Calculating Probability of Site Use, Study Area Size, and Density of Wild Turkey Hens

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Abstract: Most researchers arbitrarily delineate study areas even though a quantitative estimate of study area size can be generated from capture and subsequent locations of radio-equipped animals. Arbitrary delineation may result in biased estimates of density. Density is often determined with capture-mark-recapture designs that do not include locational data from radio-equipped animals. We used logistic regression to determine probability of recapture of radio-equipped wild turkey (*Meleagris gallopavo*) hens based on pre-sample distances from bait sites for hens using and not using baited sites. We then used the posterior probability function from logistic regression analogously to the detection function from variable circular plot methods. Integration of this function provided effective radius of census (the radius around each bait site, within which all hens seen represent a complete census) and effective radius of sample (the radius around each bait site, within which the observed animals are a representative sample). A 1-ha cell grid was superimposed over the study area, and cells within these radii were summed. Effective area sampled corresponded with a study area size of 8,527 ha. Turkey hen density was compared using this study area size with several estimates of population size and a single observation period census corrected for sighting probability. Estimates were comparable and were biologically sound. The technique outlined enables effective use of locational data, provides an estimate of study area size, and provides density estimates that are easier and less expensive to obtain than other methods.

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Population estimates reported as number of individuals occurring in various age or sex classes are useful only for within-site comparisons. To enable comparisons among sites, population estimates must be converted to densities, which requires an estimate of area. Many researchers arbitrarily assign a value to study area size. An area so defined may have no direct relationship with the population under study

(Caughley 1977). This may result in biased estimates, which may lead to erroneous conclusions.

Researchers have incorporated movements of study animals to address closure assumptions of population estimates or to incorporate periphery effects within predefined study areas (Kufeld et al. 1987, Garshelis 1992, White 1993) following the recommendation of White and Garrott (1990). Recently, Miller et al. (1997) used radio telemetry to determine which animals were within search areas at the time of census and used the information to correct estimates. Other researchers have attempted to define the study area directly from the movements of individuals. Whitford (1976) suggested addition of a boundary strip equaling the home range radius around the area containing sampling locations. In Mississippi, Gribben (1986) used an 800-m band around outermost bait sites to estimate wild turkey density and Lint et al. (1992) derived estimates of study area size empirically by using the marked:unmarked ratio of reported gobbler harvests occurring at various distances from bait sites.

Information is available for populations containing radio-marked individuals prior to the census period. We present a technique based on the pre-sample locations of radio-equipped individuals to calculate probability of observation at baited sites. From this calculation, estimates of study area size and density were determined.

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Methods

Study Area

Our study was conducted in east-central (Kemper County) Mississippi in the Interior Flatwoods land resource area (Pettry 1977). In 1991 (midpoint of observation periods), 56% of the area was loblolly pine (*Pinus taeda*) plantations, 24% mature pine-hardwood forest, 13% streamside management zones and other hardwood forests, and 7% was classified as non-forest (croplands and pastures). Weyerhaeuser Company owned 72% of the area. Management included clearcutting, site preparation, planting pine seedlings, pine release through herbicide application, pre-commercial and commercial thinning, fertilizing, controlled burning, pruning, and a 30–35 year rotation (Smith et al. 1990). Average plantation size was 26.8 ha (0.5–129.2 ha). The area was traversed by several all-weather roads, and gated spur roads extended into most plantations. Most spur roads were unimproved, rarely used, and covered with herbaceous vegetation (Smith et al. 1990). Some roadsides were disked during late summer and early fall and planted to winter wheat (*Triticum aestivum*) or rye grass (*Lolium* spp.).

Turkey Capture and Location

We captured turkeys from the third week of January until the second week of March 1986–1992, during the first 2 weeks of March 1993, and from late June through mid-August 1986–1989. Turkeys were captured on roadsides at permanent bait sites using cannon nets (Bailey 1976). We individually marked turkeys using color-coded, numbered cattle ear tags placed patagially (Knowlton et al. 1964). We equipped hens back-pack style with 108-g motion sensitive radio-transmitters (Wildl. Materials, Inc., Carbondale, Ill.). We released all turkeys immediately after processing at the capture site. We located hens twice daily, 2 times per week during June to August with a Telonics, Inc. (Mesa, Ariz.) TR-2 or a Wildlife Materials, Inc. TRX-1000S receiver and a hand-held, 3-element yagi directional antenna. Locations were determined by triangulation (Cochran and Lord 1963) using the 2 closest permanent stations ($N = 144$) whenever possible. The road system usually allowed close access (<0.5 km) to hens. To minimize error from animal movement between fixes, we limited duration between fixes to 12 minutes. Only angles between 60° and 120° were used to minimize size of error polygons (Heezen and Tester 1967).

Bait Size Observation

From early July to mid-August 1990–1993, we checked bait sites ($N = 25–28$) on gated spur roads in pine plantations for turkey use at mid-day (1100–1300 hours) and evening (after 1800 hours). All bait sites that received use during 2 of the preceding 4 mid-day and evening periods were placed into a pool from which as many bait sites as possible were randomly chosen to be monitored. We monitored sites daily during July to mid-August from 0600 to 1100 and 1300 to 1800 hours. Regardless if turkeys were observed, the selection criterion was reset such that the bait site must have been used twice in succession before it could be placed back in the pool. On the last day of the summer observation period (18 Aug 1990, 18 Aug 1991, 14 Aug 1992, 13 Aug 1993), we monitored all bait sites during the morning and afternoon periods. Because visibility was much greater for some bait sites, we standardized observations between bait sites by including only turkeys that entered a 10-m x 20-m sighting area, centered on the corn pile, in analysis. Observers recorded marked status and mark number of all hens seen.

Data Analysis

For all hens with active radio-transmitters, we calculated average x, y location for 1 month before the continuous observation period. Distance from this average location to all bait sites (DIST) was then computed. To derive a sighting function (probability of a hen using a bait site given she was x meters from it), we used univariate logistic regression with use category (used/not used) as the dependent and DIST as the independent variable (SPSS/PC 1993). Years were pooled to achieve adequate sample sizes. We used all DIST from hens using a bait site at any time during the sampling period to the site of use. There was a slight violation of independence, as 4 of 39 observations were from hens that used >1 bait site per year. For hens not known to have used bait sites, we included a random subsample of equal size as the used category such that there was equal representation per year and only 1 observation per individual. Univariate logistic regression fits data to a curve of the form:

$$f(x) = \frac{1}{1 + e^{-(b_0 + b_1 x)}} \qquad (1)$$

where b_0 is the y-intercept, b_1 is the regression coefficient, and x is DIST.

Most population estimation analyses assume representative sampling. However, as distance from a bait site increases, probability of being included in sampling decreases. If it is assumed that all animals with DIST of 0 from a bait site are equally likely to be included in samples, and animals are randomly distributed, it follows that the observed animals are representative of those within the radius (R), which is given by:

$$R = \frac{\int_0^\infty \frac{1}{1 + e^{-(b_0 + b_1 x)}} \, dx}{f(0)} \qquad (2)$$

where b_0 is the y-intercept, b_1 is the regression coefficient, $f(0)$ is from equation 1 evaluated at 0, and x is the observed DIST. The logic used here is analogous to development of variable circular plot methodology (Buckland 1987) with 2 important differences: 1) we chose logistic regression because it allowed use of data from animals using and not using sites, and 2) because DIST is an average distance of locations taken before sample initiation, animals with a DIST of 0 were not observed with a probability of 1. The radius can be converted to an areal measure (area $= \pi R^2$). Because summing areas for each bait site double-counts areas of overlap, we used a grid of 1-ha blocks encompassing the expected study area to determine total study area size. Blocks falling within R of bait sites were counted to obtain study area size.

We used a similar procedure to estimate turkey density in a manner analogous to variable circular plot methods. Univariate logistic regression was used to estimate the probability that a hen was observed in the pm period of the last day of observation given her average x, y location for 1 month before bait initiation. We chose to use only hens from the last observation period for this analysis to emulate a point census that managers could employ. The radius (R') from each bait site within which the sample from the pm observation period of the last observation day is identical to a complete census, is given by:

$$R' = \int_0^\infty \frac{1}{1 + e^{-(b_0 + b_1 x)}} \, dx \qquad (3)$$

Again, an area larger than, but encompassing, the expected total census area was divided into 1-ha blocks. Blocks falling within R' of bait sites were counted. This sum represented total area censused.

Results

For the period 1990–1993, 39 distances between average x, y location and bait site used from 35 radio-equipped hens were available for analyses. Of these, 33% used the closest bait site. Average distance was 1.07 km.

Table 1. Parameter estimates and fit of logistic regression models used to derive an estimate of study area size and a population estimate for hen wild turkeys in Kemper County, Mississippi, 1990–1993.

Model	B_0	S.E.[a]	B_1	S.E.	−2 Log Likelihood	*df*	Correct Classification
Study area	2.2033	0.526	−0.0003	0.0000	71.845	76	80.77%
Population estimate	2.7445	0.733	−0.0005	0.0001	49.062	58	83.33%

a. Standard error of parameter estimate.

Posterior probability scores, calculated from the model parameters (Table 1), indicated an approximate 6-km distance before probability of use was less than 0.01 (Fig. 1). The estimate of R, from equation 2, was 2.56 km. This corresponds to an effective area of bait site influence of 2,059 ha for individual sites. Estimate of total study area size was 8,527 ha. Population estimates (Weinstein et al. 1995) derived from techniques described by Jolly (1965), Buckland (1980), Arneson et al.

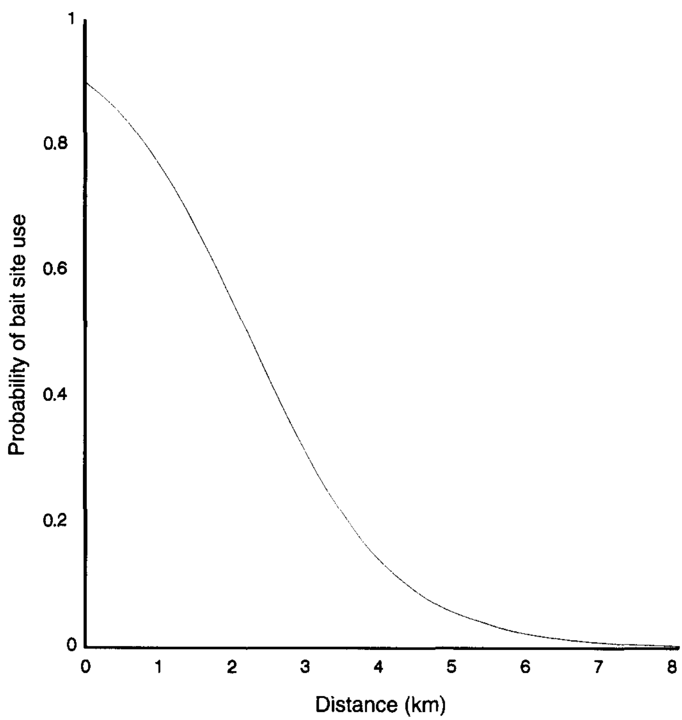

Figure 1. Posterior probability (from logistic regression) that a hen wild turkey with average *x, y* location, for 30 days prior to bait initiation, at a given distance from a bait site, used that bait site in the continuous observation periods, 8 July–17 August 1990; 8 July–15 August 1991; 2 July–13 August 1992; and 3 July–12 August 1993, Kemper County, Mississippi.

Table 2. Wild turkey hen density estimates (95% confidence limits) based on models derived by Jolly (1965), Buckland (1980), Arneson et al. (1991), Minta and Mangel (1990), and modified circular plot, Kemper County, Mississippi, 1986–1993.[a]

	Model				
Sample period	Jolly-Seber	Buckland	Arneson et al.	Minta and Mangel	Modified plot
1990	1.4 (0.5–2.5)	1.9 (1.0–2.9)	1.2 (1.0–1.4)	1.5 (1.4–1.8)	1.2
1991	1.3 (0.4–2.2)	1.5 (0.8–2.6)	1.2 (1.0–1.5)	1.8 (1.7–2.0)	1.2
1992	2.6 (0.0–5.4)	2.2 (1.0–5.2)	1.3 (1.0–1.6)	2.9 (2.7–3.2)	1.8
1993			1.0 (0.8–1.3)	3.4 (3.0–3.8)	1.0

a. Modified from Weinstein et al. 1995.

(1991) and Minta and Mangle (1989) were converted to densities using this area (Table 2).

Integration of derived probability density function (Fig. 2) indicated a radius, R' (equation 3), of 1.68 km. This corresponds with an effective complete census of 891 ha per bait site. Overall area of census was estimated as 5,851 ha. Turkey hen densities derived in this manner were within the range of other estimates (Table 2).

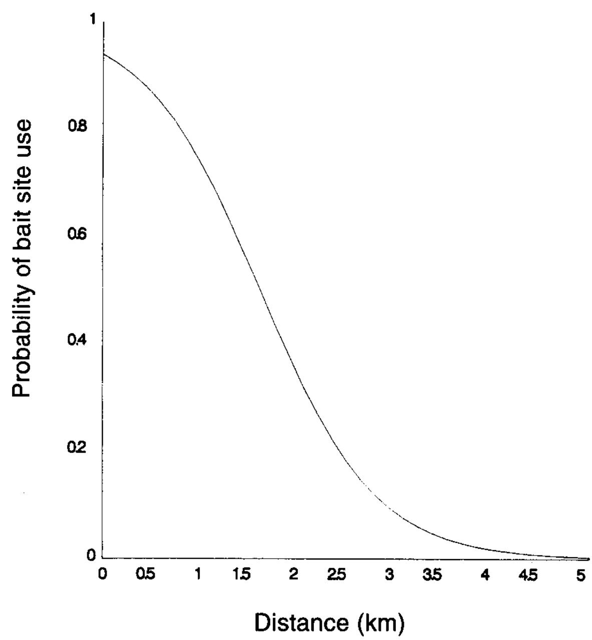

Figure 2. Posterior probability (from logistic regression) that a hen wild turkey with average *x*, *y* location, for 30 days prior to bait initiation, at a given distance from a bait site, used that bait site in the pm (1300–1800 hours) observation period, 13–18 August 1990–1993, Kemper County, Mississippi.

Discussion

Average distance traveled (1.07 km) agrees with Gribben's (1987) recommendation of an 0.8-km boundary strip around bait site area. The posterior probability function from logistic regression can provide managers with a useful tool when designing capture studies. These data enable informed decisions for spacing of capture sites.

Data from hen locations and positions of known bait use were used to derive an objective and biologically reasonable estimate of study area size. Objective measurement of study area size is critical to research focused on density estimation and/or population dynamics. Because of the relatively inexpensive nature of this method, bait site counts offer managers an effective means to index population size of wild turkey hens. However, before this technique can be recommended for density estimation, additional research is needed with greater sample sizes. Further, we did not calculate a variance estimate for the census technique presented. Repeating this design for small mammals or other species for which many individuals can be captured is necessary. We recommend validating this technique with a population of known size or a population for which more precise estimates of density are available. Although estimates from this technique fell within the range of estimates from established methods, it is unclear to what extent this presents a validation of our method, because of the imprecision of these estimates. Finally, we assumed all animals and bait sites had identical sighting functions. With larger samples, the ability of logistic regression to incorporate more explanatory variables (e.g., weather, sex, reproductive status) can be fully exploited.

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