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Harvest management of game species for the purpose of maintaining or manipulating populations requires estimation of at least 3 population parameters: population size (density), recruitment, and mortality. Knowledge of these parameters is important because hunters, as well as anti-hunters, and the general public call for managers be able to defend their management activities (Lancia et al., 2000). Managers most often use indices, such as number of deer observed per unit distance driven during a spot-light survey, in place of population parameters. In doing so, the assumption is made that a constant, linear relationship exists between the index and the population parameter of interest (Lancia et al., 1996). Use of such indices is based on tradition, simplicity, and low cost. However, few indices have been validated (Rotella and Ratti, 1986), and none serve as a perfect substitute for population parameter estimation.

Different approaches are available to estimate density, recruitment, and mortality (Johnson, 1996; Lancia et al., 1996). Density estimation has been conducted using mark-recapture techniques (Peterson, 1896; Lincoln, 1930; Bartmann et al., 1987), distance sampling (Buckland et al., 1993), area sampling (Seber, 2002), and removal techniques (Zippin, 1958; Lancia et al., 1988). For white-tailed deer in the southeastern U.S., density estimates are most often derived using mark-recapture approaches, but distance sampling is becoming more widely used (Langdon, 2001; Lopez et al., 2004). Area sampling, which is most commonly used for large ungulates in the western U.S., is not very applicable in the southeastern U.S. due to limited visibility using traditional techniques (e.g., helicopter surveys). However, advances in the use and technology of thermal infrared imagery are changing the ability to employ area sampling during leaf-off conditions in deciduous hardwood areas of the Southeast.

Recruitment is typically estimated using a sex/age ratio approach (Downing, 1980; Ginnett and Butch-Young, 2000). Population size is estimated and an independent estimate of the number of young per adult female (e.g., fawns/100 does) is applied to the population estimate. The manner in which the ratio is obtained varies depending upon location. Spotlighting is most commonly used to obtain ratios in the southeastern U.S., whereas visual aerial surveys are used in the western U.S.

Estimation of mortality is directly provided by radio-telemetry (Lancia et al., 2000). Mortality estimation using radio-telemetry, however, requires a great amount of time and is financially expensive. Most mortality of white-tailed deer is due to harvest (Dusek et al., 1989), and harvest is usually used as an index to mortality.

Population-parameter estimation has not been used often by managers for white-tailed deer in Arkansas. With implementation of new management strategies for white-tailed deer or acquisition of new properties, baseline data that includes population parameters are useful to determine the efficacy of the management strategies employed. The Arkansas Game and Fish Commission (AGFC) purchased a new property, the Choctaw Island Wildlife Management Area (CIWMA), in October 2001. The deer population was not hunted for 2 seasons following the purchase. The first hunting season under the direction of the AGFC was during fall 2003. Because the CIWMA was a newly acquired wildlife management area, AGFC desired baseline data for white-tailed deer management. Our objectives were to 1) estimate winter deer density on Choctaw Island Wildlife Management Area, and 2) determine if the population was reduced based on harvest.

The study was conducted on the CIWMA located in Desha County, Arkansas (Lat. 33°35′ 47″ N, Long. 91°11′20′ W). The CIWMA was approximately 3268 ha in size and lies within the levee of the Mississippi River. The area was divided into two parts, the mainland (2361 ha) and an island (907 ha) in the Mississippi River, but was managed as one property and one population. Topography was flat and elevation ranged from 33.5 to 46.0 m. The entire area was subject to seasonal (winter-spring) flooding. Cover types were bottomland hardwood forests, cottonwood (*Populus deltoides*) plantations, open fields, and food plots. Dominant tree species were oaks (*Quercus* spp.), pecan (*Carya illinoensis*), and cottonwood. Mean total precipitation for February and March was 13.34 cm and 13.46 cm, respectively. The mean minimum temperature during February and March was 2°C and 6.5°C, respectively (Dermott, AR, Station 031962).

Non-overlapping, parallel transects were established and surveyed from a Cessna 182 fixed-wing aircraft. Transects were approximately 400 m apart. The site was surveyed once each night on 8 and 9 March 2003 and on 20, 21, 22, and 27 February 2004. Flights were conducted at approximately 457 m above ground level (AGL), and height AGL was maintained using an on-board altimeter; resulting strip transects were approximately 110 m wide. Flights were conducted between 2000 and 2300 hrs in 2003 and between 2300 hrs and 0600 hrs in 2004. Flights were conducted at different times the second year in an attempt to maximize the detection of thermal signatures. Flight paths (lat., long., WGS84), altitude (ft), speed (mph), date and time were collected by an onboard Global Positioning System (GPS) unit. The GPS signal was routed through a video encoder-decoder (VED). Locations of the plane obtained from the GPS unit were recorded on the audio portion of the video tape. The VED continuously labeled the video tape with position, time, date, speed, and altitude information.

Surveys were conducted using an IR-M700 thermal infrared imager (Mitsubishi, Inc., Ontario, Canada) with a 50 mm lens mounted in the belly of the plane in a fixed, vertical position. Wavelengths ranging from 1.2 to 5.9 _m were used. The detector array size was 801 x 512 pixels with a sensitivity of 0.08 oC. Output was conducted through an RS170, 75 _ connection to a digital video camera (Sony DCR-TRV1000). Video was reviewed using a 33 cm, 1000 line resolution, black and white monitor (Sony PVM-137).

We used area sampling to estimate deer density in the CIWMA. The assumption made when using area sampling is that all animals are detected within the area surveyed. A high rate of detection (94%) was reported for thermal targets in associated research (Kissell and Tappe, 2004). The number of deer observed in each strip transect was recorded. Double counting was prevented by use of GPS locations integrated with videography and spacing of transects (Naugle et al., 1996). GPS data were transferred into a geographic information system (GIS). Length and width of transects were used to compute the area sampled during each survey. We assumed an average altitude of 457 m AGL for the purpose of calculating the area surveyed. Density was calculated as the number of deer recorded per unit area, and nights were used as replicates.

A comparison of density estimates between years for the mainland and the island was conducted using t-tests adjusted for unequal variance when necessary (SAS Institute, Inc., Cary, N.C.). All analyses were conducted with _ = 0.05.

Recruitment was assessed using spotlight surveys conducted from the back of a pickup truck moving ≤ 8 km/hr. Surveys were conducted during January 2004 following the hunting season. Both sides of the road were scanned using a 750,000 candle power spotlight. Upon detection of animals, the age (adult or juvenile), sex, time, and group number were recorded. Surveys began at least 1 hr after sundown and continued until a pre-determined route was completed. Surveys were conducted nightly until 100 does were observed. The number of fawns per 100 does was calculated to represent recruitment. Harvest data were provided by the AGFC. During 2003, 33 transects on the mainland and 18 transects on the island were surveyed, and in 2004, 84 transects on the mainland and 47 transects on the island were surveyed. The strip transect area covered during the surveys in 2003 varied from 434 ac (175.6 ha) to 1248 ac (505.1 ha), and from 621 ac (251.3 ha) to 1344 ac (543.9 ha) in 2004 (Table 1). The mean density was 1 dee per 7.4 ac (3.0 ha) and 1 deer per 8.8 ac (3.6 ha) on th mainland in 2003 and 2004, respectively. The mea population sizes on the mainland during the winters of 200 and 2004 were estimated to be ~ 788 and ~ 659 dee respectively.

No significant differences were found between years fo the densities on the mainland ($p = 0.300$, $t = 1.19$) or the island ($p = 0.397$, $t = 1.38$). Only two replicate flights were obtained during 2003 and this resulted in more variance compared to that obtained from 4 replicates in 2004. A difference between densities on the island and mainland during 2004 ($p = 0.003$, $t = 4.96$) existed but was not detected in 2003 ($p = 0.205$, $t = 1.86$) due to the variance. Though conditions were good during both nights that transects were flown in 2003, slightly poorer conditions were experienced the second night. Daytime heating translated into greater thermal loading of vegetation and water. This may partially explain why density estimates from the second flight were slightly lower than those from the first flight. We flew after sunset and prior to 0100 hrs. To minimize the effects of thermal loading, flights were conducted later in the night in 2004. Variability of detection was much higher on the island compared to the mainland. We believe this may have been due to either the poorer conditions experienced during the second flight, a change in deer behavior (e.g., animals moving off the island or being bedded under vegetation), or a combination of these factors.

While there was no difference in deer density between years, more deer were observed on the island in 2004 (Table 1), the year following the first deer harvest season. Deer are known to increase movements, increase home range size, and even shift activity centers in response to hunting pressure (Root et al., 1988). It is possible that deer moved to the island in response to hunting pressure on the mainland and remained there at least through February when the flights were conducted. Assuming that the increase in numbers observed on the island was due to movement, it is not known whether the movements were permanent because no active radio-telemetry work was under way at the time. Another possible explanation is that the deer population on the island increased from one year to the next. We believe this is very unlikely, however, due to the relatively poor habitat on the island.

In addition to the density data, spotlighting surveys indicated 32.2 fawns:100 does (recruitment) and 15.7 bucks per 100 does. The level of recruitment suggested a population above carrying capacity. Poor recruitment is a function of population density (Gilbert and Raedeke, 2004) and nutrition (Fryxell et al., 1991; McCullough, 2001). Nutrition most likely has a time-lag effect on recruitment (Fryxell et al., 1991), and managers should expect a slow recovery due to nutrition-mediated recruitment when densities have been high for a prolonged period of time.

The CIWMA deer population is an exemplary model of these conditions.

The AGFC reported a harvest of 181 deer during the 2003-2004 season, of which 157 were does (C. Gray, Arkansas Deer Program Coordinator, pers. comm.). In response to the failure of harvest to initially reduce the population, AGFC changed their harvest strategy to encourage the harvest of more does. During the 2004-2005 deer season, a total of 269 deer was harvested, of which 189 were does (C. Gray, pers. comm.). While a density estimate was not provided during winter 2005, it is believed that a sufficient number of animals were harvested to begin decreasing the population.

We recommend further estimation of population parameters annually because harvest is skewed toward does, a sizeable proportion of the population is being harvested, and the duration of a nutrition-mediated time-lag in recruitment is unknown. This work serves as a model for white-tailed deer management in Arkansas and encourages managers and biologists to make decisions based on population parameter estimation and not indices.

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Table 1. Density estimates (number of deer per acre; ha are in parentheses) of white-tailed deer on Choctaw Island Wildlife Management Area, Desha County, Arkansas, calculated from aerial thermal infrared videography during 8-9 March 2003 and 20-27 February 2004. See text for description of Island and Mainland.

Site	Date flown	Acres sampled (ha)	Number of deer observed	Density #deer/acre	Mean(ha)	S.E.(ha)	Estimated number of deer
Island	8 March 2003	434 (176)	20	0.046 (0.114)			
	9 March 2003	660 (267)	12	0.018 (0.045)	0.026 (0.065)	0.014 (0.035)	58
Mainland	8 March 2003	1163 (471)	194	0.167 (0.417)			
	9 March 2003	1248 (501)	144	0.115 (0.286)	0.135 (0.333)	0.026 (0.066)	788
Island	20 February 2004	621 (251)	50	0.081 (0.200)			
	21 February 2004	642 (260)	44	0.068 (0.169)			
	22 February 2004	676 (274)	40	0.059 (0.147)			
	27 February 2004	673 (272)	39	0.058 (0.143)	0.065 (0.161)	0.005 (0.013)	147
Mainland	20 February 2004	1332 (539)	148	0.111 (0.278)			
	21 February 2004	1328 (537)	149	0.112 (0.278)			
	22 February 2004	1333 (540)	185	0.139 (0.345)			
	27 February 2004	1344 (544)	131	0.097 (0.238)	0.114 (0.278)	0.009 (0.022)	659

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