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Spring Migration Patterns of Male Red-winged Blackbirds (Agelaius phoeniceus) from Two Migratory Roosts in South Dakota and Minnesota

C. EDWARD KNITTLE, GEORGE M. LINZ[1], JOHN L. CUMMINGS, JAMES E. DAVIS, JR., BRAD E. JOHNS AND JEROME F. BESSER[2]

U.S. Department of Agriculture, Animal & Plant Health Inspection Service, National Wildlife Research Center, 1716 Heath Parkway, Ft. Collins, Co. 80524

ABSTRACT.—During March 1985 male red-winged blackbirds (*Agelaius phoeniceus*) were marked with aerially applied fluorescent-colored pigments at two migratory roost sites in southeastern South Dakota and western Minnesota to determine their dispersal to breeding areas. Postspray samples revealed that approximately 54% (1.58 million) of the males present were marked with at least one of four pigments used. During late spring, breeding males were shot in 16 predetermined collecting areas in four N-central states in the United States and three central Canadian provinces. Of 3289 males collected, 555 (16.9%) were marked with one or more pigments; 86.8% (482) of the marked birds were from the South Dakota marking site and 13.2% (73) from the Minnesota site. The 16 collecting areas where male redwings were shot were grouped into six recovery regions for chi-square analysis. Results showed unequal proportions of marked breeding males among the recovery areas ($P = <0.001$). Temporal use of the South Dakota roost site by migrating males also affected breeding male distribution ($P = <0.001$). Inadequate sample sizes precluded analysis of temporal distribution of marked birds from the Minnesota marking site. Although marked redwings were dispersed over several thousand square kilometers from South Dakota to Alberta, Canada, 76% of the marked male redwings from South Dakota were concentrated in southern Saskatchewan and N-central North Dakota; 74% of the marked birds from Minnesota were concentrated more easterly in southern Manitoba, northeastern North Dakota and northwestern Minnesota. The N-northwestward distances traveled by migrating male redwings from marking sites to breeding areas was significantly different ($P = 0.006$) among groups marked at different time intervals at each site. Distances traveled ranged from 856 km to 1093 km.

INTRODUCTION

Birds, particularly blackbirds and European starlings (*Sturnus vulgaris*), annually cause millions of dollars worth of agricultural and property damage in North America (Pierce, 1970; Knittle and Guarino, 1974; Steenblik, 1983; Besser, 1986; Besser and Brady, 1986; Hothem *et al.*, 1988; Merritt, 1990). Attempts to design population management schemes to reduce these substantial economic losses must be predicated, in part, on migration dynamics (*i.e.*, regional movements, dispersal patterns and distribution information) for each blackbird species.

Historically, leg-banding has been used to provide such information, but banding large numbers of blackbirds, particularly red-winged blackbirds (*Agelaius phoeniceus*), is labor-intensive with recovery rates as low as 0.31% to 0.51% (Guarino, 1968; Besser *et al.*, 1983; Gammell *et al.*, 1986). Increases in band recovery rates of 57% to 250% have been demonstrated by the use of colored leg-streamers on red-winged blackbirds, yellow-headed black-

[1] Present address: U.S. Dep. Agric., National Wildlife Research Center, Great Plains Field Station, 2301 University Dr. Bldg. 23B, Bismarck, North Dakota 59504

[2] Retired. Present address: 655 S. Miller Street, Lakewood, Colorado 80226

birds (*Xanthocephalus xanthocephalus*), brown-headed cowbirds (*Molothrus ater*) and starlings (Guarino, 1968; Bray *et al.*, 1974; Bray *et al.*, 1977).

Guarino (1968) suggested that a method of marking thousands of birds was needed to increase the recovery rates of banded birds and to facilitate identification of specific crop-depredating populations. In 1982 and 1983, Knittle *et al.* (1987) used an aerial marking method, developed at the Denver Wildlife Research Center, to mark an estimated 10.6 million male redwings with fluorescent pigments at two spring migration roosts in northwestern Missouri and southeastern South Dakota. The recovery rates for marked territorial male redwings collected in the upper Great Plains states and several areas in three southern Canadian provinces were 10.2% and 5%, respectively, from the two marking sites. This represented a 10- to 20-fold increase in the amount of recovery information previously reported by Besser *et al.* (1983).

Understanding the migration patterns of red-winged blackbirds is necessary for the development of management strategies to help mitigate agricultural crop losses. For this study, we used an aerial mass-marking technique (Otis *et al.*, 1986; Knittle *et al.*, 1987; Linz *et al.*, 1991) to determine the spring breeding locations of adult male red-winged blackbirds migrating through two roosting sites in South Dakota and Minnesota. Secondarily, we were interested in determining whether migrating male redwings were temporally segregated in breeding areas depending on when they moved through the marking sites. If so, this information could be used to infer whether certain populations might be differentially responsible for subsequent fall crop damage, particularly sunflowers, in northern Great Plains states.

METHODS

STUDY AREA AND SAMPLING PROCEDURES

Spring roost locations and population estimates.—One roost was located at Lake Thompson (44°23′N, 97°33′W), near DeSmet in southeastern South Dakota. This site was a 2835-ha cattail (*Typha* spp.) marsh interspersed with approximately 405 ha of scattered islands of giant reed (*Phragmites* sp.) that were used by roosting redwings (Otis *et al.*, 1986; Knittle *et al.*, 1987; Linz *et al.*, 1993). The second roost, approximately 160 km NE of the South Dakota site (Fig. 1), was along the East Fork of the Chippewa River (45°19′N, 95°36′W) near Benson, in western Minnesota. Male redwings collectively occupied ca. 150 ha of cattail in three separate areas along nearly 11 km of marsh straddling the river. For our purposes, these three areas were treated as a single roost.

On the evening before each marker application, we made species composition and population estimates at each roost. Visual censusing techniques, described by Meanley (1965) and Arbib (1972), were used to produce population estimates while composition estimates followed the method described by Dolbeer *et al.* (1978).

Marking procedures.—Male redwings were aerially marked between 17 and 27 March with one of four colors of DayGlo®[3] fluorescent pigment (Dayglo Color Corp., Cleveland, Ohio), Fire-orange (FO) and Saturn-yellow (SY) at Lake Thompson, and Invisible-blue (IB) and Pink (PK; a mixture of 75% Corona-magenta and 25% Horizon-blue) at Benson. Each color was used only once (Knittle *et al.*, 1987), with treatments made at arbitrary 6-day intervals at each site. Piper Pawnee and Cessna Agtruck fixed-wing agricultural-spray aircraft were used to apply marking formulations during the twilight after sunset. The formulation and application methods are described by Otis *et al.* (1986) and Linz *et al.* (1991). Because of the size of the Lake Thompson test site, the applicator miscalculated the amount of time

[3] Use of brand names does not imply U.S. government endorsement

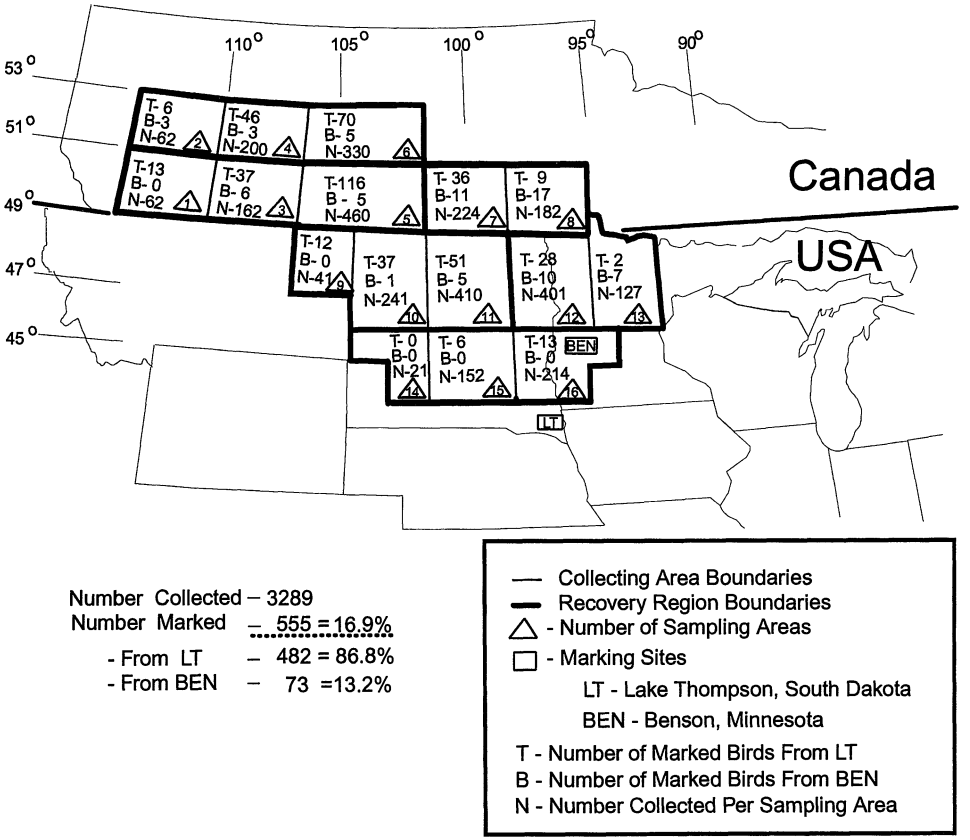

FIG. 1.—Sixteen collecting areas were grouped into six recovery regions for statistical analyses. The values in each sampling area indicate the number of male red-winged blackbirds collected and the number of these which were marked from each of the two marking sites in 1985—Lake Thompson (LT), South Dakota, and Benson (BEN), Minnesota

needed to effectively locate and mark the separated congregations of roosting birds; thus 2 successive evenings were required to apply the first treatment. Subsequently, the next application was applied more efficiently and required only 1 evening. At Benson, applications were made by two aircraft simultaneously during each treatment period.

Spray-area sampling.—Within 24 h following each completed marker application, male redwings were shot haphazardly within approximately 16 km of each treated roost. This area contained the daytime foraging range of most of the birds emanating from each roost. Each bird was bagged individually, labeled by distance and direction from the marking site with whole birds being examined for marks the day they were collected. Examined birds were classified into three categories: unmarked, single-color marked or double-color marked.

Breeding-area sampling.—From mid-May to mid-July in 1985, territorial adult male redwings were shot in riparian habitats, primarily cattail marshes, within 16 collecting areas covering the N-central U.S. and S-central Canada (Fig. 1). The sampling scheme was similar

to one used by Knittle *et al.* (1987) with a collecting area being comprised of an unequal number of adjacent blocks measuring 1° lat by 1° long (*i.e.*, blocks) delineated by geographic and political boundaries.

Sampling quotas of 10, 30 or 50 males were assigned to each of 115 blocks comprising the 16 collecting areas. Based on data provided by Stehn, and later presented in an unpublished report (Stehn, 1989), the highest quotas were assigned to core blocks corresponding to the highest density of breeding males, and the lowest quotas to the outer blocks.

Cooperators from various federal, state and Canadian provincial wildlife agencies helped collect breeding males from their assigned collecting areas and were instructed to mail only individually bagged pairs of wings from each bird to the Denver Wildlife Research Center. Collected birds were identified by the latitude-longitude coordinates of the SE corner of the block of collection and by the distance and direction from the nearest municipality or other point of reference within the block (Knittle *et al.*, 1987).

Marker examination procedures.—Whole bodies or wings of all male redwings collected were examined in a dark room under a model B-100A Blak-Ray® long-wave (360 nm) ultraviolet light by observers wearing UVC-503 safety goggles. A 10× hand magnifier was used, when necessary, to determine the validity of a mark. Only splash marks, streaks or individual particles firmly attached to wing feathers or other exposed body parts were considered to be conclusive evidence of marking (Knittle *et al.*, 1987).

STATISTICAL PROCEDURES

To determine the distribution of marked male redwings, data from the 16 collecting areas were grouped into six recovery regions. Even though we collected a substantial number of breeding males, the number of marked birds was distributed over a relatively large area, creating small (or no) samples for some collecting areas, particularly for Benson birds. The six recovery regions (Fig. 1) were created using two criteria: (1) combining adjacent collecting areas within latitudinal tiers, and (2) arbitrarily splitting mid-latitudinal tiers into E and W regions to achieve reasonably balanced sample sizes. These criteria were based on the knowledge that the spring migratory orientation of redwings tends to be N-northwestward in the northern Midwest (Besser *et al.*, 1983; Gammell *et al.*, 1986) and a desire to achieve reasonably equal precision in the estimates derived.

Three hypotheses were tested by chi-square analysis: (1) the proportion of marked birds collected from each treated roost was equal among the recovery regions; (2) the proportion of temporally distinct FO- and SY-marked birds from Lake Thompson was the same in each recovery region; and (3) the proportion of temporally distinct IB- and PK-marked birds from Benson was the same among recovery regions. Double-color marked birds were included in final tallies under the color of the second pigment applied at each roost site, because these birds did not leave the marking site until after the second pigment was applied. Our primary interest was not how often each bird was marked, but when it was last marked before dispersing to a breeding area.

A fourth hypothesis, that the distances traveled by marked birds between marking sites and collection areas were the same, was tested by a one-way ANOVA (SAS PROC GLM) with the means separated by Duncan's Multiple Range test. These data were developed by measuring the straight-line distance on a map for each marked redwing recovered from its marking site to the center of the block where it was collected.

RESULTS

Lake Thompson, South Dakota.—On the evenings of 17 and 18 March (considered one treatment), we sprayed an estimated population of 769,000 redwings (95% males) with FO

pigment. Of 300 male redwings collected on 19 March, 157 (52.3%) were marked; therefore, we estimated approximately 382,000 males had been marked with FO pigment. On 24 March, we sprayed an estimated 987,000 redwings (98% males) with SY pigment. From a collection of 325 males made the following day, 202 (62.2%; 602,000) were marked with SY, 87 (26.8%; 259,000) exhibited both FO and SY pigments, and 8 (2.5%; 24,000) were marked with FO. Thus, we marked an estimated 984,000 male redwings with either or both pigments at this site.

Benson, Minnesota.—On 21 March, we sprayed approximately 632,000 redwings (88% males) with IB pigment. Of 286 males collected the following day, 139 (48.6%; 270,000) were marked with IB. On 27 March, approximately 745,000 redwings (86% males) were sprayed with PK pigment. The following day, 115 (51.3%; 329,000) of 224 males collected were marked with PK, 61 (27.2%; 174,000) with both IB and PK pigments, and 23 (10.3%; 66,000) marked with IB. Therefore, we estimated that 599,000 male redwings had been marked with either or both pigments at Benson.

Collectively, we marked an estimated 1.58 million male redwings with at least one pigment during approximately 3.0 h of aircraft flight time at both sites. This represents approximately 54% of the estimated 2.9 million male redwings present during the marking operations.

Breeding male sampling.—Of the 3289 breeding male redwings we collected from the 16 collecting areas, 555 (16.9%) were marked with at least one pigment; 482 (86.8%) were marked at Lake Thompson and 73 (13.2%) at the Benson site (Fig. 1). Hypothesis 1: The proportion of marked redwings collected from the Lake Thompson and Benson marking sites was unequal among the six recovery regions ($\chi^2 = 80.4$, df = 5, P = <0.001). Nearly 65% of the total χ^2 was contributed by the southern Manitoba (areas 7 and 8) and eastern North Dakota and northern Minnesota collecting areas (areas 12 and 13; Fig. 1). In these two recovery regions, 62.5% of the marked birds came from Lake Thompson vs. 37.5% from Benson. Hypothesis 2: The proportion of early FO- and later SY-marked birds from Lake Thompson was also unequal ($\chi^2 = 27.6$, df = 5, P = <0.001) among the six regions. The significance was primarily contributed by Manitoba and South Dakota (collecting areas 7–8 and 14–16, respectively; Fig. 2). Hypothesis 3: The equality of proportions of IB- and PK-marked birds from Benson could not be tested because of insufficient sample sizes.

Hypothesis 4: There was a significant difference (P = 0.006) in mean distances traveled between marking and collection sites by two of the four pigment-marked groups of redwings. SY-marked birds from Lake Thompson traveled significantly farther ($\bar{x}$ = 1092.9 km) than PK-marked birds ($\bar{x}$ = 855.7 km) from Benson. No other comparisons of means of distances traveled were significantly different among pigment-marked groups (Table 1).

DISCUSSION

We could not determine whether later migrating males moved farther NNW from the marking sites to breed than earlier migrating males. First, some birds may have lost their markers before being collected. Knittle and Johns (1986) showed that 4.8% of marked male redwings completely lost their marks within 6 wk following a marker application. Second, the marking period during our study covered only a small portion of the 6- to 8-wk spring migration period. Third, although Otis *et al.* (1986) showed that roosting redwing populations were dynamic (*i.e.*, daily population turnover) at the marking sites during the experiment period, we found that a considerable number of birds marked during the first period were still present at each site during the second marking period, 29.3% at Lake Thompson and 37.5% at Benson. Many of these birds, 26.8% at Lake Thompson and 27.2% at Benson, received the second pigment and thus were included in the second "wave" of

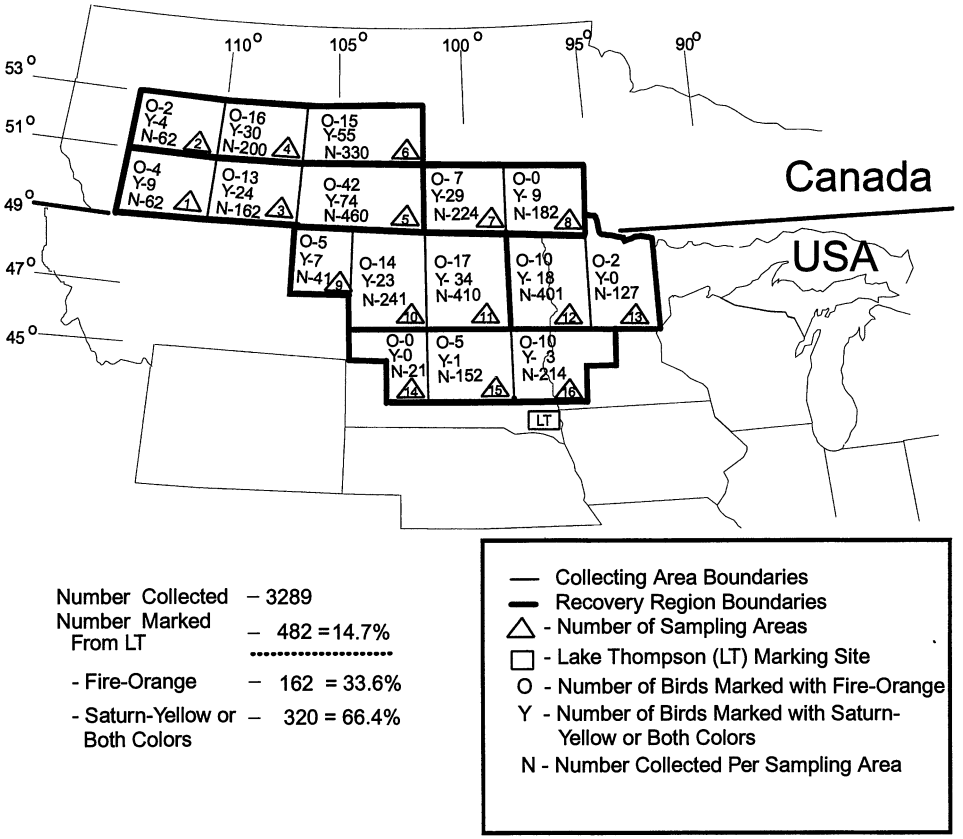

FIG. 2.—The values indicate the number of male red-winged blackbirds collected in each collecting area, and the number of these which were marked early with Fire-orange (O) or later with Saturn-yellow (Y; includes double pigment-marks) pigment in 1985 at Lake Thompson (LT) South Dakota

TABLE 1.—Mean distances traveled by pigment-marked male redwings from marking sites in South Dakota and Minnesota to 115 different latitiude-longitude blocks where they were collected

Pigment applied	No. of marked birds collected	Mean distance traveled (km)	Significance[1]
Benson, Minnesota			
Pink	66	856	A
Invisible-blue	7	914	AB
Lake Thompson, South Dakota			
Fire-orange	162	997	ABC
Saturn-yellow	320	1093	BCD

[1] Means with no letter in common are significantly different (P = 0.0056)

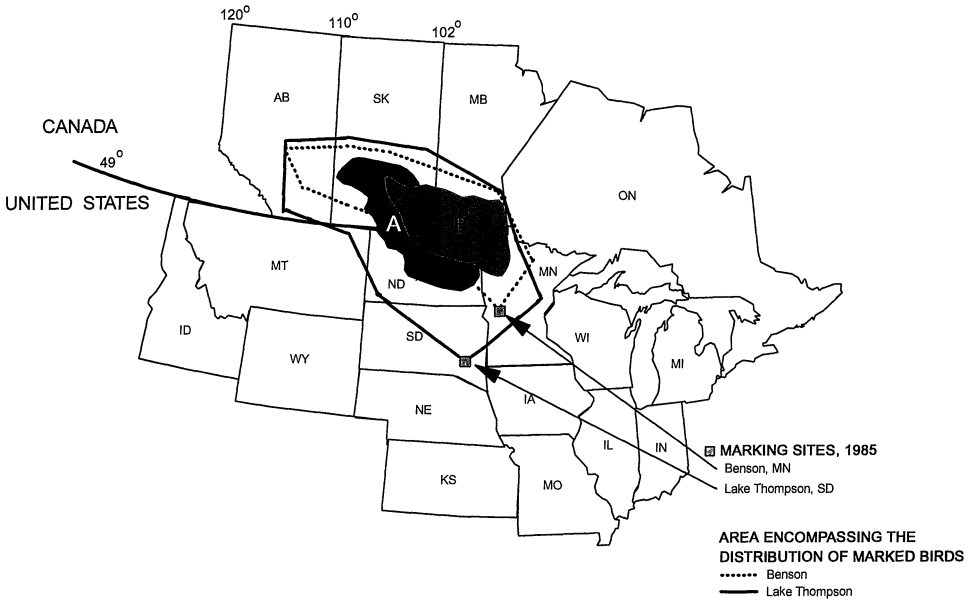

FIG. 3.—The outlined areas represent the pattern of distribution where marked male redwings were collected from each marking site; approximately 796,000 km² for Lake Thompson birds, and 454,000 km² for Benson birds. Area A contained 76% of all marked birds collected from Lake Thompson, Area B contains 74% of the marked birds from Benson

migrants rather than the first from each marking site. Fourth, immediate postspray samples at each site showed there were actually 5–7 times more males marked with the second or both pigments than the first pigment, thus providing a disproportionally large number of SY and double-marked males available for collection in breeding areas.

The disparity between the percentage of marked redwings collected during breeding-area sampling and the higher percentage of marked birds collected immediately postspray may be partially explained by our exclusive selection of riparian habitat in the collecting areas. Robertson (1972) suggested that a substantial population of redwings nest in upland habitat, which we did not sample. Robertson (1972) also noted that riparian-nesting redwings nest earlier than upland-nesting redwings, and that riparian habitats are more suitable nesting sites and are available earlier than upland sites.

Marked redwings from Lake Thompson and Benson were dispersed over a sizable area in the agricultural belt of S-central Canada and the N-central U.S. where a number of cereal grains and sunflowers are grown. These areas are characterized as prairie pot-hole country, which provides prime breeding habitat for redwings (Besser, 1985). Seventy-six percent of the male redwings marked at Lake Thompson were collected in southern Saskatchewan and N-central North Dakota (Area A, Fig. 3) and 74% of the redwings marked at Benson were collected more easterly, primarily in southern Manitoba, northeastern North Dakota, and northwestern Minnesota (Area B, Fig. 3). The overall distribution of birds marked at Lake Thompson encompassed approximately 796,000 km² while marked birds from Benson were dispersed over a 454,000-km² area. In contrast, the dispersal of marked redwings from the more southerly northwestern Missouri spring roost used as a marking site in 1982 by Knittle *et al.* (1987) encompassed 1.8 million km², including all of the dispersal areas of

marked redwings noted above. Together these data support the idea that prebreeding migratory male redwings using more northerly spring migration roosts are closer to their final breeding areas than those using more southerly roosting sites, thus dispersal from the southerly sites is more widespread.

Figure 3 also shows that as redwings approach the northern latitudes of the central United States the migratory direction tends toward the NW. Royall *et al.* (1980), Besser *et al.* (1983), Gammell *et al.* (1986) and Knittle *et al.* (1987), using recovery information from redwings marked with bands, colored leg-streamers, and aerially applied fluorescent markers, reported a similar trend in movements. This directional change seems to coincide with preferred agricultural foraging areas in the southern part of Canada.

Understanding the migration pattern of regional populations of red-winged blackbirds is fundamental, in part, to developing management strategies which may reduce damage to agricultural crops in certain areas of the United States and Canada. Methods for enhancing and expediting the amount of recovery information for selected populations, such as aerially marking large numbers of a population with fluorescent particles, has been demonstrated to be effective for this process. The percentage of marked redwings recovered during this study, 16.9%, is a 32- to 53-fold increase over the 0.32% banding-only recovery data reported by Guarino (1968) and the 0.51% reported by Besser *et al.* (1983). The increased quantity and expeditious return of data from marked birds in this study allows for management decisions to be addressed promptly rather than waiting for years to acquire enough movement information to formulate management strategies.

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