Ecology and Management of the Florida Grasshopper Sparrow

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ABSTRACT

The Florida Grasshopper Sparrow (*Ammodramus savannarum floridanus*) is a sedentary songbird endemic to the dry prairie landscape of interior south-central Florida. It is the only bird entirely restricted to this region and habitat. Discovered in 1901, its range has contracted severely as most of its habitat has been destroyed, altered, or fragmented. The ecology of the Florida Grasshopper Sparrow was summarized most recently by Delany (1996) and the United States Fish and Wildlife Service (1999), but results of several studies published subsequently warrant an updated, detailed account. Although federally endangered since 1986, Florida Grasshopper Sparrow numbers continue to decline. Sparrows are known from only three publicly-owned properties and a few private ranches. Moderate to large numbers of sparrows (>50 pairs) now occur at only two sites. The Florida Grasshopper Sparrow is a short-lived (generally <3 years), ground-nesting bird with low nesting success. Depredation is the primary cause of nesting failure. Several facets of the sparrow's ecology have been studied in recent years, but much information remains to be learned or refined. Dispersal distance and frequency, adult and juvenile survival, and the effects of cattle grazing are important facets of the sparrow's ecology that need to be better understood. A recent population viability analysis predicted an 18% chance that Florida Grasshopper Sparrows will become extinct within the next 50 years. Based on this alarming prognosis, we recommend that several actions be undertaken by state and federal agencies: efforts to purchase all remaining privately-owned dry prairie should be accelerated; research into restoring pastures back into dry prairie should be established; and additional research into translocating sparrows into currently unoccupied habitats should begin. We also recommend that monitoring activities at all publicly-owned sites be continued.

INTRODUCTION

The Florida Grasshopper Sparrow (*Ammodramus savannarum floridanus*) is a small, sedentary songbird endemic to the dry prairie landscape of interior south-central Florida. It was classified as endangered by the United States Fish and Wildlife Service because of its restricted distribution, loss of habitat, and population decline (Federal Register 1986). Its range has contracted severely due to conversion of prairies to incompatible land uses such as pastures, sod farms, citrus groves, or pine plantations (Federal Register 1986, Delany and Linda 1994, Shriver and Vickery 1999, Delany et al. 2005). Within the remaining dry prairie fragments, changes in fire seasonality and frequency, alteration of hydrologic regimes, cattle grazing, and other factors have also affected the sparrow's habitat. Florida Grasshopper Sparrows were discovered by Edgar Mearns (1902) on the Kissimmee Prairie (on or near the present-day Three Lakes Wildlife Management Area) in 1901. For the next 80 years, small numbers of sparrows were reported at scattered locations north and west of Lake Okeechobee, often with many years elapsing between observations (Delany et al. 1985, McNair 1986). Formal research with the sparrow began in 1980 with Mike Delany and has continued to the present, with a majority of the studies having been conducted since the latter 1990s. Public study sites are Avon Park Air Force Range (AFR) in Highlands and Polk counties, Kissimmee Prairie Preserve State Park (hereafter, Kissimmee Prairie Preserve) in Okeechobee County, and Three Lakes Wildlife Management Area (WMA) in Osceola County. A fourth study site, Ordway-Whittell Kissimmee Prairie Sanctuary (hereafter, Kissimmee Prairie Sanctuary) in Okeechobee County, became part of Kissimmee Prairie Preserve in 2002.

Despite recent attention given to Florida Grasshopper Sparrows, much information remains to be learned or refined, owing to the sparrow's secretive habits, extremely limited range, and small population size. Furthermore, the similarly-plumaged Eastern Grasshopper Sparrow (*A. s. pratensis*) winters in central Florida, and the two subspecies cannot always be distinguished in the field (Dean 2001). Point-count surveys conducted from March through June have been used to monitor Florida Grasshopper Sparrow numbers at Three Lakes WMA since 1991, Avon Park AFR since 1996, and Kissimmee Prairie Preserve since 1998. However, no long-term, year-round study of marked Florida Grasshopper Sparrows has been conducted, and such a study may not be feasible given the subspecies' secretive behavior. Herein, we summarize the ecology and management of Florida Grasshopper Sparrows. Out of necessity, we have prioritized the information that we present, and we emphasize papers published in peer-reviewed journals over unpublished manuscripts such as reports or theses.

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DESCRIPTION

Grasshopper Sparrows are small terrestrial songbirds in the subfamily Emberizinae of the family Emberizidae and the order Passeriformes. Members of the genus *Ammodramus* are ground-dwelling sparrows characterized by large flat heads, short wings, and short tails. Florida Grasshopper Sparrows are about 13 cm in length and 17-18 g in weight (Delany et al. 1994). The sexes cannot be distinguished by plumage. Delany et al. (1994) found that during the breeding season, males tended to have slightly longer wings (60.7 mm, ± 0.25, $n = 25$ vs. 57.9 mm, ± 0.30, $n = 8$) and lower mass (17.17 vs. 18.39 g) than females, but 12% of individuals were misclassified to sex using these two measurements. The greater weight of females during the breeding season may result from unlaid eggs in their bodies (Delany et al. 1994). Methods to distinguish the sexes of Florida Grasshopper Sparrows during the non-breeding season have not been determined.

The plumage of Grasshopper Sparrows varies according to subspecies, but all adults are pale buff below and darker above, with streaking on the mantle and scapulars. The head is buffy with a central crown stripe, yellowish lores, and grayish auriculars. A whitish eye-ring is conspicuous. The bill, short, thick, and proportionately large, is pale with a dark culmen. The wings are brownish with faint wingbars and a yellow shoulder patch that typifies the genus. The legs are pinkish and the irides are dark. Juveniles are whitish below with bold blackish streaking on the breast. The Florida Grasshopper Sparrow is darker above and paler below than other subspecies, with a longer bill and longer tarsi (Mearns 1902, Delany 1996) but these characters cannot always be reliably used for field identification. For more detailed descriptions, consult Smith (1968), Delany et al. (1994), Delany (1996), Vickery (1996), or Beadle and Rising (2002); the latter source contains photographs of adult and juvenile Florida Grasshopper Sparrows.

DISTRIBUTION

Twelve subspecies of the Grasshopper Sparrow are recognized, breeding widely in the eastern and central United States, with populations locally in Florida, the western United States, the Caribbean, and Central America. Four subspecies occur in North America: *A. s. pratensis* in the east, *A. s. floridanus* in central Florida, *A. s. perpallidus* in the west, and *A. s. ammolegus* in southern Arizona and northern Sonora (Vickery 1996, Beadle and Rising 2002). Migratory populations winter widely in the southeastern United States, Mexico, and Cuba. The resident Florida subspecies is isolated from breeding populations of *A. s. pratensis* in southwestern Georgia by 480 km (Vickery 1996). However, *A. s. pratensis* winters throughout Florida (Stevenson and Anderson 1994, Delany 1996, Vickery 1996), and *A. s. perpallidus* occurs in the state at least occasionally (Stevenson and Anderson 1994).

Florida Grasshopper Sparrows are endemic to the dry prairie landscape of interior central Florida (Fig. 1). Specimens, egg sets, or blood samples document the occurrence of sparrows in Highlands, Okeechobee, Osceola, and Polk counties, with fairly recent observations from DeSoto and Glades counties. The sole Hendry County report refers to two nests found by Oscar Baynard (Howell 1932) on the Hicpochee Prairie, which may no longer exist in a natural state. The presence of Florida Grasshopper Sparrows in Collier County seems less certain; the sole report is by Howell (1932: 452), who mentions that Donald Nicholson saw "a number" of sparrows, "presumably" *A. s. floridanus*, "on the prairies southeast of Immokalee, where they appeared to be breeding"—no date is given. The Immokalee Prairie, perhaps 40-50 km southwest of the Hicpochee Prairie, also may have been converted to agriculture in the intervening years. Based on the amount of dry prairie historically found in Charlotte County, and on the presence of sparrow populations nearby in DeSoto and Glades counties, Florida Grasshopper Sparrows probably occurred in Charlotte County (Fig. 1), but there is no known report.

Comparison of historic and recent distributional data implies a considerable reduction in the range of Florida Grasshopper Sparrows (Shriver and Vickery 1999, Vickery and Perkins 2003, Delany et al. 2005, Fig. 1). Currently, Florida Grasshopper Sparrows appear to be limited to eight sites in a 500-km^2 area in Highlands, Okeechobee, Osceola, and Polk counties (Fig. 1), with a total population perhaps under 1000 individuals (Delany et al. 2005). Undiscovered sparrows on private lands may exist (Vickery and Perkins 2003); Delany et al. (2005) were denied access to several ranches during their recent survey. However, many ranches, including some with relatively pristine prairie remaining, and some known to support Florida Grasshopper Sparrows within the past 20 years, have been surveyed recently without discovery of any extant sparrows (Delany et al. 2000*a*, 2005). It may therefore be misleading to presume that sites with sparrows remain to be discovered (T. F. Dean pers. comm.). Florida Grasshopper Sparrows are known presently from only three publicly-owned properties: Avon Park AFR (three sites, not necessarily isolated: Delta Trail/OQ Range and Echo Range in Highlands County, and Bravo/Foxtrot Range in Polk County), Kissimmee Prairie Preserve, and Three Lakes WMA. Sparrow numbers at Avon Park AFR have declined precipitously since 1997 and are in danger of extirpation; no sparrows were found at Bravo/Foxtrot Range in 2003 (Vickery and Perkins 2003; Tucker and Bowman 2004, 2005; Table 1). Sparrow numbers at Kissimmee Prairie Preserve and Three Lakes WMA fluctuate annually (Table 1) but appear secure.

Florida Grasshopper Sparrows also have been detected in recent years on three private ranches: Adam's Lake Marian Ranch adjacent to the east side of Three Lakes WMA in Osceola County; Cutrale Farms/Beatty Ranch in Okeechobee County; and Triple Diamond Ranch adjacent to the south side of Kissimmee Prairie Preserve (Vickery and Perkins 2003, Delany et al. 2005, P. Miller pers. comm., Fig. 1, Table 1). Since the early 1980s, Florida Grasshopper Sparrows have disappeared from several sites, largely as a result of prairie conversion to pastures or sod farms (Delany et al. 1985, 2005; Delany and Cox 1986; Delany and Linda 1994; Stevenson and Anderson 1994).

Three reports of breeding Grasshopper Sparrows from the early 20th century fall far outside the document-

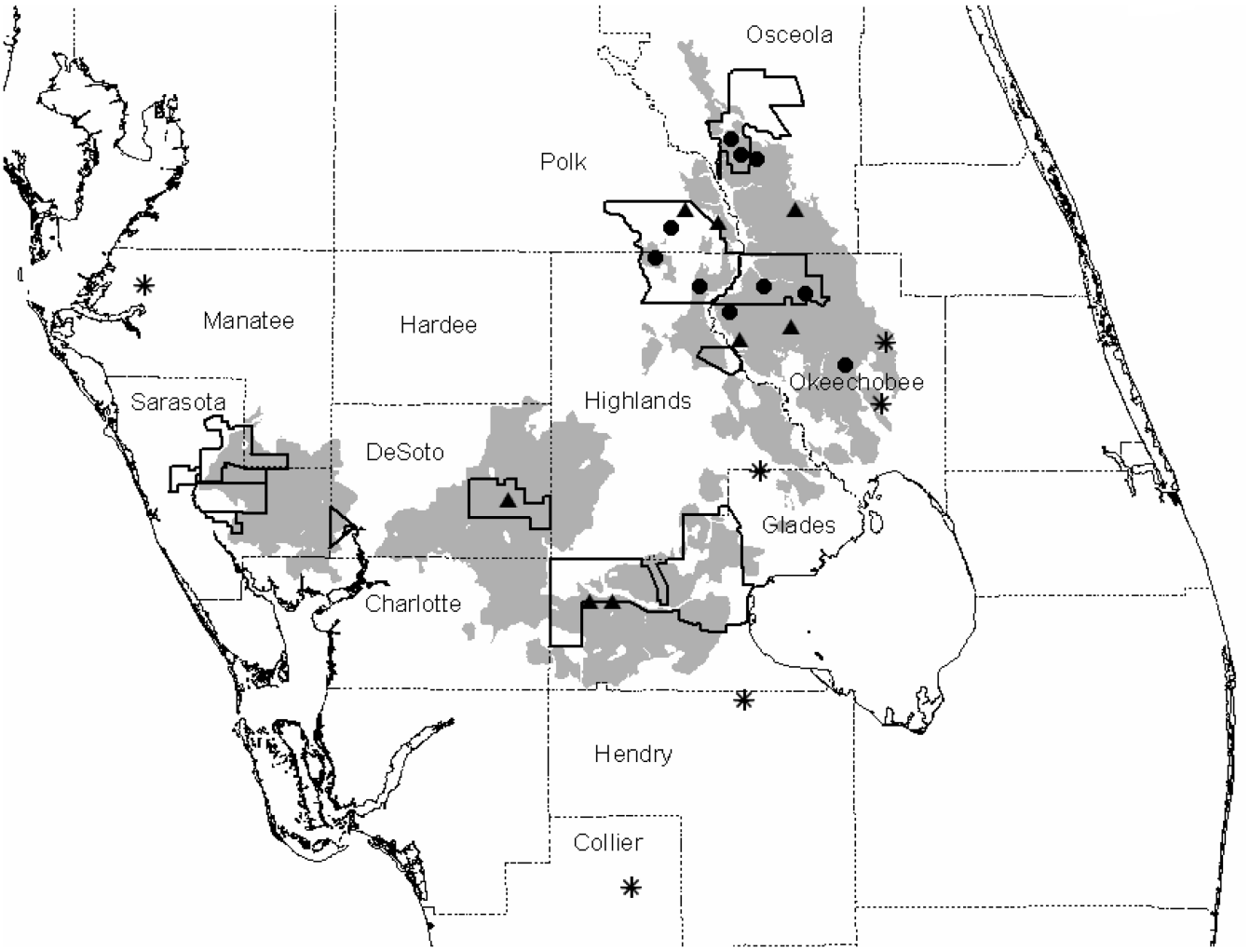

Figure 1. Distribution of Florida Grasshopper Sparrows, dry prairie habitat, conservation areas that contain dry prairie habitat, and counties with reports of former or current Grasshopper Sparrow locations. Current (2000-2005) sparrow locations are marked (●), recent (1980-1999) locations with (▲), and historic (1901-1979) locations with (*). Not shown on this map are three sites far outside the known range of Florida Grasshopper Sparrows, at Everglades National Park in Miami-Dade County (1968), Paynes Prairie in Alachua County (before 1913), and west of Titusville in Brevard County (1917-1925). Extent of historic dry prairie (shaded areas) is from Bridges (2006). The boundaries of conservation areas (solid lines) within the historic range of dry prairie are shown for Avon Park AFR (Highlands and Polk counties), Bright Hour Ranch conservation easement (DeSoto County), Carlton Reserve (Sarasota County), GDC Preserve (DeSoto County), Hickory Hammock Preserve (Highlands County), Kissimmee Prairie Preserve (Okeechobee County; includes Kissimmee Prairie Sanctuary), Lykes Brothers Ranch conservation easement (Glades County), Myakka River Preserve (Sarasota County), Myakka River State Park (Manatee and Sarasota counties), Ringling-MacArthur Tract (Sarasota County), and Three Lakes WMA (Osceola County).

ed range of *A. s. floridanus*: a pair of sparrows with fledglings at Paynes Prairie, Alachua County in the early 1900s (Baynard 1913, Howell 1932); an adult carrying food near Erie, Manatee County on 24 June 1924 and other dates (Howell 1932); and 30 pairs of sparrows (no date supplied) and egg sets collected in 1917 and 1925 at Titusville, Brevard County (Stevenson and Anderson 1994). Opinions concerning the subspecies occupying these sites have differed among authors (we presume that the reports are valid; see the commentary by Stevenson and Anderson 1994 regarding the Brevard County egg sets). Howell (1932) and Sprunt (1954) consider the reports from Alachua and Manatee counties to *be A. s. pratensis*, while the United States Fish and Wildlife Service (1999: 4-373) considers it "questionable" that the Manatee County report pertained to *A. s. floridanus*. However, Stevenson and Anderson (1994) ascribe all three reports to Florida Grasshopper Sparrows. Subsequent authors (e.g., Delany 1996, Vickery 1996, Shriver and Vickery 1999, Delany et al. 2005) do not discuss these extralimital breeding reports.

While no subsequent observations of breeding Grasshopper Sparrows have originated from Manatee County, relatively pristine dry prairie remains in the southeastern part of the county and in adjacent eastern Sarasota County (Fig. 1), most notably at Myakka River State Park, which contains about 6000 ha of dry prairie (Vickery and Perkins 2003, Delany et al. 2005). We presume that the Erie breeding reports referred to *A. s. floridanus*, but habitats at the Alachua and Brevard sites probably differed considerably from dry prairie, and we render no opinion on which subspecies may have been represented. Alachua

Table 1. Florida Grasshopper Sparrow population estimates, 1996-2005. Survey methodology and effort varies among sites and years, especially on privately-owned ranches. Population estimates follow the methodology of Walsh et al. (1995), where the number of singing males is doubled, and sparrows of unknown sex are added to this total. APAFR = Avon Park Air Force Range, TLWMA = Three Lakes Wildlife Management Area. Kissimmee Prairie Sanctuary was incorporated into Kissimmee Prairie Preserve in 2002. Data are from Delany et al. (1999, 2005), Tucker and Bowman (2004), and P. Gray (pers. comm.). For information on sparrow numbers before 1996, see Delany et al. (1985), Delany and Cox (1986), and Stevenson and Anderson (1994).

	Adam's Ranch	APAFR, Bravo/Foxtrot	APAFR, Delta/OQ	APAFR, Echo	Beatty Ranch[1]	Kissimmee Preserve[2]	Kissimmee Sanctuary[3]	River Ranch	TLWMA, main	TLWMA, Prairie
Size	171	206	700	1195	388	7689	1000	?	4000	861
1996			69	102			10		186	
1997		43	113	142			6	2	172	
1998		28	90	115			1		168	
1999		27	80	137		128	0		194	
2000	50	11	73	81		121	0		220	
2001		8	52	92	46	226	0		258	
2002		7	45	92		537[4]			206	
2003		0	5	12		129			196	
2004	36	0/2[4]	0/8[4]	13/20[4]	16	214			248	12[5]
2005		2/2[4]	6/8[4]	3/6[4]		86			228	

[1]Referred to as Cutrale Farms by Vickery and Perkins (2003).

[2]Only 6% of the prairie is surveyed (P. Miller pers. comm.; not 50% as reported by Vickery and Perkins 2003); the total population likely is much larger than indicated here.

[3]Data refer to the number of sparrow territories (Perkins and Vickery 2005).

[4]Includes supplemental data to point-count data from established plots. The first number refers to population data obtained solely from point counts following the Walsh et al. (1995) method, while the second number refers to data obtained from point counts and additional surveys following the Walsh et al. (1995) method.

[5]Translocation site.

County lies roughly midway between the breeding ranges of the Eastern and Florida subspecies of the Grasshopper Sparrow, as mapped by Vickery (1996). Smith (1968: 726) discusses the "interesting situation" concerning the "wide territorial gap" between the breeding ranges of these two subspecies, especially considering that much of the region has been converted to agriculture.

HABITAT

Florida Grasshopper Sparrows are endemic to the dry prairie landscape of interior south-central Florida. Sparrows occur sporadically, with sites often separated by several km of seemingly suitable but unoccupied habitat (Nicholson 1936, Smith 1968, Walsh et al. 1995, Delany et al. 2005). Bridges and Reese (1999) provide comprehensive analyses and color photographs of six distinct dry prairie communities that they describe from the Kissimmee Prairie: dry-mesic sandy; mesic; wet-mesic (spodic); wet-mesic (alfic); typical acidic wet prairie; and calcareous fringing wet prairie. Florida Grasshopper Sparrows occur primarily in dry-mesic sandy and mesic prairie types, which generally are the least flooded and contain the greatest amount of bare ground (Bridges and Reese 1999). Compared to other Grasshopper Sparrows, habitats used by the Florida subspecies are characterized by greater shrub cover (19.2%), greater amount of bare ground (21.9%), similar grass cover (25.5%), lower mean vegetation height (27.8 cm), and lower mean litter cover (14.4%; Delany et al. 1985). Tucker and Bowman (2006) provide a more comprehensive review of habitat associations and requirements at Avon Park AFR.

The United States Fish and Wildlife Service (1988: 7) states that Florida Grasshopper Sparrows "might be downgraded to threatened status if populations of 100-200 adults (50-100 breeding pairs) become established at 10 secure, discrete sites dispersed throughout the former range of the subspecies." On the basis of population density, Delany et al. (1995) estimate that 50 pairs of sparrows would need 814-1348 ha of dry prairie. However, Perkins et al. (2003) suggested that in sparrow territories <400 m from habitat edges (forests or pasture), mortality exceeds reproduction (i.e., are population sinks). Only in Florida Grasshopper Sparrow territories >400 m from habitat edges does reproduction exceed mortality (i.e., are sources). Based on their calculations, Perkins et al. (2003) suggest that extremely large (>4000 ha) patches of dry prairie may be required to sustain viable numbers of Florida Grasshopper Sparrows.

Conversion of prairies to pastures or sod farms planted with exotic grasses such as bahia (*Paspalum* spp.), pangola grass (*Digitaria* spp.), and American joint vetch (*Aeshynomene americanus*) drastically changes the vegetation structure by removing clumps of vegetation growing among more open areas (Delany and Linda 1998*b*). Delany and Linda (1994) compared vegetation in occupied territories and in territories that were extirpated due to conversion to pasture (n = 5 territories each) and noted significant differences between the two types: an increase in grass cover (37% vs. 83%) and decreases in shrub cover (20% vs. 2%), bare ground (26% vs. 1%), and vegetation height (21 vs. 11 cm). Florida Grasshopper Sparrows became extirpated from six prairie sites following their conversion to pastures (Delany and Linda 1994). Although Florida Grasshopper Sparrows occur—at least in the short term—in pastures near or adjacent to occupied

dry prairie (Delany et al. 1985, T. F. Dean pers. comm., P. Miller pers. comm.), it appears that such altered habitats cannot sustain sparrows in the long-term (*see* Delany and Linda 1994). Studying the demography of Florida Grasshopper Sparrows that inhabit altered habitats should be a research priority; Kissimmee Prairie Preserve contains pastures that are occupied by sparrows currently (P. Miller pers. comm.).

DEMOGRAPHIC CHARACTERISTICS

Genetics—Three studies have recently examined the genetic structure of Florida Grasshopper Sparrows, and each reports low genetic differentiation among *floridanus* populations, or between Florida Grasshopper Sparrows and other subspecies (Delany et al. 2000*b*, Vickery et al. 2002, Bulgin et al. 2003). Delany et al. (2000*b*) analyzed DNA samples of Florida Grasshopper Sparrows from the six extant sites on public lands (Bravo/Foxtrot Range, n = 7; Delta Trail/OQ Range, n = 40; Echo Range, n = 17; Kissimmee Prairie Preserve, n = 20; Kissimmee Prairie Sanctuary, n = 9; and Three Lakes WMA, n = 25) and found no significant genetic differences. Overall, 98% of the genetic variation occurred within, rather than among, sites (Delany et al. 2000*b*). Vickery et al. (2002) compared DNA from "historic" (n = 37) and current (n = 106) Florida Grasshopper Sparrow samples, and likewise found no significant genetic differences. Historic samples were obtained from specimens collected before 1950 (some during months when *A. s. pratensis* is present in Florida; it was not made clear how these specimens were conclusively identified to subspecies). Bulgin et al. (2003) analyzed recent DNA samples (n = 105; many of the same samples analyzed earlier by Delany et al. 2000*b*) to compare differences among Florida Grasshopper Sparrows and two other subspecies: *A. s. pratensis* populations from Massachusetts (n = 39), Ohio (n = 34), and Georgia (n = 19); and *A. s. ammolegus* from Arizona (n = 17). Bulgin et al. (2003) found low but significant genetic divergence between *A. s. floridanus* and the other two subspecies, but no differences between *A. s. pratensis* and *A. s. ammolegus*. The various Grasshopper Sparrow populations are thought to have diverged within the past 25,000 years, a duration too short to allow for the evolution of substantial genetic differences (Bulgin et al. 2003).

Low genetic differentiation and relatively high genetic diversity among Florida Grasshopper Sparrows may indicate that gene flow is occurring among sites (Delany et al. 2000*b*). Alternatively, or perhaps additionally, genetic similarities may reflect that sites have become isolated only recently from habitat fragmentation. Conversion of dry prairies to non-compatible uses has greatly reduced the amount of habitat available for Florida Grasshopper Sparrows (Delany et al. 1985, Federal Register 1986, Shriver and Vickery 1999, United States Fish and Wildlife Service 1999). As a result, the remaining sites are more isolated than they were in the past (Delany et al. 2000*b*). Bulgin et al. (2003: 840) point out that despite the recent severe habitat fragmentation and loss, the lack of genetic bottlenecks in the Florida Grasshopper Sparrow creates a "window of opportunity" to preserve most of its historic genetic diversity.

Nesting—Florida Grasshopper Sparrows build well-hidden nests on the ground, in slight depressions (<3.2 cm) in the sandy substrate, with the nest cup lying at or slightly (<1.3 cm) above the surface (Delany and Linda 1998*a*). Nests are domed, with a small entrance on one side. Nests are built at the base of grass clumps or shrubs, and are shielded from above by vegetation. Fifteen of 20 *A. s. floridanus* nests at Avon Park AFR were shielded by runner oak (Delany and Linda 1998*a*). Other nests were shielded by saw palmetto, wiregrass, bluestems (*Andropogon* spp.), gopher apple (*Licania michauxii*), yellow-eyed grass (*Xyris* spp.), Atlantic St. John's-wort (*Hypericum reductum*), or dwarf huckleberry (*Gaylussacia dumosa*; Nicholson 1936, Delany 1996, Delany and Linda 1998*a*, Pranty 2000). Fifteen nests at Avon Park AFR were constructed mainly of wiregrass, bluestems, and short-leaf yellow-eyed grass (*Xyris brevifolia*), and were lined with Elliot's yellow-eyed grass (*X. elliottii*) and roadgrass (a.k.a. Baldwin's spikerush; *Eleocharis baldwinii*, Delany and Linda 1998*a*). Orientation of Florida Grasshopper Sparrow nest entrances is distributed randomly with respect to compass direction but is correlated with bare ground or sparse vegetation (Delany and Linda 1998*a*).

Grasshopper Sparrow eggs are ovate, smooth, and slightly glossy. They are whitish with reddish-brown markings, usually more numerous at the larger end (Sprunt 1954, Vickery 1996). The eggs of Florida Grasshopper Sparrows do not differ from those of other subspecies in size, shape, or color (Vickery 1996). Incubation, performed solely by the female, begins with the penultimate (i.e., next to last) egg and requires 11-12 days (Smith 1968). Nestlings fledge after an additional six to eight (Delany 1996) or nine (Smith 1968) days.

McNair (1986) reports that 51 complete clutches of Florida Grasshopper Sparrow eggs are known in museums, collected mostly by Donald and Wray Nicholson on the Kissimmee Prairie during 1932-1950. Mean clutch size was 3.71 eggs (± 0.46; no range given), although two-egg clutches were considered incomplete and were discounted, which may overestimate clutch size. Perkins et al. (2003) describe 74 nests of Florida Grasshopper Sparrows found on the Kissimmee Prairie during 1996-1998. Nests were active from 15 April to 27 August, but the ranges of egg dates and nestling dates and the mean date of clutch initiation, were not provided. Clutch size by site was 3.47 (± 0.62; n = 17) at Avon Park AFR, 3.56 (± 0.53; n = 9) at Three Lakes WMA, and 3.75 (± 0.50; n = 4) at Kissimmee Prairie Preserve (Perkins et al. 2003).

The number of Florida Grasshopper Sparrow broods produced annually is not known due to the extreme secrecy of females. In fact, it is not even known whether pairs of sparrows are monogamous over the course of a breeding season. Nicholson (*in* Smith 1968) claims that Florida Grasshopper Sparrows are triple-brooded, with eggs laid from mid-April through early May, in early June, and in July. However, these observations were based entirely on unmarked individuals. Vickery (1996) states that *A. s. floridanus* may potentially produce up to four broods per year, a statement apparently based solely on the sparrow's prolonged breeding season in Florida. Based on 74 Florida Grasshopper Sparrow nests found during 1996-1998, Perkins et al. (2003) estimated annual productivity to be 1.46-4.09 fledglings per pair, with each successful nest fledging 3.20 young.

Noting that "the lack of adequate surveys both early and late in the breeding season prevents an accurate assessment of the duration of the breeding season," McNair (1986: 49) points out that Florida Grasshopper Sparrows may begin egg-laying in late March and may continue into July "or even afterwards." Recent studies (e.g., Perkins et al. 1998, 2003, Pranty 2000, Tucker and Bowman 2004) indicate that the nesting season of Florida Grasshopper Sparrows is prolonged, ranging from perhaps late March to early September. Nine of 13 nests found at Avon Park AFR and Three Lakes WMA in 1996 contained eggs beyond the latest collected egg-set date of 22 June, and five of those nests were active more than a month beyond that date (Perkins et al. 1998, B.P. pers. obs.). B.P. found a nest with three eggs at OQ Range on 19 August 1996 that were still present two days later, but the nest was empty the following day (Perkins et al. 1998, Pranty 2000). Had this nest been successful, the nestlings might have fledged in early September, resulting in a potential maximum nesting season exceeding 180 days (Pranty 2000). Perkins et al. (2003) used a nesting season of 160 days for calculating source-sink dynamics of Florida Grasshopper Sparrows.

Shriver et al. (1996, 1999) associate nests built in July or August with an "extended" sparrow breeding season related to prairies that burned weeks earlier in June. However, other sparrow researchers have found late-season nests built in prairies that had burned the previous winter or spring. Four of the five latest nests found at Avon Park AFR and Three Lakes WMA in 1996 were built in prairies that had burned prior to one or two months previously (Perkins et al. 1998). One of these nests, found at OQ Range on 19 August 1996 (mentioned above), was built in prairie that had burned on 27 February 1996 (Avon Park AFR unpublished data). Similarly, J.W.T. has found two late-season nests at Avon Park AFR: one nest found at Echo Range on 2 August 2003 was built in prairie that had burned on 13 March 2003 (Avon Park AFR unpubl. data), and another nest found at OQ Range on 1 August 2005 was built in prairie that burned on 5 April 2005 (J.W.T. pers. obs.). Thus, it seems that the breeding season of Florida Grasshopper Sparrows may regularly last into August when prairies are burned 2-6 months earlier. The time-since-fire interval of *A. s. floridanus* nests has otherwise not been reported and would be valuable information.

Brood parasitism of Grasshopper Sparrow nests by Brown-headed Cowbirds (*Molothrus ater*) has been reported for *A. s. pratensis* and *A. s. perpallidus* (Smith 1968, Vickery 1996) but is not yet known for *A. s. floridanus* despite the presence of cowbirds during the breeding season within the sparrow's range (<http://www.archbold-station.org/abs/staff/rbowman/cowbirdegg.htm>, B.P. and J.W.T. pers. obs., P. Miller pers. comm.). The Shiny Cowbird (*M. bonariensis*) remains rare inland in central Florida and has yet to be confirmed breeding in the state, although breeding likely has taken place (Pranty 1999). The Bronzed Cowbird (*M. aeneus*) is increasing in Florida and may soon be confirmed as a breeding species (Pranty 2005), but does not yet occur during the nesting season within the range of Florida Grasshopper Sparrows.

Dispersal—Florida Grasshopper Sparrows have long been considered non-migratory (*contra* Bailey 1925), and their sedentariness is suggested from extensive color-banding data and limited radio-telemetry monitoring. Several hundred sparrows have been color-banded at Avon Park AFR, Kissimmee Prairie Preserve, and Three Lakes WMA since 1989 (Delany et al. 1992, 1993; Dean et al. 1998; Perkins and Vickery 2001). Only one of these sparrows has been observed to move between sites: a juvenile color-banded at OQ Range, Avon Park AFR in July 1996 was recaptured at Kissimmee Prairie Preserve in January 2003. This movement represents a 30 km dispersal (Miller 2005), the longest known movement by a marked Florida Grasshopper Sparrow. Miller (2005) also discovered the second-longest dispersal (4.0 km) within Kissimmee Prairie Preserve.

Dean (2001) reports four non-breeding season movements of radio-tagged Florida Grasshopper Sparrows at Avon Park AFR and Three Lakes WMA of >3 km, with the longest distance of 3.8 km. All of these movements, however, are eclipsed by the Florida Grasshopper Sparrow that was found far from suitable habitat at Anhinga Trail, Everglades National Park, Miami-Dade County, on 9 July 1968 and collected the following day (Stevenson and Anderson 1994; this location is not near Marathon as per Vickery 1996). This sparrow (specimen ENP 4900) was 210 km south of Brighton, Glades County, the closest site known to be occupied by Florida Grasshopper Sparrows through the 1960s (Delany et al. 1985, Stevenson and Anderson 1994), and presumably represents an anomalous long-distance extralimital movement. Determining dispersal rates of Florida Grasshopper Sparrows is a high research priority (Vickery and Perkins 2003).

Mortality—Sources of Florida Grasshopper Sparrow mortality are not well studied. Documented natural predators are the Northern Harrier (*Circus cyaneus*, Dean 2001), Loggerhead Shrike (*Lanius ludovicianus*, Pranty 2000), and corn snake (*Elaphe guttata*, G. Quigley pers. comm.), while likely predators include other snakes, Sharp-shinned Hawks (*Accipiter striatus*), Cooper's Hawks (*A. cooperii*), and mammals (Vickery 1996). Avian predators represented the primary cause of mortality for Florida Grasshopper Sparrows during the non-breeding season at Avon Park AFR and Three Lakes WMA, accounting for 86% (10 of 14) of depredations (Dean 2001). Minor sources of mortality reported for Florida Grasshopper Sparrows include one juvenile at Avon Park AFR that was probably struck by a vehicle (Pranty 2000), and a radio-tagged adult at Three Lakes WMA that was suspected of having been shot (Dean 2001).

Predation accounts for most nesting failure of Florida Grasshopper Sparrows. Perkins et al. (2003) found that 89% of 74 sparrow nests that failed were depredated; other causes of nesting failure were desertion (6%) and flooding (3%). Predators of Florida Grasshopper Sparrow eggs and nestlings are snakes, spotted skunks (*Spilogale putorius*), striped skunks (*Mephitis mephitis*), and feral hogs (*Sus scrofa*; Smith 1968), and probably armadillos (*Dasypus novemcinctus*, Vickery 1996). Flooding from summer thunderstorms can lead to abandonment of eggs or nestlings (Pranty 2000, Perkins et al. 2003). Unnatural water impoundment caused the (temporary) extirpation of the sparrows that inhabited Kissimmee Prairie Sanctuary, likely due to the prevention of nesting attempts (Perkins and Vickery 2005). Some nests at Avon Park AFR probably are trodden by cattle (Stevenson and Anderson 1994).

Red imported fire ants (*Solenopsis invicta*), which are native to Brazil and were inadvertently released into the southeastern United States in the 1930s, have been shown to negatively affect several ground-nesting birds and numerous other fauna (Allen et al. 1999 and references therein). Allen et al. (1999) studied red imported fire ant abundance and distribution at Avon Park AFR during 1997-1999 and concluded that the ants had low-level negative impacts on Florida Grasshopper Sparrows. Fire ants are also found at Kissimmee Prairie Preserve and Three Lakes WMA, but their abundance and distribution have not been quantified (P. Miller pers. comm., S. Glass pers. comm.).

Parasites of Florida Grasshopper Sparrows are not well studied but are thought to pose little threat to populations. Delany and Forrester (1997) reported a low incidence (2.7%) and intensity (<2 ticks/sparrow) of Gulf coast ticks (*Amblyomma maculatum*) and bird ticks (*Haemaphysalis chordeilis*) from Florida Grasshopper Sparrows (n = 73) banded at Avon Park AFR during 1989-1992. Delany and Forrester (1997) surmised that frequent fires in dry prairie may maintain the density of ticks at low levels. However, Dean (*in* Forrester and Spaulding 2003) reported much higher tick infestation rates on Florida Grasshopper Sparrows during 1996-1997, finding ticks on 19% (n = 16) and 67% (n = 12) of sparrows at Avon Park AFR and Three Lakes WMA, respectively. Dean et al. (*in* Forrester and Spaulding 2003) also reported two helminths (one unidentified microfilariae and seven intestinal *Mediorhynchus papillosum*), an intestinal parasite (probably an undescribed species of *Isospora*; the first report of Coccidia for any subspecies of Grasshopper Sparrow); an additional tick (*Haemaphysalis leporispalustris*); and three feather mites (*Trouessartia capensis* and probably undescribed species of *Mesalgoides* and *Pterodectes*) on Florida Grasshopper Sparrows examined at Avon Park AFR, Kissimmee Prairie Preserve, and Three Lakes WMA during 1996-1998. (We presume that the location for the *Mesalgoides* listed by Forrester and Spaulding 2003 as Brevard County is incorrect.)

Life Span and Survivorship—Based on 48 adult male Florida Grasshopper Sparrows color-banded at Delta Trail/OQ Range during 1989-1992, Delany et al. (1993) determined annual survival to be 59.8%, and estimated mean life expectancy as 2.95 years. In contrast, Perkins and Vickery (2001) estimated annual survival of color-banded adult males at Delta Trail/OQ Range (n = 40) and Three Lakes WMA (n = 54) during 1995-1998 to be 48.2% and 53.3%, respectively. They suggest that the decline in sparrow survival at Delta Trail/OQ Range was due to the installation of 4.7 km of barbed-wire fencing after 1993. Perkins and Vickery (2001) imply that the fencing provided perches and increased the density of avian predators, which led to a decreased survival rate of male sparrows. Because of the difficulty associated with obtaining estimates of juvenile survival, Perkins and Vickery (2001) used estimates of adult survivorship, reproductive success, and territory density to estimate juvenile survival at Avon Park AFR and Three Lakes WMA during 1995-1998 to be 35.1%.

Five longevity records of Florida Grasshopper Sparrows determined by resighting or recapturing marked individuals are 4.0, 4.0, 6.0, 6.6, and 6.6 years (Delany et al. 1993, Dean et al. 1998, Miller 2005). These records represent the five longest-lived individuals of any subspecies of Grasshopper Sparrow, surpassing the previous record of 3.1 years from Nebraska (Klimkiewicz and Futcher 1987). Whether the apparent longevity of *A. s. floridanus* is due to its sedentary nature, inadequate sampling of other subspecies, or other factors, is not known.

BEHAVIOR AND TERRITORIALITY

Florida Grasshopper Sparrows nest and presumably forage exclusively on the ground and are very secretive and easily overlooked (Delany 1996, Vickery 1996). During the breeding season, males are conspicuous as they sing from exposed perches and defend territories, but they are secretive during the non-breeding season. Females spend most of the time on the ground, hidden by vegetation, and are never conspicuous. Florida Grasshopper Sparrows appear reluctant to fly and usually flush only when approached within a few meters or less. When flushed, they usually fly low above the vegetation for a relatively short distance (<50 m) before dropping back to the ground. After landing, the birds either run on the ground or hide among vegetation. Breeding females are reluctant to flush, and often remain on the nest until approached within about 30 cm or less (Nicholson 1936, B.P. pers. obs.). When flushed, nesting females run along the ground while performing an injury distraction display (Nicholson 1936, Smith 1968, Vickery 1996, B.P. pers. obs.). When nestlings are present, adult sparrows generally land in vegetation near the nest, run to the nest and feed the young, and then quickly move away before flying or perching again, presumably to deter predators from following them directly to the nest (B.P. and J.W.T. pers. obs., D. W. Perkins pers. comm.).

Male Grasshopper Sparrows are one of few sparrows that sing two different songs (Vickery 1996). The Primary (or Short) Song is somewhat variable and consists of a short, high-pitched, insect-like *pit-tuck-zeeeeeeeee*, while the Sustained (or Long) Song consists of a series of short, squeaky notes that may last for 15 seconds (Vickery 1996). Male sparrows defend breeding territories and territorial boundaries, which appear to be delineated by singing perches, remain relatively stable throughout the breeding season (Delany et al. 1995). Territorial males perform a fluttering "butterfly" flight, often while singing the Sustained Song. Males also perform a wing-flicking display as part of their territorial defense (Smith 1968, Vickery 1996). After singing, a male will crouch with his head between his shoulders and rapidly flutter one wing (sometimes both wings) in the direction of a neighboring male (Smith 1968, Vickery 1996) or a human observer (B.P. and J.W.T. pers. obs.).

Delany et al. (1995) found that territories (n = 30) of Florida Grasshopper Sparrows at Avon Park AFR did not contain trees, even in low density (<1/ha), and that territories were located >75 m from the edge of forested areas such as cypress (*Taxodium* spp.) domes and pine (*Pinus* spp.) plantations. Similarly, only one of 74 nests found by Perkins et al. (2003) was located within 100 m of large wooded tracts adjacent to dry prairie. Territory sizes for 30 color-marked males at Avon Park AFR averaged 1.8 ha

(range 0.6-4.8 ha; Delany et al. 1995). Average territory densities of Florida Grasshopper Sparrows expressed by time-since-fire interval range from 0.16-0.38 territories/ha (Shriver and Vickery 2001, Delany et al. 2002).

Behavior of Florida Grasshopper Sparrows during the non-breeding season was studied by Dean (2001) using radio telemetry. There is no apparent territoriality, with both sexes occupying overlapping home ranges. Non-breeding season home ranges (n = 44) are substantially larger than breeding territories, with a mean of 29.0 ha (± 5.78) and a range of 1.0-173.6 ha. Distances traveled vary considerably by individual, with a maximum detected distance of 3.8 km. Males move farther than females. Some sparrows moved across unsuitable habitats that formed complete visual barriers—one sparrow at Avon Park AFR repeatedly traversed >200 m of oak (*Quercus* spp.) hammock (Dean 2001).

FOOD HABITS

The foraging behavior and food items of Florida Grasshopper Sparrows are largely unstudied. They presumably feed exclusively on the ground, as do other subspecies (Vickery 1996). The primary prey of Grasshopper Sparrows during spring and summer is orthopterans, while seeds comprise the bulk of their diet during the non-breeding season, based on studies north of Florida (Vickery 1996). The diet of Eastern and Florida Grasshopper Sparrows during the non-breeding season in Florida is unstudied and likely differs from more northern areas due to the lack of snow cover and the persistence of insect prey (P. Miller pers. comm.). Stomach contents of 10 Florida Grasshopper Sparrow specimens collected in May 1929 contained 69% invertebrate prey (primarily grasshoppers, crickets, beetles and their larvae, flies, and bugs), and 31% seeds of sedges, grasses, and stargrass (*Hypoxis* spp., Howell 1932). Stomachs recovered from two nestlings salvaged in 1997 contained 32 prey items: five katydids (*Orchelium* spp.), two grasshoppers (*Melanoplus* spp.), one Scudder's mantis (*Oligonicella scudderi*), 12 unidentified orthopterans, one click beetle (*Elateridae*), one ground beetle (*Carabidae*), one two-lined spitttlebug (*Prosapia bicincta*), one fly (*Tabanidae*), one parasitic wasp (*Braconidae*), one wolf spider (*Lycosa helluo*), one orb weaver spider (*Acantheperia venusta*), one jumping spider (*Habronattus calacaratus*), one seed of a sedge (*Scleria* spp.), and three unidentified seeds (Delany et al. 2000*c*).

CONSERVATION AND MANAGEMENT

Federally listed as endangered, the Florida Grasshopper Sparrow would be considered for down-listing to threatened status when: 1) further loss, fragmentation, and degradation of prairies within the Kissimmee River basin has ceased; 2) at least 10 protected and managed sites contain stable, self-sustaining populations of 50-100 pairs of sparrows within their historic range; and 3) sparrows occupying each site exhibit a rate of increase >0 sustained as a 2-year running average over at least six years (United States Fish and Wildlife Service 1998). Presently, only two sites, Kissimmee Prairie Preserve and Three Lakes WMA, support >50 pairs of Florida Grasshopper Sparrows (Table 1).

Based on population modeling of current conditions, Vickery and Perkins (2003) predict an 18% chance that Florida Grasshopper Sparrows will fall below the "metapopulation threshold" of 60 individuals (i.e., will become extinct) within the next 50 years. Vickery and Perkins (2003) recommend several management actions to decrease the sparrow's chance of extinction. Chief among these are protecting all dry prairie currently occupied by sparrows, introduction of sparrows to currently unoccupied but suitable sites, increasing the amount of dry prairie by restoring pastures, and increasing survivorship by burning prairies during summer and by removing abandoned fence posts that may be used as perches by avian predators (Vickery and Perkins 2003).

The revised recovery plan for the Florida Grasshopper Sparrow (United States Fish and Wildlife Service 1999) recommends several management actions. These include maintaining sparrow numbers on public and private lands via frequent prescribed burning and other appropriate management activities, restoring habitat to allow for recolonization of formerly-occupied sites, developing a reserve design, continuing and expanding research on the ecology of the sparrow, and—presumably as a last resort—beginning a captive-breeding program.

We agree with Vickery and Perkins (2003) that the highest priority for conservation of the Florida Grasshopper Sparrow is to target for public acquisition all remaining privately owned fragments of dry prairie, whether or not they currently support sparrows. Shriver and Vickery (1999) estimated that 81% of the original dry prairie habitat had been destroyed by 1995, and they identified several privately-owned ranches that still supported marginal to high quality dry prairie remnants. Two ranches with extensive tracts of dry prairie—Bright Hour Ranch in DeSoto County and Lykes Brothers Ranch in Glades County—have been subsequently protected via perpetual conservation easements, but Florida Grasshopper Sparrows apparently now are extirpated from those sites (Delany et al. 2000*a*, 2005). On the other hand, three other ranches that support or have recently supported sparrow populations—Adam's Lake Marian Ranch in Osceola County, and Beatty Ranch and Triple Diamond Ranch in Okeechobee County—remain unprotected. Once all remaining privately-owned dry prairie has been acquired publicly, the next highest priority should be to investigate whether pastures can be restored to dry prairie via reseeding of native grassland species.

Another important tool to help conserve the Florida Grasshopper Sparrow is to expand research into creating new sites occupied by sparrows via translocation techniques. To date, translocation of Florida Grasshopper Sparrows has been attempted at one site, Three Lakes WMA, but no results have been published (T. Dean pers. comm.).

The primary tool for management of Florida Grasshopper Sparrows is frequent (i.e., every 1-3 years) prescribed fire. Several studies have examined the influence of time since fire on Florida Grasshopper Sparrows, and all have found either higher densities (Walsh et al. 1995, Shriver and Vickery 2001) or higher reproductive success

(Shriver and Vickery 2001, Delany et al. 2002) in prairies the first breeding season following fire, as well as reduced densities and/or reproductive success by the third breeding season following fire. At Three Lakes WMA, Walsh et al. (1995) note that sparrows "strongly preferred" areas burned within the preceding 12 months. Sparrows also avoided areas not burned for >24 months and used the intermediate burn regime in proportion to its occurrence. Similarly, during winter, Florida Grasshopper Sparrows preferentially used prairies burned within the previous 12 months and used less frequently prairies not burned for >24 months (Dean 2001). Thus, it appears that fire is needed either annually or biennially to maintain high quality habitat for Florida Grasshopper Sparrows.

In addition to frequency of fire, the seasonality of burning may be important to Florida Grasshopper Sparrows. Historically, lightning-ignited fires probably burned prairies every one or two years, primarily early in the May-September fire season (Chen and Gerber 1990, Bridges and Reese 1999, United States Fish and Wildlife Service 1999). Seasonality of fire greatly affects the flowering response of dry prairie vegetation. Wiregrass and other grasses and forbs flower profusely following burns set in late spring or summer, but flower little following fires set during winter or early spring (Biswell and Lemon 1943, Abrahamson 1984, Shriver 1996). This increase in vertical cover during the first winter following a late spring or summer burn may provide sparrows with important escape cover from aerial predators (Shriver 1996).

Shriver et al. (1996, 1999) addressed the influence of summer fires on Florida Grasshopper Sparrows and found that sparrows reoccupied prairies burned in mid-June within a week following fire. Shriver et al. (1999) also document that sparrows can nest successfully ($n = 1$ nest) following fires set in mid-June, and they suggest that burning prairies in mid-June resulted in an "extended breeding season" relative to prairies burned during the winter. Shriver et al. (1996, 1999) state that burning prairies during the summer may double the number of breeding attempts by sparrows, may increase the number of sparrow pairs that attempt additional clutches, and may offer sub-dominant males their first breeding opportunities. However, Shriver et al. (1996, 1999) do not document whether this purported "extended breeding season" results in increased reproductive potential, or simply represents renesting by sparrows that lost nests during summer burns, or whether the "extended breeding season" represents an increase in territorial behavior (e.g., singing) that may be unrelated to breeding productivity. Although the work of Shriver et al. (1996, 1999) suggests that burning prairies during summer may be more beneficial to Florida Grasshopper Sparrows relative to prairies burned during the winter, there should be some concern for breeding-season burning of prairies occupied by small numbers of sparrows (e.g., those at Avon Park AFR), where potential sources of mortality should be minimized (M. F. Delany pers. comm.). Additional research is needed to evaluate fully the benefits of summer vs. winter burning on Florida Grasshopper Sparrows.

The influences of feral hog rooting and cattle grazing on Florida Grasshopper Sparrows largely are unstudied. Based strictly on the observation that sparrows were present in prairies at Avon Park AFR that were grazed by cattle, Delany et al. (1985) and Delany and Linda (1998*b*) suggest that low stocking rates and short-duration grazing by cattle are compatible with management of Florida Grasshopper Sparrows. However, two major differences in management between Avon Park AFR, where sparrow numbers have declined severely, and Kissimmee Prairie Preserve and Three Lakes WMA, where sparrow numbers appear to be secure (Table 1), is that cattle continue to graze prairies at Avon Park AFR—even during the sparrow nesting season—and that prairies are burned primarily during late winter or early spring to benefit cattle grazing.

Several anecdotes suggest that cattle grazing might negatively impact Florida Grasshopper Sparrows. For example, compared to results obtained by Delany et al. (1993), Perkins and Vickery (2001) noted a lower survival rate of adult male sparrows at Delta Trail/OQ Range, Avon Park AFR following the installation of 4.7 km of barbed-wire fencing. They suggest that mortality from avian predators might have increased due to the presence of fenceposts that offered perches for predators (Perkins and Vickery 2001). Pranty (2000) and Dean (2001) both found that fenceposts are used by Northern Harriers and Loggerhead Shrikes, which are known predators of Florida Grasshopper Sparrows. Cattle grazing also may increase sparrow mortality rates by reducing escape cover of grasses and shrubs (Shriver 1996, Perkins and Vickery 2001) and by trampling nests (Stevenson and Anderson 1994).

Sutter and Ritchison (2005) found that Eastern Grasshopper Sparrows in Kentucky had much lower breeding success (25% vs. 70%; $n = 35$ nests) in grazed vs. ungrazed areas. Renfrew et al. (2005) report that trampling by cattle was the second most frequent cause of nest loss of ground-nesting birds in Wisconsin, and Sutter and Ritchison (2005) document two nests of Eastern Grasshopper Sparrows that were trampled by cattle. Nack and Ribic (2005) used video cameras to monitor nests of ground-nesting birds in Wisconsin and found that 14 of 54 nests (26%) failed due to cattle disturbance. Among several ways that cattle caused nest failure, one nest was destroyed when a cow laid down on it, two nests were trampled, and cattle removed (and presumably consumed) the eggs or nestlings in two nests of the Savannah Sparrow (*Passerculus sandwichensis*) and one nest of the Eastern Meadowlark (*Sturnella magna*).

Only one study (Tucker and Bowman 2005) has attempted to examine the influence of cattle grazing on Florida Grasshopper Sparrows. Although data were limited to a single, relatively small (13.7 ha) exclosure at OQ Range, Tucker and Bowman (2005) found evidence that exclusion of cattle might have been beneficial to sparrows. Occupancy rate of sparrows inside the exclosure was statistically greater than rates outside the exclosure during 1996-2003, although inferences are extremely limited due to a small sample size. Additional research is needed to examine the influence of cattle grazing on *A. s. floridanus*.

Florida Grasshopper Sparrow numbers at Avon Park AFR declined annually from 1998-2004 and now are threatened with extirpation (Tucker and Bowman 2005). Specific causes for the decline are unknown, but Tucker and Bowman (2004, 2005) identify several potential contributing factors. In addition to the effects of cattle grazing, other factors considered include degradation of

remaining prairies via long-term off-season burning and edge effects that reduce availability of core habitat (*see* Perkins et al. 2003), and prairie loss and fragmentation from the establishment and maintenance of slash pine (*Pinus elliottii*) plantations. Comparison of aerial photographs of Avon Park AFR from 1943 with those from 2003 revealed that trees have encroached into the prairies from adjacent forested areas, and that many isolated trees or copses have become established, further reducing the amount of quality habitat available to sparrows (Tucker and Bowman 2005). Efforts undertaken by Department of Defense personnel during 2004-2005 to rectify prairie loss and degradation at Avon Park AFR include the removal of selected pine plantations, removal of trees and shrubs scattered within prairies and along fencelines and roadways, removal of abandoned fence posts, and implementation of a biennial prescribed burning program during spring or summer. These management practices should contribute toward restoring a more natural dry prairie landscape and improving habitat quality for Florida Grasshopper Sparrows at Avon Park AFR, and may perhaps lessen the likelihood of extirpation. On the other hand, the continuance of cattle grazing—especially during the sparrow nesting season—and an increase in planned military activities (including Navy air-to-ground training using live ordnance, and Joint Integrated Firing Exercises) beginning in 2006 may adversely affect sparrows at Avon Park AFR and may inhibit monitoring and research activities.

Habitat improvement practices across the range of Florida Grasshopper Sparrows should begin with the reestablishment of large, treeless expanses of dry prairie with a configuration to minimize edge, and implementation of an aggressive program of prescribed burning during late spring or summer. At Kissimmee Prairie Preserve (primarily the former Kissimmee Prairie Sanctuary), removal of 158 km of ditches and agricultural dikes restored or enhanced 2136 ha of uplands (P. Gray, unpublished ms). Roller-chopping and burning of prairies overgrown with wax myrtles (*Myrica cerifera*) and other shrubs restored habitat at Kissimmee Prairie Preserve (P. Gray pers. comm.), Myakka River State Park (Fitzgerald and Tanner 1992), and Three Lakes WMA (Delany et al. 2005).

We recommend that monitoring efforts at all public sites that support Florida Grasshopper Sparrows be continued to evaluate population trends. We also recommend a change in the way that point-count data are presented. Currently, the number of singing males detected during point-count surveys is doubled, and the number of unknown-sex individuals is added to this total, following Walsh et al. (1995). The Walsh et al. (1995) method is based on the unfounded assumption of a 1:1 sex ratio of adult sparrows and tells us little about the actual numbers of sparrows. Additionally, the Walsh et al. (1995) method ignores detection probabilities and does not produce estimates of precision for these numbers. Sparrow researchers at Kissimmee Prairie Preserve incorporated distance sampling into their annual survey methodology in 2005 to enable the estimation of detection probability (P. Miller pers. comm.).

In summary, the Florida Grasshopper Sparrow is an endangered species that continues to decline in range and numbers. Several management options need to be implemented to prevent further declines and perhaps even extinction. Among these options are public acquisition of all remaining privately-owned dry prairie, examining the possibility of restoring pastures back into prairie, implementation or continuance of a 1-2 year burning regime primarily during late spring or summer, and further research into translocating sparrows into unoccupied sites. At the present time, there is no need for a captive-breeding program to increase sparrow numbers.

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