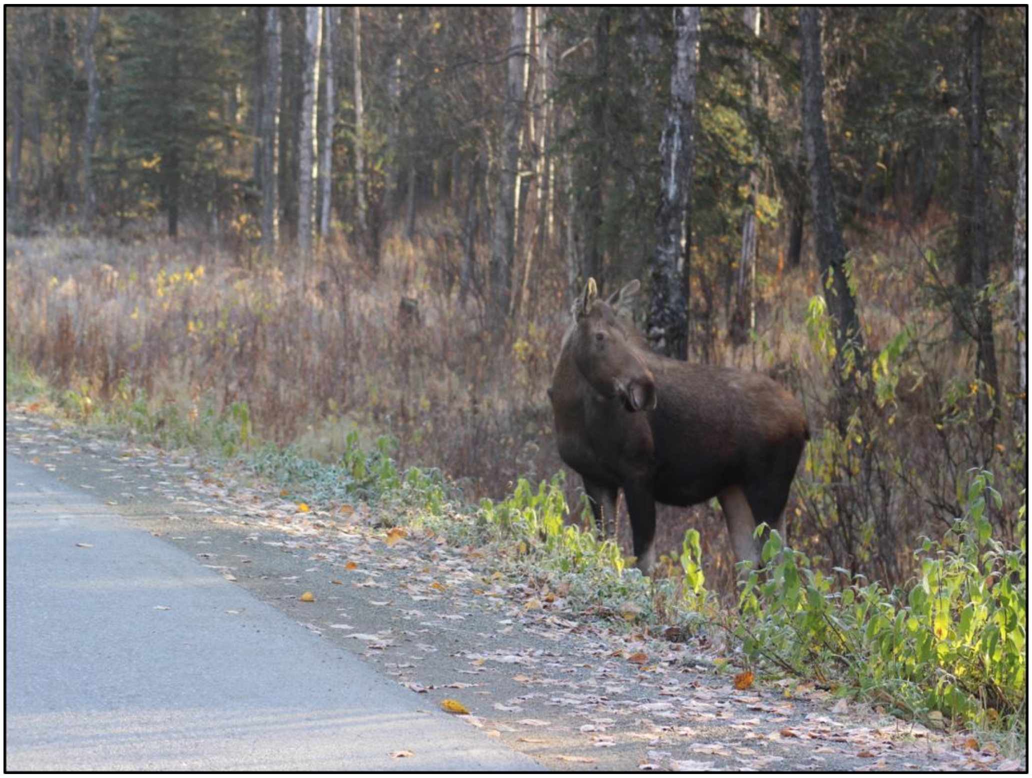
2018 Annual Report

Assessment of Factors Associated With Moose-Vehicle Collisions and Their relationship to Moose Seasonal Movements in the Matanuska and Susitna Valleys of Alaska



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Executive Summary

Moose-vehicle collisions (MVC) continue to be a major issue in the state of Alaska, with the Matanuska-Susitna Valley reporting nearly one-third of the collisions reported statewide. From June 2016 to January 2018, data were recorded at 333 MVC sites to compare the local-scale landscape and habitat metrics along roadsides where collisions were reported to random locations along the same roadway. In March 2017, sixty moose were fitted with global positioning system (GPS) radio-transmitters deployed on necklace-style collars. These GPS transmitters provided location data hourly and the data are transferred via satellite every 12 hours. These data, in conjunction with MVC data, will be used to develop recommendations to mitigate MVC human health and safety risks and moose mortalities in the Matanuska-Susitna Valley.

Introduction

Wildlife-vehicle collisions are an ongoing threat to both motorists and wildlife populations (Conover et al. 1995). In addition to direct injuries and mortalities from wildlife-vehicle collisions (WVC), indirectly impacted drivers are at greater risk of accident due to traffic congestion and road obstructions associated with WVCs. Wildlife crossing signs have been found to be largely ineffective due to the almost immediate habituation of drivers to installed signage (Sullivan and Messmer 2003, Al-Ghamdi and AlGadhi 2004, Huijser and McGowan 2010). Past studies have identified numerous factors associated with WVCs, the importance of which are known to vary among species, locations, and seasons (Litvaitis and Tash 2008).

Most of the WVCs in Alaska involve moose (*Alces alces gigas*). Between 2000 and 2012, the Alaska Department of Transportation and Public Facilities (ADOT) documented 9,949 moose-vehicle collisions (MVC) in Alaska. These MVC resulted in not only thousands of moose mortalities, but also 23 human fatalities, 118 incapacitating injuries, and approximately 1,400 minor injuries (ADOT, unpublished data). The ADOT estimated that $35,000 is lost every time an MVC occurs in the state. This estimate only accounts for the auto damage and medical expenses of each crash and excludes the value of a human life which is placed at $6 million. The average annual rate of 765 MVCs per year remained relatively constant through this time period, regardless of the various attempts to reduce MVCs. Since June of 2016, 515 MVCs have been reported in the Matanuska-Susitna (Mat-Su) borough alone.

Study Purpose

Parallel to the various methods available to the ADOT to ameliorate the MVC problem (e.g. roadway lighting, vegetation clearing, fencing), the Alaska Department of Fish and Game (ADF&G) has the regulatory authority to establish targeted moose harvests in areas where high moose concentration or concentrated moose movement create increased MVC risks. Unfortunately, ADF&G currently lacks the information required to model and predict where targeted hunts will be most effective relative to moose movement, seasonal habitat, land access, and public safety.

To gain a better understanding of the factors associated with MVCs and moose movement patterns in a rapidly developing landscape in Alaska and, subsequently, to better inform efforts to minimize MVC risks, the ADF&G initiated this research project in 2016 to collect site-specific information from MVC sites. Additionally, to better understand seasonal moose movement patterns, sixty moose (45 female, 15 male) were fitted with global position system (GPS) transmitters deployed on necklace-style collars.

Study Area

The Matanuska and Susitna Valleys (i.e. the Mat-Su Valley) are located in the Mat-Su Borough of south-central Alaska. The area is approximately one hour north of Anchorage via the Glenn

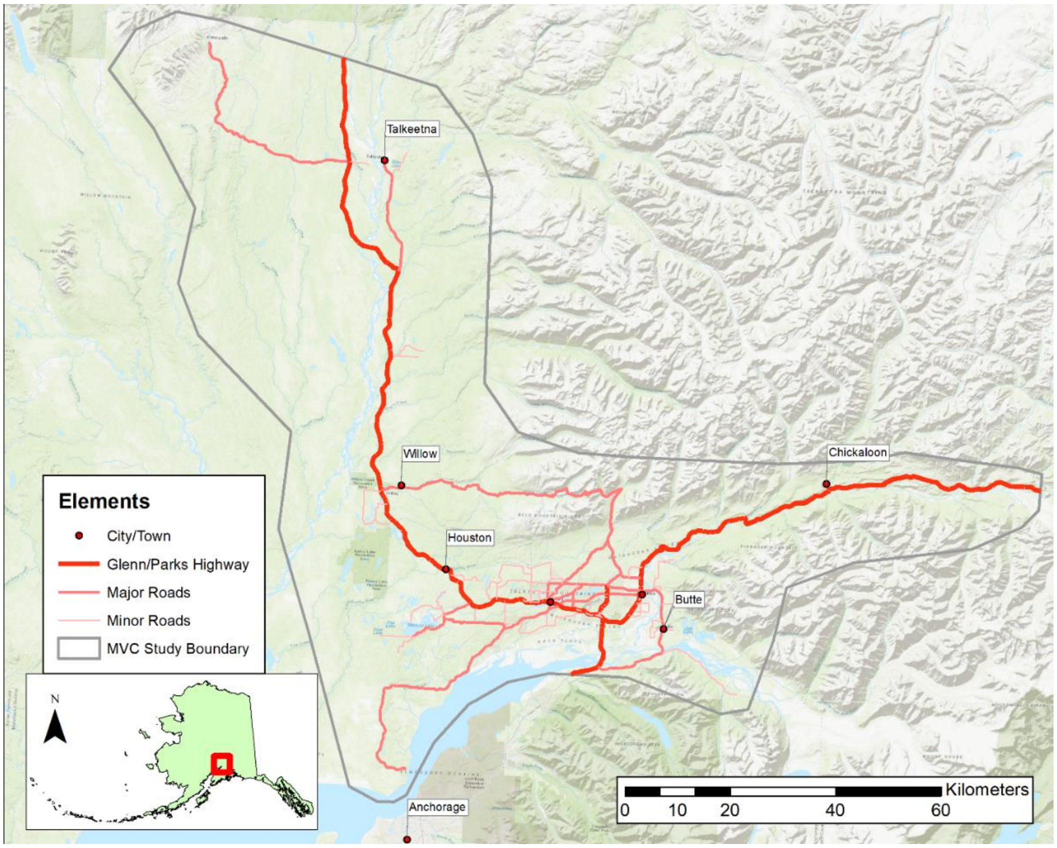


Figure 1. MVC study area map emphasizing major road systems, Mat-Su Valley, Alaska, 2016-2019

Highway. The area has three cities, Wasilla (population ~8,000), Palmer (population ~7,000), and Houston (population ~2,000); however, the Mat-Su Borough has a population of approximately 100,000 mostly suburban citizens.

This study focuses mainly on the major highways in the Mat-Su Valley which can be seen in red in Figure 1. The major highways include the Glenn Highway, which follows the Matanuska River east towards Glennallen and Tok, and the Parks Highway, which follows the Susitna River north towards Talkeetna, Denali National Park, and Fairbanks. Other major roads include the Old Glenn Highway, Knik Goose Bay Road, Trunk Road, Bogard Road, Palmer-Fishhook Road, and Wasilla-Fishhook Road, all of which carry considerable amounts of traffic during the rush hours.

The average annual temperature is 8.1 ℃ with the minimum monthly temperature falling to -12.6 ℃ in January and the maximum monthly temperature rising to 20.9 ℃ in July. In the summer, average precipitation varies between 4 and 7 centimeters per month. In the winter, average snowfall varies monthly between 20 and 30 centimeters (Western Regional Climate Center 2016)

The elevation ranges from near sea level at the southern reach of the study area to near 1,000 meters at the eastern end of the Glenn Highway. The vegetation along the roadside is typically a mixture of alders (*Alnus* spp.), cottonwoods (*Populus* spp.), willows (*Salix* spp.), or spruces

(*Picea* spp.) of various heights and various grasses and forbs. During the summer months, fireweed (*Chamaenerion angustifolium*) is the dominant roadside plant. The moose population in this area is primarily managed under Game Management Unit (GMU) 14A and consists of approximately 7,500 moose. The upper reach of the study area is included in GMU 14B and GMU 16A. A map of the GMUs covering the Mat-Su Valley can be found in Appendix A. In the most recent completed harvest report, 1051 (27%) of the moose hunters in 14A & and 109 (20%) of the moose hunters in 14B reported a successful harvest (ADF&G 2016).

Methods

MVC Data Collection

When a moose is struck by a vehicle in the state of Alaska, the driver is expected to report said collision to the local authorities (Figure 2). At the beginning of this project, the state troopers or police officers would contact the Alaska Moose Federation (AMF), which is an organization that collects moose following a MVC and transports the moose to a local charity. The AMF would provide the ADF&G with information regarding the collision such as the call time, date, weather conditions, location via coordinates, and sex of the animal.

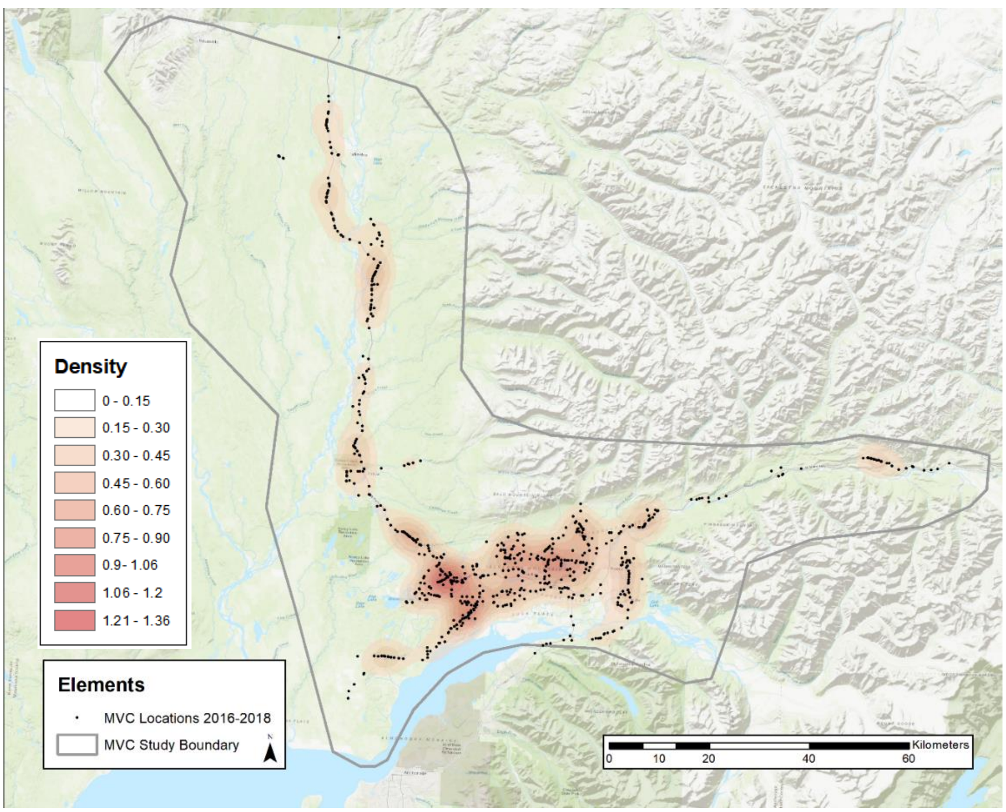


Figure 2. Reported MVC locations, point density shaded in red, Mat-Su Valley, Alaska, 2016-2018

In March 2017, the AMF stopped salvaging moose for the state, so general location information began being passed directly from the law enforcement dispatch center to the ADF&G office in Palmer. As of December 2017, this information is being emailed directly to the ADF&G office in Palmer as the information is recorded at the dispatch office. Upon finding a reported MVC site, a waypoint is taken using the Petosoft GPS iPhone app and a Garmin GLO receiver and named numerically.

The waypoint from each site, *i*, is used to create three randomly generated points via an R shiny web app. The random points are chosen from a shapefile of the road system that has been clipped to only include the area within 10 km and further than 2.5 km from site *i*. Two of these points are chosen and the same measurements are made at these two control sites as at site *i*. The names of these points are also numeric and simply equal the addition of 10000 or 20000 to *i*, so that after one collision you would have three records named *i, 1000i, and 2000i*. This naming convention is used to quickly separate the collision and control sites in the database while simultaneously being able to link associated control sites to collision sites.

The following observations are noted at both collision and control sites: date, time, road type (curved, hill, straight, etc.), speed limit, estimated traffic per 10 minute interval, number of lanes, presence of a median, presence of lighting structures, functionality of observed lighting structures, estimated distance to observed lighting structures, presence of moose warning signage, estimated distance to observed moose warning signage, presence of snow, presence of construction, presence of collision evidence, presence of fencing, type of observed fencing, position of fencing in relation to collision, presence of bodies of water, presence of housing, and type of vegetation measured in the verge.

Quantitative measurements are taken for the site in general regarding lane width, shoulder width, and snow depth. Further, at two-meter increments from the shoulder to the tree line (or other barrier), quantitative measurements are taken regarding the height of any obstruction along the roadway, typically vegetation, and the depth of the verge that runs along the roadside to develop a measurement of the visible area in which the moose may have occupied before the collision (Figure 3). For the purposes of this study, the obstruction area is the vertical area in the verge that is covered by vegetation or other barriers. The area between the road and the nearest tree line is referred to as the verge. The verge depth is calculated by multiplying the length of the verge by the difference in depth between the road and the ground surface. The verge depth measurements, calculated by taking the inverse tangent of the depth divided by the two meter length, can also be used to describe the angle of the roadside.

These measurements will be included in models to try to explain what factors contribute to MVCs. Models will be developed using a variety of landscape level factors such as habitat type, light pollution, and proximity to water features, as well as the site specific local factors measured in this project such as the presence or absence of moose-warning signs, fencing, and lighting structures (Appendix B).

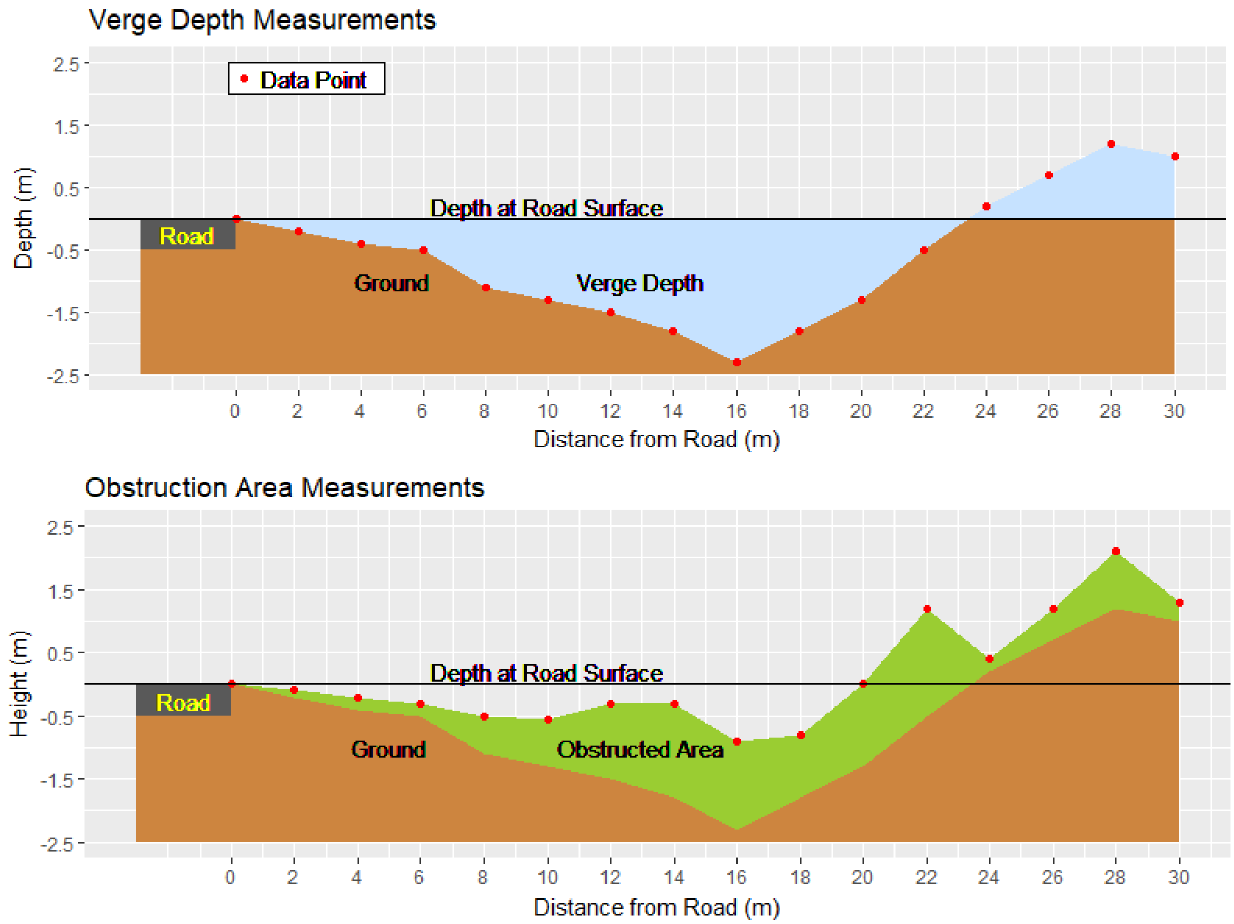


Figure 3. Verge depth and obstruction area are compiled from measurements taken at MVC sites, Mat-Su Valley, Alaska, 2016-2018

Moose Movement Data Collection

Within the study area, 60 moose were darted and fitted with Vectronic Satellite GPS collars in March of 2017. Location data is collected by the collar hourly and uploaded every 12 to 36 hours. Figure 4 shows the initial location of each moose. Moose were opportunistically selected from roadsides across GMU 14A. The lower portion of the study area (the area within GMU 14A) was stratified into seven 500-750 km^2 areas. Each strata was given a target of 6 females and 2 males. The remaining 3 females and 1 male were chosen at random. All 60 moose were darted from the ground within a three week period by ADF&G personnel. Captures were conducted in accordance with ADF&G Division of Wildlife Conservation IACUC protocol 2016-31. The transmitters were sized to fit 45 females (cows) and 15 males (bulls). Thirty of the cow collars have virtual fencing capabilities that increase the fix rate to get location data every five minutes when the cows are inside pre-determined “fenced” areas (Figure 4). These “fences” surround areas where collision rates are generally high (i.e. Parks Highway, Glenn Highway, Knik-Goose Bay Road, Palmer-Fishhook Road and Wasilla-Fishhook Road).

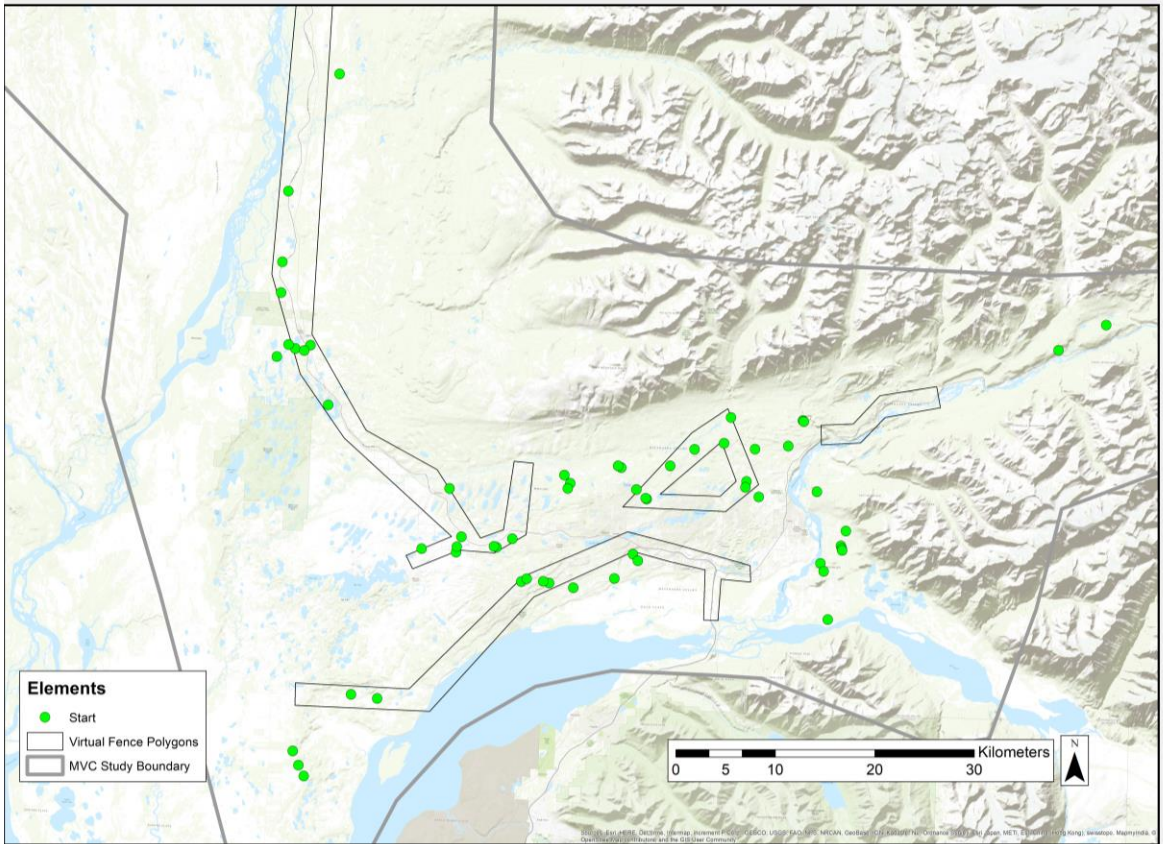


Figure 4. Initial locations of the 60 captured moose in relation to the virtual fencing, Mat-Su Valley, Alaska, March 2017

MVC Preliminary Results

Since 1 July, 2016, data have been collected for 333 of the 515 reported MVC in the Mat-Su Valley. Data were not collected at collision sites that were outside the study boundary (Figure 1). Physical evidence of a collision (e.g. moose hair, blood, broken car parts) was found at 131 of the 333 collision locations. The remaining 202 collision locations were chosen based on either GPS coordinates from AMF or descriptions of the area received from the law enforcement dispatch center. Data were also collected at 524 control sites within the study boundary. As seen in Figure 5, MVCs in the Mat-Su Valley between 2016 and 2018 typically occurred near dusk or dawn. Fifty percent of the collisions between 2000 and 2012 occurred within 12.6 % of the total time frame, centered on the dusk and dawn of winter. The exact same trend has occurred for the 2016 to 2018 data.

Seasonal Variation Model

Over half (55%) of the reported MVCs this year occurred between December and February which is typical for the area (Figure 6). This sharp increase in collisions is most likely a result of the hazardous winter driving conditions (e.g. snow, shorter day length) and the influx of moose from the surrounding mountains.

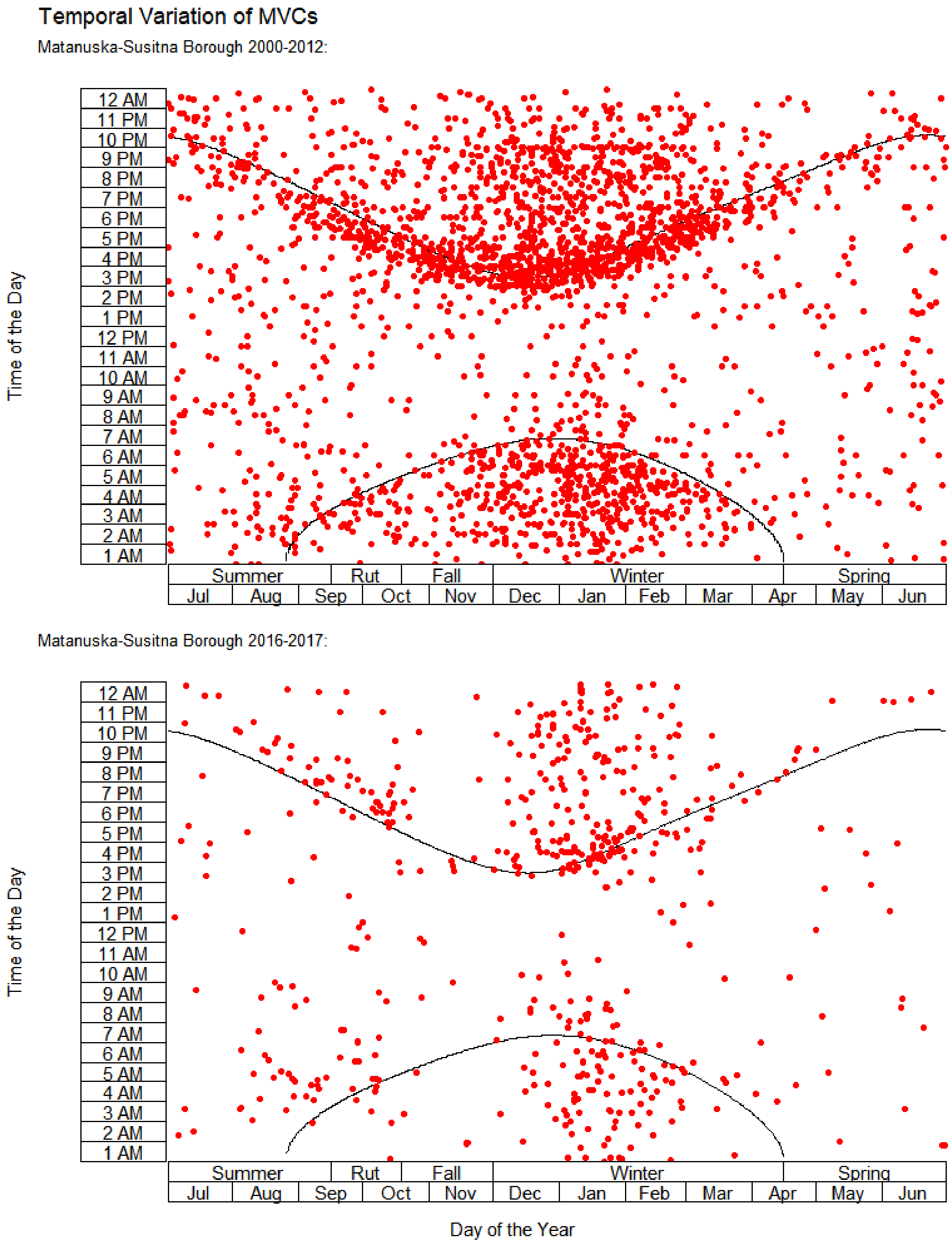


Figure 5. Timing of reported MVCs, Mat-Su Valley, Alaska, 2016-2018 (Lines indicate sunrise and sunset.)

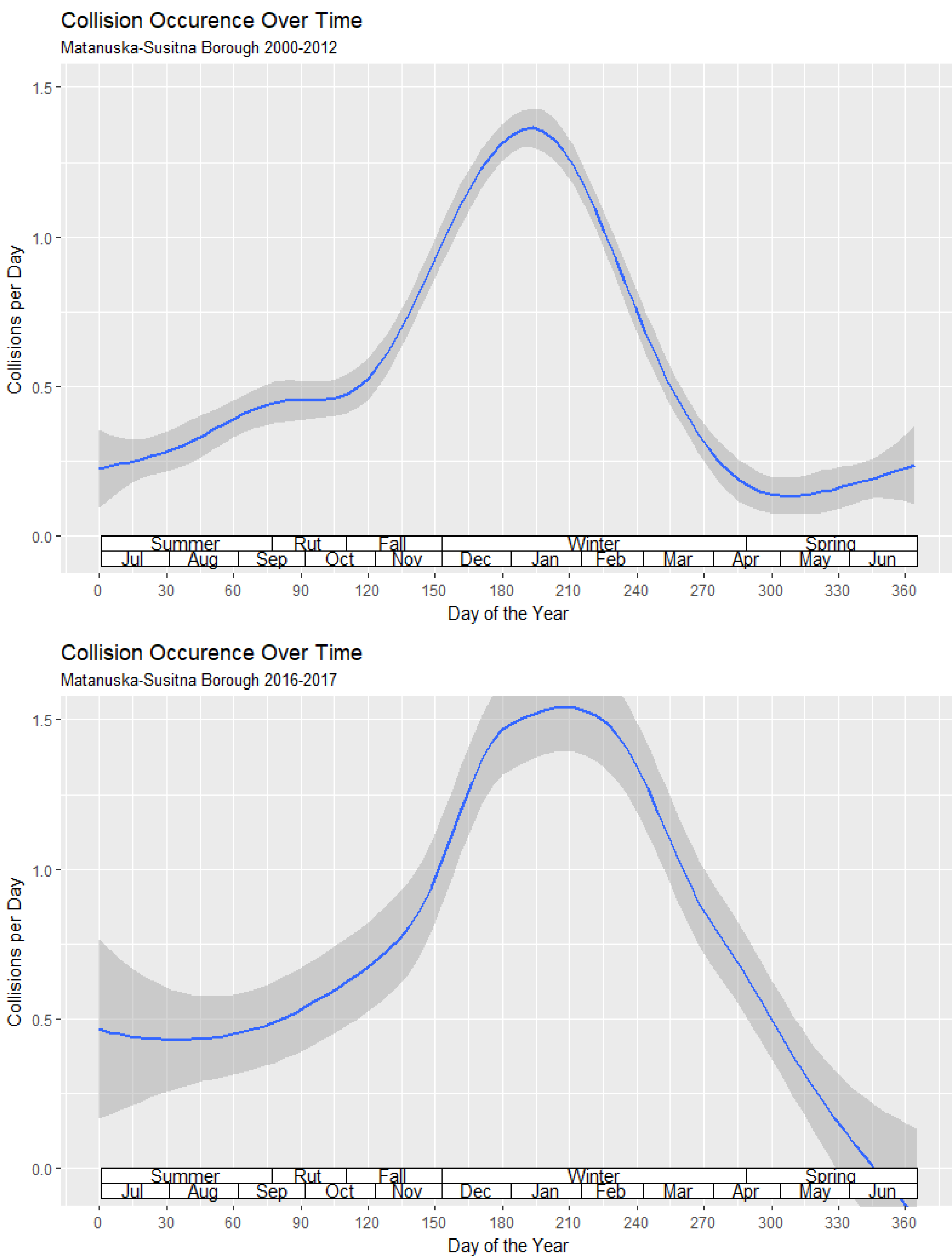


Figure 6. MVCs reported per day in 2000-2012 compared to the 2016-2018 data, Mat-Su Valley, Alaska

Reported MVC data from 2000 to 2012 was used to form a frequency table of MVC dates. This data was fitted with a generalized additive mixed model (GAMM). In the GAMM, the frequency data was explained by the day of the year and smoothed with a cyclic penalized cubic regression spline with matching ends and a degrees of freedom of 10. Traffic counter data from the Parks and Glenn Highways for the same time frame was used as an offset to account for traffic fluctuations. Using the mgcv package (Wood 2006) in R, the model building method used a Poisson error distribution and a log link (Krauze-Gryz 2017). Recent MVC data was also used for a similar analysis, the results of which are also shown in Figure 6. The fitting method 'Loess' was used rather than the GAMM fitting method due to a lack of data.

Machine Learning Model

Due to the high volume of variables measured at each site, as well as the complexity of the analysis, using traditional model fitting to analyze the difference between control and collision sites requires a very dramatic reduction in the amount of data used. To perform analyses using as many variables as possible, we analyzed the data collected at each site using a machine learning model. To create a machine learning algorithm, a portion of the data representing both outcomes (collision or control) is subset into a training dataset that is used as the basis for the model's predictions. The remainder of the data is then used to test the model. This testing dataset does not include whether the site is a control or collision site, but instead predicts whether the site is a control or collision site (Lantz 2016).

Seven datasets were formed from the overall database of collision and control site measurements and used to test this method in its most basic form data and shows encouraging results. We formed each dataset with a different number of variables and named each group according to which variables were added. Group 'Base' refers to only the measurements of the road surface such as speed limit, lane width, shoulder width, and lighting. The other groups consist of the 'Base' variables and the verge depth, obstruction height, and obstruction type for the corresponding number of meters from the road surface, 2 through 12 (Figure 3).

In Table 1, these results have been simplified to show the number of variables used in the model, the percentage of control sites used in the testing and training data (Ratio), the number of instances (N) in each subset of the data, the resulting proportion of correct predictions (True Positives, True Negatives), and the resulting proportion of incorrect predictions (False Negatives, False Positives).

In this form, the model relies strictly on the measurements collected at each site and cannot compare sites that do not have equal representation of measurements on each side. Because the group 'Base' contains no verge or obstruction measurements, it is able to use 676 date points (466 for training, 210 for testing). As it is further developed, the model will yield a probability of MVC based on location and time. Once this is combined with the elevation data procured from the Mat-Su Borough LiDAR and Imagery Project and the habitat and movement models developed using the moose movement data, we will develop a prediction surface showing areas with a high probability of moose crossings as well as MVCs.

Table 1. Variation in machine learning model successes and failures based on the addition of new variables

Group	*Variables*	*Training Ratio*	*Train N*	*Testing Ratio*	*Test N*	*True Positive*	*True Negative*	*False Negative*	*False Positive*
Base	28	64%	466	64%	210	22%	56%	8%	14%
Two	39	63%	403	63%	182	25%	49%	14%	12%
Four	50	55%	325	55%	146	25%	49%	6%	21%
Six	60	50%	248	50%	111	31%	40%	10%	20%
Eight	70	47%	190	47%	85	34%	29%	18%	19%
Ten	80	44%	142	44%	64	36%	31%	13%	20%
Twelve	90	43%	72	44%	32	34%	25%	19%	22%

Moose Movement Preliminary Results

Of the initial 45 female (cow) and 15 male (bull) moose radio-marked in March 2017, we have confirmed 10 cow and five bull mortalities. Additionally, one cow and one bull had a collar that malfunctioned and stopped transmitting location data. Seven of the cows and three of the bulls were legally-harvested. One cow was involved in an MVC. We could not confirm the cause of death for the other two bulls and two cows, but believe it was likely natural causes. We recovered and refurbished the radio-transmitters for a future deployment.

Of 19 cows observed during a parturition survey on 26 May 2017, 15 were accompanied by a calf. These cows had 19 calves, with 4 of the cows having twins. A database is being built to compile the spatial data collected from these radio-transmitters. Figure 7 shows the current distribution of the radio-marked moose or the mortality locations.

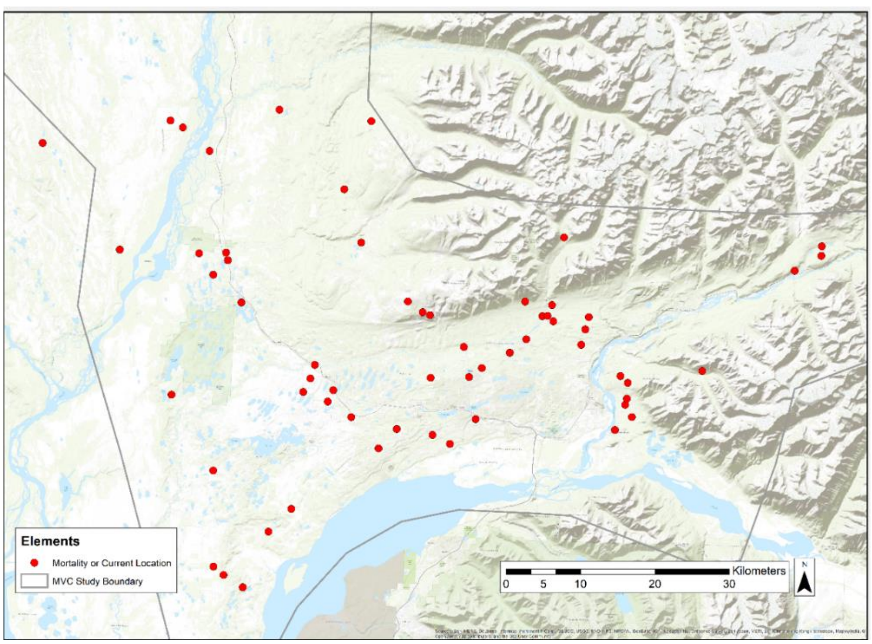


Figure 7. Current or mortality locations of the 60 radio-marked moose, Mat-Su Valley, Alaska, January 2018

Seasonal Movement

Alaskan moose have a typical seasonal movement strategy in untamed areas that is outlined in Table 2 (Ballard and Whitman 1988, Pritchard et al. 2013).

Table 2. Alaskan moose movement strategies (adapted from Ballard and Whitman 1988, Pritchard et al. 2013)

Season	*Months*	*Elevation Expected*
Winter	December – mid-April	Low due to snow depth in mountains
Spring Migration	mid-April – mid-July	In transit to higher elevations
Summer	July – August	High
Rut (Breeding)	September – October	Highest
Post-Rut (Fall Migration)	late-October - November	In transit to lower elevations

This pattern can be recognized in the seasonal variation in MVCs (Figure 6). Due to the correlation between human habitation and lower elevations, the risk of an MVC increased as moose move into lower elevations during the winter.

Many of the radio-marked moose showed different patterns of movement. While some moose migrated greater than 40 kilometers away from the original capture point (n = 7) or greater than 750 meters higher in elevation than the initial capture point (n = 8), over half of the collared moose stayed within 250 meters of their original elevation (n = 35) or stayed within 10 kilometers of their original capture location (n = 31).

At the other extreme, four of the radio-marked moose never traveled farther than three kilometers from their capture point and fourteen never had a change in elevation greater than 100 meters when compared to the elevation of the capture point. Figure 8 and Table 3 show the vast difference in seasonal movement strategies.

Table 3. Maximum distance and elevation change of radio-marked Alaskan moose, Mat-Su Valley, Alaska, March 2017-January 2018

Max Change in Distance	*N*
> 40 km	7
> 20 km	15
> 10 km	7
> 5 km	21
> 3 km	6
< 3 km	4

Max Change in Elevation	*N*
> 750 m	8
> 500 m	8
> 250 m	9
> 100 m	21
< 100 m	14

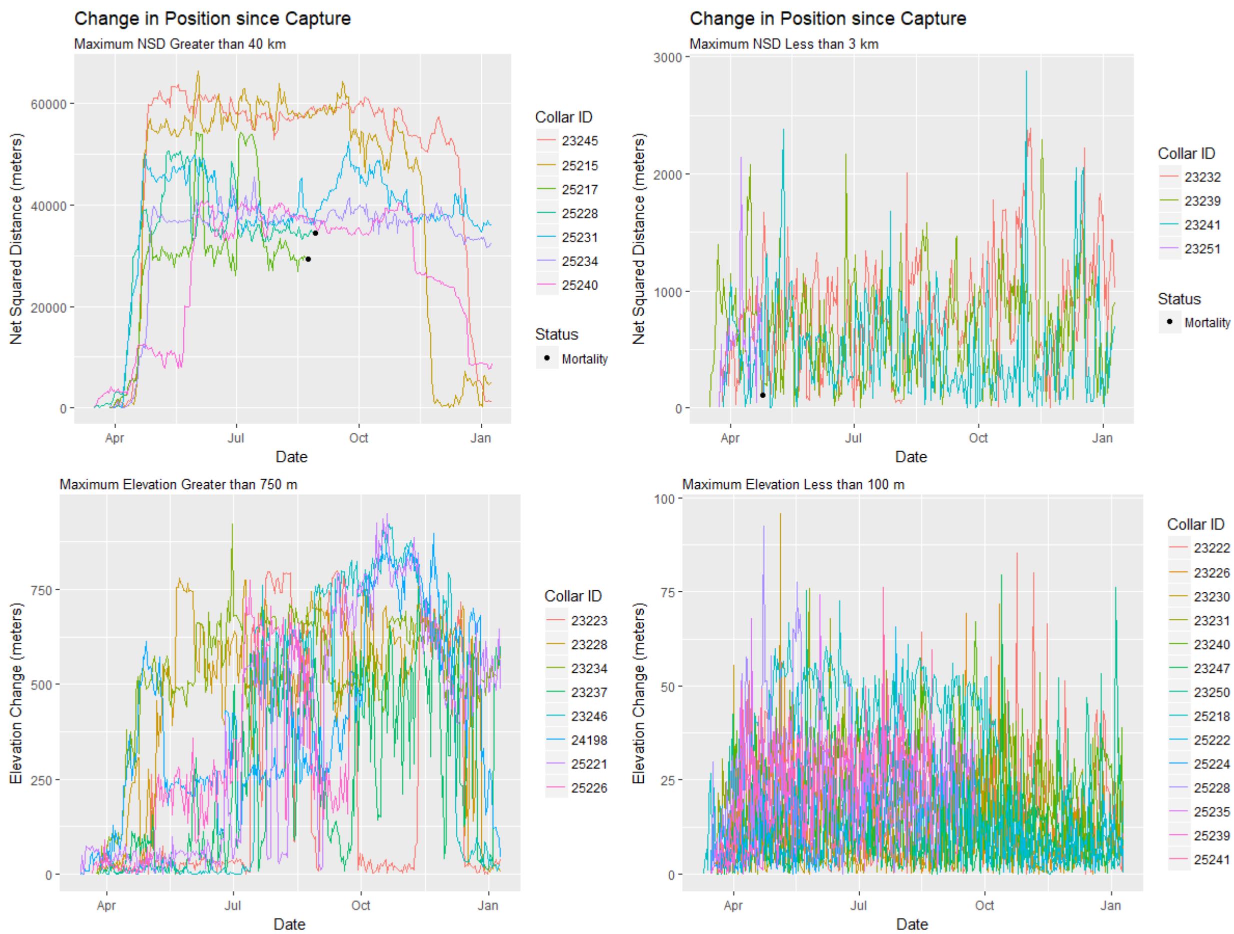


Figure 8. Seasonal movement variation between radio-marked moose, Mat-Su Valley, Alaska, March 2017-Janurary 2018

2018 Work Plan

January – May 2018:

- Complete 9 course credits at Utah State University.
- Present at The Wildlife Society Annual Meeting in Utah
- Draft paper: Seasonal MVC variation analyses
- Draft paper: Effects of pyrotechnic shows on Moose Movement

May – December 2018:

- Final field season collecting additional MVC site data in Mat-Su Valley, AK
- Further development of machine learning model
- Further development of moose trajectory and habitat use analysis
- Development of prediction surface for MVC probability

Literature Cited

Al-Ghamdi, A. S., and S. A. AlGadhi. 2004. Warning signs as countermeasures to camel-vehicle collisions in Saudi Arabia. Accident Analysis and Prevention 36:749–760.

Alaska Department of Fish and Game. 2016. GMU 14A, 14B, Alaska. Harvest Lookup: 2016, Moose, 14A, Harvested. https://goo.gl/jwhDvm. Accessed June 15, 2017.

Ballard, W. B., and J. S. Whitman. 1988. Susitna Hydroelectric Project, Final report, Big game studies, Vol. II—Moose Upstream. Alaska Department of Fish and Game. 150 pp.

Clevenger, A. P., B. Chruszcz, and K. E. Gunson. 2001. Highway mitigation fencing reduces wildlife-vehicle collisions. Wildlife Society Bulletin 29:646–653.

Conover, M. R., W. C. Pitt, K. K. Kessler, T. J. DuBow, and W. A. Sanborn. 1995. Review of human injuries, illnesses, and economic losses caused by wildlife in the United States. Wildlife Society Bulletin 23:407–414.

Huijser, M. P., and P. T. McGowan. 2010. Reducing wildlife-vehicle collisions. Pages 51–74 *in* J. P. Beckmann, A. P. Clevenger, M. P. Huijser, and J. A. Hilty, editors. Safe Passages: Highways, Wildlife, and Habitat Connectivity. Island Press, Washington, DC.

Kahn, C. A., V. Cisneros, S. Lotfipour, G. Imani, and B. Chakravarthy. 2015. Distracted driving, a major preventable cause of motor vehicle collisions: “Just hang up and drive.” Western Journal of Emergency Medicine 16:1033–1036.

Krauze-Gryz, D, M. Zmihorski, K. Jasinska, L. Kwasny, J. Werka. 2017. Temporal pattern of wildlife-train collisions in Poland. Journal of Wildlife Management. DOI: 10.1002/jwmg.21311.

Lantz, B. 2015. Machine Learning in R. Second Edition. Packt Publishing, Birmingham, UK.

Litvaitis, J. A., and J. P. Tash. 2008. An approach toward understanding wildlife-vehicle collisions. Environmental Management 42:688–697.

McCollister, M. F., and F. T. van Manen. 2010. Effectiveness of wildlife underpasses and fencing to reduce wildlife-vehicle collisions. Journal of Wildlife Management 74:1722–1731.

Prichard, A. K., N. A. Schwab, and B. E. Lawhead. 2013. Big-game movement and habitat use study. Susitna–Watana Hydroelectric Project, FERC Project No. 14241. 2012 Technical Memorandum, prepared for the Alaska Energy Authority, Anchorage, by ABR, Inc.—Environmental Research & Services, Fairbanks. 27 pp. + appendices.

Sielecki, L. E. 2010. WARS 1998-2007: Wildlife accident reporting and mitigation in British Columbia, Special Report. Victoria, British Columbia, Canada.

Sullivan, T. L., and T. A. Messmer. 2003. Perceptions of deer-vehicle collision management by state wildlife agency and department of transportation administrators. Wildlife Society Bulletin 31:163–173. < https://goo.gl/g9xog4>.

Sullivan, T. L., A. F. Williams, T. A. Messmer, L. A. Hellinga, and S. Y. Kyrychenko. 2004. Effectiveness of temporary warning signs in reducing deer-vehicle collisions during mule deer migrations. Wildlife Society Bulletin 32:907–915. <http://doi.wiley.com/10.2193/0091-7648(2004)032[0907:EOTWSI]2.0.CO;2>.

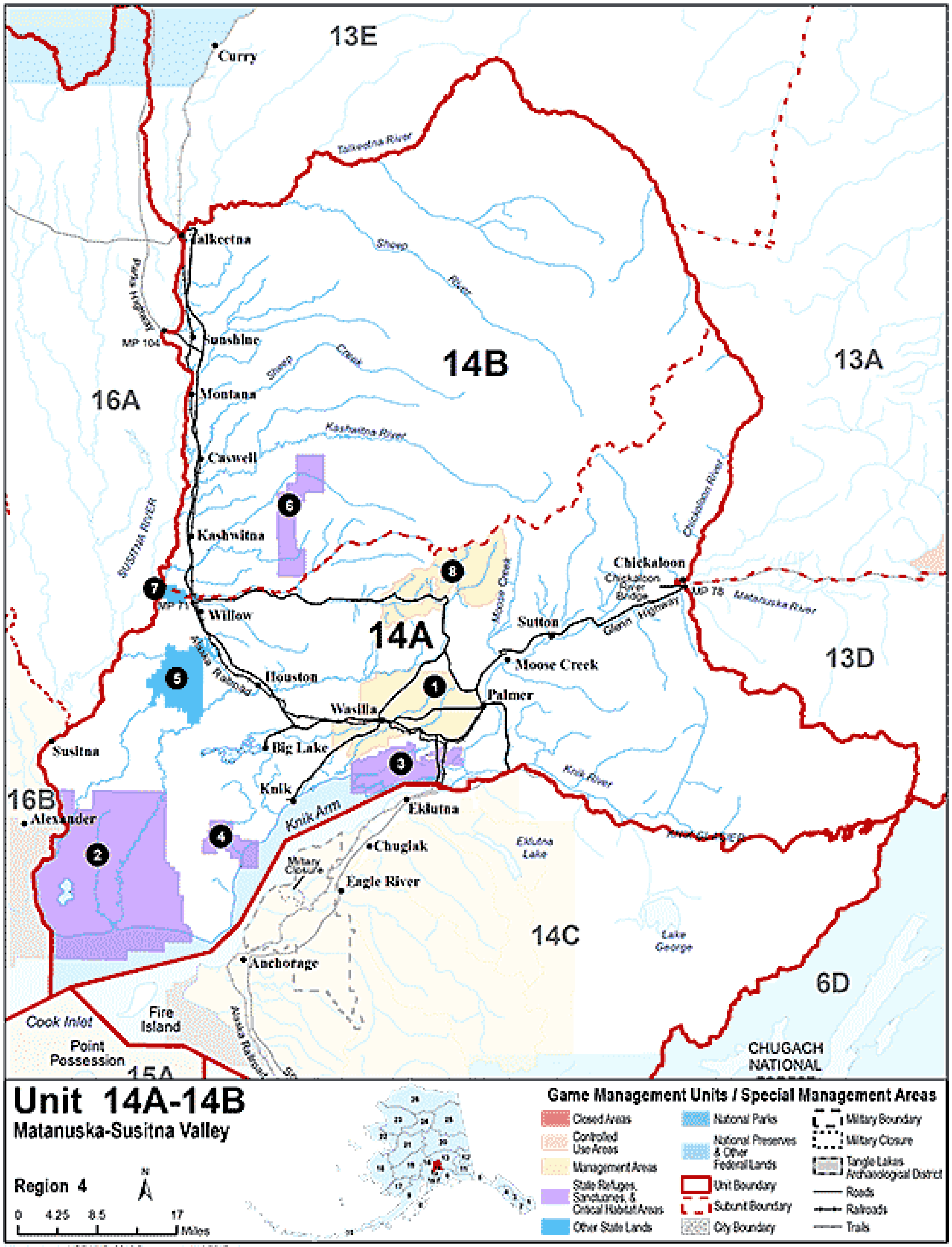
Thuiller, W., B. Lafourcade, R. Engler, and M. B. Araújo. 2009. BIOMOD - A platform for ensemble forecasting of species distributions. Ecography 32:369–373.

Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska vegetation classification. USDA General Technial Report 142.

Wilson, R. E., S. D. Farley, T. J. McDonough, S. L. Talbot, and P. S. Barboza. 2015. A genetic discontinuity in moose (Alces alces) in Alaska corresponds with fenced transportation infrastructure. Conservation Genetics 16:791–800.

Western Regional Climate Center. 2017. Matanuska Valley, Alaska (509759). Period of record: 1949 to 2017, https://goo.gl/L1yzKC. Accessed June 15, 2017.

Appendix A


13E
Curry
Talkeetna River
Talkeetna
Sheep
River
Sunshine
MP 104
14B
13A
Montana
16A
Kashwitna River
Caswell
Kashwitna
Chickaloon
Willow
14A
Sutton
Moose Creek
Houston
Palmer
Wasilla
13D
Susitna
Big Lake
Knik
Knik River
Knik Arm
Eklutna
16B
Alexander
Chugiak
Eagle River
14C
Lake George
Anchorage
6D
Cook Inlet
Fire Island
Point Possession
CHUGACH NATIONAL
Unit 14A-14B
Matanuska-Susitna Valley
Region 4
0 4.25 8.5 17 Miles
Game Management Units / Special Management Areas
Closed Areas
Controlled Use Areas
Management Areas
State Refuges, Sanctuaries, & Critical Habitat Areas
Other State Lands
National Parks
National Preserves & Other Federal Lands
Unit Boundary
Subunit Boundary
City Boundary
Military Boundary
Military Closure
Tangle Lakes Archaeological District
Roads
Railroads
Trails

Appendix B

ID		CAD		Date and Time	
Estimated Heading of MVC		MVC on		Randomly Generated?	☐
Road Type		Speed Limit		Unusable Coordinates?	☐
Cars per 10 min		Number of Lanes		Median?	☐
Lane Width		Shoulder Width		Lighted?	☐
Fence on Same Side?	☐	Fence on Other Side?	☐	Light not functioning?	☐
Type (S)		Type (O)		Moose Crossing Sign?	☐
Distance (S)		Distance (O)		Snow?	☐
Height (S)		Height (O)		Construction?	☐
Position (S)		Position (O)		Evidence of Collision?	☐
Notes					

Meter	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
(S) Veg Class																
(S) Height																
(S) Depth	0															

Residential on Same Side? ☐ Water on Same Side? ☐

Same side Med GR? ☐

(M) Vegetation Class							
(M) Height							
(M) Depth	0						

Opp side Med GR? ☐

(O) Veg Class																
(O) Height																
(O) Depth	0															

Residential on Other Side? ☐ Water on Other Side? ☐