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

2005–2023 Trend Report



A white-tailed deer on Pea Ridge National Military Park.
NPS/HTLN

White-tailed deer monitoring at Pea Ridge National Military Park, Arkansas: 2005–2023 trend report

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Abstract

During 19 years (2005–2023) of monitoring trends in white-tailed deer populations 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 moderately at a rate of 3.2% annually ($P < 0.03$). The number of deer in the survey area ranged from 14.6 ±7.1 (mean ±95% CI) individuals/km^2 in 2007 to 62.6 ±19.1 individuals/km^2 in 2023. The amount of visible area surveyed each year varied between 1.0 and 1.4 km^2 (coefficient of variation = 11.0%).

Annual deer harvest data in the area near Pea Ridge National Military Park exhibit 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 adds a level of complexity to implementing the Pea Ridge National Military Park Cultural Landscape Report and Vegetation Management Plan recommendations to restore the oak savanna and oak forest vegetation present at the time of the battle. Deer deferentially browse native vegetation over exotic vegetation, which promotes 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 suggest, 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 eastern and midwestern 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 if 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, which concentrates 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 because of 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 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 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 that may carry Lyme disease (Connelly et al. 1987), a debilitating immune system disease transmitted to humans by tick bites. 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 populations 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 White-tailed Deer monitoring over a 19-year period on Pea Ridge National Military Park beginning in 2005.

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 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 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 changes 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). These are the deer that most impact herd size and park resources throughout the year. Therefore, the target population included all deer within the boundaries of the park at the time surveys were conducted (although the sample frame was limited to the road corridor).

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Following methods outlined in the Heartland Network white-tailed deer protocol (HTLN 2018), surveys were conducted from a survey vehicle moving no more than 16 km/hr using two 1,000,000-candlepower spotlights. All deer seen along the survey route were counted and their locations were recorded using GNSS. 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, for deer less than 10 m from the vehicle, by visual estimates. Deer were usually observed in groups, in which case distance was taken or estimated to the centermost 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. An attempt was made to complete three survey replicates each night. Replicates started one hour after official sunset and then each hour thereafter. Planned exceptions occurred in 2006 and 2007 when one replicate each night was completed and the first and third week of surveys in 2018 through 2023 when visibility estimates were taken during what would have been in most others years the third deer survey replicate (Table 1). Other exceptions occurred when large numbers of deer were encountered and only two survey replicates could be completed because of time constraints.

Table 1. Effort utilized to sample white-tailed deer on Pea Ridge National Military Park, Arkansas, from 2005 through 2023.

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–February 20	4	9	2	–
2020	January 7–January 28	4	8	2	–
2021	Surveys cancelled due to the covid 19 pandemic	–	–	–	–
2022	January 11–February 8	4	10	2	–
2023	January 10–February 6	4	8	2	–

* Visible area was determined from data collected in 2006.

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 (0.10 miles) 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 [0.05 miles] or 0.053 km [0.033 miles]). The location at each perpendicular measure was taken using GNSS technology. 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 GIS technologies, perpendicular distances were plotted on a map, a polygon was created, and the visible area was determined.

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:

$$AC = MC/VA$$

where AC = Adjusted Count (individuals/km^2), MC = Maximum Count for the survey night, and VA = Visible Area (km^2) 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 statistical package "rtrim" (built under R version 3.6.3) was used to evaluate trends in deer monitoring data. Rtrim is the R version of the statistical software package "TRIM," a program developed for the analysis of count data obtained from wildlife population monitoring (Pannekoek and Van Strien 2005). 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 habitats used by deer, the locations of individuals or groups observed during the highest count during the 2023 survey year were mapped.

Results

Adjusted counts of white-tailed deer numbers for the visible area on Pea Ridge National Military Park ranged from 14.6 ±7.1 (mean ±95% CI) individuals/km^2 in 2007 to 62.6 ±19.1 individuals/km^2 in 2023 (Figure 1). Using the rTRIM analysis on annual adjusted counts of deer over the 19-year sampling period, we found a moderately increasing trend (slope = 1.032, SE = 0.014, $P < 0.03$) in the number of deer. This trend equates to an overall increase of 3.2% in the adjusted count of deer annually.

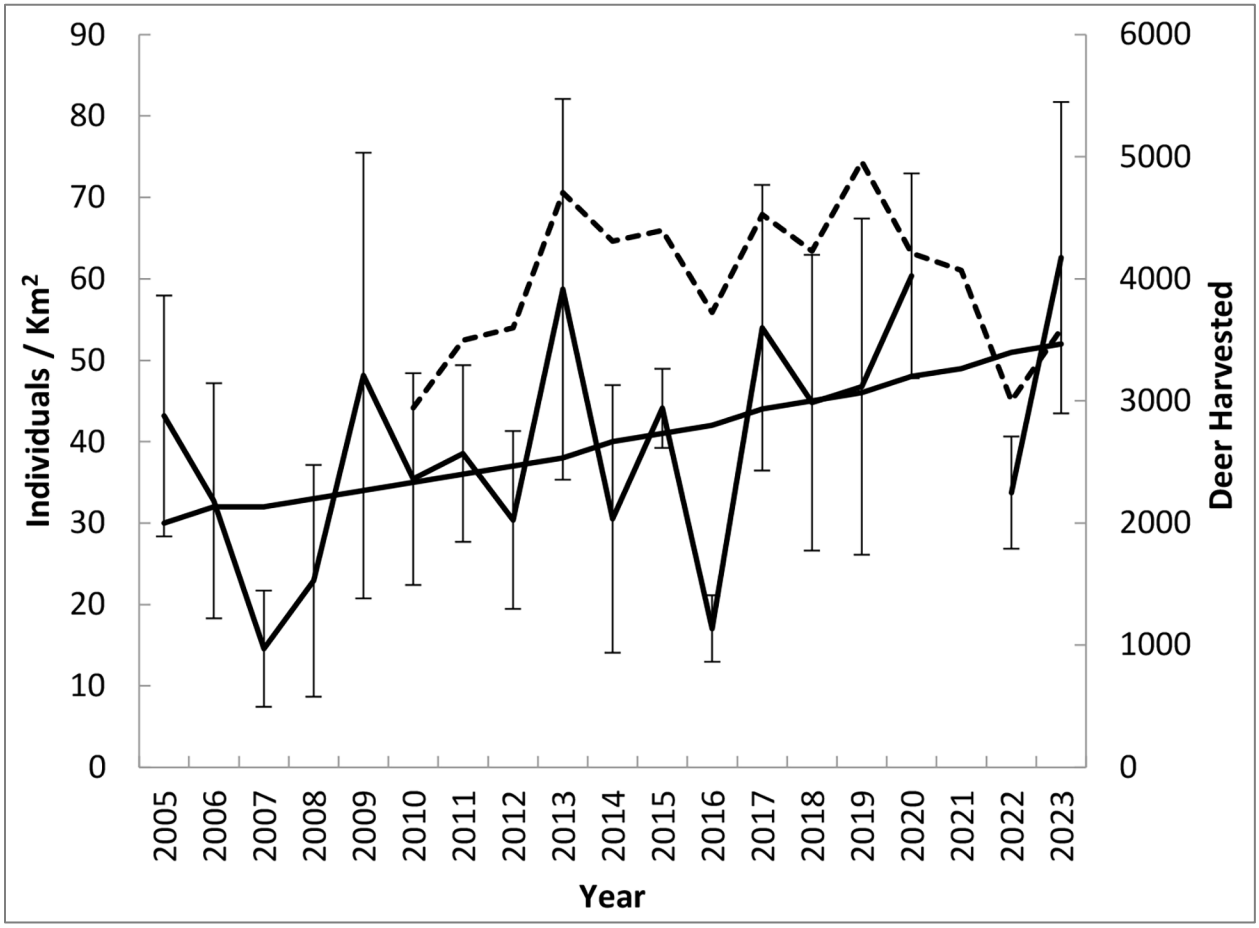


Figure 1. The adjusted counts of deer from 2005 through 2023 at Pea Ridge National Military Park, Arkansas. The left axis shows adjusted count of deer as individuals/km^2 (Solid line overlaid by a trend line), and the right axis shows number of deer harvested in Benton County, the county in which the park is located for the 2009–2010 through 2022–2023 hunting seasons (dashed line). Error bars represent 95% confidence intervals. Surveys were cancelled in 2021 due to the covid 19 global pandemic.

Deer harvest data for Benton County Arkansas (Table 2), obtained from the Arkansas Game and Fish Commission (2023; Arkansas deer harvest reports [https://www.agfc.com/en/hunting/big-game/deer/deer-harvest-reports/]) demonstrates survey results from this study were not significantly correlated with deer hunter success in Benton County (Figure 1). Consistent deer harvest data are

available only after the 2009–2010 hunting season. We were able to establish a correlation coefficient of $r = 0.432$ ($P = 0.14$) using the 14 years of comparisons between deer harvest information and adjusted numbers of deer seen within the visible area of Pea Ridge National Military Park.

Table 2. Deer harvest numbers for the 2009–2010 through 2022–2023 hunting seasons in Benton County Arkansas, where Pea Ridge National Military Park is located (deer harvest reports [https://www.agfc.com/en/hunting/big-game/deer/deer-harvest-reports/]).

Hunting Season (Year)	Total Individuals Harvested
2009–2010	2944
2010–2011	3497
2011–2012	3599
2012–2013	4707
2013–2014	4309
2014–2015	4398
2015–2016	3725
2016–2017	4525
2017–2018	4229
2018–2019	4960
2019–2020	4209
2020–2021	4069
2021–2022	3000
2022–2023	3588

The amount of visible area surveyed each year varied between 1.0 and 1.4 km^2 (coefficient of variation = 11.0%; Figure 2). The locations of individuals or groups of deer in the highest replicate count for the last survey year (2023) were mapped (Figure 3).

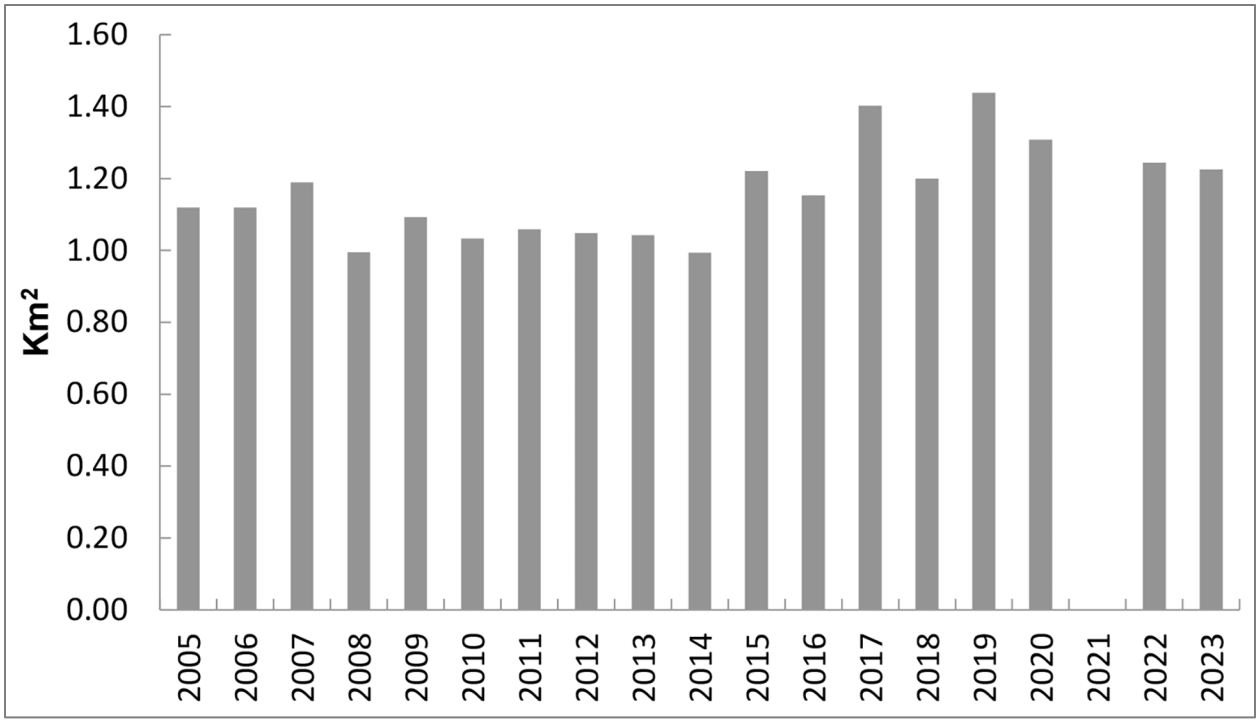


Figure 2. Visible area (km^2) surveyed during annual white-tailed deer counts on Pea Ridge National Military Park, Arkansas, for years 2005 through 2023. Visible area in 2005 was determined from measurements taken during 2006 surveys and represents only an approximation of the area visible during 2005 surveys. Surveys were cancelled in 2021 due to the covid 19 global pandemic.

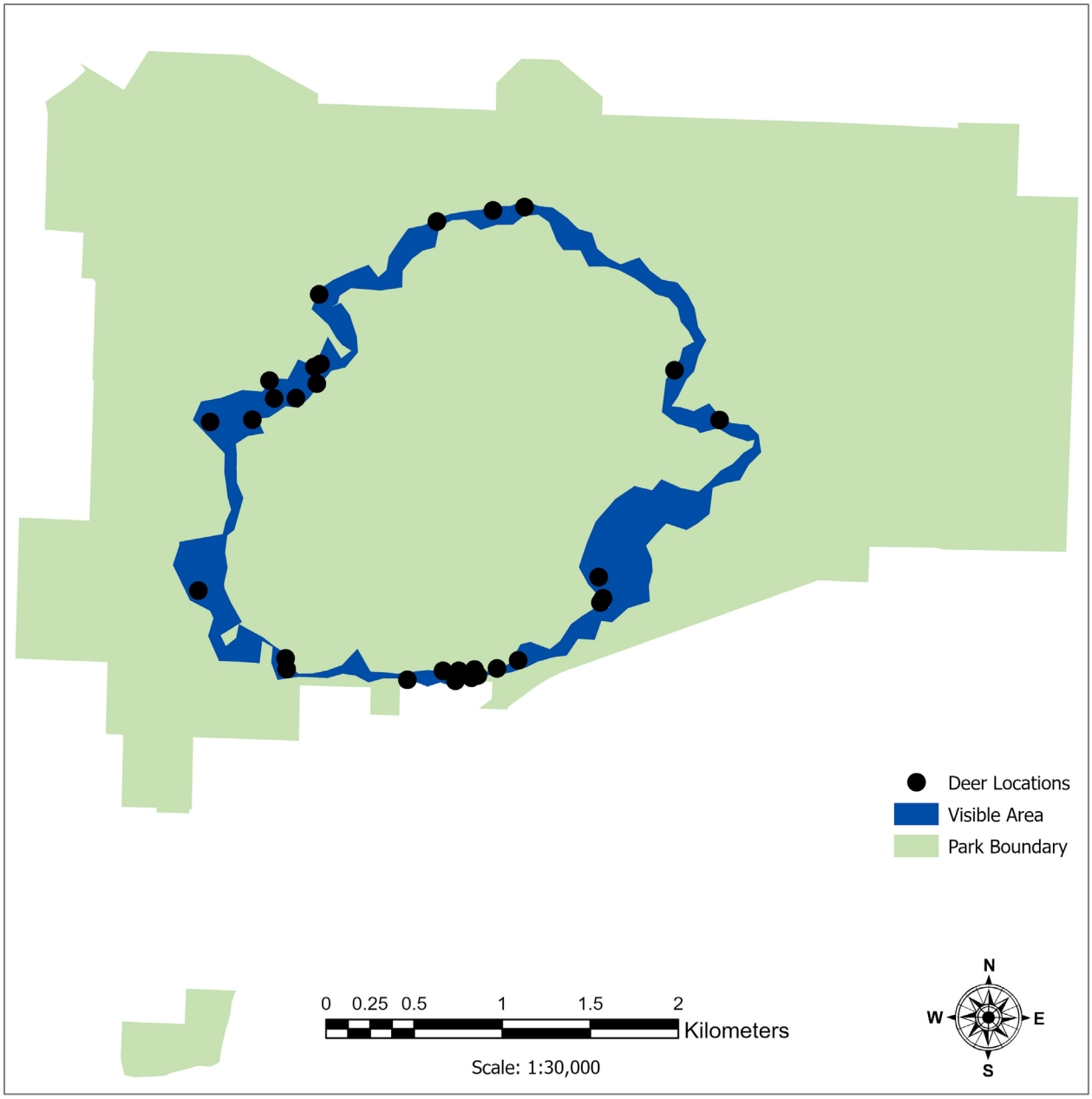


Figure 3. Representative map showing the visible area (km^2) surveyed on Pea Ridge National Military Park, Arkansas, during 2023 monitoring. Visible area is the extent of the dark blue colored area. Visible area surveyed during annual white-tailed deer counts for years 2005 through 2022 produced similar maps. Dots represent the locations where deer were recorded during the highest replicate counts in 2023.

Discussion

The survey design has evolved over the 19 years of monitoring, including adjustment of sampling efforts (Table 1) to improve sampling efficiency, data quality, and post processing time. Sampling from 2017 to 2023 (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. 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 the number of deer provides one measure for assessing their potential as a problem for the park. Similar to the evolution of sampling efforts, over the years we 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.

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, a moderate overall increase in annual numbers of deer seen was observed over the 19 years of monitoring, resulting in the highest number of deer recorded in 2023. This demonstrated the high reproductive potential of white-tailed deer in an unhunted population with a good supply of food available.

Pea Ridge National Military Park's Cultural Landscape Report and Environmental Assessment and Vegetation Management Plan and Environmental Assessment (NPS 2014a and 2014b) call 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. Several 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 costs 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 may need to be accompanied by successful control of deer on the park.

Trends in adjusted deer counts at Pea Ridge National Military Park loosely mirror (although not significantly) 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; potentially unreported disease outbreak in 2016), and possibly road mortality from deer-vehicle collisions. If park managers want 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 deer populations expose deer, along with livestock and humans, to an increased risk of contracting a number of density dependent diseases such as hemorrhagic disease and chronic wasting disease (University of Missouri Extension 2018) among others. Hemorrhagic disease occurs in two different but closely related forms in Arkansas: epizootic hemorrhagic disease and bluetongue. 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). Epizootic hemorrhagic disease is not known to infect humans or domestic livestock, but domestic sheep may develop severe illness and die when infected with bluetongue. Like epizootic hemorrhagic disease, chronic wasting disease 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. Chronic wasting disease 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 minimizing of unnatural concentrations of deer are the only methods currently available for managing the spread of chronic wasting disease. Another concern for human and domestic livestock health is disease spread by ticks (Lyme disease, ehrlichiosis, Rocky Mountain spotted fever, etc.). Tick-borne diseases are generally not fatal to deer but can 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 per year occurred in Benton County, where Pea Ridge National Military Park is located (Arkansas State Police 2019). Although the Arkansas State Police reports do not separate out the type of animal involved in each collision, it would be safe to assume that some involve deer. On average only 1.25 deer-vehicle accidents are reported annually within one mile of the Pea Ridge National Military Park. However, 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, at least 24 more than were likely reported. Additionally, the difference between reported and unreported deer-vehicle incidents is probably much greater than 24 given the short reporting period for the study at Wilson's Creek National Battlefield.

With 19 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, averaging 3.2% annually even though data from years with declines (i.e., 2006–2007 and 2016) were included in the analysis. Hunting success in the region loosely correlates to our annual population index suggesting that annual fluctuations in the number of deer, both within and outside the park, are driven by factors other than hunting. Increases in the deer population pose several problems for Pea Ridge National Military Park related to implementing their Cultural Landscape Report and Vegetation Management Plan 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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