

White-Tailed Deer (*Odocoileus virginianus*) Monitoring and Population

Density at Jug Bay Wetlands Sanctuary

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Introduction

Pre-colonially, white-tailed deer (hereafter deer) maintained a density of about 10 deer/mi² in North America (Bressette et al., 2012). This density was maintained by subsistence hunting by humans and predation by native carnivores. By the early 1900s, forests were decimated and hunting pressure increased such that the deer population was close to extinction. As carnivores in northeast America were driven out by humans and forests allowed to regrow, the deer population flourished. Now, deer densities range from 85 to 96 individuals/mi² (Bressette et al., 2012; Anderson et al., 2012), 9 times the pre-colonial density.

Deer have long been studied throughout North America, and their populations are important in providing both consumptive and nonconsumptive revenue and recreation for humans in the form of wildlife viewing, hunting, etc. (Anderson et al., 2012). They cause both threats to human life and monetary loss through vehicular collisions, which are especially frequent in suburban areas of high deer and human densities. Other threats posed by deer to humans include Lyme Disease and damage to agricultural crops (Coalition for Responsible Deer Management). Finally, they can damage vegetation through browsing and rutting.

Jug Bay is a relatively small protected area, surrounded by suburban and urban areas and therefore subject to immigration and dispersal by different populations. Conducting research on the deer population in Jug Bay informs managers and biologists on the potential for deer populations to continue degradation of protected forests in Maryland, and therefore inform management implications. Deer have long been noted as a keystone species and have widely radiating impacts on forests. They exhibit direct effects on the plants they browse as well as indirect effects on other trophic levels and even abiotic factors of an ecosystem.

Through this project, Jug Bay will be able to census the deer population and expand our knowledge on deer populations in Maryland.

Over the years, deer predator density and human hunting have decreased, and suburban areas have increased. Extirpation of natural predators and more readily available food have decreased mortality rates of deer, but as human populations expand, there is less habitat for deer to occupy. Large populations of deer are forced into small habitats, resulting in dangerously high densities in these small areas. For example, Baltimore County has an area of 599 mi², and a population of around 50,000 deer, averaging about 95 deer/mi², with some areas having a much higher density or much lower (Coalition for Responsible Deer Management). As the deer population increases, it profoundly changes forest composition and structure (Rooney & Waller, 2003).

Indirectly, deer browsing modifies habitat for other animals and causes trophic cascade effects. Deer browse specific plants during different times of year. Red oak (*Quercus rubra*), native to Maryland, is browsed in spring and summer, limiting tree regeneration (Rooney & Waller, 2003). Since deer feed preferentially on certain plants like the red oak, they alter “relative competitive ability” of the plant community: as browse-intolerant species decrease, browse-tolerant species increase. Combined with the spread of invasive plant species and mortality due to pests such as the Emerald ash borer, deer browsing is a main cause of decreases in long-term forest regeneration (Ruzicka, Groninger & Zaczek, 2010).

By quantifying the deer population, we can understand how severely the forest will continue to be impacted over the next several years. Therefore, this study was focused on determining the extent of the deer population at Jug Bay. My research question was as follows:

What is the density of the white-tailed deer population in Jug Bay, and how does the population density explain observed impacts on the Jug Bay forest understory?

Study Site

Jug Bay Wetland Sanctuary is a park in central Maryland managed by Anne Arundel County consisting of 1,700 acres of tidal freshwater wetlands, meadows, fields, and forests adjacent to the Patuxent River. My survey was performed in the forested areas of the park, focusing on the upland and riparian forests frequented by white-tailed deer. Adjacent to the Sanctuary is the Parris N. Glendening Nature Preserve, also managed by Anne Arundel County and consisting of primarily forested land, meadows, and sand barrens. Surrounding these public lands are exurban residential areas and private farms, bordered on the north by the Route 4 highway and on the west by the Patuxent River.

Methodology

To answer my research question, I have formulated a methodology that will allowed me to census the deer population and begin to understand the population's impact on native plant species. I used distance sampling (spotlighting) and camera trap surveys to census the population. My data was analyzed using a variety of statistical methods in different programs and softwares.

According to research, both bottom-up and top-down cascade effects suggest that deer have reduced forest biodiversity in high densities (Martin et al., 2010). Many researchers have measured deer population densities, and there exist numerous techniques to do so. Anderson et al. (2012) cite aerial surveys, mark-recapture or mark-resight methods, remote cameras, herd

reconstruction from harvest data, FLIR surveys, and distance sampling as valid methods.

Distance sampling is the preferred method as it is less costly than traditional techniques, and it can be direct (counting animals) or indirect (counting animal signs such as tracks or pellets).

Anderson et al. recommend direct and indirect sampling in conjunction.

Distance Sampling (Spotlighting)

To conduct direct distance sampling, I performed driving transects throughout the Sanctuary with a spotlight. I followed the methodology used by Anderson et al. (2012) to conduct spotlighting. The methodology for the process is as follows:

The road is used as a transect with a vehicle manned by a driver and with two observers in the back. The first night of effort, each observer shines a spotlight on one side of the road. When observers see deer, they will measure the distance from the vehicle to the deer with a laser rangefinder. They will determine the number of deer in the cluster, record the distance of the cluster, and record where the deer were found. This method serves to count the number of individual deer found on transects, helping to estimate the density of deer. I obtained permission from Brian Eyler of Maryland Department of Natural Resources to conduct the spotlight survey.

I used a transect of about 2.5 miles on Blue Shirt Road, Entrance Road, Utility Road, Wrighton Road, Plummer Lane, Pindell Road, and River Farm Road. Surveys began around 9:30 each night (1 hour after sunset, as recommended) and ended between 10:30pm and 12am. There were 8 total nights of effort, with 2 planned nights cancelled due to weather (fog, rain).

Generally, literature recommends that the same observers be used every night, but this was unfeasible for this project due to the volunteer status of all assistants. Furthermore, spotlighting could not be completed on the entire route due to presence of houses and residences throughout the route.

Figure 1 below shows the approximate areas that were surveyed. Only areas highlighted in yellow were used for calculations.

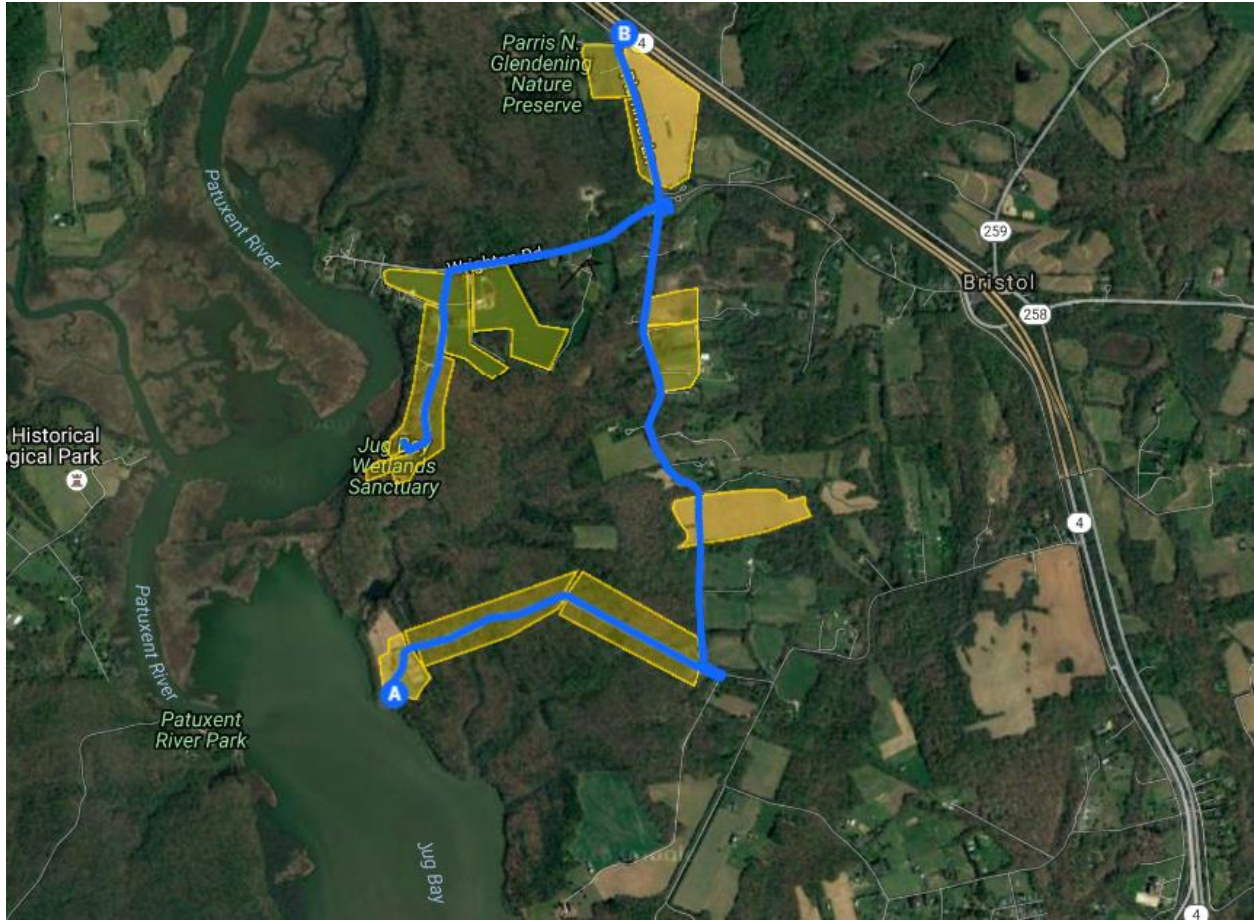


Figure 1. Map of spotlight survey, with blue line showing the route driven and yellow polygons marking the areas surveyed.

Table 1 below shows the yards of visibility throughout the route. Visibility was taken in meters using a Bushnell rangefinder then converted to yards. Areas of high visibility generally indicate crop cover with a distant tree line, and areas of low visibility generally indicate heavily forested land. Spotlighting is meant to be conducted in the winter months to increase visibility in forested areas, but due to the time limitations of this study, we sampled during summer months.

Table 1. Visibility estimates in yards of spotlight survey (taken every tenth of a mile).

Distance (Left)	Distance (Right)
19.68498	54.6805
23.075171	39.916765
40.46357	20.997312
58.180052	22.637727
52.055836	47.681396
54.133695	193.022165
5.46805	188.10092
5.46805	144.35652
5.46805	196.8498
5.46805	279.96416
5.46805	183.72648
147.63735	196.8498
1.09361	205.59868
266.84084	15.31054
379.48267	5.46805
1.09361	13.779486
46.150342	57.414525
39.807404	51.837114
58.180052	62.445131
21.762839	56.320915
33.573827	54.352417
28.215138	22.637727
29.964914	55.77411
75.45909	249.34308
159.776421	65.179156

The acreage of the property that was being surveyed (including parts of the Sanctuary and surrounding farms and houses) was about 1400 acres. The acreage of the sampled area--the number of acres actually observed on the spotlight route--was about 147 acres.

Camera Trapping

Camera trapping is a “trapping” method that is non-invasive, requires only a short survey period, has a low financial cost, and has much less required training than traditional mark-recapture/telemetry methods (Soria-Diaz & Monroy-Vilchis, 2015). Literature recommends a 2-3 month sampling period due to the improbability of birth, death, migration or immigration. I based my methodology on that outlined by Soria-Diaz & Monroy-Vilchis (2015).

The cameras used were 3 Reconyx Hyperfire HC500 and 2 Reconyx Hyperfire PC800. I used the grid system provided by Jug Bay Wetland Sanctuary to place my cameras. I assigned each grid a number in the sanctuary, and used a random number generator to assign 3 cameras to a point. I separated cameras by at least half a kilometer (or 5 grids), and re-ran the generator if I received a number that placed the cameras closer than 5 grids apart. I then repeated this process for Glendening Nature Preserve, but with 2 cameras. Therefore, I deployed a total of 5 cameras for this survey. Cameras were placed at 507Q, 509X and 511I in the Sanctuary, and 538M and 530N in Glendening. Included below is an aerial image of Jug Bay Wetlands Sanctuary and Glendening Nature Preserve, with camera points circled in red.

100 METER UTM REFERENCE/RESEARCH GRID- JUG BAY WETLAND SANCTUARY

Prepared By: The Department Of Public Works- Technical Engineering Services



I initially ran an unbaited period, where cameras were placed at their selected grid markers and left for approximately a month. Then, in mid-July, 2 cameras (538M and 507Q) were baited with 40lb bags of shelled deer corn. Ideally, all 5 cameras would have been baited, but this was not possible due to time, money, and resources devoted to the project. I ran a 5-day pre-sampling period, which is used to allow the animals to acclimate to the presence of bait. Sampling began on Monday July 18, and two 10-day sampling periods were conducted.

The thousands of photographs taken by the cameras were collected in the CameraBase database through Microsoft Access. I identified species and individuals seen in each picture, as well as the sex of each individual. To analyze data, photos were exported from CameraBase to program CAPTURE and program DISTANCE.

Results

Distance Sampling

Initial spotlight surveys yielded an average of 5 deer viewed per night. These surveys were only conducted on Sanctuary property and only included Blue Shirt Road, Utility Road, and River Farm Road, not including any surviving farmland. Under the assumption that deer were utilizing soybean crops for nighttime feeding, I expanded the survey to include surrounding farmland. Average deer viewed per night increased to 19.5.

I ran the data through the Deer Spotlight Survey Calculator, which uses the area surveyed and number of deer viewed to calculate “acres per deer”. This unit is generally how managers quantify deer populations. My data yielded an estimate of 7.54 acres per deer. This is a high population estimate, but not out of the norm for exurban Maryland.

Camera Trapping

Fifty total white-tailed deer individuals were identified in the two 10-day surveys; it is possible that some identification mistakes were made. Additional species identified include Virginia opossum, red fox, gray fox, gray squirrel, and raccoon.

In program CAPTURE, which assumes a closed population, the estimated population size of the total area (both Jug Bay and Glendening) using the M(h) model was 40 ± 6.2 [33,61]. However, p-values were abnormally high. This population of white-tailed deer is likely not closed due to the open, non-geographically constricted landscape.

Another effective method of determining deer density is the use of manual calculations. We can determine the population factor by the number of identified bucks, and then use that population factor to estimate the number of photographed does and fawns. In a study site of approximately 1300 acres, I identified 10 bucks. 413 pictures of bucks were taken. Using the method outlined by Michigan State University, I calculated the population factor to be 0.024. 1579 doe pictures and 242 fawn pictures were taken, resulting in a projected doe survey population of 38 and a projected fawn population of 6. I then located the standardized percentage of the population photographed based on camera density relationship and consecutive survey days, which was for my study 89%. Using this number, I was able to determine the extrapolation factor (1.18) from a table provided by Thomas Baden. I multiplied the extrapolation factor by the total projected photographed population (53 deer) to determine an adjusted number of 63 deer. Finally, I divided the acreage of the survey site (approximately 1,300 acres) by the adjusted population number. The resulting density is approximately 21 acres per deer. However, this method assumes that all cameras are baited. Since only two out of five cameras were baited in my study, this number is likely significantly lower than the actual population size.

Discussion

This has been a benchmark study at Jug Bay, as the first project to embark on white-tailed deer monitoring in the property. Although in wildlife biology, results from a 3-month project are generally not conclusive, my methods and results will allow Jug Bay and volunteers to continue monitoring the population. Managed hunts occur throughout the property in the winter, and it is imperative for Jug Bay to understand how the deer population will continue to be affected by continued hunts.

Spotlighting data gives us an estimated population of 7 acres per deer, which, if accurate, is as expected geographically and seasonally. However, it will be imperative that Jug Bay continues at least monthly spotlight surveys in order to develop a long-term, reliable data set. This can easily be done by citizen scientists.

Perhaps the most notable result from spotlighting data is the utilization of soybean crops by deer in the evenings. Observation numbers increased more than threefold once farmlands were included in the survey route. Jug Bay may be benefitting from the deer's use of these crops -if deer are using soybean as their main food source in the summer, they are browsing less often in the forest undergrowth. However, spotlighting is traditionally done in the late autumn and winter, when these crops will be unavailable to deer and forest visibility is much higher. Therefore, this imbalance may even out in the colder seasons.

Although camera trap population density data is not yet conclusive, the ratio of adult does to bucks is 1:1.4 according to my personal observations, and 1:3.8 according to estimated population numbers using the population factor. This range indicates the population is relatively healthy in terms of reproduction. No diseased or malnourished deer were observed. It is more difficult to conduct camera trap studies with citizen scientists due to the expertise and time

required to identify deer and analyze data; however, general population monitoring can be done easily.

Recommendations following this study include: continued spotlight surveys, continued monitoring of deer exclosures, continuation of managed hunts at the Sanctuary, implementation of carnivore monitoring projects, and the implementation of four-poster bait stations. Deer exclosures can provide information on the effect of the white-tailed deer population on the ecosystem as a whole--over years and even decades, exclosures inform us on how the presence/absence of deer influences plant diversity and richness. Managed hunts, on the other hand, inform on the population itself. Necropsies can be performed during harvests that can give information on the physiological health of the population. Even simple data collection such as antler width, sex, and fetus count from harvests can tell us about the population's status. I have also tested a carnivore monitoring protocol that should be continued here at Jug Bay; although there is no confirmed coyote population, understanding what predators of deer, if any, are present in the Sanctuary is valuable knowledge. Finally, four-poster bait stations are targeted towards tick population reduction and therefore reduction of Lyme disease. Not only do four-posters kill ticks and prevent more ticks from parasitizing deer, they can serve as useful camera stations.

In conclusion, this has been a preliminary study of the white-tailed deer population at Jug Bay. Initial results suggest a relatively large, dense population of deer, but continued efforts to monitor the population will result in more reliable numbers. We cannot know the long-term effects of deer on the ecosystem from a short study, but I have provided a template for further research and management at Jug Bay.

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