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Natural Resource Stewardship and Science

White-tailed Deer Monitoring at Wilson's Creek National Battlefield, Missouri

2005–2018 Trend Report

Natural Resource Report NPS/HTLN/NRR—2018/1703

ON THE COVER
A white-tailed deer on Wilson's Creek National Battlefield, Missouri
Photography by NPS/Heartland Inventory and Monitoring Network

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Abstract

During 14 years (2005 – 2018) of white-tailed deer monitoring within a defined survey area of Wilson's Creek National Battlefield, we observed both a rapid decline and recovery. The rapid die-off 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 the park was initiated. Even including data in the analysis from years when the die-off was occurring (2006 and 2007), the number of deer still increased on average 10.5% annually. Deer counts in the survey area ranged from a low of 14.9 + 10.1 (mean + 95% CI) individuals/km^2 in 2007 to a high of 167.2 + 57.4 individuals/km^2 in 2016. The amount of visible area surveyed each year varied between 0.6 and 1.1 km^2 (coefficient of variation = 14.1%).

Annual deer harvest data in the area nearby Wilson's Creek National Battlefield exhibit similar trends to our annual adjusted counts. This suggests that factors other than hunting are driving annual changes in the size of deer populations. An increasing number of deer poses several problems for the park. First, this trend will add a level of complexity to implementing Wilson's Creek National Battlefield Cultural Landscape Report recommendations. Deer deferentially browse native vegetation over exotic vegetation, thus promoting the spread of exotic species. The success of tree planting can be curtailed by heavy deer browsing as well. Second, controlling deer related disease, some of which can affect domestic livestock and human health in and around the park, becomes more and more difficult as the number of deer increases. Third, as additional ancillary data suggest, the largely unreported and costly deer-vehicle collisions in and around the park have the potential to rise with an increasing deer population.

Introduction

Since European settlement, white-tailed deer (*Odocoileus virginianus*) populations in North America have experienced enormous changes in size and distribution. Once 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 agriculture 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. Therefore, 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, thereby concentrating deer in available habitat in another area (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. However, the influence of deer on the status of most rare and sensitive plant species, such

White-tailed deer at Wilson's Creek National Battlefield. NPS

as the Missouri bladderpod (*Lesquerella filiformis*) found on Wilson's Creek National Battlefield, is largely unknown. Many studies have shown that deer can have a negative effect on developing forestland (Crouch and Paulson 1968; Horsely and Marquis 1983; Marquis 1981). 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).

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. However, this information is generally anecdotal in nature. White-tailed deer can present a safety hazard to motorist and park visitors when populations are high. High deer populations have the potential to increase the number of deer-vehicle collisions and the resulting 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). Lyme disease is 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 determine if control measures are necessary to protect other park resources and improve visitor safety.

It is against a backdrop of urban sprawl, altered ecosystems and concerns over visitor safety on National Park Service lands that we proposed monitoring white-tailed deer populations to assess their status and trends. Long-term trends in the number of deer provides 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 correlations with changes in vegetation (e.g., through 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. Monitoring data also help managers assess safety risks from collisions and disease transmission. In this report, we summarize results from 14 years of monitoring white-tailed deer at the park.

Objectives

The primary objectives for monitoring white-tailed deer at Wilson's Creek National Battlefield, Missouri are

- To 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.*

- To 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.*

- To 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.*

Method

Study Area

Deer surveys were limited to an area visible at night with spotlights along the main tour road that makes a 7.90 km loop through Wilson's Creek National Battlefield. 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 will yield an adjusted count 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 population 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/ km^2 of visible area, allow evaluation of annual change in addition to long-term trends.

White-tailed deer buck at Wilson's Creek National Battlefield. Image captured with a remote camera. NPS

White-tailed Deer Survey Methods

Sampling was limited to winter months, before spring vegetation emerged (January through mid-March). Therefore, the target population included all deer within the boundaries of Wilson's Creek National Battlefield at the time surveys were conducted (although the sample frame was limited to the road corridor). These are the deer that most impact herd size and park resources throughout the year.

Surveys were conducted from a survey vehicle moving no more than 16 km/hr using two 1,000,000 candlepower spotlights. We counted all deer seen along the survey route and recorded their locations using GPS. Two observers counted deer, 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 recorded using a rangefinder or a visual estimate if the deer was 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, exceptions being 2006 and 2007 when one replicate each night was completed and the first and third week of surveys in 2018 when visibility estimates were taken during what would have been the third deer survey replicate in most other years (Table 1). Replicates started one hour after official sunset and then each hour thereafter.

Visibility Estimates

Determining the area surveyed for white-tailed deer is critical for obtaining an adjusted count of deer in the survey area. For most years, visibility was measured every 0.16 km ($1/10^{th}$ 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 [$1/20^{th}$ mile] or 0.053 km [$1/30^{th}$ mile]). The location where each perpendicular measure was taken was marked using GNSS technologies. In an attempt to get a more robust picture of how much area we were surveying 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

Table 1. Effort utilized to sample white-tailed deer on Wilson's Creek National Battlefield, Missouri (2005–2018).

Year	Survey Dates	Survey Nights	Survey Replicates	Visibility Replicates	Notes
2005	March 2 – March 4	3	8	0*	Deer locations and distances were measured perpendicular to the survey vehicle.
2006	January 11 – January 13	3	3	3	–
2007	February 13 – February 15	3	3	3	–
2008	January 3 – February 7	5	15	1	–
2009	January 8 – February 12	5	15	1	–
2010	January 5 – February 11	6	16	1	–
2011	January 6 – February 10	6	18	1	–
2012	January 5 – February 9	6	18	1	–
2013	January 3 – February 7	6	18	1	–
2014	January 9 – February 13	6	18	1	–
2015	January 8 – February 12	6	18	1	–
2016	January 7 - February 11	6	18	1	–
2017	January 12 – February 2	4	11	1	–
2018	January 10 – February 1	4	10	2	–

* Visible area was determined from data collected in 2006.

example, if the view of an open field was blocked by a single cedar tree in the ditch next to the survey vehicle, we moved the vehicle 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:

$$AC = MC/VA$$

AC = Adjusted Count (individuals/km^2)

MC = Maximum Count for the survey night

VA = Visible Area (km^2) determined for the current year

We calculated an annual mean adjusted count of deer 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 andVan 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. To visually assess changes in habitat use by deer, we mapped the location of individuals or groups observed during the highest count each year.

Results

Adjusted counts of white-tailed deer for the visible area on Wilson's Creek National Battlefield ranged from 14.9 + 10.1 (mean + 95% CI) individuals/km^2 in 2007 to 167.2 + 57.4 individuals/km^2 in 2016. Using TRIM, an upward trend (slope = 1.105, SE = 0.046) in the adjusted deer counts was established, and demonstrated a moderate increase ($p < 0.05$) over the 14-year interval. This trend equates to an overall increase in adjusted counts of 10.5% annually. However, excluding the first two years of data when the population was in a sharp decline, the annual percentage increase is 14.6%. Conversely, if only the last three years of data are analyzed (2016 – 2018), there was a significant 32.1% annual decrease.

Deer harvest data for Christian and Greene counties in Missouri (Table 2; Missouri Department of Conservation 2018) demonstrate survey results from this study mirror deer hunter success in Christian and Greene counties (Figure 1). Consistent deer harvest data are only available after the 2011/12 hunting season. For all seven years of reported harvest data, the number of deer harvested increased or decreased similarly to increases and decreases seen in the number of deer within the visible area of Wilson's Creek National Battlefield.

The amount of visible area surveyed each year varied between 0.6 and 1.1 km^2 (coefficient of variation = 14.1%; 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 2011-12 through 2017-18 hunting seasons for Christian and Greene counties in Missouri, the counties in which Wilson's Creek National Battlefield is located (https://huntfish.mdc.mo.gov/hunting-trapping/species/deer/deer-harvest-reports/deer-harvest-summaries).

Hunting Season (Year)	Individuals harvested in Christian County	Individuals harvested in Greene County	Total individuals harvested
2011-12	1773	2353	4126
2012-13	1995	2599	4594
2013-14	1856	2425	4281
2014-15	1779	2693	4472
2015-16	2170	2849	5019
2016-17	2178	2575	4753
2017-18	2309	2899	5208

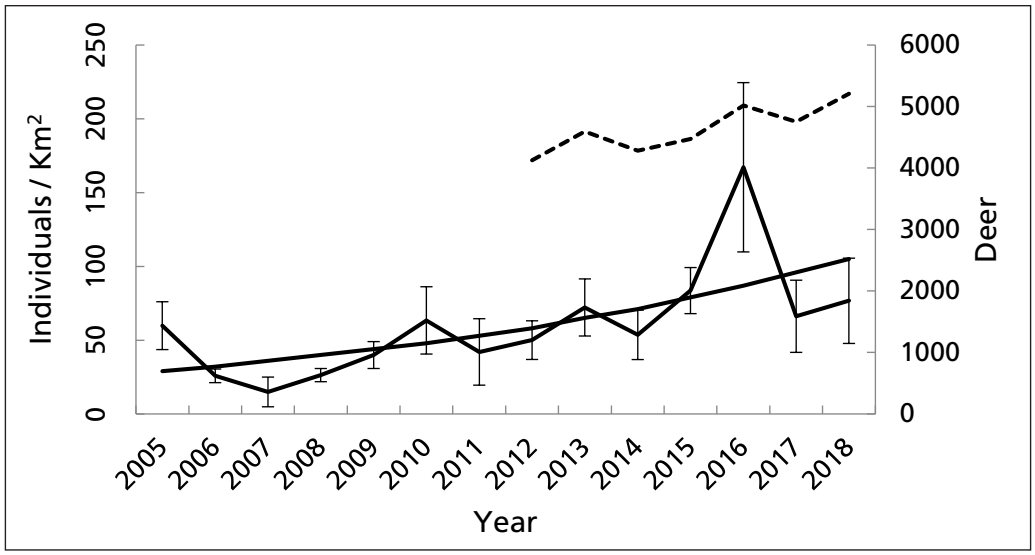

Figure 1. Adjusted count of deer (2005 through 2018) at Wilson's Creek National Battlefield, Missouri. Left axis shows adjusted count of deer (individuals/km^2, + 95% CI) and right axis shows number of deer harvested in hunting seasons 2011-12 through 2017-18 for Christian and Greene counties, the counties in which the park is located.

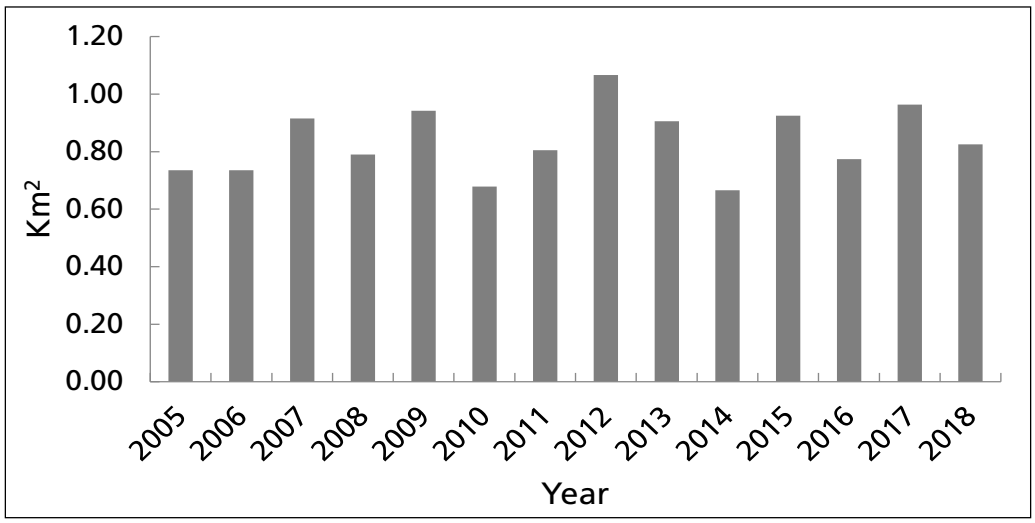

Figure 2. Visible area (km^2) surveyed during annual white-tailed deer counts on Wilson's Creek National Battlefield, Missouri for years 2005 – 2018. Visible area in 2005 was determined from measurements taken during 2006 surveys so represents only an approximation of the area visible during surveys.

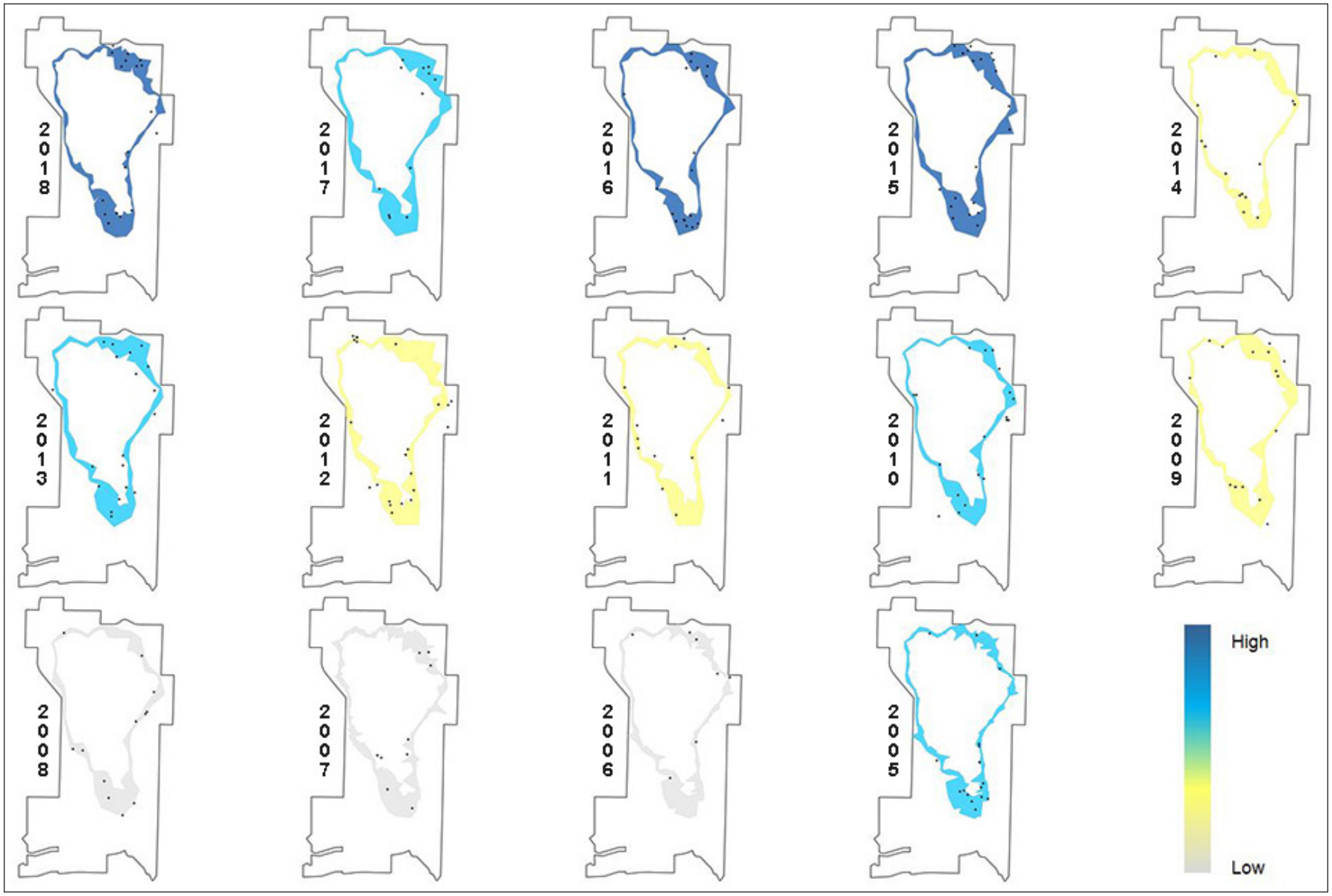

Figure 3. Range in the adjusted count of deer color-coded from relatively low (gray) to high (dark blue) over 14 years of monitoring (2005–2018) at Wilson's Creek National Battlefield, Missouri. Visible area surveyed during annual counts is the extent of the colored area. Dots represent the locations where individual or groups of deer were recorded during the highest replicate count for that year.

Discussion

Over the 14 years of monitoring, the survey design has evolved. Adjustments to the sampling efforts (Table 1) were made to improve sampling efficiency, data quality, and post processing time. Sampling in 2017 and 2018 (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 would prohibit conducting surveys. An attempt to survey deer during a four-week winter period will be carried into the future. Although sampling efforts have changed over the years, the actual method of spotlighting deer and the data collected have remained unchanged. By consistently conducting counts of deer in the visible area of Wilson's Creek National Battlefield, we can assess their status and long-term trends. Long-term trends in the number of deer provide 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 be carried into the future.

Across years, the adjusted counts of deer in the visible area on the park varied widely. The low number of deer recorded in 2007 came after a two-year hemorrhagic disease outbreak (Missouri Department of Conservation, personal communication 2008; Cribbs and Peitz 2008). However, by 2016 (nine years after the lowest reported numbers), the highest number of deer for the park was recorded, demonstrating the high reproductive potential of white-tailed deer in an un-hunted population. Overall, a moderate increase in the population of 10.5% annually was observed even with the effects of a hemorrhagic disease die-off between 2005 and 2007, and a sharp decline between 2016 and 2017 from unknown causes.

The Wilson's Creek National Battlefield Environmental Assessment and Cultural Landscape Report Implementation (NPS 2018) calls for the restoration of oak savanna 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 the functioning of prairie and woodland communities not intended with the restoration efforts. Mortality of young tree seedlings caused by deer browsing can often be quite high (Crouch and Paulson 1968; Horsely and Marquis 1983; Marquis 1981; 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 the oak-savannah landscape. Successful restoration of the cultural landscape at Wilson's Creek National Battlefield may need to be accompanied by successful control of deer on the park.

Trends in adjusted deer counts at the park mirror the success of deer hunters in Christian and Greene counties (Figure 1). If hunters are harvesting an equal proportion of the deer population from year to year, this suggests that numbers 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 – 2007 [Cribbs and Peitz 2008]; potentially unreported disease outbreak in 2016), and possibly road mortality from deer-vehicle collisions. If park managers choose to reduce the number of deer through culling, our results suggest a culling rate that exceeds regional hunting pressure may be required.

Allowing the number of deer to increase until a disease event occurs is a poor management strategy. Increasing populations expose deer, along

White-tailed deer browsing along a forest edge. NPS

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 Missouri, 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). Epizootic hemorrhagic disease is not known to infect humans or domestic livestock. In contrast, domestic sheep may develop severe illness and die when infected with BTV.

Similar to EHD, 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 the minimizing of unnatural concentrations of deer are the only methods currently available for managing the spread of this disease.

Another concern for human and domestic livestock health are any one of the numerous 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 due to deer-vehicle collisions. Since 2002, law enforcement agencies in the state of Missouri have been required to submit traffic accident reports to the Statewide Traffic Accident Records System (STARS) for accidents resulting in injury to or death of a person, or total property damage in excess of $500.00. Combined deer-vehicle collisions reported for Christian and Greene county averaged 68.17 incidents annually (coefficient of variation = 13.97), between 2005 and 2016 (Missouri State Highway Patrol 2018). Between 2005 and 2016, 15 (average 1.25 per year) accidents involving animal collisions were recorded within a mile of the park boundary, of which 12 incidents involved deer. No accident resulted in a human fatality. Monitoring by the Heartland Inventory and Monitoring Network suggests that the number of deer-vehicle collisions around the periphery of the park could be higher. In fact, for the last eight months of the reporting period (April – December 2016), 26 deer were observed dead either on the road or in the road right-of-way.

Conclusions

With 14 years of monitoring data for Wilson's Creek National Battlefield, 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 2010 following a two-year decline. Overall, the deer population increased at a moderate pace, averaging 10.5% annually when data from years with declines (i.e. 2006–2007 and 2016) were included in the analysis. The number of deer in the survey area ranged from a low of 14.9 + 10.1 individuals/km^2 in 2007 to a high of 167.2 + 57.4 individuals/km^2 in 2016.

The amount of visible area that was surveyed each year varied between 0.6 and 1.1 km^2 (coefficient of variation = 14.1%). Hunting success in the region closely correlates to our annual population index, suggesting that annual fluctuations in the number of deer, both within and outside the battlefield, are driven by factors other than hunting. An increasing deer population poses several problems for Wilson's Creek National Battlefield 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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