RESTORATION OF GRASSLAND BIRDS AT THE CHESTER RIVER FIELD RESEARCH CENTER
I. THE GRASSHOPPER SPARROW (*Ammodramus savannarum*)

A SUMMARY REPORT FOR 2002

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INTRODUCTION

The Chester River Field Research Center (CRFRC) is a research station located on the property of Grasslands Plantation, Inc. (formerly Chino Farms, Inc.) east of Chestertown, MD. The CRFRC is designed as a practical laboratory for research and training in field ecology and conservation sciences. In March 1999 a 228-acre block of land was taken out of row-crop production, was redesigned as a restoration experiment, and planted with mixtures of nine species of native perennial bunch grasses. This block was enrolled in the Conservation Reserve Program (CRP), a national program of the U.S. Department of Agriculture (USDA) designed to remove marginal agricultural lands from production in order to reduce soil erosion and chemical runoff into aquatic ecosystems and to improve wildlife habitat.

The experimental 228-acre block was divided into 12 fields averaging 20 acres each (range: 3.5 - 32.4 acres). Each field was planted with a mixture of three species of grass and separated from the other fields by firebreaks planted in clover and other species (Fig. 1). Five different mixtures of grasses (3 species in each) were the experimental treatments, and two replicate fields were assigned to each treatment (Fields 1-10). Eight of the nine species of grass planted in these fields were native warm-season grasses (Table 1). This block represents the largest contiguous stretch of warm-season grasslands on the Eastern Shore of Maryland. Management protocols to maintain the non-woody characteristics of the prairie include prescribed fires on one-third of the grasslands on a three-yr rotation.

The goal of the ornithological studies at the CRFRC has been to document the bird use of these experimental grassland fields and to conduct long-term ecological research on grassland birds. Grassland birds have received national attention due to their alarming rates of population decline.

The Grasshopper Sparrow, *Ammodramus savannarum*, a species of Special Concern or listed as Threatened in many of the states along the East Coast, colonized the experimental grasslands from the outset. Within the first year of the project at least 90 Grasshopper Sparrow were present in the grasslands. Three years after the grasslands were planted, 288 adult Grasshopper Sparrow had been captured and banded. The Dickcissel, a species of Special Concern in Maryland (MD DNR 2001), has bred successfully in the grasslands since 2000. Other grassland bird species that have been targeted for conservation in the experimental grasslands include Northern Bobwhite, Upland Sandpiper, Short-eared Owl, Horned Lark, Bobolink, Eastern Meadowlark, Vesper Sparrow, Field Sparrow, Savannah Sparrow, and Henslow's Sparrow.

In the 2002 field season, we continued our research on bird ecology of the grassland fields and expanded to other areas of the Chino Farms property. In particular, research was initiated in several fields under agricultural production and in some riparian buffer strips. The ornithological studies at the CRFRC in 2002 were focused on:

the population biology and ecology of Grasshopper Sparrows and Dickcissels.
the use of the grassland fields by Northern Bobwhite Quail.
the abundance of other bird species that have colonized or otherwise use the grasslands.
the function and behavioral significance of the vocalizations of Grasshopper Sparrows.

The following report summarizes the ornithological data that was collected at the CRFRC during the 2002 field season and synthesizes the major ornithological findings at the CRFRC in the first four years of study.

VEGETATION AND CLIMATE

From fields that had been cultivated in corn, soybeans and wheat for 50 years, the CRFRC grasslands established quickly into a vegetatively diverse ecosystem with the first couple years of the experiment, but they have required management protocols to maintain a non-woody characteristic. The herbicide Round-Up was applied extensively in 1999 and less in 2000 to suppress weeds in order to allow the warm season grasses to establish. The planted warm season grasses and forbs grew vigorously in the first two years, and reached heights of two meters or more by the end of 2000. Management protocols involving a 3-yr rotation of prescribed fires on one-third of the grasslands were activated in late winter 2001. Replicate fields 1 and 6, and 4 and 8 were burned on March 26 2001, removing all standing dead vegetation, fallen thatch, and duff, and leaving an ash covered, exposed dirt ground. By the end of that growing season, the tall warm season grass species Big Bluestem, *Andropogon gerardii*, Indian Grass, *Sorghastrum nutans*, and especially Switch Grass, *Panicum virgatum*, re-sprouted multiple culms from undamaged root bases, and were again 2 m tall by September. In late winter 2002 replicate fields 3 and 5 and replicates 9 and 10 were burned, and re-grew into thick, diverse grasslands by the end of summer. Fields 2 and 7, and 11 and 12 have had four years of growth, were decidedly rank with thick mats of thatch on the ground throughout the summer of 2002. The rotation of prescribed fires in one-third of the grasslands each year since 2001 has set up a mosaic of structural contrasting habitats across the experimental grasslands.

The summer 1999 in Maryland set century records for extreme heat and prolonged drought. While forbs and cool-season grasses (both native and exotic, annual and perennial) wilted and browned by the end of July and throughout August and September, the installed warm-season grasses persisted, grew, and many even matured by season end. The summer 2000 was the diametrically the opposite of 1999 – it set century records for cool temperatures and rain. One extremely heavy thunderstorm in July brought out the reclusive spadefoot toads, *Scaphiopus holbrooki*. Vegetation flourished in 2000, the heights of the tallest warm-season grasses reached 2m, and all went to seed by mid August. The weather of summer of 2001 was average in all respects. The summer 2002 eclipsed the records of 1999 and set new records of extremely high temperatures and prolonged drought. The vegetation wilted and browned by mid July and conditioned seemed severely stressful on vegetation and animals alike.

BACKGROUND ON GRASSHOPPER SPARROWS

Grasshopper Sparrows are native to dry grasslands throughout North, Central, and northern South America, including East Atlantic Coast prairies. It is thought that they became more common in Maryland as a result of the clearing of forests by European settlers in the 1600s and 1700s (Smith 1968). Since then, the presence of Grasshopper Sparrow in Maryland has depended largely on human disturbance. In recent decades, the Grasshopper Sparrow has experienced significant population decline because of the loss of grassland habitat to agriculture and development. Breeding Bird Survey (BBS) data from 1966 through 1989 show an average annual decline of 6.7% in Maryland populations of Grasshopper Sparrow (Holmes 1996).

Grasshopper Sparrow breed in habitat that contains a combination of grasses, forbs, and bare ground. They require vegetation of about 0.3 meters in height and at least 24% bare, litter free ground (Whitmore 1979). The female builds a nest on the ground, sometimes in shallow scrapes, but often nestled at the base of a grass clump, and well hidden by live or dead vegetation. Sometimes domed at the back, the nest is a shallow cup of dried grasses lined with rootlets and fine grasses. Grasshopper Sparrow lay an average clutch size of four eggs. Female Grasshopper Sparrow incubate eggs for approximately 11-12 d, and the nestling period is an additional 10 d.

Grasshopper Sparrows produce several types of vocalizations. Two calls, the "chip" and "trill," are produced by both sexes and are reported (Vickery 1996) to be common throughout the breeding season. Possibly unique among the family Emberizidae, male Grasshopper Sparrows also produce two distinct types of advertising song, the "buzz" ("primary song" of Vickery 1996) and the "warble" ("sustained song" of Vickery 1996). Both of these songs are pitched at extraordinarily high frequencies: buzz song = 7-9 kHz (centered at 8 kHz), warble song = 6-8 kHz (centered at 7 kHz). It is not known whether there are functional differences between the two song types of Grasshopper Sparrow and little is known about variation in song characteristics within and among populations of Grasshopper Sparrow.

METHODS

BIRD BANDING

Grassland birds were caught using fourteen, 12 m long Japanese mist nets. Each net was suspended from two 8-foot tall, hollow, aluminum poles placed over 3-foot high rebars that were temporarily pounded into the ground at strategic locations. Mist nets were effective even when fully exposed in open fields; no additional baits (food, tape-recordings, etc.) were necessary. In 1999, 2000, and 2001 nets were opened by the first week of June; in 2002 the nets were opened in the first week of May. Nets were opened at least three days a week at sunrise, and kept open for the entirety of the morning or until conditions were undesirable for netting (e.g. excessive heat or wind). The fourteen mist nets were left in a configuration for approximately two hours, moved to new locations in a field three times per day, and systematically marched across each field in a couple days. All fields were sampled at least once each season. Early in the season breeding birds were already color-banded (returning adults from previous years), marked with only a federal band (likely a bird banded as a HY in a previous year), or unbanded (new recruit of unknown origin). Nets were placed often and deliberately in areas where unbanded or federal-band-only Grasshopper Sparrows had been seen in order to reach the goal of marking all breeding adults.

Every bird caught was banded on the left leg with a U.S. Fish and Wildlife Service (USFWS) serial numbered, aluminum band. Adult Grasshopper Sparrows and Dickcissels were banded with a unique color code combination using Hughes Solid Color Celluloid bands. Two color bands were placed on the right leg, and a third color band was placed above the USFWS band on the left leg. Eleven different color bands were used and designated by a single letter: Blue (B), Flamingo Pink (F), Green (G), Black (K), Mauve (M), Orange (O), Hot Pink (P), Red (R), Turquoise (T), White (W), and Yellow (Y). Individual identification of color-banded birds was usually no problem when viewed with high quality, chromatically accurate spotting telescopes. Old faded F, O, and W bands were troublesome to distinguish from one another at a distance. We routinely replaced such discolored bands as needed, and we replaced all bands after two years because most plastic bands became brittle.

Because unbanded Grasshopper Sparrows were sexually indistinguishable in the field, we adopted a color band code to identify the sex of individuals at a distance. In the hand breeding males were identified by the enlarged cloacal protuberance and breeding females were identified by the presence of a brood patch. Color bands placed above the USFWS on the left leg denoted the sex of individuals: B, T, and Y bands on the left leg were used to designate males, while P and F bands on the left leg were used on females.

The year in which most adult male Grasshopper Sparrows were banded was also denoted, not infallibly, by the color of the upper left band: all males in 1999 received a B band, most males in 2001 received a Y, and in 2002 most males received a T band. In 2000 a mixture of B, Y, and T bands was used for males before the possibility of regularity in year codes was realized. As desirable band colors or combinations became unavailable, some year codes were broken, but individual bird color-banded identities have been nonetheless rigorous. Because fewer adult

females were captured that males, no distinctive year codes were developed for females: most females received a P band, some received an F band on the left leg.

Hatch Year (HY) birds (juvenile birds in their first year) were given only a USFWS band because the sex of HYs cannot be determined in the first year. If a HY from a previous year was recovered as an adult, it was given a male or a female color code along with other individual distinctive band combinations. Locals (= nestlings) were also banded in any active nest that was found. In 2000 an effort was made to color code siblings from each of 18 nests, but that effort was abandoned due to impracticality and limited color combinations.

Measurements of wing chord, fat, and weight were taken for all captured birds. Additionally, tail length, bill length, and the length of yellow in the supercillium were measured for Grasshopper Sparrows. Because HY Grasshopper Sparrows do not have their adult plumage, only weight, wing chord, and fat were recorded. The precise location of every captured Grasshopper Sparrow or Dickcissel was recorded as a GPS (Global Positioning System) waypoint using a Garmin GPS 12XL hand-held unit.

Through our banding program we have successfully color-banded nearly all of the adult Grasshopper Sparrows and Dickcissels in the fields. Our success has allowed us to monitor the dynamics and spatial structure of these populations at the individual and population levels.

CENSUSING

Focused on locating all breeding Grasshopper Sparrows and Dickcissels, the primary method of censusing the fields was to walk transects in each of the twelve fields and record which individual birds were seen. Transects were approximately 75 m apart and spanned the entire length of the field. The number of transects walked in each field depended on the size of the field. Each transect was walked twice a month between 6:00 AM and 10:00 AM. Whenever possible, two people walked concurrently along consecutive transects to ensure that the greatest number of birds were seen. GPS waypoints were taken where banded Grasshopper Sparrows and Dickcissels were seen. A flush and follow method (see Wiens 1969) was used in order to get several waypoints for each bird. A second method of censusing was to take GPS waypoints opportunistically as individual birds were seen in the fields. Given that several studies were being carried out in the fields throughout the breeding season, many people clicked such waypoints of color-banded Grasshopper Sparrows.

In July 2002 censuses of Grasshopper Sparrow were initiated in several agricultural fields as well as some riparian buffer zones at Chino Farms. Teams of field assistants walked the perimeter of several fields and buffer zones and recorded the number of males seen or heard. GPS waypoints were taken at all locations where color-banded Grasshopper Sparrows were found.

TERRITORY MAPPING

Males singing predictably on perches or displaying agonistic or courtship behaviors at a location were considered “on territory”. Territories were counted if there were at least three waypoints for a displaying male. Although useful for demographic data and movement records of individuals, fewer than three waypoints at a location eliminated transient or unpredictable

appearances by males. Maps of male Grasshopper Sparrow and Dickcissel territories were constructed on a computer using ArcView GIS 3.2. The area of a territory was defined geometrically as a polygon created by connecting waypoints that had been collected for each individual male. If more than three waypoints had been collected for a male, it was assumed that the outermost points represented the boundary of a male's territory. Calculations of territory size were restricted to those polygons for which at least eight waypoints were recorded, in order to eliminate an obvious bias against the artificially small territories defined by fewer waypoints (Figure 2). The number of territories in a field was all those polygons for which at least 80% of the polygon fell within the borders of that field.

NEST ECOLOGY STUDIES

Finding as many nests as possible, for as many species as possible, in the experimental grasslands was a priority. Most nests were found accidentally by flushing a female off the nest while we walked through the fields for other activities (moving mist nets, recording songs, etc.). In some areas where probable nesting behavior was observed, teams of people walked side by side in order to flush a nesting bird. Some nests were found by tracking a female observed carrying food to nestlings.

Once a nest was located it was checked approximately every three days to monitor its progress. Nestlings were banded at different ages depending on the species. All nestlings were banded according to the recommendations of Pyle (1997). Nestling Grasshopper Sparrow were banded between four and seven days of age to ensure that bands were placed on legs strong enough to carry bands and before the birds fledged.

The vegetation around all Grasshopper Sparrow nests was studied according to similar protocols in all four years. Aspect (the compass orientation) of the nest entrance, nest material, GPS location of nest, and the percent of the nest visible from directly above were noted. In addition, the vegetation above, closest to, and surrounding the nest within 1 m and 5 m of the nest was assessed: plant species were identified, and their percent cover, the percent total live cover, duff, and bare ground were estimated. In 2002 height measurements above the nest and on two sides of the nest were taken at 1, 3, and 5 m intervals from the nest along a 10 m transect, with the nest at the center of the transect. A random-numbers table generated numbers between from 0 and 360 to determine direction of the vegetation-height transect.

VOCALIZATION STUDIES

B. Lohr directed a study to determine the functional significance of the structure, the high frequency characteristics, and the dual advertising songs of Grasshopper Sparrows. All birds observed singing proved to be males; we have no observations of females singing either “buzz” or “warble” songs. Several hundred vocalizations were recorded from nearly 70 individuals on the CRFRC Grasslands in 2001 and 2002, and from a dozen males on the Arapaho Prairie, Arthur County, Nebraska in July 2002. The recordings were made with Sennheiser ME67 shotgun microphones on either Sony TC-D5M or Sony TCM – 5000EV analog tape decks. The structure and variation of the songs were analyzed in the laboratory, and computer-generated facsimiles of the two song types were synthesized using averages of song features from the

CRFRC population. The synthetic songs appeared realistic as viewed on sonograms (Figure 3), but they needed to be tested for functional effectiveness with live birds in a natural setting. Song variation was compared within and across years from known, marked individuals using the SIGNAL / RTSD digital signal analysis software; the synthetic songs were generated also by SIGNAL. The results of the analysis of Grasshopper Sparrow song variation will be reported elsewhere (Lohr and Gill, in preparation).

Preliminary, controlled playback tests were performed with male Grasshopper Sparrows active on territory at CRFRC during the 2002 season. The goal of these playbacks was to test the functional realism of the *synthetic* "buzz" and "warble" songs in comparison to *natural* "buzz" and "warble" songs and control "noise" broadcasts. The experimental design called for two sets of twelve replicate males, one set comparing the responses to the synthetic "buzz" song and natural "buzz" song, and the other set comparing synthetic and natural "warble" songs. Control broadcasts coupled to these songs were either "white" noise or a heterospecific advertising song of a Dickcissel. Each bird was subject to two test sessions, each session lasting one-half hour.

A test session consisted of a test song (e.g. synthetic "buzz") played at a rate of 10 songs / min for one minute, the behavioral response of the subject bird recorded for the next ten minutes, the second song (e.g. a control broadcast) played for one minute, the bird's response observed for next ten minutes. The order of the control broadcast and the test song was randomized across sessions and birds. One week later the second session with the alternative test song (say natural "buzz") with its control was conducted. The intervening week of "rest" was intended to minimize artifacts of unwanted habituation to the experimental conditions (speakers, human activity, machine noise, etc.

Sessions were played back to territorial males from a Sony TCM – 5000EV recorder to a custom-built directional speaker situated within the edge of a subject's known territory. Observations were dictated onto a Sony TC-D5M recorder using a Sennheiser ME67 microphone and later transcribed. The response behaviors of interest included: number of songs sung in response to the playback, latency to sing, closest approach to the speaker, number of flights/movements around the speaker, and the amount of time spent within 12 m of the speaker. The incidence, frequency, and intensity of singing by neighboring and distant territorial males was carefully noted in order to control for unwanted interference to the experimental conditions. To our knowledge this is the first experimental study of song variation in Grasshopper Sparrows (or indeed, for any *Ammodramus* sparrow).

RESULTS

GRASSHOPPER SPARROWS

Population Biology

Grasshopper Sparrows colonized the experimental grasslands in late April 1999, only one month after the experimental planting in late March 1999. Although the seeds were installed by a no-till, drill method, the warm-season grasses had not yet emerged by the time the Grasshopper Sparrows had arrived, and the fields had the appearance of dreary, abandoned corn and soybean fields in late winter. The Grasshopper Sparrows bred successfully in that first year, and have sustained a large breeding population every year since (Figure 4). The largest population was recorded in 2001, when at least 288 adult Grasshopper Sparrows were recorded. The total number of Grasshopper Sparrows in all categories (except for the number of locals) decreased in 2002 relative to the high in 2001. To the degree we have missed capturing some adults, the actual numbers may be higher.

To date, none of our 836 banded Grasshopper Sparrows has been recovered by distant banding stations, nor have we recovered any birds initially handled by non-CRFRC banders. Thus, our population studies of Grasshoppers are locally defined to CRFRC, and our recovery of our banded birds gives us our best estimate of the survival rates in this population. As the banding program progressed, increasing numbers of birds were captured and more birds previously banded at CRFRC returned in subsequent breeding seasons (Figure 5). The number and percentage of returning males were consistently higher, essentially twice that of returning females (Figure 6).

The survival rate of both adult sexes was highest from 2000 to 2001 (Table 2). The highest annual rate of recovery was among the 1999 mixed age cohort of adult males, when 82.6% of those adult males that were seen in 2000 were re-sighted in 2001. At least 20% of the original 50 1999 males were still alive in 2002 and were therefore at least four years old (Figure 7, Table 2). Nearly 62% of males breeding in 2000 were known to be alive in 2001, and 39.7% of those were seen again in 2002. Adult females were rarely observed because they, unlike territorial males, seldom perched visibly on vegetation. They were seen when flushed unexpectedly from the fields, while foraging in the clover fire-breaks and airstrip, or when captured in mist nets. The highest annual survival rate of adult females was among the 2000 cohort, when 40% of those that were known alive in 2001 were re-sighted in 2002. Of all adult females seen in 2000 31.7% were seen one year later and 12.6% were seen two years later (Figure 8).

Only twelve individuals have records with a “no-show” gap of one or two years. Records of “skipping” years exist for only the cohorts of 1999 and 2000 adults. No 1999 female has a gap in her record, but eight 1999 males do: four males were not recorded in 2000 but were seen in 2001, and four other males “skipped “ both 2000 and 2001 and were recovered in 2002. No 2000 males has a gap in its record yet, but four 2000 females “skipped” 2001 and were seen again in 2002. While it possible these birds were actually elsewhere, not on CRFRC property, it is more likely they were present on the grasslands but simply not intercepted in the “skipped” year. We do know they were not dead in the missing year, and their recovery elevated the estimate of known survivors.

The recapture of banded nestlings and hatchlings provided estimates of age-specific survivorship (l_x) of known aged cohorts. Even though mist nets were running constantly, we failed to recapture any of the 21 1999 HY Grasshopper Sparrows after they were first banded, not even later in their hatch year. In contrast, the return rates of 2000 and 2001 HYs in the following year, however, were a remarkable 16% and 14%, respectively. Thus, age-specific survivorship (l_1) from birth year to first year was 0.18 for the 2000 cohort and 0.15 for the 2001 cohort, averaging 0.17 (Figure 9). Only the 2000 cohort of HYs provided an unbiased estimate of l_2 (the probability of surviving from birth year to age 2), which was 0.116. Hence, the graduation probability from age 1 to age 2 for the 2000 cohort of HY Grasshopper Sparrow was 62.5%. If we assume a similar graduation probability from age 2 to age 3, l_3 for the CRFRC population is extrapolated to be 0.073, and similarly, l_4 is extrapolated to be 0.045.

Censuses of Grasshopper Sparrow were conducted in six crop fields at Chino Farms (four with soybeans and two with corn) in July 2002. An estimated 45 male Grasshopper Sparrow were heard or seen singing from the soybean fields and none were recorded in the corn fields. Four banded males were found holding territories in a soybean field (called Field G) approximately 0.5 - 1 km away from the grassland fields. Two of these were originally banded as HYs in 2001, one was banded as an adult male in 2001, and one was banded as an adult male in the experimental grasslands in June 2002. This is the first time that birds banded in the experimental grassland fields have been sighted in locations outside the CRFRC fields. In many cases, Grasshopper Sparrow were also observed singing from perches in the riparian buffer strips planted with warm season grasses on the perimeter of the fields. This is the first evidence collected by the CRFRC that Grasshopper Sparrow are using and establishing territories in active cropland and riparian buffer strips.

Timing and Distribution

CRFRC Grasshopper Sparrows are migratory, arriving regularly on the Grasslands in the third or fourth week of April, and disappearing by mid September. The wintering range and non-breeding ecology of the CRFRC Grasshopper Sparrows are unknown. Each year numerous male Grasshopper Sparrows appeared suddenly in the fields in late April, singing from old stalks of Mares-tail, *Conyza canadensis*, Pokeberry, *Phytolacca americana*, or any other perch that protruded above the prevailing canopy and began establishing territories right away. In the 2001 and 2002 most of the first-arriving males were returning color-banded birds. The first adult females in 2001 were mist-netted at the end of May, nearly four weeks after the first males were observed and netted. In effort to discover whether breeding females were present as early as singing males, numerous mist-nets were erected in April 2002 along both sides of the grassy airstrip (an area of short, cold-season grasses that traditionally has high numbers of Grasshopper Sparrows and where the first female had been seen in 2001). Whereas the first males were heard, seen, and captured on 18 April and regularly thereafter, the first females (two) were captured on 4 May 2002. Our data so far indicate that female Grasshopper Sparrows arrive on their breeding grounds about three weeks after males do.

Prescribed fires had some effect on the early Spring re-colonization of the experimental fields by breeding Grasshopper Sparrows. In April of both 2001 and 2002, singing male Grasshopper Sparrows were noticeably absent from the fields that had received a prescribed burn a few weeks earlier (2001: Fields 1 & 6 and 4 & 8; 2002: Fields 3 & 5 and 9 & 10) but were conspicuous in

the fields with standing vegetation (2001: Fields 2,3,5,7,9,10,11,12; 2002: Fields 1,2,north 4,6,7, 11,12). As the clumps of warm season grasses and pokeberry grew and above-ground perches emerged in the burned fields in May, singing Grasshopper Sparrows appeared in increasing numbers. By June and July territories were widespread across the grasslands. Over the course of the 2002 breeding season at least 79 male territories were identified in the grassland fields (Figure 10).

Census data collected in the 2002 field season show that male Grasshopper Sparrows were unevenly distributed throughout the fields (Table 4). Field 3 had the most male sightings and Field 8 had the least. Fields 2-6 contained the majority of male Grasshopper Sparrow. All of Field 8 and the southern half of Field 4 were essentially impenetrable monocultures of Switch Grass and had no Grasshopper Sparrow territories. Field 7 was a popular field for Grasshopper Sparrows in 1999, 2000, and 2001, but had only two territories in 2002. All of the territories in Fields 9 and 10 tended to be to the north by the airstrip. Field 4 had a comparatively large number of territories, but they were all located near the edges of the field. Overall, there appeared to be an edge effect, in that a large number of the territories in 2002 were located near the roads between the fields. Fields 5 and 6 had the highest values for territories per acre while fields 8 and 11 had no territories (Table 4).

From 2000-2002 territories were identified for 131 different adult males; 69 territories met the criteria in 2002. Most males held one territory, in one location, per breeding season. Nine individuals appeared to have changed the location of the territories they had established early in one breeding season and re-established a territory somewhere else later in the season. Of the 20 males for which territories were found in 2000, eight returned to hold territories in 2001. Of the 66 males for which territories were found in 2001, 28 returned to establish territories in 2002. At least four males held territories in all three years. Fields 3, 4, and 6 had the most territories while fields 8, 9, 10 have consistently had few territories (Figure 11). The territories tended to be near the roads/firebreaks. Several territories were present in field 7 in 2000, but by 2002 only 2 birds established territories there. The territories in Field 4 have tended to be in the north side of the field near the airstrip.

Habitat Characteristics

One major goal of the CRFRC research program was to determine the relative attractiveness of the five alternative plantings to grassland birds. Despite the fact that the general vegetation characteristics varied among the 12 experimental fields, an analysis of the variation in Grasshopper Sparrow territory abundance and vegetation structure fields in July 2002 (Table 4, see Vegetation Report 2002 for details of methods) has not yet revealed statistically significant differences in bird usage of the fields. Fields 5 and 6 had the two highest values of territories/acre, and were below average in height of warm season grasses and percent of live vegetation. Field 8, which had the highest value for height of warm season grasses and the highest percentage of warm season grasses had no territories. Field 7, which had just .06 territories/acre had above average percent cover of warm season grasses and below average percent cover of bare ground. None of the trends of declining number of territories/acre with grass height and percent cover of live vegetation or the increasing percent cover of bare ground were statistically significant. There was no significant correlation between the amount of duff in the fields and territories per acre. Territory size also did not correlate significantly with vegetation characteristics of the fields or by field size.

Nest Ecology

Over the first four years of study at the CRFRC, 76 Grasshopper Sparrow nests were located (Figure 12). The most nests found in any one year was 30, found in 2000. Assuming the average length of use of a nest was 21 days, we calculated a daily probability of nest survival in 1999 as 0.932, and the probability of nest survival to fledging was estimated to be 0.228 (see Dodge et al. 2000). In 2000 for 30 nests we calculated a daily probability of survival of 0.981 and a 66.8% chance of survival to fledging. By pooling the data for the two years, we observed 39 nests for a total 367 nest-days with 10 failures. This converts to a daily probability of nest survival of .973 and a probability of nest survival to fledging of 56.3%. Of the seventeen nests found in 2002 for which the fate is known, 59% successfully fledged young. The percent of successful nests over all four years was 62.7%. A nest with three eggs was found on August 27, 1999 and fledged two young on September 10. This nest set a new record for the late egg date for Grasshopper Sparrow in Maryland.

Grasshopper Sparrows nests (as well as territories) were concentrated in the central regions of the CRFRC grasslands, not around the perimeter or within 50 m of the wooded or hedgerow borders (Figure 13). All fields have had Grasshopper Sparrow nests and no pattern of preference for some experimental fields over others is yet apparent or statistically significant. Trends are emerging: as the density and height of Switch Grass in Fields 8 and the southern ¾ of Field 4 have increased, Grasshopper Sparrows activity and nesting have decreased. The absence of nests in Fields 9 and 10 is mostly an artifact of inadequate censusing in 1999 and 2000, but also the thick mats of Trumpet-Creeper (*Campsis radicans*) and Multiflora Rose.

Studies of the vegetation surrounding nests have been ongoing since 2000. On average 24.3% (n=48) of a nest was visible from directly above and 56% of the nests were facing in a northerly direction (n=46). Within 1 m of the nests (n=48) the average amount of bare ground, duff, and live vegetation were 36%, 33%, and 31% respectively. Average vegetation height above the nests (n=15) was 45 cm and the average height within 5 m of the nests (n=15) was 45.9 cm. There was no apparent correlation between vegetation height and distance from the nest.

Vocalizations

The Grasshopper Sparrow “chip” call was a common sound in the CRFRC grasslands, was associated mostly with females in nesting behavior. When incubating females were accidentally flushed from their nests, they routinely and incessantly chipped while moving conspicuously through the vegetation in the presence of the observer. Such chipping behavior was more intense when nests had nestlings and as females approached nests carrying food. Territorial males rarely chipped when nests had eggs, but they and the females chipped excitedly when observers approached nests with nestlings and areas with fledged young. The “trill” call described by Vickery (1996) was heard infrequently on the CRFRC grasslands, so rarely that no ecological or behavioral context can be inferred yet.

Territorial male Grasshopper Sparrows responded as vigorously to the computer-generated synthetic songs as they did to playbacks of naturals songs. In contrast to the lack of response to the controls, both natural and synthetic songs evoked a suite of behaviors: agitated approaches to

the speakers during playback, and prolonged advertising singing by the test subject male after the 1 m playback terminated.

DICKCISSEL

The Dickcissel is listed as a species of Special Concern in the State of Maryland (Maryland Department of Natural Resources 2001). Dickcissels were recorded for the first time at the CRFRC in the summer of 2000 and have returned every year since.

Sixteen individuals and five nests were found in 2000. Nesting activity (i.e. females defensively chipping and carrying food to fledglings) was observed in three other instances, indicating at least eight nesting attempts in that year. In 2001, only three Dickcissels were found in the fields and one nest was found. In 2002, six adult Dickcissels were seen in the study fields and no nests were found. Of the six adults, four were males and two were females. At least three males set up territories in the fields and all seemed to be concentrated at the east end of the grassland fields. While no nests were found in 2002, a female Dickcissel with a brood patch and possibly carrying an egg was captured in June. We interpret this as evidence that Dickcissels did breed at the CRFRC for the third year in a row.

Of special interest was the return for the third year in a row of a male Dickcissel color banded PPYX. According to Chandler Robbins of the U.S. Geological Survey Biological Resources Division and founder of the Breeding Bird Survey, this bird is the first record of a returning Dickcissel in Maryland. A successful nest was attributed to this male in 2001.

NORTHERN BOBWHITE

Northern Bobwhite quail have increased dramatically in the experimental grasslands in all four years of the study. Prior to the installation of the experimental grasslands, only two or three coveys were present (H. Davis, personal communication). In a census on 11 July 2001 at least 24 different calling males were recorded. In a similar census on June 11, 2002 at least 11 different adults were either seen of heard in a two-hour period before sunset. Five quail coveys and two nests have been observed in the fields to date. There were at least 10 fledglings in each of the 2002 coveys. The nest found in 2002 contained 16 empty egg shells. As there was no sign of predation, we presume that all of these nestlings fledged.

OTHER BIRDS USING THE EXPERIMENTAL GRASSLANDS

Through our extensive banding operation we have gathered valuable information on the birds present in the experimental grassland fields. Nearly 2,000 birds have been banded at the CRFRC in the first four years of study (Table 6). The majority of banding was conducted during the summer months between May and August. The most common species have been Grasshopper Sparrow, Field Sparrows, Red-winged Blackbirds, and Indigo Buntings. Field Sparrow activity (e.g. singing from border trees) was concentrated on the periphery of the experimental grasslands in 1999 and 2000. With the increasing maturity and density of vegetation of the grasslands in 2001 and 2002, Field Sparrows were increasingly prominent (territories and nests) in the central areas of unburned fields (2 and 7. In 2002 37 adult males, 33 adult females, and 66 HY Field Sparrows were banded in May through August.

Of particular interest are the grassland birds that have been seen in the experimental fields. These include Vesper Sparrows, Horned Larks, Eastern Meadowlarks, Upland Sandpipers, and Short-eared Owl. Pairs of Vesper Sparrows in breeding condition were captured in each of the first two years, and at least five were observed in the fields in 2000. Five Horned Larks were banded in the first two years and three were seen in the fields in July 2002. Eastern Meadowlarks have been seen in the fields in migration and winter, but inexplicably have not bred in the fields to date. A flock of 13 Upland Sandpipers were observed in the fields in 1999. A Short-eared Owl was seen hunting in the fields in the middle of November 2002.

Nine species of birds have been confirmed as breeding in the CRFRC experimental grasslands (Table 7). The most nests (76) have been found for Grasshopper Sparrow. Horned Lark and Killdeer nests were found in 1999 but no nests for these species have been found since. Only Grasshopper Sparrow, Field Sparrows, and Red-winged Blackbirds have built nests cup nests suspended in clumps of grass. All of the Blue Grosbeak and Dickcissel nests were found in small bushes or invasive tree saplings. The one Orchard Oriole nest found in 2002 was located in a group of trees in Field 1. Although not nesting in the fields American Crows were heard or seen daily throughout the year, and were suspected nest predators of grassland nesting birds.

In August of each year large flocks (up one or two thousand) of migrant Bank, Tree, Barn, and Rough-winged Swallows appear and actively feed on insects over the prairie grasslands. Bobolinks have not yet been found nesting in the fields, but several hundred of them were seen using the fields during fall migration. Also, by the end of August mixed flocks of hundreds of Brown-headed Cowbirds, Grackles, and Red-winged Blackbirds were seen feeding in the fields. Popular feeding spots were the sorghum crops planted in Fields 9, 10, and 12.

The fields at the CRFRC have attracted a diversity of wintering birds. From October to early May Savannah Sparrows feed in large numbers in the fire-breaks and the turned-soil margins of those fields subject to prescribed fires. To our knowledge Savannah Sparrows have not bred at the CRFRC and all appear to be migrants and winter residents. Song Sparrows and White-throated Sparrows were abundant feeding along the edges of fields (e.g. north edge of fields 1, 2, and 3) that have thicket and forest borders. Each winter of the present century several Northern Harriers, including at least one adult male, adult females, and juvenile have been observed scouting or sitting in the fields.

DISCUSSION

The increase in the recorded numbers of Grasshopper Sparrows during the first two years of the experimental restoration was in part due to improved technique of censusing, especially a more systematic mist-netting regimen. In 1999 priority was placed on simply developing the techniques and protocols of capturing open country birds and sampling /measuring vegetation. By 2001 and 2002 our methods were systematic. The increase in numbers from 2000 to 2001 is best interpreted as a genuine increase in population size of the birds themselves.

Because the field techniques were stabilized by 2001, the decline in Grasshopper Sparrow abundance from 2001 to 2002 in the experimental grasslands must have been attributable to other factors, including change (maturity) in the prairie vegetation and ecology, climate, and feeding conditions. In 2002 territorial male Grasshopper Sparrows were absent or scarce in several fields where they had been present in the previous years. Most notable were Fields 8 and the southern ¾ of Field 4, both of which were dense, nearly impenetrable stands of 2 m tall Switch Grass. Grasshopper Sparrows held territories in Field 4 only in the northern pockets of open ground and decimeter-high vegetation. Despite the fact that Field 7 is the largest of the experimental fields (32.4 acres) and had the highest floristic diversity, the number of territories in Field 7 dropped from seven in 2000 to only two in 2002. We interpret that drop in popularity by Grasshopper Sparrows to the mature, rank, tall stature of the vegetation, the thick thatch of duff, and the lack of open bare dirt on the ground. Mature tall-grass prairies with rich species diversity may be attractive to conservation biologists but they are not to Grasshopper Sparrows.

The severe drought in 2002 may have also contributed directly to the decrease of Grasshopper Sparrows by causing a collapse in the insect community. We do not have quantitative samples of insect abundance, rather only anecdotal field notes. In July and August 2001 acridid grasshoppers were extremely abundant in the experimental grasslands, especially in the clover fire-breaks. In contrast, as the drought of 2002 progressed, the field team observed very few grasshoppers or other insects in the last half of summer. Since the summer diet of the Grasshopper Sparrow consists of about 60% insects (Martin et al. 1951, as cited in Holmes 1996), the lack of insects in the grassland fields may have been a limiting factor in 2002. The fact that we encountered many male Grasshopper Sparrows, including several that that had been on territory in May and June in the grasslands, in adjacent soybean fields in July and August, soon after the barley was harvested and the soybeans were planted, supports this hypothesis.

The higher rates of survival from 2000 to 2001 relative to the previous 1999 – 2000 winter and the subsequent 2001-2002 winter also corresponds to the climate changes. Our poor catch and within-season recapture of HY Grasshopper Sparrows in hot, dry 2002 was strikingly lower than in the two previous cool, wet years, and reminiscent of our poor catch of HY Grasshopper in the hot, dry summer of 1999. We surmise that poor feeding conditions either impelled the young Grasshopper Sparrows to disperse out of the CRFRC grasslands, or caused starvation and induced high mortality in the cohort of the fledglings.

In all four field-seasons, the number of adult males recorded was higher than the number of adult females. There are three possible explanations of this discrepancy: 1) sex ratio of adult males to females was in reality 1:1, but the “missing” females were an artifact of our techniques, such as

difficulty in finding, capturing, and identifying females in a mature grassland habitat, 2) annual survival was the same for both sexes, but females dispersed more than males, i.e. show lower philopatry, and were alive elsewhere, off CRFRC property, and 3) annual mortality was greater for adult females than for males, the missing females were really dead, and the fewer female survivors returned to CRFRC as faithfully as males did. We comment on each possibility below, but our evidence at present supports the hypothesis of differential survival best.

Females did not sit high on perches as much as males did and did not have an elaborate song that indicated their presence. As a consequence, we could not target unbanded females and place mist nets judiciously to capture them as we regularly did for males. Also, since females are primarily responsible for maintaining and brooding the nest, they would spend more of their time on the ground than do males. Similarly, the technical difficulty of capturing adult females probably contributed as well to our low estimates of annual survival of adult females. Contradicting these plausible biases in technique are the data on "skipped year" records. Only four of the 63 females from the 2000 cohort were missed in 2001, while only 4 of 117 males known to be present on 2000 were missed in 2001. There is no significant difference between these ratios ($X2 = 0.828$, $P > 0.5$), indicating that the efficacy of capture was indeed the same for the two sexes. If censusing techniques for females were much worse than for males, the frequency of gaps in records of females would have been much higher (Gill, 1985). We are heartened to conclude that our mist-netting protocol has been as effective for breeding females as for males.

We have no evidence to date that our female Grasshopper Sparrows are dispersing away from CRFRC more than males. Indeed the re-sighting of four marked males in soybean fields outside the experimental grasslands confirms that both HY and adult males are dispersing at least short distances. No females have yet been seen off CRFRC property. To be sure, no effort has been yet made to mist-net such extralimital areas in systematic manner. With the high rates of recovery of marked males and females on CRFRC grasslands each year confirms that both sexes have a strong tendency to return to natal grounds and to prior breeding grounds.

The number of adult males captured and banded each summer greatly exceeded the number of territories as determined by the GPS mapping; in 2002 the number of males was twice the number of territories in every field (Table 3). Large numbers of males did not qualify as being "on territory" because they were seen briefly (once or twice) at a locality, and then not seen again or seen in another area of the grasslands. In May and June a common experience for the ornithology team was: we spotted an unbanded male singing from several close perches and apparently on territory, we erected several mist nets near the perches, we caught several unbanded males with enlarged cloacae in those nets simultaneously, we observed only one of the newly banded males singing from the perches the next day, but did not see the other marked males in the area. Similarly, males on territory were often seen chasing, or being chased by other individuals. Taken together these observations suggest the presence of a substantial "floater" population of sexually active males that were not on territory, but persistently challenged the territory holder. We speculate that such "underground" challengers were usually sneaking on the ground, were cryptic even to the advertising territorial bird, and may well be involved in extra-pair copulations and/or extra-pair fertilizations with females that were also hidden in vegetation on the ground.

All our observations of the breeding behavior of our CRFRC Grasshopper Sparrows indicate they are monogamous in a nesting cycle. We have no evidence yet that any male on territory was paired to more than one female at a time or had more than one active nest in his territory. We doubtless underestimated the number of territories somewhat because of our stringent criteria. The number of captured adult females was closer to the number of territories counted each year. Hence we surmise that all adult females Grasshopper Sparrows were paired and breeding, but many males were not.

The annual survival rates of adult (of mixed, unknown ages) and the annual graduation probabilities of known aged adult birds agreed well, roughly 60% for males and 30% for females. Our current estimate for males is much greater than the reported return rates of 35% in Maine (Wells 1997) and the estimate of adult survival of 49% for ground nesting sparrows in general (Martin 1995), but agrees favorably with the 60% reported for the non-migratory subspecies of Grasshopper Sparrows in Florida (Delany et al. 1993 as reported in Vickery, 1996). These estimates of Type II adult survivorships translate into estimates of median age of adults (given they reached maturity) of 1.36 yrs for males and 0.58 yrs for females. If we assume that females lay four eggs in a nest, two nests per season, but each nest has a 0.627 probability of success, and sex ratio of males:females at laying and fledging is 1:1, then the estimated fecundity of a female each season is 2.508 daughters fledged per season. Fecundity of most adult female passerines changes little with age. Combining the age-specific survivorship and constant fecundity provides estimates of the basic life history parameters of generation time ($G = \{\sum xlxmx\}/\{\sum lxmx\}$ and net replacement rate per individual per generation ($R0 = \sum lxmx$). By these formulas, G is 2.44 year, R0 is approximately 1.155, indicating that the population of CRFRC Grasshopper Sparrows is growing, that the average female Grasshopper Sparrow at CRFRC is replacing herself with 1.16 daughters each generation.

Annual depletion curves denote the survival rate of a year-group of adults of unknown but mixed ages, whereas age-specific survivorships require cohorts of individuals with known birth dates. When initiated most population studies of natural populations are forced to marked individuals without knowledge of their actual chronological age. Only after cohorts of newborns are marked can demographic analysis proceed with estimates of age-specific parameters. The slopes of both depletion curves and age-specific survivorships increase whenever individuals that apparently "skipped" one or more years reappear after the absence (and are therefore known to be alive in the missing year).

Smith (1968, as reported in Holmes 1996) found that average territory size of male Grasshopper Sparrow was 1-3 acres. Our findings suggest that the Grasshopper Sparrow territories at the CRFRC were much smaller. The average territory size of 2002 males for which there were at least eight waypoints (a total of 51 individuals) was 1654 m2 or 0.41 acres. This is comparable to the average territory size of 0.40 acres in 2001. One reason for this small territory size may be due to the high density of adult males in the grassland fields (61 adult males per 100 acres). The highest recorded density of breeding males in Maryland was 77 per 100 acres, in Prince George's County in 1945 (Holmes 1996).

The fact that a total of 83 banded male Grasshopper Sparrow territories were identified when there were at least 139 banded males present among the 12 grassland fields and Field G, has several possible explanations. Some males may have had established territories but we encountered them too infrequently to confirm their territories. Because we surveyed the fields thoroughly each month it is unlikely that we missed more than a few territories. A second explanation is that some banded birds may have had territories in adjacent fields that were not subject to research, and were simply seen in our fields while they were feeding or participating in extra-pair copulations. We have numerous observations of male and female Grasshopper Sparrows on territory in the CRFRC grasslands that were intercepted by mist nets at other locations in the grasslands long distances from their known territories. In 2001 we captured the majority of our females in or along the clover fire-breaks that partitioned the fields (Figure 14, pink dots). We infer they were vigorously feeding on the abundant acridid grasshoppers there, while their nests were more interior. The unfavorable nature of the fire-breaks in 2002 (drought, absence of clover and insects) best explains the greater spatial dispersion of female captures last year (Figure 14, white dots). Nevertheless many males and females were caught hundreds of meters away from their active territories and this behavior raised suspicions of possible extra-pair sexual activity. At present we do not have genetic data that would confirm the extent of extra-pair fertilizations and deceptive parentage. The fact that our analysis of population structure leads to the conclusion that there was a large floater population of males heightens the likelihood that cuckoldry and multiple parentage in nests exists in this population of Grasshopper Sparrows. Future research at the CRFRC will focus on this topic.

Empirical, comparative study of the behavioral and ecological contexts of “buzz” versus “warble” responses is not yet complete. Different individuals were observed to sing only “buzz” songs, only “warble” songs, both songs, or a curious combination “buzz-then-warble” song; we have no case yet of bird singing a “warble-then-buzz” song. The majority of responses given by territorial males to the experimental playbacks consisted of “buzz” songs regardless of whether the stimulus was a “buzz” song or “warble” song. This result strongly suggests that “buzz” songs are most associated with male territoriality, and that “warble” songs may serve some other function. On a few occasions males were seen to associate with females when delivering warble songs (a quantitative assessment of this tendency is still needed). These observations suggest that “warble” songs may serve one of the other two traditional song functions: female attraction and stimulation of female reproductive readiness.

The successful demonstration that the synthetic songs are effective and biologically relevant as acoustic communication signals in these birds will allow a high degree of flexibility in the types of playback tests that will be performed with Grasshopper Sparrow in future years. Since synthetic songs can be manipulated gradually and continuously along any acoustic axis (while holding all other acoustic properties constant), an array of test song variations may be produced, providing a means of determining exactly which characteristics (and what degree of change in those characteristics) encodes specific types of information in this communication signal.

Nest ecology, territory studies, and census data suggest certain trends about Grasshopper Sparrow habitat preferences. Grasshopper Sparrow tended to have a good mix of bare ground, duff, and live vegetation around their nests. Fields that had relatively tall grasses, such as Field 8, had no territories, while fields that had relatively short grasses, such as Fields 5 and 6, had the

most territories. In general, fields that had less dense concentrations of live vegetation and more bare ground tended to contain more territories. These data have direct implications for the management of warm season grass plantings. Keeping grasslands lower in height and not too dense appears to be a good way to maintain a healthy population of Grasshopper Sparrow.

SUMMARY

The data from the first four years of study at the CRFRC show that the experimental grassland restoration project has been successful for attracting grassland birds. The outstanding successes have been the remarkable incursion and establishment of the Grasshopper Sparrows, the 5-8 fold increase in calling Bobwhite Quail, and the colonization by Dickcissels. Several grassland birds such as Bobolink, Eastern Meadowlark, Upland Sandpiper, and Vesper Sparrow have been seen in the fields during migration. Northern Bobwhite, Horned Lark, and Killdeer have been confirmed as breeding in the experimental fields. Dickcissels have been seen in the fields for the past three years and are suspected to have bred in the fields each year. Other birds such as Orchard Orioles, Short-eared owls, and a variety of Swallows are active feeders in the fields.

Grasshopper Sparrow continue to be a superb indicator of the health of the experimental grasslands and due to their abundance we have been able learn more about their population biology and habitat requirements. The population of Grasshopper Sparrow peaked in 2001 when over 400 individuals were recorded. Both males and females that were born in the experimental fields have returned to breed in successive years. Annual survival rates have been as high as 82.6% for adult males and as high as high as 62.5% for adult females. Some males have been recorded in the grasslands in each of the first four years.

Males are faithful to their breeding sites and return each year to roughly the same site, but are inconsistent in the locations of their territories from year to year. Territories have been identified for 131 different adult male Grasshopper Sparrow. Most males established one territory per breeding season and remain in that location for the entire season. However some males abandoned the locations of early-season territories and re-established territories in new locations later in the breeding season.

Statistical analyses have failed to show significant correlations between the birds and the vegetation characteristics of the fields. Grasshopper Sparrow territories/acre look negatively correlated with grass height and percent cover of live vegetation and positively correlated with percent cover of bare ground; these trends, however, were not statistically significant. There was no significant correlation between the amount of duff in the fields and territories per acre. Territory size did not appear to be affected by vegetation characteristics of the fields or by field size. The average Grasshopper Sparrow nest had roughly even amounts of bare ground, live vegetation, and duff within one meter of the nest. A majority of the nests were facing in a northerly direction and there was no apparent correlation between vegetation height and distance from the nest.

Nesting of most species at the CRFRC began in early to mid-May and continued through August. State policy dictates that no large-scale management of the fields (mowing, burning, etc.) should be conducted during this period due to high nest mortality. Prescribed fires during the dormant season are recommended to maintain the grasslands free of woody successional vegetation and remove standing dead vegetation and litter. It is important to maintain a heterogeneous landscape by a schedule of rotational burning of the fields. In this manner, suitable habitat can be maintained for multiple grassland bird species.

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TABLES

Table 1. Planting Protocol for Warm Season Grasses

Field #	Seed Mix	Grasses	Seed Rate (lbs/acre)
1 and 6	Short	Little Bluestem	4
		Sideoats Grama Grass	2
		Deer-Tongue Grass	2
		Blue Grama Grass	?
2 and 7	Moderately Short	Little Bluestem	4
		Big Bluestem	2
		Eastern Gama Grass	2
3 and 5	Tall	Little Bluestem	2
		Big Bluestem	2
		Indian Grass	4
4 and 8	Moderately Tall	Eastern Gama Grass	4
		Switchgrass	2
		Red Fescue*	2
		Tall Fescue*	?
9 through 12	Mid-height	Coastal Panicum	4
		Little Bluestem	3
		Indian Grass	1

* Both Red Fescue and Tall Fescue are cool season grasses

Table 2. Annual depletion rates of adult male and female Grasshopper Sparrows*

	1999 Cohort	2000 Cohort	2001 Cohort	Weighted Average
1999 - 2000	0.4 6 / 0.09	--	--	0.4 6 / 0.09
2000 - 2001	0.8 3 / 0	0.6 2 / 0.32	--	0.6 6 / 0.31
2001 - 2002	0.5 0 / 0	0.4 0 / 0.4 0	0.51 / 0.18	0.4 8 / 0.21

* adult males / adult females

Table 3. Number of male Grasshopper Sparrow Sightings and territories per field in 2002.*

Field # (ID)	Area (acres)	Males Seen	Territories/Field	Territories/acre
1	12.41	8	4	0.32
2	20.16	17	9	0.45
3	26.04	26	13	0.50
4	24.63	21	8	0.32
5	20.17	21	11	0.55
6	14.37	15	11	0.77
7	32.36	6	2	0.06
8	17.32	2	0	0.00
9	13.49	6	4	0.30
10	15.91	6	3	0.19
11	3.51	3	0	0.00
12	16.39	10	4	0.24
Total	216.76	141	69	0.32

* Territories/Field includes only those territories of which 80% of territory fell inside of the inside of the borders of the field.

Table 4. General vegetation characteristics of the fields at the CRFRC in July, 2002. Values are means of eight random 1 m^2 sample plots. Vegetation data for field 11 in July were unavailable. For a description of the vegetation sampling techniques of the fields see the Summary Report of the Vegetation Studies at the CRFRC for 2002.

Field	% BARE	% WSG	% Live	Height	Duff
	Mean	Mean	Mean	Mean	Mean
1	11.75	1.88	58.15	45.64	30.13
2	4.13	13.88	36.02	71.74	59.88
3	57.50	33.88	35.42	86.70	7.13
4	14.50	34.75	59.89	133.00	28.63
5	48.25	17.25	26.04	67.33	25.75
6	2.25	22.01	33.91	60.27	63.88
7	3.63	33.88	43.52	80.46	52.88
8	9.88	48.13	50.14	153.19	40.00
9	9.88	0.75	41.67	63.00	48.50
10	28.88	3.00	44.17	38.35	27.00
12	6.63	10.13	33.39	109.58	60.00
Average	17.93	19.96	42.03	82.66	40.34

Abbreviations: BARE=bare ground, WSG= warm season grasses, LIVE=live vegetation, HEIGHT= mean height of WSG, DUFF= dead vegetation.

Table 5. Nest success of Grasshopper Sparrows at the CRFRC each year.

	Failures	Successes	Total	Success %
1999	7	7	14	0.50
2000	7	23	30	0.77
2001	7	7	14	0.50
2002	7	10	17[a]	0.59

[a] The number of nests in 2002 does not include one nest for which the fate is unknown.

Table 7. Nests found at the CRFRC in the first four years of study.

Species	**1999**	**2000**	**2001**	**2002**	**Total**
Blue Grosbeak	0	0	1	3	4
Dickcissel	0	5	1	0	6
Field Sparrow	0	2	0	7	9
Grasshopper Sparrow	14	30	14	18	76
Horned Lark	3	0	0	0	3
Killdeer	1	0	0	0	1
Northern Bobwhite	0	1	1	0	2
Orchard Oriole	0	0	0	1	1
Red-winged Blackbird	0	2	1	7	10

Table 6. All Birds Banded at the CRFRC in the first four years of study.

Species	1999	2000	2001	2002
American Goldfinch	14	0	14	12
American Robin	4	0	1	3
Baltimore Oriole	6	1	0	1
Bank Swallow	3	0	0	0
Barn Swallow	4	0	4	4
Blue Grosbeak	9	6	10	15
Blue Jay	2	0	0	0
Bobolink	0	0	2	0
Brown Headed Cowbird	3	0	1	3
Brown Thrasher	6	0	0	1
Carolina Chickadee	1	0	2	0
Carolina Wren	0	0	1	0
Chipping Sparrow	30	0	5	5
Common Grackle	13	0	0	3
Common Yellowthroat	4	0	18	28
Dickcissel	0	12	2	5
Downy Woodpecker	0	0	1	0
Eastern Bluebird	4	0	8	2
Eastern Kingbird	1	5	3	5
Eastern Phoebe	2	0	1	0
Eastern Towhee	0	0	0	1
Eastern Tufted Titmouse	1	0	0	1
European Starling	19	0	1	22
Field Sparrow	45	0	75	135
Grasshopper Sparrow	92	270	328	143
Gray Catbird	13	1	11	3
Hairy Woodpecker	0	0	1	0
Horned Lark	3	2	0	0
House Finch	13	0	0	1
House Sparrow	1	0	0	0
House Wren	0	0	1	0
Indigo Bunting	18	2	36	27
Mourning Dove	6	0	0	0
Northern Cardinal	9	0	3	6
Northern Mockingbird	14	0	9	13
Orchard Oriole	5	9	16	24
Purple Martin	0	0	1	2
Red-bellied Woodpecker	0	0	0	1
Red-winged Blackbird	36	0	36	107
Ruby-throated Hummingbird	0	0	1	0
Song Sparrow	2	0	15	8
Tree Swallow	0	0	4	2
Vesper Sparrow	2	2	0	0

Yellow Warbler	1	0	0	2
Yellow-breasted Chat	0	0	1	0
Total Species	33	10	31	30
Total Individuals	**386**	**310**	**612**	**585**

FIGURES

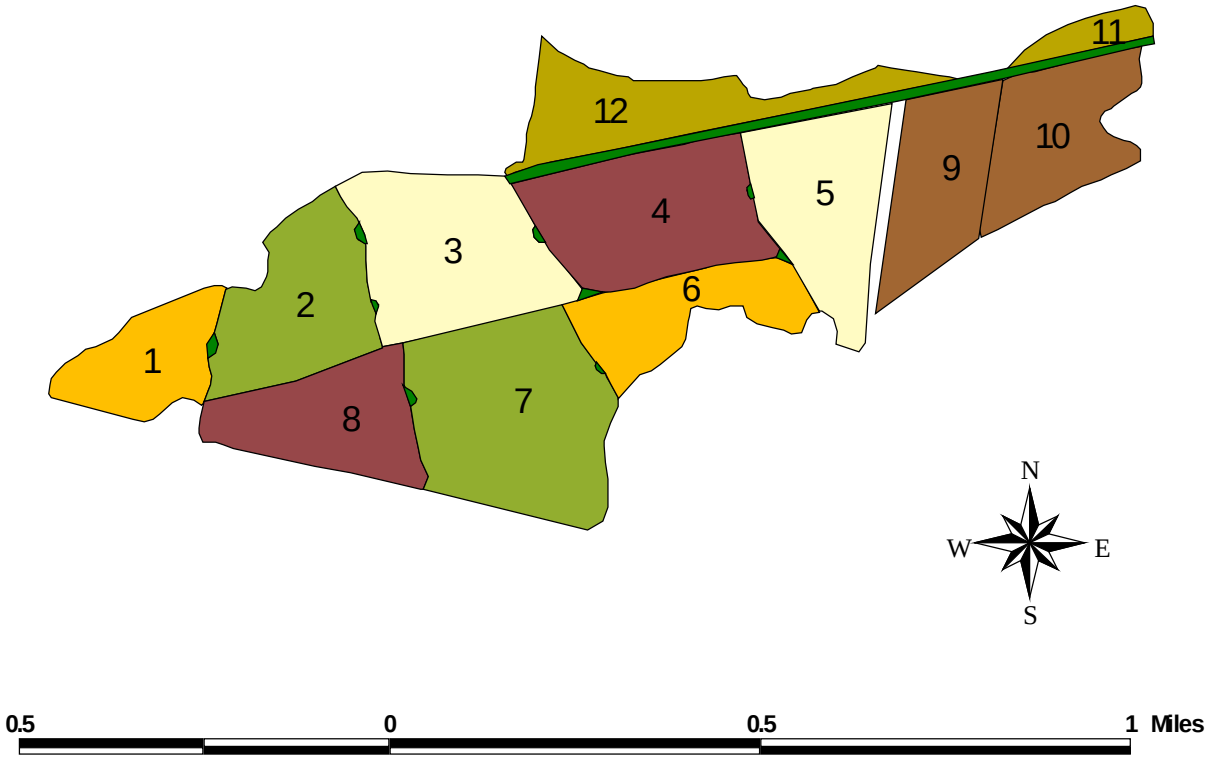

Figure 1. Map of the experimental grasslands at Chino Farms. Matching colors denote fields that were planted as replicates of warm season grasses in March 1999. The long, narrow green bar along the south border of fields 11 and 12 is a private grass airstrip. Field 7 is the largest of the experimental fields at 32.4 acres.

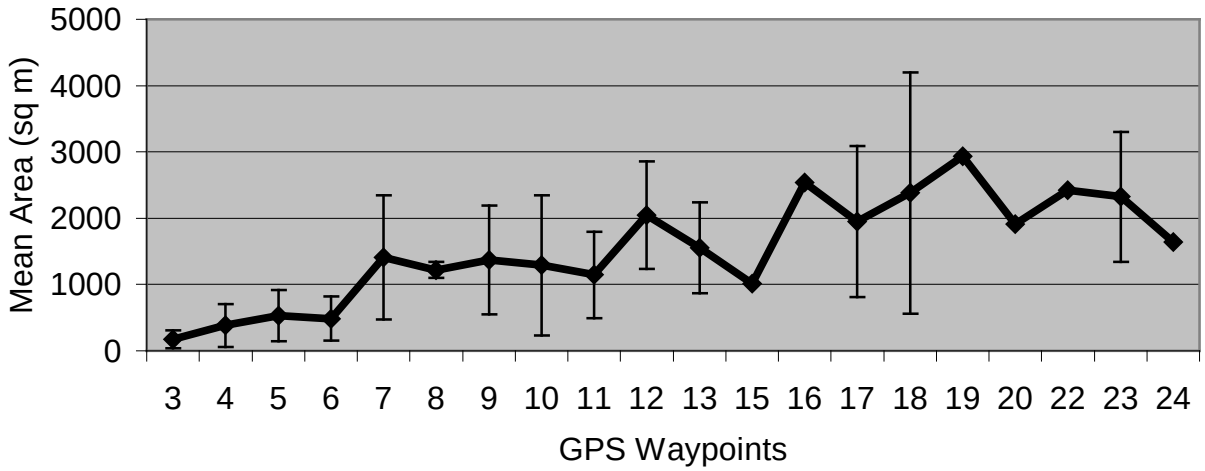

Figure 2. Average male Grasshopper Sparrow territory size in 2002 versus the number of waypoints collected. Error bars indicate one standard deviation.

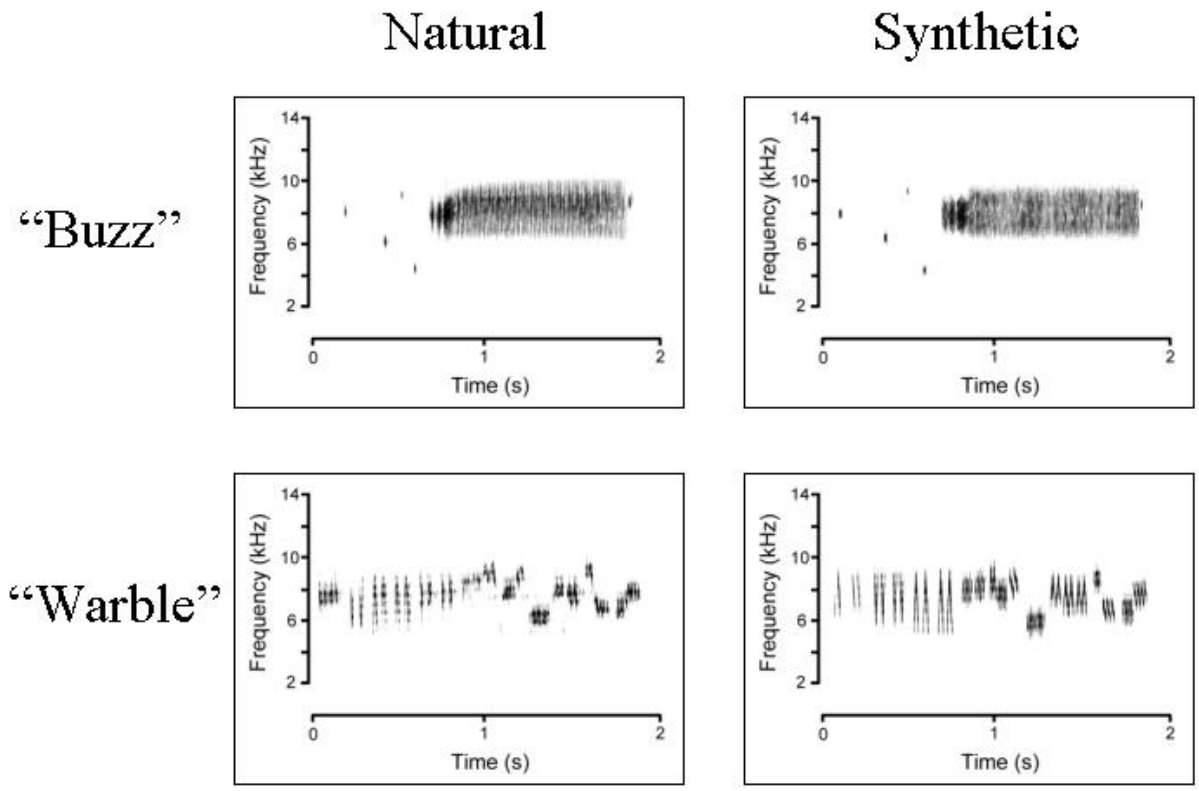

Fig. 3. Natural and synthetic songs of male Grasshopper Sparrows.

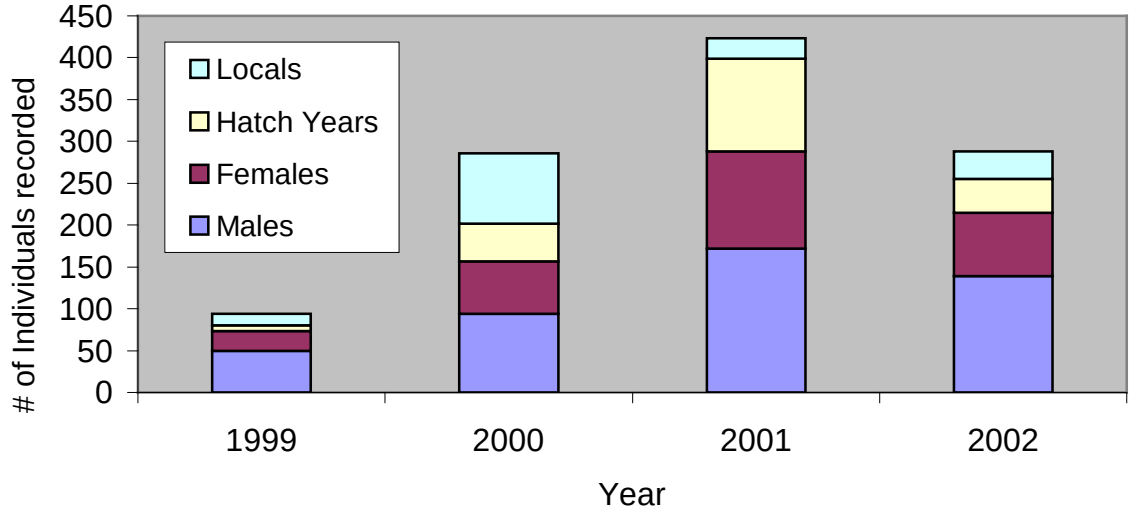

Fig. 4. Total number of Grasshopper Sparrows recorded at the CRFRC in each year.

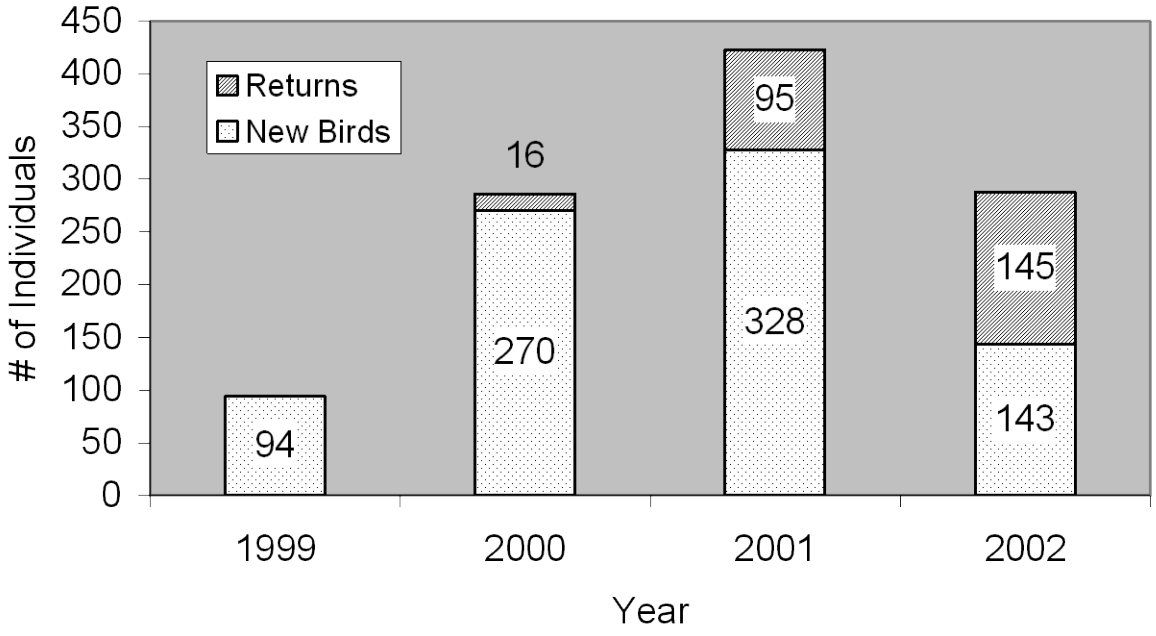

Fig. 5. Total Grasshopper Sparrows seen at the CRFRC each year.

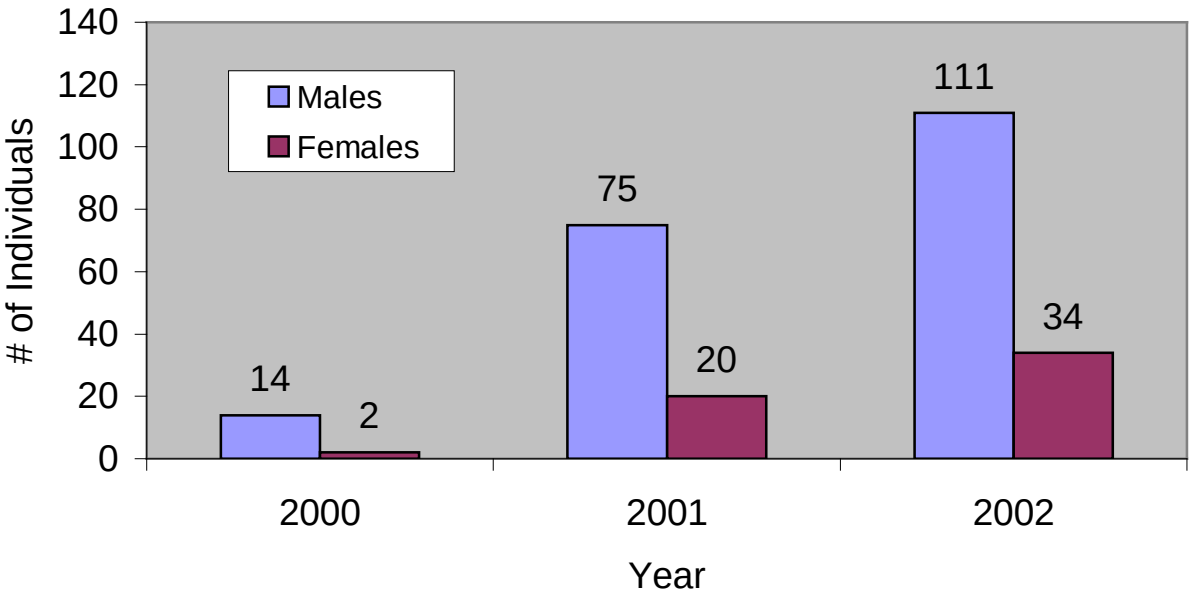

Fig. 6. Number of adult Grasshopper Sparrow returns by year.

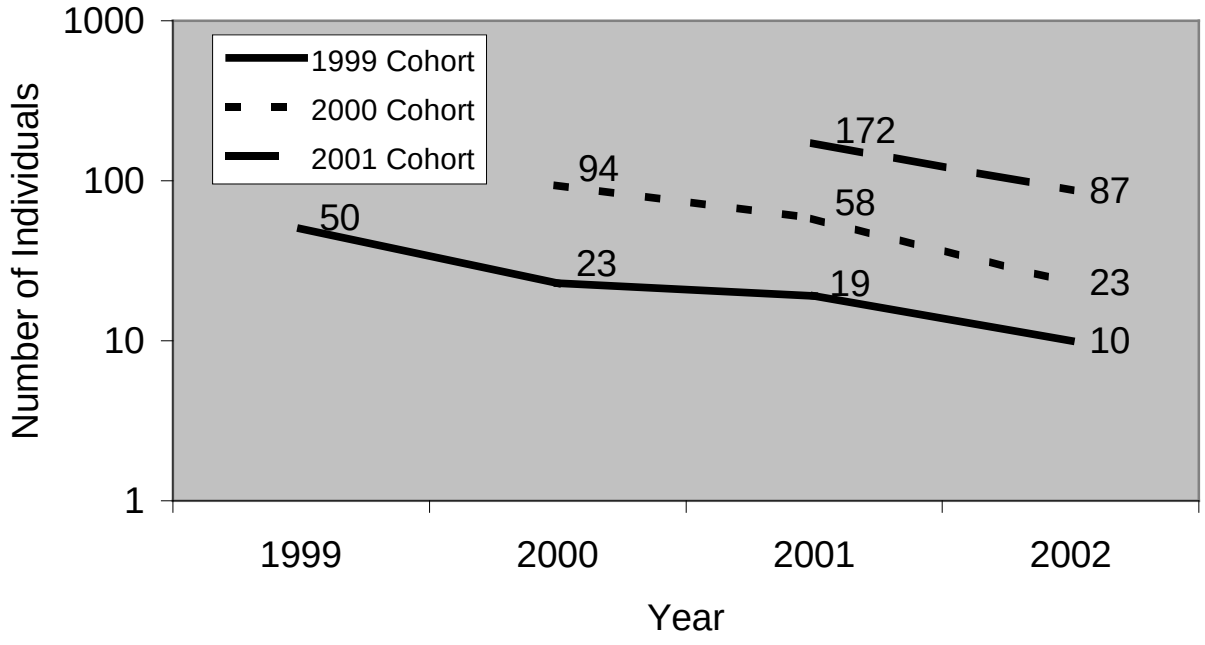

Fig 7. Depletion of adult male Grasshopper Sparrows.

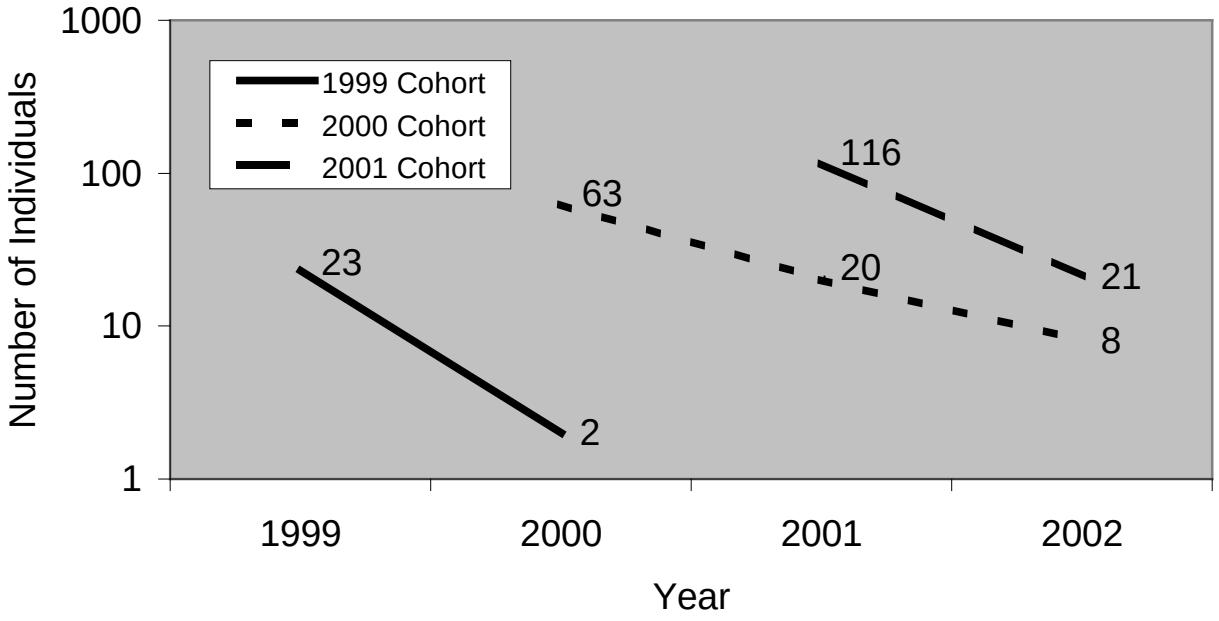

Fig. 8. Depletion of adult female Grasshopper Sparrows.

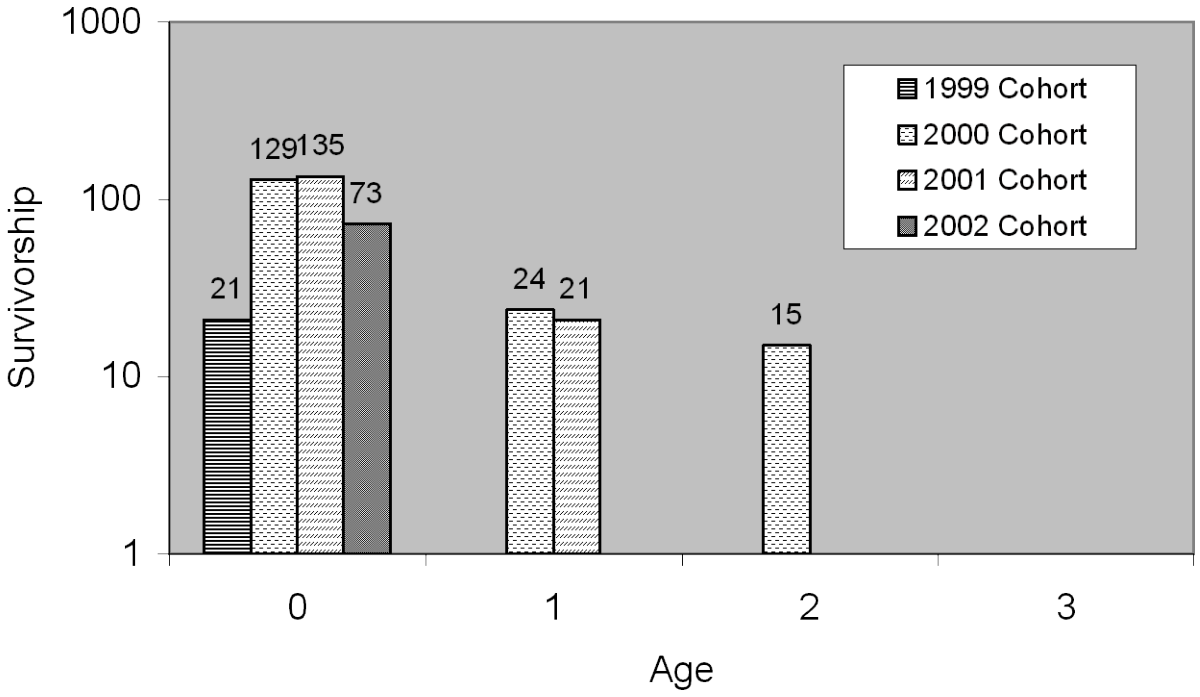

Fig. 9. Survivorship of hatch year (HY) Grasshopper Sparrows.

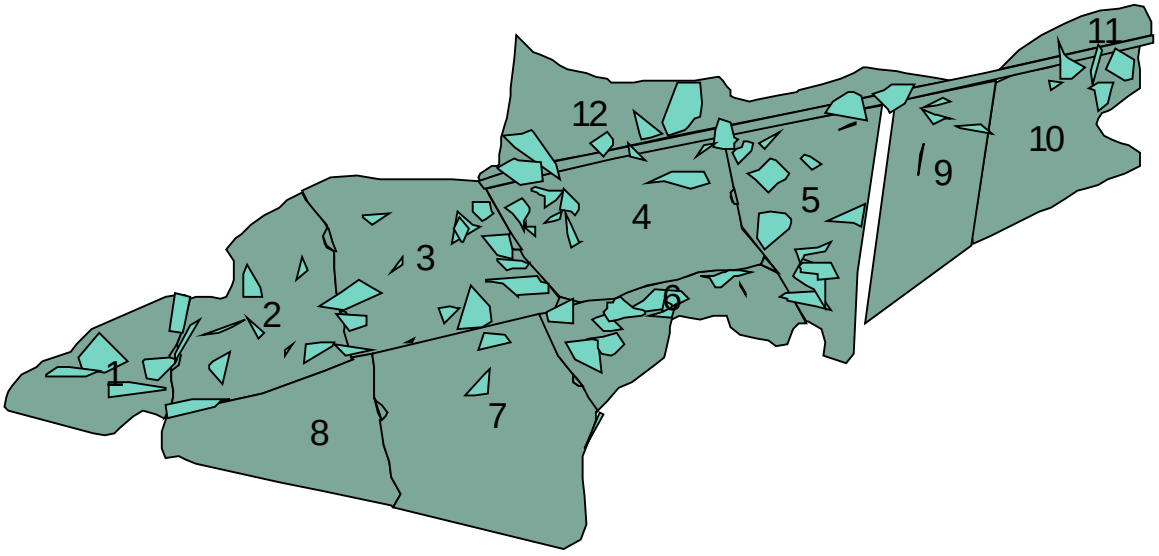

Fig. 10. Male Grasshopper Sparrow Territories in 2002.

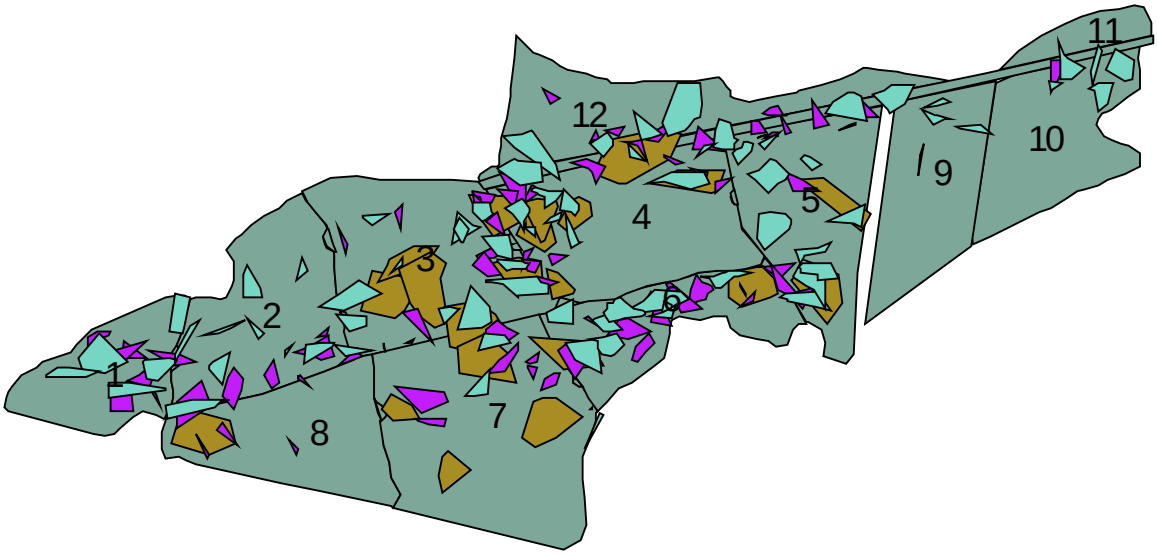

Fig. 11. Male Grasshopper Sparrow Territories from 2000-2002. Legend: Light blue = 2002 territories, Purple = 2001 territories, Brown = 2000 territories.

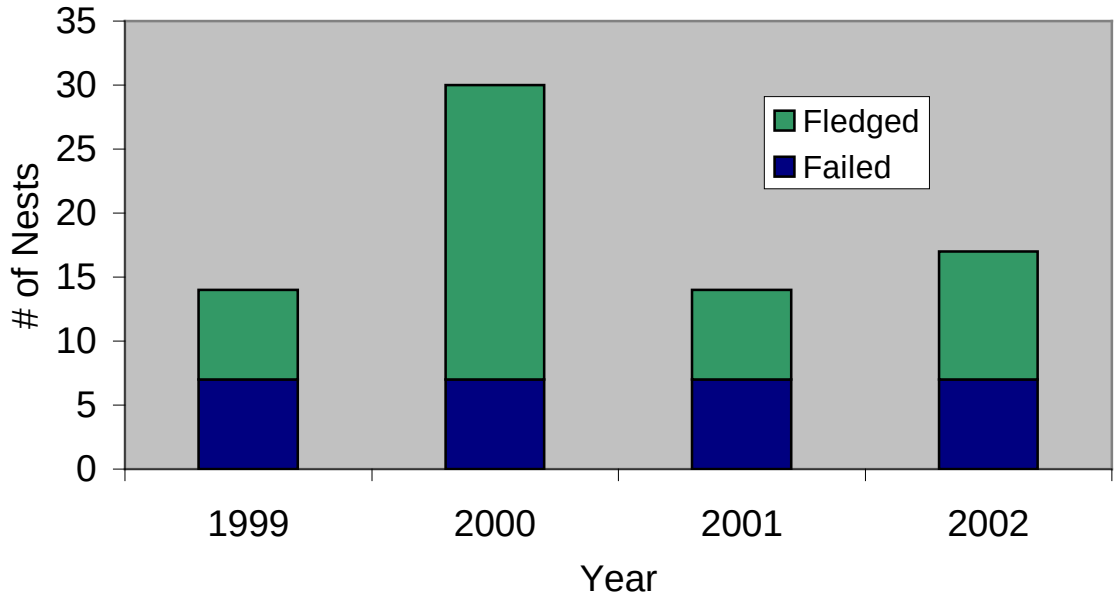

Fig. 12. Grasshopper Sparrow nest successes to fledging.

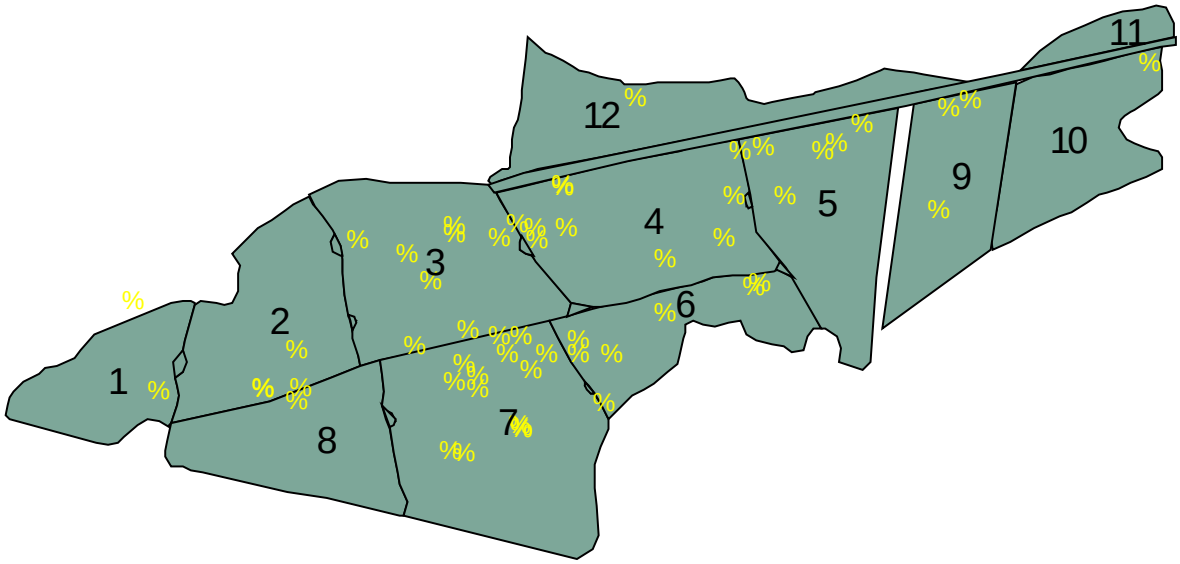

Fig. 13. Grasshopper Sparrow nest locations, combining the three years 2000-2002.

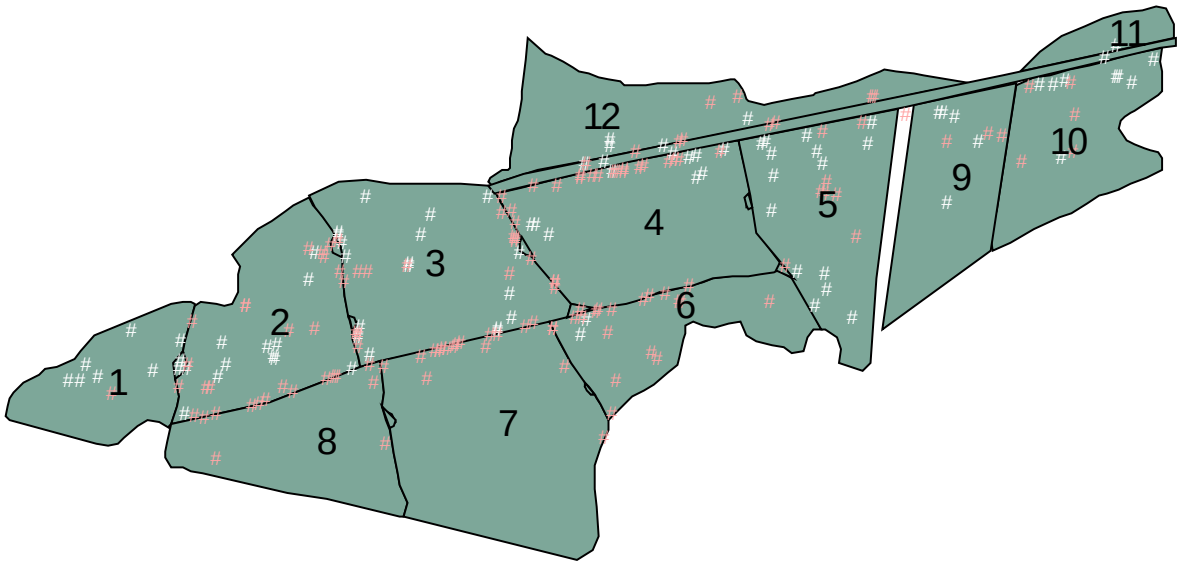

Fig. 14. Observations and captures of female Grasshopper Sparrows in 2001 and 2002. Legend: Pink = 2001 waypoints, White = 2002 waypoints.