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Doe and fawn group photographed by an infrared-triggered camera.

Infrared-triggered cameras for censusing white-tailed deer

Harry A. Jacobson, James C. Kroll, Randy W. Browning, Ben H. Koerth, and Mark H. Conway

Abstract Deer management often is hindered by lack of public acceptance and confidence in census methods. Because "seeing is believing," a method relying on photographic documentation could provide a powerful tool for deer managers. The purpose of our study was to determine if infrared-triggered cameras could be used for population estimation of free-ranging antlered white-tailed deer (*Odocoileus virginianus*) in a forested environment. Subsequently, we evaluated feasibility of using such estimates in conjunction with demographic ratios for population estimation. We used infrared-triggered cameras and monitors to census white-tailed deer on Longleaf Farms, a 4,047-ha area in Amite County, Mississippi. Two 14-day censuses were conducted, 1 in February 1992 and 1 in February 1993. Passive infrared monitors that triggered automatic cameras were used to photograph deer; previously marked deer in the photographs provided recapture data. We derived population estimates from photographs using Lincoln–Petersen Index estimates from marked and unmarked animals, and from a separate technique we termed the camera estimate. The camera estimate was calculated by determining the total numbers of branch-antlered bucks, spike bucks, does, and fawns in photographs, then determining the number of individually identifiable branch-antlered bucks and, from ratios, the number of spike bucks, does, and fawns. Camera densities tested included 65, 130, and 259 ha per camera. With the highest camera density (1/65 ha), 30 of 30 collared deer (100%) were

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recaptured in 1992 and 30 of 34 (88.2%) were recaptured in 1993. Camera estimates using ratios of spikes, does, and fawns to branch-antlered bucks yielded population estimates of 715 and 580 deer for 1992 and 1993, respectively. Lincoln–Petersen estimates yielded 727 and 573 deer for the same respective periods. However, at different camera densities, the sex ratios and Lincoln–Petersen Index population estimates differed significantly ($P \leq 0.001$). There was an inverse relationship between camera density and Lincoln–Petersen Index population estimates. Percent females increased as camera density increased, indicating higher recapture estimates of males over females at low camera densities. Although population and sex-ratio estimates differed among camera-station densities, infrared-triggered cameras are useful tools to census deer in forested environments. Minimally, they provide estimates of adult bucks present. Cost of a 14-day census amortized over a 5-year equipment life expectancy ranged \$0.37–1.29/ha/year depending on camera coverage.

Key words cameras, census, infrared, Lincoln–Peterson Index, mark–recapture, *Odocoileus virginianus*

Management of white-tailed deer (*Odocoileus virginianus*) and other large ungulates often is hindered by lack of reliable, cost-effective, and accurate means of census (Jenkins and Marchinton 1969). Population-estimation techniques applied to white-tailed deer include: drive, spotlight, strip, time-area, aerial, thermal- and infrared-scanning counts; mark–recapture and change-in-ratio estimators; population reconstruction; harvest correlations; and guesses (Downing et al. 1965, Downing 1980).

Indices such as time-area and spotlight, and direct estimates such as drive, strip, aerial, thermal and infrared counts and mark–recapture techniques can be expensive, labor intensive, or limited to habitats with high visibility and lack of dense forest cover (Lancia et al. 1994). Population reconstruction is dependent on past mortality data and does not provide current or predictive population estimation (Hesselton et al. 1965, Lowe 1969, McCullough 1979). Change-in-ratio estimates require preharvest and postharvest population observations from census and removal-harvest data (Hansen 1963, Downing 1980:251, Kroll 1991:172). Therefore, change-in-ratio estimates are limited by accuracy of the data acquisition techniques (Wallmo 1964, Downing et al. 1977, Robinette et al. 1977, Eberhardt 1982).

Infrared-triggered cameras and monitors have been used to study animal behavior (Savidge and Seibert 1988, Woods et al. 1989, Carthew and Slater 1991, Darrow 1993, Guynn et al. 1993, Mason et al. 1993, Foster and Humphrey 1995) and for population census (Mace et al. 1994). Darrow (1993), in evaluating deer response to baiting in Mississippi, photographed radiocollared deer attracted to bait stations in their home ranges. We considered application of this technology to deer census. We tested the hypothesis that infrared-triggered cameras could provide wildlife managers minimum population estimates of free-ranging antlered deer in forest environments. Additionally, we evaluated the feasibility of using such estimates along with demographic ratios for population estimation. Specific objectives were: (1) to determine camera recapture rates of a known number of marked deer, (2) determine the repeatability of counts from photographs of branch-antlered deer by experienced observers, (3) address feasibility (procedurally and economically) of infrared-triggered cameras to estimate numbers of branch-antlered deer and deer populations in a forested environment in Mississippi.

Methods

Study area

Longleaf Farms is a 4,047-ha, privately owned tract, located about 8 km south of Liberty, Amite County, Mississippi. The area lies in the Gulf Coastal Plain physiographic region and is intensively managed for white-tailed deer, wild turkey (*Meleagris gallopavo*), and upland pine. Shortleaf pine (*Pinus echinata*) and loblolly pine (*P. taeda*) are the dominant tree species, managed on a sawtimber rotation. Longleaf pine (*P. palustris*) is present in remnant, unmanaged stands. Spruce pine (*P. glabra*) and mixed hardwoods occur along the Amite River, bordering the property to the east. Hardwood species include water oak (*Quercus nigra*), willow oak (*Q. phellos*), sweetgum (*Liquidambar styraciflua*), and flowering dogwood (*Cornus florida*).

Numerous intermittent streams flow through the study area, draining into the Amite River. Average slopes range from 0 to 35% (Milbrandt 1976). Climate of the region is subtropical, with humid conditions dominating. More than half the annual rainfall occurs during winter, which generally is short in du-

ration. Occasional snowfall accumulations of 5.0–10.2 cm occur during January–March. Mean annual precipitation is 143 cm.

Deer were scarce or absent from this region of Mississippi before 1963 (F. Anderson, Long Leaf Farms, pers. commun.), but since then the herd has expanded. Harvest was bucks-only until 1975 and subsequently has been liberal either-sex harvests. In 1983, the owners initiated a management program emphasizing production and harvest of mature bucks (≥4 yrs). During 1983–1993 the mean annual harvest of bucks and does was 26 and 95, respectively.

Habitat management included planting about 1% of the property in agricultural crops with mixtures of small grains and clovers. Silvicultural treatments to benefit wildlife and timber included prescribed burning, commercial thinning, and other intermediate treatments.

Deer capture and radiotelemetry

Deer were captured by drop-net (Ramsey 1968) or telemetry dart (Lovett and Hill 1977) and marked with color-coded collars for individual identification as part of an on-going mortality and telemetry study conducted by Mississippi State University and Mississippi Department of Wildlife, Fisheries, and Parks. All radiocollars were equipped with mortality sensors set with a 6-hour delay (Advance Telemetry Systems, Isanti, Minn.).

Deer were located ≥4 times monthly during the mortality study and daily during camera censuses. Visual observations or triangulation by azimuths with a TR-2 receiver and a hand-held R-2AH antenna (Telonics, Mesa, Ariz.) were used to estimate deer locations within a 16-ha block. A developed road system made it possible to locate animals accurately in individual grids. Tests of telemetry observer ability to locate radiocollars within the correct block of Longleaf Farms were evaluated with transmitters placed in locations unknown to the observer on 6 occasions. In each case, the observer (who took all telemetry locations during our study) located test transmitters within the correct block. These accuracy determinations were part of a test involving several study areas and observers, where an overall observer accuracy of 83% (n = 41 transmitter locations) was obtained for location of transmitters within their same block, and 98% accuracy was obtained for location within the same or an adjoining block (Morgan 1995).

Camera monitors

The 4,047-ha tract was overlaid with a 16-ha block grid and 49 camera stations (Fig. 1) systematically spaced in alternate blocks. Monitors were located near the center of each grid but subjectively placed to provide ease of access and likelihood of visitation by deer.

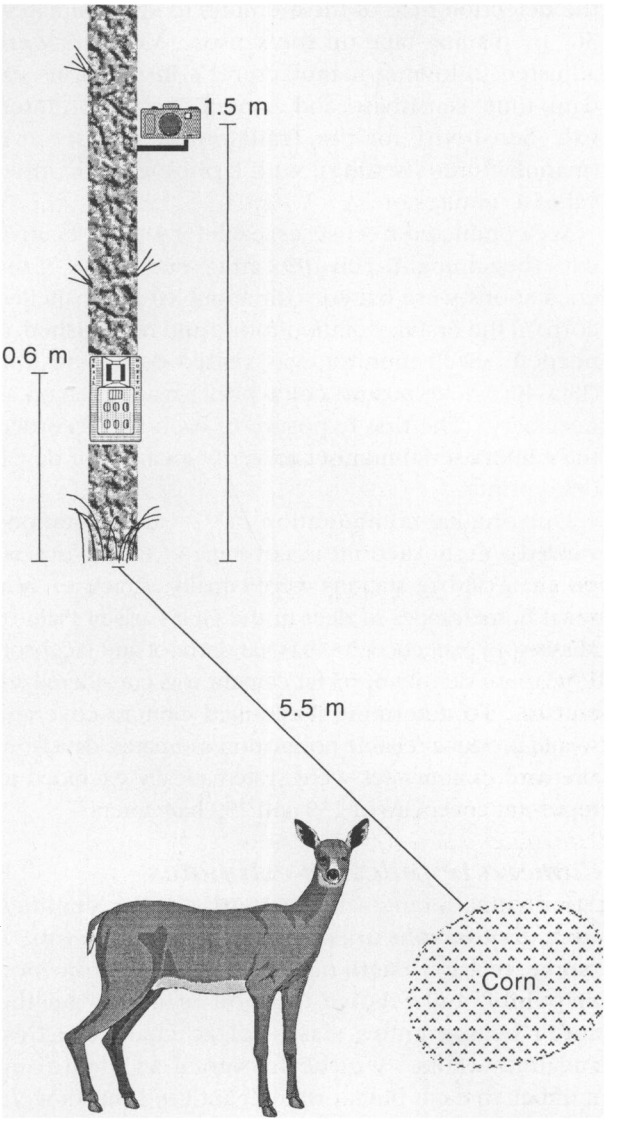


Fig. 1. Camera and monitor station used for photographic census of white-tailed deer, Longleaf Farms, Amite County, Mississippi, 1992–1993.

A TM-2500 TrailMonitor® (Gryphon Engineering, Inc., Richmond, Mich.) was used to trigger an Olympus Infinity Twin® 35mm camera (Olympus America, Inc., Denver, Colo.). Each camera was outfitted with a data back (exposure date and time) and automatic flash and frame advance. The TrailMonitor is a passive infrared sensing device with a normal detection coverage of 90°, sensitive to motion within 15 m. We positioned monitors so that an animal approaching the bait would trigger the camera. To ensure cameras would not be activated until the target animals were in the photographic field, we reduced

the detection field of the monitors to approximately 30° by placing tape on the sensor. Monitors were adjusted following manufacturer's instructions for date, time, sensitivity, and camera's activation interval. Sensitivity for the TrailMonitor was set at 6 (manufacturer's setting), with a photographic interval of 4 minutes.

We conducted 2 censuses, each for 14 consecutive days (beginning 21 Feb 1992 and 3 Feb 1993). Camera stations were baited with about 10 kg of shelled corn on the first day of monitoring and replenished as needed. Each monitor was visited daily, and film (ISO 400, 36-exposure color print) was replaced as necessary. The first exposure of each roll recorded the camera serial number to verify location of developed prints.

Our original configuration of 49 camera stations yielded an estimated mean coverage of 65 ha/camera, assuming all bait stations were equally attractive. Seasonal home ranges of deer in the Gulf Coastal Plain of Mississippi exceeded 200 ha (Vanderhoof and Jacobson 1993), so a density of 65 ha/camera was considered adequate. To determine if reduced camera coverage would produce reliable population estimates, data from alternate camera sites were systematically excluded to represent coverages of 130 and 259 ha/camera.

Camera population estimates

Individual branch-antlered bucks were identified from photographs using antler configuration (no. of points, relative length of points, angle of projection of points, and relative location of points on the antler beam), antler mass, pelage characteristics, and body traits. We then assigned an identifying number to each buck. Branch-antlered bucks were any bucks with ≥1 branched antler. An 8X magnifying loupe and a magnified lamp were used in identifying animals. Photographs were excluded from analysis when identification of an animal was uncertain.

Spike-antlered bucks were difficult to distinguish individually; therefore, spike:branch-antlered ratios were determined and the estimated total buck population calculated using this ratio; i.e.,

$$P_s = N_{sa}/N_{ba},$$

where

P_s = ratio of spike:branch-antlered bucks,
N_{sa} = total number of spike-antlered deer occurrences in photographs,
N_{ba} = total number of branch-antlered deer occurrences in photographs,

and

$$E_b = (B \times P_s) + B,$$

where

E_b = estimated total buck population,
B = number of individually identified branch-antlered bucks.

The estimated doe population was calculated using the estimated buck population and the buck:doe ratio, calculated from the photographs; i.e.,

$$P_d = N_d/N_b,$$

where

P_d = ratio of does:bucks,
N_d = total number of antlerless adult deer occurrences in photographs,
N_b = total number of antlered adult deer occurrences in photographs,

and

$$E_d = E_b \times P_d,$$

where

E_d = estimated total doe population.

The fawn population was calculated in the same manner; i.e.,

$$P_f = N_f/N_d$$

where

P_f = ratio fawns:does,
N_f = total number of fawn occurrences in photographs,

and

$$E_f = E_d \times P_f,$$

where

E_f = estimated total fawn population.

The population size was estimated by summing each segment of the population and is hereafter referred to as the camera estimate.

To examine the repeatability of our methods and accuracy of the number of individual branch-antlered bucks identified, we conducted a test on 100 photographs, taken at 3 adjacent camera stations in the February 1992 census. Five experienced observers (≥2 yrs of professional experience observing white-tailed deer) counted the number of branch-antlered males, and total number of spike-antlered males, does, and fawns in the photographs. At that time of year, fawns no longer have spots, so observer ability to judge age of photographed deer was critical. We calculated buck:doe, doe:fawn, and branch-antlered:spike buck ratios and an estimate of population size for each observer.

Mark–recapture population estimate

In addition to camera estimates, population size was estimated for all camera-coverage areas using the Lincoln-Petersen Index for mark-recapture data (Overton 1969:434). We used the Lincoln-Petersen Index instead of more recent, specialized mark-recapture programs such as JOLLY, RELEASE, or CAPTURE (White and Clark 1994) because deer were captured by photograph. When a photograph con-

stitutes capture, the animal is not marked permanently. Thus, more specialized programs currently do not accommodate photographic captures. Separate Lincoln-Petersen Index estimates were determined on 2-day intervals with 95% confidence intervals calculated using Overton's (1969:435) equation. A mean Lincoln-Petersen Index estimate was calculated at the end of each 14-day session. Friedman Rank Sum Analysis (Hollander and Wolfe 1973) was used to evaluate the effect of census period and camera coverage on ratio (buck:doe, doe:fawn, branch-antlered:spike) and number of branch-antlered bucks and population estimates. Fisher's exact test (Sokal and Rohlf 1969) was used to evaluate effect of sex and capture technique on photographic capture of marked deer at bait sites. Significance levels were tested at the 95% confidence level.

This project was approved by the Mississippi State University Institute Animal Care and Use Committee. Protocol number was 90-006.

Results

From 23 October 1990 to 8 December 1992, 39 adult males were captured (drop-net = 37, telemetry dart = 2) and radiocollared. Three yearling males were captured by drop-net and marked with color-coded collars. In addition, 11 females were captured (drop-net = 6, telemetry dart = 5) and radiocollared, and 6 females were captured by drop-net and marked with color-coded collars. We obtained 1,584 and 4,617 photographs in February 1992 and 1993, respectively. We individually identified 142 and 155 branch-antlered males from photographs in February 1992 and 1993, respectively (Table 1). Eight of 39 deer captured prior to February 1992 died, and 1 deer left the study area before the census period. Of the 30 deer present in February 1992, 100% were photographed by the camera monitors. Of 34 marked deer present in February 1993, 30 (88.2%) were photographed. In 1993, 22 of 23 (96.7%) marked males were identified (Table 1). The single exception was a yearling male without a transmitter whose presence could not be determined. During the same census, 3 of 4 (75%) marked females with no transmitters, and 5 of 7 (71.4%) radiocollared females were identified.

Friedman rank sum tests showed the number of branch-antlered bucks identified significantly decreased ($P \leq 0.001$) as camera coverage decreased (Table 1). Buck:doe ratios also decreased ($P \leq 0.001$) as camera coverage decreased. Significant differences were noted in doe:fawn ($P \leq 0.001$) and branch-antlered:spike ($P \leq 0.001$) ratios relative to camera coverage in 1992 but not in 1993. Based on ratio estimators of spikes, does, and fawns to identifiable branch-antlered buck estimate, camera population estimates of 715 and 580 deer were obtained for February 1992 and 1993, respectively (Table 1). These estimates compared favorably to Lincoln-Petersen mark-recapture estimates of 727 (95% CI 612-865) and 573 (95% CI 524-603) deer for the same respective sampling periods. However, we noted decreases ($P \leq 0.001$) in camera population estimates and increases ($P \leq 0.001$) in Lincoln-Petersen Index population estimates, relative to decreasing camera coverage (Table 1).

Table 1. Deer population estimates for Longleaf Farms near Liberty, Mississippi, in February 1992 and 1993 from infrared camera monitors.

	Camera coverage (ha)			Friedman rank statistic[a]
	65	130	259	
1992 census				
No. marked bucks[b]	29/30[c]	24/30	17/30	
No. marked does[b]	1/1	1/1	0/1	
Buck:doe ratio	1:1.47	1:1.20	1:1.03	26.1 (0.001)
Doe:fawn ratio	1:0.65	1:0.63	1:0.58	19.0 (0.001)
Branched:spike	1:0.47	1:0.60	1:0.53	19.0 (0.001)
No. branch-antlered	142	104	77	28.0 (0.001)
Population estimates				
Photos marked/unmarked	134/3,248	87/1,921	33/1,087	
Camera estimate	715	490	309	28.0 (0.001)
Lincoln–Petersen estimate	727	662	988	21.0 (0.001)
1993 census				
No. marked bucks	22/23	20/23	12/23	
No. marked does	8/11	5/11	1/11	
Buck:doe ratio	1:0.70	1:0.62	1:0.57	26.1 (0.001)
Doe:fawn ratio	1:1.31	1:1.24	1:1.31	8.6 (0.07)
Branched:spike	1:0.43	1:0.51	1:0.58	8.6 (0.07)
No. branch-antlered	155	118	67	28.0 (0.001)
Population estimates				
Photos marked/unmarked	534/8,991	256/4,632	102/2,160	
Camera estimate	580	424	245	28.0 (0.001)
Lincoln–Petersen estimate	573	615	720	21.1 (0.001)

[a] $P <$ value in parenthesis ($k = 3$, $n = 14$).
[b] Number photographed/number present prior to census.
[c] One of these deer left the study area and was not available for recapture.

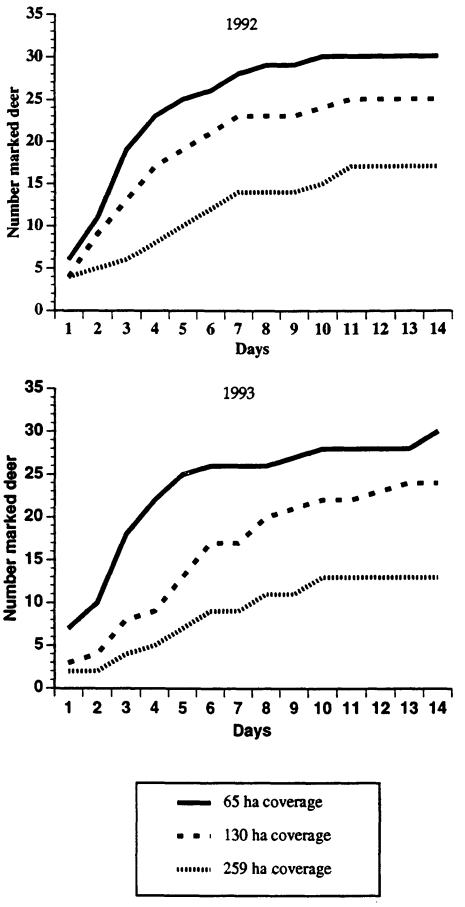


Fig. 2. Cumulative catch rates for marked deer on Longleaf Farms using 3 densities of infrared-triggered cameras in Amite County, Mississippi, February 1992 and February 1993.

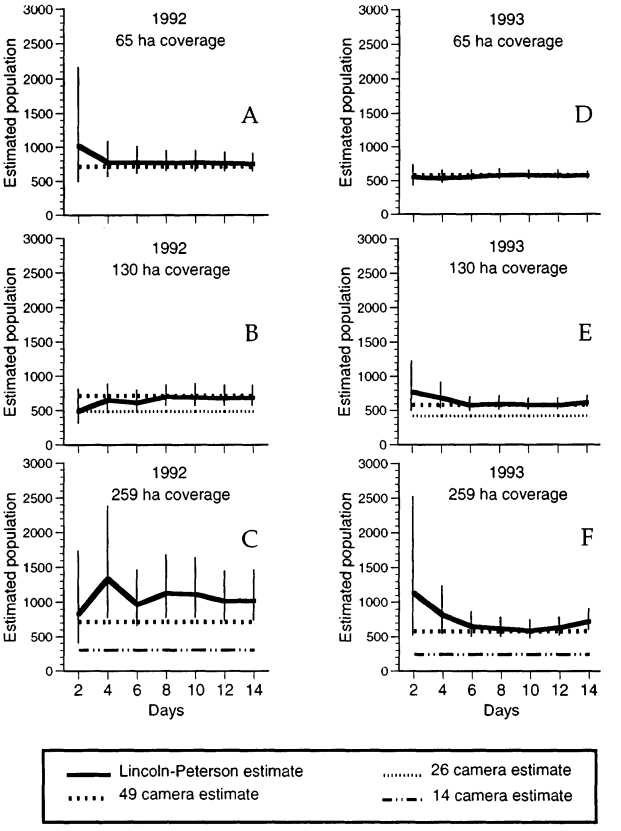


Fig. 3. (A–F) Estimated deer population based on Lincoln–Petersen Index and 3 densities of infrared-triggered cameras on Longleaf Farms, Amite County, Mississippi in February 1992 and February 1993. Vertical bars indicate 95% confidence limits on Lincoln–Petersen estimates.

Cumulative catch rates stabilized by Day 11 (Fig. 2). All camera coverages (65, 130, and 259 ha) produced stable Lincoln-Petersen Index population estimates, as evidenced by high overlap between 95% confidence intervals, after 4–6 days of sampling (Fig. 3). Coverages of 65 and 130 ha appeared most reliable because 95% confidence intervals for all mark-recapture calculations included the highest density (1/65 ha) camera estimates (Fig. 3A–D). Lincoln-Petersen Index confidence intervals under camera coverages of 1/259 ha did not overlap any camera estimate by Day 14 (Fig. 3E–F).

Estimates of branch-antlered bucks, population ratios and size were similar for experienced observers with estimates of 13–15 ($\bar{x}$ = 13.8) branch-antlered bucks, and 39–45 ($\bar{x}$ = 42.4) total animals from the sample population of 100 photos (Table 2).

Two concerns arose during this study. First, there was a possibility for a sex bias in our procedures. We recaptured 22 of 23 (96.7%) males in 1993; the exception was a yearling male that may have left the area. In contrast, we recaptured 8 of 11 (72.7%) females. When examined by Fisher's exact test, this difference for photographic recapture of marked deer by sex was not significant (P = 0.30). The second concern was a bias from capture technique. Because more males than females were captured by baiting, the higher recapture rate for males may have resulted from greater susceptibility to baiting.

To examine for capture-technique bias, we partitioned the number of males and females captured by each technique, and the number recaptured at monitor stations (Table 3). Only the 1993 data provided sufficient degrees of freedom for statistical analysis. Although sample sizes were small, when examined by Fisher's exact test there was no apparent relationship between male and female response to camera stations whether caught by drop net or telemetry dart (P = 0.96). Hence, males and females appeared equally attracted to bait, irrespective of capture method. However, there may have been a sex bias inherent to our experimental design stemming from the density of monitor stations. Estimated buck:doe ratios for 1992 and 1993 censuses (Table 1) showed a precipitous decline in number of females recorded

Table 2. Interpretations by experienced observers for 100 photographs of white-tailed deer taken by infrared-triggered cameras on Longleaf Farms, Amite County, Mississippi, February 1992.

Observer[a]	Total branch-antlered bucks	Ratios			Estimated number of deer
		buck:doe	doe:fawn	branch:spike	
Observer 1	13	1:0.67	1:0.72	1:0.45	41
Observer 2	14	1:0.79	1:0.70	1:0.34	44
Observer 3	14	1:0.63	1:0.86	1:0.51	45
Observer 4	13	1:0.63	1:0.85	1:0.39	39
Observer 5	15	1:0.67	1:1.03	1:0.28	43
Mean	13.8	1:0.67	1:0.83	1:0.39	42.4

[a] Observers had ≥2 years professional experience observing white-tailed deer.

and highly significant ($P < 0.01$) changes in buck:doe ratios as camera density decreased (i.e., from 1/65 to 1/259 ha).

Discussion

For a census technique to be useful, it must be unbiased, precise, and cost-effective. Most studies on deer census techniques are limited by lack of a population in which the number of animals is known to compare with the population estimate. Although our study was based on an open population of an unknown number of deer, our findings suggest at the highest camera-station density (1/65 ha) we obtained a close estimate of the true population. We photographed 100% of all marked deer available in 1992 and 88.2% of marked deer in 1993. Population estimates for 1992 and 1993, derived from camera and Lincoln-Petersen Index calculations, were similar for both years and methods (Table 1). Camera estimates for February 1992 and 1993 differed by 1.6% and 1.2% from Lincoln-Petersen Index estimates, respectively. Although the assumption of a closed population inherent to the Lincoln-Petersen Index was not met in our study, only 1 of 50 radiocollared deer left the study area. Additionally, we conducted each census during a relatively short time (14 days), in a month when dispersal was not expected. Thus, we believe there was no serious violation of a closed-population assumption in our study.

Probably the most critical factor in our population estimation by camera was accurate identification of individual branch-antlered bucks. Population estimates depended on number of individual branch-antlered bucks and sex and age ratios. Trained observers varied little in their estimates of these. We found antler, pelage, and body parameters provided unique profiles of individual branch-antlered deer. Hence, we feel our procedures are repeatable.

We believe differences in capture rates of males and females at different camera densities relate to differences in the size of home ranges used by males and females. Because home-range size of male white-tailed deer is typically twice that of females (Progulske and Baskett 1958, Mott et al. 1985, Scanlon and Vaughan 1985, Kroll 1991:128, Vanderhoof and Jacobson 1993), at low camera density, males are more susceptible to capture than females. Further research should address whether higher densities of cameras (<1/65 ha) would influence capture rates.

High population estimates for Lincoln-Petersen Index at low camera densities may be related to proportional differences in male and female capture rates. Both male and female recapture proportions declined as the density of camera stations declined, but males were recaptured in higher proportions than females at low-density camera stations. Marked deer also would be expected to have higher recapture rates at high rather than low camera densities because repeat photographs are more probable within the core area of an animal's home range than at the periphery. These factors likely inflated Lincoln-Petersen Index population estimates at camera densities of 1/259 ha. In 1992, a higher proportional increase for the 1 cam-

Table 3. Relationship between capture method and recapture of deer by infrared-triggered cameras on Longleaf Farm, Amite County, Mississippi, 1992–1993.

Sex / Marking method	Drop-net				Telemetry dart			
	Number caught		Number photographed		Number caught		Number photographed	
	1992	1993	1992	1993	1992	1993	1992	1993
Males								
Transmittered	26	20	25	20	1	2	1	2
Nontransmittered	3	1	3	0				
Females								
Transmittered	1	4	1	3		3		2
Nontransmittered		4		3				

era/259 ha Lincoln-Petersen Index estimate was seen than in 1993 (Fig. 3E-F). This would seem unlikely because a greater proportion of marked deer were actually seen in the 1992 census (17 of 31) than in 1993 (13 of 34). However, the difference may be explained by the proportion of marked deer in the sample of photographs. With the 1/259 ha camera coverage, 33 of 1,087 (3.0%) of the photographs of deer were marked in 1992, compared to 103 of 2,160 (4.7%) of the photographs in 1993.

The high buck:doe ratios (1:0.43-1.47) we observed at Longleaf Farms were atypical of most hunted-deer populations and suggest a potential bias in capture rate of males over females. However, we believe the high buck:doe ratios were most likely a reflection of the average annual harvest of only 26 males compared to 95 does since 1983, skewing sex ratios in favor of bucks. In 1992, 140 does and 52 bucks were harvested, which could account for the change in sex ratios between the 2 years of the study.

We conducted a simple economic analysis for sampling the 4,047-ha study area at 65-, 130-, and 259-ha coverages. Average cost of the devices we used was about $400/unit, and cost of film and processing averaged $0.42/photograph. Cost of a 14-day census ranged from $1.47 to $5.16/ha, depending on coverage. With a 5-year equipment life-expectancy, cost ranged from $0.37 to $1.29/ha/year.

Management implications

Our data demonstrate that census of adult bucks can be reliably and accurately obtained using infrared-triggered cameras. We were successful in using these devices to "recapture" >96% of marked bucks and >72% of marked does on the study area. At the camera densities tested, we found evidence for a sex bias in the ratio of bucks to does photographed at bait stations, with does less likely to be accounted for than bucks at low camera densities. Our results, demonstrating significant sex-ratio differences at different densities of bait stations, may have implications for mark-recapture studies in general. Before population estimates are made from mark-recapture data, the relationship between trap density and sex-related vulnerability to trapping should be examined. Additionally, possible bias for adult:fawn ratio estimates should be considered. Further study is needed on the relationship of this technique to other population-estimation procedures. Application of this technique to other geographic areas and species, using different baits, and estimating the effects of seasonal variation on the results is needed. Additional research could evaluate whether the technique has wide application and can be modified for use as an index to deer populations on a regional or state-wide basis.

The usefulness of infrared-triggered cameras for providing information for deer management has been debated by Rice (1995) and Kucera and Barrett (1995). We used equipment that was similar but from a different manufacturer than that used by these authors. Like Kucera and Barrett (1995), we found that these devices can be effective and reliable tools for research and management.

We believe infrared-triggered cameras have the potential to provide reliable estimates of white-tailed deer populations in dense woodland habitats. At the least, they provide a means of obtaining a minimum estimate of adult bucks present in a population. They also provide data on sex and age composition. Lack of public acceptance of census results often hinders deer management. Seeing is believing, so a census method based on photographs could provide a powerful tool to deer managers.

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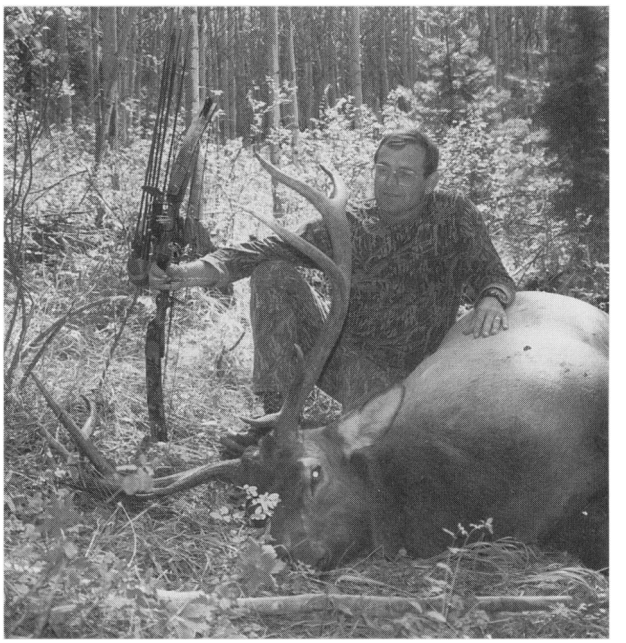
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Harry Jacobson suggested the following quote to accompany his photograph, "The prey must have the predator, just as the predator needs the prey. One without the other eventually becomes something less. The wolf becomes the dog. The deer becomes a cow. And what does man become?" (Larry Marchington, address to keepers of the hunting spirit, Melbourne, Australia, June 1991).

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