FOR-133

University of Kentucky
College of Agriculture,
Food and Environment
Cooperative Extension Service

Using Camera Surveys to Estimate White-tailed Deer Populations

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Camera surveys utilize photographs to formulate population and demographic estimates of the deer herd in the surveyed area. The concept of game cameras was invented in the 1880s by George Shiras, who attached tripwires to cameras and flashlights to capture images of wildlife. Luckily, game camera technology has improved dramatically since then. Now relatively inexpensive cameras can be used to take hundreds of professional quality pictures without the need to collect film or reset trip wires. Increased resolution, shutter speed, and durability coupled with smaller sizes and ease of use, game have made game cameras practical tools for hunters, wildlife managers, researchers, or anyone with an interest in wildlife.

One of the traditional applications of this tool, and still one of the main reasons people buy game cameras, is to determine the location and behavior of the game species of interest to hunters. This application, while useful for the hunters, overlooks the value of the pictures taken. Most hunters dispose of the collected images after a period of time, except for a few images of trophy-sized bucks or interesting wildlife behaviors. By deleting the collected pictures, hunters are discarding valuable data that could be used for managing deer populations and herd health. Hunters could use the data they capture each year to develop better hunting strategies and set management goals each season by utilizing the data relating to the population dynamic trends in their deer herds over the years. To use this data, hunters need to start thinking a little more like a wildlife biologist and a little less like a hunter.

For more than 20 years, wildlife biologists have used game camera surveys to estimate population size and health in many wildlife species including white-tailed deer. Population estimates of wildlife populations have historically been conducted through capture-mark-recapture surveys, line-transect surveys, helicopter surveys, and other methods. These methods have proven accurate, but they are often costly, time-consuming, and not readily available to the average landowner. In the 1990s, researchers at Mississippi State University and Steven F. Austin State University separately evaluated the reliability of camera surveys based on proven methods of population estimates. Both studies indicated that camera surveys are a reliable method for accurate population estimates of white-tailed deer, and more recent studies have continued to support this method. The simple yet robust method offers a reliable, easily implementable tool to allow public to inventory deer herds on the properties they own or lease.

Population Characteristics

Deer management depends on a myriad of factors, such as population demographics, herd health, and habitat limitations. These factors are interdependent in many ways, and usually positive improvements in one area will have positive impacts in others. Demographic information includes age structure, sex ratio, and fawn recruitment; habitat limitations include carrying capacity (the maximum number of deer that the landscape can support) and habitat diversity. Understanding the status of these variables and how they change over time will lead to insight into herd health and how the herd responds to management activities. Monitoring these characteristics should occur on a small scale, such as on your property; habitat availability should be examined on a larger landscape level, such as your property and the surrounding properties. Population characteristics combined with other data, such as habitat information, can help give a more complete picture of the deer herd on the landscape.

Age Structure

Age structure is the percentage of deer distributed into particular age classes. For bucks, this structure can be heavily impacted by hunting pressure, as mature bucks are often targeted over younger ones. Thus, there are often few mature bucks in the population due to heavy hunter harvest, as well as other natural causes. Too high of a harvest in certain ages can negatively impact future populations. For example, if a large percentage of adult does (2.5 years +) are harvested, population levels will drop over the next year.

Sex Ratio

Sex ratio, also called buck-doe ratio, is the relationship between the number of bucks and number of does in a population. A ratio of 1:3 would indicate that for every buck there are three does in the population. Just like age structure, the sex ratio can be skewed due to hunting pressure or regulations, since bucks are more likely to be targeted than does in many instances. Fawns, under ideal conditions, are born in an approximately 1:1 ratio of bucks to does; however, as deer age, the sex ratio often becomes biased toward females. This tilt is influenced not only by hunter harvest but also can be impacted by the other heavy stresses on bucks during the breeding phase, called the rut. Bucks end the rut in their worst physical condition of the year, yielding a higher mortality rate than does because the end of the rut typically coincides

with the onset of winter. During the rut, a male deer can lose up to 30 percent of his body weight, leaving the animal vulnerable to malnutrition, starvation, predation, and disease during the late winter and early spring. A study done in south Texas showed that mortality of adult bucks in the post-rut could be as high as 23 percent.

An unbalanced sex ratio can have important management consequences. A population heavily skewed toward does can lead to an overpopulation problem. In that situation, harvesting adult females could help reduce the population and provide more quality habitat per individual deer. Some deer managers use sex ratios to set and monitor management goals. A1:3 buck to doe ratio is a good management goal as it usually is an indicator of a healthy deer herd. Some have suggested a ratio of 1:1 for hunting purposes, but this low ratio is not practical as it is rarely seen in the wild. Other factors, such as fawn recruitment, habitat quality, and number of deer, should also be taken into account for healthy management of a deer herd, not just hunting goals.

Fawn Recruitment

Fawn recruitment is the number of fawns per doe that make it to six months of age. Fawn recruitment is dependent on a number of factors, including suitable habitat for food, cover, weather conditions, and predation. To achieve a stable population, the number of fawns recruited each year will offset any reduction in the deer herd the previous year.

Predators can play a role in fawn recruitment by removing fawns from the landscape; however, this varies drastically by locality and fawn survival. Research in Kentucky has not shown that predators impact deer populations in the state. Habitat quality is much more important than predator control to increasing fawn recruitment in most areas. A study from Pennsylvania showed that in forested habitat fawns have a 40 percent survival rate to nine months of age, compared to 50 percent in agricultural habitat. These numbers are consistent with other studies across the country. In southern Illinois, areas that have more diverse habitat saw higher survival rates than areas with a more monoculture landscape.

Figure 1. Adult doe and her two fawns

Early successional habitat (e.g. regenerating forests or old fields) can provide some of the best habitat for fawns. This habitat offers a variety of quality cover in which fawns can hide from predators and be buffered from harsh weather conditions. In crop field edges and old forests, predators can more easily locate fawns because there are fewer places for the fawns to hide.

Jacobson Camera Survey

The Jacobson camera survey uses the picture rate of individual branch-antlered bucks (bucks that have at least one forked antler) to calculate approximations of the population as a whole. Since this type of survey relies on bucks' antlers as defining characteristic to identify individuals, surveys must be conducted sometime from late summer through mid-winter (August to mid-January in Kentucky) while bucks have antlers that allow identification of individuals. The ability to identify individual bucks is the key to the entire method, and without it the estimates will not be accurate.

Conducting a camera survey is not complicated, but it does require an investment of time. First, one must determine how many cameras are needed to adequately estimate the deer herd and the proper placement of the cameras on a property. Research has shown that a two-week survey with one camera per 100 acres will capture photos of about 90 percent of the deer population visiting the baited camera site.

Timing

The timing of the survey is important. Surveys done before hunting season inform hunters about the state of their herd before any harvest takes place. Surveys after hunting season yield information about the herd after harvest has occurred. Surveys conducted during hunting season are a little trickier; they can give inaccurate results since animals could be harvested during the survey period. If conducting the survey before the hunting season, be sure that the bucks have lost their velvet or are far enough along in antler development that the antlers are unlikely to undergo significant changes. Individual buck identification will be more accurate if bucks' antlers have stopped growing.

Kentucky hunting season starts the first weekend in September and offers one of the few opportunities in the country to harvest a velvet buck. While archery hunting has a negligible impact on deer herds compared to other forms of hunting, it would be best to conduct surveys prior to the start of archery season. In Kentucky, antler development should be sufficiently complete by mid- to late July. If conducting the survey after hunting season, make sure bucks still have antlers and are not likely to shed them during the survey period. (In Kentucky that means before the beginning of February.)

Baiting a Site

While it is not necessary to use bait, it will significantly increase the number of deer visiting the survey site(s) and will offer a better chance at capturing a higher percentage of the deer in the area. Bait will also make it easier to identify the individual bucks as often bait will keep bucks around longer, yielding multiple pictures of the antlers at different angles.

Prior to beginning the camera survey, pre-bait the site for five to seven days to ensure that deer are regularly coming into the survey site. Note: Baiting for deer is legal in Kentucky during the recommended survey period (August through January), but other states have further restricted or outlawed baiting of bears, elk, and other animals (sometimes including deer). Check state regulations on baiting prior to starting your camera survey. If an animal that is illegal to bait comes to your camera site, remove all bait from the site and run the survey without bait. Place the camera at the site during the pre-baiting period to help ensure that the camera is set up and working properly before the surveys begins.

Bait can be can be anything that attracts deer, usually salts and minerals or a food source such as corn. Note: Unlike baits such as corn, deer will need more time to find and start using the minerals and salts consistently. Thus, the pre-baiting period with minerals should be longer. Pre-bait by placing a liberal amount of bait at the camera site. During subsequent visits, make sure that there is still bait left at the site when you arrive to re-bait, so that there is always a reliable attractant when deer come to the camera site. If the deer are going through the bait faster than you are visiting your cameras, either add more bait to the site or visit your sites more frequently.

After pre-baiting for the recommended number of days, begin to survey deer. Make sure that each camera has plenty of storage and battery, especially if using bait, as bait can increase the quantity of pictures. Check the camera station every two to four days to re-bait and to check battery life and storage capacity. Re-bait and replace batteries and storage as needed.

Camera Placement

When placing a camera for a survey, the goal is to have an equal probability of capturing any deer that has a home range within the camera survey location. Therefore, divide the land parcel in a grid of 100-acre survey areas. If the property is less than 100 acres, one camera is sufficient. Game cameras should be located toward the center of each grid around areas of high deer activity. Natural funnels and game trails should be taken into account to offer the best chance of capturing the most deer. Sometimes a grid will inevitably fall completely within an agricultural field. If this happens, try to grid the property so that the agricultural field is divided among the different grid areas so that each grid contains at least some deer habitat. As long as the camera density is roughly one camera per 100 acres, the grid can be adjusted slightly to ensure total coverage of the property. If there is no way to adjust the grid so that an agricultural field is not the dominate land cover type in a grid, then the field area can be removed from the survey since deer utilize, but don't live in, agricultural fields.

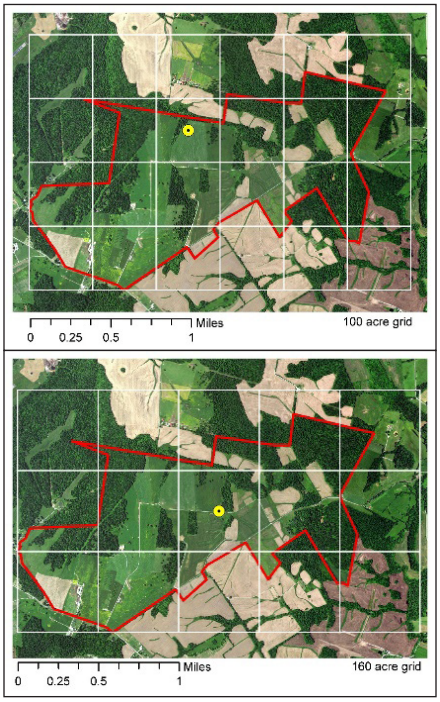

Figure 2. Grid maps of example farm at both one camera per 100 acres and one camera per 160 acres

Cameras should be placed 3 to 4 feet off the ground for deer and approximately 12 feet away from the bait pile or the trail that is under surveillance. Angle the camera so that it looks over the bait pile and not at it; otherwise there is a risk of missing the antlers of a buck if his head is raised. Facing the camera in a northern direction will eliminate exposure to sunlight that can distort pictures. Clear away vegetation to allow an unobstructed view of any animal at the bait. Removing vegetation within the camera shot also reduces the amount of false triggering from vegetation moving in the wind or rain.

Game cameras are typically mounted to trees at least 6 inches in diameter using small bungee cords or rope. If there is no suitable tree available, an artificial mounting post can be created using a fence post or log stuck into the ground. In populated areas or in areas that have bears, specially designed protective security boxes made for game cameras can help prevent theft or damage.

Some people prefer to add a numbered sign or post in each camera shot to ensure that they know from which camera each picture comes. Another alternative is to label the SD cards for each camera. Regardless of the method, keeping track of the source of each picture can be an important factor when identifying individual deer.

Figure 3. Example of camera placement

Data Management

Data management is important when conducting game camera surveys. Surveys can generate large numbers of pictures, especially when using bait at the camera site. To make sure that data can be easily accessed and sorted, have a plan on how to organize the photos before the survey begins. Photo management software is available through some game camera companies, as well as through independent sources; however, management software is not necessarily needed. You can manage photos with a simple system using folders on your computer.

First, make folders into which you will sort your images. Number each station and create folders for each. In each station folder, create subfolders labeled "Doe," "Fawn," and "Buck," and subfolders under "Buck" called "Spike" and "Branched." Sort the photos from each camera station into the categorized folders. With a simple method such as this, you will be able to organize the data the survey generates and ensure accurate data collection and application.

Programming

Programming modern game cameras poses little to no difficulty, as instructions are typically easy to follow and the LED screen offers easy reading and use to set up the desired functions on the camera. For camera surveys, all cameras should be programed the same, usually one still image every 1 to 10 minutes. Video is not typically used for camera surveys. Make sure to program the correct date and time into the camera, as this may be important later in determining individual bucks.

Photo Analysis and Calculation

Camera surveys can yield thousands of images, especially if using bait; therefore, analyzing the photos will be the most time consuming part of the survey. First, combine all the images of deer from each camera together for sorting. Set aside photos without deer in them, or photos of deer that cannot be identified (i.e., just a rump of a deer, or blurry antlers) and do not factor them into the survey. When sorting, separate the images into those with branch-antlered bucks in them and those without. From the group of those that do not have branch-antlered bucks, separate the photos that contain spikes. From the remaining photos, select those that contain fawns. Finally, separate the photos that contain does from the remaining photos. When finished sorting, you should have the following categories of images:

- those with branch-antlered bucks
- those with spike bucks
- those with fawns
- those with does
- those with no deer or only unidentifiable deer in them

For this survey, consider all fawns that have lost their spots to be adult deer; button bucks count as spikes and young females as does. Classifying fawns in this manner will be more useful in a post-season survey than in a pre-season survey. If unsure about the classification of a young deer (i.e., cannot see the buttons on a male fawn), classify it as a doe. The remaining photos that have not been sorted should only contain does.

Take the photos of the branch-antlered bucks and using antler and body characteristics identify as many individual bucks as possible. Identifying features include number of points, relative length of tines, relative positioning of points, antler mass, and angle of point projection. In addition, look at deer pelage (fur) coloration and body characteristics to ensure accurate identification. Assign a unique identifying number to each branch-antlered buck found. Next, count all occurrences of branch-antlered bucks in the pictures and the total occurrences of spike bucks. Because spike bucks can be difficult to identify uniquely, don't worry about determining individuals.

Next, use the total occurrences of spikes and branch-antlered bucks to create a spike buck to branch-antlered buck ratio. Use the equation $P_s = N_{sa} / N_{ba}$ for this this calculation, where P_s is the ratio of spikes to branch-antlered bucks, N_{sa} is the total occurrences of spikes captured in the images, and N_{ba} is the total occurrences of branch-antlered bucks in the images.

Use the spike:buck ratio to calculate the total number of bucks in the population. The equation for this is $E_b = (B \times P_s) + B$, where E_b is the estimated number of bucks in the population and B is the number of individually identified branch-antlered bucks.

Now count the number of occurrences of does in the images from the cameras, and combine the number of spikes and the number of branch-antlered deer so that you have the total occurrences of all bucks. Calculate an estimate for does in the population using all the occurrences of bucks and does in the images with the equation: $P_d = N_d / N_b$, where P_d is the ratio of does to bucks, N_d is the total occurrences of does, and N_b is the total occurrences of bucks (both spikes and branch-antlered combined).

With the number you just found for P_d and the buck estimate (E_b) that was calculated earlier, estimate the total population of deer on your land using the equation $E_d = E_b \times P_d$, where E_d is the estimate for the total deer population within the survey area.

If calculating an estimate when fawns still have spots, the equation $P_f = N_f / N_d$ will give you the ratio of fawns to does, where P_f is the ratio of fawns to does, and N_f is the total number of fawn occurrences in the images. Then use the equation $E_f = E_d \times P_f$ to calculate an estimate for the fawn population, where E_f is the fawn estimate.

A calculation sheet is available in the appendix to help with population calculations.

Choosing a Camera

Megapixels

Megapixels give a picture its sharpness and resolution. The more megapixels that a camera has, the more detail each picture will have. However, high megapixels increase the file size, requiring more storage space on the camera or card. For game cameras, 5 megapixels are more than enough to capture quality images with sharp enough detail to identify individual deer. If high resolution is desired, make sure to have enough memory to store the images on the camera.

Flash Options

Flash allows game cameras to take pictures at night or in low light conditions. Two flash options that are available today are visible flash and infrared flash. Visible flash is the white flash that typical handheld cameras use. As the name implies,

the animal can see the flash, especially at night when no ambient light is present. Infrared, however, usually cannot be seen by the animal, except as a faint red glow. Some blackout models eliminate even this faint light, rendering the light source invisible to both humans and animals.

Each flash has several advantages and disadvantages. Visible flash has the advantage of being able to take color photos at night and have increased nighttime resolution compared to infrared flash. However, it can increase the likelihood of the camera being located and stolen, since the flash will give away its location. Infrared flash has the advantage of being virtually undetectable when it takes a picture, especially if the camera is equipped with a blackout function. The downside to infrared is that images taken at night are in black-and-white. This can make it more difficult to identify individual bucks using multiple features because their pelage (fur) color and some pattern characteristics can become unrecognizable in the black-and-white images. In addition, as mentioned above, nighttime images captured with infrared flash are of lower resolution. Regardless of the choice of flash type, make sure that the camera has an effective flash range of 50 feet, so that it can easily capture nighttime images of deer 25 feet away.

Triggering and Timing

Triggering simply means that the camera takes a picture. Game cameras are classified into two triggering categories—passive and active. Active cameras are time-lapse cameras that take pictures at a constant interval. This is useful when monitoring a particular place for time windows of use, but for camera surveys, this type of camera will often generate too much data, making it time consuming to sort through to find useful images. Consequently, most camera surveys use passive-triggering mechanisms such as motion-sensing cameras that only take a photo when the sensor is triggered by motion.

Timing refers to the delay between camera triggers. On active cameras, timing is the interval between pictures being taken. On passive cameras, it refers to the time lapse between a picture being taken and the motion sensor triggering for the next image. Camera time delay intervals should be set anywhere between 1 and 10 minutes. The most important part is that all cameras in your survey are set for the same time interval.

Video Function

While all cameras are equipped with picture functions, video capabilities are increasingly common. Still images are used for the camera survey, but the video function can be used outside of the survey to capture animal behaviors, such as deer social interactions. This function is not necessary to conduct a population survey.

Storage and Memory

Cameras now use external storage in the form of secure digital (SD) cards. SD cards offer a compact size with a large storage capacity for a cheap price (64 gigabytes [GB] for around $20). Once purchased, an SD card can be used an almost infinite amount of times to collect data. With only a few gigabytes of storage, SD cards can store thousands of pictures (depending on megapixels) without ever having to be replaced.

Memory is probably the most important thing to consider when purchasing a game camera or an SD card for it. A large memory capacity will enable storage of a large quantity of data on the camera. Too small a data capacity runs the risk of filling up the storage before the survey is complete. Some game cameras are equipped with internal storage, but most require an external memory device such as an SD card. When purchasing an external memory device, buy one that has at least 8 gigabytes to ensure that the storage capacity does not fill up during the survey. However, if a camera has high megapixels (8 or greater), each individual image will use up more space, so more storage is required.

Battery Options

Battery life on cameras will depend on a few factors such as weather conditions, the programming of the camera (i.e., video or still image), and how often the camera is triggering. The more images the camera captures, the more battery it uses, so make sure that it is only photographing animals.

Some game cameras have ports to attach external batteries or charging devices, such as solar panels, but game cameras today most often run on internal batteries. Internal batteries are usually AA but can be C or D cell batteries, especially in older camera models. Choosing the appropriate batteries to use in a game camera is an important part of the system. Both disposable batteries and rechargeable batteries will work for game cameras; although rechargeable batteries have the advantage of reuse, they also have poor performance in cold weather conditions. In winter they will have to be monitored more closely; however, if weather permits, the rechargeable batteries will save money in the end. During the camera survey make sure to check your batteries every time you re-bait, and replace them if the batteries get below 25 percent.

Conclusion

While camera surveys can generate valuable population information for the average landowner or hunter, they are not the magical tool to manage deer herds. Camera surveys are just *another* tool to help assess population dynamics and characteristics during a snapshot in time. Camera surveys do not give the true population of deer for a property but rather an *estimate* of the true population. Deer captured in these camera surveys merely have a home range that overlaps the property during the survey period. Free-ranging deer move across the landscape depending on resources and the time of year and can suffer mortality due to various natural causes. While inferences can be derived from camera surveys, they do not account for the entire picture of the deer population across a landscape, guarantee deer residence on a property, or make predictions of deer health or survival. Camera surveys do provide indices of the deer population on your property, which can help inform localized management decisions over time; however, there is still a need to rely on wildlife agencies collecting harvest and other data to create the best management plans for the deer herd at large.

Camera surveys give a practical and affordable instrument to hunters and land managers to help assess and manage

deer populations on their land. Conducting camera surveys can be exciting and fun as one pieces together the data to create management goals for the upcoming season. In addition, camera surveys help evaluate existing management goals or even help to influence long-term goals for a local deer herd.

Tips for a Successful Camera Survey

- Test the camera in the field to be sure that it is taking pictures correctly. If possible, view the pictures in the field before starting the survey to be sure that the camera is placed properly.
- Make sure that the date and time displayed on the camera are correct so that you can easily categorize the data later.
- Open backgrounds, such as fields, can often reduce the quality of the images at night. Therefore, conduct surveys in an area with a closed background, such as an area with trees. However, be careful that the background is not too close to the camera as the images can become distorted by the flash at night, making identifying animals difficult.
- Use aerial images of the survey location to determine funnels and natural travel corridors in which to place the game cameras. (This strategy can also be effective in finding good spots for hunting locations as well.) Aerial images can be obtained easily from online mapping applications such as Google Earth.
- If using multiple cameras (i.e., the survey area is greater than 100 acres), use numbered signs by each bait pile to ensure quick, accurate identification of where each image was taken.
- Spread the bait into a wide U shape (rather than piling it up) to allow for less competition if multiple deer are feeding at once. Place the bend in the U at the furthest point from the camera so that the deer are likely to be facing the camera as they feed. This should help capture good pictures of bucks' antlers.
- Beware of areas that are prone to have early morning fog, such as creek bottoms, as this can hinder data collection in the early morning hours. Camera lenses can collect condensation that blurs images or the fog can reduce the visibility of the site. To reduce rain or condensation issues, coat the camera in a water repellant product.

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	Jacobson Camera Survey Data Entry Sheet by Camera						
	Total Occurrences of Spikes	**Total Occurrences of BA Bucks**	**Total Occurrences of All Bucks (Spikes + BA Bucks)**	**Number of Unique Branch Antlered Bucks**	**Total Occurrences of Does**	**Total Occurrences of Fawns**	**Total Occurrences of Identifiable Deer (Total All Buck Occurrences + Doe Occurrences + Fawn Occurrences)**
Camera 1							
Camera 2							
Camera 3							
Camera 4							
Camera 5							
Camera 6							
Camera 7							
Camera 8							
Camera 9							
Camera 10							
Totals							

* An occurrence is each time a deer appears in a photo (i.e. an image with 5 does has 5 occurrences of does)
**BA Buck = Branch Antlered Buck

Calculation Sheet for Deer Population Estimate

SPIKE:BA-BUCK Ratio **(Spike Occurrences / BA-Buck Occurrences)** $P_s = N_{sa} / N_{ba}$
BUCK ESTIMATE **((Unique BA Bucks* Spike:BA-Buck Ratio) + Unique BA-Buck Number)** $E_b = (B \times P_s) + B$
DOE:BUCK **(Occurrences of Does / Total Occurrences of Bucks)** $P_d = N_d / N_b$
DOE ESTIMATE **(Buck Estimate * Doe:Buck Ratio)** $E_d = E_b \times P_d$
FAWN:DOE **(Occurrences of Fawns / Occurrences of Does)** $P_f = N_f / N_d$
FAWN ESTIMATE **(Doe Estimate* Fawn:Doe Ratio)** $E_f = E_d \times P_f$
Total Deer Number Estimate **(Bucks + Does+ Fawns)** $E_b + E_d + E_f$

Issued 8-2019