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ABSTRACT

Passive mist netting has led to estimates of annual survival probabilities for many species of birds, but robust survival estimates for most other species have proven difficult to obtain using this method because of poor capture frequencies. Target netting using conspecific vocalizations and other procedures improves capture rates for many uncommon species and is now used extensively in some studies. Here we describe target netting field methods that provide data more amenable to the analytical tools used to estimate survival and other demographic parameters. The procedures are based on visiting randomly generated locations during each sampling occasion and target netting the first individual encountered. Target netting conducted at or near random locations may be tailored to different methods for collecting and analyzing mark-recapture data. We provide results from field trials that comply with assumptions of two methods commonly used to analyze mark-recapture data (Cormack-Jolly-Seber model and the robust design model). Field trials were designed to gather demographic data on Bachman's Sparrow (Aimophila aestivalis), *a declining species associated with open pinewoods in the southeastern US.*

INTRODUCTION

A fundamental goal of bird banding is to generate estimates of survival probabilities for many different species using mark-recapture analysis (DeSante et al. 1993). Scores of analytical tools have been developed in recent years to analyze mark-recapture data (White and Burnham 1999), and analyses that make use of these tools and based on data collected via passive mist netting (e.g., DeSante et al. 1993) have provided important survival estimates for many species (Michel et al. 2006).

Data collected from passive mist netting have proven to be less effective in estimating survival rates for many species that occur at low densities or else are difficult to capture. A review of data collected through the Monitoring Avian Productivity and Survivorship (MAPS) Program at locations in southeastern states in the US (Michel et al. 2006) suggested samples needed to estimate survival were sufficient for fewer than 40 species and only three of 10 passerines considered to be species of management concern throughout the region (Cox and Widener 2008). The data upon which these results were based spanned 15 years and involved passive netting at scores of MAPS stations (Michel et al. 2006), but low recapture rates made it difficult to estimate survival reliably for several species.

Target netting is used frequently to improve capture rates and netting efficiency for individual species (Sillett and Holmes 2002, Bakian and Paxton 2004, Kearns et al. 2006, Jones and Cox 2007). Target netting has been conducted at nest sites and other locations where individuals predictably aggregate (Anon. 2009), and conspecific recordings also are used frequently to attract targeted species into nets (Bayne and Hobson 2002, Sillett and Holmes 2002, Jones and Cox 2007). For example, Jones and Cox (2007) used conspecific recordings to lure male Bachman's Sparrows (*Aimophila aestivalis*) and

frequently captured ≥8 adult male Bachman's Sparrows each day as compared to one individual captured per day when using passive netting techniques.

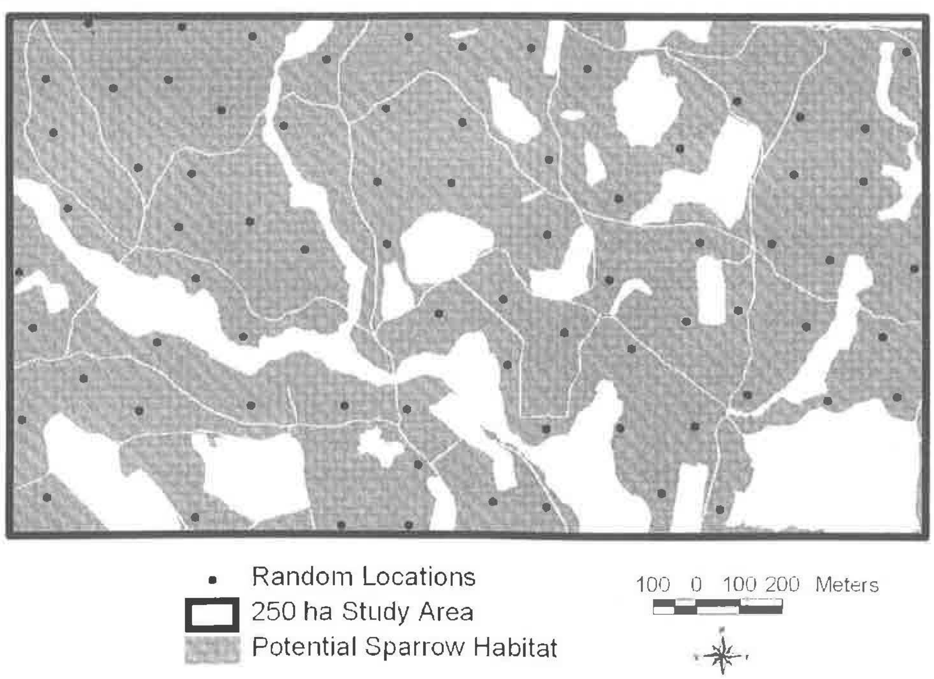
We describe sampling procedures that can make target netting more amenable to some of the analytical tools now available for analyzing mark-recapture data. The sampling procedures we describe were designed to satisfy assumptions associated with the Cormack-Jolly-Seber (CJS) model (Pollock et al. 1990) and the robust design (Sandercock 2006) that are commonly used to estimate survival and other population parameters. We conducted field trials at several sites on or near Tall Timbers Research Station that support large populations of Bachman's Sparrow. We hope this note will motivate others to assess the potential utility of these methods with other uncommon or elusive species.

METHODS

Netting of Bachman's Sparrow is best accomplished using playback vocalizations and a system of nets and poles that can be transported and deployed easily in open pinewoods (Jones and Cox 2007). Briefly, the net system we use involves two 12-m nets attached to easy-to-assemble poles. When singing males are encountered, nets are deployed, a recorded conspecific vocalization (on CD or MP3 player) is placed at the base of nets, and territorial males are chased into nets (Jones and Cox 2007). Over the past four years, these procedures have resulted in netting >150 males each year.

Field approach for the Cormack-Jolly-Seber model - The CJS model (Pollock et al. 1990) is one of the most commonly used procedures for estimating annual survival probabilities (Sandercock 2006) when individuals can be marked uniquely. Key assumptions (Sandercock 2006) of the CJS model are: (1) marked animals represent a random sample of the population and (2) capture and release of marked animals are made within relatively short time periods (during which the population is assumed to be closed to immigration and emigration) relative to time intervals between capture efforts (during which the population is assumed to be open). Target netting can be tailored to fit the first of these assumptions by generating random points for a study area and attempting to net the first individual detected near the point. We

Fig. 1. Random points *(n = 75)* used to structure field captures of male Bachman's Sparrows in 2007. We visited 15 points each morning and attempted to net the first male heard singing within 100 m. A new set of random points *(n = 75)* was generated and sampled in 2008 to satisfy assumptions of the Cormack-Jolly-Seber (Pollock et al. 1990) model used to assess survival probabilities.



addressed the second assumption simply by attempting to net individuals near random points within a few days or weeks (given that an assessment of annual survival was our objective).

In our CJS field trial with Bachman's Sparrow, we generated 75 random points for a 250-ha study area (Fig. 1) in 2007 and 2008 (150 total points) using ArcView (Environmental Systems Research Institute 1998) geographic information system (GIS) and the Animal Movement extension (Hooge and Eichenlaub 1997). We set the minimum distance between points at 150 m because the radius of a typical sparrow territory is approximately 150 m (Cox and Jones 2007), and we also stipulated points be located >20 m from habitat edges (Fig. 1). We visited 15 points each on five mornings during a two-week period in April and attempted to net the first singing male heard within 100 m (distance again based on territory extents). If no male was heard singing within 100 m after two minutes, we visited the next point in the sequence.

Field approaches for the Robust Design - The robust design (Kendall et al. 1997) is a combination of the CJS model and closed-capture models (Sandercock 2006). Estimating annual survival involves repeated sampling whereby the samples yield multiple captures of some individuals. The within-year samples must be conducted during short time intervals because the model makes the assumption that populations are closed during the period these samples are collected (i.e., no mortality or emigration occurs). The advantages of this design include (1) estimates of population size and recruitment are less biased; (2) abundance, survival, and recruitment can be estimated for all time periods; (3) estimates of temporary emigration can be obtained; (4) better precision is achieved with smaller samples; (5) estimates of recruitment can be made when two age classes exist; and (6) the sampling allows for finer control of precision (Sandercock 2006).

Similar to the field approach taken for the CJS model, target netting can be tailored to satisfy assumptions of the robust design by using random points to structure netting efforts. In June 2007, we conducted two field trials based on this design that differed in terms of sampling intensity and extent of study areas. For the more intensive trial, we generated 15 random points covering an 80 ha area each day and then visited the points on 15 mornings (225 total points). In the second less intensive trial, we generated 10 random points covering a 25 ha area each morning and then visited points on three mornings (30 total points). In both trials, we attempted to net the first singing male heard within 100 m of random points.

RESULTS

Sampling conducted under the CJS design resulted in an average capture of 0.63 individuals per netting attempt and a range of five to12 sparrows captured each morning. We netted 50 males in 2007 and 45 males in 2008, and the proportion of birds recaptured in 2008 was 0.52 (n = 26). We estimated that the study area (250 ha; Fig. 1) was capable of supporting ca. 125 territorial males based on available habitat and density estimates (0.5 males per ha) derived from point counts conducted in the same area (J. Cox, unpubl.), so annual samples appeared to mark roughly a third of the population.

Under the more intensive trial conducted using the robust design (15 visits to 15 points each morning), we captured 54 individuals with an average capture rate of 0.65 individuals per netting attempt. The captures during the more intensive effort included 30 males (55.5% of total), 18 juveniles (33.3%), and six females (14.8%). We recaptured an average of 1.3 (SD = 0.7) marked individuals each day, and cumulative totals were 44, 6, 3, and 1 individuals captured 1, 2, 3 and 4 times, respectively (includes juvenile recaptures). The study plot likely supported approximately 40 territorial males, so our sampling marked approximately 75% of the population. In the less intensive trial using the robust design (three visits to a 25-ha plot), we netted 20 individuals, and our samples included 15 males, 4 juveniles, and 1 female. We appeared to capture most of the males within this plot, but there were no recaptures.

DISCUSSION

Structured target netting using procedures outlined here may improve capture frequencies and lead to more robust survival estimates for uncommon or elusive species that would otherwise be captured infrequently using traditional passive mist netting methods. Use of conspecific vocalizations, of course, lead to male-biased samples for Bachman's Sparrows, but these estimates represent a valuable starting point for many uncommon species and can be used to assess population stability in different settings. In addition, the netting we conducted later in the breeding season in June using the robust design produced captures of several females and juveniles, and further refinements to target netting females (e.g., use of fledgling begging notes) would be beneficial.

Variation in the density of points sampled influenced the relative proportions of the population marked in our trial studies. The density of sampling points across all three trials ranged from 0.3 per ha (CJS) to 2.8 points per ha (intensive robust design), and higher densities led to capture of >75% of the estimated population of territorial males, while the lower densities led to capture of 33% of the estimated population. Although high capture rates are beneficial, time constraints may make it difficult to visit a high density of points each year. Marking individuals using lower point densities but across a large study area also might provide valuable information on dispersal and movement patterns as well as lead to better survival estimates. Furthermore, by using a standardized number of random points when sampling different study areas, random target netting potentially also allows capture rates to be compared among different study plots. GIS was used here to generate random points, but GIS also could be used to assess co-variation in land-cover features and capture probabilities.

Estimating survival probabilities using the CJS model requires three sampling periods (White and Burnham 1999), but a naïve estimate of survival based on the proportion of individuals we recaptured in 2008 (0.53) approximates the survival probability (0.59) estimated in one long-term study (Cox and Jones 2007). For Bachman's Sparrows, the CJS approach used to sample over 250 ha should lead to robust survival estimates within four to five years and also provide important information on movements and site fidelity. The CJS approach also could be conducted at multiple sites on public lands with comparatively small staff commitments (ca. five to seven mornings per site per year). Alternatively, field crews consisting of two banders and two technicians could sample multiple sites (ca. 12) established using more complex experimental designs that attempt to address specific research questions.

A limitation of the CJS model is that permanent emigration is confounded with survival because individuals that leave the study area can not be monitored (Sandercock 2006). The robust design provides an estimate of emigration and thus has advantages that make it well suited to studies where subtle differences in survival are anticipated. The length of time within which repeat samples are collected is a consideration because the robust design assumes populations are closed during this period. Male Bachman's Sparrows that are tending fledged young have been documented moving >800 m (Cox and Jones 2007), and we believe this assumption may be violated for Bachman's Sparrows if sampling is limited to a small study area and conducted over a period much longer than a month. The appropriate length of time for repeat sampling likely varies for different species. For Bachman's Sparrows, we estimate three study areas could be sampled within a single month if the eight visits were made to individual study areas each breeding season (24 total mornings of netting).

Another key advantage of the robust design is that recruitment and immigration are both separately estimable (Kendall et al. 1997) when two age classes are present. The larger number of juveniles we marked in our June samples suggests estimates for annual productivity and recruitment might be feasible.

A potential problem with random target netting could be net avoidance among marked birds during follow-up netting attempts. During our more intensive netting effort using the robust design, we found it difficult to net some marked birds during repeat sampling. Use of decoys and new playback recordings might reduce net avoidance, but color-marking provides another potential solution. Random points again could be generated to structure field searches for singing males. If the male nearest a point is not color banded, an attempt could be made to band the bird. If the male is color banded, the individual could be identified using band combinations. Analytical tools that combine capture and re-sighting data (e.g., Barker 1997, McClintock and White 2009) can be utilized.

We will continue to evaluate these procedures for Bachman's Sparrow in hopes of refining the technique and, importantly, obtaining estimates for survival, emigration, and other parameters of interest. We encourage others engaged in target netting to experiment with these approaches. Target netting based on the CJS approach described above might be used as an adjunct to MAPS sampling to help refine survival estimates for focal species that are not adequately captured. Indeed, target netting is already used in some areas with MAPS (Anonymous 2009), and structuring the sampling using procedures outlined here could provide more robust estimates of survival and other demographic parameters.

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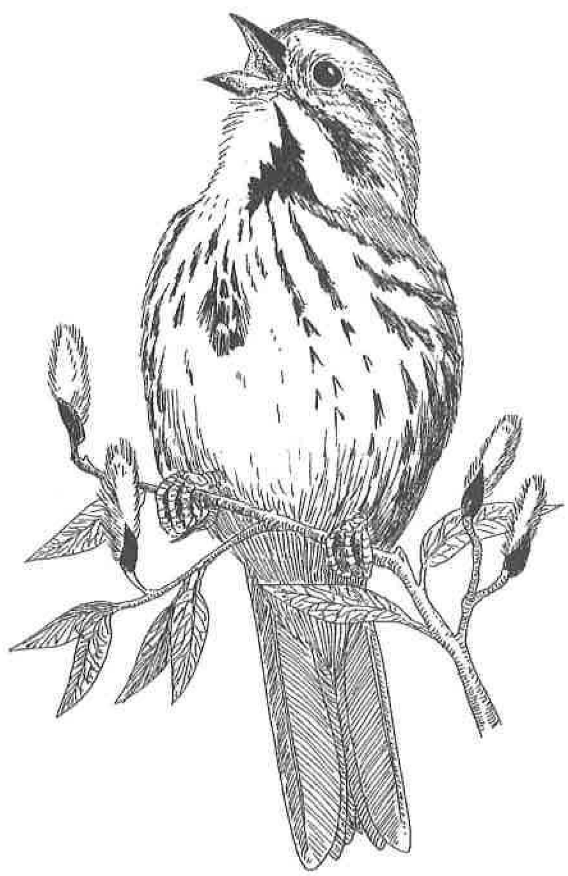

Song Sparrow
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