



White-tailed Deer Monitoring at Pea Ridge National Military Park, Arkansas

2005–2019 Trend Report

Natural Resource Report NPS/HTLN/NRR—2019/1987



ON THE COVER

White-tailed deer on Pea Ridge National Military Park, Arkansas
Photograph by NPS/Heartland Inventory and Monitoring Network

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David G. Peitz

National Park Service
Heartland Inventory and Monitoring Network
6424 W. Farm Rd. 182
Republic, Missouri 65738

Editing and Design by
Tani Hubbard

National Park Service &
Northern Rockies Conservation Cooperative
12661 E. Broadway Blvd.
Tucson, AZ 85748

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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 received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

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Executive Summary

During 15 years (2005–2019) of monitoring trends in white-tailed deer within a defined survey area of Pea Ridge National Military Park, we have been able to demonstrate both rapid declines and recoveries. The rapid die-off of 2005 to 2007 was the result of a region-wide hemorrhagic disease outbreak reported by the Missouri Department of Conservation that started in the fall of 2005, six months after deer monitoring on Pea Ridge National Military Park in north Arkansas was initiated. Even including data in the analysis from years when die-offs were occurring (2006–2007, 2016), the number of deer increased by an average of 2.8% annually. This trend was not statistically significant, however, and a 95% confidence interval includes zero (-1.3 to 6.9%). Deer numbers in the survey area ranged from 14.6 ± 7.1 (mean $\pm$ 95% CI) individuals/km² in 2007 to 58.7 ± 23.4 individuals/km² in 2013. The amount of visible area surveyed each year varied between 1.0 and 1.4 km² (coefficient of variation = 12.0%).

Annual deer harvest data in the area near Pea Ridge National Military Park exhibits similar trends to our annual adjusted counts. This suggests that factors other than hunting are driving annual changes in deer population size. Increasing deer populations pose several problems for Pea Ridge National Military Park. First, it will add a level of complexity to implementing the Pea Ridge National Military Park Cultural Landscape Report recommendations to restore the oak savanna and oak forest vegetation present at the time of the battle. Deer differentially browse native vegetation over exotic vegetation, thus promoting the spread of exotic species, and the success of tree planting can be curtailed by heavy deer browsing. Second, controlling deer-related disease, some of which can affect domestic livestock and human health in and around the park, becomes increasingly difficult when there are more deer. Third, as additional ancillary data suggests, the largely unreported and costly deer-vehicle collisions in and around Pea Ridge National Military Park have the potential to increase as deer populations grow.

Introduction

Since European settlement, white-tailed deer (*Odocoileus virginianus*) populations in North America have experienced enormous changes in size and distribution. Previously abundant deer populations declined to near extinction by the early 1900s. Clearing of forested lands and unrestricted hunting contributed heavily to the decline of this species (Stoll and Donohoe 1973; Dennis 1983). Declines in the number of deer were especially prevalent in the East and Midwest sections of the country where much of the land was converted for row-crop farming.

Regulated white-tailed deer hunting and extermination of most of their natural predators has led to unprecedented population growth throughout their range. With natural deer habitat severely reduced, row-crop agriculture and other agricultural practices provide artificial food sources that deer utilize. The ability of white-tailed deer to adapt to human disturbance has also aided in the recovery of this species. Urban sprawl benefits deer by fragmenting continuous blocks of forested lands into small sections with increased edge habitat, which is favored by deer and rarely available for hunting. Deer experience high rates of population growth as long as food is available in these small blocks of patchy habitat. Grass and forb production is greater in these areas as is mast production by oaks, hickories and other trees when compared to larger blocks of forested land (Peitz et al. 2001). Urban sprawl also redistributes deer by eliminating habitat in one area, and thereby concentrating deer in available habitat in another (Shafer-Nolan 1997).

Deer become vulnerable to overpopulation, disease, and starvation in the absence of natural predators and hunting. When deer occur in high densities, diseases are transmitted more readily. In years when forage or mast production is restricted due to climatic conditions, starvation or poor herd health can occur. Deer browsing from high density herds

also has a negative effect on vegetation. Research has shown that high deer populations contribute to over-browsing of vegetation, which leads to plant mortality, decreased plant reproduction, and may tend to favor less preferred exotic species (McShea and Rappole 1997). This shift in species assemblages can reduce plant diversity at a local level and cause changes in the functioning of prairie and woodland communities.

Many studies have shown that deer can have a negative effect on developing forestland (Crouch and Paulson 1968; Marquis 1981; Horsely and Marquis 1983). Browsing on young tree seedlings causes stunted growth as well as mortality (Michael 1992; Mladenoff and Stearns 1993). Research has shown that in some situations, damage from deer as well as mice and rabbits may be a key impediment to forest restoration projects (Crouch and Paulson 1968; Strole and Anderson 1992). The influence of deer on the status of most rare and sensitive plant species found on Pea Ridge National Military Park, such as the Chinquapin (*Castanea pumila*) and several sedges (*Carex* spp), is largely unknown.

White-tailed deer are often viewed as an important component of park ecosystems. Deer have a tremendous following among the public and many parks



White-tailed deer (*Odocoileus virginianus*) in the evening at Pea Ridge National Military Park.

provide information on the status of deer through their interpretive programs, though this information is generally anecdotal in nature. A downside to high white-tailed deer populations in parks is that they can present a safety hazard to motorists and park visitors. High deer populations increase the number of vehicle-deer collisions that result in property damage and personal injuries. In some cases, deer-vehicle collisions can result in the loss of human life. Deer also disperse ticks, which may carry Lyme disease (Connelly et al. 1987), a debilitating immune system disease transmitted to humans by the bite of ticks. Ticks carrying other human transmittable diseases, such as Rocky Mountain spotted fever and Ehrlichiosis, may be spread by deer as well. Information on the status and trends in deer population size helps park managers assess safety risks and determine if control measures are necessary to protect other park resources and visitors.

Against a backdrop of urban sprawl, altered ecosystems and concerns over visitor safety on National Park Service lands, we proposed monitoring the status and trends of white-tailed deer populations. Long-term trends in deer abundance provide one measure for assessing their potential as a problem for a park. Documenting long-term patterns in the number of deer allows us to evaluate potential correlations with changes in vegetation (e.g., restoration of the cultural landscape). With this information, resource managers can more effectively identify and potentially mitigate damage caused to vegetation communities and endangered plant populations by deer. This report summarizes survey results from 15 years of monitoring.

Objectives

The following are the primary objectives for monitoring white-tailed deer at Pea Ridge National Military Park, Arkansas.

- Determine annual changes in the number of white-tailed deer.

Justification. Significant annual changes in the number of deer may signal the presence of illegal deer harvest, disease or other acute factors of concern for park management.

- Determine long-term trends in the number of white-tailed deer.

Justification. Understanding decadal trends in the number of deer will help park management determine if measures need to be taken to maintain herd health, minimize vegetation damage within a park, or alleviate visitor health concerns.

- Annually map locations of white-tailed deer observed.

Justification: Mapping deer locations allows park management to assess the influences of management actions on deer usage of an area, habitat type, etc.

Methods

Study Area

Deer surveys were limited to an area visible at night with spotlights along the main tour road that makes a 10.0-km loop through the park. This permanent sampling route was selected from all existing roads and trails within the park, including service roads, because it is easily traversed and passes through all major habitats found on the park. It is important for long-term monitoring that the survey route is an all-weather route so that it will be passable shortly following inclement weather. Counting deer along this road corridor yields an adjusted count of the number of deer, which we assume is positively related to abundance, but to an unknown degree. The adjusted counts provide information to park managers on trends in the park's deer populations and may provide feedback on the effects of implemented management efforts (e.g., population control or vegetation restoration efforts). Adjusted counts, defined as the number of individuals observed from the road per square kilometer of visible area, allow for evaluation of annual change in addition to long-term trends.

White-tailed Deer Survey Methods

Sampling was limited to winter months before spring vegetation emerged (January through mid-March). The target population included all deer within the boundaries of the park (although the sample frame was limited to the road corridor) at the time surveys were conducted. Deer present during these winter months most impact herd size and park resources throughout the year.

Surveys were conducted from a vehicle moving no more than 16 km/hr using two 1,000,000 candle-power spotlights. All deer seen along the survey route were counted and their locations were recorded using GPS. Deer counts were made by two observers, one seated on the left and the other on the right side of the vehicle. Distances from the stopped survey vehicle to all deer were determined by a rangefinder, or by visual estimates for deer less than 10 m from the vehicle. Deer were usually observed in groups, in which case distance was to the center most deer in the group. To map locations of deer, the direction and angle of all deer or deer groups from the survey vehicle were recorded as well.



White-tailed deer observed from the permanent survey route along the main tour road in Pea Ridge National Military Park.

Following methods outlined in Peitz et al. (2007), an attempt was made to complete three survey replicates each night. Replicates started one hour after official sunset and then each hour thereafter. Exceptions occurred in 2006 and 2007 when one replicate each night was completed, and the first and third week of surveys in 2018 and 2019, when visibility estimates were taken during what would have been in most others years the third deer survey replicate (Table 1).

Visibility Estimates

Determining the area surveyed for white-tailed deer is critical for obtaining an adjusted count of deer in the survey area. In most years, visibility was measured every 0.16 km (1/10th mile) along the survey route. However, in years when multiple measures were

made, survey points were distributed evenly around the tour road [i.e. 0.08 km (1/20th mile) or 0.053 km (1/30th mile)]. The location at each perpendicular measure was taken using Global Navigation Satellite System (GNSS) technologies. In an attempt to get a more robust picture of how much area was being surveyed along the route, the location of the survey vehicle was adjusted slightly if objects were encountered that blocked the true area observed during a survey. For example, if the view of an open field was blocked by a single cedar tree in the ditch next to the survey vehicle, the vehicle was moved forward or backward to see the field. Using geographic information system (GIS) technologies, perpendicular distances were plotted on a map, a polygon was created, and the visible area was determined.

Table 1. Effort utilized to sample white-tailed deer on Pea Ridge National Military Park, Arkansas, 2005 through 2019.

Year	Survey Dates	Survey Nights	Survey Replicates	Visibility Replicates	Notes
2005	March 10 – March 12	3	9	0*	Deer locations and distances were measured perpendicular to the survey vehicle.
2006	January 17 – January 19	3	3	3	–
2007	January 22 – January 24	3	3	3	–
2008	January 8 – February 5	5	15	1	–
2009	January 13 – February 17	5	13	1	–
2010	January 12 – February 10	5	14	1	–
2011	January 4 – February 8	5	13	1	–
2012	January 4 – February 7	6	18	1	–
2013	January 8 – February 12	5	14	1	–
2014	January 14 – February 25	6	18	1	–
2015	January 6 – February 10	6	18	1	–
2016	January 5 – February 9	6	18	1	–
2017	January 10 – January 31	4	8	1	–
2018	January 9 – January 30	4	10	2	–
2019	January 30 – Feb 20	4	9	2	–

*Visible area was determined from data collected in 2006

Data Analysis

For each survey night, an adjusted count of deer was calculated by dividing the maximum count for that night by the visible area determined for that year:

$$AC = MC/VA$$

AC = Adjusted Count (individuals/km²)

MC = Maximum Count for the survey night

VA = Visible Area (km²) determined for the current year

An annual mean adjusted count of deer was calculated from the nightly adjusted counts for that year, along with a 95% confidence interval.

The software package TRIM (Trends and Indices for Monitoring Data; Pannekoek and Van Strien 2005) was used to evaluate trends in deer monitoring data. TRIM produces a regression line based on a loglinear model using generalized estimating equations, which allows temporal autocorrelation to be taken into account. TRIM reports qualitative interpretations according to statistical significance and the magnitude of change. A Pearson Correlation test was used to assess similarities between annual deer counts and deer harvest rates for Benton County, the county in which the park is located. To visually assess changes in habitat use by deer, the locations of individuals or groups observed during the highest count each year were mapped.

Results

Adjusted counts of white-tailed deer for the visible area on Pea Ridge National Military Park ranged from 14.6 ± 7.1 (mean $\pm$ 95% CI) individuals/km² in 2007 to 58.7 ± 23.4 individuals/km² in 2013. Using TRIM, an uncertain trend (slope = 1.028, SE = 0.021, $p < 0.08$) in the adjusted counts of deer was found over the 15-year interval. This trend equates to an overall increase in adjusted counts of 2.8% annually, although the 95% confidence interval includes zero (-1.3 to 6.9%). Because the P-value is greater than the widely accepted critical value of 0.05, and the confidence interval includes zero, the trend is not robust enough to be considered statistically significant. TRIM recognizes two types of statistically non-significant outcomes: (1) a “stable” population has a non-significant trend and the magnitude of change is less than 5% per year (i.e., the 95% confidence interval would not be greater than 5% on either side); and (2) the “uncertain” category of TRIM, which is what was found here, indicates a non-significant trend, but it is not certain if change is less than 5% per year (i.e., the high end of the 95% confidence interval in this case is 6.9%).

Deer harvest data for Benton County in Arkansas (Table 2), obtained from the Arkansas Game and Fish Commission (2019; <https://www.agfc.com/en/hunting/big-game/deer/deer-harvest-reports/>) demonstrates survey results from this study roughly mirror deer hunter success in Benton County (Figure 1). Consistent deer harvest data is available only after the 2009-10 hunting season. However, for eight of the nine seasons of reported harvest data (2017-18 being the exception), the number of deer harvested increased or decreased similarly ($r = 0.6134$; $p = 0.08$) to increases and decreases seen in the number of deer within the visible area of Pea Ridge National Military Park.

The amount of visible area surveyed each year varied between 1.0 and 1.4 km² (coefficient of variation = 12.0%; Figure 2). The locations of individuals or groups of deer were mapped for the highest replicate count for that year (Figure 3).

Table 2. Deer harvest numbers for the 2009-10 through 2017-18 hunting seasons in Benton county, Arkansas, the county in which Pea Ridge National Military Park is located (<https://www.agfc.com/en/hunting/big-game/deer/deer-harvest-reports/>).

Hunting Season (Year)	Individuals Harvested by Sex			Total Individuals Harvested
	Antlered Buck	Button Buck	Doe	
2009-10	1576	236	1132	2944
2010-11	1712	266	1521	3499
2011-12	1844	269	1482	3595
2012-13	2185	310	2212	4707
2013-14	2090	311	1909	4310
2014-15	2120	294	1984	4398
2015-16	1771	257	1702	3730
2016-17	2366	345	1814	4525
2017-18	2403	320	1971	4694

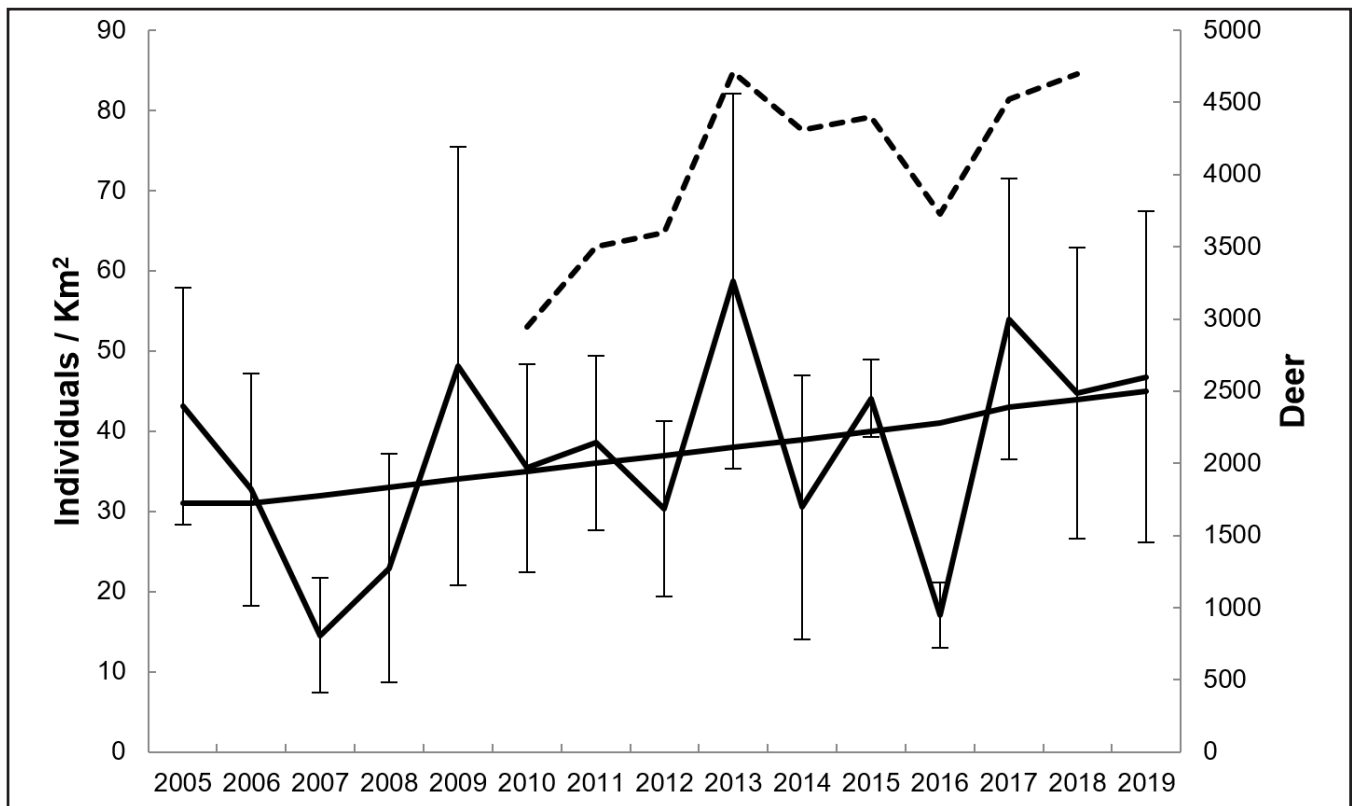


Figure 1. The adjusted counts of deer for years 2005 through 2019 at Pea Ridge National Military Park, Arkansas. The left axis shows adjusted count of deer (individuals/km² + 95% CI) and the right axis shows number of deer harvested in hunting seasons 2009-2010 through 2017-18 for Benton county, the county in which the park is located.

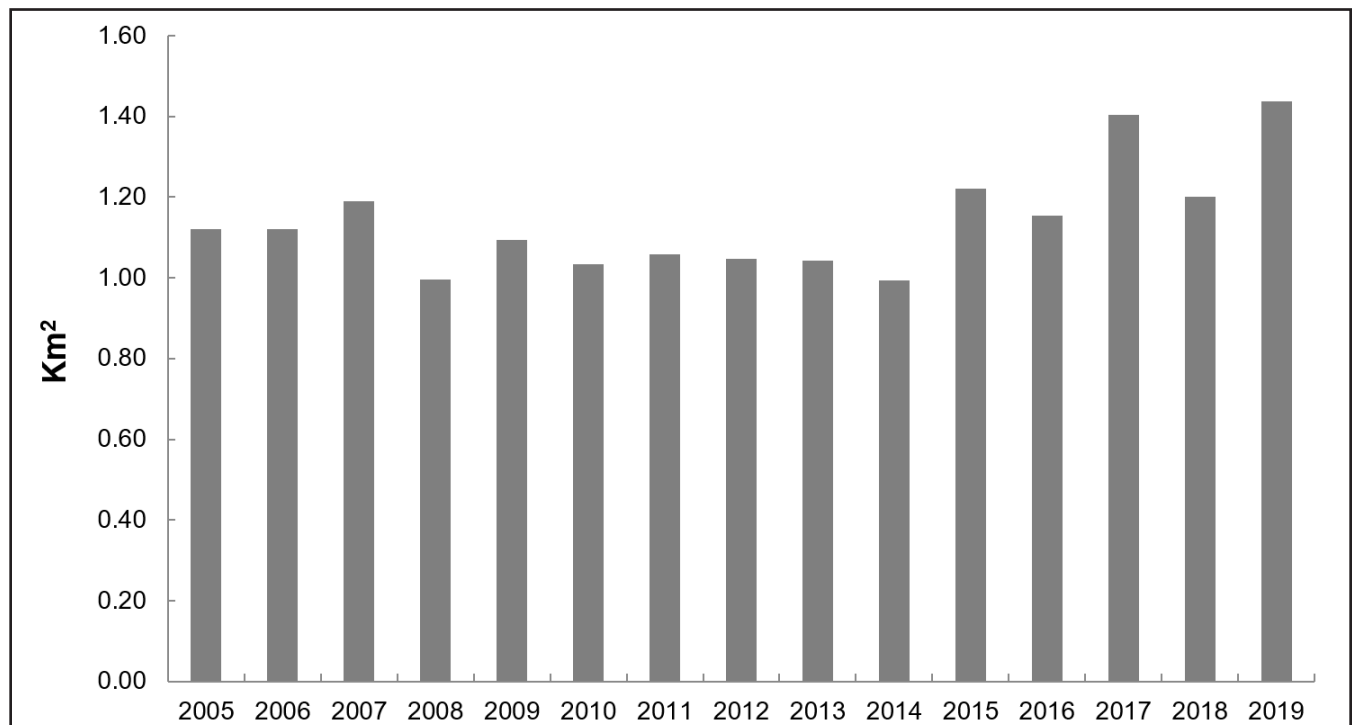


Figure 2. Visible area (km²) surveyed during annual white-tailed deer counts on Pea Ridge National Military Park, Arkansas, for years 2005 through 2019. Visible area in 2005 was determined from measurements taken during 2006 surveys and represents only an approximation of the area visible during surveys.

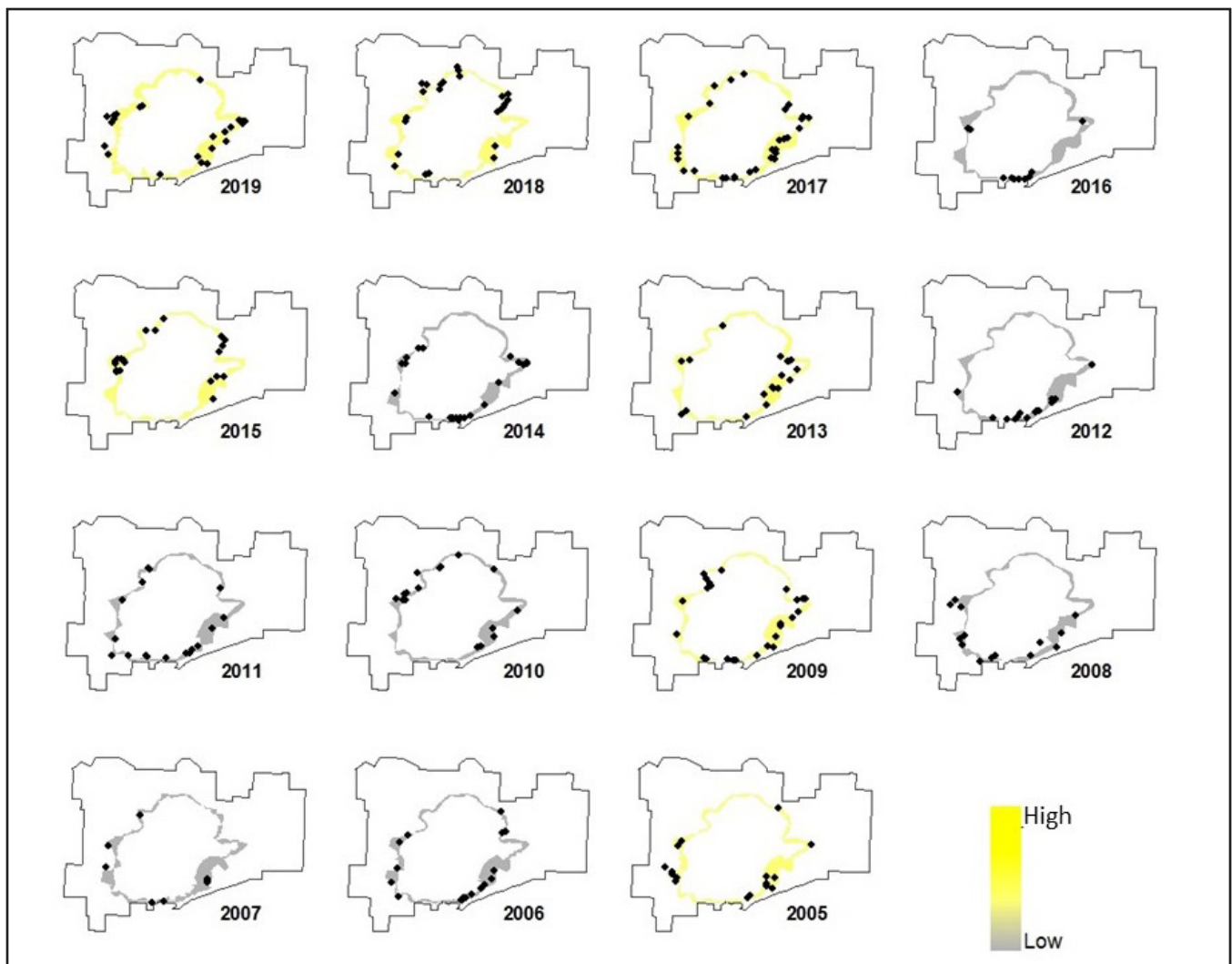


Figure 3. Color coded range (low to high) in the adjusted count of deer within the visible area of Pea Ridge National Military Park, Arkansas, during monitoring years 2005 through 2019, shown in reverse order (i.e. 2019 top left, 2005 bottom right). Visible area surveyed during annual counts is the extent of the colored area. Dots represent the locations where deer were recorded during the highest replicate count for that year.

Discussion

The survey design has evolved over the 15 years of monitoring, with adjustment to the sampling efforts (Table 1) being made to improve sampling efficiency, data quality, and post processing time. Sampling from 2017 to 2019 (four survey weeks) reflects our experiences with trying to survey as much of the winter survey window as possible while accounting for times when inclement weather will prohibit conducting surveys. An attempt to survey deer during a four-week winter period will be carried into the future. Although sampling effort has changed over the years, the actual method of spotlighting deer and the type of data collected has remained unchanged. By consistently conducting counts of deer in the visible area of Pea Ridge National Military Park, we can assess their status and long-term trends. Monitoring long-term trends in deer counts provides one measure for assessing their potential as a problem for the park.

Similar to the evolution of sampling efforts, over the years it was found that measuring visibility during two survey nights each year and combining the measurements produced the most accurate and robust estimate of visible area surveyed. An attempt to measure visible area twice each year and combine the measurements to create an estimate of visible area surveyed will continue in the future.

Across years, the adjusted counts of deer in the visible area on Pea Ridge National Military Park varied widely. The low number of deer recorded in 2007 came after a two-year regional hemorrhagic disease outbreak (Missouri Department of Conservation, personal communication, 2008; Cribbs and Peitz 2008). However, by 2013 (six years after the lowest reported numbers), the highest number of deer for Pea Ridge National Military Park was recorded, demonstrating the high reproductive potential of white-tailed deer in an unhunted population. Over the 15 years, no significant change in the population was observed, even with the effects of a hemorrhagic disease die-off between 2005 and 2007 and a sharp decline in 2016 from unknown causes.

The Pea Ridge National Military Park: Cultural Landscape Report and Environmental Assessment (NPS 2014) calls for the restoration of oak savanna and oak forest vegetation present at the time of the battle. Deer browsing may inhibit restoration of

the cultural landscape. A number of studies have demonstrated that habitat restoration efforts are negatively impacted as the number of deer increases (Crouch and Paulson 1968; Marquis 1981; Horsely and Marquis 1983; Michael 1992; Strole and Anderson 1992; Mladenoff and Stearns 1993; Healy 1997; McShea and Rappole 1997). Browsing of restored vegetation by deer may lead to an increase in exotic plant species invasions. If deer alter vegetation communities to favor exotic plant species, this will curtail the restoration of native plant communities and increase the overall cost of restoration efforts. Additional cost in both herbicides and manpower will be incurred to control the exotic species. The shift in species assemblages can also reduce plant diversity at a local level and cause changes in prairie and woodland community functions. Mortality of young tree seedlings caused by deer browsing can often be quite high (Crouch and Paulson 1968; Marquis 1981; Horsely and Marquis 1983; Tilgham 1989; Michael 1992; Strole and Anderson 1992; Mladenoff and Stearns 1993; Temblay et al. 2007). Recruitment of oak trees is central to the restoration of oak-savannah and oak-forest landscapes. Successful restoration of the cultural landscape on the park may need to be accompanied by successful control of deer on the park.

Trends in adjusted counts at Pea Ridge National Military Park mirror the success of deer hunters in Benton County (Figure 1). If hunters are harvesting an equal proportion of the deer population from year to year, this suggests that the number of deer, both within and outside the battlefield, are fluctuating similarly from year to year. In other words, deer populations appear to be regulated by factors other than hunting. Known factors that regulate the deer population in the park include disease (e.g., hemorrhagic disease die-off of 2005 to 2007, Cribbs and Peitz 2008; and a potentially unreported disease outbreak in 2016), and possibly road mortality from deer-vehicle collisions. If park managers desire to reduce the number of deer through culling, our results suggest a culling rate that exceeds regional hunting pressure may be required.

Allowing deer populations to increase until a disease event occurs is a poor management strategy. Increasing numbers expose deer, along with livestock and



White-tailed deer browsing in the forest at Pea Ridge National Military Park.

humans, to an increased risk of contracting a number of density-dependent diseases such as hemorrhagic disease (HD) and chronic wasting disease (CWD; University of Missouri Extension 2018, <https://extension2.missouri.edu/g9489>), among others. Hemorrhagic disease occurs in two different but closely related forms in Arkansas: epizootic hemorrhagic disease (EHD), and bluetongue (BTV). Hemorrhagic disease can result in the loss of 50 percent or more of a local or regional deer population annually, and persist for several years (Figure 1). EHD is not known to infect humans or domestic livestock, but domestic sheep may develop severe illness and die when infected with BTV. Similar to EHD, CWD is not seen as a human or domestic livestock health issue. However, once established, the disease spreads throughout a deer herd and is always fatal. CWD is transmitted by direct animal to animal contact or soil to animal contact and is nearly impossible to eradicate from a population. The culling of deer and the minimizing of unnatural concentrations of deer are the only methods currently available for managing the spread of CWD. A concern for human and domestic livestock health is tick-transmitted diseases (Lyme disease, ehrlichiosis, Rocky Mountain spotted fever, etc). Tick-borne diseases are generally not

fatal to deer but have devastating effects on humans. While deer don't transmit tick-borne diseases directly to humans, they serve as both a host species for the diseases and as a vector for spreading infected ticks.

Deer in and around the park also pose a serious safety issue relating to deer-vehicle collisions. Between 2005 and 2014, an estimated 19 animal-vehicle accidents occurred per year in Benton County, the county in which Pea Ridge National Military Park is located (Arkansas State Police 2019; <https://asp.arkansas.gov/services-and-programs/detail/highway-safety-office>). Although the Arkansas State Police reports do not separate out the type of animals involved in each collision it would be safe to assume that some involve deer. Monitoring by the Heartland Inventory and Monitoring Network suggests that the number of deer-vehicle collisions could be much higher than what is reported. In fact, for an eight-month reporting period (April–December 2016) on roads bordering Wilson's Creek National Battlefield, Missouri, 26 deer were observed dead either on the road or in the road right-of-way. On average only 1.25 deer-vehicle accidents are reported annually within one mile of the battlefield.

With 15 years of monitoring data for Pea Ridge National Military Park, we were able to capture both a disease outbreak and a rapid recovery in the deer population under study. The adjusted count of deer quadrupled between 2007 and 2013 following a two-year decline. Overall, the deer population increased at a moderate pace (not statistically significant), averaging 2.8% annually even though data from years

with declines (i.e. 2006–2007, and 2006) were included in the analysis. Increasing numbers of deer pose several problems for Pea Ridge National Military Park related to implementing their Cultural Landscape Report recommendations, mitigating domestic livestock and human health concerns, and decreasing costly deer-vehicle collisions on roads in and around the park.

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1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525