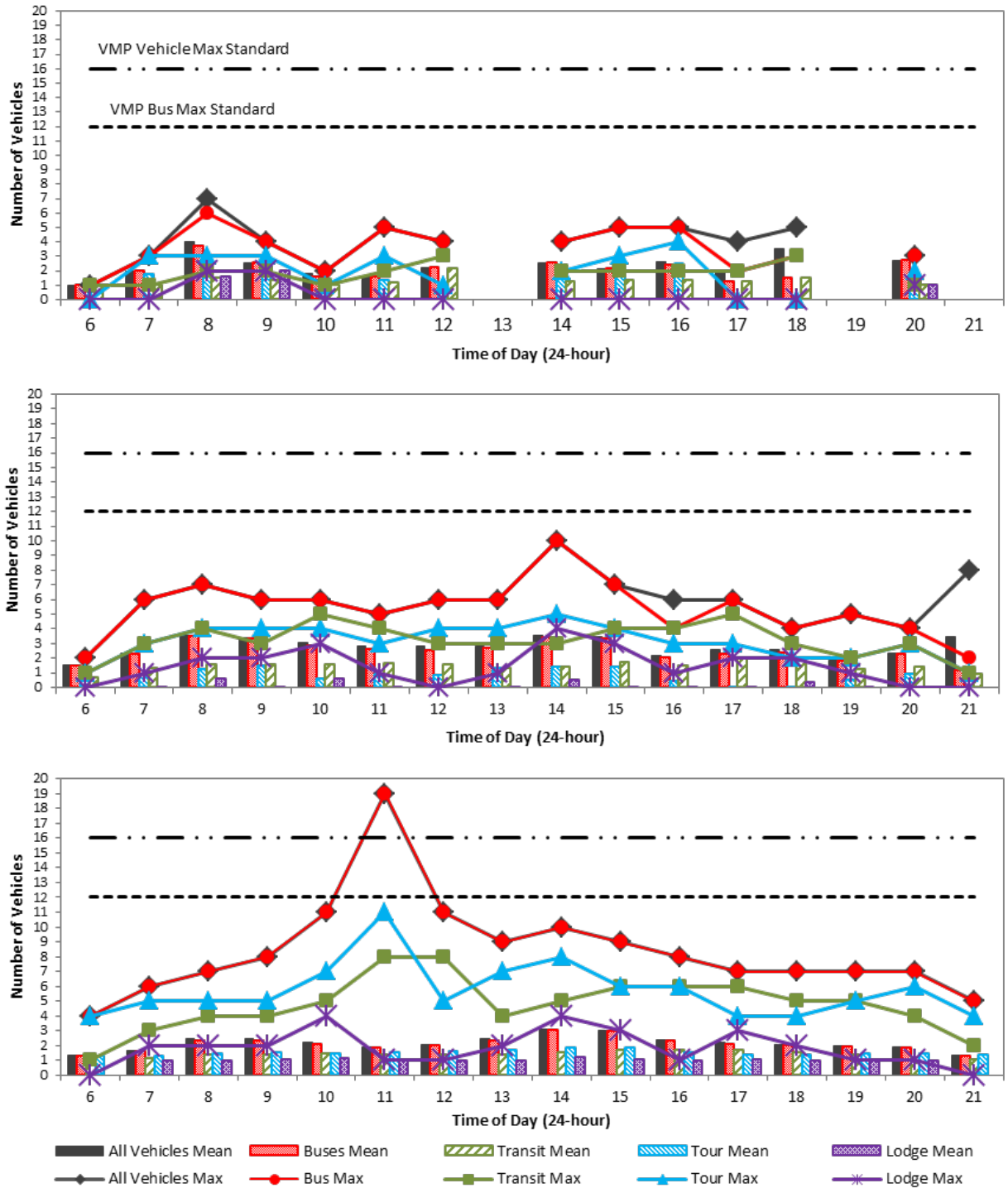


Figure 7. The mean and maximum number of buses and vehicles recorded at the Teklanika Rest Stop during the 2014 regulatory season. Data were collected via NPS observations (top), ROAR observers (middle) and satellite-based GPS units (bottom). NPS observations were not collected during the 1300, 1900, and 2100 hours. The lower dashed line indicates the standard for the maximum number of buses and the upper dashed line indicates the maximum number of vehicles.

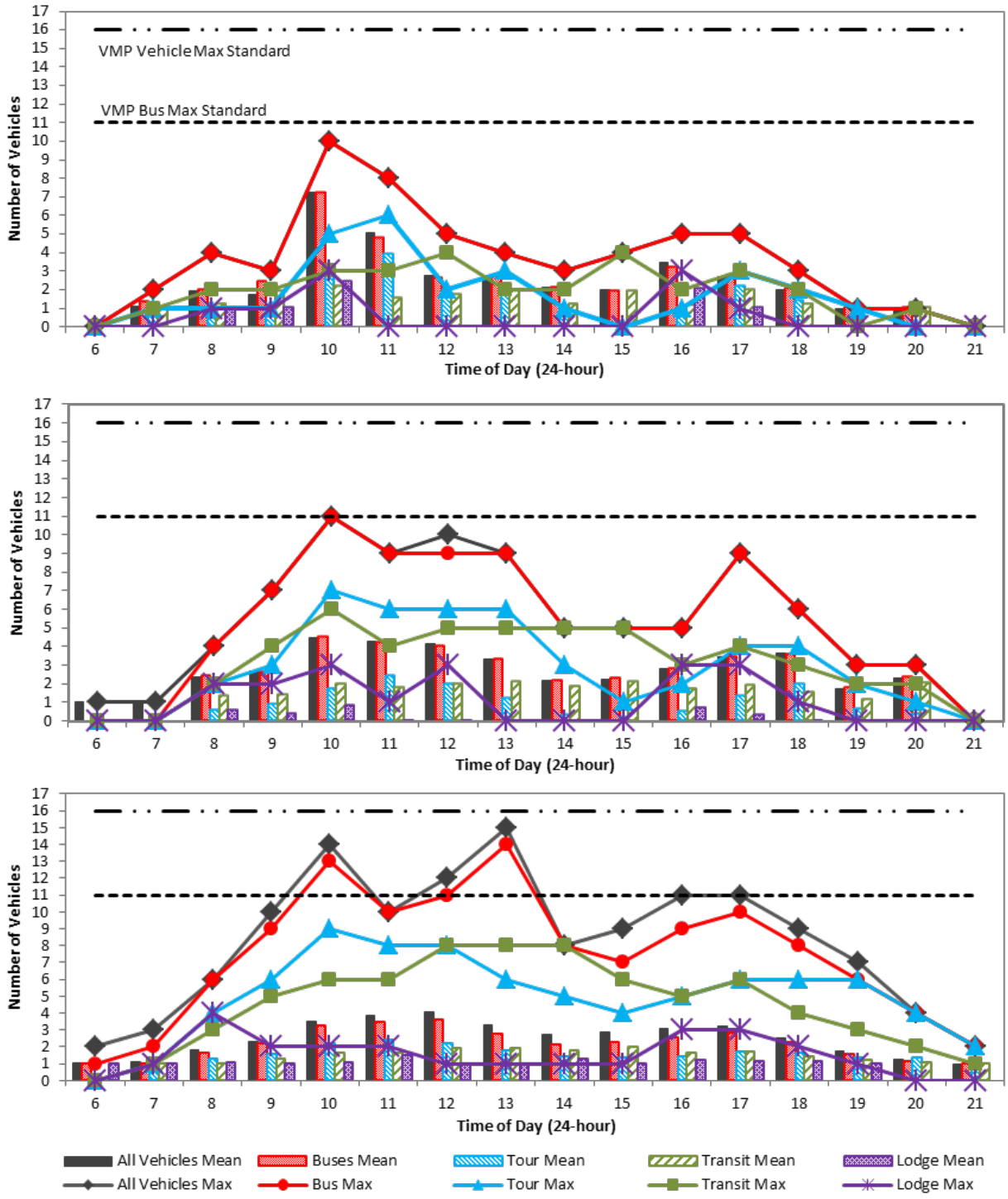


Figure 8. The mean and maximum number of buses and vehicles recorded at the Toklat Rest Stop during the 2014 regulatory season. Data were collected via NPS observations (top), ROAR observers (middle) and satellite-based GPS units (bottom). The lower dashed line indicates the standard for the maximum number of buses and the upper dashed line indicates the maximum number of vehicles.

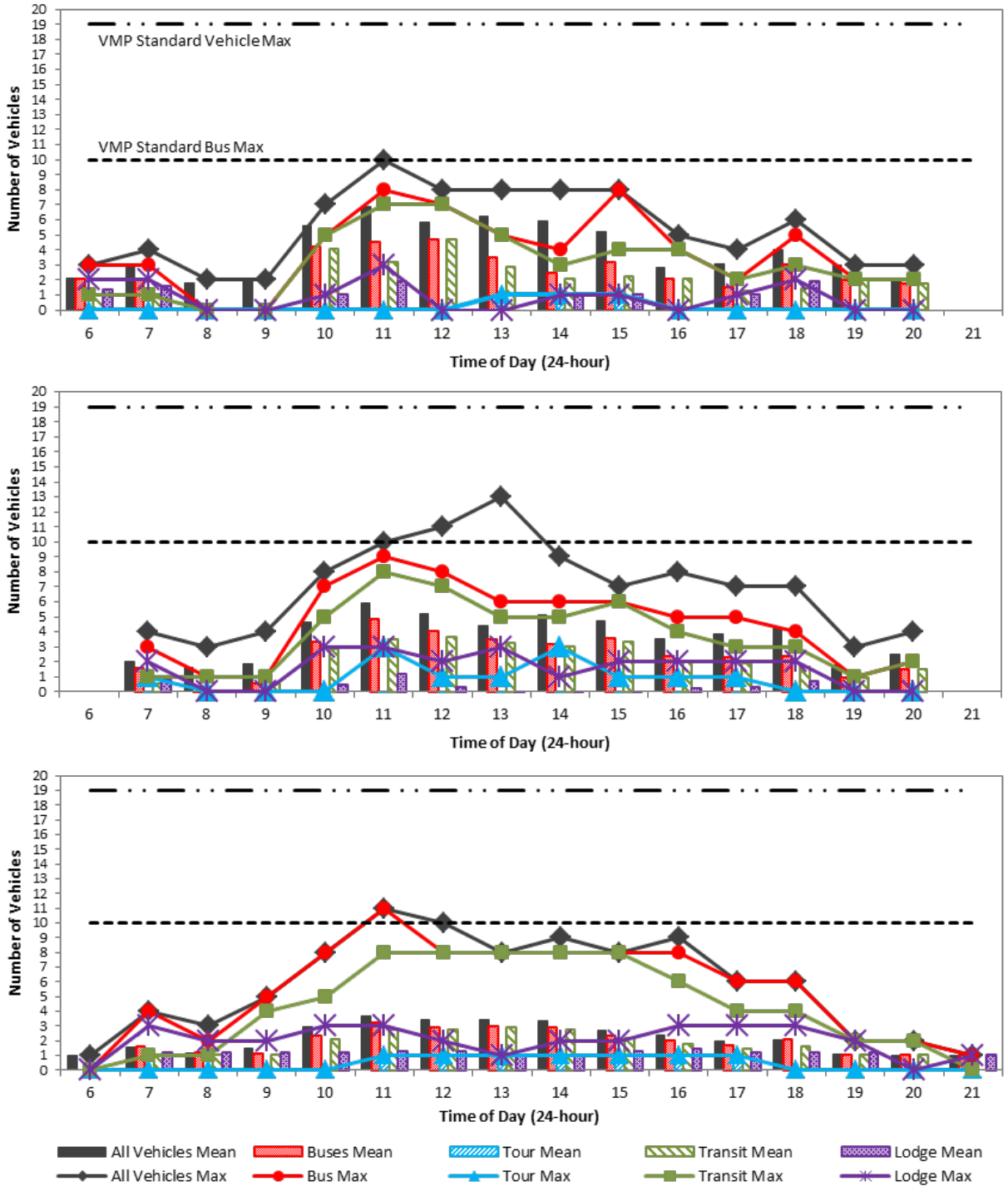


Figure 9. The mean and maximum number of buses and vehicles recorded at the Eielson Visitor Center during the 2014 regulatory season. Data were collected via NPS observations (top), ROAR observers (middle) and satellite-based GPS units (bottom). The lower dashed line indicates the standard for the maximum number of buses and the upper dashed line indicates the 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 2014 regulatory season (Table 9). During 2014, NPS staff recorded the number of vehicles visible in the mile 26 (n=270), mile 55 (n=340), mile 62 (n=330), and mile 68 (n=280) viewscapes (Table 9). Based on NPS observations, Mile 26 had the highest average number of vehicles visible at one time and high variation (Figure 10). Mile 62 and Mile 55 had the next highest average and Mile 68 had the lowest average number and the least variation in the observations. As with rest stops, the data shows peaks in crowding conditions during the morning and afternoon hours (Figure 10). Due to sampling logistics, some hours were not sampled, but sampling did occur during the busiest times of day.

Table 9. Proportion of observations when the average number of vehicles visible at one time was within the VMP standards. These results include data when no vehicle was present. The VMP minimum annual standard is provided for comparison. The standard was the minimum proportion of observations required to meet desired conditions.

	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	80	90	80	90	80	90	80	90
NPS Observations	99.3	100	92.9	97.1	92.4	99.1	92.9	98.2

Sheep Gap Spacing

NPS staff recorded data at sheep gaps during 153 observation periods made during bus operating hours during the 2014 regulatory season. The Grassy Pass traffic counter monitored 2,200 hours during the season. Based on NPS observations, the standard for the percentage of hours with at least one ten-minute gap in traffic was met at Mile 37.6 and Mile 68.5. It was not met at Mile 21.6, Mile 52.8, and Mile 60.6 (Table 10). Based on the traffic counter data at Mile 68.5, a higher proportion of hours had a 10-minute gaps in traffic (100% of hours monitored) as compared to the proportion of hours estimated from the NPS observations (93.3% of hours monitored).

Table 10. The percentage of hours with at least one ten-minute gap in traffic at each of the five sheep gaps. Three of the five sheep gaps failed to meet the standard during the 2014 regulatory season (*bold text). NPS observations were used to determine compliance at all five sheep gaps. The Grassy Pass traffic counter was also used to monitor the Mile 68.5 sheep gap. The standard was the minimum proportion of monitored hours required to meet desired conditions.

	Mile 21.6	Mile 37.6	Mile 52.8	Mile 60.6	Mile 68.5
	% hours	**% hours**	**% hours**	**% hours**	**% hours**
Standard	90	90	90	90	90
NPS Observations	84.6* (n=26)	92.9 (n=28)	85.3* (n=34)	82.9* (n=35)	93.3 (n=25)
Traffic Counter					100 (n=2200)

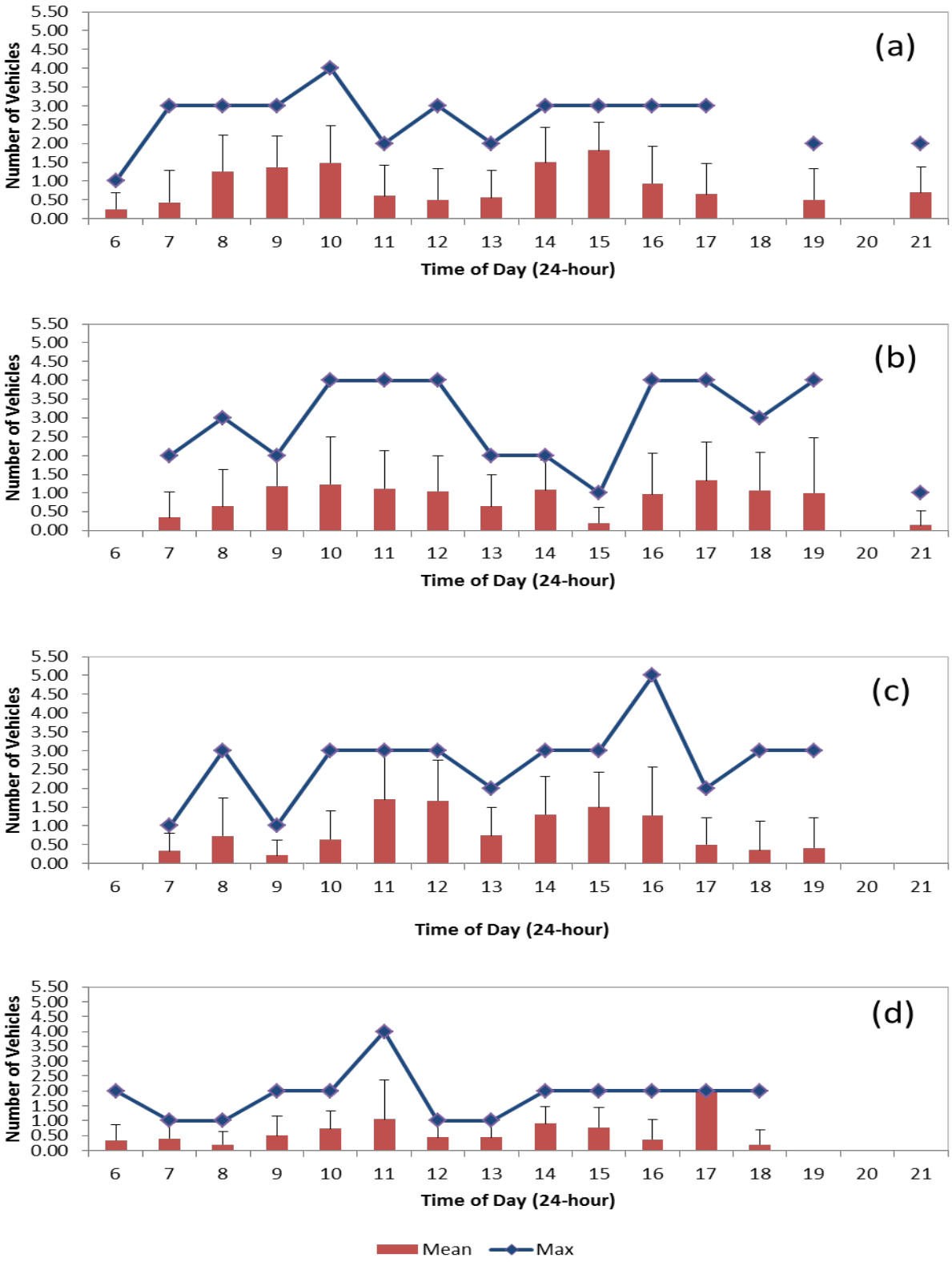


Figure 10. The mean (+ 1 standard deviation) and the maximum number of vehicles visible at one time at the Mile 26 (a), Mile 55 (b), Mile 62 (c), and Mile 68 (d) viewscapes as recorded by NPS observers during the 2014 regulatory season. Missing values indicate hours that were not monitored.

Night-Time Traffic

We used data from six of the seven traffic counters to evaluate the volume of night-time traffic along the park road. The Savage traffic counter did not produce reliable data during the 2014 regulatory season; therefore, these data were excluded from analysis. The percentage of nights with an average of three or fewer per hour vehicles met the standard based on data from the Stony traffic counter (Table 11). This standard was not met based on data from the Tek 28, Tek Gate, Sable, and Grassy Pass counters. The standard for the percentage of nights where there were six or fewer vehicles per hour was met at all six of the traffic counter locations. Grassy Pass had the highest maximum average number of vehicles per hour and it had the same values as the Tek Gate for the percentage of nights with three or fewer vehicles per hour and percentage of hours with six or fewer vehicles per hour (Table 11).

Table 11. Summary of night-time traffic (10:00 p.m. – 6:00 a.m.), based on traffic counter data collected during the 2014 regulatory season. Nightly rates are the mean numbers of vehicles per hour. The standard was the minimum proportion of nights or hour required to meet desired conditions. Exceeded standards are in bold text.

	Maximum nightly rate	Minimum nightly rate	% nights ≤3 vehicle per hour	*n*	% hours ≤6 vehicles per hour	H
Standard			95%		95%	
Tek 28	4.50	0.00	**94%**	100	97%	800
Tek Gate	6.00	0.00	**88%**	100	95%	800
Sable	5.50	0.00	**93%**	111	96%	888
Toklat	5.00	0.00	95%	103	99%	824
Stony	4.63	0.00	96%	103	99%	824
Grassy Pass	7.88	0.00	**88%**	82	95%	649

There were some nights with high volumes of night-time traffic on both the east and west end of the road with Toklat as the dividing line. For example, the Tek Gate traffic counter recorded 24 vehicles in one hour on July 14 (Figure 11) and Grassy Pass traffic counter recorded 13 vehicles in one hour on July 18 (Figure 12). There were also periods of time when mean traffic levels were high. From July 14 through July 23 the Tek 28, Tek Gate, and Sable traffic counters recorded high nightly averages as illustrated by the Tek Gate traffic counter (Figure 11) The Tek Gate counter recorded 11 nights when the average exceeded 3.00 vehicles per hour, including one night that had an average of 7.00 vehicles per hour. The Tek Gate counter also recorded 42 instances when the number of vehicles exceeded 6.00 per hour, including 20 nights when the hourly average exeeded 10.00. The Grassy Pass counter recorded 11 nights when the average exceeded 3.00 vehicles per hour, including one night that had an average of 8.38 vehicles per hour and another night with an average of 8.75 vehicles per hour. This counter also recorded 34 instances when the number of vehicles exceeded 6.00 per hour, including seven nights when the hourly average exeeded 10.00.

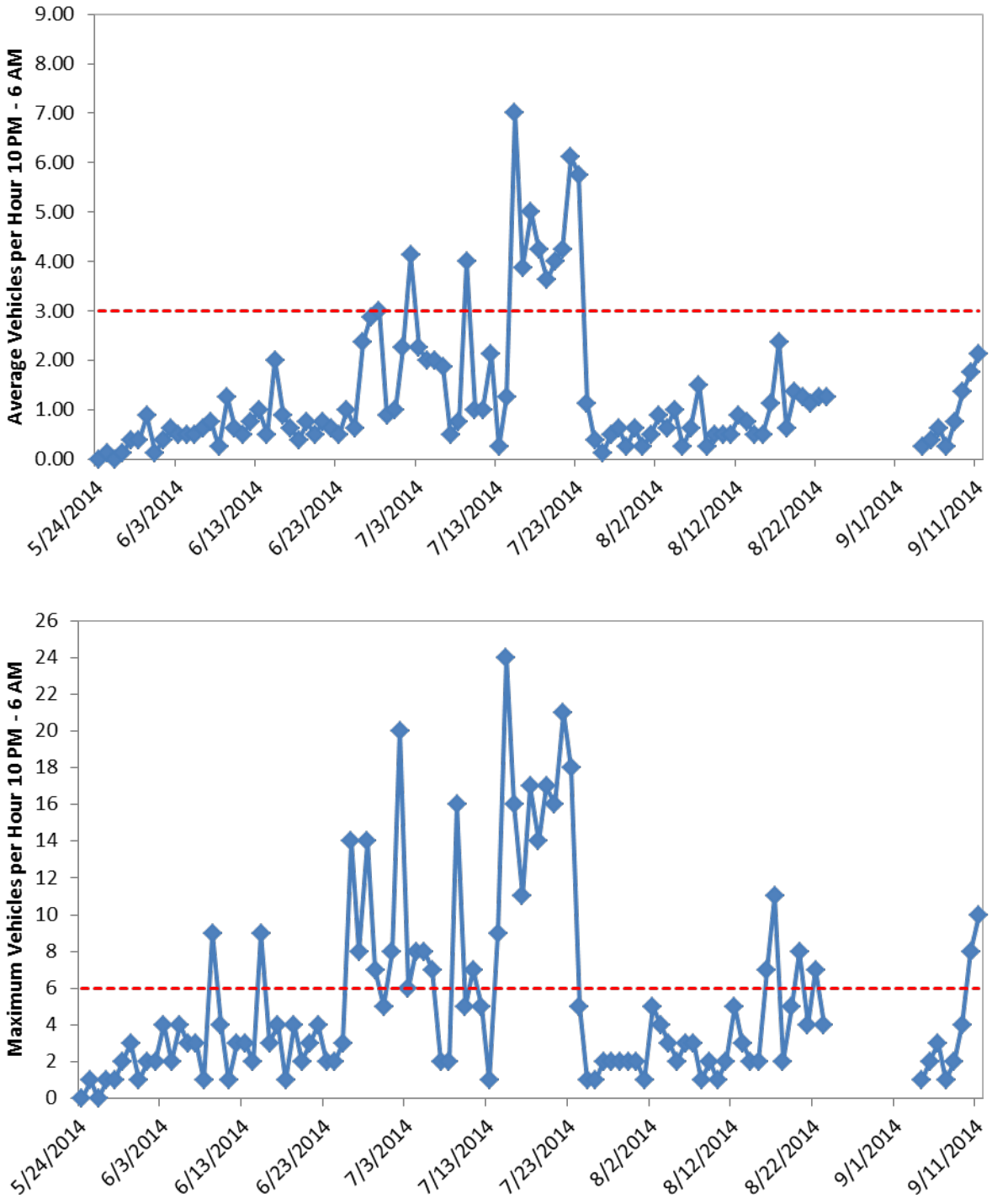


Figure 11. Mean numbers of vehicles per hour (top) and the maximum numbers of vehicles per hour (bottom) per night as recorded by the Tek Gate traffic counter located west of the Teklanika Rest Area on the Denali Park Road. These data represent a continuous period from 10 p.m. to 6 a.m. (night-time) and the dates shown are for the 12 a.m. to 6 a.m. time period. The VMP standards for night-time traffic are a percentage of nights at or less than the specified amount which are shown as red, dashed lines. Data was not recorded between August 24 and September 3, 2014 due to operator error.

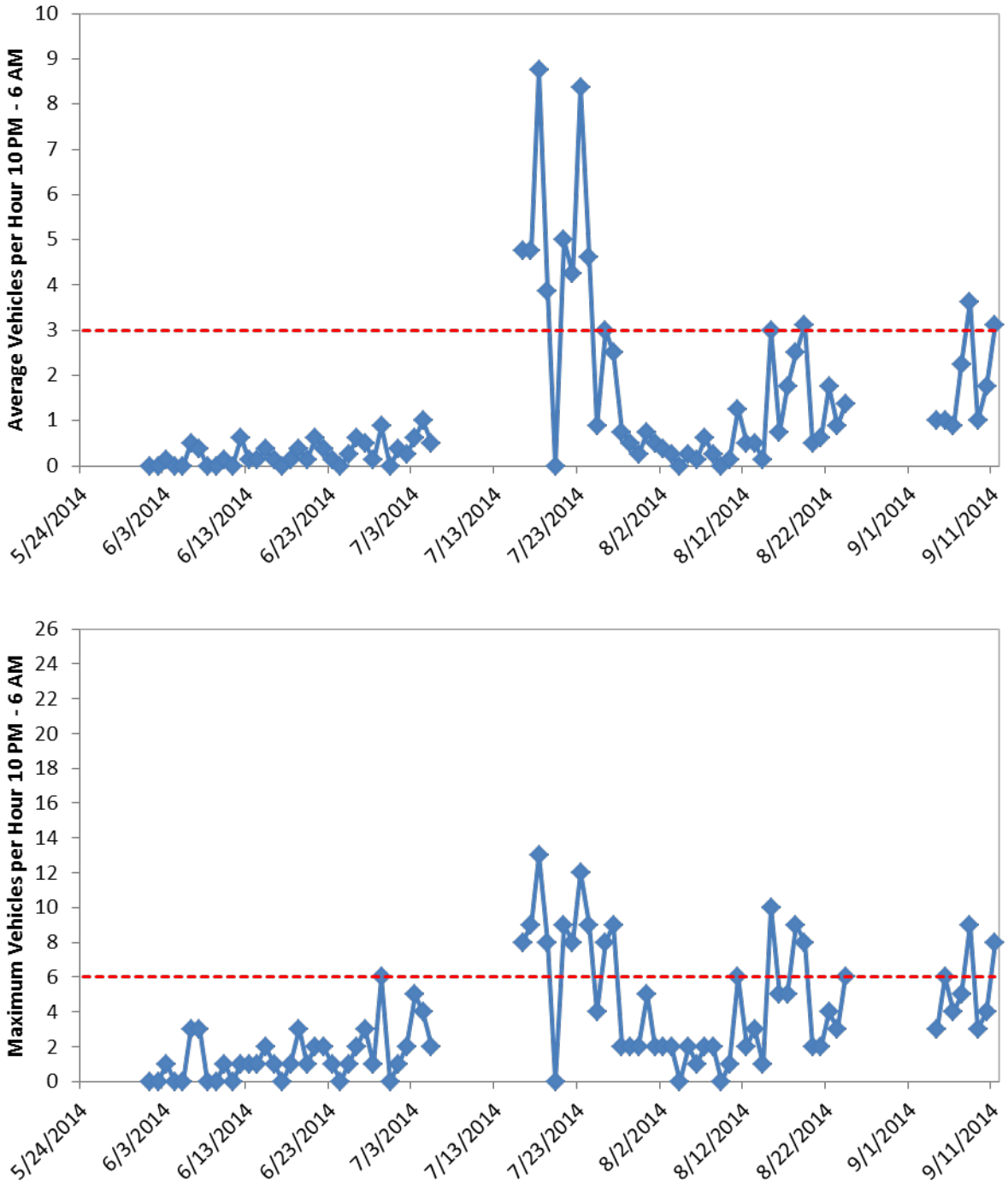


Figure 12. Mean numbers of vehicles per hour (top) and the maximum number of vehicles per hour (bottom) per night as recorded by the Grassy Pass traffic counter located west of the Eielson Visitor Center on the Denali Park Road. These data represent a continuous period from 10 p.m. to 6 a.m. (night-time) and the dates shown are for the 12 a.m. to 6 a.m. time period. The VMP standards for night-time traffic are a percent of nights at or less than the specified amount which are shown as red dashed lines. Data was not recorded between July 6 and July 15 due to technical malfunction, and August 24 and September 3, 2014 due to operator error.

Hiker Wait Time

The standard for hiker wait time was met during the 2014 regulatory season (Table 12). Data from the Eielson Visitor Center had the lowest percentage of hikers waiting less than 30 minutes for a bus, while the bus driver information suggests that hikers being picked up along the road and at designated stops are least likely to wait longer than 30 minutes.

Table 12. A summary of hiker wait times as reported by concessioner dispatch staff at the Eielson Visitor Center, concessioner bus drivers, and ROAR observers. The standard for hiker wait time is a minimum percentage of hikers waiting for a specified period of time for a bus with an available seat. The standard was the minimum proportion of hikers waiting for the specific period of time.

	% Time ≤30 min	*n*	% Time ≤60 min	*n*	% Time ≤90 min	*n*
Standard	70%		93%		98%	
Eielson Visitor Center	75.6	9,848	97.7	12,736	99.7	12,997
Bus Driver	96.4	30,274	99.0	31,108	99.4	31,210
ROAR	81.9	127	96.8	150	98.1	152

Fleet-Based GPS

Of the 165 vehicles with GPS units installed in them, 137 were used to travel the park road beyond Savage during the 2014 regulatory season (Figure 13).

Data Collected All Season

The GPS in 51 vehicles (37%) appear to have collected all of the monitoring data required by NPS staff from May 24 (or if the unit was installed in 2014, from the date it was activated) until the vehicles last run of the season or the unit was uninstalled (some vehicles were taken out of service mid-summer). These vehicles appear to collect accurate locations of: ignition on/off events, correct boundaries, 15-minute breadcrumbs, and end idle events. Vehicles missing two or fewer days of data due to a message limit exceeded were included in this tally. This tally does not include issues related to updating the geotag menu, although it was an ongoing project throughout the summer.

Corrected Problems:

These vehicles had problems collecting some or all data for part of the summer, but were functioning properly by the end of the season. The corrected problems were split into the following general categories:

Minimal Loss of Data:

The GPS in 31 vehicles (23%) were missing two weeks or less of data (ignition, idle, boundary) or were missing breadcrumbs for part of the season but all other data appears to have been collected. Data gaps typically occurred as a result of firmware updating, message limit exceedance, or the GPS being unplugged (four units were unplugged by NPS mechanics due to concerns regarding battery drain).

Major Loss of Data:

The GPS in 17 vehicles (12%) appeared to function at the end of the season, but had problems during the regulatory season that included: 1) failure to collect data for >two weeks, 2) failure to record

some or all boundaries, or 3) ongoing problems with hardware (e.g., loose antennas loose, MLT hardware failure). These 17 vehicles may have produced some useable data during 2014 but are either missing large time blocks of data or key attributes (boundaries). A few never collected data all season but after a firmware update at the end of the season appeared to be functioning properly. This cannot be verified until the units are reactivated.

Unresolved Problems:

Technical issues with the GPS in 38 vehicles (28%) were not resolved during 2014. The issues included mechanical issues with the unit or installation and technical issues with the MLTs configuration. Some issues could not be resolved because the vehicles were out of service and could not be troubleshot before the end of the season.

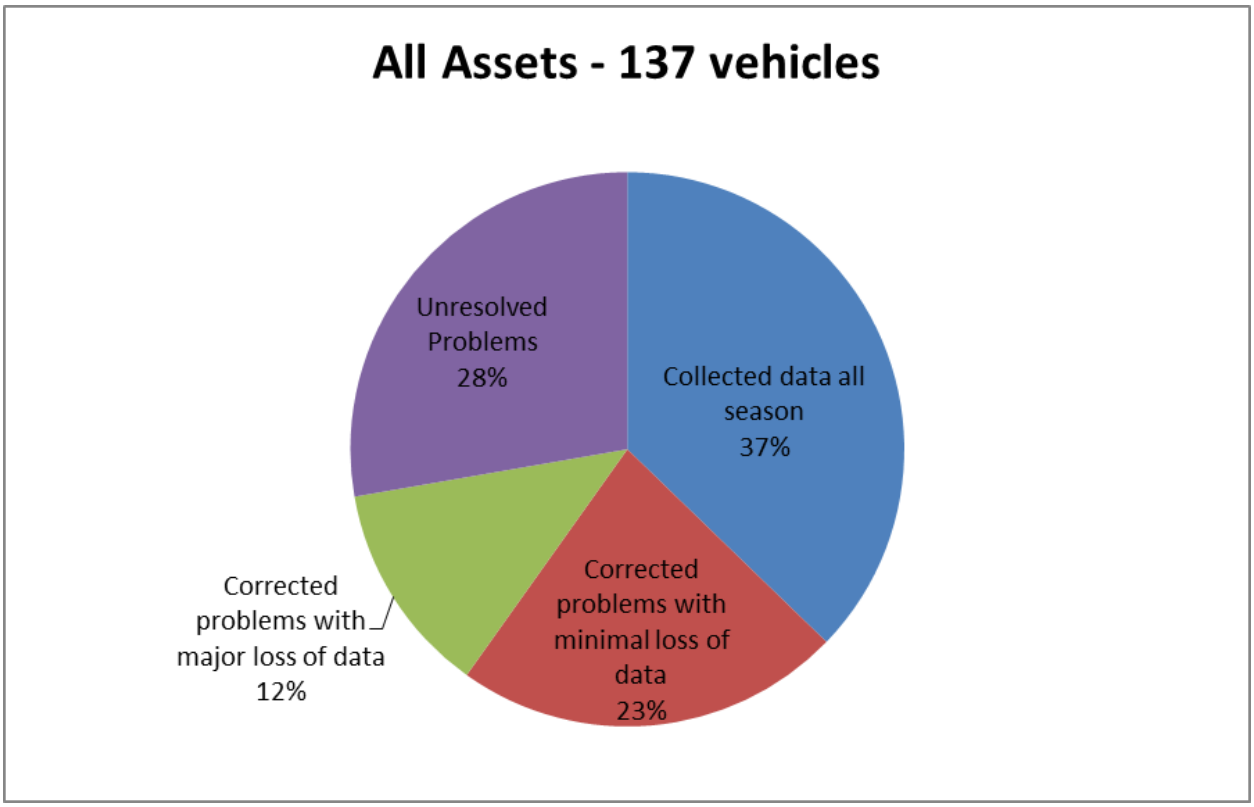


Figure 13. The 2014 functionality of the FMS GPS units was defined into one of four categories to assess the reliability of their output for monitoring the VMP indicators for compliance with the standards.

Discussion

Number of Vehicles at Wildlife Stops

Crowding conditions at wildlife stops, as measured by ROAR, met standards in all three Wildlife Viewing Subzones during the 2014 regulatory season. This was an improvement over results from 2012 and 2013, which found the park out of standard in Subzone 3 (McKenny et al. 2014a, 2014b). These results may be a reflection of the increased sampling effort conducted in 2014 capturing a greater number of samples with a greater temporal diversity. During 2014, we increased our staffing levels (including paid staff, interns, and volunteers) to increase the number of ROAR observations from buses traveling to Wonder Lake and Kantishna and we tried to diversify the times they were departing from the Wilderness Access Center. We were also able to get some data from wildlife stops west of Eielson Visitor Center early in the morning; although flooding in Kantishna reduced the amount of time we were able to house staff on that end of the road. There was an early morning pulse of traffic from Kantishna due to overnight lodge guests being bused east to catch the train, and the departure of the first camper bus whose driver spends the night at Wonder Lake. The accuracy of our data could be improved if ROAR observers spent the night on the west end of the road and return east with the first camper bus.

In all but one instance (Wildlife Subzone 2, percentage of stops with ≤2 vehicles) the GPS data indicates that a greater percentage of stops were at or below standard in comparison to the ROAR data. Only about 81% of the vehicles traveling the park road had GPS units installed, and of those units, only 37% were consistently functioning during the 2014 season. Therefore, it was not surprising that the GPS data underreported crowding conditions (showed fewer vehicles at wildlife stops compared to ROAR). We did not check these data for accuracy (e.g., did the GPS assign the correct location and time stamp when a CQM was sent, was the species accurate—we discovered some units consistently sent “wolf” or “coyote” for example). This quality control could be done using the validation data collected by ROAR who wrote down vehicle IDs when they were collecting ROAR data. While we may not be able to monitor the standards with these data, these data will be valuable for use in the park road traffic scheduling model. For example, we will be able to estimate the length of time wildlife events occur, the length of time individual vehicle types stop at wildlife events, and the frequency and distribution of wildlife events.

Number of Vehicles at Rest Stops

Based on the ROAR and NPS Observation data, the standards for the total number of buses and vehicles parked at one time were met at all three rest stops. The GPS data was able to capture a few instances where the standards were exceeded at all three rest stops. This was surprising given how poorly the system was functioning during 2014. As with 2013 (McKenny et al. 2014a), the Toklat Rest Stop and the Eielson Visitor Center continue to have periods of time in the morning when the crowding conditions are at standard for the maximum number of buses. Park management needs to continue to monitor this situation, and develop solutions to improve the situation before standards are exceeded (e.g., shorter duration stops, more dispersed scheduling).

The ROAR observations appeared to provide a more accurate assessment of crowding conditions throughout the day as compared to the NPS observers. This was likely because ROAR observers traveled with the fleet as opposed to NPS observers who bounced between indicators and may have missed critical flows in traffic that contribute to crowding conditions. Based on these results, NPS observations at rest stops could be stopped except in cases where concerted efforts to conduct extended observations over multiple days are warranted to better understand crowding during specific hours or days. This would enable observers to spend more time collecting data at viewscapes. Monitoring rest stops using ROAR observers could be further improved by following the recommendations made under Wildlife Stops, as well as continuing to improve the timing and distribution of ROAR observations.

Number of Vehicles at Viewscapes

Based on NPS observations, the standards for the number of vehicles visible in a viewscape at one time were met during the 2014 regulatory season. Data from the NPS observations tracked the concessioner and lodge bus schedules to some extent, but these data could be improved. In most cases, the hours that were sampled, were only sampled once or twice during the regulatory season (one sampling event with the maximum being recorded every two minutes for 20 minutes total). If scheduling of traffic is adjusted, it would be valuable to increase the sampling effort at viewscapes, which would be logistically feasible if rest stop observations are discontinued. These data would provide managers with an improved understanding of current conditions, and would increase our ability to understand how changes in the schedule affect this indicator.

Sheep Gap Spacing

The Mile 21.6, Mile 52.8, and Mile 60.6 sheep gaps were all out of standard during the 2014 regulatory season. Mile 37.6 and Mile 68.5 were within standard. These results reflect a worst case scenario because they are based on the number of hours that were observed to have ten-minute gaps in traffic rather than continuous monitoring throughout the 24-hour period. During the 2014 regulatory season, we experimented with the use of a traffic counter for monitoring the Mile 68.5 sheep gap. This technology provided 24-hour monitoring of this location. There was a short period when the traffic counter did not collect data due to an unknown malfunction, and another short period that likely resulted from the technician failing to restart the counter after changing the battery. These issues can be resolved through additional training of the technician, and working in partnership with other NPS staff to have the counters checked more frequently. Aside from the minor technical issues, the traffic counter at Grassy Pass (milepost 68.5) worked well for monitoring this indicator and provided an accurate assessment of traffic at this location. Unfortunately, the remaining traffic counters (Tek 28, Tek Gate, Sable, Toklat, and Stony) are not installed at locations that would adequately monitor the sheep gaps. TRS style traffic counters should be installed at the sheep gaps to provide an accurate assessment of traffic spacing throughout the regulatory season.

Night-Time Traffic

Night-time vehicle traffic was out of standard at four of the six traffic counter locations. Given the pattern observed at the Tek 28, Tek Gate, and Sable traffic counter, it is very likely that night-time traffic crossing the Savage traffic counter was also out of standard. The emergency and follow-up

response to flooding in Kantishna contributed to some of the high levels of night-time traffic. There was the initial mobilization that occurred at the end of June during which the Alaska Department of Transportation (AK DOT) and the park sent equipment out to Kantishna to repair flood damage. To complete the repairs, the AK DOT used rip rap that the park had stored at Toklat. In July, AK DOT replenished the park's rip rap by trucking in material from outside of the park to Toklat. Trucks returning east were loaded with material for doing road repairs at Polychrome. These night-time trips between July 14 and 23 are apparent in the night-time data collected by the traffic counters: a pulse of traffic is recorded at Tek 28, Tek Gate, and Sable. A corresponding pulse was not recorded by the Toklat traffic counter, west of Toklat indicating that this traffic did not go beyond Toklat. The Grassy Pass counter recorded high levels of night-time traffic during that likely resulted from night-time road construction west of Eielson Visitor Center. During this project, the Thorofare Pit (Mile 70) was used for staging material. Consequently, a greater volume of night-time traffic was moving across the Grassy Pass traffic counter during certain phases of this project. Night-time traffic also increased during some nights at the Toklat and Stony traffic counters as a result of this project. These periods of high night-time construction traffic provide the park with an opportunity to further investigate the impacts of high night-time traffic volumes on wildlife sightings. These data, in addition to previous year's data that include accurate night-time traffic volumes and wildlife sightings, provide the park a more robust dataset for determining the impacts of night-time traffic. Previous research suggests that large vehicles have a greater impact on wildlife sightings (NPS 2012). Additional experimentation with the volume, behavior, and spacing of large-vehicles would be valuable for refining the large-vehicle and night-time traffic standards. Monitoring should be conducted during these experiments to ensure contractors are abiding by conditions set forth in their contract (e.g., vehicle speed, use of air brakes, vehicle spacing).

Large Vehicle Traffic

The Savage traffic counter is the only traffic counter that is designed with the capability to classify vehicles (number of axels, length); however, it did not produce reliable data during 2014. This counter uses pneumatic tubes that must be placed on a paved or concrete surface. Therefore, the counter was set up about 100 feet west of the Savage Check Station. It is not clear why the counter was unreliable, but part of the issue may be that vehicle speed is highly variable in this section of road; vehicles are speeding up or slowing down as a result of the check station. Additionally, vehicles may not run over the tubes perpendicular to their placement on the road surface. The park should explore other options for monitoring large vehicle traffic. Weather and road conditions will be a challenge to find a technology that reliably measures large vehicle traffic without having to make substantial commitments in labor. Infrared detectors could be an effective tool. They can be mounted on either side of the road (to a bridge for example) to count and classify vehicles, but they can be negatively impacted by poor weather conditions and dust. Remote cameras could also be used, but this technology requires a great deal of labor to process the photos. There are two primary points of entry onto the road system at night, Savage and Toklat. To accurately monitor night-time traffic volumes and large vehicle traffic, the park should install classifying traffic counters at Savage, and east and west of Toklat.

Hiker Wait Time

Hiker wait times were within standard during the 2014 regulatory season. ROAR observers recorded longer wait times than drivers. This could be a factor in how data were collected by drivers. The park should continue to work with the concessioner to improve the collection of hiker wait times by bus drivers.

Fleet-Based GPS

During 2014, the NPS increased the proportion of vehicles regularly traveling the park road with FMS GPS units to approximately 81%. This was accomplished by installing GPS units in most of the private lodge buses and vans. The remaining approximately 19% of vehicles without GPS units include Teklanika campers, NPS staff, non-bus in-holder vehicles, concessioner non-bus vehicles, professional photographers, and other special road permit holders. Professional photographers and commercial film crews were given portable Garmin GPS to use during the 2014 regulatory season. These data will be used for developing rules of behavior for the traffic scheduling model. To use GPS data to accurately monitor standards, 90-95% of the vehicles traveling the park road on any given day would need to have the units installed and accurately reporting. Achieving the remaining 9-14% would be difficult given the challenges with the current technology. Additionally, the FMS GPS system performed very poorly during the 2014 regulatory season. The system was unreliable, NPS staff had to put in a lot of effort into troubleshooting issues, and the quality of the data (especially for identifying boundaries) was poor. Consequently, the park should discontinue use of the current FMS GPS system for monitoring the standards. NPS and ROAR observations, and traffic counters have proven to be effective tools for monitoring viewscapes, sheep gaps, rest stops, and wildlife stops. These methods should be further improved using the suggestions outlined above in this discussion. The FMS GPS data will be valuable for establishing “rules of behavior” for the different vehicle types (e.g., travel speed, amount of time spent at rest stops) in the traffic schedule model. Assigning realistic attributes to the model using the empirical data is crucial for the development of this tool. As GPS technology improves over time, the park may want to experiment with its use as a monitoring tool in the future.

Management Recommendations

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

- Discontinue use of the fleet-based GPS. Retest the use of GPS when the technology becomes more reliable and the ability to instrument 90% to 95% of the vehicles traveling the road with GPS becomes more attainable.

- Continue to improve NPS and ROAR monitoring strategies to ensure the timing and distribution of observations cover the full range of bus operating hours.

- Test alternative traffic counter technology for classifying vehicles at Savage (Mile 15), east of Toklat (Mile 52.8) and west of Toklat (Mile 60.6). Ideally, these counters will also have the capacity to monitor vehicle spacing at sheep gaps. To do this the counter would need to

capture time-stamped records of individual vehicle passes or the total number of vehicle passes in one-minute bins.

- Install TRS-style traffic counters at Hogan Creek (Mile 21.6) and Igloo Creek (Mile 37.6) to improve monitoring of sheep gaps.
- Schedule night-time construction traffic in a manner that meets night-time and large-vehicle traffic standards.
- Schedule some ROAR observations so that they collect afternoon data west bound to Kantishna, spend the night, and collect early morning data eastbound. Ensure that some Mondays and Fridays are included in the sampling.
- Monitor Rest Stop crowding conditions using ROAR only.
- Improve the timing and increase the number of NPS observations conducted at viewscapes.
- 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.
- Continue to include Terms and Conditions in road access permits to manage for VMP goals and objectives and to stay within or improve compliance with standards.
- Continue to improve the methodology for collecting hiker wait times.
- Monitor travel by professional photographers and commercial film crews using hand-held GPS units during the 2015 regulatory season. Assign blackout dates and reduce permits during known high visitation periods. Provide locations for resting every approximately 30 miles to reduce road travel and mitigate safety concerns. Analyze 2014 and 2015 data for effects of user groups on indicators and effectiveness of management actions on maintaining indicator standards.

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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

Number of vehicles visible at one time in four scenic viewscapes during bus operating hours (Number of vehicles in a 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.

The amount of time a hiker spends waiting to be picked up by a bus (Hiker wait time)	
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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