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NESTING SUCCESS AND SURVIVAL OF VIRGINIA RAILS AND SORAS

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ABSTRACT.—Lack of estimates of nesting success and annual survival of North American rails limits our ability to monitor rail populations, regulate harvest levels, and institute recovery programs. We here present Virginia Rail (*Rallus limicola*) and Sora (*Porzana carolina*) population trends from Breeding Bird Surveys (BBS) throughout North America, estimates of nesting success from the Cornell Laboratory of Ornithology's Nest Record Program, and estimates of survival from radio-marked and banded birds in Arizona, 1985–1987. Virginia Rail populations declined 2.2% annually from 1982–1991, and Sora populations declined 3.3% annually from 1966–1991. Annual survival probability of radio-marked and banded Virginia Rails in Arizona was 0.526 ± 0.195 and 0.532 ± 0.128, respectively. Non-breeding survival probability did not differ between radio-marked Virginia Rails (0.545 ± 0.191) and Soras (0.308 ± 0.256) in Arizona. All documented mortality occurred between October and March for both Virginia Rails and Soras. Virginia Rail and Sora nesting success was 53%. Despite reproductive success and survival rates adequate for population maintenance, rail populations appear to have declined proportionately with continental wetland loss. *Received 24 Sept. 1993, accepted 20 Jan. 1994.*

Few studies have estimated reproductive success and annual survival of rails because they are secretive and attract little interest from hunters. Because wetland habitats have declined throughout the United States, information on population trends and life-history parameters is vital for determining whether populations of wetland-dependent species such as rails have suffered proportionately and are vulnerable to extirpation or extinction. Although Clapper Rail (*Rallus longirostris*), King Rail (*R. elegans*), Virginia Rail (*R. limicola*), and Sora (*Porzana carolina*) have liberal hunting regulations in many states, western taxa of Clapper Rail and Black Rail (*Laterallus jamaicensis*) are endangered. Nonetheless, few states monitor rail populations, and the effects of wetland destruction on rails have not been addressed. In addition, because few estimates of nesting success and annual survival of North American rails are available, our ability to monitor rail populations, regulate harvest levels, and institute recovery programs is limited. Effective management and conservation of rails requires identification of the environmental features affecting nesting success and survival.

In this paper, we present Virginia Rail and Sora population trends

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throughout North America from 1966–1991. We also estimate annual survival from radio-marked and banded birds in Arizona from 1985–1987 and nesting success, using nest record cards from throughout North America from 1920–1987.

METHODS

We examined Virginia Rail and Sora population trends (rates of annual change) in North America from 1966–1991, using North America Breeding Bird Survey (BBS) data from the U.S. Fish and Wildlife Service's (USFWS) Office of Migratory Bird Management. The Office of Migratory Bird Management has used route-regression analysis of BBS data to estimate population trends (Geissler and Noon 1981, Geissler and Sauer 1990) and bootstrapping (N = 400 repetitions) to estimate variances of trend estimates (Geissler and Noon 1981, Geissler and Sauer 1990). We examined 25-year (1966–1991) and 10-year trends (1982–1991) for both species, using weighted average numbers of birds tallied per BBS route (Robbins et al. 1980, Geissler and Sauer 1990). We present trends for Canada, the United States, North America, the Eastern region of North America (all States and Provinces east of the Mississippi River), the Central region (between the Rocky Mountains and the Mississippi River), and the Western region (west of the Mississippi River and north of Mexico, excluding Alaska). Sample sizes represent the number of BBS routes within the species' range that were conducted at least two years by the same observer during the time period.

In 1986 and 1987, we caught 88 Virginia Rails and 83 Soras in Yuma County, Arizona. Rails were captured with drop-door traps with lead fences and banded with USFWS aluminum bands. We radio-marked 42 of the 88 Virginia Rails and 26 of the 83 Soras. Radio transmitters weighing 3 g (Model MPB-1070-LD, Wildlife Materials, Inc., Carbondale, Ill.) were glued onto the backs of these birds. We monitored radio-marked birds from four fixed-tower, null-peak receiving stations for 1–6 h daily, six days/week. Tracking sessions were stratified so that each period of the day was represented, and birds were monitored during all four seasons. We obtained simultaneous azimuths from the two telemetry stations providing the best bearing intersection. Radio contact was never obtained on six Virginia Rails and three Soras, and these individuals were excluded from analyses. Loss of radio contact may have been a result of migrant departure, but at least one case was a result of radio failure. The mean duration of contact with radio-marked birds was 47.4 days (SD = 38.6) for 36 Virginia Rails and 24.6 days (SD = 15.6) for 20 Soras. Three Soras depredated within four days of capture were assumed to be a result of radio-marking and not used in survival analyses. Capture and telemetry techniques are described in further detail by Conway (1990) and Conway et al. (1993).

We calculated daily and interval survival probabilities for radio-marked Soras and Virginia Rails using MICROMORT version 1.3 (Heisey and Fuller 1985). Estimates of survival probability were for all age and sex classes combined because no valid sex criteria are available for rails, and because we had inadequate sample size for age groups. We calculated annual survival for Virginia Rails and non-breeding (August–April) survival for Soras because Soras migrated from our study area to breed elsewhere. We also calculated annual survival probability of banded Virginia Rails using Model D of the capture-recapture program JOLLY (Pollock et al. 1990). For JOLLY analyses, we divided capture histories into ten three-month capture periods. Goodness-of-fit tests were performed to confirm the adequacy ($\chi^2 = 26.92$, $P = 0.03$, df = 15) of Model D, which assumes constant survival and capture probability over the entire sample period (Pollock et al. 1990). JOLLY also calculates estimates of population size and capture probability. Sample sizes of banded birds were

TABLE 1

VIRGINIA RAIL AND SORA POPULATION TRENDS[a] FROM ROUTE-REGRESSION ANALYSES OF NORTH AMERICAN BREEDING BIRD SURVEY DATA FROM 1966–1991 (DROEGE 1990)

Species	Region	1966–1991[b]			1982–1991		
		Trend[a]	SD	N[c]	Trend	SD	N
Virginia Rail	Canada	0.2	0.6	37	−3.0	2.8	16
	United States	−0.4	0.6	142	−1.9[d]	0.8	77
	North America	−0.2	0.5	179	−2.2[d]	0.9	93
	East	0.2	0.6	96	0.4	1.8	44
	Central	−0.2	0.6	37	−3.6[e]	0.7	19
	West	−1.0	0.8	46	−3.3	2.9	30
Sora	Canada	−2.0	1.6	196	4.0	2.5	149
	United States	−9.9	6.1	332	−8.5[e]	2.1	241
	North America	−3.3[d]	1.7	528	1.6	2.2	390
	East	−0.6	0.6	169	0.4	2.4	102
	Central	−13.9[d]	6.3	136	−6.2[d]	2.7	108
	West	−0.6	1.1	223	3.0	2.7	180

[a] Percent change/year in abundance; data from USFWS, Office of Migratory Bird Management.
[b] Analyses began in 1966 in the east, 1967 for central regions, and 1968 in the west (Droege 1990).
[c] Number of BBS routes.
[d] Trend differs from 0.0 (Route-regression, $P < 0.05$).
[e] Trend differs from 0.0 (Route-regression, $P < 0.01$).

insufficient to calculate survival for Soras using JOLLY. We compared non-breeding survival probabilities between species and compared breeding and non-breeding survival probabilities for Virginia Rails using z-tests (Zar 1984).

We obtained 164 Virginia Rail and 203 Sora nest records from the Cornell Laboratory of Ornithology's Nest Record Program. We calculated nesting success using Mayfield's method (Mayfield 1961, 1975; Hensler and Nichols 1981) and compared estimates between species using z-tests (Zar 1984). Only 81 Virginia Rail and 108 Sora nest records were used for calculating nesting success because the Mayfield method requires that nests be visited ≥ two times. Mayfield estimates of nesting success assume constant survival throughout the nesting stage. Our small sample prevented us from validating that assumption. Nonetheless, Mayfield estimates are usually preferable to traditional ratio estimates of nesting success. Virginia Rail and Sora nest records were from 21 states and provinces (1920 to 1987), but 70% of Virginia Rail and 73% of Sora nest records were from the central U.S.

RESULTS

Virginia Rail populations were stable ($P > 0.10$, N = 179 BBS routes) from 1966–1991 but declined ($P < 0.05$, N = 93 BBS routes) 2.2 ± 0.9% annually from 1982–1991 in North America (Table 1, USFWS, unpubl. data). Sora populations declined ($P < 0.05$, N = 528 BBS routes) 3.3 ± 1.7% annually from 1966–1991 in North America (Table 1). From 1982–1991, Sora populations were stable ($P > 0.10$, N = 149 BBS routes) in Canada, but U.S. populations declined ($P < 0.01$, N = 241 BBS routes) 8.5 ± 2.1% annually (Table 1). Declines were most dramatic in central North America (Table 1), where wetland loss has been most severe (Tiner 1984, Dahl 1990, Dahl and Johnson 1991).

Daily survival probability of radio-marked Soras in Arizona was 0.996 ± 0.003 and non-breeding (August–April) survival probability was 0.308 ± 0.256 for all age/sex classes combined. Daily survival probability of radio-marked Virginia Rails was 0.998 ± 0.001 and non-breeding survival probability was 0.545 ± 0.191 for all age/sex classes combined. Non-breeding survival probability did not differ (z = 0.74, P = 0.23) between species. Survival probability of Virginia Rails during the breeding season (1.00 ± 0.06) did not differ (z = 0.04, P = 0.484) from non-breeding survival probability, but all documented mortality (3 Virginia Rails and 2 Soras) occurred between October and March.

Because Virginia Rails were present throughout the year in Arizona and survival probability did not differ between seasons, we also calculated total daily and annual survival probabilities. Daily survival probability of radio-marked Virginia Rails was 0.998 ± 0.001 and annual survival probability was 0.526 ± 0.195 for all age/sex classes combined. Annual survival probability using capture-recapture was 0.532 ± 0.128 for all age/sex classes combined. Virginia Rail population size on our 112-ha study area was 54.5 ± 27.5 rails and probability of capture was 0.23 ± 0.04.

Daily nesting success (the daily probability of nest survival) for Virginia Rails throughout North America was 0.978 ± 0.005 (N = 81 nests). Over the 28-day nesting interval, overall nesting success was 0.530. Daily nesting success for Soras throughout North America was 0.978 ± 0.004 (N = 108 nests). Over the 28-day nesting interval, overall nesting success was 0.529.

DISCUSSION

The BBS is a roadside survey not specifically designed to monitor wetland birds (Gibbs and Melvin 1993), and only small numbers of rails are recorded along most BBS routes. The BBS prohibits eliciting responses from any species of birds, so encounters with rails on BBS routes were opportunistic. Location of roads influences estimates of relative abundance, and palustrine wetlands preferred by rails may be undersampled (Bystrak 1981, Robbins et al. 1986). Also, assessing the sensitivity of the BBS to detect population changes for species that have poorly understood life histories is difficult. However, patterns of population change detected from BBS data corroborate results of other independent surveys for other species (Droege 1990), and they may represent the best available data for evaluating long-term rail population trends.

Population trends from BBS data have a positive bias for species with low abundance (average count < 1.0) such as rails. Consequently, if a species shows a significant negative trend, the trend is probably real and may be an underestimate of the actual trend (Geissler and Sauer 1990; B. Peterjohn, pers. comm.). Virginia Rail populations declined in North America during 1982–1991, and Sora populations plunged between 1966–1991, especially in the U.S. Declines were most apparent in the central U.S., where palustrine wetland loss has been particularly severe (Tiner 1984, Dahl 1990, Dahl and Johnson 1991). The 1982–1991 interval includes a national drought which began in 1980 (U.S. Fish and Wildlife Service 1986, 1988; Reynolds 1987), wherein many wetlands were dried naturally but not lost to agriculture or development. Hence, if water levels and precipitation return to normal levels, both wetlands and rail populations may recover. Palustrine wetland loss results in rail population declines (Eddleman et al. 1988), and consequently, habitat for rails has been diminished in both quality and quantity (U.S. Fish and Wildlife Service 1988).

We are unaware of any published estimates of survival probability for any species of rail. Our estimates of Virginia Rail survival are similar to those for other rallids. Annual survival of first and second year birds was 31% and 77%, respectively, for Common Moorhens (*Gallinula chloropus chloropus*) in West Germany (Cramp 1980) and 13–24% and 28–52%, respectively, for Eurasian Coots (*Fulica atra atra*) in northwest Europe (Cramp 1980). Annual survival of American Coot (*F. americana*) was 45% based on band-recovery data from western North America (Ryder 1963) and 43% and 21% for adult and juvenile birds in central North America (Burton 1959).

Non-breeding survival probability of Soras was low, compared to the species cited above, and may reflect increased mortality of radio-marked birds. For MICROMORT survival analyses, we assumed that loss of radio contact was statistically independent of death and minimized potential bias by obtaining frequent relocations on radio-marked birds (Heisey and Fuller 1985). Survival estimates of Virginia Rails were similar between MICROMORT and JOLLY estimates which used distinct subsets of individuals, lending support to the validity of our Virginia Rail estimates.

Although reported estimates of nesting success for rails are simple ratios of successful: total nests found, and hence are upwardly biased (Mayfield 1961, 1975), we compared our estimates to these because they are the only estimates available for rails. Our estimate of nesting success for Virginia Rails (0.53) is generally comparable to other estimates: 0.50 (8 nests) in Minnesota (Pospichal and Marshall 1954), 0.75 (24 nests) in Connecticut (Billard 1948), and 0.78 (27 nests) in Iowa (Tanner and Hendrickson 1954). Similarly, our estimate of nesting success for Soras (0.53) is generally comparable to others' estimates: 0.63 (16 nests) in Connecticut (Billard 1948), 0.61 (36 nests) in Michigan (Walkinshaw 1940), and 0.79 (34 nests) in Minnesota (Pospichal and Marshall 1954), but substantial variability does exist, even within sites. For example, Sora nesting success varied from 0.60 to 0.81 (50 nests) in two consecutive years in Alberta (Lowther 1977). Our estimates of nesting success for both species (0.53 and 0.53) are similar to 0.56 reported for California Clapper Rails (*R. l. obsoletus*) (Harvey 1988) and the 0.588 Mayfield estimate for Sandhill Cranes (*Grus canadensis pratensis*) in Florida (Dwyer and Tanner 1992) but lower than the 0.81 reported for Light-footed Clapper Rails (*R. l. levipes*) in California (Massey et al. 1984).

Virginia Rails are legally harvested in 37 states and Ontario, and bag limits are very liberal (25 birds/day in 35 states) (Conway and Eddleman 1994). Allowing such liberal bag limits without understanding the causes of population declines or estimates of nesting success and survival is not tenable. The USFWS has proposed the National Migratory Bird Harvest Information Program (NHIP) which would provide information on rail harvest and hunter pressure. Such a program is vital to proper rail management and monitoring and should be implemented immediately. Management agencies should either institute more effective harvest and population monitoring programs (e.g., NHIP) or reconsider rail harvest seasons until viable management programs are developed.

Rail population trends estimated from BBS data have shown declines. However, our results and previous studies suggest that rails have adequate reproductive success and survival for population maintenance/growth. Regional and continental rail population declines, if real, are best explained by loss of habitat. Rail populations appear to have suffered proportionately with continental wetland loss and should be monitored more effectively (Gibbs and Melvin 1993). The BBS does not adequately census rails. A more appropriate continent-wide survey (e.g., Gibbs and Melvin 1993) should be initiated immediately so that rail populations can be properly managed and conserved.

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