Analysis of the White-Tailed Deer Population of Hobbs State Park

Jesse Morrison

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Analysis of the White-Tailed Deer Population of Hobbs State Park

Jesse Morrison

Biological Engineering Program

Biological and Agriculture Engineering Department

College of Engineering

University of Arkansas

Undergraduate Honors Thesis
Abstract

White Tailed deer (Odocoileus virginianus) are the only deer species native to Arkansas, playing a crucial role in the ecosystem. Healthy deer populations are important for environmental and human wellbeing, and overpopulation can lead to poor herd health, overgrazing, increased vehicle collisions and transmission of diseases. Monitoring deer populations through surveys can be a useful tool in managing wildlife and maintaining Arkansas’ natural resources.

This study analyzed trends in Hobbs State Park’s deer population and estimated the current roadside deer population of the park. Data from past surveys was analyzed for trends using a Mann-Kendall Test, and a distance sampling approach was implemented using a 2021 survey to estimate the deer population. This new approach involved finding the relationship between the number of deer spotted and the distance from the viewer. For five nights, deer were counted in spotlight surveys and the distance to each deer was measured using laser rangefinders. This data was used to estimate the proportion of deer sighted and the total deer population of Hobbs State Park.

The number of deer spotted per km each year was highly variable, and from 1999 to 2021 it did not show a significant trend. However, there was a decrease in sightings per km from 2009 to 2021 with the newest 2021 survey having one of the lowest sightings on record. The distance sampling survey yielded an estimated roadside habitat density of 8.5 deer per km². This amounts to a population of 40 deer in Hobbs’ roadside habitats and potentially 414 deer throughout the entire park. Due to the biased nature of roadside surveys, the latter figure is less accurate than the former, but this method still allowed for an estimate of the deer population of Hobbs State Park.
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**Introduction**

Deer populations can increase quickly, and overpopulation can have negative effects. Whenever there is plenty of food and an absence of predators, deer populations rise dramatically until they exceed the land’s carrying capacity (Halls and Crawford, 1960). Deer populations have been rising throughout the United States and within Arkansas over the last 40 years (AGFC, 2019).

Overpopulation and competition for food can lead to starvation, environmental damage, and poor health. Deer overpopulation can be hard on local plant species as well as the animals that depend on plants for sustenance and shelter (Tilghman, 1989). Overpopulation’s detrimental effects on plant biodiversity can last for over a decade after heavy browsing (Pendergast et al., 2015). Large herds also have problems with increased neonatal mortality and failure to inherit immunity (Sams et al., 1996), as well as reduced growth and antler development (French et al., 1955). Reduced antler growth can lead to further overpopulation as some hunters select deer to harvest based on antler size (Ramanzin and Sturaro, 2013).

In addition to the potential adverse environmental impacts, overpopulation of deer may also cause problems for humans. For example, tick-borne illnesses have become a major problem in the United States. The number of tick related illnesses has been steadily increasing in the United States, and ticks transmit more vector-borne diseases than any other agent (David et al., 1993). The reason for these increases is not fully understood, but the spread of Lyme Disease has been linked to increased outdoor activity and rural development which has allowed humans and animals such as deer to come into closer contact (David et al., 1993). Increases in deer population within Arkansas may allow ticks to have more potential hosts and potentially increase the spread of harmful diseases.
Monitoring deer population is also important for keeping track of Chronic Wasting Disease (CWD), which is a deadly illness that affects deer and their relatives (Richards, 2020). It was first observed in the 1960s in Colorado (Klein, 2013), since then CWD has spread to 26 states including Arkansas. Increasing herd density as well as congregation due to human feeding of deer may facilitate the spread of CWD. Although there have not been any confirmed cases of CWD spreading to humans, there may be a possibility since CWD is a Transmissible Spongiform Encephalopathy (TSE). TSEs are a group of prion related diseases that can cause mental impairment and death (Collins et al., 2004). Another TSE, Mad Cow Disease, can be transferred to humans through beef consumption. In some parts of America over 60% of people have eaten deer or elk, and it is considered risky to eat venison that is CWD infected (Abrams et al., 2011). Keeping the local deer population in balance can help to reduce the risk of the disease spreading within the population.

Deer overpopulation may also increase the chance for deer vehicle collisions. In the United States there are an estimated 1.5 million deer vehicle collisions per year (Langbein et al., 2010). These collisions cause over $1300 of vehicular damage on average, and 0.04% of these collisions are fatal to drivers (Bissonette et al., 2008). The frequency of deer vehicle collisions is affected not only by human driving patterns but also by increasing deer population densities and hunting (Hothorn et al., 2015). In Arkansas, there tend to be high deer vehicle collision rates in areas where forests and fields meet with high road densities and human population (Farrell and Tappe, 2007). For example, Hobbs State Park is heavily forested with fields and intersecting paved roads near the urban parts of Northwest Arkansas. Elevated deer populations within the park could lead to more vehicle collisions in the surrounding area.
Objectives

The objectives of this study are to:

1. Evaluate how deer sightings have changed over time.
2. Introduce a distance sampling method to the park.
3. Estimate the park’s deer population.

These findings will be presented to Hobbs State Park to inform park authorities and help with deer management.

Study Area

In the early 20th century, deer populations in Arkansas were struggling due to human development and unregulated hunting (AGFC, 2019). Over the past century, deer populations rose dramatically throughout the United States due to wildlife management, hunting regulations, changes in land use, and lack of predators. Between 1980 and 2019, the total number of deer harvested annually in Arkansas more than quadrupled despite a decrease in the number of hunters (AGFC, 2019). In 2020, more deer were harvested in Arkansas than in any year since records began in 1938 (AGFC, 2019, 2021). Arkansas has developed significantly over the past 50 years with the state’s population increasing by 58% (U.S. Census, 2020). Urbanization can leave less untouched habitat for deer and increase population densities causing more deer to move into developed areas (Honda et al., 2018).

Deer populations in Arkansas appear to be at an all-time high, but without careful management, starvation, competition, or the spread of diseases could threaten deer and lead to underpopulation. Limited food resources due to extreme weather events or competition from invasive species can cause deer populations to decrease in Arkansas’ State Parks. Winter storms
in 2009 caused major disruptions in the habitat and food of deer in Hobbs State Park (Chyrchel, 2021). The increasing feral hog population throughout the state could eventually compete with deer for food resources such as acorns during droughts and other periods of low food availability (Rollins, 1999). Since there is not a known immunity or solution to Chronic Wasting Disease, there is also the potential for this to significantly alter deer population levels as it spreads throughout Northwest Arkansas. Without deer, the role of large herbivores will be unfulfilled and the plants that deer feed upon can grow without limit and cause imbalance in the state’s ecosystems. A lack of large herbivores can be detrimental to plant biodiversity (Nishizawa et al., 2016).

Hobbs State Park Conservation Area is the largest state park in Arkansas with 48.8 km² of land south of Beaver Lake (Figure 1). The park covers parts of Benton, Carroll, and Madison County. The park is hilly and covered in pine and hardwood forests with some areas with small fields and park buildings. The park’s borders form several enclaves and come in close contact with many low-density residential areas and pastures. There are also several two-lane paved roads and many single lane dirt roads that run through the park; often, the roads in the park tend to run along ridges. There are also several walking and biking several trails throughout the park.
Methods Literature Review

Since it is not plausible to count every deer in Hobbs State Park, the population must be estimated using a function that accounts for the deer that were not counted. There are a variety of methods available to estimate the population of animals in an area. Many of these methods, both new and old, are still under development and their effectiveness is continually being debated. Accuracy in estimating animal populations can become very labor intensive or expensive.

A common method for monitoring wildlife is through tagging. Tagging is a method of identifying animals so that they may be reidentified later and their behavior may be monitored. Tagging also prevents recounting animals. Tags may be physical devices, trackers, photographs of an animal, or genetic information that can identify an individual animal. Physical tags that allow for identification such as collars or ear tags may be placed on deer. Whenever the tagged deer are recognized again, information can be gained about their movements and habitat size (Verme, 1973). The proportion of tagged deer that are harvested during a hunting season may
also allow for population estimation. Deer may also be genetically tagged through the use of snares that capture bits of hair that may later be tested for individual genomes (Belant and Paetkau, 2007). Game cameras may also be used for surveying without physical tags, as a photo of a deer can be used for identification and monitoring. Without physical tags, repeat sightings of deer may be hard to identify. Photographic methods that do not require individual identification are still under development (Rowcliffe et al., 2008).

Capturing animals is another method of population estimate. The removal method may be used to estimate the population of an area using trapping. This method is rather limited since it has difficult assumptions. The birth rate, natural death rate, immigration, and emigration must be negligible during the trapping period. The probability of capturing any individual animal must be the same and the animals must not become afraid of being trapped over time (Zippin, 1958). As animals are caught and removed over time, fewer and fewer animals will be caught in subsequent trappings. Eventually as the number caught per night nears zero, the total number of animals caught from trappings will grow closer to its maximum and the trend towards the total population will become clear. Once the population is estimated the animals may be released but during the study the animals would have to be looked after or tagged. This trapping method is typically used with small creatures in a confined area and would be difficult and expensive with deer.

Hunting data may also be used to estimate population through the same removal method. If hunting data is used, the effort put into hunting must have remained relatively constant over time. Data of time spent hunting and the number of hunters can be used to determine if the effort has been constant. More often, hunting data is used to analyze population trends rather than estimate population. Using this data is convenient because it does not require a large effort for
tagging or for surveying. The Arkansas Game and Fish Commission (AGFC) currently analyzes hunting data to recommend tag limits at Hobbs State Park each year (Horrell, 2021). The limitations of the removal method make it difficult to use for a population estimate, however.

Deer populations may also be monitored through surveys. Surveys involve travelling through an area and counting animals or signs of their presence. Scrapes on trees, footprints, or droppings may also be counted. Pellet counts involve surveying for deer droppings and using this information to estimate deer abundance. These surveys have been found to be difficult to correlate with deer population since environmental conditions affect defecation rates (Fuller, 1991). It is often hard to estimate deer abundance from deer signs since the rate at which deer make these signs varies.

Surveys that count terrestrial animals may be done from the air using a variety of detection methods. Nighttime aerial surveys use thermal infrared technology to detect deer (Diefenbach, 2005). Daytime aerial surveys are typically only possible during winter whenever there is less foliage and preferably during snow whenever deer are more visible. These surveys are often better suited to animals that live in large open areas. Aerial Surveys can be done from airplanes or by using remotely controlled drones (Kays et al., 2019). Aerial surveys are often quite expensive and can cost up to four times as much as ground based surveys (LaRue et al., 2007).

Whenever deer are counted from the ground, surveys are typically done at night whenever deer activity peaks. This may be done using thermal imaging or spotlights. Thermal imaging is an effective method since it can be used to spot the heat reading of deer that might otherwise go unnoticed due to foliage. Dense trees, however, may still block thermal imaging (Belant and Seamans, 2000). Infra-red can also be difficult to use since the animal of interest
must be distinguished from other creatures that appear as heat sources (Wiggers and Beckerman, 1993). Thermal Imagers also tend to be expensive although the more affordable models can still be effective for deer surveys (Morelle et al., 2012). Conducting nighttime surveys using spotlights is a more affordable method of monitoring deer population from the ground. On most surveys, deer are counted and information about the sex and age of animals is recorded. This information, combined with past data, can be quite useful for analyzing population trends but it is typically not enough to accurately estimate the population of an area.

Distance sampling is a form of surveying that can be used to estimate animal population. This method involves using the relationship between the number of animals spotted and the distance of animals from the viewer to estimate the proportion of animals that were detected. Distance sampling has several important assumptions (Buckland, 1993):

- The animals along the centerline of the transect must be detected with certainty.
- Animals must be detected at their initial location.
- The measurements must be accurate.
- The distribution of animals around the transects should be random.

The effectiveness of the distance sampling method and using spotlight data in general for white-tail deer has been questioned since detectability of deer may be quite low (Collier et al., 2010). In particular, road-based distance sampling has been criticized. Distance sampling along roads has the potential to violate the fourth assumption since deer may either avoid or congregate near roads due to the danger of cars or the availability of open areas to graze (McShea et al., 2011). Roads also tend to run along ridges and contours which causes their locations to be less random. Roads also almost never follow parallel transects so they usually do not cover an area as
completely as straight line transect surveys. Roadside sampling has been called “convenience sampling” by some biologists since it is convenient and has potential bias (Anderson, 2001).

Despite these drawbacks, roadside surveys have several advantages since they reduce reactive animal movement, are more time efficient, and yield more data (Heydon et al., 1999) (LaRue et al., 2007). The deer at Hobbs State Park are probably more accustomed to cars driving on the roads than surveyors walking straight transects through the park. On foot, it is likely that many of the deer would smell or see the surveyors before they were spotted, and they would move away (Marini et al., 2008). Cars will also be able to move faster, and the deer will have less time to try and avoid the surveyors. This makes it easier to uphold the second assumption of distance sampling by reducing reactive animal movement.

The distance sampling method is useful because it allows the surveyors to find the proportion of deer that were detected and use this to estimate the number of deer that were not spotted during the survey. The distance sampling method uses the following equation:

Equation 1:  
\[ N = \frac{n/P}{a/A} \]

Where, \( N \) is the estimated number of animals in the region and \( n \) is the number of animals seen in the study area, \( P \) is an estimate of the proportion of animals that were spotted in the study area, \( A \) is the area of the entire region and \( a \) is the area of the study area. \( P \) is estimated using the distance from the viewer at which animals are sighted. The frequency of sightings can be graphed against the distance from the viewer. This plot will be compared to a plot of the sightings if frequency remained the same at any distance. Dividing the integral of the second curve by the first will give an estimate of \( P \) (Marques, 2009). The method of finding \( P \) is demonstrated below for an imaginary stretch of road surrounded by deer.
The data in figure 2A has been plotted in figure 2B, and the dotted trend line reveals the increasing difficulty of spotting deer further away from the road. This increased difficulty can be due to foliage, terrain, or simply distance. It is assumed that all of the deer that are zero meters from the viewer will be visible and countable. If it is assumed that the density of deer is constant as distance from the viewer increases, it can be assumed that the actual level of wildlife at each distance is roughly equal to that near the viewer. This is not always accurate since a herd of deer might be very dense near the viewer but less dense further away, but it can be used as an approximation. The level of wildlife can be visualized by the green horizontal line on the graph below. To find P, the area under the red dotted curve must be divided by the area under the green curve. It is estimated that 71.6% of the deer have been spotted in this example. Now this P value can be used in equation 1 to find the estimated number of deer (Rexstad, 2015). Using the aforementioned method of estimating P and accounting for unseen deer, should allow the population of white-tailed deer at Hobbs State Park to be more accurately estimated. For this study, the software DISTANCE will be used (Distance, 2020). This program will complete the calculations and fit the detection curve to the data collected.
Since deer are not a particularly rare or threatened species and since limited time and resources are available to complete this survey, many of the more costly or labor-intensive methods such as an aerial survey or tagging of deer were ruled out. The park has a tradition of spotlight surveys and was willing to modify their methods, so a distance sampling approach seemed appropriate. The only difference from past surveys was that the perpendicular distance between the viewer and deer was recorded using a rangefinder. The park employees’ experience from past surveys was also very beneficial in designing and carrying out the study and this expertise might not have been as usable with methods that did not involve a survey.

Distance sampling using laser rangefinders was also much more efficient for the park. From 1999-2002 Hobbs State Park took visibility data on foot to estimate the probability of a deer sighting. Visibility measurements were done by walking with a reflector into the forest and measuring the maximum distance at which the reflector could be seen. This method was abandoned since these surveys typically took seven hours per night. The surveys after 2002 took around four hours each night and the 2021 survey with distance measurements did not add much time because of the speed of using a laser rangefinder. This difference in time is especially important whenever deer surveys start at dark and use volunteers.

**Methods and Materials**

**Objective 1:** Evaluate how deer sightings have changed over time.

Deer surveys at Hobbs from 1999 to 2017 used road-based spotlight surveys. On five nights, volunteers, and park employees in two trucks drove on predetermined routes throughout the park. In each truck there were two volunteers with handheld spotlights and one volunteer with a clipboard to record sightings. Volunteers sat on wooden benches that were placed in the
bed of each truck. One spot-lighter faced each direction and the data recorder could sit facing either side. The trucks were driven at around 11 km per hour. And at the end of each transect the spotters would tell the recorder how many deer were seen. The sex, age, and whether the deer was in a field or forest was also recorded. No observations of the distance to the deer were taken on these past surveys. A total of 66 km of roads were surveyed each night during these past surveys. Surveys were not done in the rain. The data from these surveys was used to estimate the number of deer spotted per km, and a Mann-Kendall Test was used to evaluate trends in the number of deer sighted over time in these surveys. This method allowed the significance of trends to be analyzed despite high variance over time.

**Objective 2: Introduce a distance sampling method to the park.**

In Spring 2021, a road-based spotlight survey was once again conducted for five nights. The distance sampling approach used in 2021 necessitated changes in the previous method. The surveyor and driving configurations were kept the same as in past surveys. For safety, volunteers did not stand up unless the truck was fully stopped and volunteers were allowed into the truck’s cab between transects. Busier roads were also avoided and any time another car was on the transect the truck would pull over to let them pass. Care was taken to drive under 11 km per hour. Due to the potential dangers of riding in a truck bed, perhaps further safety methods could be taken such as wearing some sort of harnesses or conducting surveys from seats in an SUV in the future. In addition to 120 lumen spotlights, Bushnell laser rangefinders were also distributed to each spot-lighter. Instead of having the spot-lighters count deer and report them at the end of the transect, the truck was stopped any time a deer was sighted during this survey. Any time a deer was spotted the lights were kept on the deer to keep them stunned. The driver would move into position so that the perpendicular distance to a deer from the road could be measured using
the laser rangefinders. If multiple deer were spotted in a group, the distance to the approximate center of the group was measured and the number of deer was recorded on a pre-printed survey sheet.

The type of vegetation and characteristics of each transect where deer were spotted was also determined. Cover type data was divided into deciduous forest, evergreen forest, developed, and open area categories. At first, the cover type was not always recorded by the surveyors and it was not until instructions were revised for later surveys that this was always recorded. For the sightings that did not have cover type recorded, the location of the sighting was examined for cover type at a later time in person or through ArcGIS. Since some of the cover type data was determined after the fact, there could be some error in this aspect of the data. Whenever cover type data was recorded in real time it depended upon the viewers judgement and this may have contributed further bias. If future surveys are conducted with these methods, the cover type should always be recorded during surveys. Every other night, the order in which the routes were run was swapped so that differences in deer activity at the beginning and end of the survey would have less overall effect on deer distribution between transects.

This study was conducted on the roads of Hobbs State Park where 32 sections of road were selected from past surveys to be used in the 2021 distance sampling survey. Roads were deemed suitable if they were not busy and ran through or near Hobbs State Park. Most of the roads in this survey were gravel or dirt and did not have large open areas to each side. It was hoped that this could lessen the bias that can result from using roads as transects. These small roads with close forest would presumably have less of an impact on deer distribution than some of the larger roads in the park with more traffic and large open areas to each side. In total 53.8 km of road were surveyed in the new study (Figure 3). Approximately 20 km of road that was
previously covered by deer sampling surveys was not used in the 2021 study due the dangers of stopping to conduct distance readings in areas with higher traffic. Although the survey routes did not cover the entirety of the park and often run outside of the park, they covered through a variety of habitat types that are representative of the park (Figure 3).

![Figure 3 Hobbs State Park survey routes for 2021 distance sapling survey with land cover classes (USGS, 2016)](image)

**Objective 3:** Estimate the park’s deer population.

Distance sampling analysis was conducted on the 2021 survey data using the program, DISTANCE (*Distance*, 2020). Originally, it was planned that the cover type data would be used to find the density of animals in each cover type and then these densities would be multiplied by the area of each cover type within the park to estimate the total population. This method would
have been more accurate than calculating the density of deer with a single detection function for the entire park since the proportion of deer spotted varies based on cover type. For example, a higher proportion of deer will be spotted in an open area than in a deciduous forest. This method also would have allowed the deer sightings outside of the park to be used, since the sightings would be used to find the density in each cover type rather than the park’s area. After attempting this method in DISTANCE, it became clear that there was not enough data to create an accurate detection curve for four individual cover types since the coefficient of variance for the densities created by these curves was above 50% (Rexstad, 2021).

Since it was not possible to create accurate detection functions for each cover type, the data was reanalyzed to estimate the density of deer in the park as a whole. The transects that ran outside of the park were removed. Some transects that ran short distances between sections of the park or ended just past the park edge were kept if they resembled the park in terms of land cover. The data from transects outside of the park was still used for comparisons with sightings from previous years since the previous surveys all used the routes that stretched outside of the park.

**Deer Sighting Trends**

Prior to this study, Hobbs State Park conducted spotlight surveys from 1999 till 2017. The data collected over the years at Hobbs State park is useful in many regards as it can help the park to see trends in deer sightings. The past data, however, was not suitable for making an accurate estimate of the total deer population. The data shows the minimum known deer population of Hobbs State Park and without more information there is not a way to estimate the number of deer that were not seen or to extrapolate the population estimate to areas of the park that were not covered by the survey.
The number of deer spotted in the historical surveys varied from 657 deer in 2009 to 169 in the most recent survey (Figure 4). The number of deer varied highly from 1999 to 2021 and fewer deer were seen in the 2021 survey than in any previous year. The 2021 survey covered 18% less road than the past surveys for safety reasons. Even whenever this is considered the most recent survey still spotted less deer per km than in any survey since 2003 (Figure 5). The number of deer spotted did not show an upward or downward trend from 1999 to 2021 (Mann-Kendall Test, $\tau = 0.204$, $p=0.112$). However, if only the data from 2009 to 2021 is analyzed, then the number of deer spotted per km can be said to have decreased significantly (Mann-Kendall Test, $\tau = -0.480$, $p=0.023$).
The sections of road that were removed from the surveys in 2021 were more heavily travelled paved roads. In the past, some of the clear areas next to paved roads where deer tend to graze have yielded many sightings, it is possible that removing the larger roads for safety could have skewed the 2021 data somewhat.

The last two nights of the 2021 survey had two of the lowest sightings of any of the park’s recorded surveys where only eight deer were observed on 3/31/2021 and only five on 4/1/2021. Deer behavior can be unpredictable and for some reason on March 31st and April 1st the deer were not very active. It was cold on these two nights at 7 ° and 5 ° Celsius, but low temperatures did not seem to deter deer activity on the third survey night when the temperature was 5.5 ° C. Even if these two nights of extremely low deer activity are not counted, the sightings of the first three nights would still be 47.3 on average which is below the 1999-2017 average of 69 deer per night.

It is possible that the major snowstorms of early 2021 had an effect on the population and behavior of deer at Hobbs State Park. However, after the major 2009 ice storms, deer counts were at an all-time high (Figure 5). Major winter storms can cause a decline in deer population, but deer activity can also increase after a winter weather event. The food sources that deer depend upon are harmed and they must spend more time searching for new food sources. The weather events of 2020 may have also been hard on the deer population as there was a late freeze on April 18th (“nwarwk.com,” 2021). Fewer acorns may have been available to deer at Hobbs in the year before the 2021 survey due to this (Chyrchel, 2021).

More surveys would be necessary but from this data it seems that deer sightings have decreased significantly since 2009, and this may suggest that the deer population at Hobbs has
reduced. With more data, it could be determined that there are less deer in Hobbs now than there were only 10 years ago.

Cover Type Results

The distance, group size, and cover type of each deer sighting was entered into DISTANCE, and an estimate of population for each cover type was made using the software’s stratification function. Unfortunately, there was not enough data to create an accurate detection function for each cover type. The coefficient of variation for the densities created by these functions ranged from 50-77%. An acceptable coefficient of variance for these estimates is below 50% (Rexstad, 2021).

Although there were not enough sightings to stratify the deer detection data by cover type and estimate the population for each cover type, the cover type data is still revealing of the behavior of deer within Hobbs. Most of the deer spotted were in deciduous forest areas (Figure 6). This was expected since deciduous forests covered most of the survey routes and they tend to offer more food than evergreen forests in the form of acorns. There were a disproportional number of deer spotted in developed areas and open areas (Figure 6 and 7). This was noticeable during the surveys whenever many deer were spotted grazing in residential areas or in small fields. The developed area sightings were confined to only seven out of the thirty-two total transects, while sightings in open areas were only in three of the transects. This disproportional number of sightings may be due to the plentiful grazing that these areas offer or due to the ease of spotting deer without intervening trees. Some people near the park also put out food for deer and this may attract deer to these areas. Only 0.5% of the park’s area is developed and most of the sightings in developed areas were seen on transects that ran between sections of park or along the park edge. It is likely that many of the deer that live within Hobbs boundaries also spend time
in these residential and open areas outside of the park as deer home ranges can be as large as 60 km$^2$ for young males (Lesage et al., 2000).

Figure 6 Deer Sightings in each cover type along transects at and near Hobbs State Park during 2021 Survey

Figure 7 Percent Area of each cover type within Hobbs State Park (USGS 2016)
The large number of deer sightings just outside of Hobbs State Park suggests that low density residential areas and pastureland near forest is attractive deer habitat. If Hobbs State Park had a deer overpopulation problem, the spread of tick-borne diseases to humans could be worsened by the high number of deer venturing into developed areas. Deer that are feeding from common sources in developed areas such as human controlled feeders could also be at a greater risk of spreading diseases amongst themselves.

Although there was not enough data to create detection functions with enough accuracy to predict population, the functions created by DISTANCE do reveal the general differences in detectability between cover types. The functions display the fitted sighting proportion curve as a red line with 100% proportion of sightings at a distance of zero meters. This red line is fitted to the blue boxes that represent a histogram of the proportion of deer spotted at different distances (Figure 8). The deciduous forests of the park had a high number of sightings close to the road, but detectability rapidly decreased after approximately 20 meters (Figure 8A). This is to be expected since deciduous forests tend to have the thickest foliage of the cover types in the park. In the evergreen forests, deer were spotted at further distances than in deciduous areas, this may have been due to differences in the amount and type of undergrowth and foliage compared to deciduous areas (Figure 8B). Open areas had the flattest detection curve since deer were seen at further distances (Figure 8C). This made sense since it was very easy to detect any deer in the pastures on the routes even at long distances. The sightings in developed areas had some far sightings but far more near the road. This was to be expected since most of the residential areas on transects were located near the road (Figure 8D). The developed sightings that were spotted at a longer distance were mostly seen at a large water treatment plant just outside of the park.
These detection plots also reveal further elements of deer behavior at Hobbs State Park.

In all of the detection plots except for the deciduous cover type, deer are not spotted as frequently in the 20 meters closest to the road as they are in the 30-55 meters from the road. This
difference is not likely to be due to detectability since deer near the road should be easier to spot. It appears that deer are avoiding the areas adjacent to roads. It is possible that the deer in the deciduous cover type are also avoiding the roads but do not have to go as far to feel adequately concealed. This behavior is a problem for this study since it means that the density of deer is not constant as the distance from the road increases. Since this study only used small roads with less traffic and less roadside grazing areas it was assumed that roads would not have as much of an effect on deer distribution, but this does not appear to be the case. The advantages of roadside distance sampling may not outweigh the problem of road bias.

**Distance Sampling Results**

Since the data did not permit a cover type-based estimation of the park’s total population, the roadside density of deer throughout the park was estimated using DISTANCE without cover type stratification. This meant that data from outside of the park could not be used. As mentioned in the cover type discussion, the data from just outside of the park contained more developed and open areas. These cover types held a disproportionate amount of the sightings and it appears that the deer in the area are very active outside of the park. The removal of transect data from outside of the park lowered the total transect length by 8.8 km and meant that a total of 91 deer sightings out of the total 169 could not be used for the total population analysis. Fortunately, there was still enough data to create a detection function with a suitable coefficient of variation.

The density of deer in all of the roadside habitat was estimated using DISTANCE. The area of roadside habitat was calculated by multiplying the total length of transects by the effective transect width. Ten percent of the data was truncated which made the transect width 84 meters to each side. This truncation created a more compact sighting probability graph compared to those used for the attempted cover type method (Figure 9). Removing some of the data from
further distances is necessary since these values do not contribute much to the shape of the detection curve near the transect and fitting an appropriate curve is crucial for calculating the proportion of deer spotted. The total area of roadside habitat was calculated to be 4.7 km². DISTANCE used the detection curve to estimate that 61% of deer within the roadside study area were spotted (Figure 9). The density of deer in roadside habitats is estimated to be 8.49 deer per km² and the total number of deer in roadside habitats is estimated to be 40 individuals. The coefficient of variance for both of these values was 24% which was considered acceptable since it was far below 50% (Rexstad, 2021).

![Detection function for 2021 Distance Sampling Survey with ten percent of data truncated](image)
Due to the road bias that is present in the data, only the roadside population of the park may be estimated with complete accuracy. However, it is still possible to extrapolate the roadside data to include the entire parks area. This was done to provide an estimate of the deer population of the entire park. This estimate should, however, be viewed as a biased estimation since the density of deer near roads is not necessarily the same as the density of deer throughout all of the park. By applying the roadside density of 8.49 deer per km$^2$ to the entire park, it is estimated that there are 414 deer in Hobbs State Park. This density is realistic and matches the USDA estimate of the deer densities of Benton, Carroll and Madison County of less than 9.32 deer per km$^2$ (USDA, 2008).

It is difficult to determine whether 8.49 deer per km$^2$ is a healthy density of deer for Hobbs State Park. The habitat within Hobbs varies enough that the ideal density in one area of the park would be very different than in another. According to the AGFC, the ideal density of deer is low enough to reduce the risk of spreading Chronic Wasting Disease and low enough that deer can obtain adequate forage to stay healthy, but high enough that the population is able to be enjoyed by the public (Meeker, 2021). One study that used enclosures to test carrying capacity for deer in the Ozark highlands found that carrying capacities averaged only 2.5 deer per km$^2$ to 5.5 deer per km$^2$ (Rogers et al., 1990). For comparison, the cross timber and prairies region of Texas is estimated to have a carrying capacity of 8.15 deer per km$^2$ to 20.6 deer per km$^2$ (Dillard, 1993). It is interesting that the current density estimated for Hobbs is considered average or even high since the number of sightings in 2021 was quite low compared to previous years. This could mean that the deer population was above carrying capacity in the past and has lowered back to healthy levels.
Conclusion

From the past data and 2021 survey it appears that the deer activity and potentially deer population in Hobbs State Park has declined since 2009. More surveys would be necessary to substantiate this, and the distance sampling method could be a good method for the park to continue monitoring their deer population. Despite the decrease in deer sightings, the estimated deer density within the park appears to be normal and healthy at 8.49 deer per km$^2$. The 2021 survey revealed that many of the deer around Hobbs also frequent the nearby residential areas and pastures. The exclusion of these areas from the survey analysis means that the effective deer population could be much higher. The data also showed that using roads as transects affected deer behavior and skewed the detections curves. This effect from road bias may have made the estimation of population inaccurate.

In the future, if the cover type method is used, surveys should carefully record cover data from the start of the survey to prevent the potential bias of finding this information after the fact. If the cover method is not used out of the concern that there will once again be insufficient data, new transects should be devised that do not leave the park’s boundaries. Due to the bias of road-based distance sampling that is evident in the data from Hobbs, it is possible that a different method should be used in the future. Walking straight transects through the park could eliminate bias but might yield less data and could be more labor intensive. It will be up to the park to decide if the benefits of roadside sampling and the ability to use methods consistent with those used to collect past data outweigh the problems caused by deer’s tendency to avoid the roads at Hobbs. If the park authorities only want to continue examining trends in survey data, the distance sampling may not be necessary but if more estimates of the total population are desired, distance sampling surveys could be continued and the methods further adapted.
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