



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

2019 Summary Report

Natural Resource Report NPS/DENA/NRR—2020/2160



ON THE COVER

A transit bus stops trails behind a bull moose with full fall colors in the background on the Denali Park Road.
NPS Photo (A. Kirk)

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Natural Resource Report NPS/DENA/NRR—2020/2160

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Executive Summary

Conditions of six Vehicle Management Plan (VMP) indicators, the probability of observing the “big five” wildlife species (caribou, grizzly bear, moose, sheep, and wolf) from a bus, and statistics related to the number of vehicle entrances on the permit-controlled section of the Denali Park Road were observed and recorded for the 2019 regulatory year (May 25–September 12, 2019) (National Park Service 2012). The six tier-1 indicators are: (1) Number of vehicles stopped for 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 established 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.

Here we: (1) compare current conditions of the VMP indicators to the 1-year VMP standards; (2) use 2015–2019 data to assess 5-year VMP standards; (3) recommend monitoring method improvements; and (4) provide recommendations for meeting the desired conditions of the resource as described by the VMP and measured by the indicators.

Of 41¹ metrics, 31 met standards defined in the VMP for 2019.

Assessment of the 1-year VMP standards:

- 1.) Wildlife stop standards were met in all three Wildlife Viewing Subzones (WVS).
- 2.) Rest stop standards for total vehicles and total number of buses were met at all sites.
- 3.) Viewscape standards were met at three of four sites. A construction project in the mile 62 viewscape caused the first observed failure of a viewscape since observations began in 2012; both standards failed at the site.
- 4.) Sheep gap standards were met at two of five sites (Tattler Creek and Grassy Pass); three sites failed standard: Hogan Creek, Toklat, and Stony.
- 5.) Nighttime traffic standards for the percentage of time with less than three vehicles each hour was met at four of five sites and the percentage of time with no more than six vehicles in any hour was met at two of five sites. Maintenance and weather-related road emergencies contributed to several nights of high nighttime traffic on the park road in 2019.
- 6.) Hiker wait time standards were met.

Assessment of the 5-year VMP standards:

¹ Traffic counter data from mile 28.7 (Teklanika) are no longer used to measure the nighttime traffic standard because of its proximity to the TekGate counter. The Teklanika counter is still used to determine traffic patterns

- 1.) All wildlife stop 5-year standards were met—an improvement from 2018 when WVS 3 failed the percent time one or fewer vehicles were present at wildlife stops.
- 2.) Viewscape standards were met at four of five sites. The 2019 failures were extreme enough at mile 62 that the 5-year average fell below standard.
- 3.) Sheep gap standards were met at one site and failed at four sites: Hogan Creek, Tattler Creek, Toklat, and Stony.
- 4.) All hiker wait time 5-year standards were met.

Total vehicles entrances on the controlled section of roadway was 13,004, a 0.9% increase over 2018. This value includes a 5.9% increase in entrances by short tours and a 7.0% decrease in lodge bus entrances. The maximum number of vehicles observed in a single day was 155, which occurred July 11. The average number of vehicle entrances per day was 117.

Sheep gap success rate continues to be a management challenge. A remote, automated device was installed at one site in 2019 to capture 24-hour data. However, analysis was not possible as technical issues persisted throughout the season. Troubleshooting of this device will begin in 2020.

The summer of 2019 was historically wet and brought into sharp focus how the physical integrity of the park road may threaten the extent and kind of road access, and thus further challenge the desired conditions established by the VMP (e.g. traffic effects on 90 miles of road are different than the same amount of traffic on 45 miles). Continued success of the VMP relies on a sustained commitment by management and communicating timely information to all road users about their individual role in the collective management effort. For example, the establishment of park-authorized parking places helps ensure that desired conditions related to viewsapes are maintained. Continued integration of specific VMP Terms and Conditions into commercial use agreements, contracts, operating plans, and road use permits, in addition to careful traffic scheduling (including nighttime projects), and continued internal and external education and outreach are necessary to meet desired conditions.

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Introduction

Annual monitoring related to the Vehicle Management Plan (VMP) will be reported in the format herein: results will be reported in this stand-alone document while a background narrative including definition of standards is available at <https://irma.nps.gov/DataStore/Reference/Profile/2258362>. Additionally, methods and analysis protocols are available at <https://irma.nps.gov/DataStore/Reference/Profile/2258367> and <https://irma.nps.gov/DataStore/Reference/Profile/2258369>, respectively. Any changes to methods or analysis protocols will be documented solely in their respective documents.

Park staff and volunteers collected data to assess the current state of VMP indicators. The primary objective of this report is to compare the current conditions of the indicators to their defined standards (i.e. desired conditions). The results will help inform adaptive management strategies to affect the transportation system to achieve desired conditions. This report summarizes data for six of 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 viewscapes; (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.

Results

Data Collection Effort

We sampled 260 VTS and 18 Tour trips using the Ride Observe and Record (ROAR) protocol and 43 regulatory days of sampling using the National Park Service Observation (NPSO) protocol. We completed 746 VMP condition observations in 2019 (Table 1). Observations closely matched the schedule for the Peak and Late subseasons and were further from target values in the Early subseason (Table A-1).

Table 1. VMP indicator observations were made throughout the Early, Peak, and Late subseasons of the summer on the Denali Park Road (Denali National Park and Preserve, Denali Park, Alaska USA). The rate of observation is lowest during the Early subseason due to training days and other commitments.

Samples	Early (26 days)	Peak (49 days)	Late (36 days)	Total
ROAR	68	141	51	260
NPSO	104	219	163	486
Observations per day	6.6	7.3	5.9	–
Total	–	–	–	746

Number of Vehicles at Wildlife Stops

ROAR observers recorded 3,683 wildlife stops. The majority (81%) of wildlife stops occurred in Wildlife Viewing Subzone (WVS) 2, 13% occurred in WVS 1, and 6% occurred in WVS 3. WVS 2 was the most animal-rich road segment (Table 2).

Table 2. The number of ROAR observations recorded in three subzones during the 2019 regulatory year on the Denali Park Road. The number of stops was normalized to Subzone lengths (miles) to report stops per mile. WVS 2 is the most animal-rich subzone in the park by this measure.

Stop Type	WVS 1	WVS 2	WVS 3
Number of wildlife stops	474	2,997	212
Stops per mile per season	23	79	11

All wildlife stop measures met VMP 1-year standards in all subzones (Table 3). Wildlife stops in 2019 were slightly less crowded in all WVS when compared to 2018. A maximum of 13 vehicles was observed once to view a golden eagle near Toklat and 12 vehicles to view a moose near the Sanctuary River. Otherwise, the maximum number of vehicles observed at a wildlife stop never exceeded eight. The 5-year (2015–2019) standard for wildlife stops was also met for all three wildlife viewing subzones (Table 4).

Table 3. Traffic volume conditions as a percentage of time x or fewer ($\leq$) vehicles were observed at a wildlife stop on the Denali Park Road. All wildlife stop 1-year standards were met in 2019.

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	94.1	98.1	99.6	83.8	94.6	98.3	78.3	92.9	98.6

Table 4. The 5-year VMP standards for number of vehicles at a wildlife stop was met for all criteria on the Denali Park Road.

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	75	90	95	75	90	95	75	90	95
ROAR result	94.1	97.8	99.4	82.5	93.4	97.5	75.2	93.8	99.1

Number of Vehicles at Rest Stops

We collected 2,482 traffic volume samples using the ROAR protocol, and 122 samples using the NPSO protocol at Teklanika, Toklat, and EVC rest stops (20 minutes each). All rest stops standards were met in 2019 (Table 5, Figure 1, Figure 2, Figure 3). The EVC continued to have the highest average number of buses and total vehicles observed (Table 6, Table 7). The observed maximums and averages of buses and total vehicles is consistently greater from the NPSO protocol compared to the ROAR protocol at each rest stop. The average number of vehicles at the EVC decreased compared to 2018.

Table 5. Maximum (and sample size, n) number of buses and vehicles parked at one time at the Teklanika and Toklat rest stops and Eielson Visitor Center (EVC) during the 2019 regulatory year on the Denali Park Road. All standards were met in 2019.

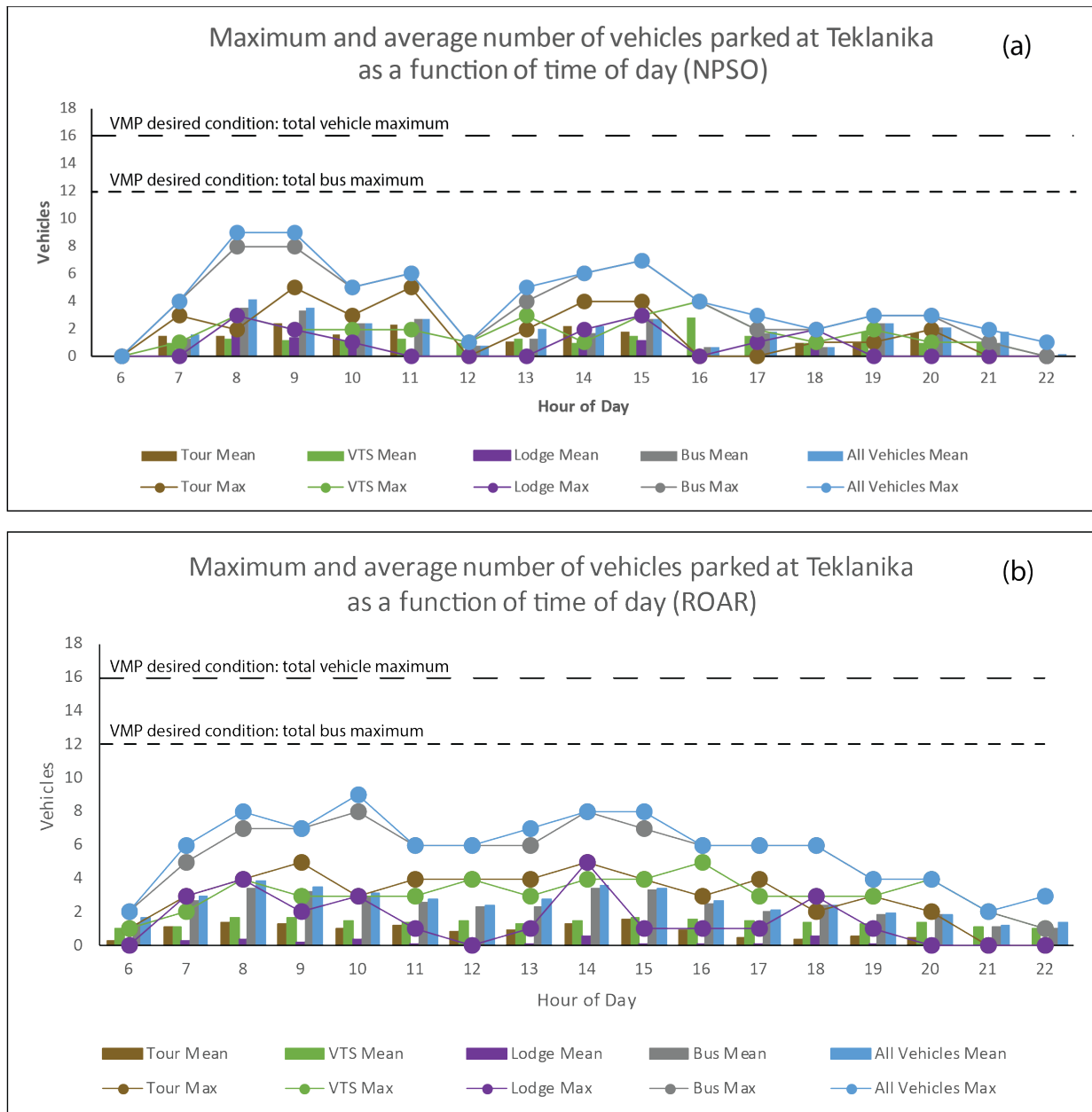
Method	Teklanika			Toklat			EVC		
	bus max	vehicle max	n	bus max	vehicle max	n	bus max	vehicle max	n
Standard	12	16	–	11	16	–	10	19	–
NPSO result	8	9	430	9	10	390	9	11	400
ROAR result	8	9	1,016	10	12	904	9	14	562

Table 6. Mean (and standard deviation, σ , and sample size, n) number of total buses parked at one time at the Teklanika and Toklat rest stops and Eielson Visitor Center during the Denali Park Road. ROAR data were consistently greater than NPSO data; the most buses were observed at EVC.

Method	Teklanika		Toklat		Eielson Visitor Center	
	mean (σ)	n	mean (σ)	n	mean (σ)	n
NPSO result	1.9 (± 1.7)	430	2.3 (± 2.1)	390	2.1 (± 2.0)	400
ROAR result	2.7 (± 1.4)	1,016	3.9 (± 1.9)	904	3.7 (± 1.7)	562

Table 7. Mean (and standard deviation, σ , and sample size, n) number of total vehicles parked at one time at the Teklanika and Toklat rest stops and Eielson Visitor Center during the 2019 regulatory year on the Denali Park Road. The margin of difference between EVC and Toklat grows when we considered mean total vehicles compared to total buses. The EVC frequently has non-bus traffic because it is the duty station for park employees. The standards for the number of total vehicles parked at rest stops were met in 2019.

Method	Teklanika		Toklat		Eielson Visitor Center	
	mean (σ)	n	mean (σ)	n	mean (σ)	n
NPSO result	2.1 (± 1.7)	430	2.7 (± 2.3)	390	3.7 (± 2.1)	400
ROAR result	2.9 (± 1.5)	1,016	4.5 (± 2.1)	904	5.6 (± 1.9)	562



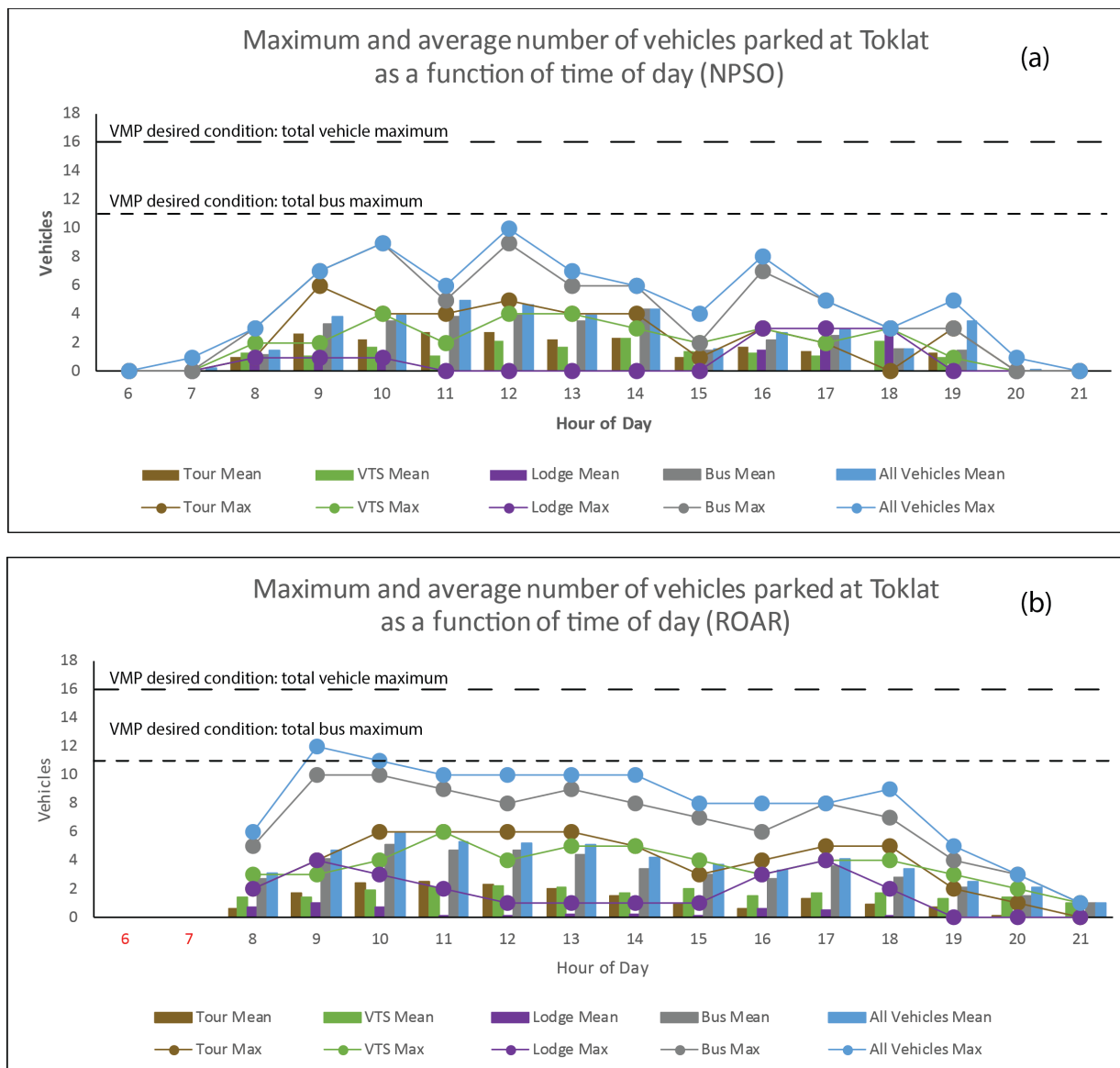


Figure 2. Maximum and average number of vehicles parked at the Toklat rest stop based on the NPSO (a) and ROAR (b) protocols used on the Denali Park Road. All bus and vehicle maximums met VMP standards in 2019. Red hour blocks on the x-axis indicate the time was not observed (i.e. no data available).

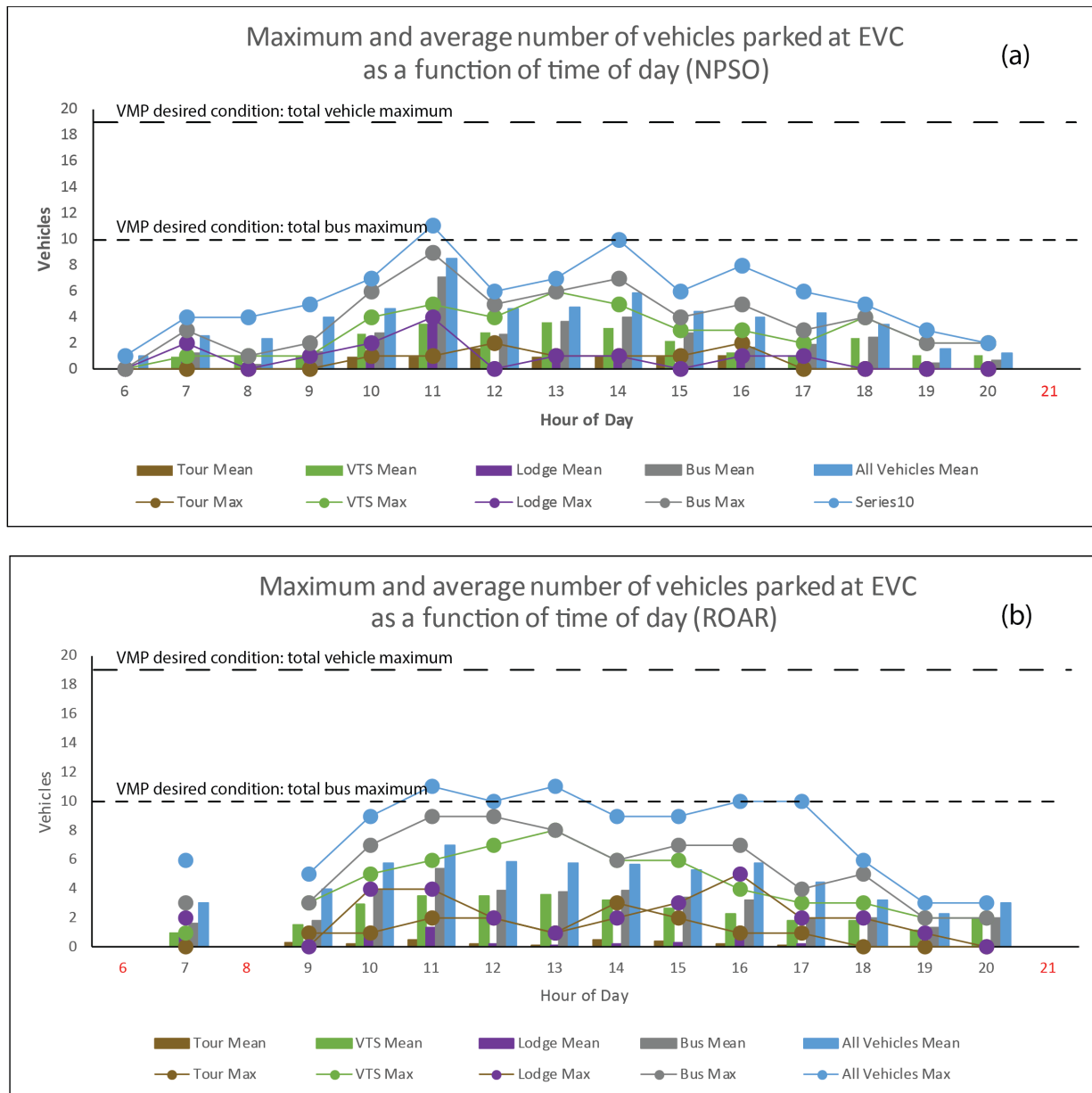


Figure 3. Maximum and average number of vehicles parked at Eielson Visitor Center (EVC) based on the NPSO (a) and ROAR (b) protocols used on the Denali Park Road. All bus and vehicle maximums met VMP standards in 2019. Red hour blocks on the x-axis indicate the time was not observed (i.e. no data available).

Number of Vehicles in Viewscapes

We collected 161 viewscope observations at mile 26 (20 minutes each; $n = 44$), mile 55 ($n = 39$), mile 62 ($n = 39$), and mile 68 ($n = 39$). Both the 1-yr and 5-yr VMP standards for vehicle visibility in each of the four viewscapes were met at all sites except for the mile 62 site, which failed both measures (Table 8, Table 9). The highest maximum number of vehicles observed (15 vehicles) occurred twice at mile 62 during the 0900-hour block and the 1700-hour block, an increase from the 2018 maximum of nine vehicles (Figure 4).

Table 8. Traffic conditions measured as a percent of time x or fewer ($\leq$) vehicles were observed within a viewscape on the Denali Park Road. VMP viewscape standards were met at all sites except the mile 62 site in 2019.

Method	Mile 26		Mile 55		Mile 62		Mile 68	
	% ≤ 3 vehicles	% ≤ 4 vehicles	% ≤ 2 vehicles	% ≤ 3 vehicles	% ≤ 2 vehicles	% ≤ 3 vehicles	% ≤ 1 vehicles	% ≤ 2 vehicles
Standard	80	90	80	90	80	90	80	90
2019 result	99.8	100	96.2	99.5	31.5*	43.3*	95.1	99.2

* Failed VMP standard, also shown in red.

Table 9. Three of four viewscape sites met the 5-year VMP standard along the Denali Park Road met standards in 2019—the mile 62 site failed.

Method	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	85	95	85	95	85	95	85	95
2019 result	98.0	99.6	95.6	98.4	84.1*	89.2*	92.9	98.4

* Failed VMP standard, also shown in red.

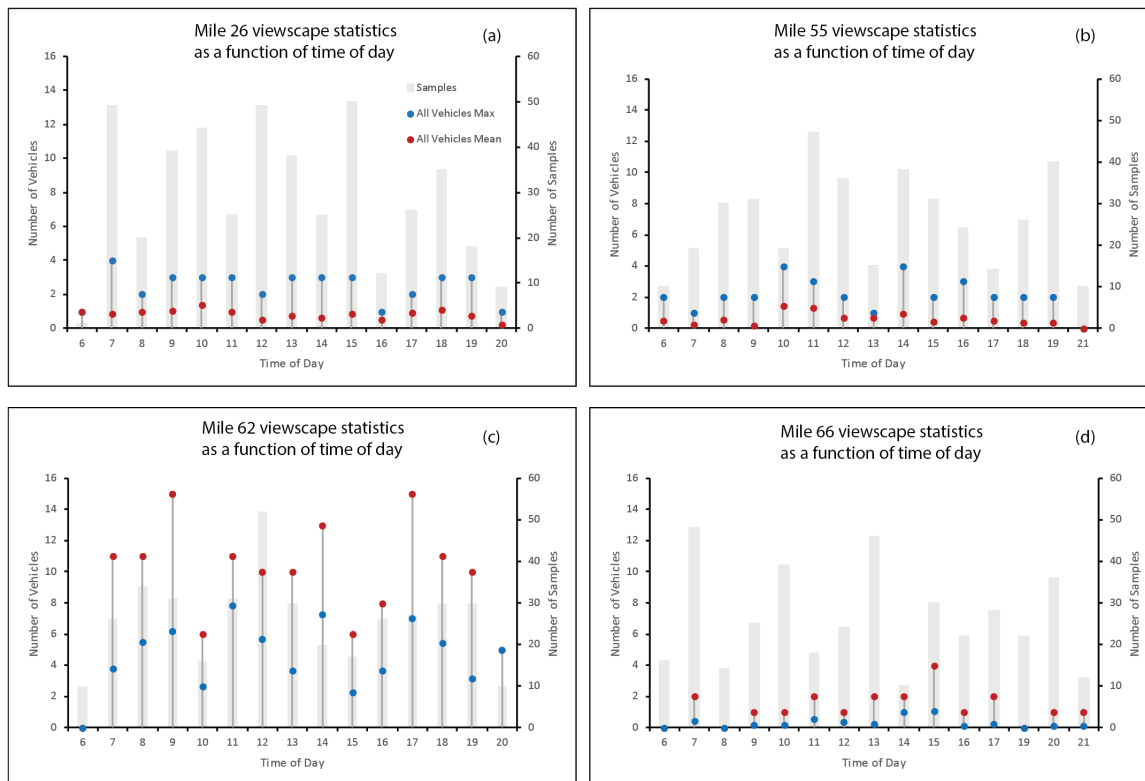


Figure 4. The maximum and mean ($+1\sigma$) number of vehicles visible at one time at the mile 26 (a), 55 (b), 62 (c), and 68 (d) viewscales on the Denali Park Road. Bars show the number of observations for that site and hour block.

The total cumulative percentage of time that VMP viewscape metrics were at or above the standard has decreased each year since 2016—there are eight viewscape metrics, thus a total of 800% would be a perfect score (Figure 5). Cumulative success has decreased from 773% to 665% of observed minutes.

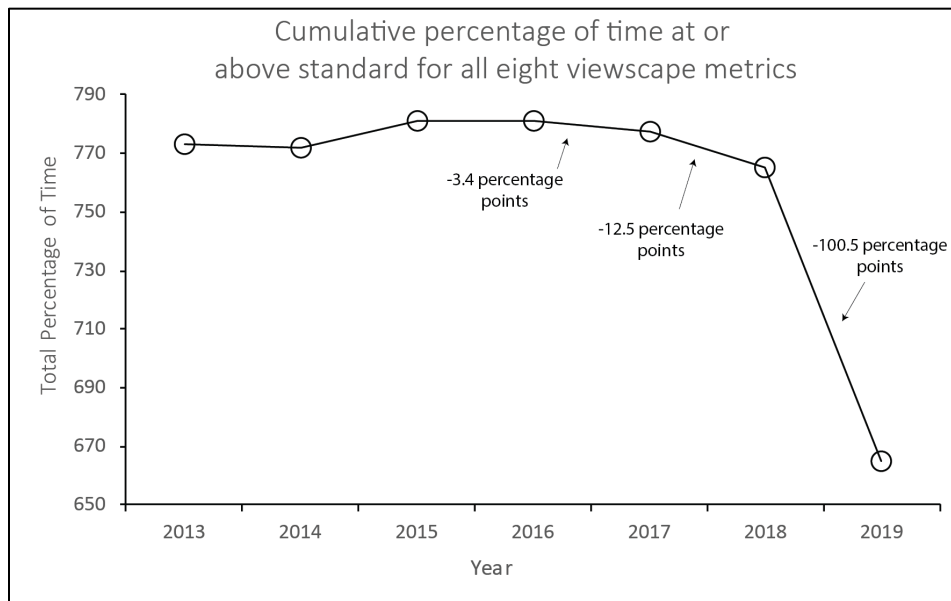


Figure 5. The total cumulative percentage of time that viewscape metrics were at or above the standard threshold has fallen for the past three years on the Denali Park Road. There are eight viewscape metrics—a total of 800% is possible.

Sheep Gap Spacing

Staff recorded 203 sheep gap observations in 2019. Additionally, we recorded 2,158 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 were met at mile 37.6 (Tattler Creek) and mile 68.5 (Grassy Pass, as measured by both NPSO and traffic counter). The VMP standard was not met at the other three sites: mile 21.6 (Hogan Creek), 52.8 (Sheep Hill), and 60.6 (Stony Hill, Table 10). The observed success rate decreased at all sites compared to 2018 observations.

Over the five-year period from 2015–2019, we have collected 1,300 sheep gap samples. Four of the five sheep gap sites have failed the 5-year standard (Table 11). The Stony Hill site is the most frequent to fail, never having met the 1-year or 5-year standard.

Table 10. The percentage of hours (and number of samples, *n*) with at least one 10-minute gap in traffic at each of the five sheep gaps established along the Denali Park Road. Two of five sheep gaps met the standard during the 2019 regulatory season.

Protocol	Mile 21.6 % hours	Mile 37.6 % hours	Mile 52.8 % hours	Mile 60.6 % hours	Mile 68.5 % hours
Standard	90	90	90	90	90
NPSO	72.5* (<i>n</i> = 40)	92.9 (<i>n</i> = 42)	87.8* (<i>n</i> = 41)	75.6* (<i>n</i> = 41)	100 (<i>n</i> = 39)
Traffic Counter	–	–	–	–	99.7 (<i>n</i> = 2,050)

* Failed VMP standard, also shown in red.

Table 11. The 5-year (2015–2019) sheep gap standards were not achieved at four of five sites along the Denali Park Road.

Protocol	Mile 21.6 % hours	Mile 37.6 % hours	Mile 52.8 % hours	Mile 60.6 % hours	Mile 68.5 % hours
Standard	95	95	95	95	95
NPSO	83.8* (<i>n</i> = 252)	93.0* (<i>n</i> = 273)	88.7* (<i>n</i> = 265)	89.4* (<i>n</i> = 262)	100 (<i>n</i> = 248)

* Failed VMP standard, also shown in red.

Nighttime Traffic

Nighttime traffic data are collected along the controlled section of road for the entire regulatory period. The traffic counters experienced short interruptions in data collection (Figure 6, Table 12). Four traffic counter locations met the VMP standards for both percentage of nights that averaged three or fewer vehicles per hour, and two locations met the percentage of nights with six or fewer vehicles passing in any one hour.

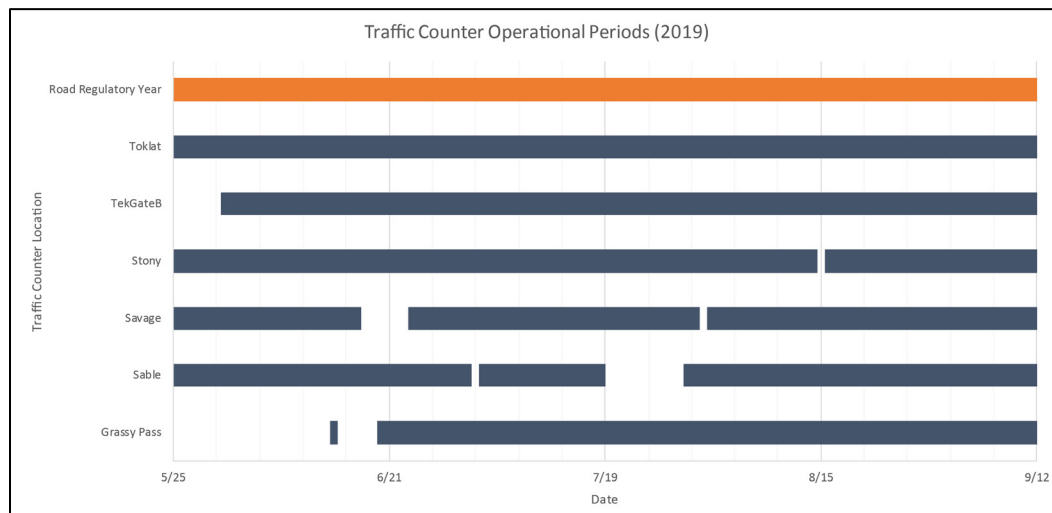


Figure 6. Gantt chart of traffic counter operation periods compared to the Denali Park Road regulatory year for 2019.

Table 12. Summary of nighttime (10pm–6am) traffic rates on the Denali Park Road. All counter locations passed fine-scale (≤ 6 vehicles in any hour) and coarse-scale (≤ 3 vehicles/hour over the night time period) VMP standards in 2019.

Location	% 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%	—	95%	—
TekGate	99.0%	1	90.2%*	10
Sable	99.0%	1	89.8%*	10
Toklat	88.2%*	13	80.9%*	21
Stony	100%	0	96.2%	4
Grassy	100%	0	97.6%	2

* Failed VMP standard, also shown in red.

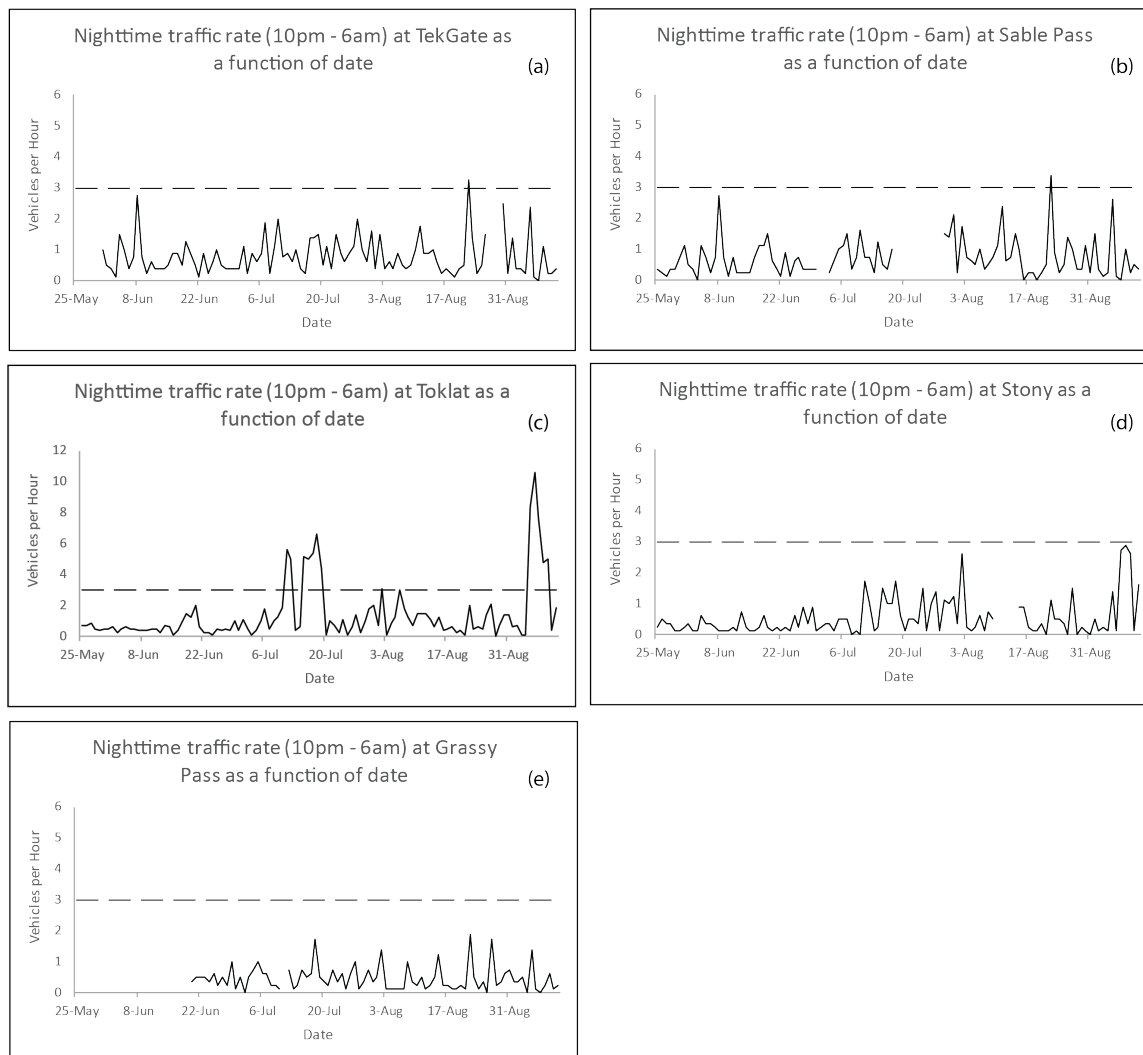


Figure 7. Average nighttime (2200–0600) traffic rates (west and eastbound combined) for (a) TekGate, (b) Sable Pass, (c) Toklat, (d) Stony, and (e) Grassy Pass on the Denali Park Road.

Hiker Wait Time

We collected the length of time that hikers waited for a bus on the gravel portion of the road of 1,126 day and overnight hikers using the ROAR protocol and over 11,000 and 22,000 passengers from EVC dispatch and VTS driver datasets, respectively. Both the 1-year and 5-year standards for hiker wait time were met during the 2019 regulatory season (Table 13, Table 14). Data collected using the ROAR protocol had the lowest percentage of hikers waiting less than 30 minutes. Additionally, we recorded 138 hikers who were not picked up because the bus was full. The rate of capacity exceedance (the number of times we observed hikers were not picked up because the bus was full per the number of VTS buses in the season) increased for the first time since recording began in 2016 (Figure 8). Sample size is dependent on sampling method but independent of meeting the VMP standard for 2015–2019 data (Figure 9).

Table 13. 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. All hiker wait time VMP standards were met in 2019.

Method	% Time <30 min	<i>n</i>	% Time <60 min	<i>n</i>	% Time <90 min	<i>n</i>
Standard	70%	–	93%	–	98%	–
EVC Dispatch	88.2	11,546	99.2	12,994	99	13,093
VTS Driver	93.8	22,427	97.8	23,392	99.1	23,712
ROAR	80.7	802	95.7	951	97.9	973

Table 14. The 5-year standard for hiker wait time was met for all categories between 2015–2019 on the Denali Park Road.

Five-year	% Time <30 min	% Time <60 min	% Time <90 min	<i>n</i>
Standard	75%	95%	99%	–
2015–2019 result	90.6	98.4	99.3	207,140

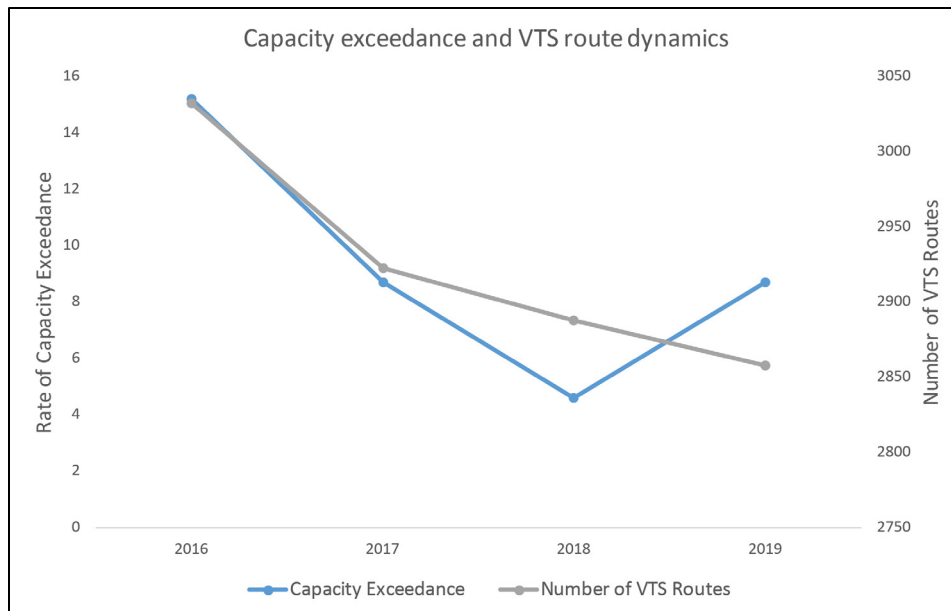


Figure 8. Bus capacity exceedance has increased in 2019 for the first time since recording the statistic began in 2016 (Denali National Park and Preserve, Denali Park, Alaska, USA).

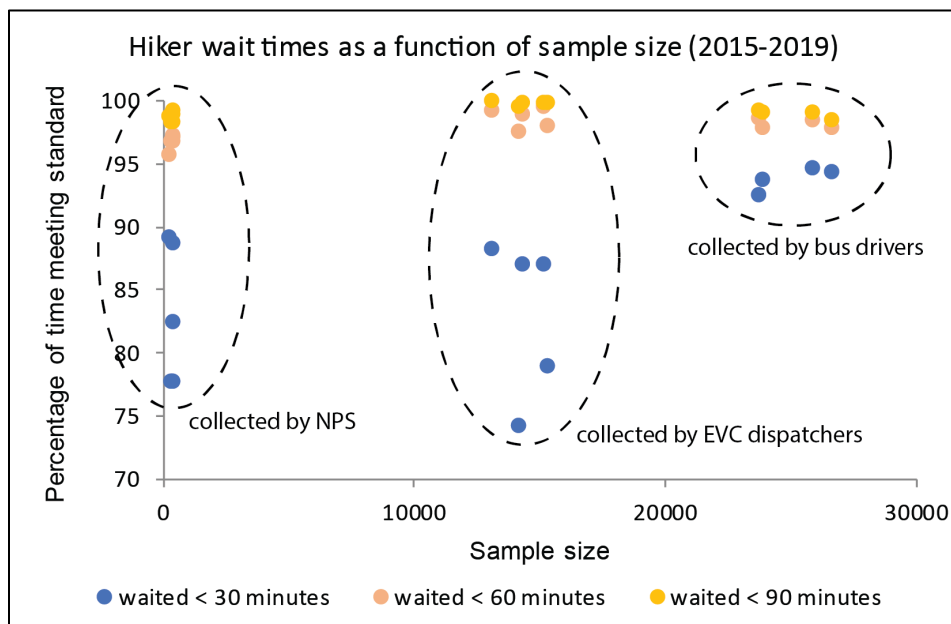


Figure 9. Percentage of time that hiker wait time standards were met as a function of sample size for the three methods used to collect hiker wait time data, 2015–2019, on the Denali Park Road. Sample size does not affect the percentage of time that hiker wait time standards are met. However, the dataset suggests VTS driver-collected data are a different population.

Vehicle Statistics

In 2019, 13,004 vehicle entrances were counted on the controlled section of roadway, 12,550 qualified toward General Management Plan statistics. The maximum number of vehicle entrances

was 155 (July 11) and the average was 117 (Figure 10). Over the last five years, vehicle entrances peaked in 2015 (Figure 11). Vehicle entrances have increased 4% since the VMP was signed in 2012 and decreased 6% since the high in 2015. All bus traffic, except for VTS, have increased while GOV entrances have decreased compared to 2012 (Table 15).

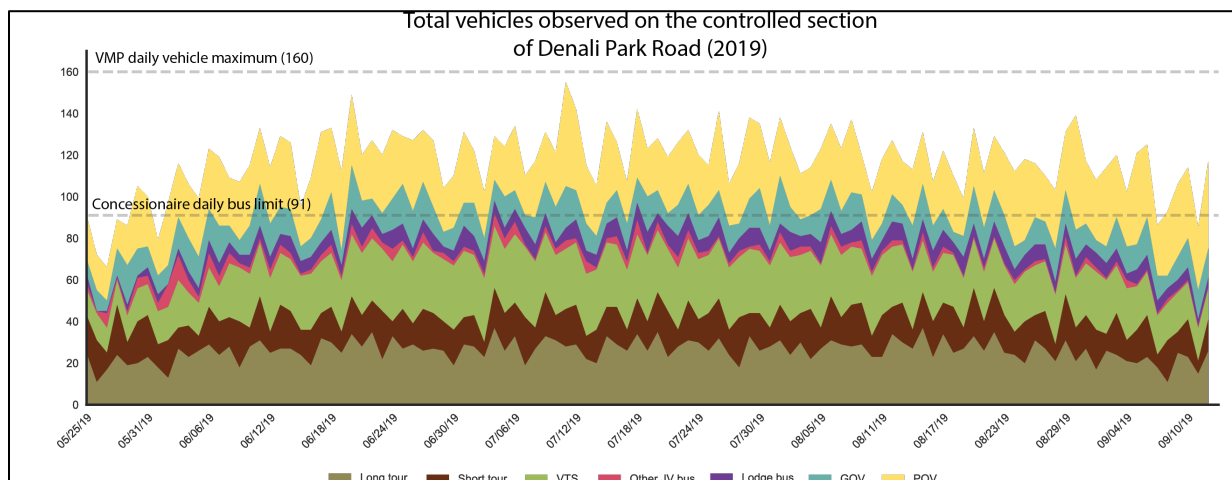


Figure 10. The VMP daily capacity limit was never exceeded in 2019—the maximum number of vehicles on the Denali Park road in a day was 155 (July 11). There were consistently fewer concessionaire buses on Saturdays and Sundays.

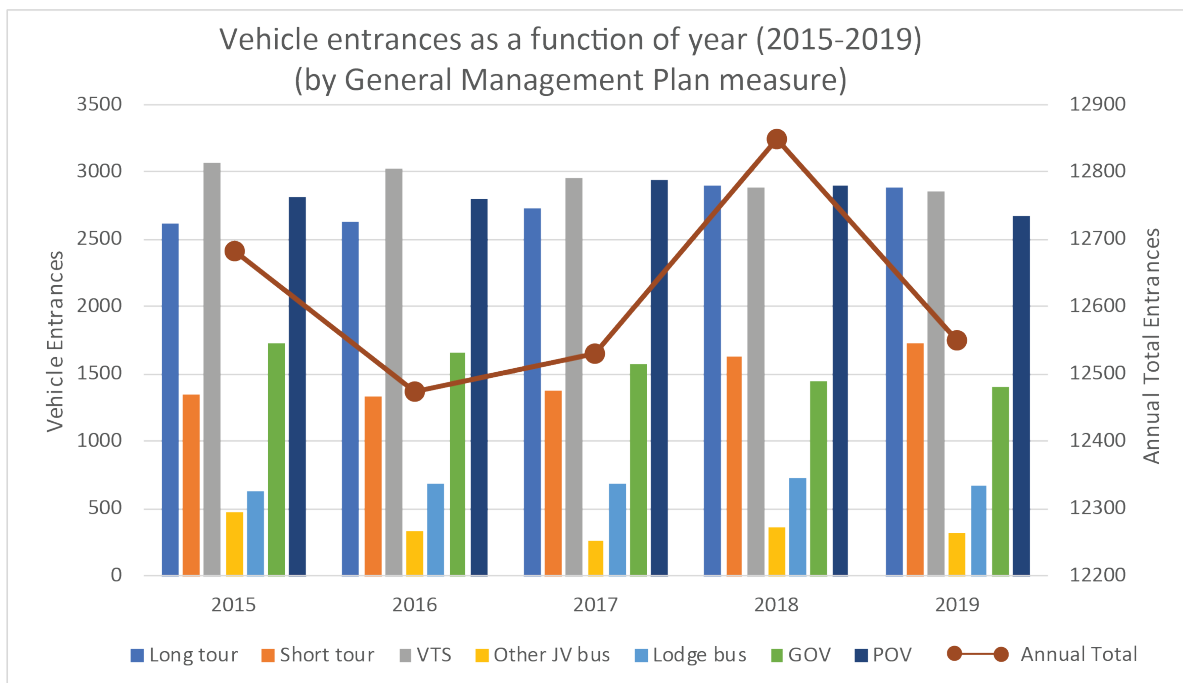


Figure 11. Vehicle entrances by vehicle type on the Denali Park Road (2015–2019). (*) beginning in 2017, Short Tours terminated at mile 28 (Teklanika Flats). Prior to this time, they terminated at mile 17 (Primrose). Contractor vehicle permits are included as POVs. The General Management Plan (GMP) does not include certain vehicle types in the total count of entrances.

Table 15. Vehicle entrance statistics for the Denali Park Road in 2019 compared to the previous year and compared to the year the Vehicle Management Plan was signed (2012).

Vehicle Type	Total 2019 Entrances	% Share of 2019 Entrances	% Change from 2018	% Change from 2012
Long tour	2,890	23	-0.1	28.4
Short tour	1,729	13	6.3	3.8
VTS	2,858	23	-1.0	-0.6
Other JV bus	325	3	-3.8	32.1
Lodge bus	669	6	-6.6	3.1
GOV	1,403	11	-0.2	-16.3
POV	3,130	24	2.7	1.1

Wildlife Sighting Probability

The probability of seeing one of the “big five” wildlife species from a VTS bus increased for caribou and moose but decreased for grizzly bear, sheep, and wolf compared to 2018; the probability of seeing wolves significantly decreased (Figure 12).

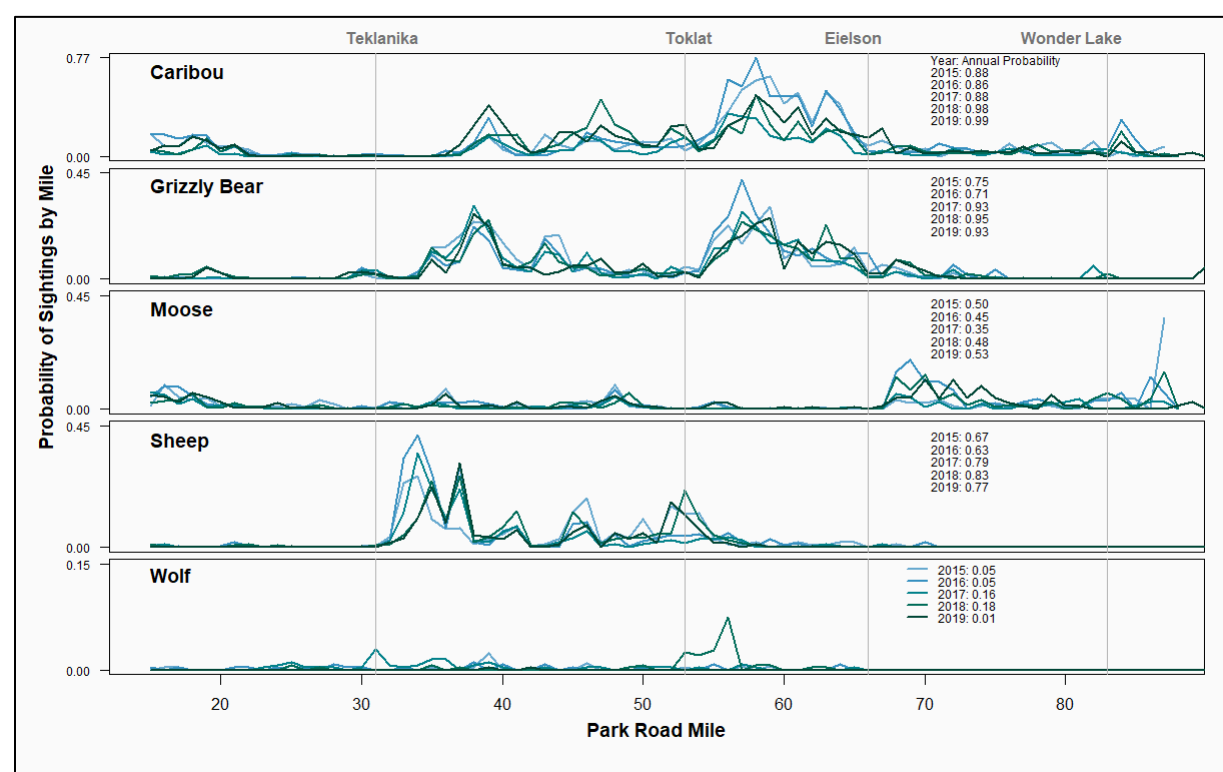


Figure 12. The probability of seeing one of the “big five” wildlife species (caribou, grizzly bear, moose, Dall sheep, and wolf) on the Denali Park Road. The probability of seeing caribou and moose are at a five-year high (2015–2019), while the probability of seeing a wolf is at a five-year low.

Discussion

The Road Ecology Program (REP) measured 41 metrics related to the Vehicle Management Plan (VMP) indicators in 2019; 31 metrics met standards and ten metrics failed to meet standard.

Number of Vehicles at Wildlife Stops

The number of vehicles at wildlife stops is the only VMP indicator where we collect data that measures conditions with implications to both park natural resources (e.g. animal sighting numbers) and visitor experience (i.e. crowding at viewing opportunities). The number of vehicles at a wildlife stop is a particularly important indicator of park socio-bio dynamics.

In 2019, the transportation system met all 1-year and all 5-year wildlife stop standards, while providing approximately 13,004 vehicle entrances. The majority (84%) of all observed wildlife stops were occupied by either one or two buses. Only 1.6% (16 out of 1,000) of all observed wildlife stops had greater than four buses present at one time. Most (seven of nine) wildlife metrics indicate that crowding at wildlife stops may be decreasing. Additionally, the 5-year standard for the percent time of ≤ 1 vehicles at wildlife stops in WVS 3 was met for the period of 2015–2019. This is the most strict wildlife-related criterion in the VMP.

Many factors could cause vehicle crowding at wildlife stops to decrease even when vehicle entrances have increased. For example, the concentration either temporally or spatially of sightings along the road corridor (though our data show they are most prominent in WVS2), driver behavior, or quality of wildlife viewing opportunities (in general, sightings from longer distances cause shorter stops, which decreases opportunities for crowding). A meta-analysis of years of program data is required to test these hypotheses.

Number of Vehicles at Rest Stops

Rest stop standards were met at all three locations: Teklanika, Toklat, and EVC. The average number of vehicles observed at Toklat increased from 2018 but were the same at Teklanika and EVC. In previous years, the share of observed traffic at rest stops was not evenly distributed through the days of the week (i.e. some days of the week were busier than others)—14% of observed traffic for each day creates an “even” schedule (100% divided by seven days in a week). In 2019, Mondays and Fridays contributed the most to weekly traffic volumes. At Teklanika, 18% of traffic was observed on Fridays and 16% was observed on Mondays, whereas only 10% was observed on Sundays, at Toklat 17% of traffic was observed on Fridays, whereas only 12% was observed on Sundays, and at EVC 17% of traffic was observed on Fridays, whereas only 12% was observed on Wednesdays and 13% was observed on Sundays and Saturdays. Additionally, there may be further capacity at rest stops if carefully scheduled: early afternoon hours (i.e. 2pm onward) at Teklanika, Toklat, and at EVC were under capacity of VMP standards. Each shift of 2% of buses is equivalent to three buses moving from one day to another or one hour block to another and can even out the schedule benefiting the visitor and the resources (i.e. sheep gaps and wildlife stops).

Maximum number of vehicles at rest stops observed using the ROAR protocol is consistently greater than that observed using the NPSO maximum (McKenny et al. 2015, McKenny et al. 2014, Clark

2016, Clark 2018(a), Clark 2018(b), Clark 2019). 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 within 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.

Number of Vehicles within Viewscapes

The viewscope standard was met at three of four sites but failed at mile 63. A fish-friendly culvert construction project located in the viewscope caused severe failure—enough to condemn the 5-year standard to fail even though every other season has met standard. While the construction project served to prove that the viewscope standard is sensitive to the scale of that activity, the project likely negatively affected visitor experience. Additionally, the construction project illustrates how vulnerable viewscapes are—one project caused both 1-year and 5-year standard failures.

Sheep Gap Spacing

The 1-year sheep gap standard was met at two of the five sheep gap sites and for the second year in a row, the 5-year standard was only met at mile 68.5. The mile 60.6 sheep gap site has never achieved 10-minute gaps in 90% of observed hours since monitoring began.

We believe that the mile 60.6 site's proximity to a popular scenic view, Stony Overlook, makes it difficult to meet VMP standards. The mile 60.6 sheep gap 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-year sheep gap standards failed at four sites; miles 21.6, 37.6, 52.8, and 60.6. The sheep gap at mile 68.5 has passed the 1-year standard every year and passed the 5-year standard again in 2018. A larger sample size of high-success results will help increase overall averages for future years because the 5-year standard is a moving window.

The sheep gap indicator is defined as a 24-hour standard. Currently, it is sampled by staff during bus operating hours only. We hypothesize that with 24-hour monitoring at sheep gaps, we will observe that desired VMP condition is meant more frequently than currently reported. For this purpose, we installed a traffic counter near the 60.6 mile sheep gap site. Unfortunately, the unit malfunctioned and did not provide an adequate dataset for 2019.

An in-depth analysis and discussion of sheep gap and how to use adaptively manage to meet desired conditions continues within management discussions (Appendix B).

Nighttime Traffic

Data collection for nighttime traffic was more successful in 2019 than in recent years. 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, and to take advantage of any road closures to monitor for effects of decreased traffic patterns on affected sections of the roadway.

Nighttime traffic failures in 2019 were largely related to weather-caused road closures, which required emergency maintenance requirements and an planned nighttime culvert replacement project stationed out of the Toklat ranger station.

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 hiker wait time measures were within VMP standard. While the overall data suggest park management is meeting the desired condition, this is the first year that the rate of instances when a bus was too full to pick up hikers relative to the number of VTS buses on the road increased since collecting these data began in 2016 (capacity exceedance). This could be caused by passenger behavior (e.g. increased day hiking, which causes more people to require a pick-up from a different bus later in the day) or because 2019 featured the fewest VTS routes since 2016.

In theory, the hiker wait times collected by NPS while riding buses should very closely match that of the VTS driver collections. However, the data appear to be from different populations (Figure 8). The VTS drivers consistently record higher levels of compliance (shorter wait times). Both metrics are within the desired condition, however it may indicate that the training of NPS staff or VTS drivers is different.

Large Vehicle Traffic

The VMP defines large vehicles as vehicles > 80,000 pounds gross vehicle weight rating (a concessionaire bus is 36,000 pounds). 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 purchase (~ \$45,000) and maintain (yearly calibrations) and research suggests it is finicky. 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 Denali 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. Thus, this standard will continue to be refined.

Vehicle Statistics

With 13,004 vehicle entrances, the single day, 160 entrance VMP limit was not exceeded. Increases from 2018 were driven by small increases in entrances for Short Tours and POVs.

Wildlife Sighting Probability

The probability of sighting most species did not change significantly in 2019—caribou and moose are again at 5-year highs. However, the probability of sighting wolves decreased significantly to a 5-year low of 1% down from a maximum of 18% in 2018. ROAR observers only saw three wolves all season.

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Appendix A. 2019 Sampling

Table A-1. The distribution of VTS ROAR observations compared to the 2019 VTS schedule on the Denali Park Road. The target proportion of observations was close in Peak and Late subseasons; variance was greater in the Early subseason.

Subseason	Location	Proportion of Trips		n
		VTS schedule (target)	ROAR observations (actual)	
Early	Toklat	35	31	21
	EVC	44	50	34
	Wonder Lake	13	15	10
	Kantishna	7	4	3
Peak	Toklat	14	13	18
	EVC	45	47	66
	Wonder Lake	24	25	35
	Kantishna	17	16	22
Late	Toklat	12	14	7
	EVC	43	45	23
	Wonder Lake	24	22	11
	Kantishna	21	20	10

Table A-2. The 2019 sampling was stratified through times of day and season on the Denali Park Road.

Mile	Indicator	Time Block					Total
		6–9	9–12	12–15	15–18	18–22	
21.6	Sheep Gap	8	9	10	8	5	40
26	Viewscape	7	11	11	9	6	44
30	Tek Rest	7	11	11	8	6	43
37.6	Sheep Gap	8	10	8	10	6	42
53.5	Toklat Rest	7	8	9	9	6	39
52.8	Sheep Gap	6	9	10	7	9	41
55	Viewscape	6	10	9	7	7	39
60.6	Sheep Gap	6	9	10	8	8	41
62	Viewscape	7	9	9	7	7	39
66	Eielson Rest	8	8	8	8	8	40
68	Viewscape	8	8	8	8	7	39
68.5	Sheep Gap	8	8	8	8	7	39

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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