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Characteristics of animal-related motor vehicle crashes in select National Park Service units—United States, 1990–2013

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Abstract

Objectives: Nationally, animal–motor vehicle crashes (AVCs) account for 4.4% of all types of motor vehicle crashes (MVCs). AVCs are a safety risk for drivers and animals and many National Park Service (NPS) units (e.g., national park, national monument, or national parkway) have known AVC risk factors, including rural locations and substantial animal densities. We sought to describe conditions and circumstances involving AVCs to guide traffic and wildlife management for prevention of AVCs in select NPS units.

Methods: We conducted an analysis using NPS law enforcement MVC data. An MVC is a collision involving an in-transit motor vehicle that occurred or began on a public roadway. An AVC is characterized as a collision between a motor vehicle and an animal. A non-AVC is a crash between a motor vehicle and any object other than an animal or noncollision event (e.g., rollover crash). The final data for analysis included 54,068 records from 51 NPS units during 1990–2013. Counts and proportions were calculated for categorical variables and medians and ranges were calculated for continuous variables. We used Pearson's chi-square to compare circumstances of AVCs and non-AVCs. Data were compiled at the park regional level; NPS parks are assigned to 1 of 7 regions based on the park's location.

Results: AVCs accounted for 10.4% (5,643 of 54,068) of all MVCs from 51 NPS units. The Northeast (2,021 of 5,643; 35.8%) and Intermountain (1,180 of 5,643; 20.9%) regions had the

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largest percentage of the total AVC burden. November was the peak month for AVCs across all regions (881 of 5,643; 15.6%); however, seasonality varied by park geographic regions. The highest counts of AVCs were reported during fall for the National Capital, Northeast/Southeast, and Northeast regions; winter for the Southeast region; and summer for Intermountain and Pacific West regions.

Conclusions: AVCs represent a public health and wildlife safety concern for NPS units. AVCs in select NPS units were approximately 2-fold higher than the national percentage for AVCs. The peak season for AVCs varied by NPS region. Knowledge of region-specific seasonality patterns for AVCs can help NPS staff develop mitigation strategies for use primarily during peak AVC months. Improving AVC data collection might provide NPS with a more complete understanding of risk factors and seasonal trends for specific NPS units. By collecting information concerning the animal species hit, park managers can better understand the impacts of AVC to wildlife population health.

Keywords

National Park Service; motor vehicle crashes; wildlife; traffic; seasonality

Introduction

Animal–motor vehicle crashes (AVCs) represent a safety risk for drivers and animals. In 2014, approximately 266,000 of 6,064,000 (4.4%) motor vehicle crashes (MVCs) on U.S. roads were the result of a collision with an animal; 158 of these AVCs resulted in human fatalities (NHTSA 2016). The annual economic burden from reported AVCs is estimated at approximately $1 billion from injuries and property damage (Langley et al. 2006; Sullivan 2011). The majority of AVCs cause only property damage; therefore, certain AVCs might go unreported (Bissonette et al. 2008; NHTSA 2015). Accounting for underreporting, estimates are that 1–2 million large mammal (e.g., deer, elk, moose, or bear) AVCs occur each year in the United States (Huijser and McGowen 2010; Sullivan 2011).

In addition to public health concerns (e.g., injury and death) and costs associated with AVCs, these crashes affect wildlife populations. Previous research has indicated that 92% of AVCs resulted in the death of at least one animal (Bissonette et al. 2008). Although animal mortality from AVCs does not pose a substantial threat to large, robust populations, road mortalities can have a substantial effect on threatened or endangered animal populations (Beckmann and Hilty 2010). Road mortalities threaten the survival of at least 21 federally listed threatened or endangered animal species (Huijser et al. 2008). Therefore, AVCs are an important wildlife conservation concern. A previous study (Stout et al. 1993) reported that the public’s preference regarding the size of a deer population was influenced by the public’s risk perception of deer-related AVCs. If the public perceived a higher risk for deer-related AVCs, then their preference was for a decreased herd size (Stout et al. 1993). AVCs affect public support of wildlife conservation.

An increased risk exists for AVCs in rural areas and in urban-rural interfaces (Huijser and McGowen 2010), similar to the areas where many National Park Service (NPS) units are located. The majority of NPS units have many of the previously researched risk factors for

AVCs, including single lane or 2-lane rural roads, high animal density, and habitats favorable to animals (Huijser et al. 2008; Langley et al. 2006). Additionally, many NPS units have substantial motor vehicle traffic concentrated on few and narrow roadways. MVCs are the second leading cause of unintentional injuries among persons in parks (Heggie et al. 2008; NPS, unpublished data, December 2009).

NPS units are among the most popular travel destinations in the United States (Heggie et al. 2008). Each year, millions of visitors travel on approximately 5,500 miles of paved roadways in NPS units (NPS 2018). Some NPS units do not charge an entrance fee and park unit's roads might be used for commuting or visitation. Certain NPS units are national parkways, which are pleasure vehicle roads constructed to provide a scenic drive that is free from billboards, buildings, and other commercial development (Unrau and Williss 1983). National parkways differ from other NPS units in that the primary purpose of visitation is recreational driving or commuting. Given that NPS units have certain risk factors for AVCs, this study's purpose was to describe conditions and circumstances involving AVCs in select NPS units, including seasonality trends, to guide traffic, wildlife management, and public health interventions for AVCs in NPS units. This analysis focused on conditions and factors present during AVCs but did not examine MVC outcomes (e.g., injury, health outcome, or costs).

Methods

Data collection and reporting

This analysis was conducted by using NPS MVC data. The NPS law enforcement program defines an MVC as a collision involving an in-transit motor vehicle that occurred or began on a public roadway (NPS 2002). We categorized all MVCs into AVCs or non-AVCs. An AVC is characterized as a collision between a motor vehicle and an animal. A non-AVC is a crash between a motor vehicle and any object other than an animal (e.g., another motor vehicle, fixed object, or pedestrian) or noncollision event (e.g., rollover crash; NPS 2002). Although an animal in the environment might have contributed to certain non-AVCs (e.g., a driver swerving to avoid hitting an animal), MVCs were categorized based on the most harmful object the vehicle hit. No additional information on the species or size of animal was collected.

The U.S. Department of the Interior (DOI) defines a park unit as a physical property owned or administered by the NPS (e.g., national park, national monument, or national parkway; NPS 2003). NPS units are federal lands and law enforcement jurisdictions differ by park based on the enabling legislation of the park. NPS units are assigned to 1 of 7 regions based on geographic area (Figure 1). In NPS units where NPS commissioned law enforcement officers (U.S. Park Rangers or U.S. Park Police) have jurisdiction, officers investigate MVCs to determine and record the probable MVC causes, causative and contributing factors, and any need to address potential violations of state or federal regulations.

During calendar years 1990–2005, NPS collected MVC data using the Servicewide Traffic Accident Reporting System (STARS). NPS units directly entered data from an accident report form (Motor Vehicle Traffic Accident Report [NPS Form 10-413]) into STARS, and data were sent electronically to a centralized database manager for national-level analysis. NPS units without computer access mailed forms to a central location and data were entered manually in STARS. In 2006, use of STARS was discontinued because of changes in computer software; individual NPS units still collected MVC data locally and stored the data in paper files or in an electronic format. The NPS Washington Transportation Office implemented an effort to collect the 2006–2013 MVC data from units and centralized these data into the NPS Crash Data System along with the 1990–2005 records. Given differences in reporting, complete records might not be available for all NPS units or across all years.

Data management and analysis

Given complexity of the raw data described previously, intensive data cleaning was required for this study. The uncleaned data set had 80,591 records of MVCs in select NPS units from which data were available ($n = 101$). To remain in the data set, records had to meet the following inclusion criteria: Records contained only a single NPS unit location; crashes occurred inside an NPS unit; records with a specific date and time of crash; and parks that are accessible to the public by motor vehicle. Additionally, motor vehicle-train crashes were removed from the analysis given the unique nature of these MVCs. Data cleaning was performed using SAS 9.3 (SAS Institute, Cary, NC). The initial data cleaning left 62,216 records (77.2%).

None of the parks that provided data had MVC data available across all years. Underreporting was a concern for these data, because several parks had large year-to-year fluctuations. Inconsistent national-level data reporting required that additional rules be created for data cleaning, as follows:

For a reporting year to be included in the final analysis, the year had to have >10 MVCs across all NPS units reported for that year.

For an individual park unit to remain in the data set, the park unit needed to have more than 1 year of data reported and report yearly crash counts that were >0.001% of the park visitation for the corresponding year (i.e., 1 MVC per 100,000 visitors).

Individual years of data for a given park unit were included if a <30% reduction in crashes from the previous year was reported. If the previous year was not available for comparison, years that were lower outliers for the park unit (1.5 times interquartile range) were excluded.

After these exclusion criteria were applied, 54,068 MVC records (67.1%) from 51 NPS units during 1990–2013 remained for final analysis. Due to the risk of underreporting, these data are considered to represent years for a given park unit that had close to full reporting. Note that for some smaller parks, some years still had zero MVCs.

Data were compiled at the park regional level. Certain NPS units span more than one park region. The Northeast/Southeast designation is given to 2 NPS units that are present in both the Northeast and Southeast regions. No data were reported from NPS units from the Alaska region.

Data were analyzed using SAS 9.3. Categorical variables (e.g., crash location, weather and lighting conditions during crash) were described using counts and proportions; continuous variables were described using medians and ranges. Missing data were excluded from analysis. We used the Pearson's chi-square statistical test to compare circumstances of AVCs and non-AVCs and to compare conditions of AVCs by region. Seasons are defined using the 4 Northern Hemisphere meteorological seasons as follows: spring, March 1-May 31; summer, June 1-August 31; fall, September 1-November 30; and winter, December 1-February 28 or 29. Average monthly MVC counts by region were also calculated. The Midwest was not included in the seasonal analysis of AVCs by region because of the limited sample size ($n = 10$). The Centers for Disease Control and Prevention (CDC) reviewed this study for human subjects protection and deemed it to be non-human subject research.

Results

Final analysis included 54,068 MVC records from 51 NPS units. Data collection dates were during 1990–2013, although no park unit had complete data across all of these years (Table 1). The number of years of available data ranged by NPS unit from 2 to 19 years (median: 6 years). All regions, except Alaska, have ≥2 NPS units presented (range: 2–14 NPS units/region; median: 7 NPS units/region).

AVCs accounted for 10.4% (5,643 of 54,068) of all MVCs (Table 1). November was the peak month for AVCs across all regions (881 of 5,643; 15.6%). Investigation reports listed the leading contributing factor for AVCs as the presence of an animal in the environment (4,346 of 5,008; 86.8%), followed by a distracted driver (358 of 5,008; 7.2%) and the driver's speed (109 of 5,008; 2.2%). Virtually all AVCs (5,425 of 5,495; 98.7%) occurred on a roadway, compared with off-road; half of AVCs were on straight and level roads (2,697 of 5,393; 50.0%). The majority of drivers were driving straight ahead (4,030 of 5,338; 75.5%) at the time of the AVC. Approximately half of all AVCs (2,502 of 5,431; 46.1%) occurred during dark, unlighted conditions. The most common weather type for AVCs was clear conditions (3,968 of 5,398; 73.5%).

AVCs were reported across all participating regions. The Northeast (2,021 of 5,643; 35.8%) and Intermountain (1,180 of 5,643; 20.9%) regions had the largest percentage of the total AVC burden (Table 1; Figure 1). When examining the proportion of AVCs among all types of MVCs in a region, the Northeast (2,021 of 6,788; 29.8%) and Southeast (923 of 3,322; 27.8%) reported the highest proportion of all MVCs being AVCs (Table 1).

Light and weather conditions at the time of AVCs differed across regions. The most common lighting condition at time of AVCs was dark, unlighted conditions for National Capital (586 of 1,037; 56.5%), Southeast (456 of 896; 50.9%), Northeast (881 of 1,863; 47.3%), and Intermountain (478 of 1,163; 41.1%) regions; however, it was not the most common lighting condition for AVCs in Midwest (3 of 10; 30.0%), Northeast/Southeast (71 of 245; 30.0%), and Pacific West (27 of 217; 12.4%) regions ($\chi^2 = 277.3$; degrees of freedom [df] = 18; $P < .0001$). For these 3 regions, the majority of AVCs occurred during daylight, including Pacific West (160 of 217; 73.7%), Midwest (6 of 10; 60.0%), and Northeast/Southeast (128 of 245; 52.2%). Regarding weather, the most common weather type was clear conditions for all regions' AVCs (Pacific West [193 of 214; 90.2%], Intermountain [920 of 1,160; 79.3%], National Capital [781 of 1,028; 76.0%], Northeast/Southeast [180 of 245; 73.5%], Southeast [610 of 857; 71.2%], Northeast [1,278 of 1,884; 67.8%], and Midwest [6 of 10; 60.0%]). Compared to all other weather types, all regions were more likely to have AVCs during clear weather ($\chi^2 = 152.1$; $df = 36$; $P < .0001$).

Month of year for the highest number of AVCs varied by region. November was the peak month for AVCs for National Capital (295 of 1,040; 28.4%), Northeast/Southeast (53 of 249; 21.3%), Northeast (323 of 2,021; 16.0%), and Southeast (133 of 923; 14.4%) regions. August was the peak month for AVCs for the Intermountain region (602 of 1,180; 51.0%) and July was the peak month for the Pacific West (49 of 220; 22.3%). The highest counts of AVCs were reported during fall for the National Capital (564 of 1,040; 54.2%), Northeast/Southeast (109 of 249; 43.8%), and Northeast (825 of 2,021; 40.8%) regions; winter for the Southeast region (343 of 923; 37.2%); and summer for Intermountain (602 of 1,180; 51.0%) and Pacific West (104 of 220; 47.3%) regions. For each region, there were peak month(s) that had a higher average number of AVCs than the total average of AVCs across the region for all months and years (Figure 2). These above-region-average AVC months are as follows: for Intermountain: June, July, August, September, and October; for National Capital: October, November, and December; for Northeast: September, October, November, and December; for Northeast/Southeast: June, July, October, and November; for Pacific West: May, June, July, September, and October; and for Southeast: January, February, March, November, and December (Figure 2).

Discussion

NPS units have a higher percentage of AVCs compared to national statistics. AVCs represented 10.4% of all types of MVCs in NPS units. Nationally, AVCs account for 4.4% of all reported crash types (NHTSA 2016). NPS units have many of the known risk factors for AVCs, including single-lane or 2-lane rural roads that traverse through animal habitats. These risk factors might contribute to NPS units having a higher percentage of AVCs than the national average. Understanding characteristics of these crashes will help the NPS develop targeted strategies and messages to protect visitors and wildlife. Seasonality is an important component to understanding AVCs. November was the peak month for AVCs overall; however, variability was reported in the peak months for AVCs by NPS units. This finding is similar to the pattern observed nationally for AVCs. Previous analysis of insurance claims filed for AVCs has reported that claim frequency rises substantially during October, peaks in November, and then drops off in December and January; claim frequencies are the lowest during August, overall (Highway Loss Data Institute 2014). U.S. insurance claims for AVCs are approximately 3 times higher during November than during summer months (Highway Loss Data Institute 2014). Much of this activity likely is attributable to deer mating season, when bucks and does are more likely to roam. However, neither the NPS data set used in this study nor the insurance claim data specify the animal species involved. Previous studies have reported that the majority of vehicle collisions with large animals involve deer (CDC 2004; Langley et al. 2006).

Although November was the peak month for all AVCs, peak season for AVCs varied when analyzed at the NPS regional level. The highest counts of AVCs were reported in the fall for the Northeast and National Capital regions; winter for the Southeast region; and summer for Intermountain and Pacific West regions. Certain NPS units in the Intermountain and Pacific West regions are large, natural resource parks with a variety of wildlife not reported in other regions. Without knowledge of the species involved in AVCs, determining whether the summer peak in these regions is related to animal migration routes, peak park visitation, or a combination of factors is difficult. Many NPS units have higher visitation during the summer.

Knowledge of regional trends of AVCs' characteristics can help park staff develop mitigation strategies. Individual NPS unit leadership might consider the park's peak season for AVCs, areas where animals cross roads, locations where the majority of AVCs occur, species commonly involved in AVCs, and the species' home range and migration patterns when planning mitigation strategies. Temporary, seasonal warning signs can be placed in at-risk areas during peak season to warn visitors of the increased AVC risk. Temporary signs are more effective than permanent passive signs; drivers can learn to ignore permanent signs that are used frequently (Hedlund et al. 2004; Huijser and McGowan 2010). During periods of substantial animal movement, certain roads might be closed temporarily. Road closure might be possible only on low-volume roads or at night. Because 63% of AVCs in NPS units occurred during dark, dusk, or dawn conditions, the likelihood exists that seasonal, night road closures would reduce the number of AVCs (Huijser and McGowan 2010).

Although temporary interventions can be implemented, installation of wildlife underpasses or overpasses is a more permanent and effective mitigation strategy for reducing AVCs (Bissonette et al. 2008; Hedlund et al. 2004). These types of wildlife crossings allow animals to cross a road any time of the year without encountering motor vehicles (Hedlund et al. 2004). Underpasses and overpasses are most effective when combined with fencing or other barriers to direct animals to use the crossings (Bissonette et al. 2008; Hedlund et al. 2004). Multiple types of crossing structures could be constructed at crossing points to allow for passage by various species of animals (Beier et al. 2008). Structures and fencing must be maintained in good repair to ensure that animals have no other way to cross roadways (Hedlund et al. 2004). Permanent structures would alleviate the need to increase seasonal mitigation strategies.

Although more effective than seasonal mitigation strategies, permanent wildlife crossing structures are expensive to construct, particularly when the structures are added to existing roadways (Hedlund et al. 2004). Road construction in NPS units during the 1920s and 1930s focused on creating roadways with high scenic value (Heggie et al. 2008; Sellars 1997; Unrau and Williss 1983). Since then, certain roadways have remained structurally unchanged. Road alterations would need to be evaluated for compatibility with the mission of the park unit and associated cultural and natural resource concerns. Substantial road alterations might be prevented because of competing historical, cultural, or natural preservation concerns (Heggie et al. 2008; Office of Law Revision Counsel 2014). Although fencing combined with underpasses and overpasses has been shown to be effective in reducing AVCs (Hedlund et al. 2004), these methods might not be practical in many NPS units given the cost and potential effects of the infrastructure to other park resources.

Multiple limitations to this study exist, including that the crash data sets were subject to biases in reporting because of changes in centralized reporting procedures, variable NPS unit jurisdictions, and known inconsistencies with reporting. Underreporting of MVCs was possible in NPS units with concurrent or proprietary law enforcement jurisdiction, and state and local law enforcement might not have used NPS Form 10-413R during the investigation or not reported the MVC to the centralized NPS database. Conservative data cleaning rules were applied that might have prevented certain trends from being observed. This analysis only examined MVCs that were coded by NPS law enforcement as a collision with an animal. The likelihood exists that certain other types of MVCs (e.g., collision with another motor vehicle or a fixed object) might have been the result of swerving to miss an animal and therefore the true number of animal-related MVCs is underestimated. Additionally, the species of animal involved in the MVC was not provided in the data set and we are unable to provide specific recommendations targeting species-level behavior, nor can we infer potential population-level effects for the species involved. Collisions with small animals are likely underreported, because resulting vehicle damage or injury might not occur or be minor and not reported to authorities. This analysis did not include the outcomes of AVCs (e.g., cost, severity, and location of vehicle damage or occupant injuries or fatalities).

In 2012, the DOI released a new law enforcement management system, known as the Incident Management, Analysis, and Reporting System (IMARS). In 2016, the DOI added a new crash report to IMARS that allows law enforcement to directly enter crash data into the IMARS database, thus providing the NPS with a centralized electronic reporting system for MVCs. The new crash report captures detailed crash information on the primary cause of the MVC and sequence of events and includes animal species information for AVCs. Improving AVC data collection might provide the NPS with a more complete understanding of risk factors and seasonality trends for specific NPS units. By collecting information concerning the animal species hit, NPS employees can focus attention on learning the migration, breeding, and feeding patterns of these species. Knowing the behaviors and patterns of these species might identify locations within the park to increase AVC interventions. Coupling AVC data with roadkill reports might further enrich the park's understanding of high-risk AVC areas. All NPS units are encouraged to consistently report MVC data through IMARS.

AVCs represent a public health and wildlife safety concern for the NPS. In an increasingly urban landscape, many NPS units provide an oasis for wildlife threatened by habitat fragmentation. Knowledge of NPS regional trends in AVCs can help NPS employees develop specific interventions to improve road safety in NPS units. Both temporary, seasonal mitigations and permanent road alterations should be considered to safeguard human and animal lives.

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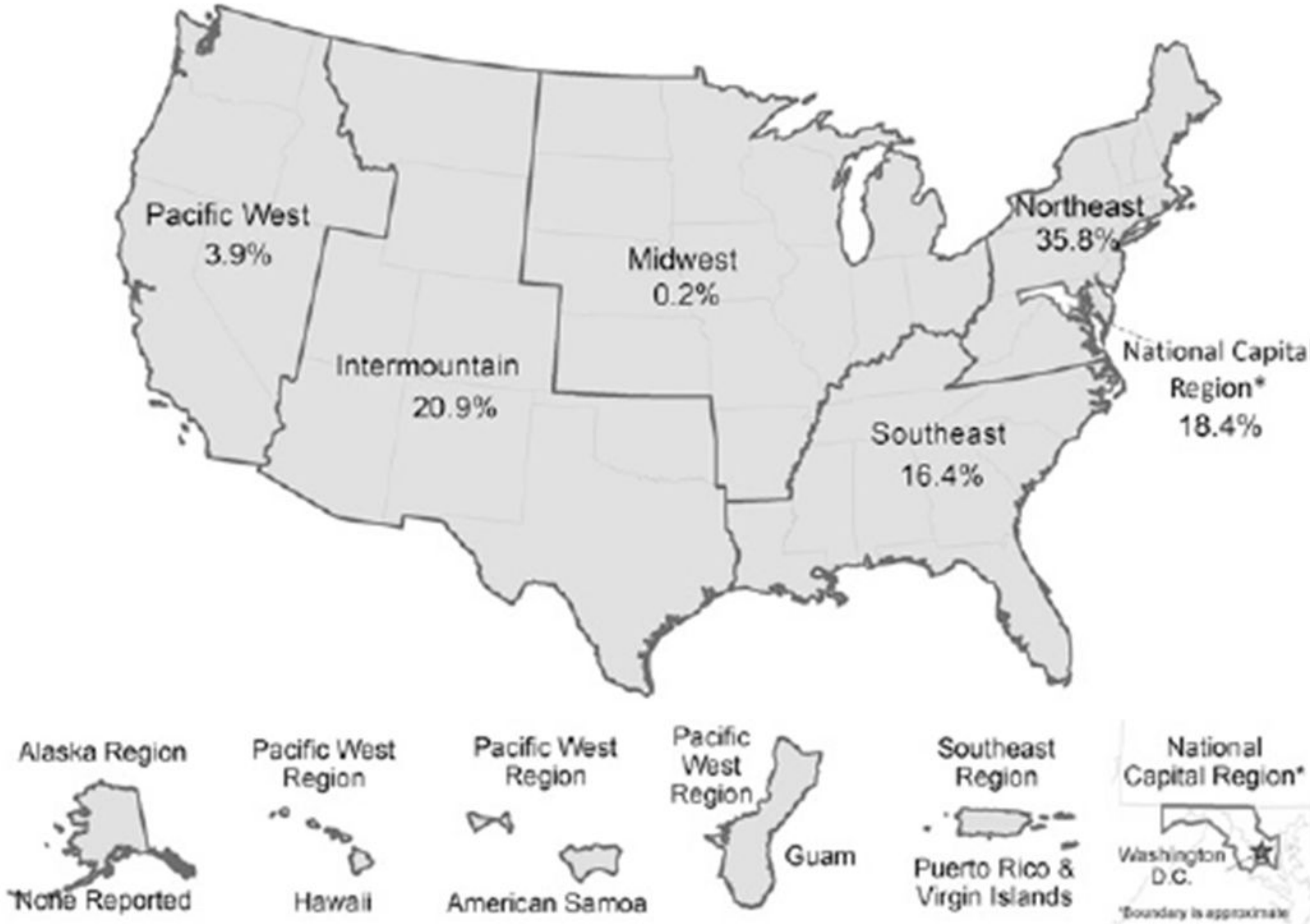

Figure 1.
Animal-motor vehicle crashes (N = 5,643) by National Park Service region — United States, 1990–2013. The seven National Park Service regions are Northeast, National Capital, Southeast, Midwest, Intermountain, Pacific West, and Alaska. Outlying island NPS units belong to the Pacific West or Southeast regions. During 1990–2013, 5,643 animal-motor vehicle crashes (AVCs) were reported in select National Park Service (NPS) units. The percentage on the map is the region's contribution to the total number of AVCs for all NPS units. The NPS units in the Northeast, Intermountain, National Capital, and Southeast regions contributed to the majority (91.5%) of the AVCs reported. No data were reported from NPS units from the Alaska region. The Northeast/Southeast designation (not shown) is given to two NPS units that are present in both the Northeast and Southeast regions and these units contributed 4.4% of AVCs.

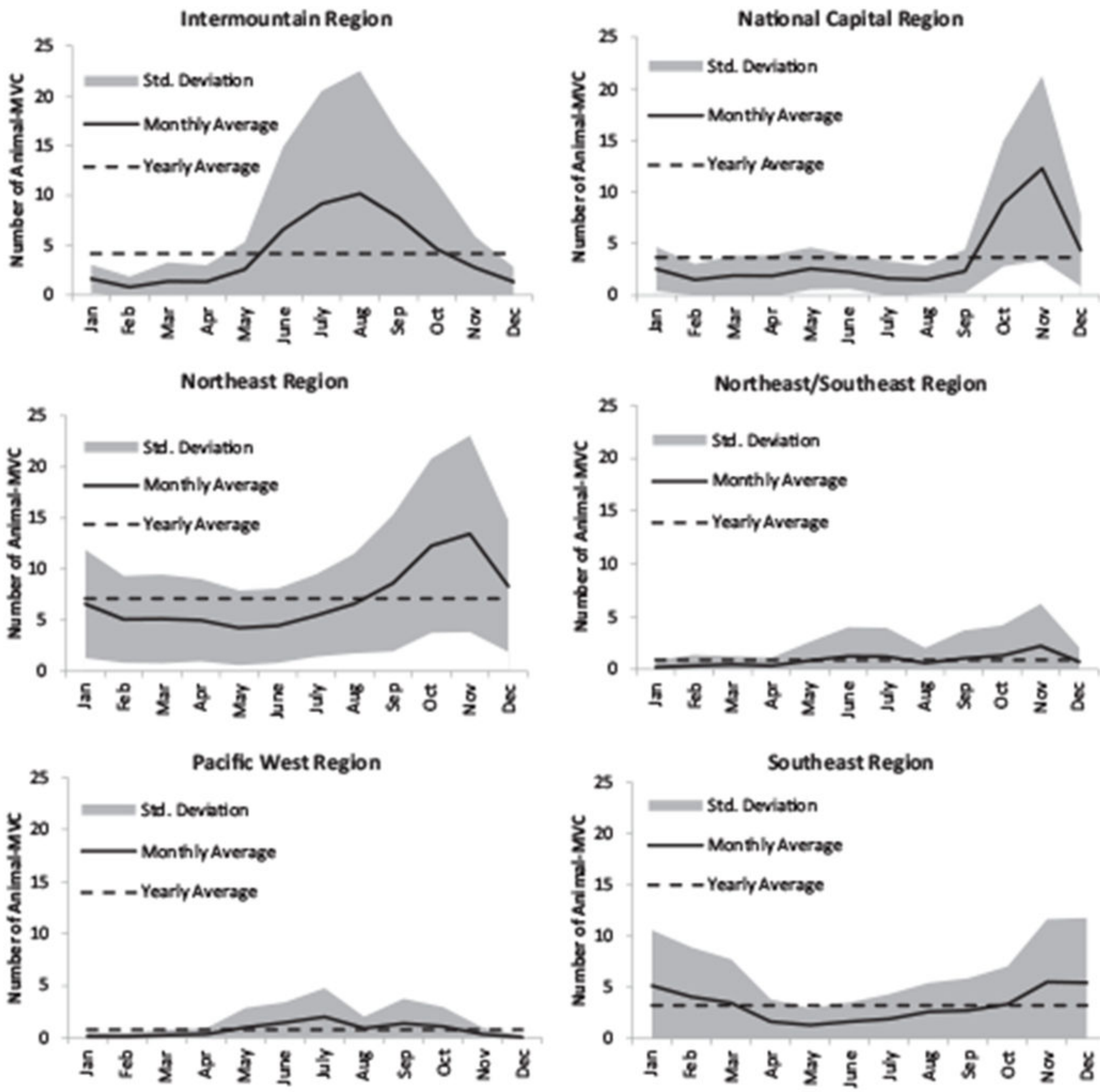

Figure 2.

Mean number of animal-motor vehicle crashes by month and by National Park Service region — United States, 1990–2013. The figure displays animal-motor vehicle crashes (AVCs) by month by National Park Service region. The dotted line is the average of all yearly AVCs in the region. The solid line is the monthly average AVCs. The gray shading is the standard deviation for each month of AVCs.

Table 1.

Motor vehicle crashes from select NPS units by park region—United States, 1990–2013 (AVPRAG; SD).

	Intermountain	Midwest	National Capital	Northeast	Northeast/Southeast	Pacific West	Southeast	Total
NPS units included	14	3	7	11	2	8	6	51
Years available	1994–2012	1997–2012	1990–2013	1993–2012	1998–2012	1995–2011	1996–2013	1990–2013
Median years of data	6.5	3	11	9	8	6	3.5	
All MVCs	8,316	246	29,206	6,788	1,490	4,699	3,323	54,068
Average MVCs per year	438 (109–936; 292)	21 (14–30; 5)	1,391 (9–2,163; 622)	339 (63–497; 94)	99 (22–397; 125)	276 (101–760; 184)	185 (18–307; 107)	2,253 (423–3,308; 811)
All AVCs	1,180	10	1,040	2,021	249	220	923	5,643
Average AVCs per year	62 (11–162; 51)	1 (1–3; 1)	52 (1–85; 22)	106 (35–179; 38)	18 (1–70; 23)	13 (2–39; 11)	54 (1–101; 36)	235 (15–406; 96)
% AVC of MVC per year	14.2 (4.9–19.7; 4.0)	4.1 (0–18.8; 5.3)	3.6 (0–7.7; 1.4)	29.8 (0–38.1; 9.3)	16.7 (0–32.0; 7.8)	4.68 (1.2–9.5; 2.0)	27.8 (0–36.0; 11.1)	10.4 (2.8–23.6; 6.2)