REPRODUCTIVE SUCCESS OF GRASSLAND SPARROWS ON A RECLAIMED SURFACE MINE IN WEST VIRGINIA[1]

THOMAS WRAY, II, KENNETH A. STRAIT, AND ROBERT C. WHITMORE

Division of Forestry, Wildlife Biology Section, West Virginia University, Morgantown, West Virginia 26506 USA

ABSTRACT.—The reproductive success of Grasshopper Sparrows (*Ammodramus savannarum*), Savannah Sparrows (*Passerculus sandwichensis*), Vesper Sparrows (*Pooecetes gramineus*), and Field Sparrows (*Spizella pusilla*) breeding on a reclaimed surface mine in northern West Virginia was studied from 1978 through 1980. Only Vesper Sparrows showed significant ($P < 0.05$) annual differences in clutch size. Predation was the major cause of egg and nestling losses during all 3 yr. Of 185 nests located, 80 (43%) were presumed lost to predators. Our study site, surrounded by woodlots and pastureland, apparently concentrated predators. We believe northern black racers (*Coluber constrictor constrictor*) and Common Crows (*Corvus brachyrhynchos*) were the major predators. Generally, predators were equally successful in locating nests during the incubation and nestling periods. Variable nesting success, calculated from exposure for the species during the 3 yr, reflects differential predation pressure. Productivity estimates suggest that adults are not replacing themselves and immigration is necessary to maintain a stable population. Apparently, environmental cues are sufficient to elicit a settling response, but, due to predation, reproductive success is low. Although surface mining is providing new nesting habitat for these species, the inadequate reproductive success experienced on our site suggests that these manmade grasslands may not be of benefit to the sparrow populations in this area. Breeding densities during the 3 yr were variable and may reflect poor breeding success, changes in the vegetation, availability of more suitable nesting habitat, and differential mortality during migration and on the wintering grounds. *Received 6 March 1981, accepted 9 July 1981.*

SURFACE mining in West Virginia drastically alters the environment. What may have once been a hardwood forest becomes a field of grasses, forbs, and some woody plants. As habitat complexity is reduced, a major shift in the bird community occurs, and those species that nest on or near the ground and require little if any woody vegetation are attracted to the area. This community includes the Grasshopper Sparrow (*Ammodramus savannarum*), Savannah Sparrow (*Passerculus sandwichensis*), Vesper Sparrow (*Pooecetes gramineus*), Horned Lark (*Eremophilia alpestris*), Eastern Meadowlark (*Sturnella magna*), and Killdeer (*Charadrius vociferus*). As woody vegetation invades the area, Field Sparrows (*Spizella pusilla*) and Indigo Buntings (*Passerina cyanea*) may initiate nesting activities.

Although these grasslands are quite different from the habitats where true grassland sparrows evolved, these species are now using this new land resource (Whitmore and Hall 1978). Whether or not the sparrows are actually benefiting from this new habitat is unknown. Accordingly, we studied the breeding biology of the sparrow species nesting on a reclaimed surface mine in northern West Virginia.

STUDY AREA AND METHODS

A 41.5-ha reclaimed surface mine (Great Mine), located 1 km south of Valley Point, West Virginia (39°34′ and 79°38′) at an elevation of 580 m, was chosen for this study.

This site was stripped for coal three times before final reclamation in 1974. The gently rolling topography is dominated by tall fescue (*Festuca arundinacea*), with some serecia lespedeza (*Lespedeza cuneata*), blackberries (*Rubus* spp.), many invading herbaceous species, and scattered black locust (*Robinia pseudoacacia*) and autumn olive (*Eleagnus umbellata*). The site also has bare areas due to highly acidic materials and very rocky soils and is surrounded by woodlots and pastureland.

Data were collected during three successive breed-

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TABLE 1. Mean clutch size for four sparrow species, 1978–1980.

Year	Vesper Sparrow	Grasshopper Sparrow	Savannah Sparrow	Field Sparrow
1978	3.8 ± 0.4 (20)[a]	4.5 ± 0.6 (16)	3.9 ± 0.7 (14)	—
1979	3.9 ± 0.5 (22)	4.5 ± 0.5 (15)	4.1 ± 0.8 (12)	3.4 ± 0.5 (5)
1980	3.5 ± 0.6 (21)	4.1 ± 0.8 (13)	4.2 ± 0.6 (10)	3.8 ± 0.4 (18)

[a] Sample size.

ing seasons (1978–1980). Nests were located by traversing the site systematically and flushing incubating and brooding adults. They were carefully visited every other day and their status recorded. Mayfield's (1961) method, which allows the use of all nests, regardless of the developmental stage and knowledge of outcome, was used to calculate nesting success. We used Austin's (1977) method of calculating the number of nesting attempts per year in combination with Pinkowski's (1979) estimate of annual productivity to determine whether or not the breeding sparrow populations on Great Mine are replacing themselves. All breeding-success and productivity calculations assume that, within a species, nests have an equal likelihood of being located. After nests were vacated, the vegetation associated with them was measured following the procedures in Wray and Whitmore (1979).

RESULTS AND DISCUSSION

Clutch size.—Clutch sizes of the four species of sparrows (Table 1) conform with those reported in the literature (Baird 1968, Berger 1968, Smith 1968, Walkinshaw 1968). Although not significant, clutch size generally decreased as the breeding season progressed. This late-season decrease may result from a number of factors, including a shorter day-length, diminishing food supplies, a tapering off of the reproductive endocrine cycle, and others. Kendeigh et al. (1956) suggested that high midsummer temperatures reduce feeding rates, which results in smaller clutch sizes. Additionally, the four sparrow species are double-brooded, and female metabolic resources may become drained, because the females are actively feeding fledglings while laying the second clutch. The 1980 Field Sparrow population was only single-brooded on our site, however. Because they are known to select nest sites higher off the ground as the breeding season progresses (Walkinshaw 1968, Best 1978), it is likely they chose saplings in edge habitat for later nesting attempts. Only Vesper Sparrows showed significant annual differences in clutch size, as both 1978 ($t = 1.87$, $P < 0.05$) and 1979 ($t = 2.38$, $P < 0.05$) were greater than 1980.

Mortality.—Predation was the major cause of egg (Fig. 1) and nestling (Fig. 2) losses for all 3 yr. Reclaimed surface mines and adjacent areas seem to harbor many predatory species, as indicated by the sighting or identification by sign of 20 potential species (Wray et al. 1978). We categorized potential nest predators by the appearance of predated nests. Nests left intact and empty were attributed to snake and avian predators, while disturbed nests with or without eggshells were attributed to mammalian predators (Rearden 1951, Best 1978). Of the 185 sparrow nests located, 80 (43%) were presumed lost to predators. Of these 80 nests, 62 (78%) were left visibly undamaged. Consequently, we believe that snakes and crows were the major predators. Northern black racers (*Coluber constrictor constrictor*) were seen frequently, and Common Crows (*Corvus brachyrhynchos*) were commonly present on and around the study site. From his analysis of nest predation in old-field habitats, Gottfried (1978) concluded that snakes were the major predators and that aerial predators were responsible for only minor losses. Best (1978) found that the blue racer (*Coluber constrictor foxi*) was the major predator of Field Sparrow nests in Illinois.

Examination of the annual variation in the percentage of nests lost to predators reveals that Vesper Sparrow losses were relatively constant, Grasshopper Sparrow losses increased considerably in 1979 and 1980, and Savannah Sparrows suffered moderate losses in 1978 and 1980 but a very low loss rate in 1979 (Table 2). This annual variation within and among species may reflect the degree to which nests were concealed from predators. Well-concealed Grasshopper Sparrow nests, however, suffered higher losses than the more open nests of the Vesper Sparrow in 1979 and 1980. Certainly, the type of predator responsible for the losses would influence the importance of nest concealment. Best (1978) suggested that cover had little influence on the vulnerability of nests to

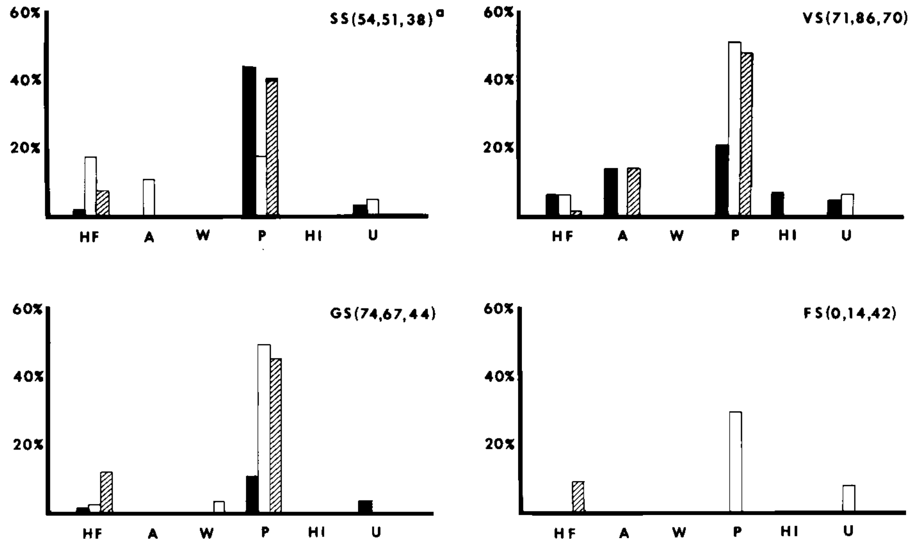

Fig. 1. Analysis of egg losses. SS = Savannah Sparrow, VS = Vesper Sparrow, GS = Grasshopper Sparrow, FS = Field Sparrow. HF = hatching failure, A = abandonment, W = weather, P = predation, HI = human interference, U = unknown. Solid = 1978, Open = 1979, Hatched = 1980. Footnote a: total eggs found in 1978, 1979, and 1980.

snake predation. Also, nocturnal mammals should benefit little from more visible nests. However, the success of those species relying on sight, such as crows and Blue Jays (*Cyanocitta cristata*), probably is influenced by nest visibility. This annual variation in nests lost to predators may also be explained by a switch in predator pressure; we have no supportive data, however. It is more likely that we are observing a random process and no single explanation is appropriate.

Predators were equally successful in locating nests during the incubation and nestling stages (Table 2). Lack (1954) stated that many species suffer greater losses during the incubation stage but offered no clear explanation. In a study of Savannah Sparrows, Dixon (1978) reasoned that the growth in vegetation during the nesting period provides greater concealment with time, thereby reducing visibility during the nestling stage. Our data, however, show no significant difference between the nest vegetation of the first and second brood for all species; thus, nest concealment did not increase. Perhaps of greater importance is the difference in exposure time a nest receives during these two stages of the nesting period. Our data show a 60:40 ratio of exposure time for the incubation and nestling stage, respectively. This ratio is conservative, as it does not account fully for the number of nests lost during incubation that results in renests. Because nests during incubation are exposed to predators a minimum of 20% longer than nests during the nestling stage, even higher losses are expected in the incubation stage than we observed. Also, many nests are lost during the incubation period, leaving fewer nests for predators to locate during the nestling period, and yet predators did locate a large percentage of nests in the nestling stage during our study, which may reflect easier location due to increased parental activity.

Weather was an unimportant factor except during the breeding season of 1980, when four nests were found flooded and contained dead nestlings after violent thunderstorms or prolonged periods of rain. A small percentage of nests was inadvertently destroyed by landowners or was abandoned (Figs. 1 and 2). Unknown losses occurred when an egg or nestling disappeared from an active nest. We believe these partial losses resulted from the removal of unhatched or damaged eggs and dead nestlings by adults or from predators becoming satiated before removing all the nest contents. Savannah Sparrows experienced the largest hatching failure.

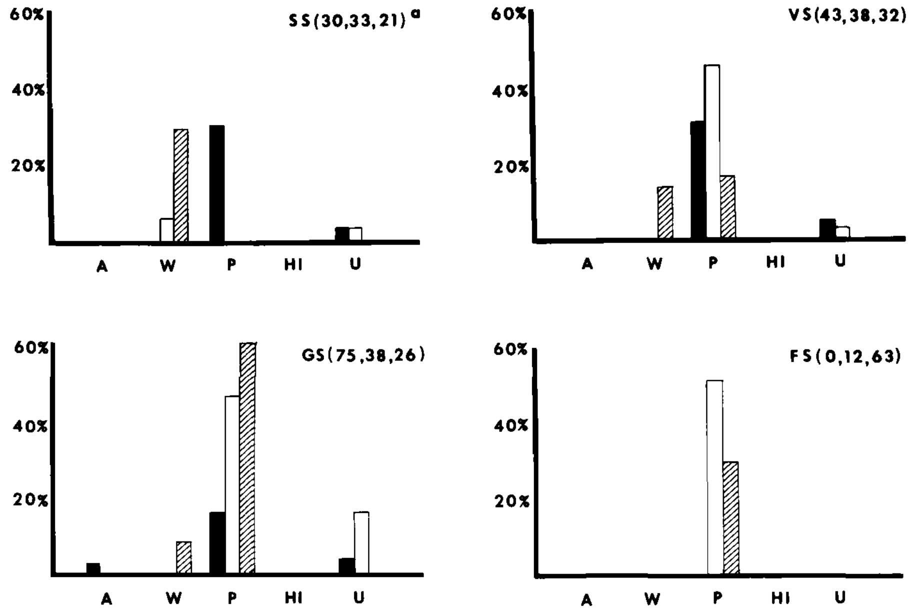

Fig. 2. Analysis of nestling losses. SS = Savannah Sparrow, VS = Vesper Sparrow, GS = Grasshopper Sparrow, FS = Field Sparrow. A = abandonment, W = weather, P = predation, HI = human interference, U = unknown. Solid = 1978, Open = 1979, Hatched = 1980. Footnote a: total nestlings found in 1978, 1979, and 1980.

Investigator effect upon nesting success is difficult to assess. Gottfried and Thompson (1978) concluded that visits to nests by investigators did not appear to affect success or failure. Willis (1973) found survival rates of visited and unvisited nests of Bicolored Antbirds (*Gymnopithys bicolor*) similar, with visited nests fledging slightly more young than unvisited ones. In contrast, Bart (1977), using data from the Nest Record Card Program, found that the daily mortality rate was higher on the first day after a visit to the nest than on subsequent days. This suggests that the investigator is leaving scent around a nest, which in-

TABLE 2. Fate of nests of four sparrow species.

	Vesper Sparrow			Grasshopper Sparrow			Savannah Sparrow			Field Sparrow		
	1978	1979	1980	1978	1979	1980	1978	1979	1980	1978	1979	1980
Number of nests found	22	25	23	20	18	13	15	16	10	—	5	18
Percentage of nests lost to predators[a]	45	64	52	30	72	77	53	19	40	—	60	29
Percentage of predated nests lost during incubation period[b]	24	40	48	10	47	50	40	13	40	—	20	0
Percentage of predated nests lost during nestling period[b]	36	40	20	17	44	71	25	0	0	—	50	29
Percentage of successful nests[c]	36	28	30	70	22	15	40	69	40	—	40	72
Mean number of young fledged/successful nests	3.0	3.0	3.1	4.1	3.5	4.0	3.3	3.0	3.7	—	3.0	3.3
Mean number of young fledged/total nests	1.1	0.8	1.0	2.8	0.8	0.5	1.3	2.1	1.5	—	1.2	2.4

[a] For other losses refer to Figs. 1 and 2.
[b] Percentage of total active nests lost during that stage.
[c] Fledged at least one young.

TABLE 3. Nesting success of four sparrow species calculated from exposure, 1978–1980.

Species	1978	1979	1980
Vesper Sparrow	0.22[a]	0.15	0.17
Grasshopper Sparrow	0.47	0.08	0.07
Savannah Sparrow	0.24	0.39	0.22
Field Sparrow	—[b]	—[b]	0.47

[a] Probability an egg will survive to fledge.
[b] Insufficient sample size.

TABLE 4. Annual productivity measured in young fledged per pair for four species, 1978–1980.[a]

Year	Vesper Sparrow	Grasshopper Sparrow	Savannah Sparrow	Field Sparrow
1978	4.7	10.9	6.6	—[b]
1979	4.4	4.8	6.7	—[b]
1980	3.4	2.9	4.7	4.0
$\bar{x}$	4.2	6.2	6.0	4.0

[a] Calculated according to Austin (1977) and Pinkowski (1979).
[b] Insufficient sample size.

creases the likelihood of predation by a mammal. We believe that the extensive amount of human activity and scent scattered over our study site would be of little use to potential mammalian predators. Moreover, we visited nests in an indirect manner in order to lessen the likelihood of mammalian predation. Crows have been reported using nest-site markers to locate nests (Picozzi 1975), but in this study the markers were inconspicuous and placed 10 m away from the nest. If, in fact, snakes were our major nest predators, it is questionable whether they benefited from human activity around nest sites. In summary, we conclude that investigator effect was minimal in our study.

Although these species are reported as hosts of the Brown-headed Cowbird (*Molothrus ater*) (Baird 1968, Berger 1968, Smith 1968, Walkinshaw 1968), none of the 185 nests located was parasitized, even though cowbirds were occasionally seen along the periphery of the study area. There may be several reasons for this. Cowbirds may have located nests of other host species living in the area surrounding the site more easily or the local cowbird population may not have developed a search image for grassland sparrow nests. Also, we may not have found parasitized nests, because some species respond to parasitism by abandoning nests (Best 1978).

Productivity.—Estimates of annual nesting success varied both within and among species (Table 3). Vesper Sparrows achieved their highest success rate during 1978, while Grasshopper Sparrow success decreased substantially during the last 2 yr of the study. Savannah Sparrow success increased in 1979 and then decreased to approximately the 1978 level in 1980. Insufficient nesting data for Field Sparrows in 1978 and 1979 precluded any success estimates; in 1980, however, Field Sparrow eggs had a 47% chance of surviving to fledge. Because predation was clearly the major cause of mortality, this variation reflects the differential predation pressure that the four species experienced.

Annual productivity values (Table 4) were calculated following Pinkowski (1979), where: P = (young fledged/successful nest)·(percentage success)·(nests/season). Austin (1977) provides the method used to determine the number of nesting attempts per season. Fledgling survival must be considered when determining whether or not productivity is sufficient to balance adult mortality. Annual adult survival for small passerines is estimated to be 50%, while fledgling survival to the first breeding season is estimated to be one quarter of adult survival, or approximately 12.5% (Ricklefs 1977). This estimate is similar to the 11% survival rate that Austin (1977) found for the Verdin (*Auriparus flaviceps*). Pinkowski (1979) found fledgling survival to be about 25% for the Eastern Bluebird (*Sialia sialis*), but the young of cavity-nesters fledge at a more developed state and have a higher post-fledgling survival rate than young of open-nesters (Haartman 1957).

An annual productivity of at least 8.0 young per pair is necessary to balance 50% adult mortality for birds with a fledgling survival to the first breeding season of 12.5%. The required annual productivity is 6.7, 5.0, and 4.0 per pair if fledgling survival equals 15, 20, or 25%, respectively. Many birds that are not double-brooded or lay small clutches cannot possibly produce 8.0 young per pair and therefore must have higher adult and fledgling survival. Only the Grasshopper Sparrow population in 1978 produced enough young to maintain a stable population without immigration, assuming a 12.5% fledgling survival rate (Table 4). None of the species produced enough young for re-

TABLE 5. Duration and number of nesting attempts for four sparrow species, 1978–1980.[a]

	Vesper Sparrow			Grasshopper Sparrow			Savannah Sparrow			Field Sparrow[b]
	1978	1979	1980	1978	1979	1980	1978	1979	1980	1980
Daily mortality rate	0.04	0.06	0.05	0.02	0.07	0.08	0.04	0.02	0.04	0.01
Length of unsuccessful cycle (days)	9.6	9.1	9.2	10.8	8.7	8.1	9.8	10.8	9.8	10.9
Length of average nesting attempt (days)	20.4	19.0	19.4	25.3	17.8	16.3	21.1	25.2	21.1	25.6
Length of breeding season (days)	69.9	77.1	62.2	87.6	86.6	75.6	88.9	59.9	58.8	37.6
Average number of nesting attempts	3.4	4.1	3.2	3.5	4.8	4.6	4.2	2.4	2.8	1.5

[a] Calculated according to Austin (1977).
[b] Insufficient data for 1978 and 1979.

placement when averaged over the 3 yr. Assuming a 15% survival rate, only the Grasshopper Sparrow in 1978 and overall and the Savannah Sparrow in 1978 and 1979 produced an adequate number of young. A literature search failed to find estimates of overwintering survival for open-nesting passerines greater than 15%. The annual trend suggests that productivity is decreasing to insufficient levels for all species.

The values for annual productivity (Table 4) may be overestimated. This exaggeration probably is a result of the way in which the number of nesting attempts per season was calculated (Table 5). The method used assumes that all pairs attempt another nest after a first brood is raised and also may inaccurately estimate the length of the breeding season (Pinkowski 1979). We assumed that the number of nests found during a particular month was proportional to the number of clutches initiated that month.

We believe the sparrows on Great Mine can be considered "sink" populations in a suboptimal habitat whose continued existence depends on immigration from "source" populations in better habitat elsewhere (Wiens and Rotenberry 1981). The four sparrow species continue to attempt breeding in this suboptimal habitat due to site tenacity and the availability of attractive nest sites (Hildén 1965). These factors are sufficient to elicit a settling response but are apparently insufficient to insure adequate reproductive success.

Breeding sparrow densities varied during the 3-yr study (Table 6). Vesper Sparrow numbers remained relatively constant, Grasshopper and Savannah sparrows decreased, and Field Sparrow numbers increased dramatically. These trends in annual variation may, in part, reflect changes in the vegetation on Great Mine. Areas covered by dense vegetation in 1978 became more dense, while the sparsely vegetated areas associated with acid burns or rocky soil changed little. Thus, sparsely vegetated habitat selected by Vesper Sparrows was still present and breeding numbers remained relatively constant. Habitat suitable to Grasshopper and Savannah sparrows, however, became too dense (Whitmore 1979), which may reduce the foraging efficiency of these species. Moreover, the denser vegetation and the presence of woody invaders attracted Field Sparrows, evidenced by their sharp increase in 1980. Competition for space among these three species may be occurring. Other factors responsible for these trends may be poor breeding success in previous years, availability of other reclaimed surface mines as nesting habitat, and differential mortality during migration and on their wintering grounds. Colder temperatures and greater snowfall than normal did occur during the winter of 1979–1980 on the wintering grounds of these sparrows. Fretwell (1972) stressed the importance of the nonbreeding season to breeding densities the following spring.

TABLE 6. Annual variation in number of breeding sparrows on Great Mine.

Species	1978	1979	1980
Vesper Sparrow	21	19	20
Grasshopper Sparrow	33	31	25
Savannah Sparrow	24	24	14
Field Sparrow	1	5	20

The purpose of our study was to determine whether or not the grassland sparrow species are benefiting from the creation of nesting habitat by surface mining. Clearly, the extensive tracts of reclaimed surface mines created in northern West Virginia during the past decade provided nesting habitat for these species. Simply providing habitat for nesting, however, does not in itself demonstrate that these species are benefiting. If reclaimed surface mines in this area were actually suboptimal habitat and, consequently, sparrow reproductive success were low, then clearly these areas would not be benefiting the populations as a whole. We believe the creation of these temporary grasslands surrounded by woodlots and pastureland tends to concentrate predators that subsequently inflict heavy losses. Although our study site is but a small portion of the total area under concern, our conclusions may be reasonable for similar reclaimed surface mines in northern West Virginia.

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