National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

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

A Summary Report 2011–2012

Natural Resource Technical Report NPS/DENA/NRTR—2014/867

ON THE COVER
Passengers on a Visitor Transit System bus enjoying the iconic Mile 62 Viewscape (Stony).
Photo courtesy of Denali National Park and Preserve.

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

A Summary Report 2011–2012

Natural Resource Technical Report NPS/DENA/NRTR—2014/867

Heather C. McKenny, Melanie S. Roed, Bridget L. Borg, and Melissa L. Snover

National Park Service
Denali National Park and Preserve
PO Box 9
Denali National Park, Alaska 99755

May 2014

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

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Technical Report Series is used to disseminate results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service mission. The series provides contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

This report is available in digital format from The Center for Resources, Science, and Learning at Denali National Park and Preserve and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/). To receive this report in a format optimized for screen readers, please email irma@nps.gov.

Please cite this publication as:

McKenny, H. C., M. S. Roed, B. L. Borg, and M. L. Snover. 2014. Standards in the Denali park road vehicle management plan — how current conditions measure up: A summary report 2011–2012. Natural Resource Technical Report NPS/DENA/NRTR—2014/867. National Park Service, Fort Collins, Colorado.

NPS 184/124547, May 2014

Contents

Contents (continued)

Figures

Page

Tables

Page

Appendixes

Page

Abstract

This report summarizes data collected in 2011 and 2012 by NPS staff and volunteers for four 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, and 4) the maintenance of hourly, 10-minute gaps in traffic at sheep crossing locations (sheep gaps). The primary objective of this report is to compare the current conditions of the indicators to the VMP standards. The monitoring results will help inform management of vehicle travel on the park road (e.g., bus scheduling, turn-over rates, driver behavior) through implementation of the VMP. Thus, the secondary objective of this report is to assess traffic patterns within shorter periods (daily or subseason) that indicate potential sources of future problems, if crowding increases to the point where standards are not being met, and areas where management could improve existing conditions to ensure that the goals of the VMP (maintaining high-quality visitor experiences and minimizing wildlife impacts) are being achieved. Results include:

- During 2011 and 2012, the number of vehicles stopped at one time to view wildlife was within the standards established by the VMP for Subzones 1 and 2. Subzone 3 (Eielson Visitor Center to Wonder Lake) was out of compliance in 2012.

- The number of buses and vehicles parked at one time at the Toklat and Teklanika Rest Stops and the Eielson Visitor Center were within standards for both years. The maximum number of buses recorded at the Toklat Rest Area and the Eielson Visitor Center, however, were approaching the standards.

- The numbers of vehicles visible in each of the four viewscapes at any one time were within standards for 2011 and 2012 at all four viewscapes. Although the standards are based on annual averages, an analysis of the data by subseason is also presented to assess the level of impact parking construction and lodge vehicles in viewscapes has on the crowding conditions.

- The standard for maintaining at least a 10-minute gap in traffic during the hours that were monitored was only achieved at one of the sheep gaps during both years. Two of the sheep gaps failed to meet the standards both years and the other two sheep gaps failed to meet the standards during one of the years.

Our results suggest that traffic scheduling and volumes during 2011 and 2012 enabled the park to be mostly in compliance with the VMP standards during the hours monitored. The results also highlighted areas where conditions of the indicators could be improved. These data illustrate the importance of installing GPS systems to monitor traffic on the park road as was called for in the VMP. The GPS technology will improve the accuracy of our monitoring and will enable us to assess how scheduling and the behavior of different vehicle types (e.g., vehicle residence time in viewscapes or at rest stops) affect the indicators.

Acknowledgments

Funding for this study was provided by the National Park Service, Denali National Park and Preserve, AK, USA. We'd like to thank the many people who made this project a success. In particular, we would like to thank the 2011 and 2012 Road Study volunteers and staff. W. Clark provided assistance with data analysis. P. Hooge, S. Arthur, M. Valentine, and D. Schirokauer provide valuable reviews of the draft report.

Introduction

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

Much 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 all who travel the road. 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 and Olaus Murie, fought to protect the "wilderness atmosphere" of the road. Because of their efforts, the road is only paved as far as the Savage River Bridge (Mile 15) and it is only widened to the Teklanika River (Mile 31). Westbound visitors cross the Teklanika River Bridge, and are welcomed on the other side by the rustic character of road that has persisted for over seventy years.

The road improvement story is an example of one of the biggest challenges faced by national parks, balancing the need to protect park resources while making them available for people to enjoy. The challenge is particularly great in Denali, where park managers must balance the growing demand for visitor opportunities to tour the park road with the need to ensure that park resources are protected and visitors continue to have a safe, high-quality experience. To balance these sometimes conflicting responsibilities, park managers have restricted private vehicle travel beyond the Savage River since 1972 and in 1986 they instituted a vehicle limit of 10,512 round trips annually for all users combined (NPS 1986).

The 1972 restrictions were implemented by park mangers to address the anticipated substantial increase in motor vehicle access to the park resulting from the opening of the George Parks Highway. The vehicle restrictions were promulgated in special park regulation (36 CFR § 13.930 et seq.) and further refined in the 1997 Entrance Area and Road Corridor Development Concept Plan (NPS 1997). Vehicle use was allocated between 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. Traffic on the road was restricted starting the Saturday before Memorial Day until the second Thursday after Labor Day or September 15, whichever came first.

Denali Park Road Capacity Study

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

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

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

To identify possible links between vehicle traffic and wildlife behavior, 20 grizzly bears (*Ursus arctos horribilis*) and 20 Dall sheep (*Ovis dalli dalli*) were collared and tracked using GPS. Data were also collected to determine the number and distribution of the "big five" large mammals, caribou (*Rangifer tarandus*), grizzly bears, Dall sheep, moose (*Alces alces*), and wolves (*Canis lupus*) sighted from the park road. Traffic data were collected using traffic counters placed at six locations along the park road and wildlife sightings were recorded by bus drivers using touch-panel interfaces installed in 20 buses (Phillips et al. 2010b, Phillips et al. 2012). The results suggested that the volume and patterns of vehicle traffic might affect the distribution and movements of wildlife, although the effects were not statistically significant. The clearest indication of negative impacts from vehicle traffic on wildlife included findings that Dall sheep increased their movement rates when approaching the road and they were located farther from the road during higher traffic volumes. Some bands of sheep migrate between habitats in the Outer Range (primarily winter habitat) and the Alaska Range (primarily summer habitat). Other bands may use habitats on both sides of the road throughout the summer. During migration, these sheep must cross the road. Therefore, understanding and mitigating the impacts to sheep movements is important for maintaining healthy sheep populations. This study also found a reduction in the number of early morning sightings of the big five wildlife following high levels of night-time traffic. The night-time traffic considered in this study often included large construction vehicles which may have a greater impact on wildlife due to the nature and behavior of these vehicles—they produce more noise and dust and likely move more quickly when passing wildlife than do visitor buses that stop to view the wildlife. Thus, one of the uncertainties relating to the relationship between night-time traffic and morning wildlife sightings is the specific impact of large vehicles, including both contractor vehicles and NPS maintenance 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 that 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 amount of large (>80,000 gross pounds) vehicle traffic during any time of the day.

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

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

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

A Long-term Plan for Managing the Park Road

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

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

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

The VMP also replaces the annual vehicle limit with a daily limit of 160 vehicles and it modifies the Wildlife Viewing Subzones to clarify the management objectives necessary for achieving the desired conditions within specific segments of the park road. Crowding standards (number of vehicles at wildlife stops, number of vehicles at rest stops, and number of vehicles in viewscapes) are established for each subzone to preserve the character-defining qualities and attributes of the different road segments in relation to visitor experience. Managers expect subzone 1 to have the greatest amount of traffic and consequently, the greatest crowding conditions. As visitors travel further out on the park road, the volume of traffic decreases and the standards become more stringent to reflect visitor's expectations for lower crowding conditions further out into the park. The VMP was approved in September 2012, and park managers anticipate full implementation of the plan in 2015, when a new concessions contract to operate the park's public transportation system is in place and the special park regulations have been updated in the U.S. Code of Federal Regulations with the 160 vehicle daily limit.

In summer 2011 and 2012, park staff collected monitoring data to assess the current state of the indicators in relation to the standards, and to aid in the development of monitoring techniques and protocols. This report summarizes these data for four of the seven 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, and 4) the maintenance of hourly 10-minute gaps in traffic at sheep crossing locations (sheep gaps). The primary objective of this report is to compare the current conditions of the indicators to the VMP standards. The monitoring results will help inform management of vehicle travel on the park road (e.g., bus scheduling, turn-over rates, driver behavior) through implementation of the VMP. Thus, the secondary objective of this report is to assess traffic patterns within shorter periods (daily or subseason) that indicate potential sources of future problems, if crowding increases to the point where standards are not being met, and areas where management could improve existing conditions to ensure that the goals of the VMP (maintaining high-quality visitor experiences and minimizing wildlife impacts) are being achieved.

Indicators and Standards

Number of Vehicles at Wildlife Stops

Wildlife stops are random events that can occur at any point along the park road when one or more vehicles stop to observe wildlife. One or more individual animals, representing one or more species may be present at a given wildlife stop. The most frequent wildlife stops involve sightings of the "big five" large mammal species: caribou, grizzly bears, Dall sheep, moose, and wolves, although vehicles will stop for other species as well. The VMP manages for crowding at wildlife stops by establishing standards for the maximum number of vehicles stopped at the same location to view wildlife at the same time. The standards vary depending on the 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. The design standards for each facility's parking lot were used to set the standard for the maximum number of buses and vehicles parked at one time.

Number of Vehicles in Viewscapes

The VMP identified four iconic viewscapes—mile 26 (Teklanika Flats), mile 55 (west of Toklat), mile 62 (Stony Overlook), and mile 68 (Grassy Pass). The standard for each viewscape is based on the social normative curves developed from the 2007 visitor surveys (Manning and Hallo 2010) and the desired conditions for visitor experience established for the wildlife viewing subzone where the viewscape occurs (NPS 2012).

Sheep Gap Spacing

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

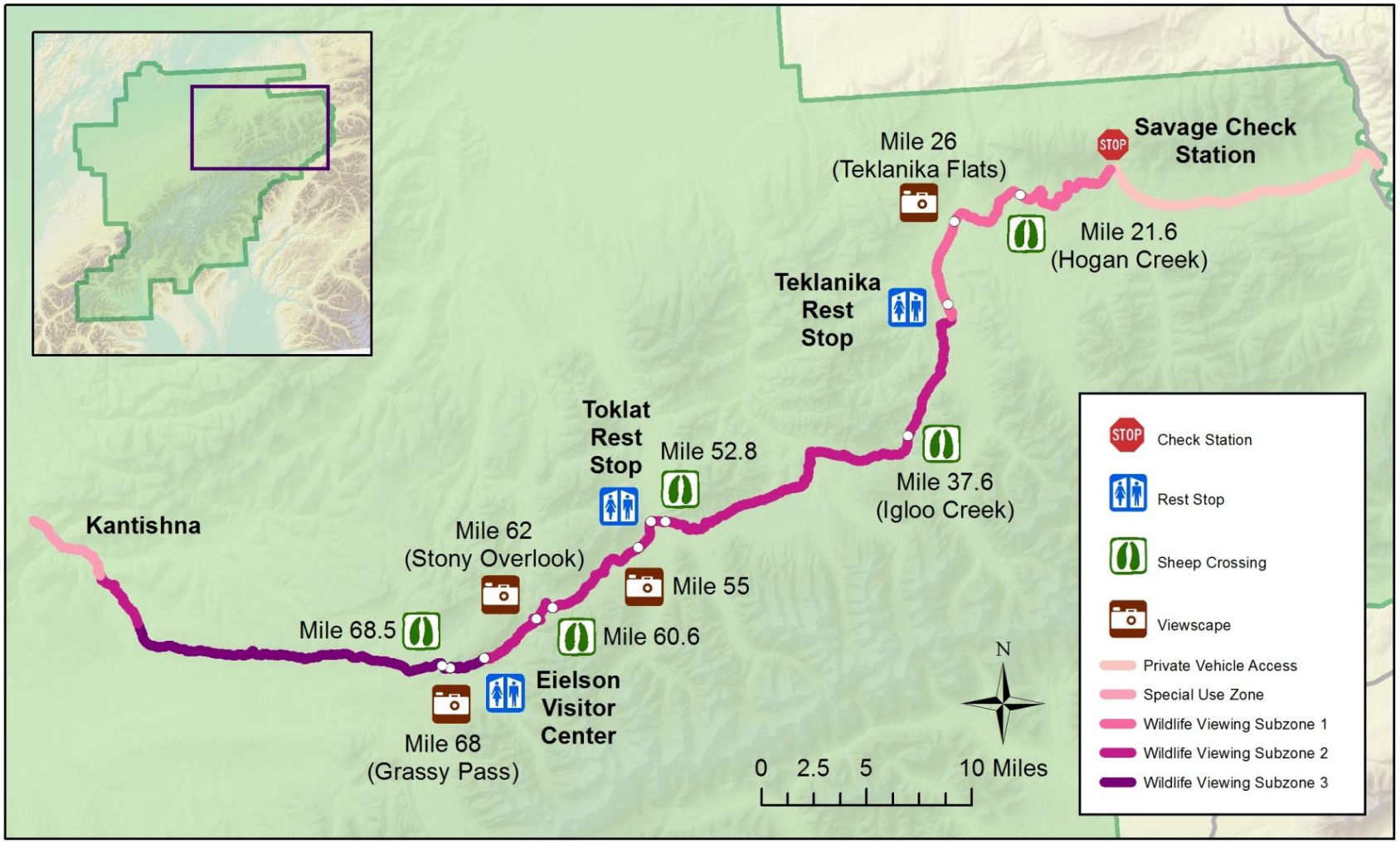

Figure 1. The Vehicle Management Plan established indicators (rest stops, sheep crossings, and viewscapes) that would be monitored for maintenance of desired conditions. The standard which must be met for each indicator depends on the Wildlife Viewing Subzone

Methods

Study Area

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

Data Collection

NPS Staff Observations

NPS staff collected data at designated observation points along the controlled portion of the park road every one to two weeks during the regulatory period in 2011 and 2012. For sampling purposes, the monitoring period was divided into "early", "peak", and "late" subseasons to ensure adequate sampling across the regulatory period (Appendix A). 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. Although scheduling logistics prohibited randomized sampling, each observation site was sampled at least once during each time period, within each subseason. For rest areas and viewscapes, the maximum number of vehicles, by vehicle type was recorded in two-minute intervals for a period of at least 20 minutes. At sheep gaps, NPS staff recorded vehicle interarrival times until a 10-minute gap in traffic was achieved or an hour had passed, whichever came first. The number and type of vehicles at wildlife stops were recorded opportunistically while traveling to and from the observation sites. Vehicles were defined as tour bus, transit bus, lodge bus, government vehicle, or private vehicle. We recorded the type of permit on private vehicles when it was visible. Data were recorded on datasheets in the field and entered into Microsoft Excel software for analysis (Microsoft, Redmond, WA).

Table 1. Sampling periods were broken up into three subseasons to ensure adequate distribution of samples across the entire regulatory period. Although, most of the standards are based on annual averages, analysis of the observations within subseasons provides a means of assessing the impacts of management activities and the scheduling and behaviors of different categories of road users on the standards.

	Early Season	Peak Season	Late Season
2011	5/28 – 6/22	6/23 – 8/10	8/11 – 9/15
2012	5/26 – 6/20	6/21 – 8/8	8/9 – 9/13

Ride, Observe, and Record (ROAR)

Ride, Observe, And Record (ROAR) observers (NPS staff and volunteers) recorded data at wildlife stops, rest stops, and other stops (scenic, campground, and hiker pickups) while traveling the park road on concessioner-operated bus trips. Observations began in May 2011 and 2012. In 2011, ROAR observers recorded data during trips to the Eielson Visitor Center while riding Visitor Transit System (VTS) buses as scheduling permitted. In 2012, the park conducted a study to determine the effects of hourly night-time traffic on the following day's wildlife sightings (Snover, in preparation). The wildlife sighting data were collected by ROAR observers riding the first VTS bus departing from the Wilderness Access Center destined for the Eielson Visitor Center every day from 6/8/12 – 9/5/12. Consequently, most of the 2012 ROAR data were collected from a VTS bus operating on the early morning schedule. ROAR data were also collected from government vehicles by NPS staff observers as part of the sampling scheme described above.

ROAR observations were recorded in a data dictionary installed on Trimble JUNO™ Series Handheld GPS Devices (Trimble, Sunnyvale, CA) (Appendix E). Wildlife observation data included time and date, GPS coordinates, species, number of individuals, group composition if possible (sex and adult/juveniles) and distance from the road using calibrated range finders. Rest stop data included the rest stop name, time and date, and maximum number of buses and vehicles parked at one time by vehicle category (tour, transit, lodge, government vehicle, and private vehicle). The data were downloaded using Pathfinder Office software (Trimble, Sunnyvale, CA) and geoprocessed in ArcGIS Desktop (Release 10, Redlands, CA: Environmental Systems Research Institute). Geoprocessed data were transferred directly into a Microsoft Access database for analysis.

Indicators and Standards

Number of Vehicles at Wildlife Stops

We used ROAR data to compare 2011 and 2012 conditions for the number of vehicles at wildlife stops to the VMP standards. ROAR observers recorded the type and maximum number of each class of vehicle at each stop. They also recorded when they observed any of the "Big Five" wildlife (caribou, brown bear, Dall sheep, moose, and wolves) but there weren't any vehicles stopped or when the recording vehicle (for non-bus trips) was the only vehicle at the stop. Data collected from a government vehicle when there weren't any other vehicles present were not considered a wildlife stop for the purpose of monitoring the VMP crowding standards and were not included in this analysis.

During 2011, NPS and ROAR observers that were traveling in a government vehicle (i.e., a vehicle dedicated to collecting road use data) did not count that vehicle, although ROAR observers did count their bus when traveling by public transportation. In 2012, the wildlife stop protocol was changed to include the government vehicle in the counts. Inclusion of the government observer vehicle increased the number of vehicles at a wildlife stop above the number that were present as a result of the VMP (i.e., the research vehicle was not part of the normal traffic volume). To address the concern regarding this bias, we returned to the original (2011) methodology that excluded the government observer vehicle from the data and subtracted out the government observer vehicles from the wildlife stop data. ROAR data were collected beginning at each trip's initiation point at the WAC 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.

Figure 2. A Visitor Transportation System bus stops to allow visitors the opportunity to view a grizzly bear on the Denali Park Road.

Number of Vehicles at Rest Stops

We used data from the ROAR program and NPS staff observations (Appendix A) to compare the number of buses and vehicles stopped at rest stops at one time to the VMP standards. ROAR observers recorded the maximum number of vehicles, by vehicle type, at the rest stop during the time they were stopped (Figure 3). NPS staff recorded the maximum number of vehicles (by vehicle type) during two-minute intervals for a period of 20 minutes (or longer). Each of the two-minute sampling intervals was treated as a separate observation for this analysis.

As with the wildlife stops, during 2011, NPS and ROAR observers traveling by government vehicle did not count their vehicle, although ROAR observers did count their bus when traveling by public transportation. In 2012, the rest stop protocol was changed to include the government vehicle in the counts, which biased these counts high (as described above). As with the wildlife stop methodology, we addressed the concern regarding this bias by returning to the original (2011) methodology that excluded the government observer vehicle. The 2012 data were adjusted by subtracting the government observer vehicles from the rest stop data.

Figure 3. The number of buses and vehicles at the Teklanika Rest Stop (A) and Toklat Rest Stop (B) and the Eielson Visitor Center (C) are monitored as indicators of visitor experience under the VMP.

Number of Vehicles in Viewscapes

We used data from NPS staff observations (Appendix B) to compare the number of vehicles visible at one time in designated viewscapes to the VMP standards (Figure 4). NPS staff recorded observations at mile 26, mile 55, and mile 62 in 2011; the mile 68 viewscape was added in 2012. As with rest stop observations, the maximum number of vehicles by type was recorded during each two-minute interval for at least twenty minutes and each two-minute observation was treated as a separate observation for analysis.

During the 2007 visitor surveys, participants were shown a series of simulated photographs depicting a range of zero to ten buses visible in a viewscape. The participants were then asked a series of questions regarding their perception of the varying levels of crowding. Because the simulated photos and the responses from the participants did not include an observer vehicle, the standard reflects the results of the visitor surveys plus one vehicle to account for the observer vehicle. The standard is quantified as the percentage of time that a given condition exists within the viewscape during bus operating hours. The adaptive management plan for analysis of this indicator (NPS 2012, Appendix C) established that data would only be used when a vehicle was present, i.e., counts of zero would be excluded from analysis. This decision was based on concerns that zero values recorded during hours when travel is not permitted (overnight) would bias the average low, compared to the potential viewer experience. Excluding zero values, however, will bias the average high, by excluding periods during the day when vehicles could have been present but were not. Analyzing data collected only during the hours of bus operation as specified in the standard addresses both of these concerns. Analysis of the data collected within each viewscape during the hours of bus operation shows the potential experience a visitor could have while traveling through the viewscape by vehicle or while walking or hiking, and it also captures the potential experience of a visitor admiring the viewscape from another vantage point such as Stony Overlook. Therefore, the decision has been made to revise the adaptive management protocol by including the zero values recorded during hours of bus operation in the analysis.

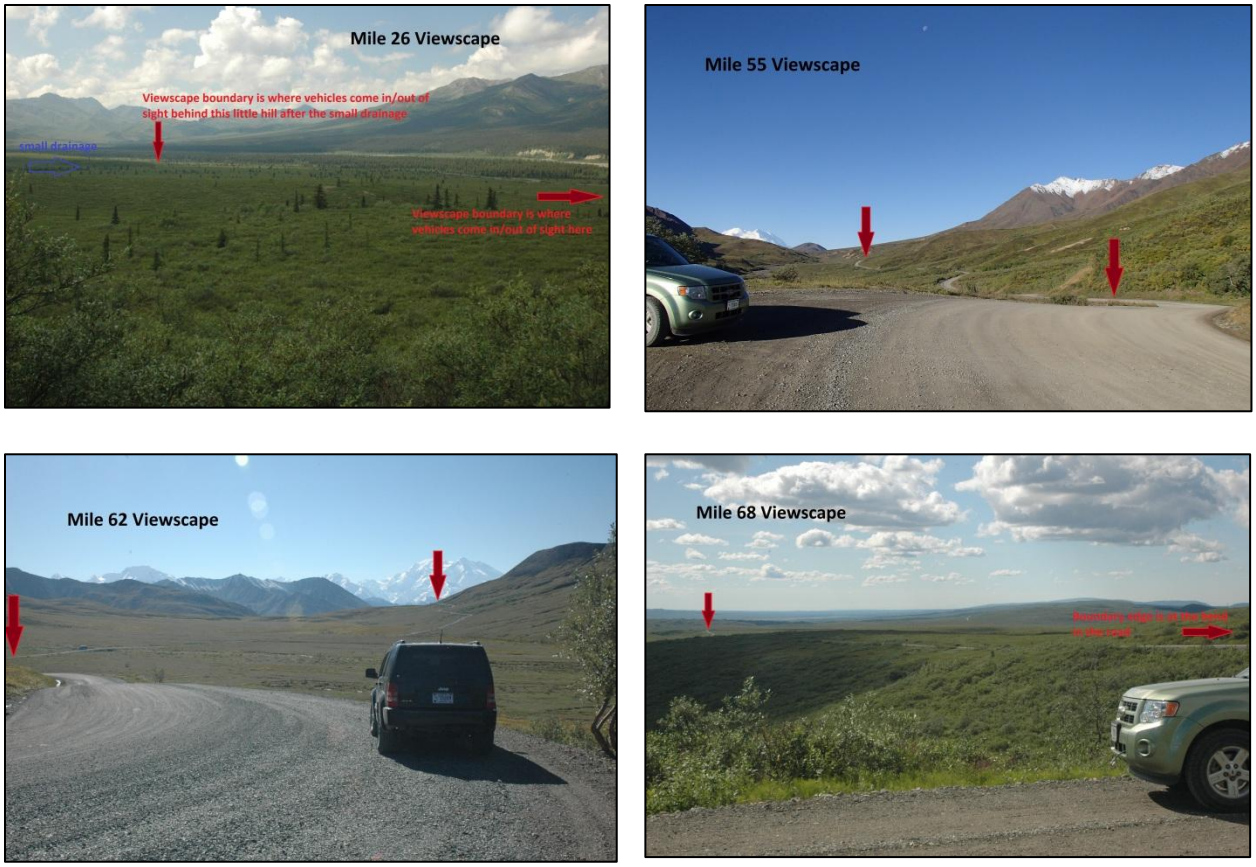

Figure 4. Four viewscapes are monitored to determine if the number of vehicles visible at one time in each viewscape is meeting the standards established in the VMP.

Sheep Gap Spacing

NPS staff observations (Appendix C) were used to compare inter-arrival time at sheep gap locations to the VMP standards. NPS staff recorded observations at mile 21.6, 37.6, 52.8, 60.6, and 68.5. A gap was considered to be present if 10 minutes passed between vehicles at least once during a 60-minute time interval. During each sampling period, observers recorded the times (rounded to the minute) when a vehicle crossed the sheep crossing location until there was either a 10-minute traffic gap or until an hour passed, whichever came first. An observation period of 60 minutes that did not have a break in traffic of at least 10 minutes was considered an observation without a gap.

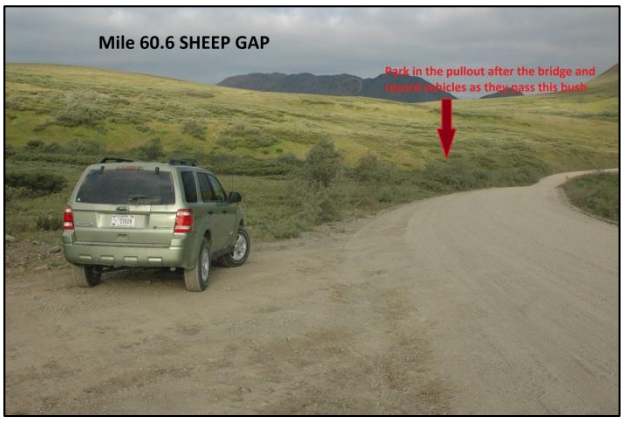

Figure 5. The spacing of traffic at five sheep crossing locations is monitored to ensure that there are adequate 10-minute gaps in traffic on an hourly basis throughout the day. The NPS wants to maintain breaks in traffic throughout the day to enable Dall sheep and other wildlife to move between adjacent habitats.

Data Analysis

Averages, standard deviations, and maximum vehicle numbers were calculated for wildlife stops, rest stops, and viewscapes using Microsoft Access and Excel software (Microsoft, Redmond, WA). The number of hours monitored that included a minimum of a 10-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.

Results

Number of Vehicles at Wildlife Stops

ROAR observers recorded 675 wildlife stops in 2011, and 1287 wildlife stops in 2012. In both 2011 and 2012, the majority of wildlife stops were recorded in wildlife viewing Subzone 2 (Table 2). In 2011, the average (±SD) number of vehicles observed at wildlife stops was 1.6 (±1.0, n=675) and in 2012, the average number of vehicles observed at wildlife stops was 1.9 (±1.3, n=1287).

Table 2. Number of observations used for analyzing compliance with the Vehicle Management Plan indicator for the number of vehicles at wildlife stops along the Denali Park Road.

	Wildlife Subzone 1	Wildlife Subzone 2	Wildlife Subzone 3
2011	*n*=83	*n*=577	*n*=15
2012	*n*=158	*n*=1116	*n*=13

All of the Wildlife Viewing Subzones were in compliance with the VMP standards for number of vehicles at wildlife stops during 2011. In 2012, Wildlife Viewing Subzone 1 and 2 were in compliance for all standards. Wildlife Viewing Subzone 3 was out of compliance for the most restrictive standard (one-year percent of stops where one vehicle was present), whereas the standards for two or fewer vehicles was achieved one hundred percent (100%) of the time and three or fewer vehicles was achieved one hundred percent of the time (100%) (Table 3).

Table 3. Two of the three wildlife viewing subzones met the one-year standard for the number of vehicles stopped at the same location to view wildlife. Wildlife Viewing Subzone 3 met the two less restrictive standards; however, the most restrictive standard (percent of wildlife stops with only one vehicle) was not met (bolded text).

	Wildlife Subzone 1			Wildlife Subzone 2			Wildlife Subzone 3		
	% ≤3 Vehicles	% ≤4 Vehicles	% ≤5 Vehicles	% ≤2 Vehicles	% ≤3 Vehicles	% ≤4 Vehicles	% =1 Vehicles	% ≤2 Vehicles	% ≤3 Vehicles
Standard (minimum)	70	85	90	70	85	90	70	85	90
2011	96	96	96	84	93	98	87	100	100
2012	94	97	99	80	91	96	**69**	100	100

Number of Vehicles at Rest Stops

During 2011, ROAR observers recorded 284 observations, and NPS staff recorded 580 observations on the number of buses and total vehicles parked at rest stops at one time. During 2012, ROAR observers recorded 590 observations, and NPS staff recorded 648 observations. Both rest stops and the Eielson Visitor Center were in compliance with the VMP standards for the maximum number of buses and the maximum number of vehicles parked at one time in 2011 and 2012. Based on the 2012 ROAR observations, Toklat had the highest average and maximum number of buses (Table 4, Table 5) while Eielson Visitor Center had the highest average and maximum numbers of vehicles present (Table 4, Table 6**)**.

Table 4. Maximum number of buses and maximum number of vehicles parked at one time at the Teklanika and Toklat rest stops and the Eielson Visitor Center in 2011 and 2012.

	Teklanika			Toklat			Eielson		
Standard (maximum)	**12 buses/16 total vehicles**			**11 buses/16 total vehicles**			**10 buses/19 total vehicles**		
	Bus Max	Vehicle Max	*n*	Bus Max	Vehicle Max	*n*	Bus Max	Vehicle Max	*n*
2011 NPS Staff Observations	6	8	210	8	8	178	7	8	192
2011 ROAR	8	8	137	10	12	99	8	11	48
2012 NPS Staff Observations	6	6	205	6	7	235	7	12	208
2012 ROAR	7	10	227	10	11	232	9	13	131

Table 5. Average number of buses parked at one time at the Teklanika and Toklat rest stops and the Eielson Visitor Center in 2011 and 2012.

	Teklanika		Toklat		Eielson	
	Avg (SD)	*n*	Avg (SD)	*n*	Avg (SD)	*n*
2011 NPS Staff Observations	1.9 (±1.4)	210	1.7 (±1.5)	178	2.3 (±2.0)	192
2011 ROAR	2.6 (±1.7)	137	3.5 (±2.1)	99	3.6 (±2.0)	48
2012 NPS Staff Observations	2.3 (±1.5)	205	2.1 (±1.5)	235	2.5 (±1.7)	208
2012 ROAR	3.1 (±1.6)	227	3.7 (±2.0)	232	3.6 (±1.9)	131

Table 6. Average number of vehicles parked at one time at the Teklanika and Toklat rest stops and the Eielson Visitor Center in 2011 and 2012.

	Teklanika		Toklat		Eielson	
	Avg (SD)	*n*	Avg (SD)	*n*	Avg (SD)	*n*
2011 NPS Staff Observations	2.6 (±1.7)	210	1.9 (±1.5)	178	3.8 (±2.1)	192
2011 ROAR	3.0 (±1.9)	137	3.8 (±2.2)	99	5.1 (±2.2)	48
2012 NPS Staff Observations	2.8 (±1.7)	205	2.4 (±1.6)	235	5.5 (±2.7)	208
2012 ROAR	3.4 (±1.8)	227	4.0 (±2.1)	232	5.6 (±2.3)	131

The ROAR data showed that the Toklat Rest Stop and the Eielson Visitor Center were near capacity for the maximum number of buses parked at one time. The highest numbers of buses were recorded on five occasions during the mid-morning hours at the Eielson Visitor Center. These records showed two to three lodge buses and five to six transit buses.

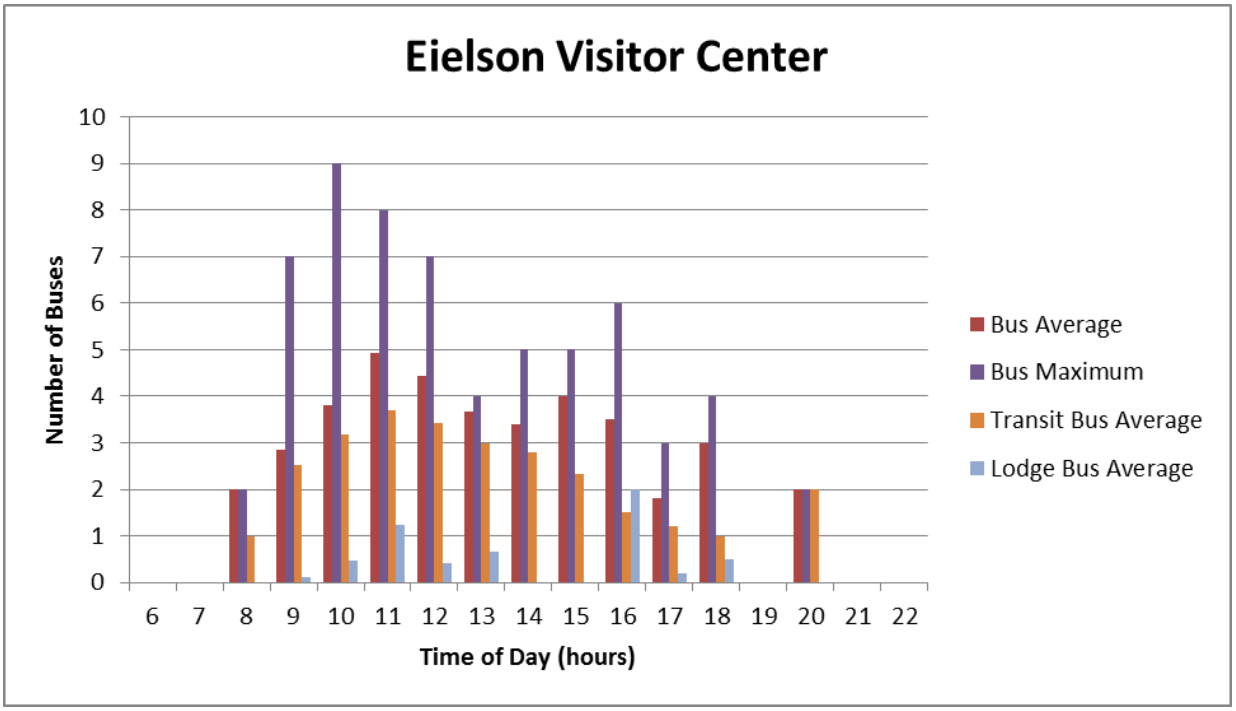

Figure 6. The average and maximum number of buses at the Eielson Visitor Center were observed during the late-morning hours in 2012. The maximum number of buses were observed one hour earlier than the highest average number of buses.

At the Toklat Rest Stop, the highest average and maximum numbers of buses were observed during the 11:00 a.m. hour, and primarily included transit and tour buses although there was one occasion where there were four lodge buses observed along with five transit buses (**Figure 7**). There did not appear to be a pattern to the crowding conditions at Teklanika where the maximum number of buses and vehicles was well below the standard.

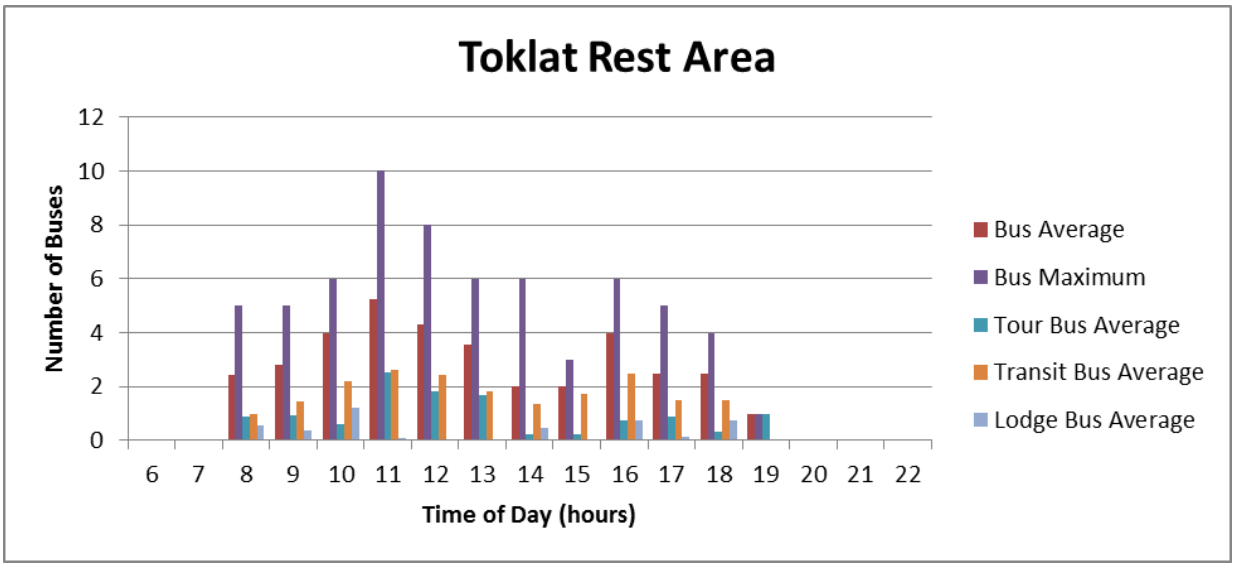

Figure 7. The average and maximum number of buses observed at the Toklat Rest Stop in 2012 were observed during the 11:00 a.m. hour.

Number of Vehicles in Viewscapes

During 2011, NPS staff recorded the number of vehicles visible in the mile 26 (n=160), mile 55 (n=256), and mile 62 (n=107) viewscapes (Table 7). During 2012, NPS staff recorded the number of vehicles visible in the mile 26 (n=176), mile 55 (n=316), mile 62 (n=160), and mile 68 (n=49) viewscapes.

Table 7. An analysis of all observational data recorded at the four viewscapes established by the VMP found that the indictors are meeting the standards for the number of vehicles visible at one time. The data presented in the table are based on the one-year average.

	Mile 26		Mile 55		Mile 62		Mile 68	
	% ≤ 3 vehicles	% ≤ 4 vehicles	% ≤ 2 vehicles	% ≤ 3 vehicles	% ≤ 2 vehicles	% ≤ 3 vehicles	% ≤ 1 vehicles	% ≤ 2 vehicles
Standard (minimum)	80	90	80	90	80	90	80	90
2011	91	91	88	93	84	91	n/a	n/a
2012	99	100	88	97	93	97	88	100

Based on an analysis of all observations, the standards for the number of vehicles visible in each viewscapes at one time, which is averaged across the entire regulatory season, were met at all four sites. Mile 26 and Mile 62 were close to exceeding the standards in 2011. Anecdotal accounts from NPS staff suggested that construction activities and parking of vehicles in viewscapes added to the crowding conditions at these locations. It is important to understand the impacts of these activities and behaviors on the indicators so that they can be addressed prior to any increase in traffic or a violation of the standards. To assess the impacts of these activities and behaviors on the standards, we analyzed the percentage of vehicles visible in the viewscapes during each subseason of each year.

The 2011 data included five sampling occasions during the peak season. In these observations, the Mile 26 viewscape had three or fewer vehicles visible in the viewscape 70% of the time, four or fewer vehicles visible 72% of the time, and five or more vehicles visible 28% of the time. During one of the five sampling occasions there were between six and seven construction vehicles in the viewscape for the entire time and on another occasion there were between two and six construction vehicles visible in the viewscape during six of the ten sampling intervals. During this same year, data were recorded on three separate occasions during the early season at the Mile 62 viewscape. In these observations, two or fewer vehicles were visible in the viewscape 63% of the time and three or fewer vehicles were visible 70% of the time. During one of the sampling occasions, two lodge buses were parked in the viewscape for the entire 20-minute sampling period.

The 2012 data included eight sampling occasions during peak season at the Mile 55 viewscape. In these observations, there were two or fewer vehicles visible in the viewscape 79.2% of the time and three or fewer vehicles in the viewscape 94.4% of the time sampled. A lodge bus was parked in the viewscape for the entire time during one 20-minute period, and a lodge bus and lodge van were parked in the viewscape for the entire time during another 20-minute period.

In addition to analyzing all of the observational data, we conducted an analysis of the data that excluded all zero observations. This provided a mechanism for looking at the actual experience of visitors traveling the park road on buses (Table 8). These data found that the crowding conditions were greater at all of the viewscapes when at least one vehicle was present.

Table 8. The actual crowding conditions experienced by visitors was estimated by excluding observations when no vehicles were present (zero vehicle observations). These data suggest that crowding conditions were greater when at least one vehicle was present. Results that are exceeding standards are in bold text with asterisk.

	Mile 26		**Mile 55**		**Mile 62**		**Mile 68**	
	% ≤ 3 vehicles	% ≤ 4 vehicles	% ≤ 2 vehicles	% ≤ 3 vehicles	% ≤ 2 vehicles	% ≤ 3 vehicles	% ≤ 1 vehicles	% ≤ 2 vehicles
2011	85	**86***	83	91	**76***	**89***	n/a	n/a
2012	99	100	82	95	89	95	**74***	100

Sheep Gap Spacing

During 2011 and 2012, NPS staff collected data at five sheep gap monitoring locations (Mile 21.6, Mile 37.6, Mile 52.8, Mile 60.6, and Mile 68.5) (Table 8). In 2011, the one-year VMP standards for maintaining at least one 10-minute break in traffic every hour at the five sheep crossing locations were in compliance at Mile 37.6 (94%) and Mile 68.5 (100%) (

Table **9**). During the same period, Mile 21.6 (79%), Mile 52.8 (89%), and Mile 60.6 (73%) were out of compliance with the one-year VMP standard. In 2012, the one-year VMP standard for maintaining at least one 10-minute break in traffic every hour was met at Mile 21.6 (89%), Mile 52.8 (90%), and Mile 68.5 (100%). During the same period, Mile 37.6 (81%) and Mile 60.6 (78%) were out of compliance with the one-year VMP standard. The VMP standards for sheep gap spacing are based on the seasonal average; however, we also analyzed the presence of gaps at sheep crossings within subseasons. This analysis was completed to determine if compliance with the standards was more challenging within one subseason or another. Mile 68.5 maintained a 10-minute gap in traffic each hour during all (100%) observation periods across all subseasons during both years. The percentage of hours that sheep gaps were maintained during the peak season at the other four locations varied between 50 and 89%. Observations made during early and late season were more variable among the sheep gap locations and between years.

Table 9. The percentage of observations that included a 10-minute gap in traffic at sheep crossing locations (sheep gaps) during the 2011 and 2012 season compared to the standards established by the Vehicle Management Plan. The standard is the minimum percentage of time (hours in a 24-hour period) that the gaps in traffic are maintained averaged over the entire season. Subseason data is also presented to look for patterns in compliance that could be addressed through scheduling. Results that are exceeding standards are in bold text with an asterisk.

	Sub-season	Mile 21.6 % success	Mile 37.6 % success	Mile 52.8 % success	Mile 60.6 % success	Mile 68.5 % success
2011	Early	83 (*n*=6)	100 (*n*=5)	88 (*n*=8)	100 (*n*=3)	100 (*n*=4)
	Peak	50 (*n*=6)	83 (*n*=6)	83 (*n*=6)	75 (*n*=4)	100 (*n*=2)
	Late	100 (*n*=7)	100 (*n*=6)	100 (*n*=5)	50 (*n*=4)	100 (*n*=4)
	Total	**79*** (*n*=19)	94 (*n*=17)	**89*** (*n*=19)	**73*** (*n*=11)	100 (*n*=10)
2012	Early	100 (*n*=6)	100 (*n*=6)	100 (*n*=6)	67 (*n*=3)	100 (*n*=3)
	Peak	71 (*n*=7)	71 (*n*=7)	89 (*n*=9)	67 (*n*=9)	100 (*n*=5)
	Late	100 (*n*=6)	75 (*n*=8)	83 (*n*=6)	100 (*n*=6)	100 (*n*=3)
	Total	**89*** (*n*=19)	**81*** (*n*=21)	90 (*n*=21)	**78*** (*n*=18)	100 (*n*=11)
Standard (minimum)		90	90	90	90	90

Pre- and post-regulatory season monitoring data were also collected in 2011 at the Mile 21.6 sheep gap location; the park road is only open to Mile 30 (Teklanika rest stop) during the early season. During the pre-regulatory season, a 10-minute gap in traffic was achieved at Mile 21.6 during 56% of the observation periods (n=13). Post-season data was collected during the road lottery, a four-day annual event that occurs in September after the regulatory period has ended. During the road lottery, up to 400 private vehicles per day are allowed to drive as much of the park road as weather allows. In 2011, monitoring data was collected at the Mile 21.6 (n=8) and Mile 37.6 (n=6) sheep gap locations. No 10-minute gaps in traffic were observed during any of the road lottery observation periods.

Discussion

Number of Vehicles at Wildlife Stops

In both 2011 and 2012, most observations of wildlife stops occurred in Wildlife Viewing Subzone 2. Wildlife Viewing Subzone 2 is the longest subzone, and the greatest numbers of wildlife sightings are reported along this portion of the road (Phillips et al. 2012). Our results suggest that traffic scheduling and volumes during 2011 and 2012 enabled the park to be in compliance with the VMP standards for the number of vehicles viewing wildlife at a given location at the same time. The exception was the most restrictive standard for Wildlife Viewing Subzone 3 (at least 70% of wildlife stops there is 1 vehicle), which was out of compliance in 2012. In 2012, ROAR observers predominantly collected data by riding the early morning VTS bus traveling to Eielson Visitor Center and back as part of a study on the effects of night-time traffic on morning wildlife viewing opportunities. As a result, only 1% of the ROAR observations were obtained from Wildlife Viewing Subzone 3 (beyond Eielson Visitor Center) and there was limited data for assessing crowding conditions at wildlife stops in this subzone. Therefore, the lack of compliance could be an artifact of small sample size rather than a reflection of true vehicle crowding at wildlife stops within this subzone. Vehicle behavior has been observed to adversely affect crowding conditions at wildlife stops. For example, if one type of vehicle stays at a wildlife stop for an extended period of time, the behavior can result in greater crowding at the individual stop, and can cascade through the system as the clumped vehicles travel through the system to other wildlife stops, rest stops, and viewscapes. Therefore, more fine scale data is needed from wildlife stops to determine if driver behavior based on vehicle type is impacting wildlife stops, and if so, how best to mitigate the behavior through training, and guidance on when the first bus into the wildlife stop should move on (e.g., a fourth bus pulling up to view the wildlife).

To improve our ability to assess crowding conditions at wildlife stops, ROAR data should be collected more proportionally from the different subzones based on the amount of vehicle traffic that occurs in each subzone, and bus trips should be scheduled to capture conditions throughout the day during bus operating hours. This data will also help assess changes in wildlife sightings, viewing distances from the road, and distribution of sightings along the road. In 2012, an Automated Vehicle Location system from Fleet Management Solutions (FMS) using Global Positioning Systems (GPS) was installed in the concessioner-operated buses and the majority of the NPS fleet traveling the controlled section of the park road. Prior to full implementation of the VMP (2016), park managers plan to install this technology in the vast majority of vehicles traveling the park road. This data will provide a powerful tool for assessing crowding conditions (standards) for all of the indicators including wildlife stops.

Number of Vehicles at Rest Stops

Our results suggest that traffic scheduling and volumes during 2011 and 2012 enabled the park to be in compliance with the VMPs standards for the total number of buses and vehicles parked at one time at the Teklanika and Toklat Rest Stops and the Eielson Visitor Center. The data showed that the Toklat Rest Stop and the Eielson Visitor Center were near capacity for the maximum number of buses parked at one time. Both of these stops have visitor attractions that likely increase the residence

time of vehicles. It will be important to understand how turn-over rate influences crowding conditions at these locations to ensure that scheduling doesn't result in the standards being exceeded. This data will help inform modifications to bus schedules and elucidate if residence time by individual users or types of user groups needs to be modified to maintain standards. These data will be available through the GPS data collected from individual vehicles as well as data collected by NPS staff.

The ROAR observations consistently showed higher crowding conditions (maximum and average) as compared to the NPS staff observations. The 2012 ROAR data was collected daily from the earliest transit bus traveling out west to Eielson Visitor Center. The scheduling of that bus overlaps to some degree with westbound lodge day trips and concessioner-operated tours as well as other transit buses. Given that the standard is an absolute maximum, the timing of the ROAR data collection may have captured periods of time when some of the worst crowding occurs at those sites.

Number of Vehicles at Viewscapes

Our results suggest that traffic scheduling and volumes during 2011 and 2012 enabled the park to be in compliance with the VMP standards for the number of vehicles visible in a viewscape at one time. Although, the standard is based on the seasonal average, it is also useful to look at the data by subseason. If traffic were to be increased, or if additional monitoring finds that the standards are being exceeded, the subseason data would help identify where the system was being stressed. The subseason analysis also illustrates how vehicle behavior can contribute to crowding conditions. These data suggest that crowding conditions are impacted by the parking of vehicles in viewscapes for extended periods of time. The Highway Pass and Stony Dome area are popular day hiking areas for Camp Denali/North Face Lodge. At times, their guides will park buses within the viewscapes for several hours during their hikes. The Stony Dome viewscape in particular provides a dramatic view of Mount McKinley that is experienced and photographed by over 100,000 visitors per year traveling on the Tundra Wilderness Tour alone. Tens of thousands more experience it while traveling on the Visitor Transportation System and lodge buses. Parking vehicles in viewscapes for several hours per day during numerous days of the summer has an impact on these viewscapes. How much of an impact these vehicles are having is difficult to assess without having a GPS tracking systems on the buses. Installing GPS units will greatly improve our ability to monitor the condition of viewscapes and mange vehicle behavior to improve crowding conditions and ensure visitors have a high-quality experience.

Sheep Gap Spacing

Our results suggest that maintaining hourly, 10-minute gaps in traffic at the five sheep crossing locations is going to be the most challenging standard to meet. Based on NPS staff observations, for the hours monitored, sheep gap spacing standards were only met at the Mile 37.6 and Mile 68.5 sheep gap locations in 2011 and Mile 52.8 and Mile 68.5 sheep gap locations in 2012.

Exploring seasonal trends, it appears the peak season observations made east of Eielson Visitor Center are the most likely to be out of compliance. Maintaining hourly, 10-minute gaps in traffic at the five sheep crossing locations is going to be the most challenging standard to meet. Currently, Teklanika camper traffic is unscheduled, which affects the Mile 21.6 sheep gap, and the Mile 60.6

receives a greater amount of traffic due to its proximity with the Stony Overlook turnaround location. The Mile 52.8 sheep gap will also need to be closely monitored due to its proximity with the Toklat Rest Stop, which is a turnaround point for some transit buses, and observations of buses stopping adjacent to the sheep gap to view wildlife, including sheep. Additionally, managing the crowding conditions at wildlife stops, rest stops, viewscapes encourages spacing vehicles out along the road, while managing for gaps in traffic at sheep crossing encourages having vehicles travel together in groups.

Supplementing the observational data with data from traffic counters installed in the road at strategic locations and GPS tracking data from vehicles will enable us to more accurately monitor the sheep gap indicator. Even with improved monitoring protocols, maintaining the standards for traffic spacing at sheep gap locations may be difficult to achieve without addressing the scheduling of vehicles, including the Teklanika campers, and exploring ways that driver behavior (e.g., dwell times at Stony Overlook and Eielson Visitor Center) can be modified to improve our ability to maintain adequate spacing at the five sheep crossings.

Future Monitoring and Data Collection

The VMP called for installing GPS units on all buses and NPS vehicles traveling the park road and issuing GPS units to other road users. Collecting GPS data from the vast majority of vehicles traveling the park road will greatly improve the accuracy of our monitoring efforts, and our ability to assess the condition of the indicators. These results will improve our ability to understand and manage vehicle behavior (e.g., residence time) to ensure desired conditions are being met. The GPS data will be supplemented by traffic counter data, and data collected via the ROAR program and NPS staff observations. These methods will remain as important tool for validating the GPS system, for collecting data on wildlife sightings, and for estimating the impact that occasional road users have on the indicators.

While the results of our 2011–2012 monitoring suggest that conditions along the park road are mostly within standards, they also highlight areas where management can be improved. During 2013–2015, we will have the opportunity to refine our ROAR and NPS observation monitoring protocols, and analyze results from the GPS systems and traffic counters. The results will be integrated into a traffic scheduling tool that will inform management of vehicle traffic to ensure that wildlife and other park resources are protected and visitors continue to have a high-quality experience while traveling the Denali Park Road.

Management Recommendations

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

- Install GPS systems on remaining buses and provide GPS units to occasional road users operating under park permits (e.g., professional photographers).
- Build awareness of the VMP goals among frequent park road travelers to protect the unique character and experience afforded by the road. In particular, encourage travelers to:

- only stay at wildlife stops long enough for visitors to enjoy the experience, but to move along when crowding conditions begin to exceed the VMP standards.
- avoid stopping or parking within viewscapes and sheep crossing locations.

Literature Cited

Bryant, J. 2011. Snapshots from the past: A road history of Denali National Park and Preserve. Center for Resources, Science, and Learning, Denali National Park and Preserve. National Park Service, Denali National Park and Preserve, Alaska.

Manning, R.E., and J.C. Hallo. 2010. The Denali park road experience: Indicators and standards of quality. Park Science 27:33–41.

Morris, T.M., J. Hourdos, M. Donath and L. Phillips. 2010. Modeling traffic patterns in Denali National Park and Preserve to evaluate effects on visitor experience and wildlife resources. Park Science 27:48–57.

National Park Service (NPS). 1986. General management plan, Denali National Park and Preserve. National Park Service, Denali National Park, Alaska.

National Park Service (NPS). 1997. Entrance area and road corridor development concept plan, Denali National Park and Preserve. National Park Service, Denali National Park, Alaska.

National Park Service (NPS). 2012. Denali Park Road final vehicle management plan and environmental assessment. Denali National Park and Preserve. National Park Service, Denali National Park, Alaska.

Phillips, L., P. Hooge, and T. Meier. 2010a. An integrated study of road capacity at Denali National Park. Park Science 27:28–32.

Phillips, L., R. Mace, and T. Meier. 2010b. Assessing the impacts of traffic on large mammals in Denali National Park and Preserve. Park Science 27:42–47.

Phillips, L.M., B. Borg, and M.L. Snover. 2012. Assessment of vehicle use and wildlife sightings in Denali National Park and Preserve: Summary report 2006–2009. Natural Resource Technical Report. NPS/DENA/NRTR—2012/600. National Park Service, Fort Collins, Colorado.

Snover, M.L. In preparation. Denali Park Road night-time traffic experiment: Preliminary report. Denali National Park and Preserve. National Park Service, Denali National Park, Alaska.

Western Regional Climate Center. 2007. McKinley Park, Alaska: period of record monthly climate summary. Available from http://wrcc.dri.edu/summary/akF.html (accessed 7 Nov 2007).

Appendix A. Subseason sampling matrix for monitoring indicators during 2011–2012

Year:		Sub season:					
Season Start Date	**Site MP**	**Duty**	**0600–0900**	**0900–1200**	**1200–1500**	**1500–1800**	**1800–2200**
	21.6	Sheep Gap					
	26	Viewscape					
	30	Tek Rest					
	37.6	Sheep Gap					
	48	Poly Rest					
	52.8	Sheep Gap					
	53.5	Toklat Rest					
	55	Viewscape					
	60.6	Sheep Gap					
	62	Viewscape					
	66	Eielson Rest					
	68.5	Sheep Gap					

Appendix B. Standard Operating Procedures (SOPs) for collecting ROAR data using a Trimble Juno GPS

To Begin

Go to Start menu drop down (upper left hand corner): Touch on TerraSync to open.

Change Status (upper left once open) to **Data***

Create New Data:

File Type: Rover

Location: SD-MMC card

File Name: Keep automatically assigned file name

Dictionary Name: ROAR

Hit "Create"

Select antenna type: Juno internal

*If you get off of your current bus during the trip to do a side excursion, please start another data file when you get onto the next bus by following these steps again.

Features

A list of feature boxes will pop up. Select the feature box that is appropriate for your stop by tapping on it once. Fill out as much information as possible within that feature, press "OK" when finished.

For any field within the feature that asks you to write in information (numbers or comments), you can open the keypad while the field is highlighted by tapping on the keypad symbol in the middle bottom of the screen (between "OK" and "Pause"), touch it again to make it disappear.

When the unit is gathering locations, the flashing number next to the satellite icon will count up. If the unit has not pinpointed your location, when you attempt to save the feature it will say, "No positions recorded, do you still want to enter?" Select NO and return to the previous screen and attempt to troubleshoot the problem (see "NOTES" section below). If you try and can't fix it immediately, try to save it again and hit "YES" to accept the entry without positions.

Trip Introduction: This is information on the introduction provided by the bus driver at the beginning of the tour. The comments section is limited to 200 characters, so if you wish to provide extra comments, you can open a word document from the Start Menu in Office Mobile: Word Mobile. In the comments section of the feature, note the file name of your Word Mobile document. As long as you don't close out of TerraSync, you can open a word document, make notes, and then close Word and return to your TerraSync File without losing information.

Wildlife Stop: Record all stops that the bus makes to view wildlife. Do not hit "ok" until the bus leaves the stop (unless recording multiple species at one stop, in that case wait to hit "ok" on your last species entry). This will give us information on time at the stop. For the number of vehicles, record the greatest number of vehicles at the stop at *one time*, **including yourself.** For example, if there are no buses at the stop when you arrive, but three VTSs show up while you are stopped, record three VTSs, and whatever type of vehicle you are in. When recording "Distance" the use of a range finder is preferred. If not available, try to estimate to the nearest 10 meters when possible. (For male, female, or young distinction see "Wildlife Classification" in NOTES section) If more than one species is present, make a new feature for each.

Wildlife (No Stop): Wildlife seen alongside the road, but the bus does not stop. For example, for the fifth group of caribou seen the bus might not stop in order to keep time, but record any information you can as you pass by. Again, distance should be approximated to the nearest 10 meters from you when possible, and include your vehicle in the count.

Rest Stop: Record the number of vehicles at all rest stops. "Rest stops" include Primrose, Tek Campground (Tek CG), Teklanika rest stop (Tek RS), Igloo CG, Polychrome, Toklat, Stony Overlook and Eielson Visitor Center (Eielson VC). Record the number of vehicles observed when you first arrive at the rest stop, **including yourself**.

Hiker Pick Up: Whenever the bus stops to pick up a hiker, record if the driver asks for a wait time and how long the hiker waited.

Other Stop: These stops include stops for passenger pick up and drop off, scenery, construction, and unknown reasons. For "Other" please describe the scenario in the comments section.

Tour Final: Evaluation of the complete tour- to be completed at the end of the trip is no longer necessary as of 2012.

Notes

Troubleshooting difficulty receiving satellites:

In TerraSync:

-Setup: Options: Reset GPS receiver or try disconnect from GPS and then reconnect

-GPS button in right corner of Setup page will also disconnect and reconnect

When unites freeze/will not respond

-First try a "soft" reset by pressing the recessed button on the right side of the unit (reset button).

-If no luck with soft reset, hold power button and rest button at the same time

Wildlife Classification:

Bear:

Male: Large with no cubs, but mostly undistinguishable unless anatomy is visible.

Female: Comparatively smaller than males, most with cubs present, but mostly undistinguishable from males without cubs present or anatomy seen.

Young: Smaller than adults; will travel with mother for first two years.

Caribou:

Male: Can be larger than females (not decipherable unless in close proximity); antlers present starting in March through late fall, appear large, thick, with wide flattened areas toward tops and front

Female: Relatively smaller than males; antlers are thin and short comparatively with no flattened areas

Young: Relatively smaller than adults; antlers may be present, but will be small.

Wolf:

Male: Undistinguishable unless anatomy is seen.

Female: Undistinguishable unless anatomy is seen.

Young: Smaller than full size adults for first summer.

Moose:

Male: Large animals (up to 1200 lbs); presence of antlers (starting in spring); pronounced hanging skin from chin

Female: Smaller in relation to males; antlerless; less pronounced skin under chin

Young: Smaller than adults; reddish brown, uniform coloring; usually seen with adult female for first year.

Sheep:

Male: large (200-250 lbs); curved thick horns- the more complete curl (i.e., half curl, ¾ curl, full curl), the older the animal. Males are generally in single sex bands during summer.

Female: smaller than males (100-150lbs); shorter, thinner horns with a slight curve. Females, lambs and yearling s are generally band together in summer. Adult rams are rare with these “nursery groups.”

Young: relatively smaller in size than their adult counterparts, varying size of horns, generally smaller and thinner than adults. Yearling male and females difficult to distinguish from adult females from a distance.

Making Changes to Saved Stops:

Keeping TerraSync open, touch on the drop down list in the upper left (under the one that should read “data”) and change it to “Update Features”. Select the name of the feature that you wish to change, and touch on “begin”. From there make any of the necessary changes, then touch “OK” to save. To get back to the Collection screen, simply touch on the dropdown list and change it to “Collect Features”.

Misc:

Options on data page: If repeat is checked under “Options” menu, the default value for each attribute will be the same as the one entered for the last feature of that type.

Appendix C. Standard Operating Procedures (SOPs) for monitoring rest stops by NPS staff

Objective

Obtain a measure of the number of vehicles at rest stops for comparison to Vehicle Management Plan (VMP) standards

Rest Stops

Teklanika

Polychrome Overlook (originally included in monitoring plan-subject to change with VMP implementation)

Toklat

Eielson Visitor Center

Sampling

Schedule at least one observation in each time period during early, peak and late season, following the sampling grid (T:\ResMgmt\Projects\Road Study\Data\Data forms\Templates\Sampling Grid Checklist.doc). Independent observations of rest stop crowding are made during Ride Observe and Record (ROAR) trips into the park. This protocol explains the collected of data for observation periods of at least 20 minutes and follows a sampling scheme that mirrors the traffic model estimation of rest stop crowding.

Observations

- Park in an unobtrusive spot at the rest stop: near the road at Tek, behind the vault toilets at Toklat, along the rock retaining wall with other government cars at EVC.
- Record the *maximum* number of vehicles (of each class/category) within the rest stop *simultaneously* during every two-minute period.
    - Record all observations on on the "Viewscape Rest Stop Obs Form ll" datasheet (T:\ResMgmt\Projects\Road Study\Data\Data forms\Templates)
        - In 2012, we began the trial use of iPad tablets (Apple Inc, Cupertino, CA) for data collection. After a further trial period in 2013, data will be collected directly in a spreadsheet on the iPad.
    - Categorize vehicles according to bus type (VTS, TWT or Lodge) or by vehicle type for non-buses (GOV, POV, or HE (heavy equipment)). Heavy equipment vehicles without government plates but known to be operated by the government are counted as government vehicles.
    - Count the observer vehicle assuming it is parked at the rest stop.

Data Entry

- After returning from the field, enter data from spreadsheets into “Rest Stops Master All Years” Excel spreadsheet (T:\ResMgmt\Projects\Road Study\Data\Indicators\RestStop).

- With the use of the iPads, data can be cut and pasted into the master data sheet.

Data Analysis

For comparison to VMP standards, calculate the maximum number of vehicles visible at each rest stop. In previous years we also calculated and included the average number of vehicles with the standard deviation for each rest stop for summary reports.

- In an Excel spreadsheet, insert a Pivot Table using “Site” for the Row Labels and the “Sum” for the Values (you can also include “Date” in the Filter Area).

- Right click in the pivot table and summarize data by Count, Maximum, and Standard Deviation to get the totals.

- In 2012, each table was copied and the values pasted as separate tables for easy reference. These tables are stored in the “2009-2012 Rest Stop Data Used for 2012 Report spreadsheet” (T:\ResMgmt\Projects\Road Study\Data\Indicators\Rest Stops\Rest Stop 2012).

Appendix D. Standard Operating Procedures (SOPs) for monitoring viewscapes by NPS Staff

Objective

Obtain a measure of the number of vehicles in a viewshed for comparison to Vehicle Management Plan (VMP) standards

Viewscapes

Mile 25:
Overlooking Teklanika River drainage and west on the road across Teklanika Flats
Viewshed distance: 1.1 miles

Mile 55
From the pullout at mile 56, looking west
Viewshed distance: approximately 1.0 miles

Mile 62
From the pullout on top of Stony, looking west towards Eielson
Viewshed distance: 2.2 miles

Mile 68.5
From yield sign to pull in for gravel pit
Viewshed distance: approx. 1 mile?
Need to collect GPS points on this still in 2013

Sampling

Schedule at least one observation in each time period during early, peak and late season, following the sampling grid (T:\ResMgmt\Projects\Road Study\Data\Data forms\Templates\Sampling Grid Checklist.doc). This protocol explains the collection of data for observation periods of at least 20 minutes and follows a sampling scheme that mirrors the traffic model estimation of viewscape crowding.

Observations

- Park at the beginning of the viewshed, facing west to view the entire viewshed.
- Record the *maximum* number of vehicles (of each class/category) visible in the viewshed *simultaneously* during every two-minute period.
    - Record all observations on the "Viewscape Rest Stop Obs Form ll" datasheet (T:\ResMgmt\Projects\Road Study\Data\Data forms\Templates)

    - In 2012, we began the trial use of iPad tablets (Apple Inc, Cupertino, CA) for data collection. After a further trial period in 2013, data will be collected directly in a spreadsheet on the iPad.

- Categorize vehicles according to bus type (VTS, TWT or Lodge) or by vehicle type for non-buses (GOV, POV, or HE (heavy equipment)). Heavy equipment vehicles without government plates but known to be operated by the government are counted as government vehicles.

- Do NOT count the observer vehicle- the observer vehicle should not be parked in the viewshed.

Data Entry

- After returning from the field, enter data in the "Viewscape Data Master All Years" Excel spreadsheet (T:\ResMgmt\Projects\Road Study\Data\Indicators\Viewscape)

- With the use of iPad tablets, data can be cut and pasted into the master data sheet.

Data Analysis

For comparison to VMP standards:

- Remove viewscape observations without vehicles (zeros) from the dataset for analysis.

- Calculate the percentage of observations with the numbers of vehicles designated in each VMP standard

    - The easiest way to sort the data is to import the Excel spreadsheet into Access.

    - Then run a series of queries to filter out the zero observations and separate the data by site.

        - For users uncomfortable with Access, this could also be done within Excel by performing a series of Sort and Filters.

- In 2012, we copied the data for each site into a separate spreadsheet within the same book (see: "2012 Viewscape Data Used for Report").

    - We averaged the total vehicles and calculated standard deviation

    - We used the CountIf function (i.e., =COUNTIF(range,"<=3") to find the number of vehicles less than or equal to each VMP standard;

    - We calculated the percentage of all observations that were less than or equal to the specified number of vehicles for each standard and reported them in the 2012 summary report.

Appendix E. Standard Operating Procedures (SOPs) for monitoring traffic at sheep gap (crossing) locations

Objective

The Vehicle Management Plan has adopted the sheep gap indicator which requires a 10-minute gap in traffic each hour at certain locations along the road known as crossing points for Dall sheep. This document outlines the protocols for measuring traffic gaps.

Locations

Traffic gap monitoring will be conducted at the five following sheep crossing locations:

Mile 21.6: Near Hogan Creek

Crossing occurs between Primrose low ridge to south of the road

Mile 37.6: East side of Sable Pass near Igloo Creek

Crossing occurs between Cathedral and Sable Mountains

Mile 52.8: East of Toklat Rest Stop

Crossing occurs between west end of Polychrome and Toklat River (Divide Mountain)

Mile 60.6: Crossing near Stony Creek

Crossing between mountain east of Stony Hill and Gravel Mountain area

Mile 68.5: West of Eielson

Crossing between Thorofare Mountain and Alaska Range

Sampling

Sampling is stratified temporally by season and time of day. Observers will sample all sheep gap locations once or more during each time period within each season. Note that pre and post season monitoring only occurs at mile 21.6 and that early morning and night monitoring do not occur at sheep gap locations that do not typically receive traffic during those periods (Table 1). So far we have looked for the presence of a gap for an hour from the time of arrival at monitoring sites (not by counting from the top of the hour). Accordingly, we cannot count a second gap as having occurred until an hour has passed (so it doesn’t work for data analysis to start a new gap count for a new sampling time period unless a full hour has passed since you started counting regardless of whether you have already had a 10-minute traffic gap).

Season:

Bus schedules are used to determine exact season dates; below dates are approximate and need to be updated yearly at the beginning of the season.

Pre-season: Road Open to Teklanika to 5/20 or first day of bus transit

Early Season: 5/20-6/20

Peak Season: 6/21-8/8

Late Season: 8/9-9/13

Daily:

Morning: 6 a.m.–9 a.m.

Late morning: 9 a.m.–12 a.m.

Afternoon: 12 p.m.–3 p.m.

Late afternoon/evening: 3 p.m.–6 p.m.

Late evening: 6 p.m.–10 p.m.

Methods

Instructions for observers

Determine sheep gap location from a handheld GPS unit (Garmin Ltd, Olathe, KS). Park at a location near, but not at, the sheep gap monitoring site and observe from off of the road or from the vehicle. Mark the exact crossing location with a cone or use a physical marker (tree, willow bush, etc) in order to determine when a vehicle passes the exact location. Record the time, direction and vehicle type for each vehicle AS it crosses the sheep gap location. Data is recorded on the datasheet found at T:\ResMgmt\Projects\Road Study\Data\Data forms\Templates\ "Sheep Gap Spacing Data Sheet".

Record all vehicle traffic for an hour at a specified location OR until one 10- minute gap is measured. If a 10- minute gap is measured, the observation period can end as we know there is at least a 10-minute gap is recorded for that hour.

In 2013 data will be entered directly into spreadsheets using an iPad (Apple Inc, Cupertino, CA) tablet computer. During an initial one month trial period one observer will enter data on the datasheet and one observer will enter the same information directly into the iPad spreadsheet. Forms are currently stored in the Indicators folder and on the Road Study #2 iPad. Master datasheets are found in the file titled "Master Indicator Sheets"'. See the iPad Data Collection Protocol document for detailed instructions.

In addition to direct monitoring of traffic gaps at sheep crossing locations, we will use data from inductive loops installed in the roadbed near sheep crossing locations to verify traffic gaps. Two traffic counters are located near sheep crossing locations (counter at mile 39.6 near the mile 37 crossing, and counter at mile 68.8 near the mile 68.5 crossing). The TRS (International Traffic Corporation Inc., Saskatoon, SK, Canada) counters installed in 2012 can store information in one minute intervals, therefore we can determine when there are 10-minute intervals with no traffic.

Data Entry

Input all data into the "Sheep Gap Master All" Microsoft Excel spreadsheet (T:\ResMgmt\Projects\Road Study\Data\Indicators\Sheep Gap Data). Data is either copied from the hard copy data sheet, or cut and pasted from the spreadsheets created in the field. In 2012, a column for observation number was added to the master spreadsheet. This allows the data to be easily grouped in Microsoft Access for analysis, once the spreadsheet is imported into an Access database.

Data Analysis

For comparison to the VMP, we need the number of hours sampled and the number of these hours with a 10-minute traffic gap. This data can be summarized using Excel and by simply counting and creating summary tables, or by importing the spreadsheet into Access and using a query to group by observation number and sub season. User comfort with the different software determines which method is most efficient.

Appendix F. Denali Park Road Final Vehicle Management Plan: Tier 1 indicators and standards

Maximum 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	No one year will have less than 70% of wildlife stops with 3 or fewer vehicles 75% of wildlife stops will have 3 or fewer vehicles (5-year average) No one year will have less than 85% of wildlife stops with 4 or fewer vehicles 90% of wildlife stops will have 4 or fewer vehicles (5-year average) No one year will have less than 90% of wildlife stops with 5 or fewer vehicles 95% of wildlife stops will have 5 or fewer vehicles (5-year average)
Wildlife Viewing Subzone 2	No one year will have less than 70% of wildlife stops with 2 or fewer vehicles 75% of wildlife stops will have 2 or fewer vehicles (5-year average) No one year will have less than 85% of wildlife stops with 3 or fewer vehicles 90% of wildlife stops will have 3 or fewer vehicles (5-year average) No one year will have less than 90% of wildlife stops with 4 or fewer vehicles 95% of wildlife stops will have 4 or fewer vehicles (5-year average)
Wildlife Viewing Subzone 3	No one year will have less than 70% of wildlife stops with 1 or fewer vehicles 75% of wildlife stops will have 1 or fewer vehicles (5-year average) No one year will have less than 85% of wildlife stops with 2 or fewer vehicles 90% of wildlife stops will have 2 or fewer vehicles (5-year average) No one year will have less than 90% of wildlife stops with 3 or fewer vehicles 95% of wildlife stops will have 3 or fewer vehicles (5-year average)

Maximum 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
Maximum 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**	No one year will have less than 80% of the time with 3 or fewer vehicles visible in the viewscape 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 90% of the time with 4 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)
Miles 55 and 62 **Wildlife Viewing Subzone 2**	No one year will have less than 80% of the time with 2 or fewer vehicles visible in the viewscape 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 90% of the time with 3 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)
Mile 68 **Wildlife Viewing Subzone 3**	No one year will have less than 80% of the time with 1 or fewer vehicles visible in the viewscape 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 90% of the time with 2 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)
Maintenance of a minimum of one 10-minute gap in traffic per hour at five sheep crossing locations (Sheep Gap Spacing)	
Milepost 21.6, 37.6, 52.8, 60.6, and 68.5	No one year will have less than 90% success rate (22 of 24 hours with gaps at each crossing) 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

NPS 184/124547, May 2014

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov