



Current Condition of Standards from the Denali Park Road Vehicle Management Plan

A Summary Report 2016

Natural Resource Report NPS/DENA/NRR—2018/1608



ON THE COVER

A cyclist explores Polychrome Pass and the expansive eastward views. Photo courtesy W. Clark.

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Natural Resource Report NPS/DENA/NRR—2018/1608

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Abstract

Conditions on six Vehicle Management Plan (VMP) indicators from the Denali Park Road were documented for the 2016 regulatory year (May 28 - September 15, 2016). The six tier-1 indicators are: (1) Number of vehicles stopped at wildlife in the same place at one time (wildlife stops), (2) number of vehicles parked at rest stops at one time, (3) number of vehicles visible in specific viewscales at one time, (4) hourly 10-minute gaps in traffic at sheep crossing locations (sheep gaps), (5) nighttime (2200-0600) traffic rates, and (6) amount of time a hiker waits for a bus (hiker wait time). The method for monitoring standards for a seventh indicator, large vehicle traffic (> 80,000 pounds gross vehicle weight rating), has not been implemented but we include recommendations for future monitoring.

Here we (1) compare current conditions of the VMP indicators to the 1-year VMP standards, (2) use 2013-2016 data to begin assessment of the 5-year VMP standards, (3) assess the efficacy of the current monitoring techniques and make recommendations for improvement, and (4) make recommendations for improving the condition of the resource as measured by the indicators.

Assessment of the 1-year VMP standards:

- 1) Wildlife stop standards were met in all Wildlife Viewing Subzones. In fact, 54% of all wildlife stops ($n = 3,211$) were occupied by a single bus and 28% were occupied by two.
- 2) Rest stop standards for number of total vehicles were met at all sites. Rest stop standards for total number of buses were met at Teklanika but failed at Toklat (>11 buses observed twice) and Eielson (>10 buses observed once).
- 3) Viewscape standards were met at all four sites.
- 4) Sheep gap standards were met at three of five sites. Sites at mile 21.6 and 60.6 maintained 10-minute gaps in traffic 87.8% and 86.0% of the time, respectively, short of the 90% standard. These results are a regression from 2015 but improved from 2014 conditions.
- 5) Nighttime traffic standards were met along – a significant increase in compliance over 2014 and 2015 conditions.
- 6) Hiker wait time standards were met.

One-year standards are less strict than 5-year standards to protect from aberrant years indicting long-term trends to failure. To predict if 5-year standards would be met while using only four years of data we assumed similar sample sizes for the fifth year. The wildlife stop indicator in Subzone 3 will fail the 5-year standard for the percent time that one or fewer vehicles are present at wildlife stops if that indicator's 2017 results are below 82.1%. The highest rate of compliance in subzone 3 to date has been 77.5%, which occurred in 2014. All other wildlife stop indicators are likely to meet 5-year standards. Additionally, all viewscape indicators are likely to meet 5-year standards.

Sheep gap indicators at mile 21.6, 52.8, and 60.6 cannot, and mile 37.6 is unlikely to, meet the 5-year standard. One sheep gap site (mile 68.5) will likely meet the 5-year standard.

Sheep gap results continue to be reported conservatively because they are only measured during the busiest times of day although the VMP defines them as a 24-hour standard. Near-continuous data are collected at the mile 68.5 sheep gap using a battery-operated traffic counter. At mile 68.5, 10-minute nighttime gaps in traffic are common. Data from traffic counters at other locations, away from sheep gap sites, suggest that 10-minute nighttime gaps in traffic are common along the road corridor. Installing traffic counters at other sheep gap sites is planned for 2018. Additionally, we recommend counters be installed at two sites (locations yet to be finalized) co-located with camera traps to monitor the seventh tier-1 indicator, large vehicle traffic.

We increased the field-based data collection effort by an average of 27% from 2015. Ninety percent (37 of 41¹ metrics) of all VMP standards were met in 2016, up from 2015 (88%). Sheep gap success rate continues to be the biggest management challenge and should be first addressed by collecting 24-hour data at sheep gap sites. A sustained effort to keep all road users aware of the unique management strategies of the road is imperative to avoid complacency. The integration of VMP-related Terms and Conditions into commercial use agreements, contracts and operating plans, and road use permits, careful traffic scheduling - particularly nighttime projects, establishing park-approved parking places, and continued internal and external education and outreach are imperative for continued progress toward meeting 100% of the VMP standards.

¹ Beginning in 2016 data collected at the traffic counter located at mile 28.7 (Tek) is not being considered to measure the nighttime traffic standard because it is only 1.6 miles from the next counter, TekGate. While the two counters' proximity is necessary for determining traffic patterns (i.e. how many vehicles turn into Teklanika campground), it is redundant information for traffic disturbance. Each traffic counter location measures two nighttime traffic metrics: percentage of nights with <3 vehicle passes per hour and percentage of nights where no one hour had >6 vehicle passes. Thus, the number of metrics measured henceforth is 41 instead of 43.

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Introduction

For nearly eighty years the Denali Park Road has provided the primary access to Denali National Park and Preserve (Bryant 2011). Beginning at the park entrance, the road travels 92 miles west following the valley that separates the Alaska Range to the south from the Outer Range to the north. While traveling the park road, visitors have the opportunity to observe wildlife species in their natural habitats, view the continent's highest peak, Denali, and access trail-less wilderness hiking and camping.

Most of the park road is one lane and sections of it hang 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 add guard rails and striping. Conservationists, including Adolph Murie, fought to protect the “wilderness atmosphere” of the road. Due to their efforts, the road is only paved to the Savage River Bridge (~ mile 15) and only widened to the Teklanika River (~ mile 31). Westbound visitors cross the Teklanika River Bridge and experience the rustic character of the road that has persisted since 1937.

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 those resources accessible for people to enjoy. That challenge is particularly great in Denali where demand for visitor opportunities to tour the park road is growing but still limited to a single, primitive, 92-mile road (Figure 1).

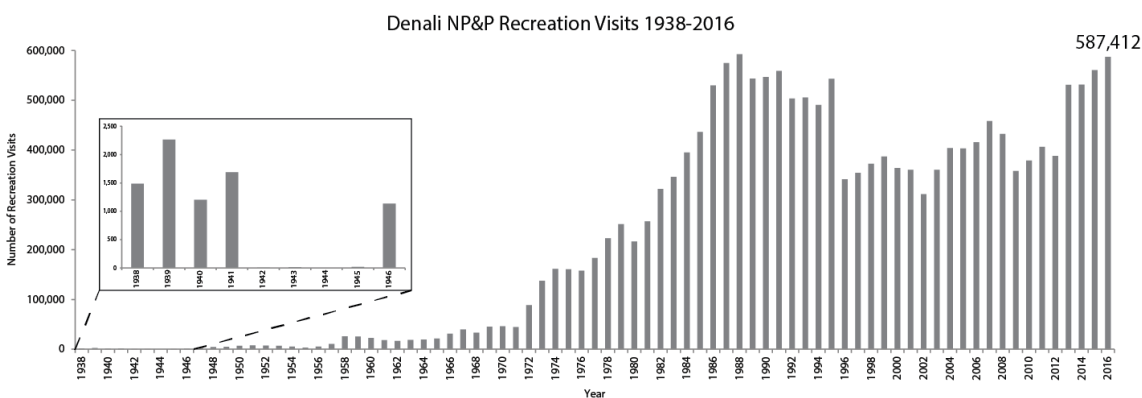


Figure 1. The number of recreation visits has steadily increased since the Alaska Road Commission finished construction of the Denali Park Road for 1938 (Denali National Park and Preserve, Alaska, USA).

To balance these sometimes conflicting responsibilities, in 1972 park managers began 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 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 redefined the regulatory season to the Saturday before Memorial Day through 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 steadily increased. In 2006, park managers, faced with increasing visitation and pressure to maintain or increase the annual vehicle limit, initiated a road capacity study 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 (i.e. metrics) of desired resource and visitor experience conditions and developing quantitative standards (i.e. acceptable measureable levels of the metric) to ensure those conditions were 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*) and 20 Dall sheep (*Ovis 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 sheep, moose (*Alces alces*), and wolves (*Canis lupus*). Traffic data were collected using traffic counters placed at six locations along the park road and wildlife sightings along the park road 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 pattern of vehicle traffic affects the distribution and movements of wildlife, although the effects were not statistically significant, which is consistent with other research (Yost et al. 2001, Jaeger 2005). The clearest indication of negative impacts from

vehicle traffic on wildlife were that Dall sheep increased their rate of movement as they approached the road. Additionally, sheep 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) (Dalle-Molle and Van Horn 1991). 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 movement is important for maintaining the natural movement and habitat use patterns of the park's sheep populations. Results of the road capacity study suggested a reduction in the number of early morning sightings of the big five wildlife species followed higher levels of nighttime traffic (4-7 vehicles/hour). Park policy generally restricts large vehicle traffic (> 80,000 pounds gross vehicle weight rating, GVWR, whereas a typical concessionaire bus is 36,000 pounds GVWR) to nighttime hours only potentially confounding the effect of traffic during nighttime hours and large vehicle traffic.

The results of these wildlife studies helped park managers identify three indicators and define 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 crossing locations; 2) the amount of nighttime (2200-0600) traffic; and 3) the hourly rate of large vehicle traffic.

Qualitative visitor surveys conducted in 2006 were used to identify the following indicators to capture the effects of vehicle crowding conditions on visitor experience: 4) the numbers of vehicles stopped at the same location and time to view wildlife, 5) the number of vehicles simultaneously visible in four iconic viewsapes, 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 experience satisfaction. Survey participants were shown a series of simulated photographs depicting a range of vehicles at wildlife stops, rest stops, and within iconic viewsapes. The results were used to assess the reaction of visitors to increasing levels of crowding and provide management guidance for establishing standards (Manning and Hallo 2010). The goal for setting these standards was to maintain or improve current crowding conditions (i.e. numbers of vehicles).

The concessionaire operates a number of bus types, one of which is specifically for transit, rather than touring. Visitors using transit get on and off the bus to hike or backpack. The effectiveness of the transit system in serving this need can be measured using two metrics. The first metric is the ability of visitors entering the park to purchase a seat on a bus, for which the concessionaire has a system in place to monitor and respond to demand by holding and releasing seats or adding bus routes depending on demand. The second metric is the wait time for hikers to re-board a bus once on the road system to get to a second location or to return to the entrance area. Therefore, a seventh indicator, the amount of time a hiker waits for a bus pick up, was developed to ensure that enough transit buses are adequately scheduled along the length of the park road ensuring available seats.

A Long-term Plan for Managing the Park Road

The VMP was approved in 2012 and was developed to improve management of vehicle traffic during the regulatory year for 15 to 20 years following the next concessionaire contract (NPS 2012). Approval of the VMP commits the park to amend a rule regarding the regulatory yearly vehicle limit

(10,512) with a daily limit of 160 vehicles, which applies only to the controlled section of Denali Park Road (west of the Savage River bridge at mile 14.9); this rule change has yet to take effect and requires replacing language in the U.S. Code of Federal Regulations.

The goals of the VMP are to ensure that visitors have the opportunity for a high-quality experience, wildlife and other park resources are protected, and the unique and historic 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 has been used since the 1970s and promotes flexible decision-making based on new knowledge; evidence-based adjustments are applied to management strategies as results of previous strategies are analyzed and better understood (Holling 1978). Many management plans use adaptive management as a tool due to the uncertainty in complex systems (Johnson 1999, Walters and Holling 1990). The complexity of the behaviors and regulations of Denali Park Road users and the long-term nature of the VMP make it an ideal system to use adaptive management techniques.

The adaptive management strategy in the VMP 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 well-defined indicators and standards (from which this report is derived), (2) monitoring changes in wildlife observations, (3) monitoring changes in wildlife populations using data from other long-term monitoring programs, and (4) conducting Before-After Condition Change Assessment (BACCA) studies. The tier-1 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 both 1- and 5-year (yr) averages. The 1-yr standard is less strict than the 5-yr standard to allow for an aberrant year of increased activity without necessarily causing the 5-yr standard to be exceeded. The results from the comprehensive monitoring program and the BACCA will enable park managers to make empirically-based decisions regarding the transportation system while protecting important park resources and maintaining a high quality visitor experience.

The VMP modifies the boundaries of Wildlife Viewing Subzones (Subzone) previously defined by the Park's 1997 Entrance Area and Road Corridor Development Concept Plan to clarify management objectives necessary for achieving the desired conditions within specific park road segments; three Subzones are defined (Figure 2). Crowding standards (number of vehicles at wildlife stops, number of vehicles at rest stops, and number of vehicles in viewsapes) are established at different levels for each Subzone. Generally, levels of accepted traffic volume decrease westward to preserve the character-defining qualities of the road segment's remoteness (i.e. wilderness character). Managers and visitors alike expect Subzone 1 to have the greatest volume of traffic and consequently, the most crowding. As visitors travel further into the park, the volume of traffic decreases and the standards become more stringent to reflect visitor's expectations for lower crowding conditions.

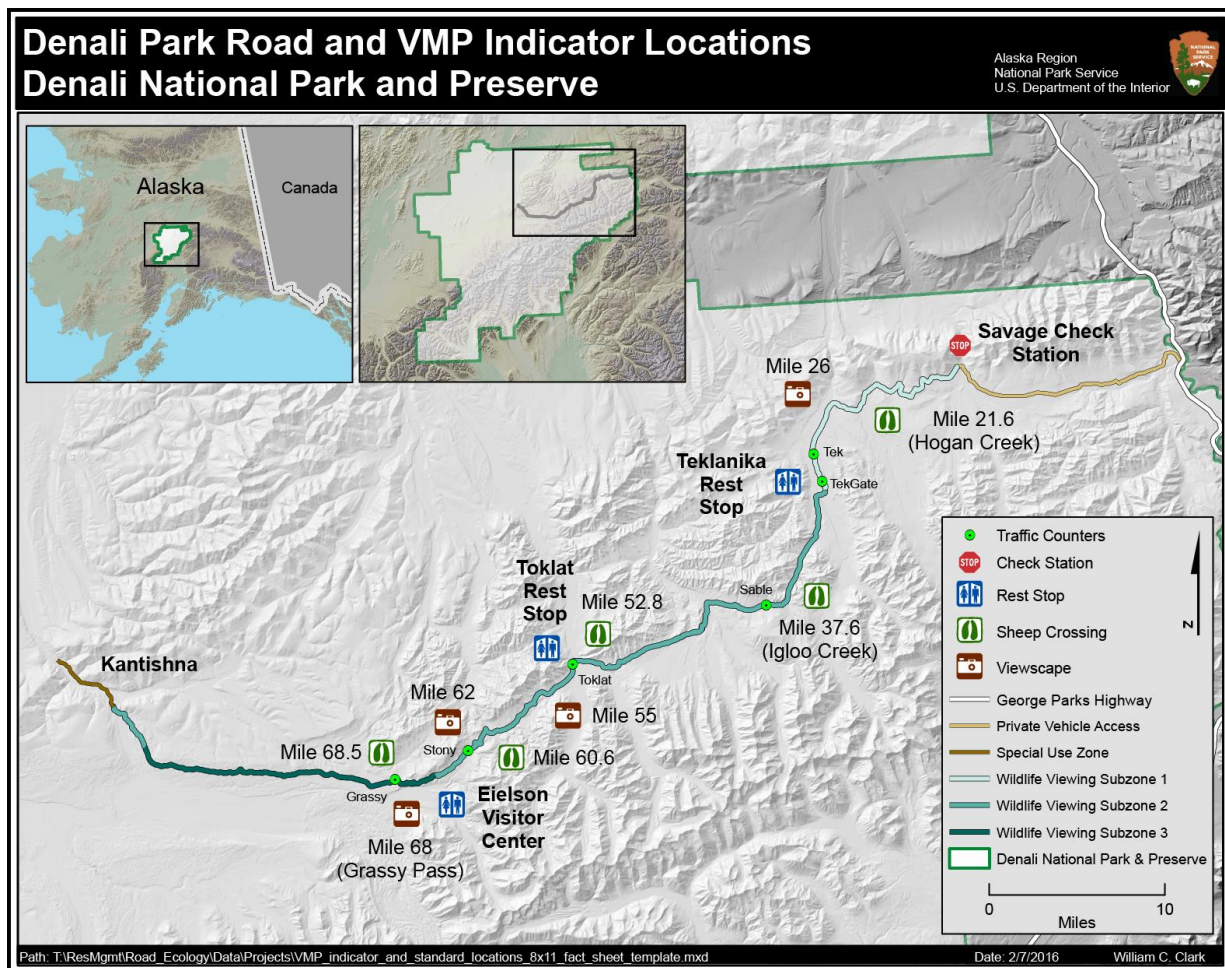


Figure 2. The Denali Park Road corridor traverses the northeast portion of Denali National Park and Preserve, Alaska, USA. There are 12 VMP indicator sites visited by field staff: five sheep gaps, four viewsapes, and three rest stops. VMP standards for wildlife stops and viewsapes vary by Subzone. Six remote, automated traffic counters are also distributed along the road and provide continuous data on traffic volume.

Park staff and volunteers have collected data to assess the current state of VMP indicators to refine monitoring techniques and protocols. The primary objective of this report is to compare the current conditions of the indicators to their defined standards. The results will help inform strategies to adaptively manage travel patterns on the park road through rescheduling, managing vehicle traffic of certain user groups, or modifying driver behavior. This report summarizes data for six of the seven Denali Park Road VMP tier-1 indicators: (1) Number of vehicles stopped at wildlife at one time (i.e. wildlife stops), (2) number of vehicles at rest stops, (3) number of vehicles visible in viewsapes, (4) hourly 10-minute gaps in traffic at sheep crossing locations (i.e. sheep gap spacing), (5) average hourly nighttime vehicle traffic, and (6) hiker wait time. The methodology used to monitor the seventh standard, large vehicle traffic, has not been implemented. Therefore, this report does not include these data. However, recommendations for measuring large vehicles are included at the end of the report.

Indicators and Standards

Indicators are defined at spatially explicit locations between mile 20 and 68 the Denali Park Road (Figure 2). Four indicators have 1- and 5-yr average standards: (1) Number of vehicles at wildlife stops, (2) number of vehicles in a viewscape, (3) sheep gap spacing, and (4) hiker wait time. The remaining indicators have 1-yr standards only (see Appendix A for a table of the tier-1 indicators and 1-yr and 5-yr standards).

Number of Vehicles at Wildlife Stops

Wildlife stops are stochastic events that can occur at any point along the park road. They are defined as one or more vehicles stopped to observe wildlife on the controlled section of road (Figure 3). One or more individual animals, representing one or more species may be present at a given wildlife stop. The most frequent stops are to view caribou, grizzly bears, Dall sheep, moose, and wolves, although vehicles will stop for other species (e.g. ptarmigan, fox, and others). The VMP manages for traffic volume at wildlife stops by establishing thresholds for the number of vehicles stopped to view wildlife in the same location at the same time. The maximum tolerable number of vehicles at wildlife stops varies by Subzone.



Figure 3. Two Lodge buses and one tour bus stop to view a grizzly bear near Stony Dome, Denali National Park, Alaska, USA. The number of vehicles stopped to view wildlife at one time is an indicator used to measure visitor experience quality and protect resources.

A *wildlife event* begins when the first vehicle stops and continues as long as at least one vehicle is present. The wildlife event ends when the last vehicle leaves the animal. Due to staggered bus schedules, it is possible that an animal (i.e. wildlife event) will experience several vehicles in a day while each vehicle may only experience one other vehicle at that animal. To capture visitor experience, the standard for the wildlife stop indicator is evaluated based on each vehicle's

perspective. Monitoring the standard for wildlife stops captures the stop duration and traffic volume experienced by each vehicle present at wildlife events for as long as the observer's bus remains at the event. The total time or total number of vehicles at a wildlife event is not captured in monitoring. Each instance of a wildlife event may have several wildlife stops.

Number of Vehicles at Rest Stops

The VMP manages for traffic volumes at the Teklanika and Toklat rest areas and the Eielson Visitor Center (EVC; collectively called rest stops) by establishing standards for the maximum number of vehicles parked at any one time in these locations (Figure 4). The design standards and capacity for each facility's parking lot were used to inform the VMP standard.



Figure 4. The number of 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 to measure visitor experience quality in Denali National Park and Preserve, Alaska, USA. The standard varies by site and describes a maximum number of buses and a maximum number of total vehicles that can be parked at one time.

Number of Vehicles in Viewscapes

The VMP identified four viewscapes: mile 26, mile 55, mile 62 (Stony Overlook), and mile 68 (Grassy Pass; Figure 5). The standard for each viewscape is based on the social normative curves developed from 2007 visitor surveys (Manning and Hallo 2010) and the desired conditions for visitor experience established for the Subzones where the viewscape is located (NPS 2012). The 1- and 5-yr viewscape standards describe the percentage of time that a threshold number of vehicles are concurrently visible within the viewscape. The threshold changes with respect to both the standard level (i.e. 1- or 5-yr) and Subzone. Viewscapes are small (~1.5-2.0 miles) and finite but are meant to be representative of the traffic volume and patterns of the larger landscape in which they are located; crowding conditions of the Subzone should be reflected within the viewscape metric. In most cases, viewscape metrics represent a conservative measure of visible traffic (i.e. a liberal measure of crowding) because the viewscape sites are in areas with large, broad views of the park landscape. In areas with greater road sinuosity the landscape will obstruct visibility and fewer vehicles are visible.



Figure 5. The number of vehicles visible in each of four viewscape is an indicator used to measure visitor experience quality in Denali National Park and Preserve, Alaska, USA. Arrows indicate the end points of the viewscape. The standard varies by Subzone and is described by a minimum percentage of time that fewer than a threshold number of vehicles are visible at one time.

Sheep Gap Spacing

The VMP identified five locations that are important for the movement of sheep and other wildlife: mile 21.6 (Hogan Creek), mile 37.6 (Tattler Creek), mile 52.8, mile 60.6, and mile 68.5 (Grassy Pass, Figure 6). Although all points along the park road may be used during seasonal migrations and/or for within-season movements between adjacent habitats, these monitoring locations represent key points along the road to monitor vehicle traffic patterns that may influence wildlife movement. 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 (Dalle-Molle and Van Horn 1991). Sheep gaps have both 1- and 5-yr standards. The 1-yr standard requires at least one 10-minute gap in traffic per hour in 22 of 24 hours (90%); the 5-yr standard requires a gap on average for 23 of every 24 hours (95%).



Figure 6. The spacing of traffic at five sheep crossing locations (i.e. sheep gaps) is used as an indicator to measure desired resource protection efforts along the Denali Park Road (Denali National Park and Preserve, Alaska, USA). Arrows indicate the monitoring reference point. The standard is a minimum percentage of hours that contain at least one 10-minute gap in traffic.

The indicator and its standard were established to balance the need to allow natural movement and seasonal migratory patterns to persist with the desire to minimize unnecessary restrictions on vehicle traffic, which could displace visitors. The sheep gap monitoring locations were established to encourage scheduling such that there are breaks in traffic along the entire length of the controlled section of the park road. Like viewscapes, sheep gaps are meant to be representative of the traffic volume and patterns of the larger landscape in which they are located; crowding conditions of the Subzone should be reflected within the sheep gap metric. Together, the sheep gap locations should

provide a representative sample of the gaps in traffic along the controlled portion of the road corridor.

Nighttime Traffic

The VMP includes an indicator designed to reduce the impact of nighttime traffic on the following morning's wildlife sightings. The indicator evaluates nightly average and peak traffic rates and is defined as the number of vehicles traveling on the park road during nighttime hours (2200-0600). The standard is an average of three or fewer vehicles per hour (total west and eastbound) per night and a separate standard of no more than six vehicles in any one hour. The standards are mutually inclusive and both are to be met at least 95% of the time. Nighttime traffic standards are measured using automated traffic counters. Traffic counters are installed at six locations, however only five sites are used for nighttime traffic analysis: TekGate, Sable, Toklat, Stony, and Grassy (Figure 2). Tek28 is used to monitor traffic pattern and not to infer impacts on wildlife in its section of roadway, which should be captured by TekGate, less than two miles west.

Hiker Wait Time

The amount of time a hiker wait to be picked up by a bus measures how well the transit service is meeting visitor demand in its primary function. A "hiker" is defined as a passenger that disembarks a transit bus and later attempts to re-embark a transit bus to continue traveling or return to the park entrance area. The VMP established 1- and 5-yr standards for hiker wait time, representing the proportion of hikers waiting less than 30 minutes, less than 60 minutes, and less than 90 minutes to be picked up by a bus. The VMP prioritizes meeting the demand for transit services over concessionaire tour and charter services.

Large Vehicle Traffic

Work by park scientists show a general positive, direct relationship between GVWR and noise. Noise (i.e. non-natural sound) is well documented to cause negative effects on the health of animals and animal populations (Barber et al. 2010). The large vehicles (> 80,000 GVWR) VMP indicator is a measure to mitigate negative impacts from vehicle noise on wildlife. The standard is defined as < 5 large vehicles per hour. "Large vehicle" is defined by weight rather than dimension, requiring a weighing system to evaluate this standard. This is a practical challenge for a remote gravel road underlain with discontinuous permafrost and has not been fully implemented.

Methods

Study Area

Denali is 2.4 million hectares and located in interior Alaska between Anchorage and Fairbanks (Figure 2). Most visitors access the park via the 92-mile road that connects George Parks Highway to the former mining community of Kantishna. The Denali Park Road (henceforth, 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. Spruce (*Picea mariana*), scrub shrub dwarf birch (*Betula nana*), and willow (*Salix* spp.) dominate the habitat along the park road. Mountain avens (*Dryas integrifolia*), graminoids, and sedges dominate higher elevation tundra. Denali has a subarctic climate: short, cool summers with an average minimum of 0°C and average maximum of 24°C (Western Regional Climate Center 2007). Annual precipitation averages 38 cm, over half of which occurs during the summer months. Snow cover is generally present from October through early May (Sousanes and Hill 2014). Due to the high latitude, daylight varies during the year from more than twenty hours in June to four hours in December. Visitation exceeds 500,000 annually.

Park Road User Groups

The park road has a diverse set of users and as such, a diverse set of permitting and access policies. The park concessionaire, Doyon/Aramark Joint Venture (JV), operates basic bus services (Visitor Transit System; VTS) and value-added tours (Tour). Together, VTS and Tours account for the majority of park road traffic. Three private lodge companies operate from Kantishna in-holdings and use buses to transport guest and supplies: Camp Denali, Denali Backcountry Lodge, and Kantishna Roadhouse (collectively, Lodge). In addition, employees drive the road in government-owned vehicles (GOV) for various purposes including road maintenance, visitor protection, interpretive programs, and resource management. All other travelers of the controlled segment of the road apply for, obtain, and display a purpose-specific permit for their personally operated vehicle (POV). POV permits include: private property right-of-ways, professional photographers/filmmakers, employee access to within-park duty stations, contractors, NPS-approved (includes researchers), and Teklanika Campground permits.

Data Collection

Overview

We collect vehicle data using: (1) a protocol conducted by NPS staff from a government vehicle (NPSO), (2) a protocol conducted by NPS staff and volunteers from a VTS bus, a program called Ride, Observe, and Record (ROAR), and (3) remote, battery-operated traffic counters. The regulatory year is divided into three monitoring subseasons to ensure stratification: early, peak, and late. Subseasons are defined by changes in the VTS bus schedule. For 2016 the subseasons were: early season: May 28-June 15, peak season: June 16-August 3, and late season: August 4-September 15. Peak season coincides with the highest level of park visitation and park road transit. We collected data at 18 sampling sites: six traffic counter locations, five sheep gaps, four viewsapes, and three rest stops.

NPS Observations (NPSO)

NPS staff collected data of viewscape and rest stop traffic volumes and sheep gap spacing at sites along the controlled portion of the park road using the NPSO Protocol. NPSO were conducted on one- or two-night stays in the park. We planned NPSO using a random number generator (RNG; www.random.org) to generate the observation start date based on a Julien Day calendar (e.g. a result of 202 created a July 21-22 observation period) and the location of the overnight stay.

We aim to have data to address both fine- (day of week) and coarse-scale (month of season) temporal trends and patterns. Thus, if a particular day of week went without sample we modified RNG results. Additionally, we modified RNG results to ensure observations during peak visitation periods because many VMP standards are based on maximum values: Memorial Day weekend (May 28-30), Independence Day (July 2-4), the Kantishna Music Festival (August 19-21), and Labor Day weekend (September 3-5).

Within subseason, NPS staff sampled during five hour blocks for each of the 12 non-traffic counter sites (traffic counters collect continuous data): 0600-0900, 0900-1200, 1200-1500, 1500-1800, and 1800-2200. These blocks cover the entirety of the concessionaire bus operating hours. We attempted to sample each site (12) during each hour block (5) at least twice during Early season and three times during Peak and Late season. Geography (e.g. transit time between sites) and scheduling logistics (e.g. efficiency considerations) prevent truly randomized sampling within the daily sampling blocks.

Ride, Observe, and Record (ROAR)

ROAR observers recorded data at wildlife stops, rest stops, and hiker pickups during trips along the park road. We stratified observations proportionally to the VTS schedule using early- (before 0930), mid- (0930-1230), and late-day (after 1230) start times. Additionally, we collected overnight ROAR trips to sample eastbound camper buses that depart early mornings from Wonder Lake heading east. ROAR trip destinations were Toklat, the EVC, Wonder Lake, and Kantishna. For simultaneous observations from a ROAR and NPSO observer at the same rest stop, one observation was discounted from analysis.

ROAR observations were recorded as features in a NPS application (app), Park Observer, using Apple iPads and iPad Minis (Apple Inc., Cupertino, CA USA). Observations were assigned a unique identifier and stored in a relational geodatabase format (FGDB) using in-house Python scripts. All features include geographic coordinates (WGS84), date, and local and UTC time. Additionally, at wildlife stops we recorded species, number of individuals, sex and age (when practicable), and distance from the road. Distance was determined using range finders (Nikon Aculon 6x20, Bushnell Elite 1500, or Legend 1200). At rest stops, we recorded rest stop name and the maximum number of vehicles parked, by vehicle type, upon the observer's arrival and departure. Four hiker wait time attributes were recorded for each feature: if the bus had available seats, if the bus picked up the hikers, the number of hikers picked up, and hiker wait time. Data were quality controlled in ArcGIS using spatial and attribute queries then linearly referenced to the park road using the geoprocessing tool *Locate Features Along Routes*.

Traffic Counters

Six traffic counters are programmed to collect continuous data during the regulatory year. Five counters parsed data into 10-minute bins, the sixth counter, Grassy Pass, parsed data into 1-minute bins (finer resolution) to also monitor the nearby sheep gap (mile 68.5).

Supplemental Data

The concessionaire provided hiker wait time data collected by VTS bus drivers and EVC dispatch staff. Additionally, the concessionaire provided daily bus manifests with route, driver, departure information, and passenger manifests including roadside pick-ups and drop-offs. These data were used for cross referencing and data quality control.

Indicators and Standards

Number of Vehicles at Wildlife Stops

The standard for the wildlife stop indicator was assessed using ROAR data. Observers recorded the maximum number of vehicles and classified the vehicles: Tour, VTS, Lodge, GOV, or POV.

Observers on buses counted every vehicle present at the wildlife stop including the bus on which they were travelling. Observers driving a government vehicle counted all vehicles except their own to avoid artificially inflating the number of vehicles present.

Often, two ROAR observers were in the field on the same day and overlapping time. To reduce pseudo-replication, same-day observations of the same species occurring within a three minute window and less than ½ mile apart and collected by different observers were considered duplicate observations. Only one duplicate was chosen to include in analysis based on data quality (e.g. completeness). When data quality was equal the record considered duplicate was chosen at random and discounted.

Wildlife data were summarized in Excel (Microsoft, Redmond, WA, USA). Calculations for the proportion of observed instances when traffic volumes met the wildlife standards within a Subzone defined in the VMP were calculated as:

$$\frac{\text{number of wildlife stops with } < \text{threshold number of vehicles}}{\text{total wildlife stops}}.$$

The normalization calculation for the number of wildlife stop density by Subzone was calculated as:

$$\frac{\text{number of wildlife stops within a Subzone}}{\text{Subzone length (miles)}}.$$

The 5-yr VMP standards were calculated as averages:

$$\overline{X_5} = \frac{\sum X}{N} = \left(\frac{\text{sum of successful observations}}{\text{total samples of 5 year period}} \right)$$

Where: X_5 is a five-year moving window.

This year, in the equation above, $X_5 = X_4$ because there were only four years of data to consider.

Number of Vehicles at Rest Stops

We used NPSO and ROAR data to assess crowding conditions (maximum vehicles and maximum buses) at three rest stops (Figure 4.). Based on NPSO, we recorded the maximum number of vehicles (by type) parked at the rest stop at the same time within 2-minute intervals for a period of 20 minutes (10 observations). This is distinct from recording a tally or count of all vehicles within the rest stop during each 2-minute interval. Vehicles must have been parked in the rest stop at the same time to count toward a maximum during a 2-minute interval. Composition of vehicles is recorded during the first instance of the vehicle maximum within a 2-minute interval and not changed if that maximum occurs another time within the same 2-minute interval. Thus, the composition of the maximum reflects that of the first instance of the maximum for that interval.

ROAR observers recorded numbers of vehicles upon their arrival and departure of the rest stop. For both ROAR and NPSO protocols, vehicles were classified using seven categories: Tour, VTS, Lodge bus, GOV, POV, heavy equipment, and maintenance. ROAR observers included the bus in which they were traveling in the vehicle count. NPSO protocols exclude the vehicle in which they were traveling because the vehicle is present only for monitoring. Thus, zero values are possible using the NPSO protocol. Zero values are not considered in analysis because this standard is based on visitors' experience and perception of acceptable levels of crowding. If there are no visitors there is no visitor experience to observe.

Rest stop data were summarized by site and vehicle category and maximum vehicle counts, averages, and standard deviations were calculated. Rest stop data were also analyzed by day-of-week, week-of-year, hour block, and subseason to examine temporal trends and patterns at each site. Temporal analyses were examined on a per-observation basis using the calculation:

$$\frac{\text{number of vehicle observations}}{\text{total number of observation periods}}$$

Rest stop data are not continuous counts but maximums within 2-minute bins. Thus, temporal analyses only provide a relative sense of traffic pattern. Relative traffic at a rest stop is calculated by

$$\frac{\text{number of vehicles recorded}}{\text{total number of observations}}$$

Appendix B of the report includes temporal analyses.

Number of Vehicles in Viewscapes

We assessed the viewscape standard using the NPSO protocol at four sites (Figure 5). Observers recorded the composition and maximum number of vehicles travelling within the viewscape at the same time during 2-minute intervals for a period of 20 minutes (10 observations). This is distinct from recording a tally or count of all vehicles that travelled through the viewscape during each 2-minute interval. Vehicles must have been visible within the viewscape at the same time to count toward a maximum during a 2-minute interval. Composition of vehicles is recorded during the first instance of the vehicle maximum within a 2-minute interval and not changed if that maximum occurs another time within the same 2-minute interval. Thus, the composition of the maximum reflects that of the first instance of the maximum for that interval.

Viewscape data were summarized by site. Tour, VTS, and Lodge bus categories were used to determine total bus count. Zero values are included in viewscape analyses because visitors may see no vehicles in the landscape. Calculations for the proportion of observed time when traffic volumes met the viewscape standards within a Subzone at a viewscape site were calculated as:

$$\frac{\text{total observed time with } < \text{threshold number of vehicles}}{\text{total observed time}}.$$

Viewscape data were examined by day-of-week, week-of-year, hour block, and subseason to analyze temporal trends and patterns at each site. Temporal analyses were examined on a per-observation basis. Viewscape data are not continuous counts but maximums within 2-minute bins. Thus, temporal analyses only provide a relative sense of traffic pattern. Results of viewscape temporal analyses are included in Appendix B of the report and calculated in two ways that reveal slightly different results:

1. (for a time period: $\frac{\text{number of vehicles recorded}}{\text{number of samples}}$) – e.g. average number of vehicles recorded by month.
2. (for a time period: $\frac{\text{maximum vehicles of observation}}{\text{number of observations for the time period}}$) – e.g. average maximum value recorded by month.

Sheep Gap Spacing

We assessed the standard for the sheep gap indicator using the NPSO protocol at five sites in addition to using the Grassy Pass traffic counter at one of those sites (Figure 6). Using the NPSO protocol, sheep gaps were monitored for between 10 and 60 minutes. The length of observation depended on traffic conditions. Once a 10-minute period passed with no vehicles, the observer recorded that a successful gap occurred. Observers remained at the site for an additional 10 minutes or until the next vehicle passed to get a better assess true gap length.

Observers record to the second when vehicles pass a reference point. For each site, the number of hours monitored that included a minimum of one 10-minute break in traffic at sheep gaps was tallied in Excel. The proportion of observed time when traffic volumes met sheep gap standards was calculated as:

$$\frac{\text{number of hours a 10-minute gap in traffic was achieved}}{\text{total number of hours observed}}.$$

The Grassy Pass traffic counter was programmed to collect data in 1-minute bins. This counter is located adjacent to a sheep gap location and was used to attain continuous, 24-hr monitoring. In this dataset, a gap was defined as at least ten 1-minute bins without traffic within the same hour block (e.g. during the 0900 or 1300 block). The percentage of hours meeting the standard was calculated using the same method as NPSO data.

NPSO sheep gap data were analyzed by day-of-week, week-of-year, hour block, and subseason to find temporal trends and patterns at each site. Temporal analyses were examined using graphs and contingency tables, where the rejection of the null hypothesis (H_0) indicated a temporal pattern other than random between maintenance of 10-minute gaps and the period examined.

Nighttime Traffic

Six International Road Dynamics Inc. Traffic Recording System (TRS; Saskatoon, Canada) 8-Loop inductive loop traffic counter assets were installed along the park road: Tek (mile 28.7), TekGate (mile 30.4), Sable (mile 39.6), Toklat (mile 53.6), Stony (mile 63.4), and Grassy (mile 68.8; Figure 2). TRS traffic counters detected a signal of magnetic interference from passing vehicles and records count and headway (direction of travel). Westbound and eastbound traffic were recorded in 10-minute bins; the Grassy counter recorded vehicle passes in 1-minute bins. The data collection period for Tek, TekGate, and Sable was May 23-September 15 inclusive and for Toklat, Stony, and Grassy was June 1-September 15 inclusive. Calculations for the proportion of nights when traffic rates at each traffic counter site met the nighttime traffic standards were calculated as:

$$\frac{\text{nights of } < 3 \text{ vehicle passes per hour}}{\text{total nights sampled}} \text{ and } \frac{\text{nights with zero hours of } > 6 \text{ vehicle passes}}{\text{total nights sampled}}.$$

All data were considered to analyze traffic volume and averages. Only periods of collection when all counters were functioning were considered when examining park-wide trends and patterns. The VMP considers this indicator only on a pass/fail basis along the whole length of road (i.e. not on a per data collection site basis – e.g. Toklat vs. Sable). However, we assert that failures at one location do not convict other locations to failure if the offending traffic volume does not propagate to the other locations. The spatial context of nighttime traffic is important because the sound disturbance is inherently spatial.

Hiker Wait Time

We used data from the EVC dispatch, VTS manifests, and ROAR observations to evaluate hiker wait time standards. Visitors who altered the standard out-and-back schedule or hikers using the EVC as a transit hub were coordinated by an EVC dispatcher who tracks their wait time.

VTS bus drivers picked up hikers at any point along the road beyond mile 17. Drivers maintained a manifest and recorded the number of passengers that got on and off the bus, how long hikers estimated that they waited for a bus to pick them up (< 30 min, < 60 min, < 90 min, or ≥ 90 min), and where pick-ups and drop-offs occurred along the road. Pick-ups and drop-offs were recorded in 12 road segments (e.g. Teklanika rest stop to Tattler Creek) and two nodes (Toklat and EVC) each with separate westbound and eastbound records.

ROAR observers recorded hiker wait time while traveling the park road on VTS buses. The methods are described above. Calculations for the proportion of observed instances when hiker wait times met the standards defined in the VMP were calculated as:

$$\frac{\text{instances of wait time category (i.e. } < 30 \text{ minutes)}}{\text{total number of wait times}}.$$

Beginning in 2015, ROAR observers recorded the instances when a bus was full and unable to pick up waiting hikers.

Results

Data Collection Effort

We sampled 297 VTS and Tour trips using the ROAR protocol and 24 trips spanning 58 days using the NPSO protocol. We increased sample sizes between 18% (viewscales) and 48% (hiker wait time) compared to 2015.

Of the 297 ROAR observations, 254 were conducted from a VTS bus, four from a Tour bus, and 39 from a GOV vehicle. Observations closely matched the schedule for the early and peak subseasons, observations drifted further from target values in the late subseason (Table 1).

Table 1. The distribution of ROAR observations compared to the 2016 VTS schedule on the Denali Park Road (Alaska, USA). The target proportion of observations was in Early and Peak subseasons; variance increased in Late subseason. The bus concessionaire offers several different VTS schedules as demand fluctuates through the summer season.

Time Period	Location	Proportion of Trips		<i>n</i>
		ROAR observations (actual)	VTS schedule (target)	
Early 2015 (May 23-June 17) (26 days)	Toklat	35.3	35.2	12
	EVC	44.1	44.4	15
	Wonder Lake	11.8	13.0	4
	Kantishna	8.8	7.4	3
Peak 2015 (June 18-August 6) (49 days)	Toklat	14.5	16.7	18
	EVC	48.9	44.8	65
	Wonder Lake	23.3	24.1	31
	Kantishna	14.3	17.2	19
Late 2015 (August 7-September 15) (41 days)	Toklat	12.2	11.9	9
	EVC	44.6	46.3	33
	Wonder Lake	29.7	28.4	22
	Kantishna	13.5	13.4	10

We completed 115 NPSO samples during the Early subseason (19 days). Each site was sampled an average of 1.9 times. One site, mile 21.6 sheep gap, was not sampled during the Early subseason. We completed 56 ROAR samples during the Early subseason. During the Peak subseason (48) we completed 297 NPSO samples, each site at least four times. We sampled 73 times using the ROAR protocol during the Peak subseason. We collected 257 samples during the Late subseason (43) using the NPSO protocol (each site at least three times), and 31 ROAR samples.

Number of Vehicles at Wildlife Stops

ROAR observers recorded 3,261 wildlife stops. Eighty-one percent of wildlife stops occurred in Subzone 2, 13% occurred in Subzone 1, and 7% occurred in Subzone 3. Subzone 2 is the most animal-rich road segment (Table 2).

Table 2. The number of ROAR observations recorded in three Subzones during the 2016 regulatory year on the Denali Park Road (Denali National Park and Preserve, Alaska, USA). The number of stops was normalized to Subzone lengths (miles) to report stops per mile. Subzone 2 is the most animal-rich Subzone in the park.

Stop Type	Subzone 1	Subzone 2	Subzone 3
number of wildlife stops	412	2,635	214
stops per mile	19.6	69.1	11.5

All wildlife stop measures met VMP standards (Table 3). Wildlife stops were slightly more crowded in 2016 compared to 2015. There were fewer instances of wildlife stops with one vehicle present (54.7% – down 2.7% from 2015) and more with two vehicles present (28.1% up 1.4% from 2015). A maximum of seven vehicles was observed six times in 2016 (all in WSV2) compared to only one instance of seven vehicles observed in 2015.

Table 3. Traffic volume conditions measured as a percentage of wildlife stops that x or fewer ($\leq$) vehicles were observed at a wildlife stop at Denali National Park and Preserve, Alaska, USA. All wildlife stop standards in each of the three Subzones were met in 2016. However, compared to 2015, most observed wildlife stops were slightly more crowded. Green up arrows indicate less crowded compared to 2015, red down arrows indicate more crowded.

Method	Wildlife Subzone 1			Wildlife Subzone 2			Wildlife Subzone 3		
	% $\leq$ 3 vehicles	% $\leq$ 4 vehicles	% $\leq$ 5 vehicles	% $\leq$ 2 vehicles	% $\leq$ 3 vehicles	% $\leq$ 4 vehicles	% $\leq$ 1 vehicles	% $\leq$ 2 vehicles	% $\leq$ 3 vehicles
Standard	70	85	90	70	85	90	70	85	90
ROAR result	95.8	98.8	99.5	81.9	92.9	97.5	71.3	92.3	99.0
% Vs. 2015	↑ 3.8	↑ 1.9	↑ 0.1	↓ 2.0	↓ 1.7	→ 0.0	↓ 2.3	↓ 2.2	↓ 1.0

Number of Vehicles at Rest Stops

We collected 2,469 traffic volume samples using the ROAR protocol and 172 20-minutes samples using the NPSO protocol at Teklanika, Toklat, and the EVC rest stops. Rest stops exceeded standards three times – all while using the ROAR protocol. The bus maximum standards were exceeded at Toklat twice and Eielson once (Figure 7, Figure 8, Figure 9). Exceedances at Toklat occurred on Saturday, July 30th (21:07) and Sunday, August 4th (11:46). The maximum allowable number of buses (11) was observed once at Toklat on August 9th (11:52). The exceedance at Eielson occurred on August 25th (19:25) composed of eight VTS and three Lodge buses (Table 4). The EVC had the

highest average number of buses observed and the highest maximum and average number of all vehicles combined (

Table 5,

Table 6). There is a systematic increase from the NPSO to the ROAR protocol in the observed maximum number of buses, maximum total vehicles, and their averages at each rest stop.

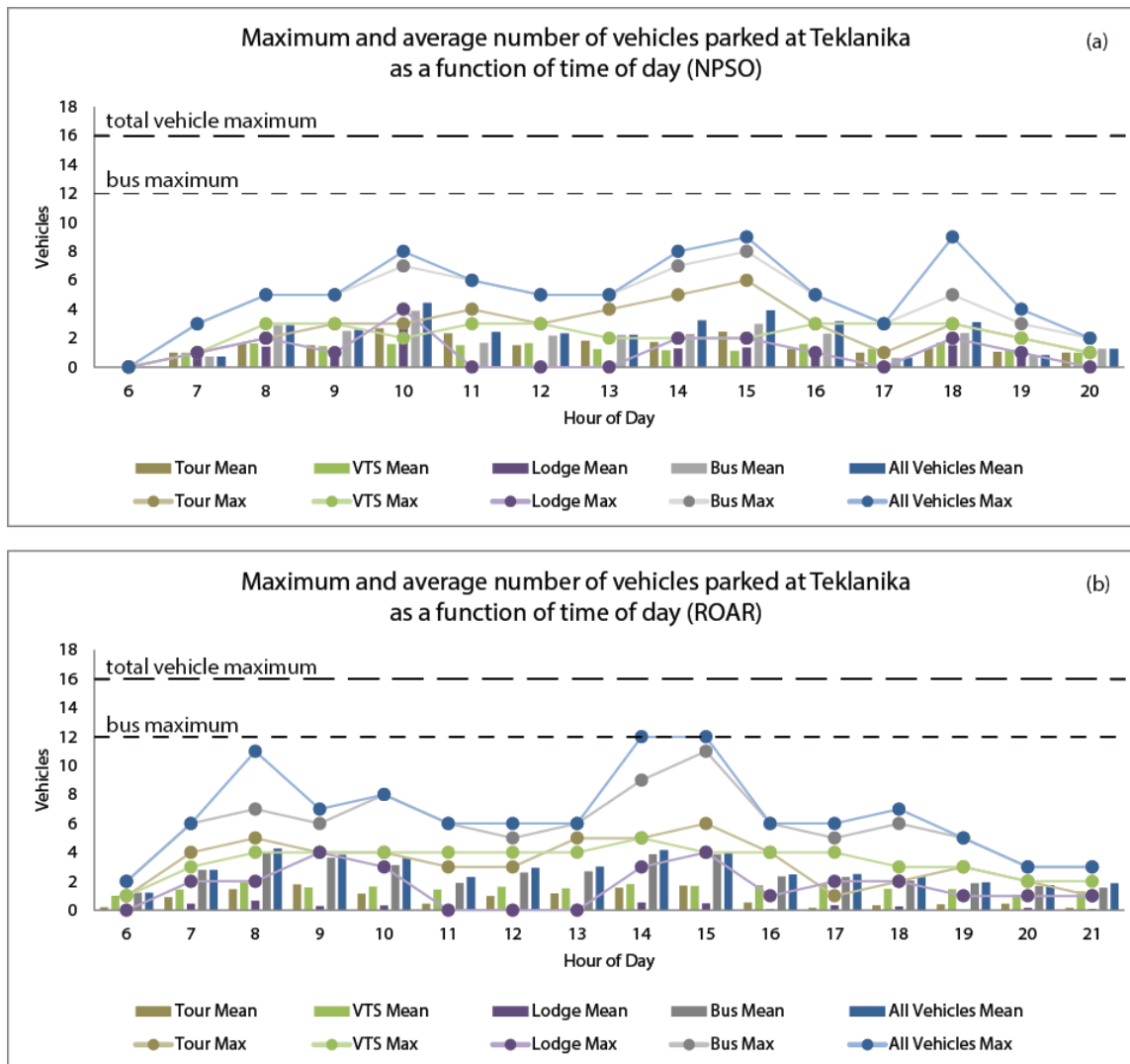


Figure 7. Maximum and average number of vehicles parked at the Teklanika rest stop based on the NPSO (a) and ROAR (b) protocols used at Denali National Park and Preserve, Alaska, USA. Both total bus and total vehicle maximums at the Teklanika rest stop met VMP standards for 2016.

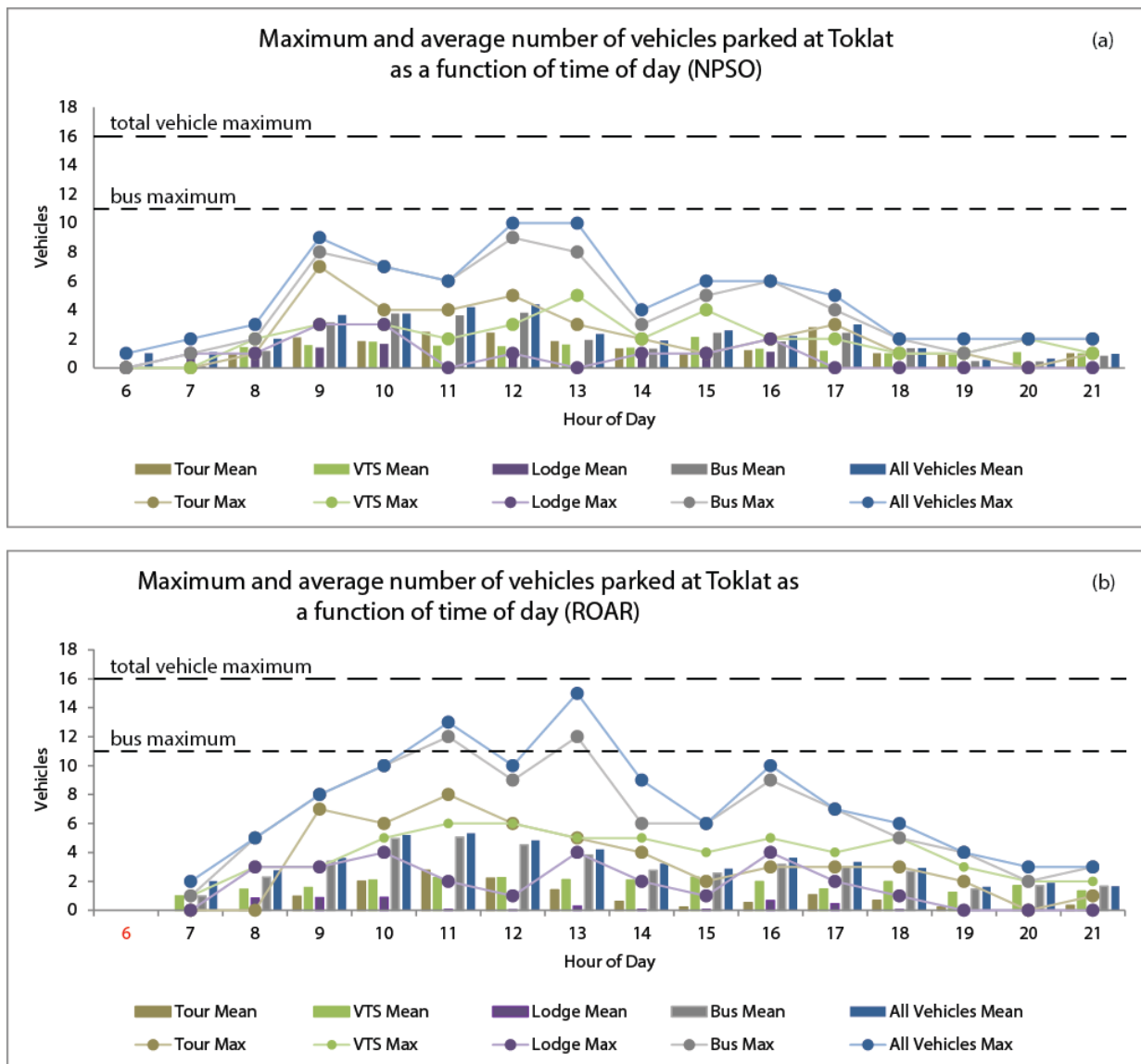


Figure 8. Maximum and average number of vehicles parked at the Toklat rest stop based on the NPSO (a) and ROAR (b) protocols used at Denali National Park and Preserve, Alaska, USA. The total bus and total vehicle maximums met VMP standards as measured by the NPSO protocol but the total bus maximum exceeded VMP standards as measured by the ROAR protocol at the Toklat rest stop. The total bus maximum was exceeded twice during observations: Saturday, July 30 at 21:07 and Sunday, August 4 at 11:46. Red hour blocks on the x-axis indicate the time was not observed (i.e. no data available).

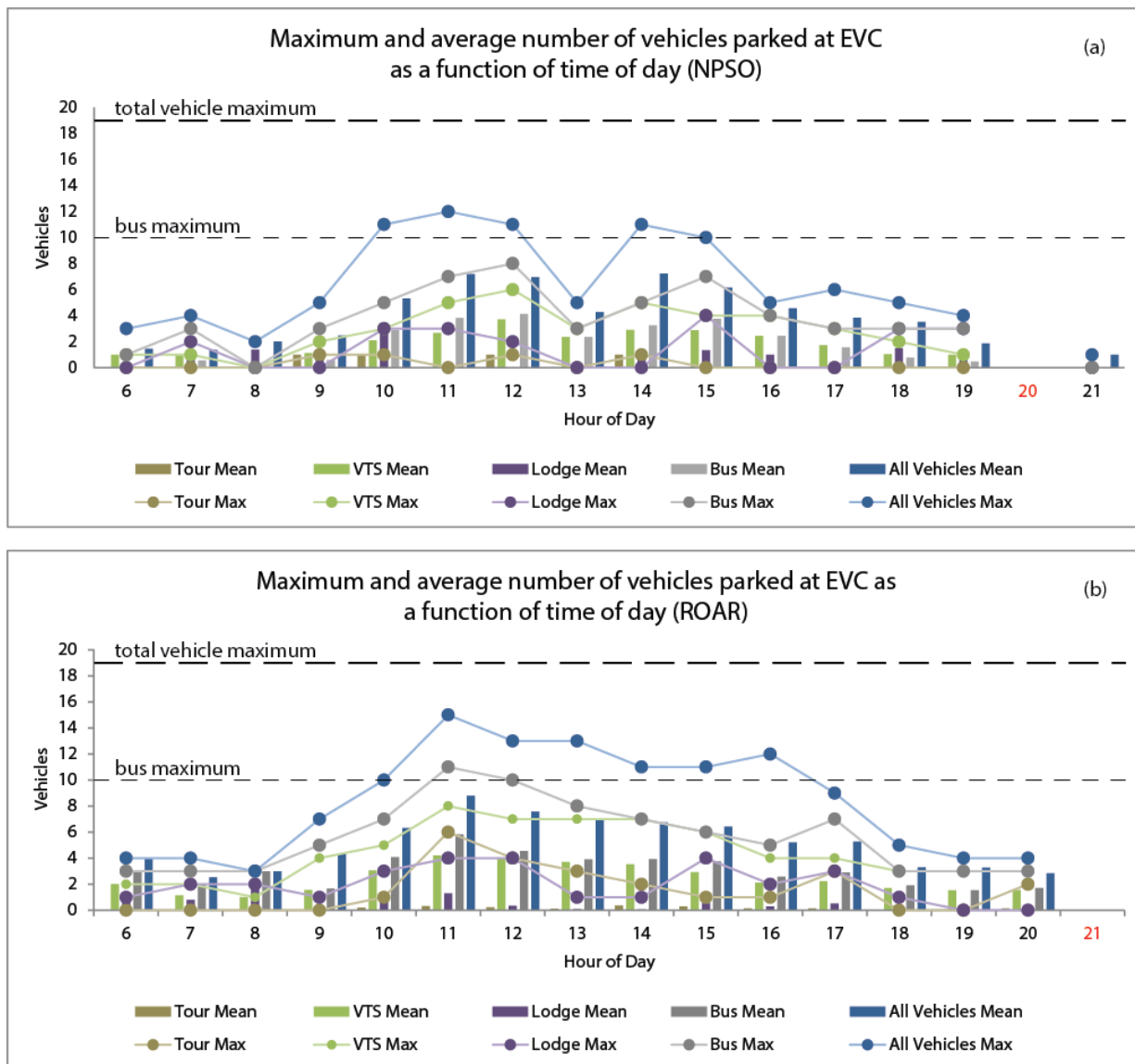


Figure 9. Maximum and average number of vehicles parked at the Eielson Visitor Center (EVC) based on the NPSO (a) and ROAR (b) protocols used at Denali National Park and Preserve, Alaska, USA. The total bus and total vehicle maximums met VMP standards as measured by the NPSO protocol but the total bus maximum exceeded VMP standards as measured by the ROAR protocol at the EVC. The total bus maximum was exceeded once during observations: Thursday, August 25 at 19:25. Red hour blocks on the x-axis indicate the time was not observed (i.e. no data available).

Analysis of day-of-week and week-of-year show few trends at any rest stops (Appendix B Figure 1, Appendix B Figure 2). At Teklanika and Toklat there is an increasing trend in relative traffic from Sunday to Saturday; relative traffic at EVC is consistent through days. Additionally, there is a spike in maximums at Toklat during the weeks beginning 24-July and 31-July.

Table 4. Maximum recorded number of buses and vehicles parked at one time at the Teklanika and Toklat rest stops and the Eielson Visitor Center (EVC) during the 2016 regulatory year on the Denali Park Road (Denali National Park and Preserve, Alaska, USA). Rest stop standards failed the maximum number of buses allowed at both Toklat and the EVC as observed using the ROAR protocol.

Method	Teklanika			Toklat			EVC		
	bus max	vehicle max	<i>n</i>	bus max	vehicle max	<i>n</i>	bus max	vehicle max	<i>n</i>
Standard	12	16	–	11	16		10	19	–
NPSO result	8	9	570	9	10	600	8	12	550
ROAR result	11	12	960	12	15	904	11	15	605

Table 5. Mean (standard deviation, σ) number of total buses parked at one time at the Teklanika and Toklat rest stops and the Eielson Visitor Center (EVC) during the Denali Park Road (Alaska, USA) 2016 regulatory year. ROAR data were consistently greater than NPSO data; the most buses were observed at the EVC.

Method	Teklanika		Toklat		EVC	
	mean (σ)	<i>n</i>	mean (σ)	<i>n</i>	mean (σ)	<i>n</i>
NPSO result	1.9 (± 1.7)	570	2.0 (± 1.8)	600	2.0 (± 1.8)	550
ROAR result	2.9 (± 1.6)	960	3.6 (± 2.0)	904	3.9 (± 1.8)	605

Table 6. Mean (standard deviation, σ) number of total vehicles parked at one time at the Teklanika and Toklat rest stops and the Eielson Visitor Center (EVC) during the 2016 regulatory year on the Denali Park Road (Denali National Park and Preserve, Alaska, USA). The margin of difference between EVC and Toklat grows considerably when we considered mean total vehicles compared to mean total buses. The EVC frequently has non-bus traffic because it is the duty station for several park employees. The standards for the number of total vehicles parked at rest stop were met in 2016.

Method	Teklanika		Toklat		EVC	
	mean (σ)	<i>n</i>	mean (σ)	<i>n</i>	mean (σ)	<i>n</i>
NPSO result	2.3 (± 2.0)	570	2.4 (± 1.9)	600	4.4 (± 2.6)	550
ROAR result	3.2 (± 1.8)	960	3.9 (± 2.1)	904	6.6 (± 2.5)	605

Number of Vehicles in Viewscapes

We collected 221 20-minute viewscape observations in 2016 at mile 26 ($n = 54$), mile 55 ($n = 58$), mile 62 ($n = 56$), and mile 68 ($n = 53$). The VMP standards for vehicle visibility in each of the four viewscales were met at all sites (Table 7). The highest maximum observed (five vehicles) was at mile 55 during the 1100 and 1400 hours blocks; the highest average maximum (1.7) for the season also occurs at mile 55 during the 1000 hour block (Figure 10). However, observations from mile 26 showed the highest maximums averaged over the daytime period (0600 – 2200). Mile 68 observations showed the lowest average maximum number of vehicles and least variability ($\sigma = 0.5$).

Peaks in volume were common at 1100 (3 of 4 sites); observed traffic is relatively limited at mile 62 and 68.

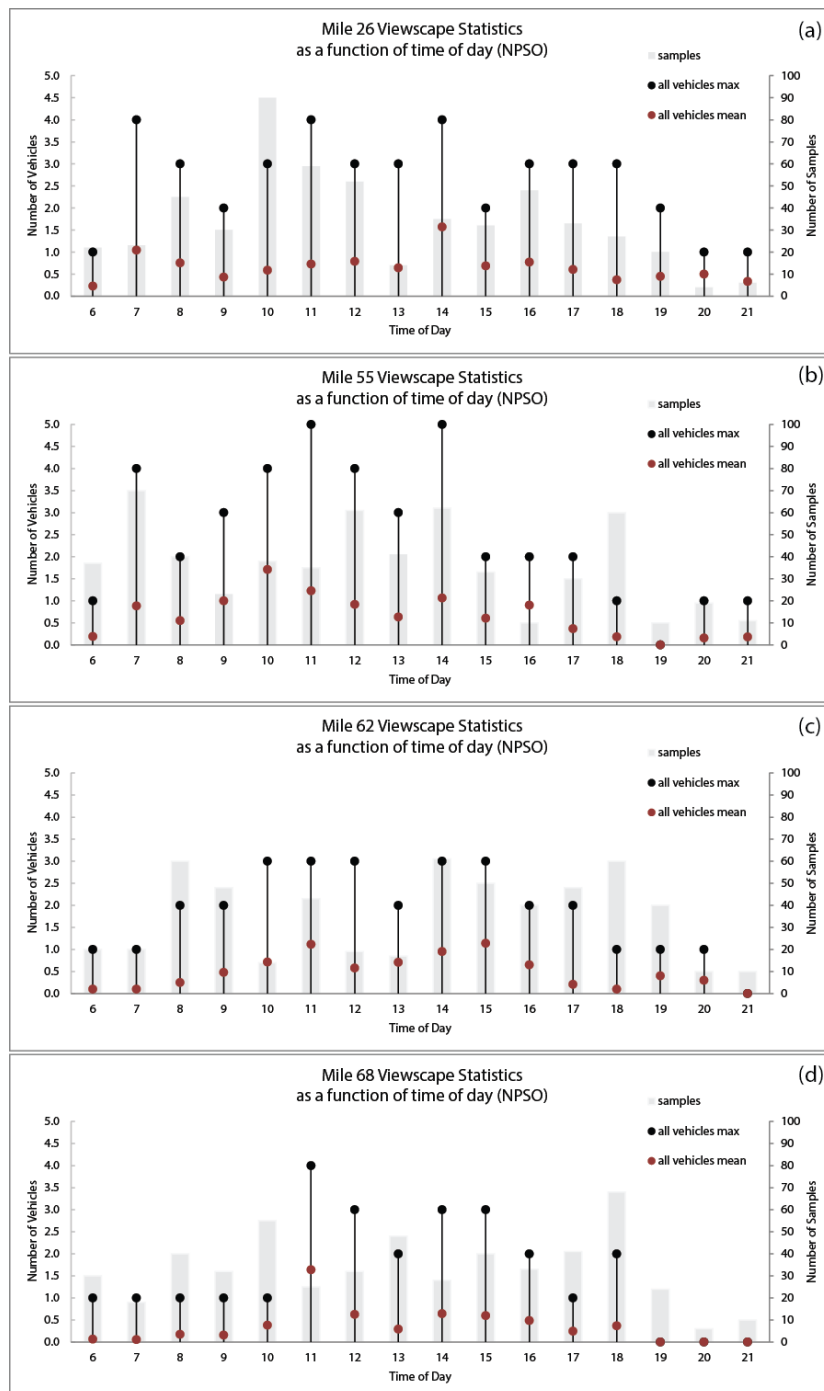


Figure 10. The maximum and mean ($+1 \sigma$) number of vehicles visible at one time at the mile 26 (a), 55 (b), 62 (c), and 68 (d) viewscales on the Denali Park Road (Denali National Park and Preserve, Alaska, USA). Bars show the number of observations for that site and hour block. The maximum number of vehicles seen at one time was five, which occurred during two-hour blocks at mile 55. All VMP viewscape standards were met.

Table 7. Traffic conditions measured as a percent of time x or fewer ($\leq$) vehicles were observed within a viewscape in Denali National Park and Preserve, Alaska, USA. All of the VMP viewscape standards were met in 2016.

Method	Mile 26		Mile 55		Mile 62		Mile 68	
	% $\leq$ 3 vehicles	% $\leq$ 4 vehicles	% $\leq$ 2 vehicles	% $\leq$ 3 vehicles	% $\leq$ 2 vehicles	% $\leq$ 3 vehicles	% $\leq$ 1 vehicles	% $\leq$ 2 vehicles
Standard	80.0	90.0	80.0	90.0	80.0	90.0	80.0	90.0
2016 result	99.4	100.0	95.5	97.0	97.9	100.0	92.8	98.3

Few temporal patterns were found in viewscape data. By two different methods, viewscape traffic volume seems to be peak in June and steadily decreases to September (Appendix B Figure 3). We found no day-of-week trends at viewscape sites (Appendix B Figure 4). Sampling hour block and season also showed no observable data trends. Non-bus sightings decrease Friday-Saturday because many government employees are typically off duty (Appendix B Figure 3).

Sheep Gap Spacing

Staff recorded 276 sheep gap observations in 2016, representing a 19% and 80% increase in collection effort over 2015 and 2014 respectively. Additionally, we recorded 2,733 hours of sheep gap observations at mile 68.5 using the Grassy Pass traffic counter. VMP standards for the percentage of hours with at least one 10-minute gap in traffic was met at mile 37.6, mile 52.8, and mile 68.5 (as measured by both NPSO and traffic counter). The VMP standard was not met at mile 21.6 nor 60.6 (Table 8). Compared to 2015, the success rate dropped 3.1% at mile 21.6 and 1.2% at mile 60.6. However, the successful gap rate increased at mile 37.6 and 52.8 by 3.3 and 5.5% respectively.

Though sheep gaps as counted by the traffic counter at Grassy Pass were very successful, there was one failure day, Sunday, August 28th. Between 2015 and 2016 there were two failure days recorded by the traffic counter at Grassy Pass, both Sundays. Of the six failure hours recorded at Grassy Pass on Sundays, four have occurred during the 1100 block.

Table 8. The percentage of hours with at least one 10-minute gap in traffic at each of the five sheep gaps established at Denali National Park and Preserve, Alaska, USA. Three of five sheep gaps met the standard during the 2016 regulatory season; mile 21.6 and 60.6 did not meet the VMP standard (bolded text and starred). The NPSO protocol was used to determine compliance at all five sheep gap sites. In addition, the Grassy Pass traffic counter was used to collect data at mile 68.5.

Method	Mile 21.6 % hours	Mile 37.6 % hours	Mile 52.8 % hours	Mile 60.6 % hours	Mile 68.5 % hours
Standard	90.0	90.0	90.0	90.0	90.0
NPSO	87.8 (n = 49)	96.6 (n = 59)	96.6 (n = 58)	86.0 (n = 57)	100.0 (n = 53)
Traffic Counter	—	—	—	—	99.7 (n = 2,733)

A larger proportion of sheep gap failures occurred on Thursday (last year it was Wednesday); however, success of sheep gap maintenance dependence on day-of-week was statistically insignificant (failed to reject H_0) and not a function of sample size (Appendix B Figure 5). The majority of sheep gap failure hours occurred in late morning (e.g. 1000 and 1100 hour block) and early afternoon hours (e.g. 1400 and 1500 hour blocks) (Appendix B Figure 6).

Nighttime Traffic

The road was open for 110 nights from the beginning of the controlled section to the Toklat rest stop and 101 nights to Kantishna. Three counters experienced interruptions in data collection due to battery failure, heavy rain, or other unknown causes (Figure 11). The Stony and Grassy counters operated without failure during nighttime hours, whereas the TekGate counter lost the most nights of data (Table 9).

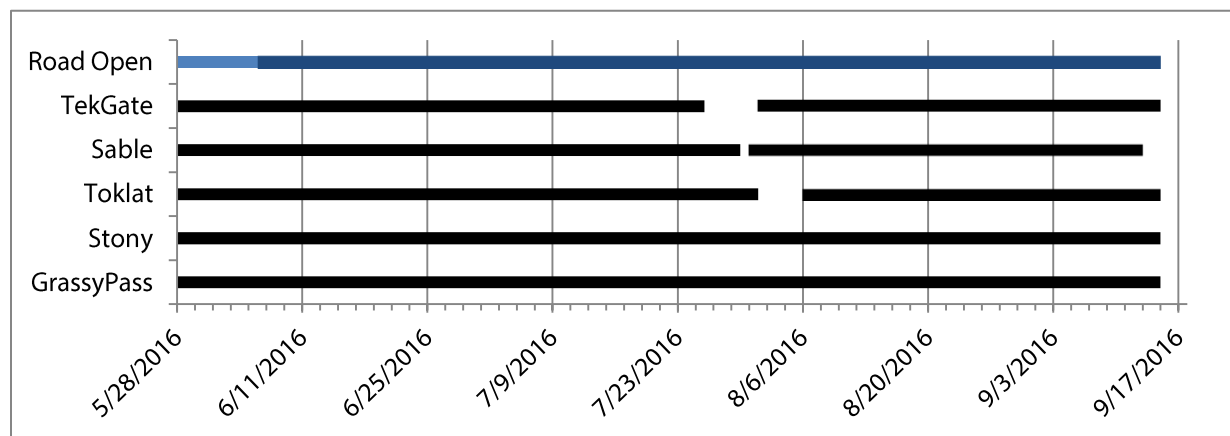


Figure 11. Gantt chart of traffic counter operation periods compared to the Denali Park Road (Alaska, USA) regulatory year for 2016. The Stony and Grassy counters functioned through all nighttime hours; the TekGate counter failed to record the most number of nighttime hours (six nights).

All five traffic counter locations met the VMP standards for both percentage of nights that averaged three or fewer vehicles per hour and the percentage of nights with six or fewer vehicles passing in any one hour (Table 9). TekGate had the highest nightly average rate of traffic.

Table 9. Summary of nighttime (hours of 2200-0600) traffic rates on the Denali Park Road (Alaska, USA). All five traffic counter locations passed the fine-scale (≤ 6 vehicles in any hour) and coarse-scale (≤ 3 vehicles/hour over the night time period) VMP standards in 2016.

Location	Number of nights sampled	% nights ≤ 3 vehicle per hour	Number of nights with >3 vehicles per hour	% nights ≤ 6 vehicles per any nighttime hour	Number of nights with >6 vehicles in any hour
Standard	–	95.0%	–	95.0%	–
TekGate	104	100.0%	0	96.2%	4
Sable	107	98.1%	2	97.2%	3
Toklat	105	99.0%	1	97.1%	3
Stony	110	100.0%	0	100.0%	0
Grassy	110	100.0%	0	100.0%	0

We looked at combinations of three variables of nighttime traffic to determine trends and patterns: time, location, and travel direction (headway). A spike in traffic at the road Toklat counter captured a road maintenance effort at Highway Pass (mile 58) using staff and vehicles based out of Toklat Ranger Station (Figure 12). A spike at the Sable counter (August 15th and 16th) is not explained by road work. Analysis of headway indicates that between 2200 on August 15th and 0300 on August 16th, about 57 round trips were made through the Sable counter. These trips did not pass the TekGate counter to the east or the Toklat counter to the west. Additionally, the data do not display characteristics of battery failure – the data appear to be valid. The majority of nighttime traffic occurs on the edges of the nighttime hours. The 0500, 2200, and 2300 and account for 66% (1,449 of 2,192 vehicles) of total traffic volume. Day-of-week did not influence nighttime traffic rates (Appendix B Figure 7).

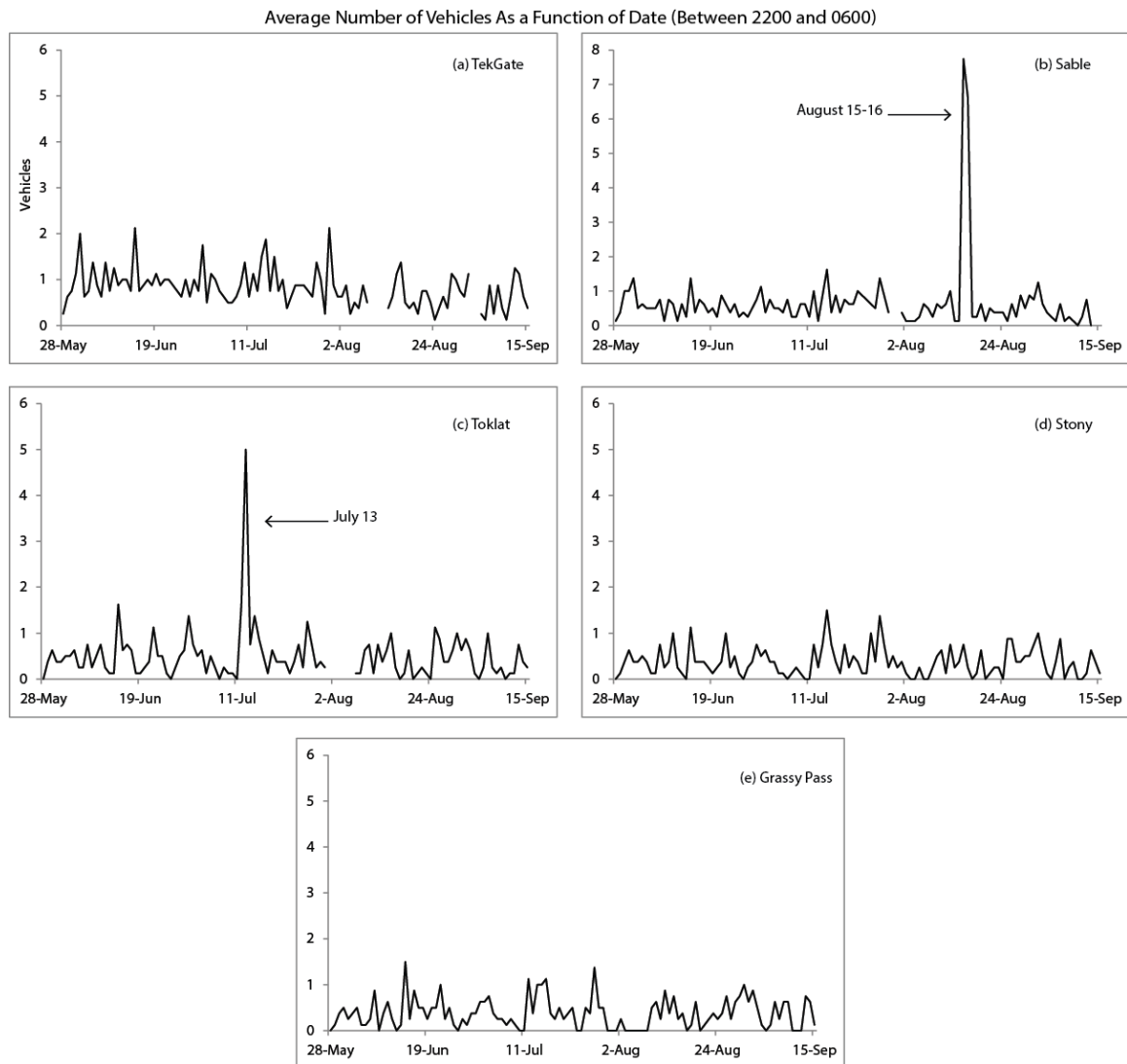


Figure 12. Average nighttime (2200-0600) traffic rates (west- and eastbound combined) for (a) TekGate, (b) Sable, (c) Toklat, (d) Stony, and (e) Grassy Pass at Denali National Park and Preserve, Alaska, USA. A spike in traffic during the night of July 13th (Toklat) is related to road work at Highway Pass (mile 58) using staff and vehicles based at the Toklat Ranger Station. The August 15th and 16th (TekGate) spikes are unexplained by road maintenance or another scheduled event. Breaks in the dataset indicate nighttime hours when the counter was not operating and data were not collected (also observable in Figure 12).

Hiker Wait Time

We collected data on 474 hiker pickups using the ROAR protocol. However, we collected wait time data on only 380 pickups. The standard for hiker wait time was met during the 2016 regulatory season (Table 10). Data from the EVC dispatch had the lowest percentage of hikers waiting less than 30 minutes for a bus. Additionally, we recorded 38 (7%) instances when a bus was too full to transport waiting hikers.

Table 10. Hiker wait times as reported by concessioner dispatch at the Eielson Visitor Center (EVC), concessioner VTS drivers, and ROAR observers on the Denali Park Road (Alaska, USA). Sample size is consistent with data of previous years. All hiker wait time VMP standards were met in 2015.

Method	% Time <30 min	<i>n</i>	% Time <60 min	<i>n</i>	% Time <90 min	<i>n</i>
Standard	70.0%	–	93.0%	–	98.0%	–
EVC Dispatch	78.9%	12,060	98.0%	14,979	99.9%	15,277
VTS Driver	98.9%	30,059	98.9%	30,059	98.9%	30,067
ROAR	88.7%	337	97.1%	369	99.2%	377

We plotted 2013-2016 hiker wait time results (proportion of time meeting standard as a function of sample size) based on sampling method to assess the efficacy of each method (Figure 13). Sample size is dependent on sampling method but percentage of time meeting VMP standards is independent of sample size. Detecting VMP standards compliance appears to be independent of sampling method.

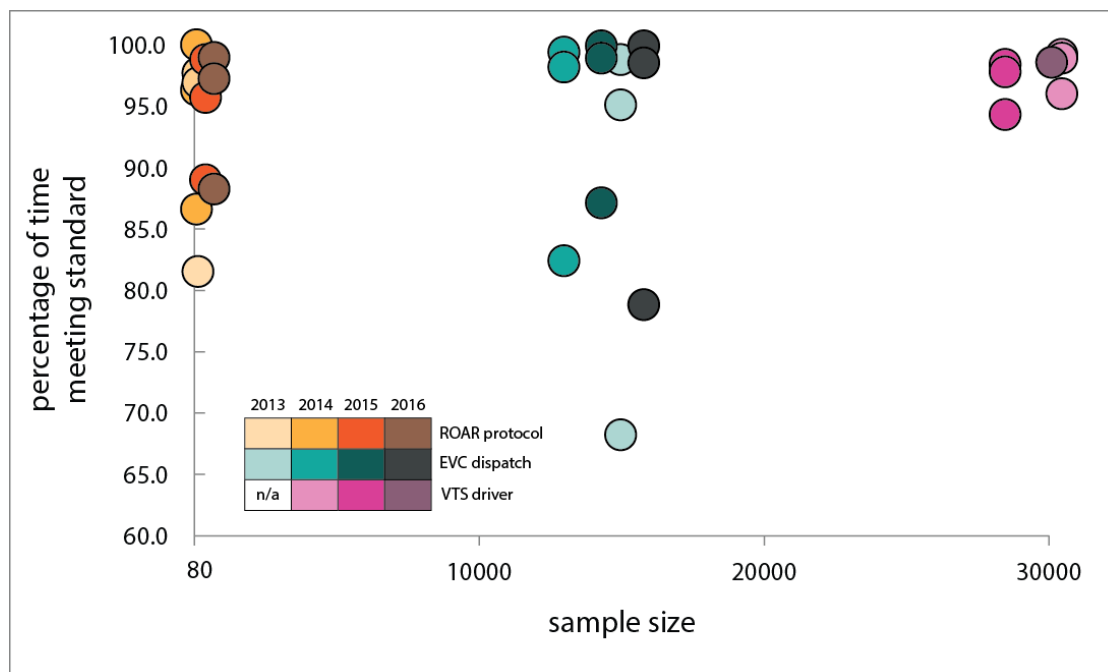


Figure 13. Percentage of time that hiker wait time standards were met as a function of sample size for the three methods used to collect hiker wait time data, 2013-2015, in Denali National Park and Preserve, Alaska, USA. Sample size does not affect the percentage of time that hiker wait time standards are met.

Discussion

The Road Ecology Program (REP) measured 41 individual metrics related to the Vehicle Management Plan (VMP) indicators in 2016 and 37 (90%) met standard. The number of samples for each VMP indicator increased in 2016 compared to 2015, except for hiker wait time observations.

Number of Vehicles at Wildlife Stops

The number of vehicles at wildlife stops is the only VMP indicator that directly measures conditions related to both park natural resources and the quality of visitor experience. Thus, the number of vehicles at a wildlife stop is a particularly important indicator of park system dynamics.

In 2016, the transportation system met this standard while serving approximately 9,924 vehicle entrances (-8% over 2015). Eighty-three percent of all observed wildlife stops ($n = 3,211$) were occupied by either one (55%) or two buses (275). Only 17% of all wildlife stops had greater than two buses present at one time.

This report focuses on the 1-yr VMP standards. However, we found it necessary to begin assessment of 5-yr VMP standards, a moving window weighted average that will be reported first in 2017. With four years of data collected, all wildlife stop metrics are likely to meet 5-yr standards except for the percent time of ≤ 1 vehicles in Subzone 3, which is will pass or fail depending on 2017 observations. The weighted average of 2013-2016 data ($n = 467$) for the percentage of time that ≤ 1 vehicles at wildlife stops in Subzone 3 is 73.24%; the standard is 75%.

Number of Vehicles at Rest Stops

Rest stop standards were exceeded on three occasions: the maximum number of buses parked at Toklat (on two occasions) and the EVC (on one occasion). However, at least one of these exceedances (July 30) was likely caused by a landslide that closed a section of the road and caused more vehicles to be staged at Toklat than planned for in the bus schedule. Despite exceeding standard at two rest stops on three total occasions, the data show that during morning and late afternoon hours at Teklanika, late afternoon at Toklat, and early morning and late afternoon hours at EVC have further capacity within VMP standards. Taken together, these two facts highlight the critical importance of strategic scheduling and the difficulty to keep vehicles well-spaced in a stochastic environment.

Maximum number of vehicles at rest stops observed using the ROAR protocol is consistently greater than that observed using the NPSO maximum (Table 4). Since 2013, ROAR maximums have been greater than NPSO 20 times, less than NPSO three times, and equal once (McKenny et al. 2015, McKenny et al. 2014a, Clark 2016). This may be caused by the difference in sampling behavior between the two protocols. The ROAR protocol is inherently tied to the bus network because the observer is travelling using the network. Network behavior is imposed on the ROAR observer's sampling schedule. The NPSO observer travels both west and eastbound sampling sites in a nonlinear fashion – the NPSO observer imposes their behavior on the sampling schedule. We believe the ROAR protocol better captures visitor experience at rest stops than NPSO.

For an "even" schedule we expect ~14% of all traffic to occur each day ($100/7 = 14.3$). Here we focus on bus traffic: There are bus traffic spikes of 17% on Thursday and Saturday at Teklanika and 18% on Saturday at Toklat. However, the concessionaire appears to be under consuming other days where there is capacity within VMP goals to meet higher customer demand. Over consuming on certain days could put further pressures on VMP indicators in the future (e.g. sheep gaps).

Number of Vehicles within Viewscapes

The viewscape standard was met at all four sites for the fourth year in a row – the only VMP indicator to do so. Viewscope results have been the most consistent of any VMP indicator. It is likely every viewscape site will meet the 5-yr VMP standard.

Though viewscape standards have been easily met to date, they remain a particularly vulnerable indicator because they are locations with grand vistas. Parking within a viewscape for extended periods would have outsized negative effects on the standard. Currently, parking in viewscapes is rarely observed but continues to be a significant management concern. We believe viewscape standards are consistently met because travel-through times in these locations are less than three minutes (they are only 1-2 miles in length) and vehicles rarely cluster within three minutes of each other.

Sheep Gap Spacing

The 1-yr sheep gap standard was met at three of the five sheep gap sites in 2016, an improvement compared to 2014 but a decrease compared to 2015. Sheep gaps at mile 21.6 and 60.6 were below the 90% standard (87.8% and 86.0%, respectively). The mile 60.6 sheep gap site has never achieved 10-minute gaps in 90% of observed hours in the four years since monitoring began; every other site has met standard at least twice.

It is likely that the mile 60.6 sheep gap's proximity to a popular overlook, Stony, makes it difficult to meet VMP standards. The site is located at the base of a hill 1.4 miles east of Stony where an iconic view of Denali awaits. The Stony overlook is also the turn-around point for the majority of the popular Tundra Wilderness Tours (TWT). TWT buses stop at Stony for approximately 10-15 minutes. The proximity of this turn-around to the mile 60.6 sheep gap increases traffic return rates. Combined with other traffic, achieving a 10-minute gap in this location is difficult.

The 5-yr sheep gap VMP standards will fail at three sites, miles 21.6, 52.8, and 60.6, because each of these sites needs >100% success of achieving 10-minutes gaps in traffic for 2017. The mile 37.6 sheep gap will likely fail the 5-yr sheep gap VMP standard depending on 2017 results because the site needs a 98% 10-minute gap success rate in 2017. The sheep gap at mile 68.5 will most likely exceed the 5-yr sheep gap standard. The current 5-yr weighted average for percentage of hours with a 10-minute gap at each site is: 89.4% (mile 21.6), 94.3% (mile 37.6), 92.1% (mile 52.8), 86.2% (mile 60.6), and 98.9% (mile 68.5). A larger sample size of high-success results will help increase overall averages for future years because the 5-yr standard is a moving window.

The sheep gap indicator is defined as a 24-hour standard. Currently, it is only sampled during bus operating hours. However, as the mile 68.5 Grassy Pass site highlights, we have the ability to

automate sheep gap data collection and achieve a continuous dataset. At the mile 68.5 sheep gap, all nighttime hours achieved a 10-minute gap in traffic. To replicate this data collection technique four additional traffic counters will need to be installed under the road surface in close proximity to the other sheep gap sites, Hogan Creek, Tattler Creek, Toklat River, and Stony Creek. Our hypothesis is that the vast majority of nighttime hours achieve a 10-minute gap in traffic at each of these locations.

Installing automated traffic counters at each sheep gap site would achieve four goals:

- 1) Sheep gap sites would be monitored 24 hours daily as intended by the VMP.
- 2) The likelihood of meeting all sheep gap standards would increase.
- 3) Field operations would be more predictable. Sheep gap observations last between ten and 60 minutes depending on traffic levels. Thus, five sheep gap sites take between 50 and 300 minutes, which is a lot of variability for which to plan.
- 4) With a more continuous dataset, the distribution of maximum sheep gap length can inform management about the system's flexibility with respect to maintaining sheep gaps. Average sheep gap lengths of 15 minutes indicate much different traffic conditions than 30- or 40-minute averages. Currently, this level of detail is not possible other than the site at mile 68.5.

Sheep gap sites would still require dedicated time to ground-truth and validate results. Additionally, as we have seen in the last several years, traffic counters do occasionally experience temporary failures due to heavy rain, low battery, user error, and other unknown, unpredictable factors. However, the amount of data lost is insignificant when compared to the amount of data we are not currently collecting by not employing this methodology.

Nighttime Traffic

Nighttime traffic rates in 2016 were similar to rates in 2015; a minor uptick in both maximum night rate (over the entire season) and the percentage of nights with ≥ 6 vehicles in a given hour occurred at the Sable and Toklat counters.

The effect of nighttime traffic on next-day wildlife sightings is still under analysis. The park plans to continue working with researchers to better describe and categorize these effects on wildlife, wildlife sightings, and visitor experience.

Hiker Wait Time

The hiker wait time indicator is the most direct performance measure of the transportation system's primary purpose as a transit service. All measures of hiker wait time were within VMP standard in 2016. Data from the EVC dispatch center and bus drivers recorded the lowest percentage of hikers waiting less than 30 minutes for a bus (78.9%).

Evidence from 2013-2016 hiker wait time data supports that collection method is independent of meeting VMP standard (Figure 13). If collecting hiker wait time continues to be in the VTS driver job description, hiker wait times collected by ROAR could be reduced in priority to free field staff to conduct other duties such as administer day hiker surveys.

Large Vehicle Traffic

The VMP defines large vehicles as vehicles > 80,000 pounds GVWR. To assess weight, park management could employ Weigh-In-Motion (WIM) technology, which does not require a vehicle to stop to be measured. However, the technology is expensive to install (~ \$45,000) and maintain (yearly calibrations) and research suggests it is fastidious. Extreme cold, frost heaves, and the gravel sections of the road would complicate the use of WIM technology in Denali. Additionally, many WIM solutions would require infrastructure counter to the historic and rustic character of the park road. Park management determined that WIM technology was inappropriate for the Denali setting and has decided to monitor large vehicle traffic using remote, motion-triggered cameras co-located with traffic counters. This solution is analysis-heavy and more subjective than WIM technology since weight will not be directly measured. How to measure large vehicle traffic as it relates to the VMP is still in discussion.

Recommendations for Management

Management recommendations are based on results from all monitoring to date though more recent data are weighed more heavily. All recommendations directly relate to the objectives of the VMP.

1. Indicators:

- **Sheep gaps**

- The mile 60.2 site has failed every 1-yr standard since monitoring began in 2013 and will fail the 5-yr standard when calculated in 2017. Due to consistently failing this standard, it is unlikely to meet VMP standards prior to 2020 without a shift in vehicle schedules, behavior, or related policy.
- Three other sites are very likely to fail the 5-yr standard: mile 21.6, 37.6, and 52.8. Alternatives to the status quo related to the behavior, timing, or quantity of buses in these regions of the park are necessary to meet VMP goals.
- The installation TRS-style traffic counters at Hogan Creek (mile 21.6), Tattler Creek (mile 37.8), east of the Toklat bridge (mile 53.6), and east of Stony Dome (mile 60.6) to enable 24-hr sheep gap monitoring may improve overall success rates because we currently bias our samples to the most trafficked times of day. Installation of traffic counters does not guarantee meeting VMP goals but will provide a better understanding of the nature of the challenge and potential management options.

- **Rest stops**

- Data support that rest stops are most effectively monitored using the ROAR protocol. Monitoring rest stops using NPSO could be reduced if priorities dictate monitoring efforts focus elsewhere.

- **Viewscapes**

- Collecting continuous data at viewscapes would improve interpretability of temporal analyses.

- **Nighttime traffic**

- We suggest developing thorough operating plans for scheduled and proposed nighttime projects that require vehicle use of the park road. Negotiating operating plans provides a venue to manage by science and achieve buy-in from project leaders on the importance of minimal road traffic at night.
- Develop a sampling scheme to disentangle the effects of nighttime traffic from nighttime large vehicle traffic on next day wildlife sightings.

- **Hiker wait time:**

- Continue using ROAR observers to document occasions when VTS buses pass waiting hikers because they are full.
- Consider only collecting VTS driver and EVC dispatch data for hiker wait times. ROAR-collected hiker wait times appear to be unnecessary.

- **Large vehicle traffic:**

- Install TRS-style traffic counters co-located with remotely triggered camera technology to classify large vehicles at Savage (mile 14.9). Explore if similar technology should be utilized at two other sites to assess along the road length (e.g. east of Toklat, mile 53.6, and west of east of Stony Dome, mile 60.6).

2. Outreach messages:

- Educate all road users about the goals and objectives of the VMP, the importance of providing for a high quality visitor experience, and how the VMP ties to wilderness values and carrying capacity science.
 - Target heavy road users for messaging: Joint Venture, ROW permit holders, NPS staff, and AKGeo staff.
- 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.

3. Program sampling scheme and structure:

- The last two years of amplified field effort has proven efficient and effective at monitoring VMP standards. Continue with this model and staff structure.
- Re-assess on-board (fleet-based) GPS technology periodically. Determine if changes in system longevity, reliability, and interchangeability improve the system's usability for monitoring conditions on the park road.
- Continue engaging youth interns, including SCA and YCC members.
- Continue scheduling overnight ROAR observations to collect westbound afternoon data and early morning eastbound data the following day. Ensure that Mondays and Fridays are included in the sampling to capture weekend conditions.
- Continue to ensure NPSO and ROAR monitoring strategies that emphasize distributing observations that cover all bus-operating hours. Continue scheduling early (e.g. 0500) and late (e.g. 1100) shifts because it distributes samples evenly around the 1200-1500 hour block; the busiest times of day receive the greatest data collection effort.

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

Wildlife Stops:

Location	Number of vehicles stopped at the same location to view wildlife at one time
<i>Wildlife Viewing Subzone 1</i>	75% of wildlife stops will have 3 or fewer vehicles (5-yr 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-yr 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-yr average) No one year will have less than 90% of wildlife stops with 5 or fewer vehicles
<i>Wildlife Viewing Subzone 2</i>	75% of wildlife stops will have 2 or fewer vehicles (5-yr 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-yr 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-yr average) No one year will have less than 90% of wildlife stops with 4 or fewer vehicles
<i>Wildlife Viewing Subzone 3</i>	75% of wildlife stops will have 1 or fewer vehicles (5-yr 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-yr 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-yr average) No one year will have less than 90% of wildlife stops with 3 or fewer vehicles

Rest Stops:

Location	Number of vehicles parked at one time at the Teklanika and Toklat and Eielson rest stops
<i>Teklanika</i>	No more than 12 buses at one time with a total of no more than 16 vehicles
<i>Toklat</i>	No more than 11 buses at one time with a total of no more than 16 vehicles
<i>Eielson Visitor Center</i>	No more than 10 buses at one time with a total of no more than 19 vehicles

Viewscapes:

Location	Number of vehicles visible at one time in four scenic viewscapes during bus operating hours
<i>Mile 26 Wildlife Viewing Subzone 1</i>	85% of the time there will be 3 or fewer vehicles visible in the viewscape (5-yr 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-yr average)
	No one year will have less than 90% of the time with 4 or fewer vehicles visible in the viewscape
<i>Miles 55 and 62 Wildlife Viewing Subzone 2</i>	85% of the time there will be 2 or fewer vehicles visible in the viewscape (5-yr 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-yr average)
	No one year will have less than 90% of the time with 3 or fewer vehicles visible in the viewscape
<i>Mile 68 Wildlife Viewing Subzone 3</i>	85% of the time there will be 1 or fewer vehicles visible in the viewscape (5-yr 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-yr average)
	No one year will have less than 90% of the time with 2 or fewer vehicles visible in the viewscape

Sheep Gaps:

Location	Maintenance of at least one 10-minute gap in traffic per hour at designated sheep crossing locations
<i>Mile 21.6, 37.6, 52.8, 60.6, and 68.5</i>	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)

Nighttime Traffic:

Location	Average number of vehicles per hour per night passing any of the traffic counters west of Savage between 10 p.m. and 6 a.m. (2200-0600)
–	There will be an average of 3 or fewer vehicles per hour per night (total westbound and eastbound) passing any of the traffic counters 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.

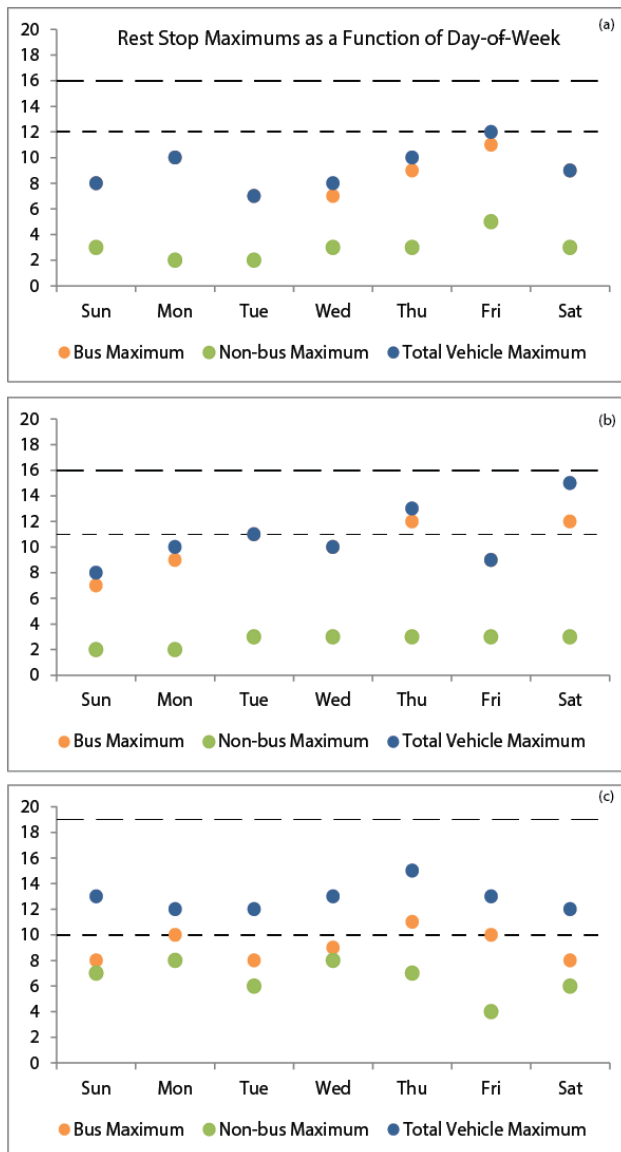
Hiker Wait Time:

Interval	The amount of time a hiker spends waiting to be picked up by a bus
<i>Less than 30 minutes</i>	At least 75% of hikers will have wait times of less than 30 minutes for pick-up by a bus, averaged over 5 yrs. No one year will have less than 70% of hikers with wait times of less than 30 minutes.
<i>Less than 60 minutes</i>	At least 95% of hikers will have wait times of less than 60 minutes for pick-up by a bus, averaged over 5 yrs. No one year will have less than 93% of hikers with wait times of less than 60 minutes.
<i>Less than 90 minutes</i>	At least 99% of hikers will have wait times of less than 90 minutes for pick-up by a bus, averaged over 5 yrs. No one year will have less than 98% of hikers with wait times of less than 90 minutes.

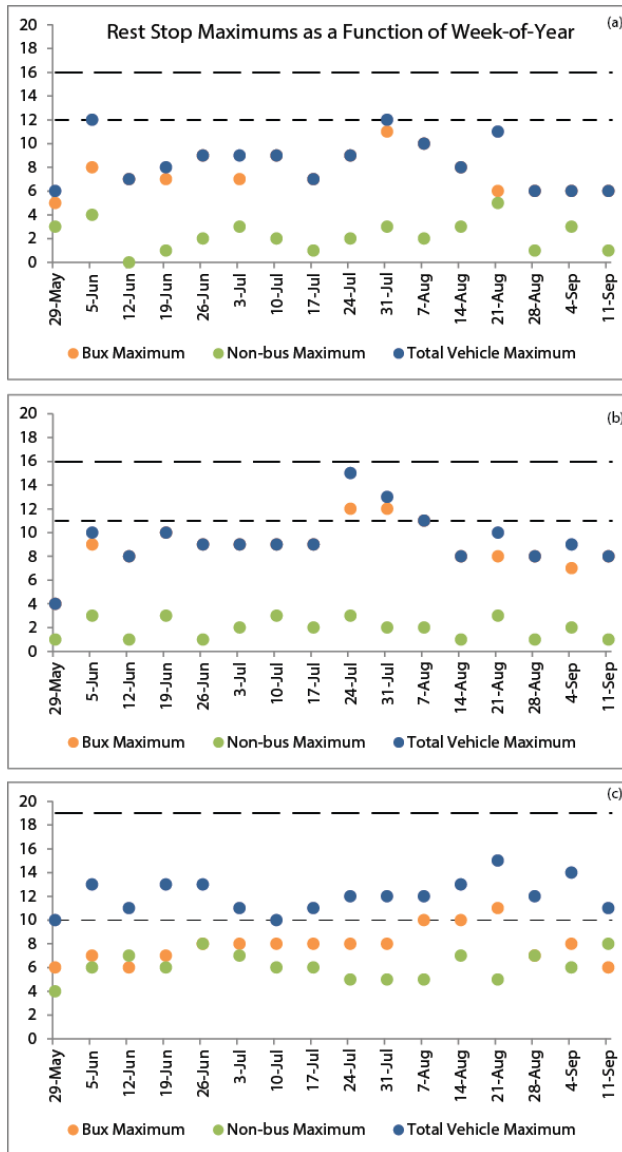
Large Vehicle Traffic:

Location	Total number of large (> 80,000 pounds gross vehicle weight rating) vehicles crossing any of the traffic counters west of Savage in any one hour
–	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.

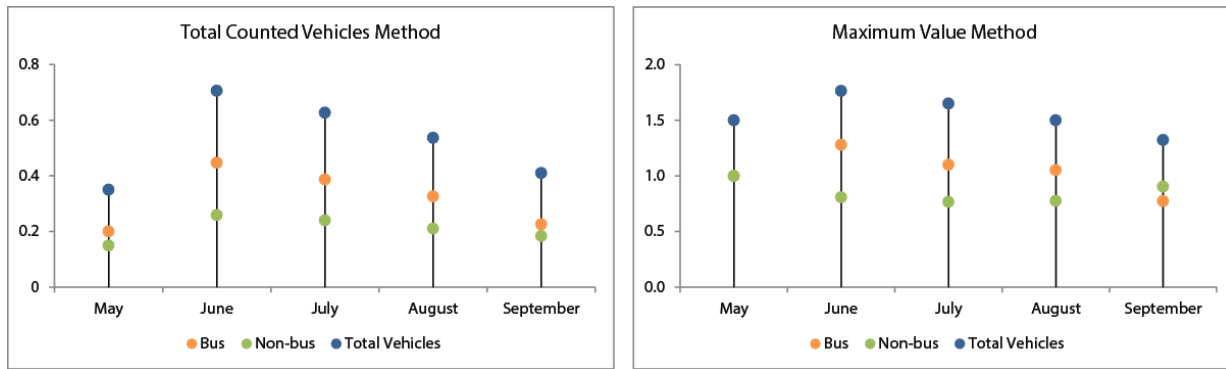
Appendix B. Temporal Analysis Graphs of Denali Park Road Indicators



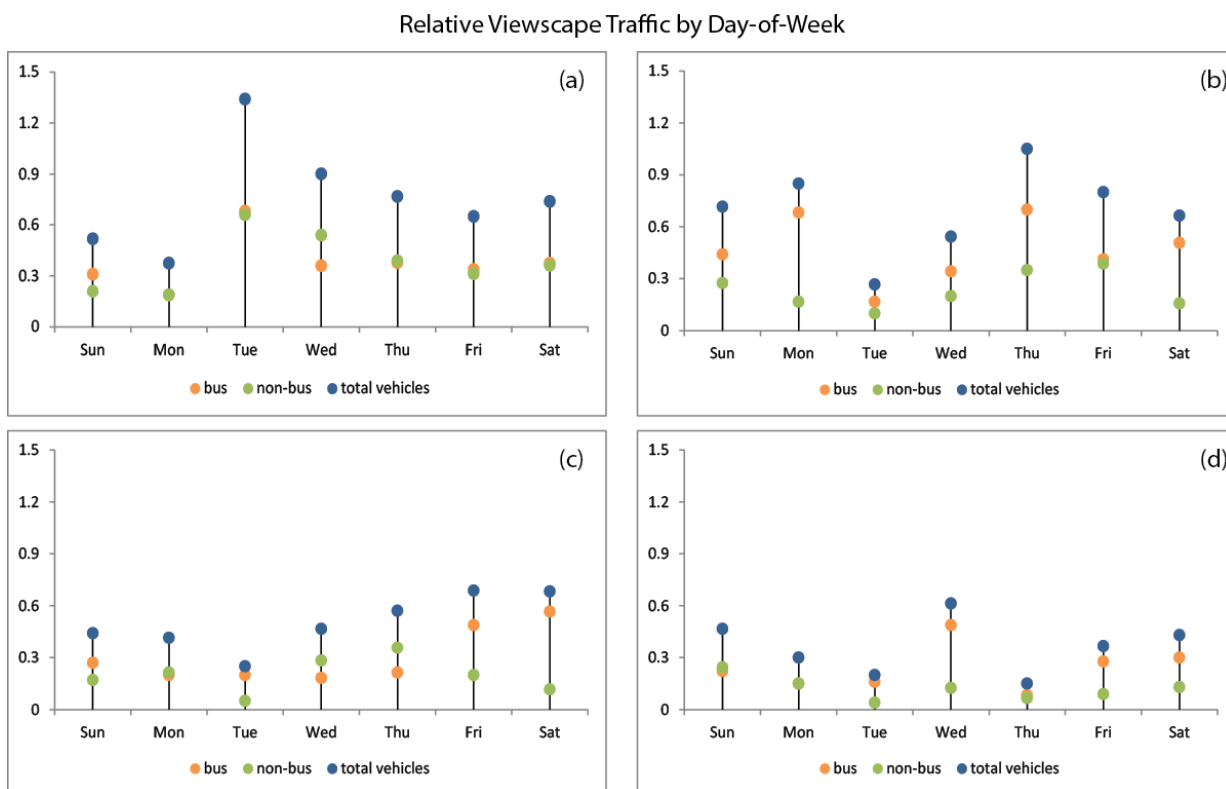
Appendix B Figure 1. Traffic volumes at the Teklanika (a), Toklat (b), and EVC (c) rest stops in Denali National Park and Preserve (Alaska, USA). Traffic increases Sunday through Saturday at Toklat, while at Teklanika, traffic increases Tuesday through Friday with a bit of a "reset" for the weekend. Traffic appears to peak at Toklat at the end of July and early August. There are no temporal patterns at EVC; however, note the markedly higher overall proportion of non-bus traffic.



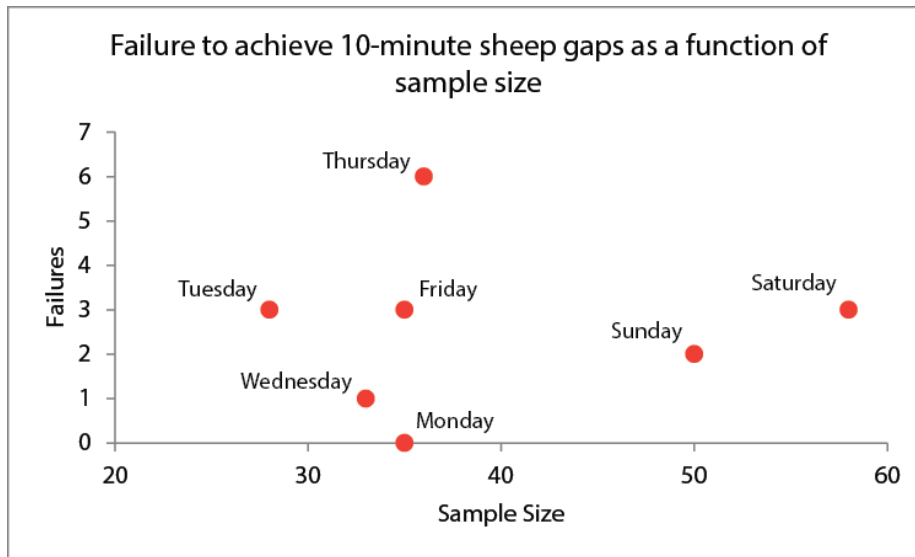
Appendix B Figure 2. No significant trends in traffic volumes, as a function of week-of-year, at the Teklanika (a), Toklat (b), and EVC (c) rest stops in Denali National Park and Preserve (Alaska, USA) were detected in 2016. Peak traffic was observed during the period of late July and early August at Teklanika and Toklat. EVC traffic is relatively consistent and peaked in late August of 2016.



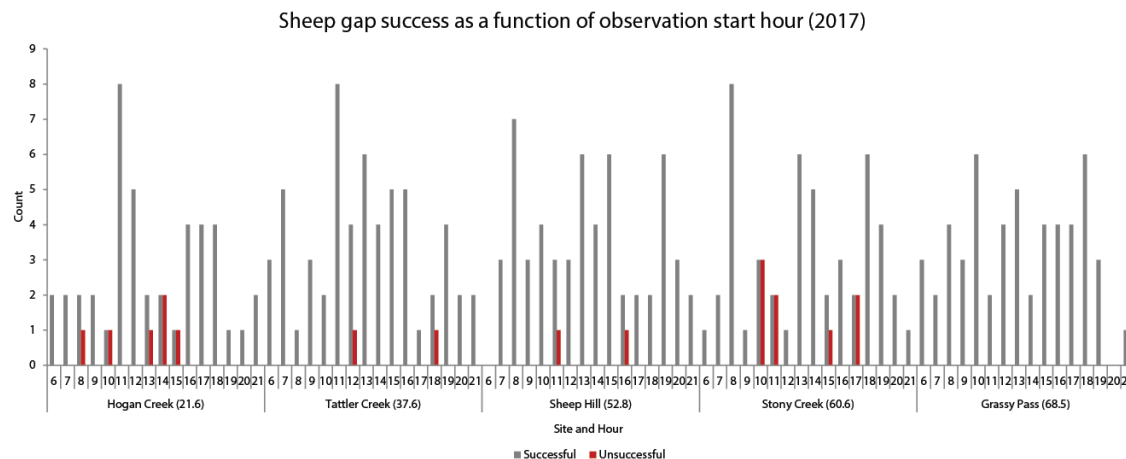
Appendix B Figure 3. Relative traffic within VMP-defined viewsapes of Denali National Park and Preserve, Alaska, USA as a function of month. Relative traffic peaks in June and decreases each month after. Buses are the most common vehicle type observed.



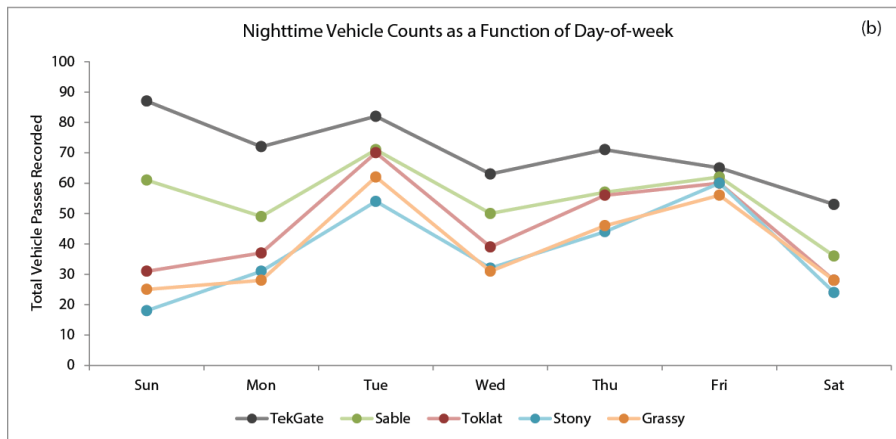
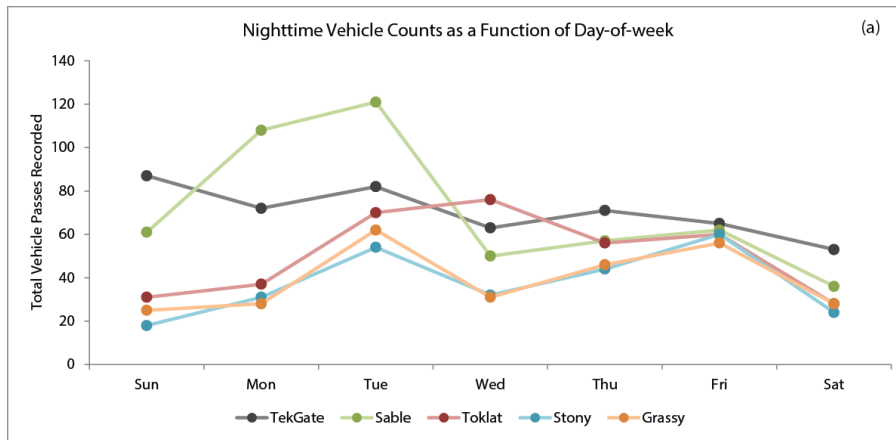
Appendix B Figure 4. Day-of-week analysis for all rest stop sites (a) at Denali National Park and Preserve, Alaska, USA. Decreases in vehicle sightings are observed on Mondays and Wednesdays and appear to be controlled by Teklanika (b) buses and EVC non-buses (d). Traffic conditions observed at Toklat (c) showed little day-of-week variability through the 2015 regulatory year.



Appendix B Figure 5. Failure to maintain a 10-minute sheep gap as a function of sample size for the Denali Park Road (Alaska, USA). The high failure rate of sheep gap maintenance on Wednesday could be due to sample size.



Appendix B Figure 6. Success of sheep gap observation occur throughout the bus operating day (0600 – 2200) however late morning and early afternoon hours are most prone to failure of a 10-minute gap along the Denali Park Road (Alaska, USA). Seven of the 18 failures observed in 2016 occurred during the 1000 and 1100 hour blocks.



Appendix B Figure 7. Nighttime traffic patterns on the Denali Park Road (Alaska, USA) are not as expected (a) until average data substitutes for nighttime work (July 13th, Toklat) and unexplained data (Aug. 15th-16th) (b). Traffic volumes were greatest on Mondays and Tuesdays. Sunday recorded the lowest traffic volumes through the 2016 regulatory year.

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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