



White-tailed Deer Monitoring at Arkansas Post National Memorial, Arkansas

2005–2020 Trend Report

Natural Resource Report NPS/HTLN/NRR—2021/2244





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ON THIS PAGE

White-tailed deer feeding in the Memorial Unit of Arkansas Post National Memorial, Arkansas.
Photography by NPS/Heartland Inventory and Monitoring Network

ON THE COVER

White-tailed deer in the Memorial Unit of Arkansas Post National Memorial, Arkansas.
Photography by NPS/Heartland Inventory and Monitoring Network

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David G. Peitz,¹ Naomi S. Reibold²

¹National Park Service
Heartland Inventory and Monitoring Network
Republic, MO

²American Conservation Experience/National Park Service
Heartland Inventory and Monitoring Network
Republic, MO

Editing and Design by
Tani Hubbard

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

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Executive Summary

From 16 years (2005–2020) of monitoring trends in white-tailed deer within a defined survey area of Arkansas Post National Memorial, we have been able to demonstrate both population declines and recoveries. The adjusted count of deer had a seven-fold increase between 2007 and 2011 following a two-year decline and a three-fold increase between 2017 and 2019 following a six-year decline. Overall, the deer population has declined slightly, averaging a 0.5% reduction in herd size annually. The number of deer in the survey area ranged from 16.77 ± 21.26 (mean + 95% CI) individuals/km² in 2007 to 118.95 ± 39.03 individuals/km² in 2011. The amount of visible area surveyed each year varied between 0.25 and 0.47 km² (coefficient of variation = 16.47%).

If the white-tailed deer population becomes too large, this poses several problems for Arkansas Post National Memorial. First, it adds a level of complexity to implementing active natural resource management critical to preventing the cultural landscapes of Arkansas Post National Memorial from changing into something that has little resemblance to the historical character of the park. 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 Arkansas Post National Memorial have the potential to increase if the deer populations grow.

Introduction

Since European settlement, white-tailed deer (*Odocoileus virginianus*) populations in North America have experienced enormous changes in size and distribution. 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 will experience high rates of population growth as long as food is available in these small blocks of patchy habitat. Grass and forb production are 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, 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



White-tailed deer at Arkansas Post National Memorial, Arkansas. NPS

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 density (>8 individuals/km²) 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 (Tilghman 1989; McShea and Rappole 1997; McGuinness 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; Tilghman 1989; McGuinness 1997). Browsing on young tree seedlings causes stunted growth and mortality (Michael 1992; Tilghman 1989; 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 or around Arkansas Post National Memorial, such as the Turk's-cap lily (*Lilium superbum*) 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, although this information is generally anecdotal in nature. A downside to large white-tailed deer populations in parks is that they can present a safety hazard to motorists and park visitors. Large 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 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 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 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 16 years of monitoring.

Objectives

The following are the primary objectives for monitoring white-tailed deer at Arkansas Post National Memorial, Arkansas.

- Determine annual changes in white-tailed deer numbers.

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

- Determine long-term trends in white-tailed deer numbers.

Justification: Understanding decadal trends in deer numbers 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 two main tour roads that traverse 3.42 km of the park. These permanent sampling routes were selected from all existing roads and trails within the park, including service roads, because they are easily traversed and pass through all major habitats found on the park. It is important for long-term monitoring that the survey routes are all-weather routes so that they will be passable shortly following inclement weather. Counting deer along road corridors 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 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 deer sampled at this time are the ones 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 road corridors).

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 Global Navigation Satellite System (GNSS) technologies. 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

range-finder or by visual estimates for deer less than 10 m from the vehicle. Deer were usually observed in groups, in which case distance was taken or estimated 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.

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 through 2020 when visibility estimates were taken during what would have been in most other years the third deer survey replicate (Table 1). The latter surveying schedule will be carried into the future (HTLN 2018).

Visibility Estimates

Determining the area surveyed for white-tailed deer is critical for obtaining an adjusted count of deer numbers 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 rounds of measures were made, survey points were distributed evenly around the tour roads (i.e. 0.08 km [1/20th mile] or 0.053 km [1/30th mile]). The location at each perpendicular measure was taken using 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 Arkansas Post National Memorial, Arkansas, for years 2005 through 2020.

Year	Survey Dates	Survey Nights	Survey Replicates	Visibility Replicates	Notes
2005	March 28–March 30	3	9	0*	Deer locations and distances were measured perpendicular to the survey vehicle.
2006	January 3–January 5	3	8	3	–
2007	February 20–February 22	3	3	3	–
2008	January 7–February 4	4	12	1	–
2009	January 5–February 9	5	15	1	–
2010	January 11–February 4	4	12	1	–
2011	January 3–February 7	5	15	1	–
2012	January 3–February 6	6	18	1	–
2013	January 7–February 5	5	15	1	–
2014	January 13–February 24	5	15	1	–
2015	January 5–February 9	6	18	1	–
2016	January 4–February 8	6	18	1	–
2017	January 9–January 30	4	12	1	–
2018	January 8–February 12	4	10	2	–
2019	January 29–February 19	4	10	2	–
2020	January 6–January 27	4	10	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 Arkansas 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

Over the 16-year data record, adjusted counts of white-tailed deer on Arkansas Post National Memorial ranged from 16.77 ± 21.26 (mean + 95% CI) individuals/km² in 2007 to 118.95 ± 39.03 individuals/km² in 2011. The adjusted count of deer had a seven-fold increase between 2007 and 2011 following a two-year decline and a three-fold increase between 2017 and 2019 following a six-year decline. Over the entire data record, an uncertain trend (slope = -1.005, SE = 0.05, $p = 0.93$, 95% confidence interval = 0.907 to 1.104) in the adjusted counts of deer was found. This trend equates to an overall decline in adjusted counts of 0.5% annually, with a 95% confidence interval of -9.3% to 10.4%. 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: 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, an “uncertain” category, which is what was found here, that indicates a non-significant trend but it is not certain if change

is less than 5% per year (i.e., the low and high ends of the 95% confidence interval in this case are -9.3% and 10.4%, respectively).

Deer harvest data for Arkansas County in Arkansas are available starting with the 2009–10 hunting season (Table 2; Arkansas Game and Fish Commission 2020). For eight of the ten seasons of reported harvest data (2011–12 and 2017–18 being the exceptions), the number of deer harvested in the county either increased or decreased similarly to increases and decreases in the number of deer within the visible area of Arkansas Post National Memorial (Figure 1). Although the direction of change was usually the same, the relative magnitudes of the increases and decreases between the two variables were not always similar; overall, there was no significant association ($r = -0.33$; $P = 0.36$).

The amount of visible area surveyed each year varied between 0.25 and 0.47 km² (coefficient of variation = 16.47%; Figure 2). The locations of individuals or groups of deer in the park were mapped for the highest replicate count for that year (Figure 3).

Table 2. Deer harvest numbers for the 2009–10 through 2018–19 hunting seasons in Arkansas County, Arkansas, the county in which Arkansas Post National Memorial is located ([deer harvest data are available at https://www.agfc.com/en/hunting/big-game/deer/deer-harvest-reports/](https://www.agfc.com/en/hunting/big-game/deer/deer-harvest-reports/)).

Hunting Season	Individuals Harvested by Sex			Total Individuals Harvested Each Year
	Antlered Buck	Button Buck	Doe	
2009–10	1795	196	1328	3319
2010–11	2015	216	1755	3986
2011–12	2083	233	2135	4451
2012–13	2163	202	2008	4373
2013–14	2501	268	2744	5513
2014–15	2136	226	2261	4623
2015–16	2206	211	2135	4552
2016–17	1699	156	1410	3265
2017–18	1296	116	1248	2660
2018–19	na	na	na	3211

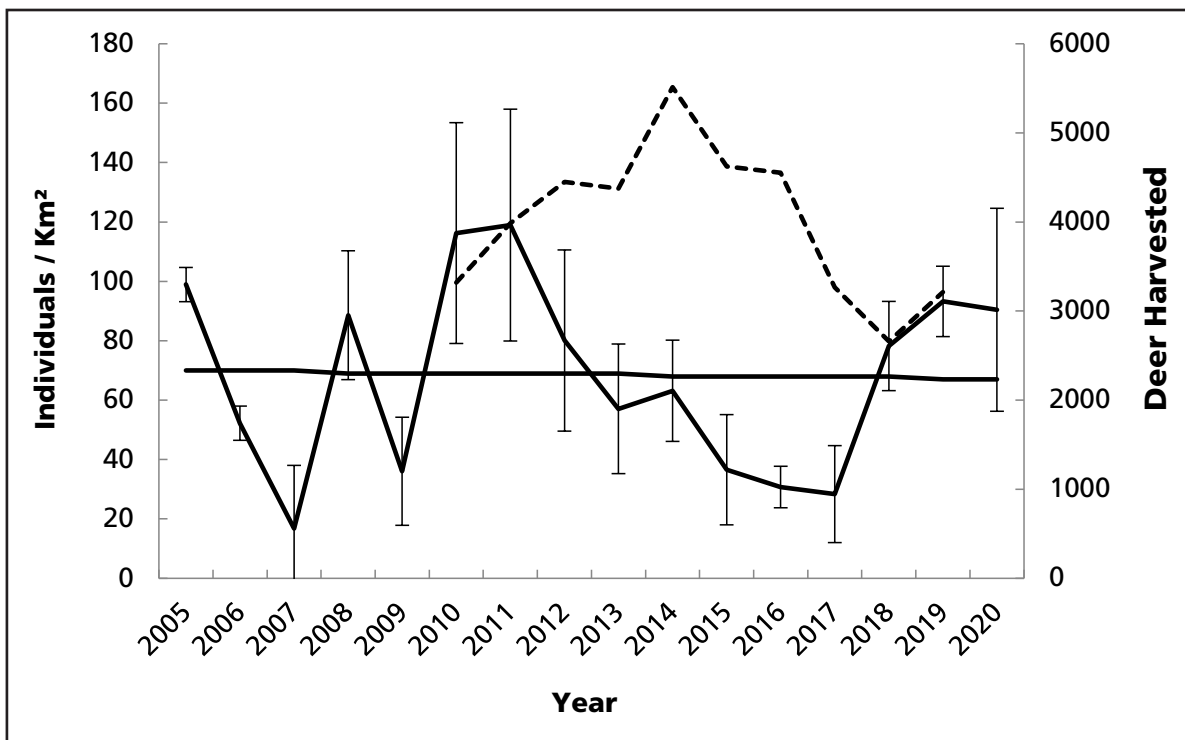


Figure 1. Adjusted counts of deer (solid line, left axis, error bars indicate 95% CI) for years 2005 through 2020 at Arkansas Post National Memorial, Arkansas, and number of deer harvested (dashed line, right axis) in hunting seasons 2009–2010 through 2018–19 for Arkansas County, the county in which the park is located.

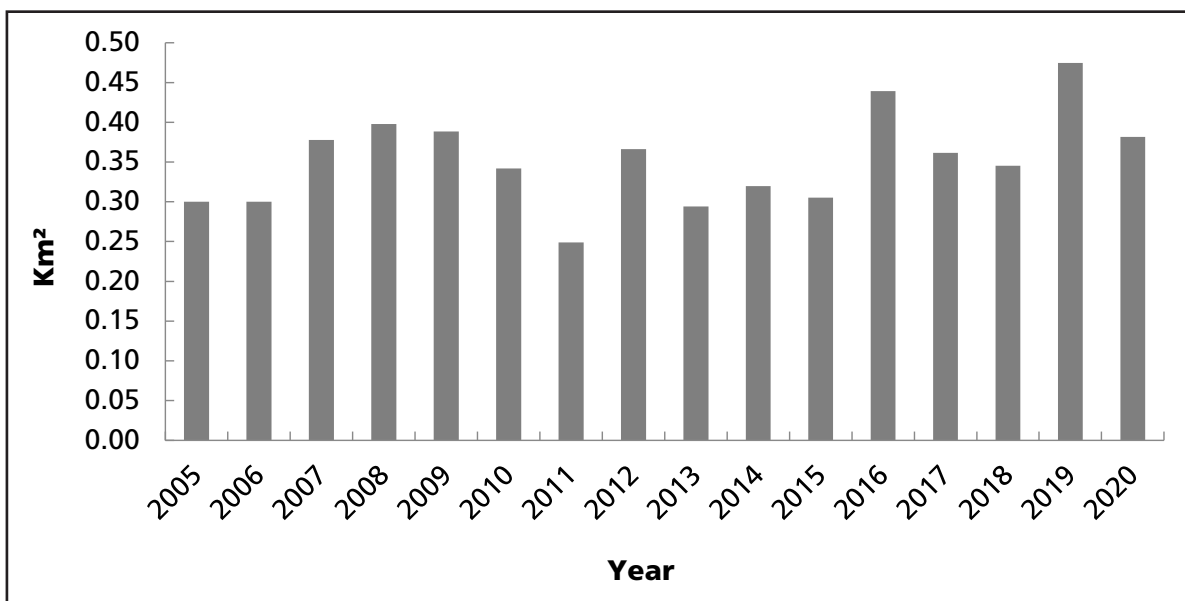


Figure 2. Visible area (km²) surveyed during annual white-tailed deer counts on Arkansas Post National Memorial, Arkansas, for years 2005 through 2020. Visible area in 2005 was determined from measurements taken during 2006 surveys and represents only an approximation of the area visible during surveys.

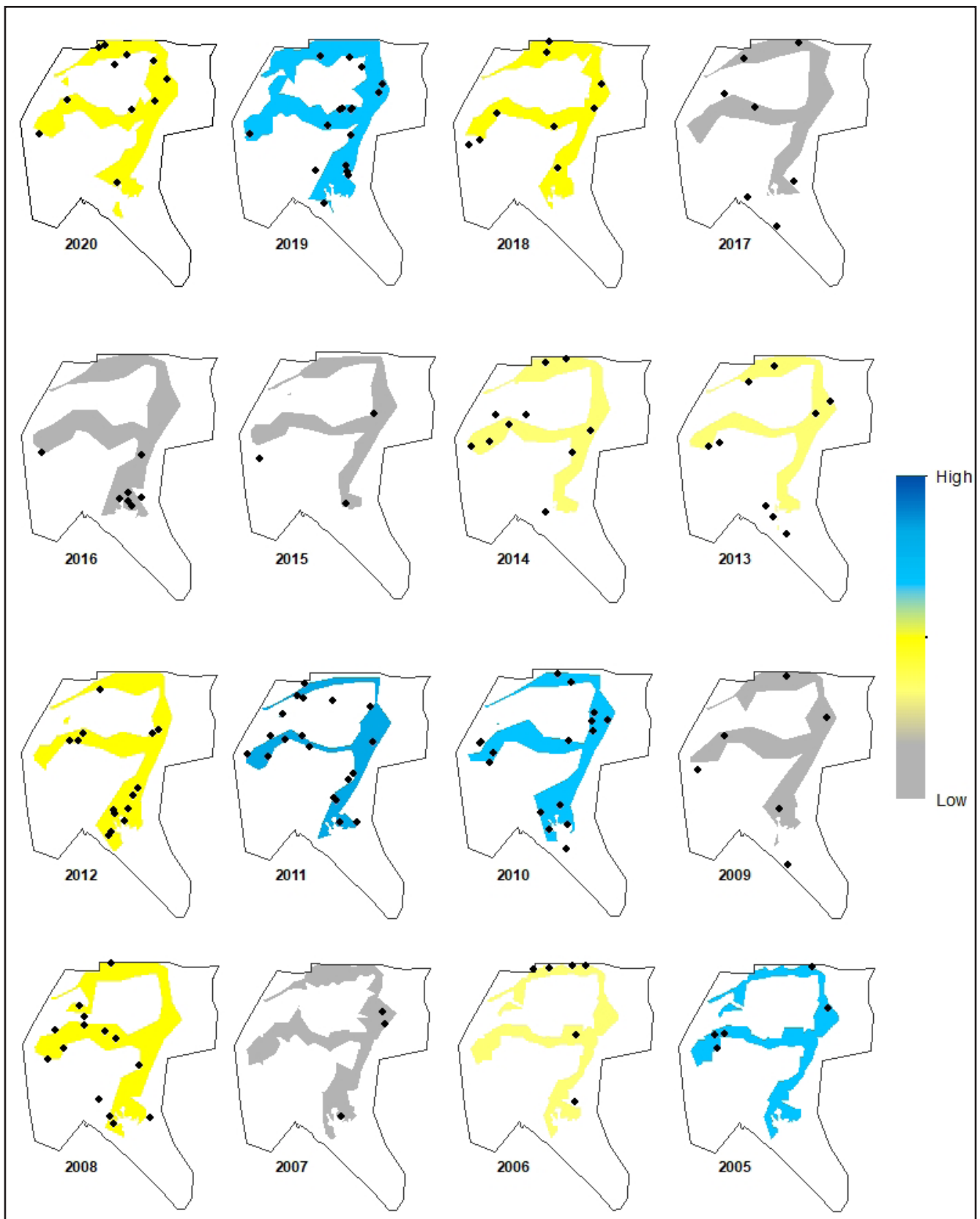


Figure 3. Color coded range (low to high) in the adjusted count of deer within the visible area of Arkansas Post National Memorial, Arkansas, during monitoring years 2005 through 2020, shown in reverse order (i.e. 2020 top left, 2005 bottom right). Visible area surveyed during annual counts is the extent of the colored area. Dots represent the locations where deer on the park were recorded during the highest replicate count for that year.

Discussion

The survey design has evolved over the 16 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 2020 (four survey weeks) reflects our experience with trying to survey as much of the winter survey window as possible while accounting for times when inclement weather prohibits 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 Arkansas Post National Memorial, 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 it was found that measuring visibility during two survey nights each year and combining the measurements produced a more precise 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 Arkansas Post National Memorial varied widely. The lowest number of deer recorded (year 2007) came after a two-year regional hemorrhagic disease outbreak (personal communication with Missouri Department of Conservation staff, 2008; Cribbs and Peitz 2008). However, by 2011 (four years after the lowest reported numbers) the highest number of deer for Arkansas Post National Memorial was recorded, demonstrating the high reproductive potential of white-tailed deer in an unhunted population. Over the 16 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 protracted decline between 2011 and 2017 from unknown causes. Since 2017, deer numbers have rebounded substantially.

Although no specific recommendations were made for the management and/or restoration of the cultural landscape of the park (NPS 2005), cultural landscape

management is something that should be considered. Without active management, the landscapes will continue to evolve into something that has little resemblance to the historical character of the park. However, a number of studies have demonstrated that habitat restoration efforts, especially of forested habitat, are negatively impacted as deer populations increase (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), indicating deer browsing may inhibit management of the cultural landscape at Arkansas Post National Memorial. For example, maintaining the large sprawling oaks of various species into the future requires the establishment of replacement trees now. Yet, 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-forest landscapes and the large sprawling trees characteristic to Arkansas Post National Memorial. One of the priority natural resource management activities currently underway on the park is exotic plant species control. Deer browsing of vegetation (mostly native species) can lead to increases in exotic plant species (NPS 2005; Young et al 2012). If deer alter vegetation communities to favor invasive plant species, this will curtail the restoration of native plant communities and increase the overall cost of restoration efforts, including larger costs for herbicides and manpower to control invasive species. The shift in species assemblages can also reduce plant diversity at a local level and cause changes in the current plant community functions. Successful restoration of the cultural landscape on the park may need to be accompanied by successful control of deer on the park.

Although the direction of year-to-year change in adjusted deer counts at Arkansas Post National Memorial was the same as that of the deer harvested in Arkansas County in eight of ten years, overall the two variables are seen to diverge and then converge (Figure 1). If hunters harvest an equal proportion of the deer population from year to year, and the

number of deer both within and outside the park fluctuate similarly from year to year, this would suggest that deer populations are regulated by factors other than hunting. Based on the observed pattern, however, the effect of hunting is equivocal. 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), poaching (personal communication with Arkansas Post National Memorial staff, 2020), and possibly road mortality from deer-vehicle collisions.

Allowing deer populations to increase until a disease event occurs is a poor management strategy. Increasing numbers expose deer, along with livestock and 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](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. Another 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 1.6 animal-vehicle accidents per year occurred in Arkansas County, the county in which Arkansas Post National Memorial is located (Arkansas State Police 2020). 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. However, on average only 1.25 deer-vehicle accidents are reported annually within one mile of the Battlefield ([State of Missouri STARS Reporting 2018, https://www.mshp.dps.missouri.gov/TR15Map/index.jsp](https://www.mshp.dps.missouri.gov/TR15Map/index.jsp)). Deer-vehicle collisions in and around Arkansas Post National Memorial have the potential to increase if the deer populations grow.

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