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EVALUATION OF A REPRODUCTIVE INDEX FOR ESTIMATING PRODUCTIVITY OF GRASSLAND BREEDING BIRDS

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Abstract.—Declining populations of grassland breeding birds have led to increased efforts to assess habitat quality, typically by estimating density or relative abundance. Because some grassland habitats may function as ecological traps, a more appropriate metric for determining quality is breeding success, which is challenging to determine for many cryptic-nesting grassland birds. This difficulty led Vickery et al. (1992) to propose a reproductive index based on behavioral observations rather than nest fate. We rigorously evaluated the index for 2 years using a Savannah Sparrow (*Passerculus sandwichensis*) population in western New York and found a weak correlation in classification of the breeding stages of monitored territories among multiple observers ($r = 0.398$). We also discovered a large difference between overall territory and nest success rates independently estimated with the index (9.8% over the entire breeding cycle) and with nest searching and monitoring (41.7% of nests successfully fledged young). Most importantly, we made territory-level comparisons of index estimates with actual nest fate and found that the index correctly predicted fates for only 43% of the monitored nests. A Mayfield logistic regression analysis demonstrated that only index rank 4 (eggs hatched, but young failed to fledge) showed a strong positive correlation with nest success. Although the reproductive index may function as a coarse indicator of habitat suitability (e.g., documenting production in potential ecological traps), in our study the index exhibited neither internal consistency nor the ability to predict nest fate at the plot or territory level and functioned poorly as a substitute for nest searching and monitoring. *Received 20 May 2008, accepted 18 June 2009.*

Key words: grassland breeding birds, *Passerculus sandwichensis*, reproduction, reproductive index, sampling techniques, Savannah Sparrow, territory mapping.

Evaluación de un Índice Reproductivo para Estimar la Productividad de Aves de Pastizal

Resumen.—La disminución poblacional de aves que se reproducen en pastizales ha llevado a un aumento en los esfuerzos para determinar la calidad del hábitat para estas especies, la cual se ha determinado típicamente a través de la estimación de la densidad o de la abundancia relativa. Debido a que algunos hábitats de pastizal pueden funcionar como "trampas ecológicas", una medida más apropiada para determinar la calidad de esos hábitats es la estimación del éxito reproductivo de las aves. Sin embargo, este parámetro es difícil de estimar para varias especies crípticas que anidan en pastizales. Esta dificultad llevó a Vickery et al. (1992) a proponer un índice reproductivo que se basa en observaciones de comportamiento y no en el destino de los nidos. Evaluamos de forma rigurosa este índice estudiando por dos años una población de *Passerculus sandwichensis* en el oeste de Nueva York y encontramos una relación débil en la clasificación de las etapas reproductivas de los territorios monitoreados entre los múltiples observadores ($r = 0.398$). También descubrimos una gran diferencia entre las tasas de éxito de anidación y de territorio estimadas independientemente mediante el índice (9.8% a lo largo de todo el ciclo reproductivo) y las estimadas a través de búsqueda y monitoreo de nidos (41.7% de los nidos produjeron volantones de forma exitosa). De forma aún más importante, hicimos comparaciones de los índices estimados a nivel de territorios con los verdaderos destinos de los nidos y encontramos que el índice sólo predijo de forma correcta el destino para el 43% de los nidos monitoreados. Una regresión logística de Mayfield demostró que sólo el rango 4 del índice (huevos eclosionaron pero los polluelos no llegaron a volantones) mostró una fuerte relación positiva con el éxito de anidación. A pesar de que el índice puede servir como un indicador general de calidad del hábitat (e.g., documentando producción en trampas ecológicas potenciales), en nuestro estudio el índice no exhibió consistencia interna ni la habilidad de predecir el destino de los nidos a nivel de parcelas o de territorio y funcionó de forma pobre como un substituto para la búsqueda y monitoreo de nidos.

The success or failure of habitat management and conservation strategies is often assessed by documenting presence or absence of target species or, more rigorously, by correlating measurements of controllable habitat variables with relative abundance or density of these species (Ralph et al. 1995), to provide feedback through adaptive management (Schreiber et al. 2004, McCarthy and Possingham 2007). However, measures of density or abundance may provide misleading information about habitat quality or suitability

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(Van Horne 1983, Vickery et al. 1992, Hughes et al. 1999; but see Bock and Jones 2004), as in the case of agricultural fields that act as ecological traps for grassland breeding birds (Schlaepfer et al. 2002, Shochat et al. 2005) if they are hayed or grazed prior to fledging or if adjoining habitats attract high numbers of predators or brood parasites (Bollinger et al. 1990, Frawley and Best 1991).

Grassland breeding birds have declined precipitously as a result of widespread land-use changes and are a priority for many conservation agencies (Bollinger and Gavin 1992, Samson and Knopf 1994, Warner 1994, Herkert 1997, Vickery et al. 1999, Norment 2002, Murphy 2003, Askins et al. 2007). The potentially misleading nature of density or abundance metrics for grassland breeding birds in agricultural landscapes necessitates a more rigorous approach to quantifying habitat suitability, including the use of methods that quantify productivity within targeted habitat patches. A traditional method for collecting productivity data is nest searching and monitoring (Nur and Geupel 1993), along with statistical analyses that account for observer effort (Mayfield 1975, Hensler and Nichols 1981, Johnson and Shaffer 1990). However, searching for nests of grassland breeding birds is difficult or nearly impossible for many species. In addition, this method, which relies on repeated nest visits to document hatching and fledging, may affect success rates, although data documenting this effect are equivocal, possibly because of the variety of nesting behaviors exhibited by different species (Götmark 1992, Martin and Geupel 1993, Hoi and Winkler 1994, Mayer-Gross et al. 1997, Westemeier et al. 1998). To mitigate for these concerns and develop improved monitoring techniques, the use of indirect productivity estimators is becoming more common (Vickery et al. 1992, Powell and Collier 1998, Gunn et al. 2000).

Vickery et al. (1992) described a reproductive index for territorial songbirds, particularly grassland breeding birds, that uses indirect observations of breeding behaviors to score reproductive success for mapped territories. Across many sites in Maine, they reported successful breeding in 25% of the territories of species evaluated with their index, whereas nest searching and monitoring found a 42% success rate in the same areas. Although Vickery et al. (1992) indicated that their method required "further field testing" before it was broadly applied, it has subsequently been used to estimate breeding productivity of grassland birds (Powell and Collier 1998).

Rivers et al. (2003) compared productivity estimates from Vickery et al.'s (1992) reproductive index and from nest searching and monitoring for Dickcissels (*Spiza americana*) in Kansas. At the plot level, the index underestimated the final reproductive rank for most observed territories and reported successful nests on three plots where no young fledged. It also failed to indicate nest failure from Brown-headed Cowbird (*Molothrus ater*) parasitism, an important source of bias for the index. Although Rivers et al. (2003) indicated that the reproductive index may not be reliable for estimating overall nest success at the plot level, further analysis at the scale of individual territories and their associated nesting attempts, and with additional species, may demonstrate whether it remains a potentially useful tool for estimating reproductive success.

We gathered productivity data on another obligate grassland breeding bird, the Savannah Sparrow (*Passerculus sandwichensis*), using both Vickery et al.'s (1992) reproductive index (hereafter "the index") and traditional nest searching and monitoring. Our unique approach linked the fate of individual nests to data collected using the index on the same territories. This allowed us to analyze how well the index functioned as a predictor of individual nest fates, which we consider the true measure of its accuracy. We also compared productivity estimates from the two methods at the plot level and examined whether index values were consistent among multiple observers. If different observers monitoring the same territories obtain different values for the index, its usefulness should be suspect.

Two other aspects of our study allow us to build on that of Rivers et al. (2003). First, we conducted the study in the northeastern United States, where parasitism of ground-nesting grassland birds by Brown-headed Cowbirds is rare (Norment et al. 1999). Second, we focused on Savannah Sparrows instead of Dickcissels; by evaluating the index with another species, we can better understand the consistency of its performance across the guild of grassland breeding birds.

Methods

We conducted our study during the 2002 and 2003 breeding seasons (approximately 15 May to 15 July) at Iroquois National Wildlife Refuge (INWR) in Shelby, New York (43.145°N, 78.386°W). Our study site was a 98-ha grassland dominated by introduced cool-season grasses such as Timothy (*Phleum pratense*) and Orchardgrass (*Dactylis glomerata*), as well as a variety of forbs and shrubs, including goldenrod (*Solidago* spp.), milkweed (*Asclepias* spp.), and White Meadowsweet (*Spiraea alba*). The field was historically used as pasture but more recently has been managed by summer mowing (every 3 or 4 years) after most birds have completed breeding (Paul Hess, INWR, pers. comm.). Bobolinks (*Dolichonyx oryzivorus*) and Savannah Sparrows are the only obligate grassland breeding birds found there in large numbers (Norment et al. 1999). Eastern Meadowlarks (*Sturnella magna*) are less common; Upland Sandpipers (*Bartramia longicauda*), Grasshopper Sparrows (*Ammodramus savannarum*), and Henslow's Sparrows (*A. henslowii*) are spotted in some years (C. J. Norment unpubl. data).

We limited the project's scope to Savannah Sparrows because their nests are relatively easy to locate and they demonstrate behaviors necessary for the territory mapping required by the reproductive index (Vickery et al. 1992, Wheelwright and Rising 1993). By contrast, Bobolinks are not territorial throughout the entire breeding cycle (Martin and Gavin 1995).

At the study site, we established three 12-ha plots in which multiple observers gathered productivity data using either the index or nest searching and monitoring. Savannah Sparrow territories range from 0.05 ha in New Brunswick (Wheelwright and Rising 1993) to 1.25 ha in Nova Scotia (Stobo and McLaren 1975), so plots were located 100 m from adjacent plots to prevent double counting of territories that might overlap multiple plots. Within each plot we set a grid of plastic flags on wire stakes placed every 25 m. Flags were numbered using a coordinate system that allowed accurate transcription of each territorial bird's location to a map of the plot. Observers also used the grid to monitor nests found while searching for nests, because the flags provided reference points for relocating nests without marking their locations.

Four observers collected data for estimating the reproductive index ranks and searched for and monitored nests to calculate Mayfield daily survival rates in the 3 plots during 2002 and 2003 (2 observers participated in both years, and 2 participated in separate years). Each observer independently gathered data for the index in 2 plots while visiting each plot between 0600 and 1000 hours on alternate days. During afternoons, each observer searched for and monitored nests on a third plot. This avoided biasing data collected for the index by ensuring that observers were unaware of nest locations and status in the other plots, forcing them to rely solely on behavioral observations to calculate the index. During the field season, observers did not discuss observations related to the index.

Nests were located by tracking females during repeated trips to nests. Once nests were located, observers attempted to minimize disturbance to concealing vegetation and varied the direction from which they approached and departed from nests to avoid indicating locations to other observers or nest predators. To track survival, observers visited nests every 2 or 3 days and recorded numbers of eggs or nestlings, as well as approximate age of nestlings using descriptions in Wheelwright and Rising (1993). Visitation rates increased to once a day or more near fledging.

When collecting data for the index, observers spot-mapped (International Bird Census Committee [IBBC] 1970) each territorial Savannah Sparrow and recorded behavioral data indicating the breeding stage (1 = establishing territories, 2 = attracting mates, 3 = nest building–egg laying–incubating, 4 = feeding nestlings, and 5 = feeding fledglings; Vickery et al. 1992). Each observer visited their plots 2 or 3 times each week during the breeding season, providing data from 20 visits plot^{-1} year^{-1}, compared with 10–17 visits plot^{-1} by Vickery et al. (1992). Each visit, during which observers attempted to gather behavioral data for each territory within the plot, lasted until ~4 h after sunrise. The entry point for each plot visit was varied to randomize the paths observers traveled. Observers walked so that they came within 50 m of every point in the plot, in contrast to the IBBC (1970) protocol, which recommends a maximum viewing distance of ≤100 m for open areas. We thought that the observers would be unable to observe birds carrying small prey items at distances ≥50 m and that it would be difficult to accurately map Savannah Sparrows at greater distances, given their high density.

Data analysis.—We used the program MAYFIELD (see Acknowledgments) and the data from nest searching and monitoring to calculate modified daily survival rates (DSRs) for each plot in each year, accounting for exposure days (Mayfield 1975). We compared DSRs using CONTRAST (Hines and Sauer 1989), which facilitates multiple nonorthogonal comparisons of rate estimates and allowed us to examine patterns among various plot and year combinations.

After each field season, we superimposed territory maps created by paired observers assigned to each plot to determine how consistently the observers mapped individual territories. Territories were deemed to match if they showed ≥50% overlap of the mapped areas. We calculated Spearman rank correlation coefficients (r) for index ranks given by paired observers to matching territories for each plot and year as well as for all plot and year pairs combined. This analysis assessed consistency in estimating reproductive ranks by multiple observers regardless of breeding success or failure. We considered that rotating observers between plots in different years mitigated concerns about pseudoreplication when pooling results across years.

We plotted index ranks to examine the concordance of paired ranks between paired observers. Because index ranks are discrete, the results were plotted so that the circle size indicated the number of matches for that rank combination. A perfect correlation would provide a graph with all circles occurring on a line of slope $x = y$. In addition, the distribution of circle sizes along the line would indicate the proportion of territories ending at each breeding stage.

Nest locations were plotted on territory maps to determine which nests and territories corresponded; this allowed us to compare nest-fate predictions derived from the index with actual nest fate as determined by nest searching and monitoring, using both naive (unmodified) nest success (defined as a nest that fledged at least one nestling) and modified nest success using Mayfield DSRs. Finally, we used Mayfield logistic regression, which incorporates the number of observation days to determine DSR and avoids bias associated with monitoring nests for unequal lengths of time (Hazler 2004), to assess the ability of the index to predict nest success.

RESULTS

During 2002 and 2003, one or both observers paired to each plot mapped 190 unique territories (~2.6 territories ha^{-1}); observers also located and monitored 76 Savannah Sparrow nests (31 in 2002, and 45 in 2003). Observers spent ~11 h locating and monitoring each nest and ~2.5 h in each territory gathering behavioral data for the index.

We examined 16 nonorthogonal contrasts for patterns in DSR by year and plot. Although nest survival differed significantly among plots (plot A had higher nest survival than plots B and C), there were no significant year effects, which would have raised concerns about pseudoreplication when pooling results from 2 years. Of the 190 unique spot-mapped territories, 143 (75.3%) were independently identified by observers mapping the same plot. On these 143 matched territories, there was a weak positive correlation between index values assigned by independent observers ($r = 0.398$). Paired ranks given to these territories were plotted for all observers combined (Fig. 1) and for each observer pair (Fig. 2). The generally

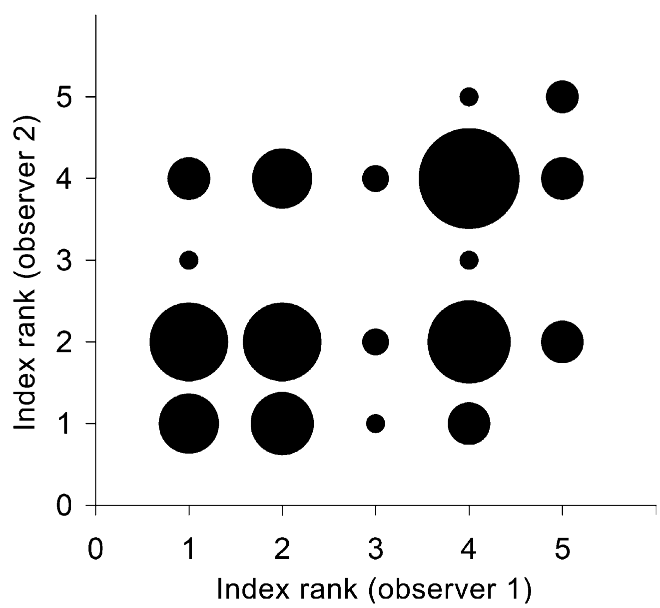

FIG. 1. Correlation between ranks given individually to all matching territories of Savannah Sparrows at Iroquois National Wildlife Refuge in Shelby, New York, in 2002 and 2003, by paired observers using Vickery et al.'s (1992) reproductive index, for all plots and years. The area of each circle is proportional to the number of nests with that pair of rankings.

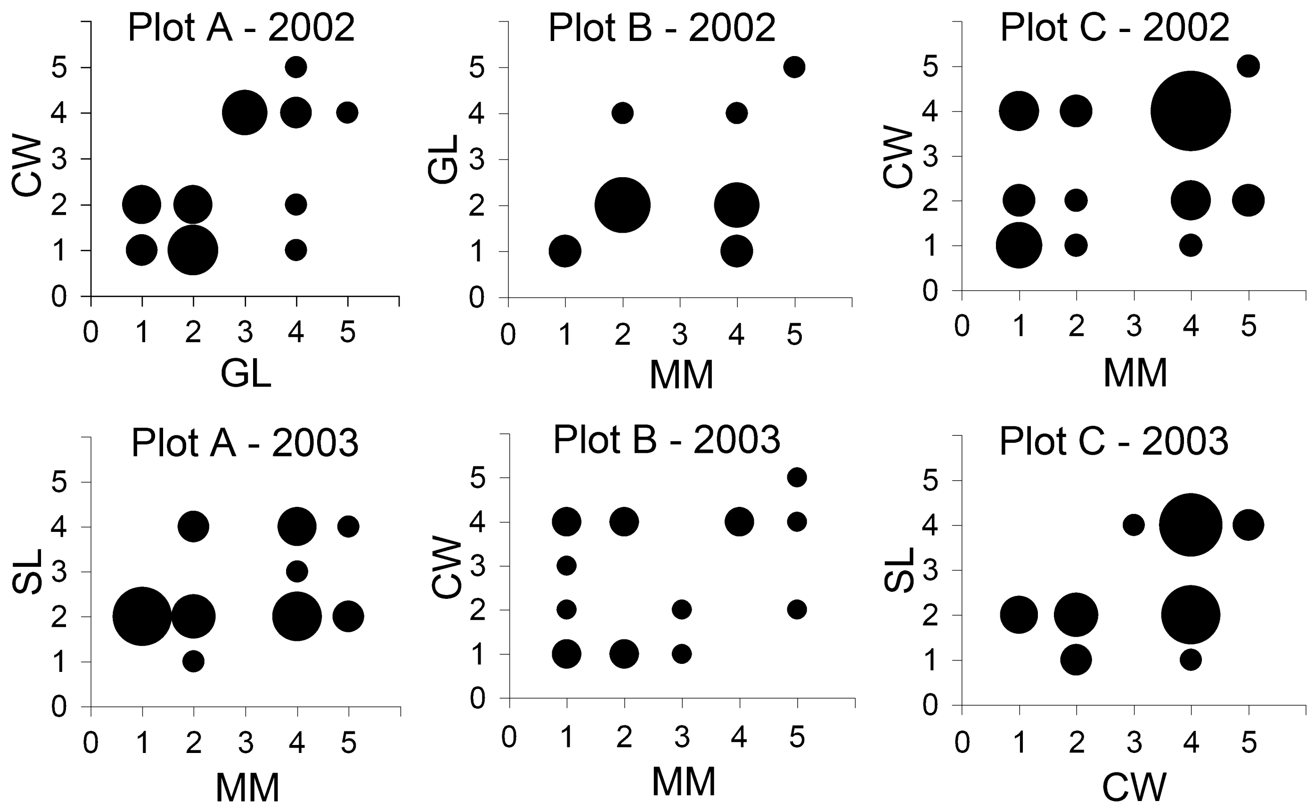

FIG. 2. Correlation between ranks given individually to matching territories of Savannah Sparrows at Iroquois National Wildlife Refuge in Shelby, New York, by paired observers using Vickery et al.'s (1992) reproductive index, for each plot and year combination. The area of each circle is proportional to the number of territories given that pair of rankings. The initials on each axis indicate the observers who assigned the ranks in each plot and year.

even distribution of the circles on each side of the diagonal fails to indicate bias in the rankings, but the wide dispersion of the circles indicates relatively low concordance between observers.

Although the number of territories assigned to each rank was not expected to be equal, only 4 territories were given a terminal rank of 3 (nest building and egg laying), based on observations of active nests by observers conducting the index, and 55 territories were ranked as failing to progress to rank 3. Observers gathering index data during the morning never observed Savannah Sparrows carrying nesting material, although this behavior was observed several times during nest searching and monitoring. Three additional territories were temporarily classified as rank 3 after observation of active nests but received higher rankings after observation of behaviors from advanced stages of the breeding cycle. Our interpretation of behavioral observations in relation to nest fate was not affected by Brown-headed Cowbird parasitism, because only one nest was parasitized (unsuccessfully) during the study.

Reproductive indices were compared with nest fates for 76 territories in which a nest was found. Joining nest locations with the independently mapped territories was relatively simple because boundaries of spot-mapped territories often shifted to center on established nest locations. One or both observers correctly assigned an index rank that matched the actual nest fate for only 33 (43%) of the 76 nests (Table 1). The index estimated a 9.8% overall success rate (percentage of territories to successfully fledge young; Table 2), whereas the success rate of territories that progressed further in the breeding cycle than attracting a female was 15.9%. Apparent nest success as determined by nest searching and monitoring was 69.7% (53 of 76 nests fledged young), although the modified success rate was 41.7% when calculated using the DSR (0.9627; Table 2). Most importantly, 77% of the successful nests were in territories ranked by both observers as having failed (Table 1). At the plot level, there was no significant correlation between

TABLE 1. Number of correct predictions of nest fate in Savannah Sparrows made by observers using Vickery et al.'s (1992) reproductive index at Iroquois National Wildlife Refuge in Shelby, New York, in 2002 and 2003. The true nest fate was determined by nest searching and monitoring.

	Observers		
Nest fate	Both correct	One correct	Neither correct
Failure	15 (65%)	6 (26%)	2 (9%)
Success	4 (8%)	8 (15%)	41 (77%)
Overall	19 (25%)	14 (18%)	43 (57%)

Table 2. Daily survival rates (DSR), associated modified nest success rates, and territory success rates estimated using Vickery et al.'s (1992) reproductive index ("index estimate"; proportion of territories reaching rank 5) for Savannah Sparrows at Iroquois National Wildlife Refuge in Shelby, New York.

Plot, year	DSR	Modified nest success rate	Index estimate
Overall	0.9627	0.417	0.098
A, 2002	0.9708	0.5058	0.087
B, 2002	0.9017	0.0926	0.115
C, 2002	0.9333	0.2044	0.059
A, 2003	0.9632	0.4222	0.177
B, 2003	0.8753	0.0467	0.094
C, 2003	0.9236	0.1607	0.071

modified nest success rates and index estimates of territory success ($r^2 = 0.115$, $P = 0.511$; Fig. 3).

We used Mayfield logistic regression to explore whether the index rank for a territory could be used as a predictor of nest success, controlling for plot and year differences. There were no significant plot effects, and odds ratios for the index ranks (the higher of the two ranks assigned by the paired observers of a territory) varied from 0.91 for rank 3 (rank 2 was the basis for comparison to other ranks in the output) to 4.5 for rank 4 to 2.8 for rank 5. Only rank 4 (hatching but not fledging young) showed a significant positive correlation with nest fate ($P = 0.035$).

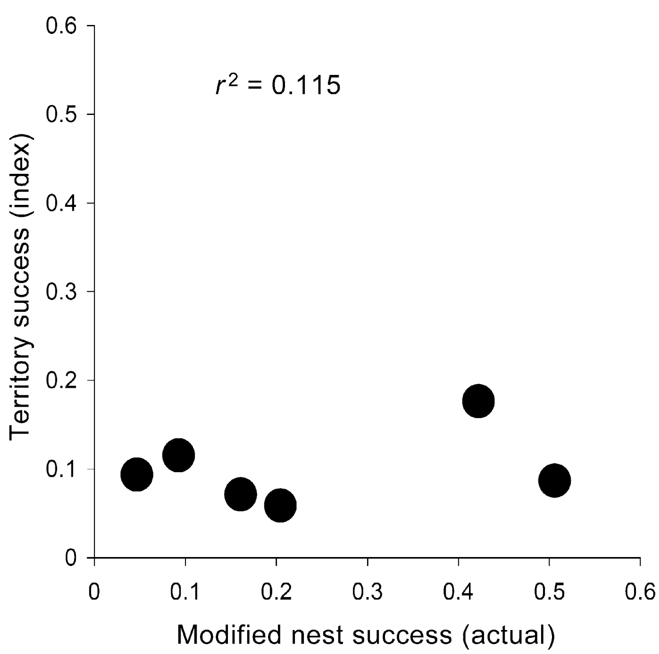

Fig. 3. Correlation between plot-level estimates of territory success based on Vickery et al.'s (1992) reproductive index and those based on nest success as determined by nest searching and monitoring, in Savannah Sparrows at Iroquois National Wildlife Refuge in Shelby, New York, in 2002 and 2003.

Discussion

Success rates of monitored nests were generally higher than those of grassland birds in other regions of North America (Best et al. 1997, Davis 2003). By contrast, the rate of nest parasitism by Brown-headed Cowbirds at our site, and on grassland birds in Vermont (Perlut et al. 2006), was much lower than in the Midwest (Rivers et al. 2003, Winter et al. 2004). Together with the high density of territorial males observed during the project (~2.6 territories ha^{-1}), these data suggest that properly managed "non-native" cool-season northeastern grasslands are valuable for conserving grassland breeding birds (Norment 2002). However, additional research on conservation strategies, management techniques, and the potential benefit of native grass varieties is required, particularly in the Northeast (Morgan and Burger 2008), and an efficient, nonintrusive technique for quantifying reproductive success (such as the index) would strengthen analyses of grassland bird response to management actions.

We found that the index allowed observers to efficiently collect more data than nest searching and monitoring (~2.5 h spent per territory vs. ~11 h locating and monitoring each nest). Unfortunately, 24.6% of territories mapped by one observer did not match territories mapped by a second observer, and the correlation in ranks assigned by observers to matching territories was poor. These results suggest an important weakness in the index's ability to meet requirements for a standardized technique for estimating breeding productivity in grassland birds. Furthermore, the failure of the index to accurately predict nest fate for 57% of the monitored nests demonstrates that this method fails as a substitute for nest searching and monitoring at the territory level. Even at the plot level, there was a very poor correlation between the two methods ($r^2 = 0.115$), as was also reported for Dickcissels by Rivers et al. (2003).

Although it is tempting to limit our comparison of the territory success rate provided by the index (9.8%) to the nest success rate calculated using the DSR for monitored nests (41.7%), such a comparison may be misleading. The success rate from the index estimates the percentage of territories to complete the entire breeding cycle by successfully fledging young, whereas the DSR and associated nest success rate estimate the success of territories that reached the nest-building stage and ignore territories in which males failed to attract a mate or pairs failed to initiate nest building. A more accurate comparison would be between the nest success rate derived from the DSR (41.7%) and the success rate for only those territories that reached the nest-building stage or higher (15.9%). However, given the disparity in success rates derived by the two methods at the plot level and the fact that plot-level comparisons provide a limited amount of information on the usefulness of the index, a rigorous assessment should include a detailed analysis at the territory or nest level, as we have done.

Results for the Mayfield logistic regression, which measured the ability of the index to accurately predict nest survival, demonstrated some unexpected patterns, particularly the large odds ratio associated with rank 4 (presence of nestlings, generally documented by observing adults carrying food toward a presumed nest) in relation to rank 5 (successful fledging of young, mostly documented by parents carrying food after the nestling stage). Under the assumption that the index is tightly correlated with nest success, we expected a smooth increase in the odds ratios as the index rank increased. The different odds ratios for ranks 4 and 5, along with the much larger number of territories classified as rank 4 than classified as rank 5 (in contrast to the high success rate of monitored nests), suggests a possible difficulty in assigning rank 5.

One assumption of the index is that observers will note breeding behaviors. While mapping territories for the index, we never observed Savannah Sparrows carrying nest material. This may be attributable to their skill at avoiding detection while establishing a nest site, as befits a species adapted for breeding in grasslands (Repasky 1996, Devereux et al. 2006). The skills that grassland birds must possess to conceal breeding activity and nest locations from visual predators, such as use of nest canopies and avoidance of nest sites when predators are near (Wheelwright and Rising 1993), conceivably reduce the probability that human observers will detect many nesting behaviors, resulting in underestimates of breeding success.

Observations of Savannah Sparrows carrying nesting material that occurred during afternoon nest searching and monitoring could also indicate differences in detection probabilities for certain breeding behaviors as a function of time of day (e.g., females foraging during the morning but selecting a nest site during the afternoon). However, observers expended more time searching for individual nests than observing behaviors in each territory; perhaps this difference increased the probability of observing secretive behaviors during afternoon nest searches.

Despite our intensive searching for nests—and validation of Mayfield's (1975) assumption that successful nests are more likely to be discovered through nest searching and monitoring than nests that fail early—we were unable to locate all nests in each plot, as indicated by the difference between observed nest success (69.7%; 53 of 76 monitored nests fledged young) and modified nest success (41.7%; determined from the overall DSR of 0.9627). The modified nest success implies that for the 53 successful nests discovered, ~74 nesting attempts failed (only 23 of which were discovered and monitored). Because the missed nesting attempts failed, their inclusion in the analyses would change neither the index's predictions of nest failure for 77% of the nests that produced young nor the effect of this misclassification in the analyses.

The high density of Savannah Sparrows in the study plots also may have compromised the ability of observers to detect some behaviors associated with the index, thus affecting assignment of ranks. For example, most plot locations to which observers traveled were within the territorial boundaries of a Savannah Sparrow. The observers' presence often elicited defensive behaviors, which commonly alerted other, nearby Savannah Sparrows, causing them to temporarily abandon breeding behaviors until the perceived threat (the observer) moved away. This may have caused observers to miss enough instances of adults carrying food that they mistook successful territories as having failed during the nestling stage. Additionally, the large number of territories within the plot made it challenging to spend sufficient time at each territory to observe behaviors associated with the breeding cycle. On an operational basis, however, we do not think that these challenges could be overcome through increased effort, especially given that one intent of the index is to reduce monitoring costs.

Proponents of the index may contend that its use will strengthen the assessment of reproductive potential on a wide range of habitats and that it need not be used as a surrogate for nest searching and monitoring. However, collecting presence–absence or density data remains more efficient than gathering index data, particularly at large scales, and is likely sufficient for a first-order assessment of habitat quality (Bock and Jones 2004). Consideration of productivity (second-order assessment) is necessary when identifying ecological traps (Schlaepfer et al. 2002), which are of most concern at high-density sites—and our research demonstrates that the index functions poorly in predicting breeding success at a high-density site.

In summary, we consider the index method inadequate for estimating the reproductive success of Savannah Sparrows in western New York grasslands, for several reasons. First, spot-mapping of territories was not reliably repeatable among different observers (see Best 1975). Second, there was a low correlation among the ranks assigned by different observers to the same territories. Third, at the plot level, there was little correlation between the success rate determined from the index and the nest success rate derived from Mayfield DSRs. Fourth, and perhaps most importantly, the index was a poor predictor of nest success at the territory level. Although our study focused on 1 species at 1 locality during a 2-year period, we intensively examined many assumptions underlying the index; our results, as well as those of Rivers et al. (2003) suggest that researchers should be cautious about employing the index as a surrogate for estimating reproductive success.

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