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EFFECTIVENESS OF CALL-BROADCAST SURVEYS FOR MONITORING MARSH BIRDS

Courtney J. Conway[1,3] and James P. Gibbs[2]

[1]*U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit, 104 Biological Sciences East, University of Arizona, Tucson, Arizona 85721, USA; and*
[2]*Environmental and Forest Biology, State University of New York, 1 Forestry Drive, Syracuse, New York 13210, USA*

Abstract.—Many species of marsh birds (e.g. rails and bitterns) are believed to be declining in North America, yet we lack an effective monitoring program to estimate their population trends. Broadcast of prerecorded calls to elicit vocalizations is a commonly used method in surveys of marsh birds, but whether gains in detection and index precision outweigh the drawbacks of call-broadcast is unclear. To evaluate the effectiveness of call-broadcast surveys, we pooled marsh-bird survey data from 8,047 point-count surveys contributed by 11 cooperators and compared numbers of birds detected and variation in numbers detected between call-broadcast and passive surveys. For most rails (particularly Virginia Rails [*Rallus limicola*]), call-broadcast surveys were effective at increasing the detection probability (e.g. average number of Virginia Rails detected per occupied point was 1.25 for call-broadcast surveys and 0.17 for passive surveys). The proportion of points at which no birds were detected was high for all species (range 74–99%) and was slightly lower on call-broadcast surveys as compared with passive surveys. Coefficient of variation (CV) among replicate surveys was higher for passive surveys, particularly for rails (average CV in number of birds detected per point was 209% for passive surveys and 189% for call-broadcast surveys). On the basis of those results, we recommend a marsh-bird monitoring protocol that includes an initial passive period followed by a period of call-broadcast to provide survey data that incorporate the benefits while avoiding the drawbacks of call-broadcast. We also recommend separating both the passive and the call-broadcast periods into 1-min subsegments that will allow estimates of components of detection probability within the monitoring effort. *Received 18 May 2003, accepted 23 September 2004.*

Key words: call-broadcast surveys, detection probability, marsh birds, monitoring, point-count surveys, rails, wetlands.

Efectividad de Censos que Reproducen Vocalizaciones Pregrabadas para Monitorear Aves de Pantano

Resumen.—Se cree que muchas especies de aves de pantano (e.g. rálidos y garzas) están declinando en Norte América, pero no contamos con un programa de monitoreo intensivo para estimar sus tendencias poblacionales. La reproducción de vocalizaciones pregrabadas para incitar a las aves a emitir vocalizaciones es un método empleado comúnmente en estudios de aves de pantano, pero no está claro si las ganancias en términos de detección y de la precisión de los índices son superiores a los problemas inherentes a esta técnica. Para evaluar la efectividad de los censos basados en la reproducción de vocalizaciones grabadas juntamos datos de 8047 censos de aves de pantano realizados mediante conteos por punto por 11

[3]E-mail: cconway@ag.arizona.edu

colaboradores, y comparamos el número de aves detectadas y la variación en este número entre censos que emplearon vocalizaciones grabadas y censos pasivos. Para la mayoría de los rálidos (particularmente *Rallus limicola*), los censos con reproducción de vocalizaciones fueron efectivos para incrementar la probabilidad de detección (e.g. el número de individuos de *R. limicola* detectados por punto ocupado fue de 1.25 en los censos con vocalizaciones y de 0.17 en los censos pasivos). La proporción de puntos en los que no se detectaron aves fue alta para todas las especies (rango 74–99%) y fue ligeramente menor en los censos con vocalizaciones que en los censos pasivos. El coeficiente de variación (CV) entre censos replicados fue mayor en los censos pasivos, particularmente para los rálidos (el CV en el número de aves detectadas por punto fue 209% en los censos pasivos y 189% en los que emplearon vocalizaciones). Con base en estos resultados, recomendamos un protocolo para monitorear las aves de pantano que incluye un período pasivo inicial seguido por un período en el que se reproducen vocalizaciones, lo cual provee datos que incorporan los beneficios y evitan los problemas de la reproducción de vocalizaciones. También recomendamos separar tanto el período pasivo como el de emisión de vocalizaciones en segmentos de 1 min para permitir la estimación de componentes de la probabilidad de detección de acuerdo el esfuerzo de monitoreo.

Populations of many marsh birds have declined in North America (Eddleman et al. 1988, Ribic et al. 1999). For example, American Bitterns (*Botaurus lentiginosus*) and King Rails (*Rallus elegans*) have declined on Breeding Bird Survey routes (Sauer et al. 2000). Black Rails (*Laterallus jamaicensis*), Yellow Rails (*Coturnicops noveboracensis*), Limpkins (*Aramus guarauna*), and American Bitterns are species of conservation concern (U.S. Fish and Wildlife Service 2002). King Rails are federally endangered in Canada (COSEWIC 2002). Black Rails are federally endangered in Mexico (Diario Oficial de la Federacion 2002) and are listed as threatened or endangered in several states within the United States (Eddleman et al. 1994), and three western races of Clapper Rail (*R. longirostris obsoletus*, *R. l. levipes*, and *R. l. yumanensis*) are federally endangered in the United States (Eddleman and Conway 1998). Moreover, Virginia Rails (*R. limicola*), Soras (*Porzana carolina*), Clapper Rails, and King Rails are game species in many states (Tacha and Braun 1994). Despite evidence of population declines and the need to set responsible harvest limits, an effective monitoring program to estimate population trends of marsh birds is lacking because the Breeding Bird Survey and other surveys do not adequately sample birds in wetlands dominated by emergent plants (Bystrak 1981, Robbins et al. 1986, Gibbs and Melvin 1993). For that reason, a continental marsh-bird monitoring program has been proposed for North America (Ribic et al. 1999). The primary goal of the program is to detect population change in marsh birds, with particular emphasis on rails and bitterns.

Monitoring plays a critical role in effective conservation by identifying declining populations before they are threatened with extinction (Goldsmith 1991, Hagan 1992). Indeed, early detection of declining populations allows more effective and less costly recovery efforts (Green and Hirons 1991). Most monitoring efforts rely on trends in count data as an index to population change. An effective index to population size should be robust (high detection probability), but more importantly, it should be precise (low temporal variation in detection probability; Johnson 1995). Hence, a survey methodology that minimizes temporal variance in detection probability will be better than one that solely maximizes total count.

Monitoring of marsh-bird populations requires aural surveys, because individuals stay concealed within emergent vegetation. A commonly used method involves broadcasting recorded calls to elicit vocal responses from birds (Johnson et al. 1981, Marion et al. 1981). Marsh birds vocalize infrequently, and call-broadcast surveys (also called tape-playback or acoustic-lure surveys) are often used with the assumption that call-broadcast increases the number of birds counted (Glahn 1974, Johnson and Dinsmore 1986, Manci and Rusch 1988, Gibbs and Melvin 1993). Moreover, proper identification of marsh-bird calls may be enhanced when observers repeatedly hear broadcast calls of target species. Hence, call-broadcast surveys have been proposed for use in a continental marsh-bird monitoring program for North America (Ribic et al. 1999, Conway and Gibbs 2001).

The extent to which call-broadcast surveys increase detection probability in comparison with passive surveys is not well known for most marsh birds. Moreover, whether call-broadcast surveys decrease temporal variation in detection probability is not known. Call-broadcast surveys have potential drawbacks for monitoring: (1) broadcasting calls of one species might decrease detection probability of coexisting species; (2) birds may habituate to broadcast calls after repeated exposure (Irish 1974, Smith 1974); (3) broadcast calls may disturb breeding birds (Glinski 1976, Kerlinger and Wiedner 1991); (4) broadcast equipment quality may change over the course of a monitoring program; (5) sound quality may decline with prolonged use of broadcast equipment; (6) broadcast volume may vary among observers; (7) the broadcast may reduce the ability of observers to hear calling birds; (8) call-broadcast surveys increase costs required of survey participants; (9) the type, origin, or dialect of broadcasted calls may affect responsiveness of birds and may vary among observers and across years; and (10) broadcast calls may prompt birds to move toward the surveyor (Legare et al. 1999, Bogner and Baldassarre 2002), introducing bias into estimates of local population density or detection probability based on distance sampling. Passive surveys avoid many of those biases and can provide trend estimates for all coexisting marsh birds simultaneously. Hence, understanding the magnitude of benefits and drawbacks associated with call-broadcast surveys as compared with passive surveys is essential before a continent-wide marsh-bird monitoring program is implemented. Because of the many potential drawbacks associated with call-broadcast surveys, we need estimates of the extent to which call-broadcast increases number of birds detected and affects variation in numbers detected.

We analyzed data pooled from 11 marsh-bird survey efforts in North America to evaluate the utility of call-broadcast surveys for monitoring marsh birds. All survey efforts included a passive survey followed immediately by a call-broadcast survey at each point, which allowed us to use paired analyses while controlling for regional variation in call-broadcast efficacy. We used pooled analyses of all data as well as a meta-analysis to compare detection probability and temporal variation in detection probability between call-broadcast and passive marsh-bird surveys.

Methods

We sent letters to 102 authors who had published papers or theses on North American marsh birds over the past 30 years, and to 40 participants of a recent workshop (Ribic et al. 1999), requesting breeding-season marsh-bird survey data. We received data from 16,406 point-count surveys from 15 cooperators (from 10 U.S. states), of which 11 data sets (8,047 point-count surveys total) included an initial passive survey followed by a call-broadcast survey. Survey data for 12 marsh-bird species were included in the pooled data set: Sora, Virginia Rail, Black Rail, King Rail, Clapper Rail, Common Moorhen (*Gallinula chloropus*), American Coot (*Fulica americana*), Pied-billed Grebe (*Podilymbus podiceps*), American Bittern, Least Bittern (*Ixobrychus exilis*), Green Heron (*Butorides virescens*), and Marsh Wren (*Cistothorus palustris*). The number of studies that included detection data for a particular species varied from 1 to 10 (Table 1). Studies varied in number of years of survey data (1–13 years), number of surveyors (1–7), distance between adjacent points (100–800 m), number of replicate surveys per year (1–36), and time of day during which surveys were conducted (Conway and Gibbs 2001). All but two cooperators used an unlimited survey radius. Contributed survey data also varied in survey duration at each point (5–46 min), length of initial passive period (2–10 min) as compared with that of the call-broadcast period (1–36 min), and number of species included in the call-broadcast sequence (1–11 species). We conducted quality checks on each data set and worked with cooperators to correct errors.

We used the pooled data set to evaluate the effect of call-broadcast on detection probability and temporal variation in detection probability in comparison with passive surveys. We assumed that local population size at each study site was relatively constant during breeding-season surveys, such that temporal variance

Table 1. Percentage of increase (effect size) in mean number of birds detected per point on call-broadcast surveys as compared with passive surveys, after controlling for differential survey duration. Percentage of increase is estimated as the y-intercept of the linear regression of proportional increase in mean number of birds per point versus proportional increase in survey duration across 11 marsh-bird survey efforts. We included only the points at which ≥1 individual was detected on ≥1 replicate survey for each species' regression. We did not estimate percentage of increase for species detected on fewer than five studies.

Species	Number of studies that detected species	Number of survey points at which species was detected	Number of replicate surveys in which species was detected	Effect of call-broadcast		
				Percentage of increase	t	P
Pied-billed Grebe	5	242	780	–67	–1.0	0.393
American Bittern	6	273	483	–44	–3.2	0.056
Least Bittern	10	151	199	13	0.3	0.791
Green Heron	3	45	59			
Black Rail	2	61	199			
Sora	10	467	946	103	1.7	0.124
Virginia Rail	10	887	1,900	657	10.0	<0.001
King Rail	5	57	139	1,303	1.1	0.353
Clapper Rail	1	39	45			
Common Moorhen	5	144	295	78	2.1	0.105
American Coot	1	64	122			
Marsh Wren	3	270	831			

in number of birds counted across replicate surveys was equivalent to temporal variance in detection probability. We calculated the proportion of points at which no birds were detected for both call-broadcast and passive surveys of each of the 12 species. The proportion of points with no birds detected affects estimates of the number of points needed to detect change, and that parameter varies, we expect, among study sites, regions, and species. In addition, we estimated the probability of detecting a species at a survey point known to be occupied (i.e. a point at which ≥1 individual of that species was detected on a prior visit) for both call-broadcast and passive surveys. Those probabilities are useful for evaluating the potential for monitoring the proportion of sites occupied rather than population size (MacKenzie et al. 2002), which may be more appealing to some resource managers because of logistical ease.

For each of the 12 species, we used a repeated-measures ANCOVA to test whether mean number of birds detected per point differed between passive and call-broadcast surveys. We used a multivariate approach for the repeated-measures ANCOVAs, because that approach requires fewer assumptions (i.e. does not require that the correlation coefficients be equal) and is more conservative (Wilkinson 1990). We also compared mean number of birds detected per point in call-broadcast and passive surveys using a meta-analysis approach (Hedges and Olkin 1985). For each species, we calculated the effect size for each of the 11 data sets as the percentage of increase in mean number of birds detected per point associated with call-broadcast as compared with passive surveys: (number of birds detected on call-broadcast survey – number of birds detected on passive survey)/(number of birds detected on passive survey). We then regressed that effect size against the percentage of increase in survey duration associated with the call-broadcast period as compared with the passive period. We examined the y-intercept of those regressions, because we were interested in whether the mean number of birds detected was greater for call-broadcast surveys after differential survey duration was controlled. The unstandardized coefficient of the y-intercept provided an estimate of the expected proportional increase in detection probability associated with call-broadcast if the duration of call-broadcast and passive surveys were equal. We included only the points at which ≥1 individual was detected on ≥1 replicate survey for each species regression.

We also used repeated-measures ANCOVAs to test whether temporal variation in number of birds detected differed between passive and call-broadcast surveys, using the coefficient of variation (CV) among replicate surveys at each point within a year. Comparison of CV is useful because CV accounts for the fact that the standard deviation is typically proportional to the mean in data sets in which zero counts are common. In the repeated-measures ANCOVA models, survey type (passive vs. call-broadcast) was a main factor, and the difference in duration between passive and call-broadcast surveys was the covariate. For all our ANCOVA analyses, we used only points at which ≥1 individual was detected on ≥1 replicate survey of that species within that particular year. We used an alpha level of 0.05 for all statistical comparisons.

RESULTS

Zero counts were relatively common among all species and both types of surveys, but call-broadcast appeared to reduce the number of zero counts, particularly in Virginia Rails (Fig. 1). The percentage of replicate surveys that detected a particular species that was present on a prior survey (i.e. at an occupied site) was low (<30%) on passive surveys for all species except Marsh Wrens (Fig. 2). Probability of detecting a resident species during a passive survey was particularly low (<15%) for rails and bitterns. For most rails, but not for other marsh birds, call-broadcast increased the probability that a particular species would be detected at an occupied point (Fig. 2). For example, surveyors detected Virginia Rails in 40% of call-broadcast surveys at points known to harbor Virginia Rails, but in only 7% of passive surveys at those same points (Fig. 2). In our pooled analyses, call-broadcast increased the number of birds detected per point for Virginia Rails (1.25 birds detected per point, compared with 0.17 in passive surveys), Soras (0.71 birds per point, compared with 0.27 in passive surveys), Clapper Rails (1.30 birds per point, compared with 0.19 in passive surveys), and Common Moorhens (1.49 birds per point, compared with 0.91 in passive surveys), but decreased the number of birds detected per point for Marsh Wrens (1.05 birds per point, compared with 1.23 in passive surveys) (Fig. 3).

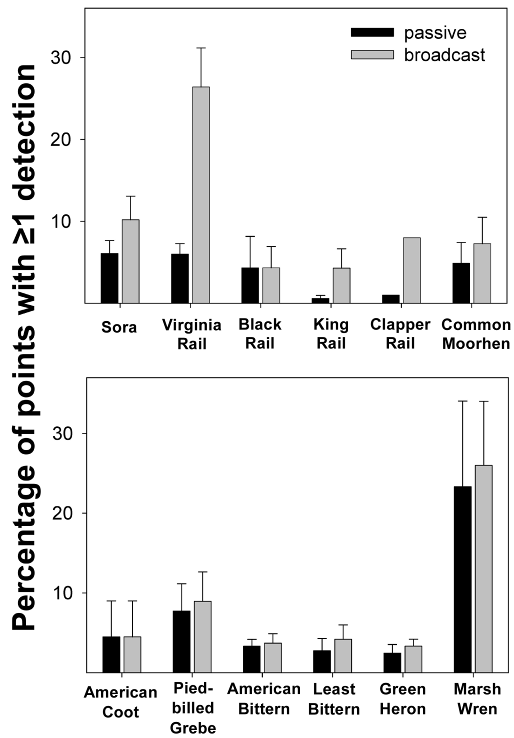

FIG. 1. Mean (± SE) of percentage of survey points at which ≥1 bird was detected for both call-broadcast and passive surveys from 11 marsh-bird survey efforts in North America. Percentages within each survey effort is based on individual survey points across all years (replicate surveys not pooled within years). Sample sizes for each species are the number of survey efforts that detected that species (see column 2 of Table 1).

Our meta-analysis of effect size across 11 data sets suggested that call-broadcast is effective at increasing detection probability for Virginia Rails, Soras, King Rails, and Common Moorhens (Table 1). The proportional increase in mean number of birds detected per survey point on call-broadcast surveys as compared with passive surveys was not consistent among studies, varied among species, and was highest for rails (Table 1). Standard deviation in number of birds detected among replicate surveys was higher for call-broadcast surveys than for passive surveys for 6 of the 12 species (higher means typically have higher standard deviations). More importantly, the CV in number of birds detected among replicate surveys was

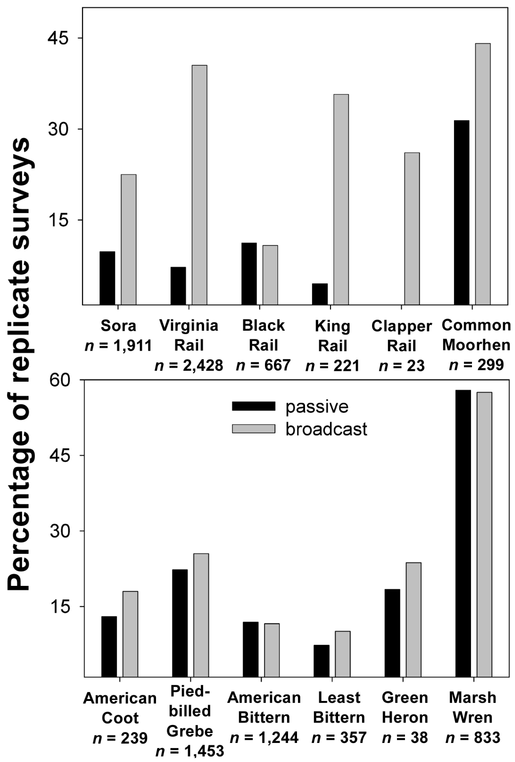

Fig. 2. Percentage of replicate surveys that detected ≥1 individual of a particular species at points at which that species was detected on a prior survey, for both call-broadcast and passive surveys from 11 marsh-bird survey efforts in North America. Sample sizes refer to the number of replicate point-count surveys at points at which the species had been detected on a prior survey.

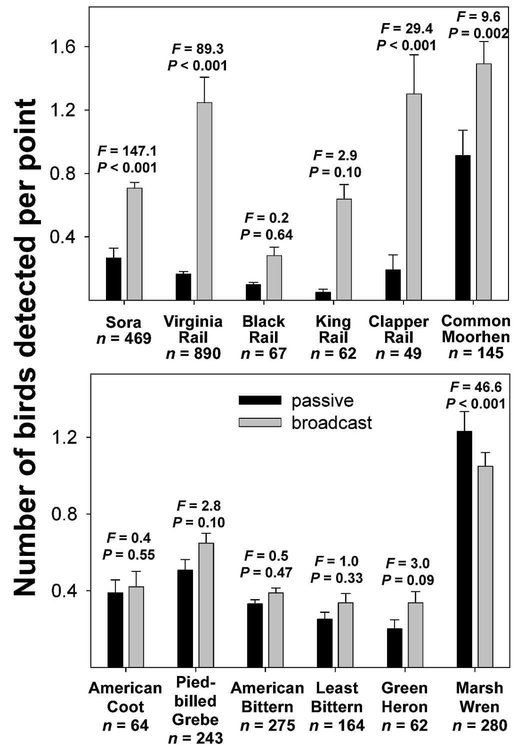

Fig. 3. Mean number of individual birds detected per point (± SE) during initial passive and subsequent call-broadcast portions of 11 marsh-bird survey efforts in North America. *F*-statistics and sample sizes are based on repeated-measures ANCOVAs examining differences between passive and call-broadcast portions of the surveys, controlling for differences in duration of survey periods. Replicate surveys at each point within a year were averaged before analysis.

lower for call-broadcast surveys of all species except Marsh Wrens (Fig. 4).

Discussion

The relative benefit of using call-broadcast surveys to increase numbers of birds detected varied among species. Both our pooled analyses and our meta-analysis suggested that call-broadcast is effective at increasing the number of individuals detected for some species of rails, even after controlling for differences in survey duration. Both analytical approaches failed to show a benefit of call-broadcast for the other species of marsh birds.

All species were relatively rare; observers detected birds at <10% of survey points for all species except Virginia Rails and Marsh Wrens. Even at survey points at which a particular species had been detected on a prior survey, the probability that an observer detected that species during a subsequent passive survey was low (e.g. <15% for all species of rails and bitterns). Clearly, the rarity of marsh birds within emergent-dominated wetlands presents challenges for using point-count surveys for detecting population trends.

The duration of the call-broadcast segment was longer than the duration of the passive segment on most surveys, but only a portion

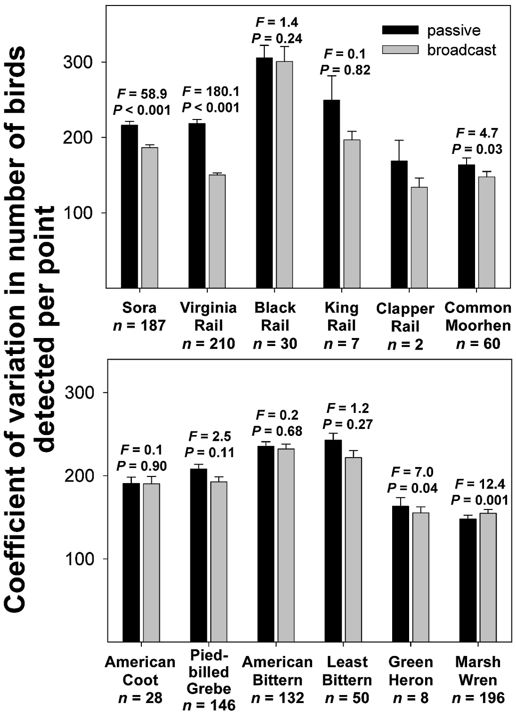

Fig. 4. Coefficient of variation (± SE) in number of individual birds detected per point on replicate surveys within a year during initial passive and subsequent call-broadcast portions of 11 marsh-bird survey efforts in North America. *F*-statistics and sample sizes are based on repeated-measures ANCOVAs examining differences between passive and call-broadcast portions of the surveys, controlling for differences in duration of survey periods.

of the call-broadcast segment involved conspecific calls, because most cooperators included multiple marsh-bird species in their broadcast sequence. Including the difference in survey duration as a covariate in our analyses was the best approach to control unequal survey duration. However, the number of new detections per minute probably declines, in some nonlinear manner, as survey duration increases. Future call-broadcast surveys that include multiple species' calls in the broadcast sequence should make the initial passive segment and the call-broadcast segment of the same duration and record detections during each of several subsegments within each survey period (Farnsworth et al. 2002).

Our failure to identify a benefit of call-broadcast in some species (e.g. Black Rail) may be attributable to the small number of studies or points at which those species were detected. Moreover, intrinsic and extrinsic factors (e.g. time of day, stage of nesting cycle, type of calls broadcast, duration of broadcast sequence, weather, population density) cause variation in detection probability (Conway and Gibbs 2001). Those factors likely influenced our ability to evaluate the effectiveness of call-broadcast using pooled data from multiple studies. Moreover, the effectiveness of call-broadcast surveys as compared with passive surveys for some species undoubtedly depends on the number (and identity) of other species included in the broadcast sequence.

Although high detection probability is helpful, an equally important consideration for monitoring is which survey methodology results in the lowest temporal variation in detection probability. Monitoring efforts commonly ignore variation in detection probability and, hence, make the unrealistic assumption (Barker et al. 1993) that detection probability is constant across time and space. Indeed, detection probability of marsh birds often differs between males and females (Brackney and Bookhout 1982, Legare et al. 1999) and changes during the course of the breeding season (Conway et al. 1993, Bogner and Baldassarre 2002). Our results suggest that call-broadcast surveys decrease the CV in number of birds detected across replicate surveys. The higher frequency of zero counts on passive surveys explains why standard deviation was lower for passive surveys. Survey methods that produce a high number of points with zero birds detected result in a low standard deviation among replicate surveys, but that result is obviously not helpful for monitoring population change.

The duration of a point-count varies greatly among marsh-bird survey efforts (Conway and Gibbs 2001). Choosing an appropriate survey duration suitable for monitoring all marsh-bird species in all regions is desirable for a standardized continental monitoring program. We recommend a survey protocol that includes an initial passive period followed by a call-broadcast period, each composed of 1-min subsegments. For example, observers during a 5-min passive period would record whether each individual bird was detected during the first, second, third, fourth, or fifth minute; one could then estimate vocalization probability by treating the data produced at each point as a removal experiment (Farnsworth et al. 2002). That design has the important benefit of estimating a component of detection probability within the sampling program (Burnham 1981, Skalski and Robson 1992), and also facilitates comparisons of results with those obtained during surveys of different duration from other areas or previous years. Recording detections within 1-min subsegments involves only modest changes to data-sheet organization, yet permits important insights regarding survey effectiveness and cross-study compatibility.

Detection probability and call-broadcast effectiveness change seasonally, and optimal survey timing differs among coexisting marsh-bird species (Conway and Gibbs 2001). Hence, we recommend replicate surveys at each point, with each replicate survey conducted during distinct seasonal survey periods. Conducting replicate surveys (1) ensures that at least one survey is conducted during the best time for all coexisting species in each local area; (2) ameliorates problems associated with high temporal variation in vocalization probability; (3) helps ameliorate biases created by annual variation in seasonal-peak vocalization probability; (4) allows estimates of the proportion of sites occupied by each species (MacKenzie et al. 2002); and (5) provides better estimates of temporal variation in numbers detected, which is useful for estimating the number of survey points needed to detect population trend.

Many previous studies have examined the usefulness of call-broadcast on one or two species and reported that call-broadcast increases the number of birds detected (Glahn 1974, Mangold 1974, Marion et al. 1981, Johnson and Dinsmore 1986). Most of the data used in our analyses came from surveys that included broadcast of multiple species' calls (Conway and Gibbs 2001). Broadcasting calls of some coexisting marsh birds may reduce detection probability of some species, whereas calls of other coexisting species may enhance detection probability. Hence, the usefulness of call-broadcast may depend on the number (and identity) of species' calls included in the broadcast sequence. That issue needs to be considered prior to development of marsh-bird monitoring protocols suitable across large geographic scales.

Published estimates of detection probability associated with marsh-bird surveys range from 19% to 100%, but many previous estimates used biased measures of detection probability (Conway and Gibbs 2001). Few reliable estimates of detection probability are available for marsh birds (but see Conway et al. 1993, Legare et al. 1999, and Bogner and Baldassarre 2002 for estimates of vocalization probability of radiotagged birds). Future studies should estimate and compare observer bias in passive and call-broadcast surveys. The best survey methodology is one that produces high detection probability and low temporal variation in detection probability. Our results suggest that call-broadcast increases detection probability and decreases temporal variation in detection probability for most rails, but may not be effective for other marsh birds. A continental survey protocol that has observers collect data within multiple subsegments at each point (Farnsworth et al. 2002) and also includes a double-observer component (Nichols et al. 2000) would provide better estimates of two components of detection probability (vocalization probability and observer bias; Conway and Simon 2003). Such efforts would provide estimates of parameters critical to developing effective monitoring protocols for marsh birds.

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