

RECOVERY OF CAPE SABLE SEASIDE SPARROW – SUBPOPULATION A



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1.0 EXECUTIVE SUMMARY

The following report presents research on the Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) conducted under a grant from the U.S. Fish & Wildlife Service (USFWS) through the Endangered Species Conservation – Recovery Implementation Funds (CFDA 15.657). Supplemental funding for Cape Sable seaside sparrow (CSSS) research was provided by the South Florida Water Management District (SFWMD), with additional support provided by Everglades National Park (ENP). Funding under these awards was provided to meet two main objectives in 2016: 1) conduct intensive demographic monitoring of CSSS subpopulations A, B and D, and 2) development of a spatially-explicit population estimator for the CSSS. Each of these objectives was meant to provide information necessary to aid recovery efforts of CSSS subpopulation A. This report is broken down into four sections as follows:

Section 1.0 is an Executive Summary of this report. **Section 2.0** provides an overview of demographic monitoring conducted in CSSS subpopulations A, B and D in 2016 and presents current breeding conditions. This is followed by **Section 3.0** which provides a summary of our current effort towards developing a spatially-explicit population (SEP) estimator for the CSSS. Our original goal for 2016 was to complete development of the population estimator; however, field conditions in 2016 limited our ability to collect the data necessary to complete the SEP estimator. Thus, we do not provide a population estimate in this report. Our goal for 2017 is to collect the additional data necessary to complete the population estimator, and provide recommendations for ways to improve current rangewide survey methods. Finally, **Section 4.0** presents literature cited throughout the report. Following is a more detailed summary of each of the two main sections of our report.

Section 2.0 – Demographic Monitoring

During 2016 we continued to focus field research on intensive nest monitoring in small sparrow subpopulation A. This subpopulation has reported a decline in sparrow numbers in recent years and is subject to current management changes, or proposed changes, and thus near real-time

information on where sparrows are nesting and the status of individuals in this area is needed to help direct water management if necessary. In 2016, we also continued intensive nest monitoring in a study plot in subpopulation B so that we could collect data from a large sparrow subpopulation for comparison with data collected from small subpopulation A. Also in 2016, we conducted demographic monitoring in subpopulation D under a separate grant agreement with the SFWMD, and results from this study are included in this report for further comparison. Finally, during 2016 we also continued a long-term mark-recapture study by banding individuals in subpopulations A and B, and resighting previously banded individuals in all subpopulations monitored.

Despite holding steady compared to the previous three years, the total number of sparrows in subpopulation A remains very low with only 15 adults detected in 2016. Subpopulation B reported an alarming decline in 2016; only 16 adults were detected on our study plot in subpopulation B this season compared to 34 adults in the previous season. Subpopulation D also declined with only six adults detected this year, but this is likely attributed to reduced survey effort in this subpopulation in 2016. It is possible that the historically high water levels that prevailed throughout the Everglades ecosystem during the winter of 2015-2016 contributed to the reported decline in subpopulation B. We are concerned that the decline observed here may be due to high overwinter mortality rates in subpopulation B since we did not detect any dispersing individuals during off-plot surveys designed specifically to detect previously color-banded birds.

The recent declines reported on our study plot in subpopulation A have been a major concern. Sparrow numbers first dropped from 2010-2011 largely due to a reduction in females on our study plot, and numbers dropped again from 2012-2013 this time due to a reduction in males. Numbers in subpopulation A have been stable for the past four seasons, but continue to be very low. We are concerned that subpopulation A could be at a minimum threshold necessary to promote settlement of breeding sparrows, perhaps due to a lack of enough conspecific cues. The past low nest success rates and low return rates in subpopulation A raise alarm that this subpopulation may face continued declines unless the causes of the lower demographic rates

here can be identified and managed. We suggest that monitoring should continue to be conducted in a large sparrow subpopulation in conjunction with monitoring in small subpopulation A for comparative purposes in order to quickly recognize potential Allee effects in small subpopulations that could lead to rapid population declines. Further, we suggest that continued monitoring in subpopulation B is critical to help us understand the nature of the decline witnessed in the 2016 season.

Overall, the 2016 sparrow breeding season was an above-average year in regards to nest success rates and overall productivity in subpopulation A, and a well below-average year in subpopulation B. Sparrows breeding in subpopulation A had a much more successful season in 2016 than reported in the past several years; however, overall productivity and total recruitment remain low due to the small population size. The hatch rate for nests in subpopulation A, which has been a persistent source of concern in past years, improved substantially in 2016. Subpopulation B had similar measures of nest success as observed during previous seasons; however, the overall productivity was substantially lower in 2016 due to a dramatic decline in the number of breeding pairs found on our study plot. Recruitment was also low in subpopulation B in 2016 despite an apparent availability of open territories due to an unusually low adult return rate. Overall productivity and recruitment remained very low in subpopulation D due to the small population size and extremely male-biased sex ratio. There was evidence of multi-brooding by breeding pairs this season in both subpopulations A and B; however, the overall percentage of pairs multi-brooding remains low. This was the first year we have observed multi-brooding in subpopulation A since 2011. This may have been possible due to an extended breeding season as a result of dry conditions that prevailed into August, possibly due in part to water management decisions to hold back water releases into this area.

Two areas of major concern in subpopulation A continue to be the highly-skewed adult sex ratio and very low recruitment rates. The adult sex ratio did become more balanced in 2015 and 2016; however, due to the already small population size this subpopulation should be monitored closely for future changes as the current sex ratio balance may not be stable. The mean return rate of previously color-banded adult female sparrows has typically been much

lower in small subpopulations A and D. For example, in 2015 the return rate for male sparrows was 0.71 in subpopulation A while the return rate for females was 0.17. In 2016, the return rates were more balanced in subpopulation A. In subpopulation B, however, we observed extremely low return rates for both male (0.28) and female (0.07) sparrows raising concern in this large sparrow subpopulation. Highly skewed adult sex ratios increase a species' risk of extinction (Dale 2001). This process was observed during the extinction of a closely-related species, the Dusky seaside sparrow (*A. m. nigrescens*), when ultimately all of the remaining sparrows in the wild were males (Delany *et al.* 1981). Thus it is critical that the skewed sex ratio in small sparrow subpopulations be monitored closely to assess the rangewide status of the Cape Sable seaside sparrow in the future. Future research should continue to document sex ratios in small subpopulations, but should also continue to examine sex ratios in a large sparrow subpopulation for comparison to potentially capture early warning signs of a rangewide pattern that could be very detrimental to overall Cape Sable seaside sparrow population viability.

With generally lower nest success and limited dispersal into subpopulation A, we are concerned that this important sparrow subpopulation may be subject to continued declines in the near term. Local recruitment and dispersal rates alone will unlikely be enough to enable this isolated sparrow subpopulation to persist. It has previously been suggested that conservation managers should consider translocation of female sparrows into subpopulation A to achieve an adequately-sized breeding population for its persistence, and that the time to do this was likely becoming critical as the existing male sparrows in this subpopulation continued to age (Virzi and Davis, 2012). Although the higher return rates for both male and female sparrows observed in subpopulation A in 2016 is encouraging, the continued low recruitment of new birds is problematic. It is possible that we may already be very close to the critical mass necessary for this subpopulation to persist. While translocation of birds may seem like a viable management option for this subpopulation at this time, we caution that until we more fully understand the mechanisms causing reduced demographic rates (e.g., low hatch rates) and recent population declines in our study plot in subpopulation A there is considerable risk associated with the translocation of sparrows. We suggest that sparrows breeding in subpopulation A should

continue to be monitored closely to determine if the population continues to decline, and that the best method to monitor the subpopulation is to conduct intensive ground surveys and nest monitoring with similar effort to that conducted in recent years. Finally, we strongly recommend that a detailed translocation plan be developed before any sparrows are translocated into subpopulation A.

Section 3.0 – Spatially-Explicit Population Estimator

A central part of our research in 2016 was to continue development of a spatially-explicit population estimator for the CSSS. While we did not accomplish our original goal of developing a spatially-explicit population estimator, we did continue to make great strides towards the development of this estimator in 2016. During 2016, we conducted a pilot study to test new survey methods to better estimate CSSS detection probability and abundance. These included comparing line transect and point count survey methods, conducting repeated surveys, incorporating distance sampling into both methods, and adding time-of-detection sampling into point count surveys. We successfully tested these methods at select survey sites in CSSS subpopulations A, B and C during 2016. Unfortunately, the difficult field conditions that prevailed this year limited our ability to conduct surveys and our data were too sparse for statistical analyses at this time. Still, our pilot study pointed out potential benefits of the new survey methods. Most importantly, our results suggest that repeated surveys are likely necessary to derive a statistically valid CSSS population estimate.

Our results provide invaluable information that can inform continued development of a spatially-explicit population estimator and provide insight into ways to improve the ENP rangewide helicopter surveys to better estimate population size. We suggest that in 2017 additional data be collected to fill information gaps needed to complete development of the population estimator, and that new survey methods tested in our pilot study in 2016 be continued so that enough data can be collected to conduct statistical analyses. In order to properly use the ENP rangewide survey data to estimate CSSS population size we also recommend that along with modification of survey methods the ENP sampling design should be

closely evaluated to see how sites are being selected annually, and to look for ways to incorporate randomization into site selection which would allow better inference.

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2.0 Demographic Monitoring

2.1 Introduction

In 2016, we continued demographic monitoring in Cape Sable seaside sparrow (CSSS) subpopulation A which has been ongoing since 2009 (Virzi *et al.* 2009). Subpopulation A continues to be one of the most important CSSS subpopulations to track because historically it was one of the two largest subpopulations before significant population declines in the 1990s. Therefore, it holds the potential for significant recovery, even as it remains extremely vulnerable due to its small population size and its downstream position west of Shark River Slough, which exposes it to freshwater management decisions during the breeding season. Monitoring is needed in this area because it is subject to current water management actions, and thus near real-time information on where sparrows are nesting and the status of individuals in this area is needed to help direct water management, if necessary.

In contrast to subpopulation A, CSSS subpopulation B contains the largest number of sparrows, has maintained relatively stable population trends since the early 2000s, and apparently supports demographic rates that produce an annual population growth rate ≥ 1.0 . As such, it serves as a high-quality reference population for comparison of demographic parameters with small subpopulation A. For this reason, in 2016 we continued demographic monitoring in this large, reference subpopulation which has been ongoing since 2012 (Virzi and Davis 2012).

We also conduct demographic monitoring in CSSS subpopulation D under a grant from the South Florida Water Management District (SFWMD) to study the effects of the C-111 Spreader Canal Project on sparrows breeding in this small CSSS subpopulation (Virzi and Davis 2016). Subpopulation D is one of the smallest sparrow populations, and is located outside of the boundary of Everglades National Park on land managed by SFWMD. Demographic monitoring has been ongoing in subpopulation D since 2006, with intensive monitoring for SFWMD since 2011 (Virzi *et al.* 2011a). In 2016, however, we were unable to conduct demographic monitoring in subpopulation D with the same intensive effort as previous years due to

historically high water levels early in the season that made walking on the site difficult and potentially dangerous.

Monitoring in these CSSS subpopulations is needed to maintain continuity with previous research and monitoring, and to evaluate and consider new opportunities for recovery as new restoration actions are being proposed. The Central Everglades Planning Project (CEPP) is the next generation of proposed projects to be implemented under the Comprehensive Everglades Restoration Plan (CERP). One goal of CEPP is to identify and plan for projects on land already in public ownership to allow more water to be directed south to the central Everglades, Everglades National Park (ENP), and Florida Bay. Although this project is expected to produce large-scale hydrological benefits to the ecosystem, there is also concern about its potential impact on endangered species, including the Cape Sable seaside sparrow, whose range is extremely limited and population very small.

In this section, we report on our demographic monitoring conducted in subpopulations A (**Section 2.2**), B (**Section 2.3**), and D (**Section 2.4**) following methods established in 2012-2013 (Virzi and Davis 2013, 2012) and continued in 2014-2015 (Slater *et al.* 2014; Virzi and Davis 2014; Virzi *et al.* 2015). We conducted intensive nest searching on existing demographic study plots and continued banding adult and juvenile sparrows, which has been ongoing since 1994 (Pimm *et al.* 2002). During 2016, as part of our demographic research we also tested ways to improve current rangewide survey methods to: 1) better estimate sparrow density and abundance, 2) increase detection of female sparrows to determine breeding status of male sparrows and estimate subpopulation sex ratios, and 3) resight previously color-banded individuals that may have dispersed off demographic study plots to improve survivorship estimates (see **Section 3.0**).

It is worth noting that our demographic research conducted during the 2016 CSSS field season was strongly impacted by the historically high water levels in the Everglades ecosystem this year. Historic rainfall amounts fell in south Florida during the winter of 2015-2016 resulting in extremely wet field conditions that disrupted our fieldwork and likely influenced CSSS

distributional patterns making the 2016 field season somewhat of an anomaly compared to previous years. Ordinarily, the marl prairies where CSSS breed are relatively dry at the onset of the sparrow breeding season; however, in 2016 at the initiation of our annual fieldwork in March most sites had standing water at levels higher than levels typically seen late in the rainy season. Some areas (e.g., most of subpopulation D) had water levels high enough to make fieldwork dangerous and/or impossible. Thus, readers of this report should keep in mind the extreme field conditions we encountered when interpreting results from our 2016 demographic monitoring. We point out specific impacts to our research and potential effects on results in the sections that follow.

2.2 Subpopulation A

At one time considered part of the 'core' habitat for the sparrow (along with subpopulation B), subpopulation A experienced a very noticeable, and consequently controversial, decline between 1992 and 1995 (Curnutt *et al.* 1998). Persistent unnatural flooding during consecutive breeding seasons caused this subpopulation to decline substantially in occupancy and numbers, leading to legal actions requiring a change in water management so that less water was delivered into subpopulation A during the peak of the sparrow's breeding season (Pimm *et al.* 2002). While these water management efforts appear to have resulted in relatively stable sparrow occupancy since 1996, at least until recently based on ENP rangewide survey data, this subpopulation continues to show little sign of recovering to pre-1990 occupancy levels (Cassey *et al.* 2007) and has apparently declined in numbers since 2008. Demographic monitoring began in subpopulation A in 2008 after a fire burned through the West Camp area.

Observations of several large juvenile flocks indicated that breeding may have been very successful in that year. More intensive demographic monitoring has been ongoing since 2009, although observations of large juvenile flocks, as seen in 2008, have not been seen again. The goal of our research in subpopulation A is to better understand why the subpopulation continues to show no sign of recovery, and to identify possible management actions to aid in recovery. Two specific objectives include: 1) to keep water managers abreast of current nesting conditions, and 2) to continue collecting basic demographic information.

2.2.1 Study Area

Intensive nest searching was concentrated in our long-term demographic study plot near the historic West Camp (within 3 km). From 2009-2014, intensive ground surveys for breeding sparrows in subpopulation A had generally been conducted in a 5 km² square study area between the following ENP helicopter survey sites: shark-40 (near West Camp), shark-28 to the north, shark-105 to the east, and shark-108 to the south (Slater *et al.* 2014). In 2015, however, our effort was concentrated in the area known as the Lower Meadow located between shark-32, shark-36, shark-69, and shark-82 (**Figure 2.1**). Overall, the total area surveyed in 2015-2016 covered approximately 1.6 km² and was thus substantially smaller in size than the area surveyed in years previous to 2015.

The size of our demographic study plot in subpopulation A was first reduced in 2014 due to funding limitations and access issues. Subpopulation A can only be accessed by helicopter, and limited funding combined with logistical constraints has historically made consistent monitoring of this remote CSSS subpopulation difficult. For this reason, in 2015 we decided to continue to monitor a smaller study plot in subpopulation A in order to ensure that we obtain adequate survey coverage over the entire plot throughout the CSSS breeding season. Also contributing to our decision to drop the Upper Meadow area from our demographic monitoring in 2015 was the fact that no sparrows were observed in this area in the previous year (Slater *et al.* 2014).

Finally, we made changes to our survey methods in 2015 that required us to better delineate the boundaries of our study plots in all subpopulations monitored, and thus led to a reduction in the size of all of our demographic study plots. We modified our survey methods to include line transect surveys using distance sampling to estimate sparrow density on our study plots (Virzi *et al.* 2016). These methods were continued in the 2016 season.

2.2.2 Sparrow Numbers

In 2016, monitoring in subpopulation A began in early April and ran through the first week in August, while territory mapping began on 4 April and ended on 22 July. We documented nine territorial male sparrows and six breeding female sparrows (**Table 2.1; Figure 2.1**). The number

of breeding pairs ($n = 7$) in 2016 had increased by one pair when compared to the previous four years; however, this is due to an unbanded female breeding with two adjacent males at different times (see **Section 2.2.3**) rather than an increase in females. The number of territorial males was similar to the numbers seen during the previous three seasons; however, this number remains substantially lower compared to previous years (2012: $n = 17$; 2011: $n = 16$; Virzi *et al.* 2011b). The number of female sparrows was consistent with previous years. Due to the recent decline in males in subpopulation A, the sex ratio crept closer to 1:1 in 2014 and remained at a similar level in 2015 and 2016 (0.60; **Table 2.1**). Male-biased sex ratios have been observed in all the sparrow subpopulations studied, although ratios have historically been more imbalanced in small sparrow subpopulations. Sex ratios reported in all CSSS subpopulations are examined more closely below (see **Section 2.5.2**).

Territory maps in **Figure 2.1** reflect an average of 28.3 GPS points per individual tracked. In 2015-2016, we conducted more systematic territory mapping than in previous years in order to obtain a more precise estimate of sparrow density on our study plots, and to better map male territories for comparison of territory sizes among subpopulations (Virzi *et al.* 2016). The density of sparrows on our West Camp study plot in subpopulation A was 9.4 birds per km^2 based on territory mapping. This density estimate is substantially higher than in previous years (**Table 2.1**); but is close to the 8.8 birds per km^2 seen in 2015. The higher density estimate over the last two seasons is a function of our smaller study plot – reduced in size from 5 km^2 to 1.6 km^2 – which was intentionally placed in the highest known density of breeding sparrows in the West Camp area (i.e., the Lower Meadow).

As seen in past years, most sparrows continued to remain outside of the area in the Lower Meadow that burned in 2008, despite the apparent recovery of vegetation in this area. Nearly one-third of the newly-defined study plot was in the old recovered burn area, and birds still do not occupy this area in the same numbers as they occupy the unburned habitat. Still, two to three territories were completely within the burn area in 2016, and nesting was attempted for the first time away from the edge of the burn (**Figure 2.1**). This slow recolonization of the recovered burn is in direct contrast to the rapid re-establishment of breeding pairs in a healthy

subpopulation (E) following the Lopez Fire in 2001 (La Puma *et al.* 2007). Eight of the male CSSS territories found on our study plot were stable for the duration of the 2016 field season while the ninth male moved 1.5 km from one end of the study plot to the other; he was single at both locations but his territories were adjacent to breeding pairs.

2.2.3 Reproduction

We located and monitored the fate of nine sparrow nests; two were early-season nests (i.e., hatched before June 1st) and seven were late-season nests. The first nest was located on 6 May and the last nest was found on 22 July, with the peak of breeding in mid- to late June. The timing of nest initiation by sparrows in subpopulation A was later than previous breeding seasons, and later than nest initiation in subpopulation B this season. The search effort expended in April and early May was the strongest in years, so the late start to breeding was not an artificial result due to delayed or reduced visitation of the plot. Water levels were substantially higher than normal in late winter through early spring due to historic winter rainfall, and this may have contributed to the late initiation of breeding by sparrows in 2016. All monitored nests were located in the Lower Meadow in our newly-defined study plot, and two nests were in areas burned by the West Camp Fire in 2008. The Upper Meadow area was not visited at all during 2016, except as part of additional off-plot surveys (see **Section 3.0**).

Breeding pairs in 2016 tended to stay on the same territory for the entire season, similar to the 2014 and 2015 breeding seasons, with only one single male changing his territory. All of the pairs stayed together throughout the 2016 season, although two adjacent males may have shared one female. She was never banded, and had a failed nesting attempt with a banded male in late May. An unbanded female was seen with the neighboring banded male in July and they attempted a nest together; at the same time the first male appeared to be single. The lack of overlap of paired behavior and nesting attempts suggests that there was only one female present, and she shifted from one male to the neighboring male. No new adults arrived in the area over the course of the summer, although a pair banded in previous years was only discovered in June. The lack of wandering sparrows in and out of our study plot suggests that

this cluster of breeding sparrows may have become isolated from other sparrows breeding in subpopulation A – if any exist.

Mean clutch size was 4.0 eggs per nest, which is higher than the estimates in previous years (**Table 2.1**). Eight of the nine nests survived the full incubation period (13 days) to hatching (hatch rate = 0.89); the only monitored nest that failed during incubation was the last nest found in late July. It is, however, almost a certainty that other nests failed during incubation before they could be found. The hatch rate in 2016 was well above the hatch rates reported in the previous three years (**Table 2.1**), and exceeded the rate of 0.71 reported in 2011 (Virzi *et al.* 2011b) – the last time this small subpopulation reported a healthy hatch rate comparable to rates reported in other CSSS subpopulations.

Overall nest success (% nests that produced ≥ 1 fledged young) was 0.44; however, this is ‘apparent’ success and we expect that real success was lower since it does not take into account nests that failed prior to being located. Our continued use of Thermochrom iButton dataloggers in nests proved to be very helpful for interpreting nest fates and timing of transitions (i.e., time of nest failure or fledging) in 2016, particularly as nest visits were somewhat irregular due to difficult field conditions and helicopter scheduling. The one nest that failed during incubation was apparently depredated by a rodent, as suggested by iButton data. Two nests had older young taken by nocturnal predators while two more failed with smaller young due to either depredation or flooding.

In all, 13 nestlings were confirmed as fledged from monitored nests in subpopulation A in 2016; this is the highest number seen since the same number fledged in 2011 (**Table 2.1**; Virzi *et al.* 2011b). The mean number of young fledged per pair and young fledged per successful nest were 1.9 and 3.3, respectively. With such small sample sizes it is hard to interpret these estimates, but they are generally higher than estimates from previous years (**Table 2.1**). Finally, we were able to document multi-brooding in subpopulation A in 2016 for the first time since 2011. An older, established pair successfully fledged two young on 11 May and fledged four more young on 23 June.

2.2.4 Mark-Recapture Data

During 2016, we newly banded six adult sparrows (four males and two females), and we also were able to band nine juvenile sparrows, the most young banded since 2011 (**Table 2.2**; Virzi *et al.* 2011b). No nestlings were banded in 2016, but the number of free-flying juveniles (12 or more) seen on the plot was consistent with the number of fledglings (13) produced in the monitored nests. Of the 13 banded adults present in subpopulation A in 2015, we resighted five males and three females this season, yielding an adult return rate of 0.62. This rate is well above the annual return rates observed in recent years, and is the highest rate observed since 2011 (0.74; Virzi *et al.* 2011b). While return rates are not directly comparable to survival rates, the observed return rate in 2016 was within the range of apparent adult survival estimates generated by Boulton *et al.* (2009) from 2002-2009 (mean = 0.59; 95% CI = 0.52-0.68). The adult return rate in subpopulation A was approximately the same for males (0.63) and females (0.60) in 2016. This is in contrast to the strongly male-biased return rates seen in 2015; the 2015 rate for males (0.71) was substantially higher than the rate for females (0.17). While female survival is expected to be approximately 14-19% lower than for males (Boulton *et al.* 2009), any large disparity in male-female return rates in subpopulation A is worrisome if it is a consistent trend.

No nestling or free-flying juveniles were banded during the previous season (2015). One of the two juveniles banded in 2013, a male, returned in 2016 for the third season in a row, although he was unable to secure a mate this year. All of the other returning birds seen in 2016 were banded as adults in 2015 or earlier. Mean return rates for nestlings and juveniles can be calculated over the 4-year period reported; however, the very small sample sizes due to a lack of enough breeding sparrows in our study plot in subpopulation A make these rates difficult to interpret. Nonetheless, return rates most seasons appear to be too low to bolster the breeding population via local recruitment alone.

We documented no between-subpopulation dispersal events involving subpopulation A in 2015. In fact, no dispersal events have been reported in subpopulation A since demographic monitoring began in 2008. While our study plot represents a very small area within the

boundary of potential breeding habitat for the CSSS in subpopulation A, it is concerning that no dispersal events have been observed over this period. We interpret this as evidence that dispersal into this isolated subpopulation is likely very limited, possibly at a rate that is too low to aid in the recovery of this critical sparrow subpopulation. In fact, there is evidence that there is little dispersal occurring even within subpopulation A and the breeding cluster in the study area may be effectively isolated from other clusters of CSSS in subpopulation A – if any exist.

2.3 Subpopulation B

Subpopulation B currently holds the largest number of sparrows and is considered part of the core habitat for the CSSS (along with subpopulation E). It is generally protected from flooding and incendiary fires by Long Pine Key, contributing towards making this subpopulation a stronghold for the CSSS (Curnutt *et al.* 1998). During 2016, we continued demographic monitoring in subpopulation B, which was initiated in 2012, so that demographic rates could be compared among subpopulations with subpopulation B being considered a high-quality reference site (Virzi and Davis 2012). Intensive nest monitoring in subpopulation B was initiated in 2013, thus data on reproductive rates for comparison only goes back four years (Virzi and Davis 2013).

Another objective of our research in subpopulation B in 2016 is to gain information about sparrows breeding in a large CSSS subpopulation that might be useful in the future if conservation managers decide to translocate sparrows from a large subpopulation into small subpopulation A to aid its recovery. During 2016, we continued to refine our methods to capture free-flying juvenile sparrows in subpopulation B, which are potential candidates for translocation.

2.3.1 Study Area

Monitoring was conducted in the Dogleg study plot (DL) off Main Park Road, a small part of subpopulation B that is easily accessible by car/foot. Selection of this site also allowed us to continue to collect mark-recapture data in this core sparrow subpopulation in an area where sparrows were banded from 1994 to 2008 (Pimm *et al.* 2002) and since 2012 (Virzi and Davis

2012). Overall, the total area surveyed in the DL plot in 2016 covered approximately 0.68 km². Similar to our West Camp study plot in subpopulation A, in 2015 we reduced the size of our DL study plot in subpopulation B as part of the new survey protocols established that year, and continued these protocols into 2016. Thus, our 2016 study plot in subpopulation B was smaller than the study plots monitored in 2012-2014, which were approximately 1.5 km².

During 2016, we also began conducting limited monitoring in a second study plot in subpopulation B, the Alligator Hammock study plot (AH), located across Main Park Road from the DL plot (see **Section 2.3.5**). We decided to add this study plot in 2016 due to an observed decline in sparrow numbers on our DL plot during the early part of the breeding season (see **Section 2.3.2**). We hypothesized that we would detect banded individuals that dispersed across Main Park Road from DL to AH. Also, we added the new study plot in preparation for possibly including a new demographic study plot in 2017.

2.3.2 Sparrow Numbers

The DL study plot experienced a severe decline in the total number of sparrows in 2016; we were only able to locate 16 adult sparrows (11 males and five females; **Table 2.1; Figure 2.2**). The numbers of both male and female sparrows were significantly lower than numbers observed in 2012-2015 (**Table 2.1**). Female numbers in 2016 were only 42% of the mean (μ) number of females counted from 2012-2015 ($\mu = 12$), and only 31% of the number observed in 2015. The male count in 2016 dropped to 11 individuals, down from the consistent range of between 16-18 males observed on the plot from 2012-2015. Of these 11 males, only eight were ever onsite at the same time, with five stable territories. A sixth male held a territory on both sides of Main Park Road, but his female stayed completely to the west in the AH study plot. Territory mapping began on 3 March and ended on 20 July; territory maps in **Figure 2.2** reflect an average of 28.3 GPS points per individual tracked. In 2016 the density of sparrows on the DL plot dropped to 23.5 from 50.0 sparrows per km² based on territory mapping. As discussed for density estimates in subpopulation A, the high density estimate reported in subpopulation B in 2015 compared to previous years was a function of the reduction in size of our DL study plot

combined with its placement in the area with the highest known density of sparrows. However, the 2016 density estimate in the DL plot reflects a true population drop from 2015 since the size of our study plot was identical in both years. Thus, the CSSS population on the DL plot declined by > 50% from 2015-2016.

It is unknown whether the population decline observed in 2016 is more widespread across subpopulation B or is a local phenomenon on the DL plot only. Our survey effort was consistent in the DL plot in 2015-2016 despite the wet conditions that prevailed during the 2016 breeding season, so this did not influence the population estimate. One hypothesis is that overwinter survival rates were significantly reduced due to the historically high water levels reported during this period. Another hypothesis is that CSSS distribution in this area was affected by the historically high water levels, and thus sparrows may have simply dispersed to nearby areas off-plot that had better habitat conditions. We tested the second hypothesis by expanding our ground surveys in 2016 to include additional sites off-plot (see **Section 3.0**); however, we found no previously color-banded sparrows from the DL plot suggesting that high overwinter mortality may be a more plausible explanation for the population decline.

We observed a strongly male-biased sex ratio (0.69) in the DL study plot in subpopulation B in 2016, which is unusual for large sparrow subpopulations (**Table 2.1**). The observed sex ratio is more similar to the highly-imbalanced sex ratios seen in small CSSS subpopulations. The imbalanced sex ratio is especially troubling considering the proximity of the DL plot to relatively large numbers of breeding sparrows in nearby areas that should provide enough dispersing females into the plot to maintain a more balanced sex ratio. If our hypothesis is correct that overwinter mortality was high this year, it is possible that female overwinter survival rates were substantially lower than male survival rates contributing to this highly unbalanced sex ratio.

2.3.3 Reproduction

We located eight sparrow nests, of which four were early-season nests and four were late-season nests. The earliest nest was found on 8 April, and the latest nest was found on 1 August. Territories were clustered on either end of the DL plot, with a greater density of birds towards

the south end (**Figure 2.2**). A maximum of 11 males held territories at some time in 2016, but there were only five confirmed pairs in addition to a pair on both sides of the road (**Table 2.1**). A pair of courting 2015 juvenile recruits was seen on the north end of DL in March, but both birds disappeared and were never encountered again, either on DL or AH, or any of the adjacent areas surveyed. The north end of DL had two consistent territorial males that bred during part of the season. One male lost his female after her nest was depredated in April; she may have been depredated as there were adult feathers at the nest. The second male had likely been on site since 2014 but was finally recaptured in 2016, and missing bands were replaced; he was single for most of the season but paired up with an unbanded female late and fledged young in early August. A third male held territory on the north end of DL for a large portion of the season, but he was never seen with a female and he disappeared before he could be banded.

The south end of DL contained more breeding activity and had the majority of females in 2016. Two returning males held stable territories for the entire season, and both were consistently paired. Three unbanded females were confirmed, and two of these were later captured and banded. A third unbanded female disappeared after her first nest attempt failed. Unbanded females were seen in three separate areas in DL with no overlap in time, so it is unknown whether they were all distinct individuals. Two new males moved into the south end of DL in mid-June and were immediately banded; one was seen with an unbanded female for about a week but she did not stay with him. This male remained single on his territory until the end of the season. The second male moved on after less than a week. Three other males were only seen on the south end of DL early in the season: one banded hatch-year 2015 recruit was only seen on one day, an unbanded male was seen from time-to-time and may have been mostly on AH, while a third returning male disappeared after his nest fledged in April. His mate reappeared later in the season, paired with the neighboring male. All males on DL with the exception of the north end unbanded male and the two males on the south end who were not present long had access to females for at least part of the season, although not each male had a mate at all times. Five of these males did not attempt breeding at any point in 2016.

The mean clutch size was 3.0 eggs per nest, which is slightly lower but otherwise consistent with previous years. Six of the eight nests found in subpopulation B survived to hatching (hatch rate = 0.75); four were early-season nests (50%) and four were late-season nests (50%). Three of the six hatched nests survived to fledge young (fledge rate = 0.50); one was an early-season nest (33%) and two were late-season nests (66%). The overall fledge rate per nest was 0.38 (three of eight nests found fledged at least one young). The mean number of young fledged per breeding pair and young fledged per successful nest were 1.6 and 2.7, respectively.

Importantly, we again documented evidence of multi-brooding in subpopulation B in 2016; a pair fledged three young in late April and afterwards the male disappeared; the female fledged three more young with the neighboring male in early July. Another attempt by this pair in early June failed. Overall, only eight young fledged from monitored nests in subpopulation B in 2016; six of them from one productive female. An unfound nest fledged at least one young in mid-July; the banded adults were seen feeding a large fledgling on 20 July.

Breeding was not especially productive this year due to the lack of females on the DL plot. In fact, DL produced fewer young than the subpopulation A study site, despite having a similar number of breeding pairs. Most of the pairs were nesting in April and then again in June. We monitored one nest very late this year; this pair fledged two young on 6 August. In contrast to most seasons, there were more successful late-season nests (hatching after June 1) than early-season nests. Of the eight nests found in DL this year, only one of four early season nests fledged. Two of the four monitored late-season nests were successful, in addition to the unfound nest.

One nest with eggs was depredated at night by an unknown predator while at another nest the female may have been lost along with the contents as adult body feathers were found in the cup, indicating that a struggle had occurred but there was no absolute evidence of her mortality. However, she was not seen again this season after consistently breeding in this area for the previous two years. The other three failed nests contained nestlings that were depredated by unknown predators. There was no evidence of nest losses due to flooding in 2016.

2.3.4 Mark-recapture Data

In 2016, we newly banded two adult males and two adult female sparrows in the DL study plot in subpopulation B and resighted five males and one female banded as adults on DL in previous seasons, and a sixth male banded on AH was seen on DL (**Table 2.2**). Few new adults were banded because of the total reduction in number of adults on DL when compared to previous seasons. Of the 33 banded adults in the DL plot in 2015, only six were resighted in 2016 yielding a return rate of 0.18. The observed return rate in subpopulation B was much lower than the range of the apparent adult survival estimate generated by Boulton *et al.* (2009) from 2002-2009 (mean = 0.59; 95% CI = 0.52-0.68). The return rate for males (0.28) was substantially higher than for females (0.07), which might be expected based on Boulton *et al.* (2009) who found that females had approximately 14-19% lower survival rates (with similar recapture rates) to males (**Table 2.2**). However, both male and female return rates were substantially lower than expected in subpopulation B in 2016. This supports our hypothesis that overwinter mortality may have been high, possibly due to the historically high water levels reported during the winter of 2015-2016.

In 2016, we resighted three of the 13 juvenile sparrows banded on DL in 2015 (return rate = 0.23). This return rate is in line with expectations based on survival analyses (Gilroy *et al.* 2012a; Boulton *et al.* 2009). No nestlings were banded in 2015 or 2016.

No between-subpopulation dispersal events were documented in subpopulation B in 2016. This is not an unusual observation, even in this large sparrow subpopulation, because dispersal among subpopulations is limited. A review of demographic data collected in several study plots in subpopulation B over the past decade reveals that dispersal events are documented approximately every other year. In our DL plot, we last recorded a between-subpopulation dispersal event in 2014, and previously in 2012.

2.3.5 Alligator Hammock Study Plot

During 2016 we conducted limited demographic monitoring on the AH study plot, which included color-banding and resighting previously color-banded sparrows; we did not conduct

intensive nest monitoring in this study plot. This site is to the west of Main Park Road and contains the following ENP helicopter survey sites: mahog-51 on the south, mahog-34 on the north and mahog-43 in the center. Our research effort was increased somewhat in 2016 in the AH plot in anticipation of adding a demographic study plot there in 2017. Further, we decided to conduct additional ground surveys in this area in an attempt to locate dispersing individuals from the DL plot since this population reported such a large decline in 2016. The close proximity of AH to the DL site results in a greater frequency of movements between these two study plots than that seen elsewhere, and thus we hoped to find dispersing individuals from the DL plot in this area.

Both adults and juveniles were targeted in the AH plot in 2015 to collect data on adult and juvenile return rates and dispersal, and in anticipation of starting demographic work on the AH plot in the future. In 2016 there was no intensive demographic monitoring conducted on the AH plot, but there was a concerted effort to resight banded birds and to band more juveniles. A few adults were incidentally banded during these efforts (**Table 2.3**). Nearly all stable territorial males in AH were covered by resighting efforts, but it is likely that some of the females were missed since intensive demographic monitoring was not conducted.

Many of the adults banded on the AH plot in 2015 were resighted in 2016 holding similar territories, with an adult return rate of 0.55; 0.71 for males and 0.25 for females (**Table 2.3**). This was in strong contrast to the decline in numbers reported across Main Park Road on DL between 2015 and 2016. More banded females may have been discovered if there had been extensive demographic work in AH, so the female return rate may not be accurate. Three birds banded as juveniles on DL in 2015 settled on AH in 2016, while the only 2015 juvenile from AH to settle on DL did not stay there long. No banded adults were observed moving between the two sites in 2016, although one male held a territory on both sides of the road (his female remained exclusively on the AH side). The return rate for juveniles banded on AH in 2015 (0.67) was much higher than that seen on DL (0.23). Juveniles hatched in 2016 wandered between DL and AH, and sometimes were seen crossing Main Park Road.

The disparate return rates observed in AH compared to DL are difficult to understand given the proximity of these two study plots. The AH plot is somewhat drier in general than the DL plot, so it is possible that water levels influenced sparrow distribution and settlement decisions in this area differently. However, we did not observe any movement of adult sparrows from the DL plot to the AH plot in 2016 suggesting that either those individuals died or moved greater distances off these study plots. Despite increased survey effort off-plot, no previously color-banded birds from either AH or DL were seen among the CSSS detected during broader rangewide surveys that were at slightly more distant (1 km or greater) locations in subpopulation B (see **Section 3.0**).

No intensive nest monitoring was done in the AH plot in 2016; however, one late-season nest was found incidentally. The nest contained nestlings but was not monitored so the outcome is unknown. Breeding productivity appeared to be higher than the DL plot based on behavioral observations and the presence of juvenile birds. Juveniles were seen in greater numbers in AH earlier in the season (late June to early July), forming flocks of up to five or six birds, and then were surprisingly hard to find late in the season (late July to August). At this time more juveniles were seen and subsequently banded on DL, so young birds may have been moving to that plot and staying there. Time will tell if these juveniles can successfully restore the breeding population in the DL plot.

2.4 Subpopulation D

Although demographic monitoring in CSSS subpopulation D was not part of our award agreement from USFWS, we present a summary of results reported to the SFWMD under a separate award agreement to monitor this small sparrow subpopulation. Subpopulation D is a very small and ephemeral CSSS subpopulation, and is the only known subpopulation located outside the boundary of ENP on land managed by SFWMD. Annual monitoring in this subpopulation has been conducted since 2006, originally funded by ENP and USFWS (Lockwood *et al.* 2010). In 2011, SFWMD began funding more intensive research in this subpopulation to gather baseline demographic data about sparrows breeding there to study potential effects

caused by hydrologic changes anticipated to occur as a result of the C-111 Spreader Canal Project, which could have detrimental effects on sparrow habitat in this area (Virzi *et al.* 2011a). We present results from demographic research conducted in subpopulation D in this report to provide further comparative data from a second small CSSS subpopulation. We refer readers to the 2016 annual report to SFWMD provided by Ecostudies Institute for a more detailed summary of this research (Virzi and Davis 2016).

2.4.1 Study Area

Demographic monitoring was in the core area in sparrow subpopulation D east of Aerojet Road and south of the East-West Road, surveying the area between the following ENP helicopter survey sites: rprse-22 to 24 and rprse-31 to 33 (**Figure 2.3**). In 2015, our demographic study plot in subpopulation D was reduced in size, as described previously for subpopulations A and B, in order to standardize our survey areas and meet the goals of our new research design. Overall, the total area surveyed in 2015 covered approximately 1.6 km² and was thus substantially smaller in size than the area surveyed in previous years. As described in our other study plots in other subpopulations, we placed our study plot in the area of the highest known density of breeding sparrows in subpopulation D. Thus, our survey area was more compact than in previous years but still covered most of the occupied habitat in this area in 2015. In 2016, however, we further reduced our study area by approximately 50% (to ~ 0.8 km²) due to difficult field conditions (see below).

High water levels as a result of historic rainfall during winter 2015-2016 made field conditions very difficult to hazardous in subpopulation D for the duration of the 2016 field season. Suspended sediment from an extended period of high water levels made the soil soft and deep, which made walking in our study plot exhausting. Basically, the ground never dried out and had a chance to firm up in the early spring, as is normally the case. Fieldwork was suspended after one replicate of our plot line transect surveys was completed on 7 April. We were unable to survey the southern and eastern portions of our study plot at all due to high water levels (see **Figure 2.3** for total extent of survey effort in 2016). Subpopulation D was again accessed by

helicopter on 24 June to confirm band resights and look for breeding activity, and to re-assess field conditions, but ground surveys were not reinitiated due to the continued hazardous field conditions.

2.4.2 Sparrow Numbers

During 2016 we located five territorial male sparrows in our study plot in subpopulation D, which is a large decline from the 11 males detected in 2015 (**Table 2.1; Figure 2.3**). This smaller number is partially a result of the reduced search effort in 2016, as we only surveyed the core breeding area and were unable to investigate areas further to the east and south. The number of territory-holding males in the core area was similar to that seen in 2015 (Virzi *et al.* 2016). We were only able to confirm the presence of one female in 2016, although the behavior of another male raised the possibility that he was also paired. The sex ratio (0.83) was slightly less male-biased than the rate observed in 2015 (0.92); however, as seen previously in subpopulation A this was not due to an increase in females but rather a reduction in males. The lack of females has been a persistent problem in this small sparrow subpopulation since intensive demographic monitoring was initiated in 2006, even as male numbers have generally increased in that time. As a result of the field conditions, there was no territory mapping in subpopulation D in 2016.

2.4.3 Reproduction

Late-season breeding activity was observed on the 24 June visit, and the presence of one breeding pair was confirmed. A banded male was seen with food in his mouth, and a female was briefly seen nearby. The pair may have been feeding fledglings based on this behavior, suggesting a successful breeding attempt in Pop D this season; however, this could not be confirmed. Water levels were low enough to permit breeding at this time in the core area.

A second banded male may have been paired during the early season; his behavior suggested this was the case and he may have been holding a territory where the only nesting occurred in 2015. This area was also one of the few areas of the study plot above water during March and

April. However, we were never able to confirm a female or nest with this bird, in addition to being unable to read his color band combination.

2.4.4 Mark-recapture Data

During the abbreviated 2016 field season we resighted three of the 11 color-banded adult sparrows (all males) that were present in the breeding population in 2015 (**Table 2.2**). A fourth male was banded, but we could never see his combination, and the fifth male present in the subpopulation was unbanded. We were unable to see if the one female present was banded or not. The low return rate of 0.27 for adult sparrows is partially a result of the reduced resight effort in 2016, but if the rate is accurate it would represent a reversal of the positive trend observed in 2014-2015. This return rate is similar to the low return rates observed in subpopulation D in 2012-2013, and is much lower than the rate expected in a healthy subpopulation (~0.60) based on previous CSSS research (Boulton *et al.* 2009, Gilroy *et al.* 2012a). The lack of new or returning females continues to be a persistent problem in subpopulation D every year.

2.5 Comparative Data

This section of our report summarizes and compares data collected in CSSS subpopulations A, B and D during the 2016 sparrow breeding season. **Tables 2.1 and 2.2** present data collected in these subpopulations from 2012-2016. For small subpopulation A, we present data from our study plot near West Camp in order to show trends in demographic parameters over recent breeding seasons. We monitored subpopulation A with similar effort in each of these years making these data comparable, albeit with somewhat reduced effort in 2015-2016 as described previously. Monitoring effort in small subpopulation D was also similar among years with the exception of the greatly reduced effort in 2016 as described previously. For large subpopulation B, we present data collected in our DL study plot from 2012-2016. Survey and nest monitoring effort was similar from 2013-2016; however, in 2012 we conducted intensive ground surveys but did not monitor nests. During 2016, we also collected mark-recapture data in our AH study plot; however, these data are not included in the comparative data for subpopulation B

presented in this section. The objective of this section is to highlight some of the important differences we observed in the demographic data from subpopulation A compared to another small subpopulation (D) and a large reference subpopulation (B).

2.5.1 Population Trends

Figure 2.4 shows trends in abundance of Cape Sable seaside sparrows on our demographic study plots in small subpopulations A and D compared with trends in large subpopulation B from 2012-2016. We should note that abundance estimates remain comparable in 2015-2016 despite a reduction in the size of our demographic study plots beginning in 2015 because we placed our plots in the core breeding areas where sparrows were located in recent years. However, survey effort was substantially reduced in subpopulation D in 2016 which would affect interpretation of trends for this year.

The most obvious trend is the sharp decline in abundance in subpopulation B in 2016. Sparrow numbers in our study plot in this large subpopulation had been increasing modestly over the past three years, at a time when numbers in small subpopulation A had been stable or declining. This trend reversed in 2016 with A reporting a modest increase while B reported a sharp decline. Small subpopulation D also reported a decline in 2016, but this is likely due to our reduced survey effort this year. Thus, the observed decline in subpopulation B is perhaps more alarming given the trends in the other small subpopulations monitored.

The decline in abundance in subpopulation B from 2015-2016 was due to large declines in both males (18 to 11) and females (16 to 5). It is unknown whether this decline was a local effect due to conditions becoming more unsuitable on the DL study plot, or if this represents a more widespread decline across subpopulation B. This illustrates a drawback of using one small sampling area to represent trends across a larger population, as other observations suggest that sparrow numbers and densities in areas of subpopulation B outside of DL may be holding more steady (e.g., mark-recapture observations in the AH study plot). Vegetation in the DL study plot generally contains more sawgrass (i.e., longer hydroperiod vegetation) than in areas where sparrows are breeding in our study plots in subpopulations A and D, and thus the high

water levels in 2016 may have influenced local sparrow habitat selection more in this area than in the other study plots being monitored. However, additional off-plot surveys did not detect any short-distance dispersal events suggesting that this is not the case. Rather, we hypothesize that overwinter mortality was likely higher in subpopulation B causing the population decline observed in 2016.

Thus, our 2016 data suggests that local factors affected the subpopulations being monitored differently. Environmental conditions (e.g., local rainfall or water depths) were relatively similar in all three breeding populations over the period examined so local annual recruitment should be expected to be similar in all three subpopulations monitored. All areas experienced above-normal water levels over the winter and early spring periods leading into the 2016 breeding season; however, this was most pronounced in subpopulation D. It is unknown what the effects of these high water levels were on territory selection; a process that, for most individuals, generally occurs prior to the start of our field season in March. Local conditions during the core CSSS breeding season (April-July) in subpopulation A were typically better than in the other subpopulations monitored, which might partially explain the declines in the other subpopulations. However, the low return rate of previously color-banded individuals in our DL study plot suggests that overwinter mortality may have been high due to the extremely wet conditions that prevailed during the winter of 2015-2016 resulting in the sharp decline in numbers observed in subpopulation B.

The density of sparrows on the DL plot in subpopulation B dropped by more than half from 2015-2016 (from 50.0 sparrows/km² to 23.5 sparrows/km²), while the density in A increased moderately (from 8.8 sparrows/km² to 9.4 sparrows/km²). Subpopulation D reported a density estimate more similar to A in 2015-2016 (7.5 sparrows/km²). The low density estimate on our study plot in small subpopulation D may be explained by a lack of enough suitable breeding habitat in this area. There does appear, however, to be suitable yet unoccupied habitat on our study plot in subpopulation A suggesting other factors are limiting sparrow density there. The inability of the sparrow population in A to reverse recent declines when apparently suitable habitat is available has been a major question to conservation managers. Unfortunately,

because the population size is small our sample sizes for estimating demographic rates are also small making it difficult to make strong inferences about limiting factors. It seems likely that several factors are working congruently to stem population recovery in subpopulation A. One pattern that appears when looking at the comparable data is that the demographic rates that drive population growth – reproduction, survival, and recruitment (juvenile survival) rates – have been generally lower in subpopulation A compared to subpopulations B and D. However, we have little information on the habitat factors (e.g., vegetation, predators, food availability) that influence these demographic rates in subpopulation A, and thus no way to develop strategies aimed at improving vital rates. An expanded demographic monitoring effort could help answer these questions and should be considered for future research.

One area on our study plot in subpopulation A where sparrows were expected to recolonize is the area that burned in the southern portion of the Lower Meadow in 2008. This area supported numerous breeding territories prior to the burn based on previous research; sparrows can reoccupy burned patches two to three years post-fire (La Puma *et al.* 2007). Prairie vegetation in this area has recovered and appears suitable for sparrows. Two territories were completely within the burned area for the entire 2016 season (**Figure 2.1**) and these birds attempted breeding; this is the first time breeding has been seen away from the edge of the burn. Still, if the population growth rate within subpopulation A remains < 1.0 , there may be no surplus birds capable of immigrating into this area. It is also possible that more sparrows have not moved into the recovered habitat near West Camp due to strong philopatry to the Lower Meadow, where sparrows have been breeding in recent years, or due to the influence of stronger conspecific attraction in those same areas (Virzi *et al.* 2012). It will be interesting to see whether breeding can persist and potentially expand in the burn area in future years.

Subpopulation A is not likely to see a substantial increase in numbers through immigration from other subpopulations. Subpopulation A is certainly the most isolated sparrow subpopulation, being the only subpopulation located west of the Shark River Slough. Sparrow dispersal probability declines greatly over longer distances and thus the likelihood of sparrows from other subpopulations dispersing into subpopulation A is low (Gilroy *et al.* 2012a; Van Houtan *et*

al. 2010). In fact, no between-subpopulation dispersal events have been documented into our study plot in subpopulation A from 2008-2016. Since 2012, we have documented two dispersal events between subpopulations B and D indicating that there is better connectivity between these subpopulations.

2.5.2 Sex Ratios

Our data suggests that there is consistently a more highly-skewed sex ratio in the small sparrow subpopulations than in large subpopulations (**Figure 2.5**). The mean sex ratios in small subpopulations A (0.64) and D (0.78) over the period from 2012-2016 were above the mean reported in large subpopulation B (0.60) over the same period. Further, annual sex ratios were lowest in subpopulation B in all years prior to 2016. This trend reversed in 2016, as the sex ratio in subpopulation B (0.69) was higher than the ratio in A (0.60) for the first time. The DL study plot in subpopulation B underwent a severe reduction in the numbers of both male and female sparrows occupying it in 2016, and took on the sex ratio characteristics of a smaller population. This is in spite of the close proximity to higher density sparrow breeding areas nearby that are well within the range of commonly-observed dispersal movements. We do not have an explanation for the shift, although we suspect it is temporary based on previous data that shows small CSSS subpopulations, as well as other threatened avian species, tend to have male-biased sex ratios (Virzi *et al.* 2011b, Donald 2007).

Possible explanations for male-biased sex ratios in sparrows are the effects of inbreeding (Liker and Szekely 2005), lower female survival rates (Gruebler *et al.* 2008) or sex-specific dispersal patterns (Steifetten and Dale 2006). Adult female survival is known to be lower than adult male survival in the CSSS (Boulton *et al.* 2009), which might be contributing towards the imbalanced sex ratios observed in small subpopulations. Small, isolated populations may be particularly vulnerable to skewed sex ratios because natal dispersal is usually female-biased (Dale 2001). It is unknown at this time why the sex ratio is so skewed in these small sparrow subpopulations, but the consequences can be severe, as was the case with the now extinct Dusky seaside sparrow (*A. m. nigrescens*). More research is needed to understand the factors that drive the

sex-ratio bias in CSSS, although the dramatic sudden change in sex ratio that occurred on the DL plot in 2016 may provide an opportunity to gain additional insight, as factors related to isolation can be ruled out here. It is possible that the historic water levels reported during the winter of 2015-2016 resulted in lower female overwinter survival, as suggested by the extremely low return rates observed in our data.

Conservation techniques to address the problem of imbalanced sex ratios in small CSSS subpopulations should be considered, including possible translocation of female sparrows from a larger and more stable subpopulation to subpopulations with severely male-biased sex ratios. However, given the decline in female abundance on our DL study plot in 2016 we suggest that other sites should be considered as potential source populations. If the decline in abundance in DL is determined to be temporary based on a reversal of trends in 2017 this site may still be a viable source population. If not, other areas located more in the core of CSSS subpopulation B (e.g., the historic Old Ingraham Highway study plot) might be better suited as a source population.

2.5.3 Reproduction

It is difficult to make statistical comparisons of nest success data among CSSS subpopulations due to small sample sizes; however, we note the following observations. First, it is clear that sparrows breeding in large subpopulation B have generally been more successful than sparrows breeding in small subpopulation A. Second, sparrows breeding in small subpopulation D have also reported higher nest success rates than sparrows in subpopulation A in recent years. Thus, it appears that factors other than possible Allee effects – which were not shown to occur in another study by Gilroy *et al.* (2012b) – may be causing the lower reproductive rates in subpopulation A. The 2016 breeding season was characterized by a reversal of the trends noted in recent years: nests monitored in subpopulation A showed greater success rates by nearly all measures than nests monitored in subpopulation B. This lends further credence to the theory that Allee effects are not the main driver of low productivity in subpopulation A.

One troubling pattern seen in the reproductive data is that the hatch rate has historically been much lower in subpopulation A than in subpopulations B or D. The mean hatch rate from 2012-2015 in subpopulation A was only 0.49, compared to mean rates of 0.76 and 0.92 in subpopulations B and D, respectively (Virzi *et al* 2016). However, in 2016, the hatch rate of 0.89 was the highest we have ever recorded in subpopulation A, while the hatch rate observed in subpopulation B (0.75) remained similar to previous years. The mean fledge rate (number nests fledged/number hatched) from 2012-2016 is actually higher in subpopulation A (mean = 0.63) compared to subpopulation B (0.59), further suggesting that the key demographic parameter influencing overall productivity is the hatch rate. Predation is thought to be the primary cause of CSSS nest failure so it is possible that nest predation rates at the incubation stage are higher in subpopulation A. One hypothesis for increased predation in A is a greater abundance of predators, such as rice rats, in the region; however, this remains untested. Another hypothesis is that predator movements are more influenced by fluctuations in water levels caused by water management decisions affecting subpopulation A resulting in more chance encounters with nests. An interesting hypothesis explaining the increased hatch rate in 2016 is that the unusually high water levels over the winter of 2015-2016 affected the survival or distribution of predators in subpopulation A to the benefit of the sparrows, but this is speculation.

Another important observation in our 2016 data is that late-season nesting (June through early August) was very important to overall reproductive success in both small subpopulation A and in large subpopulation B, despite past research showing that early season nests (March through May) generally have higher success rates (Baiser *et al*. 2008). Nesting was initiated late in subpopulation A in 2016, and more nests fledged late-season (3) than early-season (1), continuing a trend seen in 2015. This trend was also observed in subpopulation B, with two of three successful nests fledging during the late-season, despite the earlier initiation of breeding at this site compared to subpopulation A. Thus, late-season nesting is crucial for overall reproductive success and this must be taken into consideration for water management decisions that affect occupied sparrow habitats.

Multi-brooding was confirmed in both subpopulations A and B in 2016; 14% of the pairs in A and 20% of the pairs in B were able to successfully raise a second brood. Water levels were unusually high in all subpopulations over the previous winter and were slow to recede, but by early April they had dropped down to more typical levels seen during the breeding season, with fluctuations up and down in response to local rainfall. Since multi-brooding is predicted to be critical for the population viability of the CSSS it is vitally important to identify the factors that lead to successful multi-brooding. Data from past seasons indicate that low water levels may not be the sole factor necessary for sparrows to multi-brood (Slater *et al.* 2014). It is possible that water management decisions that affect the rate and quantity of late-season flow into subpopulation A could be limiting late-season breeding opportunities by affecting predator movements and thus increasing nest predation rates, but this hypothesis remains untested.

Over the period analyzed, sparrows were able to multi-brood in subpopulation B every year, while sparrows multi-brooded in subpopulation A only in 2016 and in subpopulation D in 2014. Although Gilroy *et al.* (2012b) previously found no Allee effects associated with nest success rates among CSSS subpopulations, it is still possible that there could be an unrecognized Allee effect in small sparrow subpopulations leading to a lack of multi-brooding, perhaps due to a lack of sufficient conspecific cues in the small subpopulations as one hypothesis (Virzi *et al.* 2012). We suggest that this is an area of research that deserves far more attention.

2.5.4 Survival

The return rate for adult sparrows in subpopulation A (0.62) was above the rates observed on the DL (0.18) and AH (0.55) plots in subpopulation B in 2016 (**Tables 2.2 and 2.3**). Interestingly, in 2016 the return rates for both male and female sparrows in subpopulation A (0.63 and 0.60, respectively) were similar and fairly robust, contrasting with the extremely low return rate for females (0.17) seen here in 2015. The higher female return rate in 2016 is a welcome reprieve from the low female return rates reported in previous years; however, female abundance remains very low. Low female return rates in subpopulation A are of major concern since this small subpopulation is already on the brink of extirpation. The low rates could be the result of

lower female survival or the dispersal of individuals to areas off our study plot. Long-distance dispersal is rare for the CSSS so this is unlikely to be the cause for low return rates; although we cannot completely rule out that short-distance dispersal is going undetected due to the small size of our study plot. However, additional ground surveys conducted in 2016 in adjacent areas outside of our demographic study plot boundary found no dispersing individuals (see **Section 3.0**). Dispersal patterns of both sexes and potential causes for the male-biased sex ratios seen in small sparrow subpopulations remain critical factors that need more understanding in order to better assess the rangewide status of the Cape Sable seaside sparrow.

2.6 Conclusions

Overall, the 2016 sparrow breeding season was an unusual year with regards to overall nest success rates in subpopulations A and B. Nests in subpopulation A were more successful compared to past seasons, and compared to subpopulation B in 2016. This largely appears to be a result of lower predation rates in subpopulation A during the 2016 breeding season, but the causes for these lower rates are unknown. At the same time, between 2015 and 2016 the study plot in subpopulation B experienced a steep decline in pairs attempting to nest combined with a high early-season predation rate. The sudden nature of this decline is extremely alarming, especially if it is widespread across subpopulation B and is not just a local occurrence on our DL study plot. Future demographic research should include measures to better identify nest predators since predation rates generally appear higher in subpopulation A than in either of the other subpopulations being monitored and are an important limiting factor in breeding success. One field technique that could be considered is the deployment of nest cameras to identify predators. More detailed nest survival analysis of existing data may also be warranted to better understand success rates at various stages, and to compare differences among subpopulations being monitored. Sample sizes continue to be a problem limiting such analyses due to small population sizes, small plot sizes and a limited number of demographic study plots currently being monitored annually. We suggest that demographic monitoring efforts be increased by adding additional study plots where possible; increasing the sizes of current plots is not possible

due to the distribution of sparrows in these areas (i.e., plots are already covering the areas of highest CSSS density).

An important observation is that multi-brooding, which is necessary for CSSS population viability, continues to be a rare event. While multi-brooding occurred regularly in large subpopulation B over the 5-year period analyzed, it only occurred once in each small subpopulation monitored (A and D). Factors that enable multi-brooding include an early start to nesting, when predation rates are generally lower, and an extended breeding season with water levels that allow for continued nesting through early August, when the majority of birds are physiologically finished with breeding. While managers do not have control over nest initiation times and predation rates, managed water releases into the system should be delayed until at least 1 August to allow for the completion of late nesting attempts, particularly in subpopulation A. Further research is needed to understand why multi-brooding is not more widespread across all populations, including a longer field season to monitor late-season breeding attempts until completion.

Overall productivity and recruitment remain very low in subpopulation A due to the small population size and limited dispersal into this isolated CSSS subpopulation. We have not observed any dispersal into subpopulation A since monitoring began there in 2008. While dispersal events into subpopulation A have occurred (Van Houtan *et al.* 2010), these events are certainly quite rare and likely not occurring at a rate necessary to sustain this subpopulation and promote recovery. Local productivity and recruitment rates also appear to be too low to sustain this subpopulation and prevent extinction without sufficient immigration into the subpopulation. We suggest that translocation of sparrows into subpopulation A may be necessary at this time to avoid extinction of this critical subpopulation.

The low return rate of female sparrows in subpopulation A in 2015 raised alarm that dispersal or survival rates may be lower for females in this area. Although the return rate for females recovered in 2016, and actually was higher than the mean observed in subpopulation B, it remains to be seen whether this is a positive trend or an anomaly. In the past, we have

suggested translocation of females as the best management option for bolstering subpopulation A. However, overall sparrow numbers may have declined to the point where both males and females should be considered for translocation at this time. Before conducting any translocations, we suggest that survival analyses be re-examined now that more data is available – the last analysis was conducted by Gilroy *et al.* (2012a) – to better understand if there is an issue with female survival in subpopulation A. We also continue to recommend that efforts be made to better understand the causes of low demographic rates (especially hatch rates) in subpopulation A before translocating sparrows there. Finally, a detailed translocation plan should be developed before moving any birds.

2.7 Tables and Figures

TABLE 2.1: Demographic data for Cape Sable seaside sparrows breeding in small subpopulations A and D compared with data from large subpopulation B (2012 - 2016). Nests were not monitored in subpopulation B in 2012, or in subpopulation D in 2016. Sex Ratio = male bias in subpopulation (Males / Total Population); Density = number of sparrows per square km; Chicks Fledged/S.Nest = Chicks Fledged / Nests Fledged; Chicks Fledged/Pair = Chicks Fledged / Breeding Pairs. Mean (μ) and standard deviation (σ) reported for all demographic parameters, except density estimates which are not meaningful due to changes in sizes of study plots in 2015 (see footnote).

	Pop A							Pop D							Pop B						
Data	2012	2013	2014	2015	2016	μ	σ	2012	2013	2014	2015	2016	μ	σ	2012	2013	2014	2015	2016	μ	σ
Total Population	22	15	14	14	15	16	3	8	5	14	12	6	9	4	28	27	30	34	16	27	7
Breeding Pairs	6	6	6	6	7	6	0	2	2	3	1	1	2	1	8	11	13	15	5	10	4
Males	17	10	8	8	9	10	4	6	3	11	11	5	7	4	18	16	17	18	11	16	3
Females	5	5	6	6	6	6	1	2	2	3	1	1	2	1	8	11	13	16	5	11	4
Sex Ratio	0.77	0.67	0.57	0.57	0.60	0.64	0.09	0.75	0.60	0.79	0.92	0.83	0.78	0.12	0.64	0.59	0.57	0.53	0.69	0.60	0.06
Density ^(a)	4.4	3.0	2.8	8.8	9.4	na	na	4.0	2.5	7.0	7.5	7.5	na	na	18.7	18.0	20.0	50.0	23.5	na	na
Nests	9	7	7	12	9	9	2	3	2	4	3	0	2	2	9	14	26	32	8	18	11
Mean Clutch Size	3.8	3.0	3.3	3.6	4.0	3.5	0.4	3.7	3.0	3.3	3.7	na	3.4	0.3	na	3.2	3.2	3.3	3.0	3.2	0.1
Nests Hatched	4	4	3	6	8	5	2	2	2	4	3	na	3	1	na	11	20	23	6	15	8
Hatch Rate	0.44	0.57	0.43	0.50	0.89	0.57	0.19	0.67	1.00	1.00	1.00	na	0.92	0.17	na	0.79	0.77	0.72	0.75	0.76	0.03
Nests Fledged	2	2	3	4	4	3	1	1	2	2	1	na	2	1	na	9	12	10	3	9	4
Fledge Rate/Hatched	0.50	0.50	1.00	0.67	0.50	0.63	0.22	0.50	1.00	0.50	0.33	na	0.58	0.29	na	0.82	0.60	0.43	0.50	0.59	0.17
Fledge Rate/Nest	0.22	0.29	0.43	0.33	0.44	0.34	0.09	0.33	1.00	0.50	0.33	na	0.54	0.32	na	0.64	0.46	0.31	0.38	0.45	0.14
Chicks Fledged	3	5	9	7	13	7	4	1	6	7	2	na	4	3	na	27	33	25	8	23	11
Chicks Fledged/S.Nest	1.5	2.5	3.0	1.5	3.3	2.4	0.8	1.0	3.0	3.5	2.0	na	2.4	1.1	na	3.0	3.0	3.1	2.7	2.9	0.2
Chicks Fledged/Pair	0.5	0.8	1.5	1.2	1.9	1.2	0.5	0.5	3.0	2.3	2.0	na	2.0	1.1	na	2.5	2.5	1.7	1.6	2.1	0.5
Pairs Multi-brooding	0	0	0	0	1	0	0	0	0	1	0	na	0	1	na	3	3	3	1	3	1
%Multi-brooding	0.00	0.00	0.00	0.00	0.14	0.03	0.06	0.00	0.00	0.33	0.00	na	0.08	0.17	na	0.27	0.23	0.20	0.20	0.23	0.03

^(a) Density estimated as number of sparrows per km² based on territory mapping data from study plots. Note that study plots were reduced in size in 2015, and were placed in highest density areas within former study plots. Therefore, higher density estimates reported in 2015-2016 do not indicate an increase in sparrow density compared to previous years.

TABLE 2.2: Mark-recapture data for Cape Sable seaside sparrows breeding in small subpopulations A and D compared with data from large subpopulation B (2012 - 2016). Banded Birds = total number of banded birds (by age class and sex) in subpopulation at year end (birds banded current year + resights); Resights = total number of resights of banded individuals found in breeding population in prior year; Return Rate = Resights / Banded Birds (from prior year, by age class and sex). Return rates not calculated in years where there were no color-banded individuals in any age class in the prior year. Mean (μ) and standard deviation (σ) reported for all demographic parameters.

	Pop A							Pop D							Pop B						
Data	2012	2013	2014	2015	2016	μ	σ	2012	2013	2014	2015	2016	μ	σ	2012	2013	2014	2015	2016	μ	σ
<u>Banded Birds:</u>																					
Adults (A)	21	14	13	13	14	15	3	8	5	13	11	3	8	4	28	25	29	33	12	25	8
Males (M)	17	10	7	8	9	10	4	6	3	11	10	3	7	4	18	16	17	18	9	16	4
Females (F)	4	4	6	5	5	5	1	2	2	2	1	0	1	1	8	9	12	15	3	9	5
Juveniles (J)	0	2	0	0	9	2	4	0	0	0	0	0	0	0	8	5	23	13	14	13	7
Nestlings (N)	3	3	3	0	0	2	2	3	5	12	0	0	4	5	16	17	37	0	0	14	15
<u>Resighted Birds:</u>																					
Resights – A	10	10	6	6	8	8	2	2	2	3	7	3	3	2	5	15	11	16	6	11	5
Resights – M	10	8	4	5	5	6	3	2	2	2	7	3	3	2	2	11	8	10	5	7	4
Resights – F	0	2	2	1	3	2	1	na	0	1	0	0	0	1	3	4	3	6	1	3	2
Return Rate – A	0.56	0.48	0.43	0.46	0.62	0.51	0.08	0.33	0.25	0.60	0.54	0.27	0.40	0.16	na	0.54	0.44	0.55	0.18	0.43	0.17
Return Rate – M	0.67	0.47	0.40	0.71	0.63	0.58	0.13	0.33	0.33	0.67	0.64	0.30	0.45	0.18	na	0.61	0.50	0.59	0.28	0.49	0.15
Return Rate – F	0.00	0.50	0.50	0.17	0.60	0.35	0.26	na	0.00	0.50	0.00	0.00	0.13	0.25	na	0.50	0.33	0.50	0.07	0.35	0.20
Resights – J	3	na	2	na	na	3	1	na	na	na	na	na	na	na	na	2	3	5	3	3	1
Resights – N	1	1	0	0	na	1	1	na	0	1	1	na	1	1	na	0	3	1	na	1	2
Return Rate – J	1.00	na	1.00	na	na	1.00	0.00	na	na	na	na	na	na	na	na	0.25	0.60	0.22	0.23	0.33	0.18
Return Rate – N	0.13	0.33	0.00	0.00	na	0.11	0.16	na	0.00	0.20	0.08	na	0.09	0.10	na	0.00	0.18	0.03	na	0.07	0.10

TABLE 2.3: Mark-recapture data for Cape Sable seaside sparrows (CSSS) in the Alligator Hammock Study Plot (AH) located in large subpopulation B (2015 - 2016). CSSS were first banded in AH in 2015; resight surveys were first conducted in 2016. However, survey effort was lower than our main demographic study plots in 2016.

Data	2015	2016
<u>Banded Birds:</u>		
Adults (A)	11	18
Males (M)	7	12
Females (F)	4	6
Juveniles (J)	9	4
Nestlings (N)	1	0
<u>Resighted Birds:</u>		
Resights – A	1	6
Resights – M	1	5
Resights – F	0	1
Return Rate – A	na	0.55
Return Rate – M	na	0.71
Return Rate – F	na	0.25
Resights – J	0	6
Resights – N	0	0
Return Rate – J	na	0.67
Return Rate – N	na	0.00

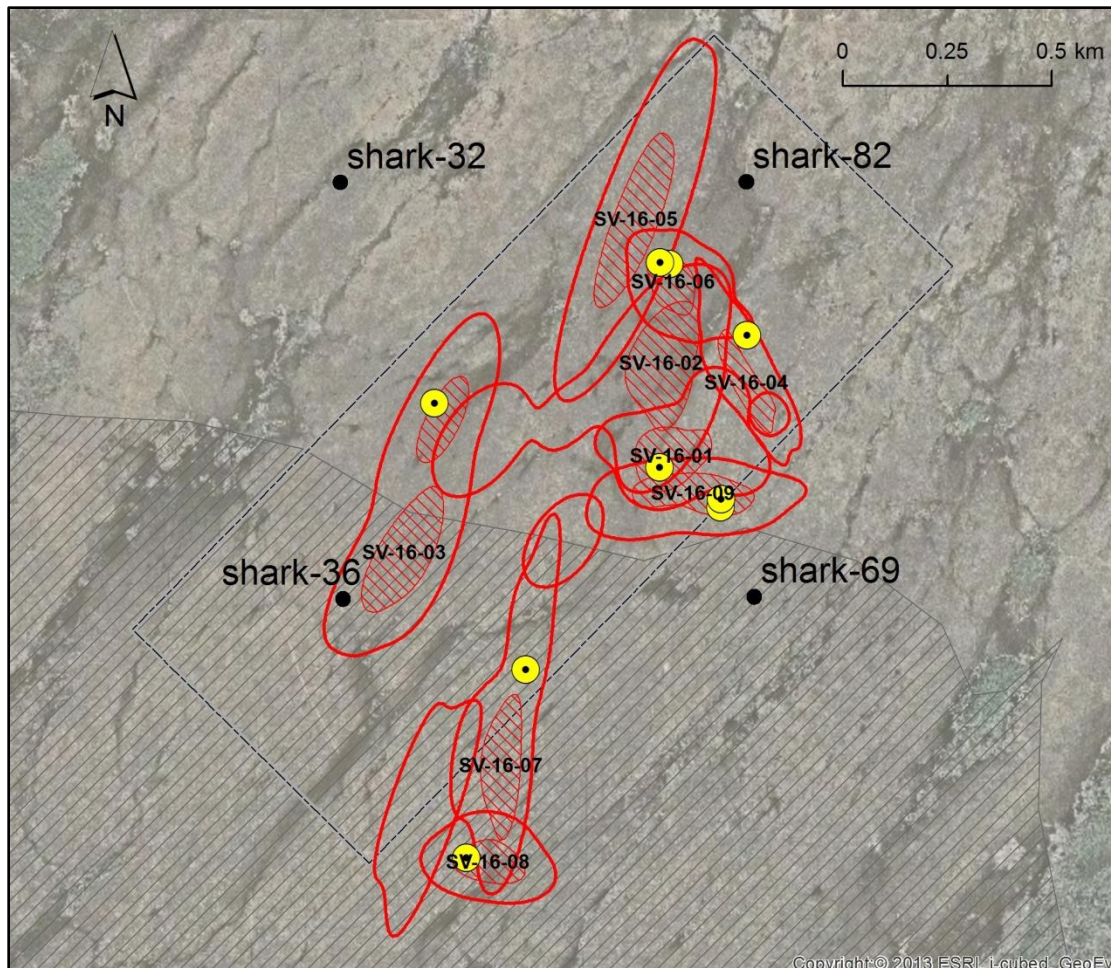


FIGURE 2.1: Cape Sable seaside sparrow (CSSS) territories for breeding (red) and single (blue) male sparrows in subpopulation A in 2016. Home ranges (95% isopleth lines) and core ranges (50% isopleths; hatched areas) were derived by kernel density estimation analysis conducted in ArcGIS 10.2.2 using the Geospatial Modelling Environment plug-in toolset (Beyer 2015). Black circles correspond to Everglades National Park helicopter survey sites. Nine male sparrows were observed singing on apparent territories during 2016, although all birds were not present throughout the season. Yellow circles correspond to locations of sparrow nests monitored during 2016. Grey hatched area represents boundary of fire that burned near West Camp in 2008.

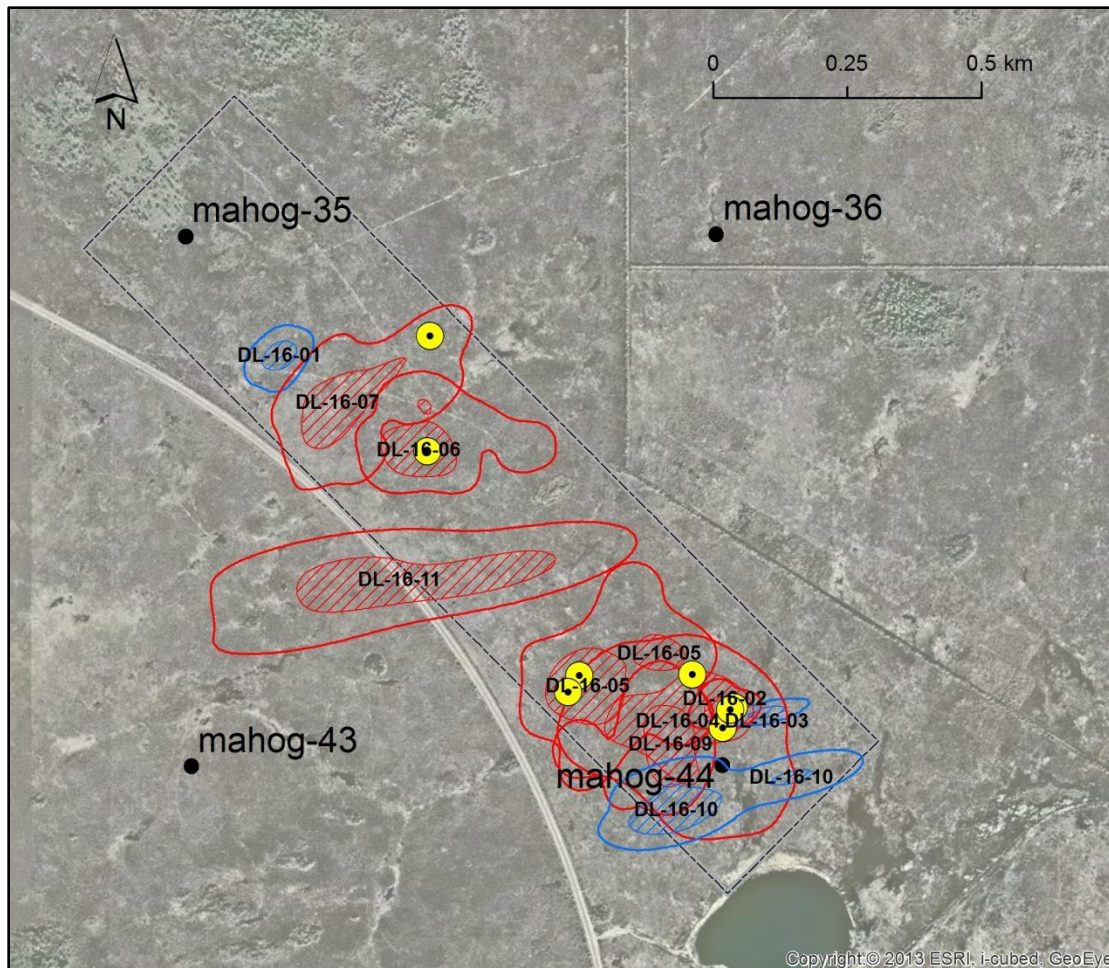


FIGURE 2.2: Cape Sable seaside sparrow (CSSS) territories for breeding (red) and single (blue) male sparrows in subpopulation B in 2016. Home ranges (95% isopleth lines) and core ranges (50% isopleths; hatched areas) were derived by kernel density estimation analysis conducted in ArcGIS 10.2.2 using the Geospatial Modelling Environment plug-in toolset (Beyer 2015). Black circles correspond to Everglades National Park helicopter survey sites. Eleven male sparrows were observed singing on apparent territories during 2016, although all birds were not present throughout the season. Yellow circles correspond to locations of sparrow nests monitored during 2016.

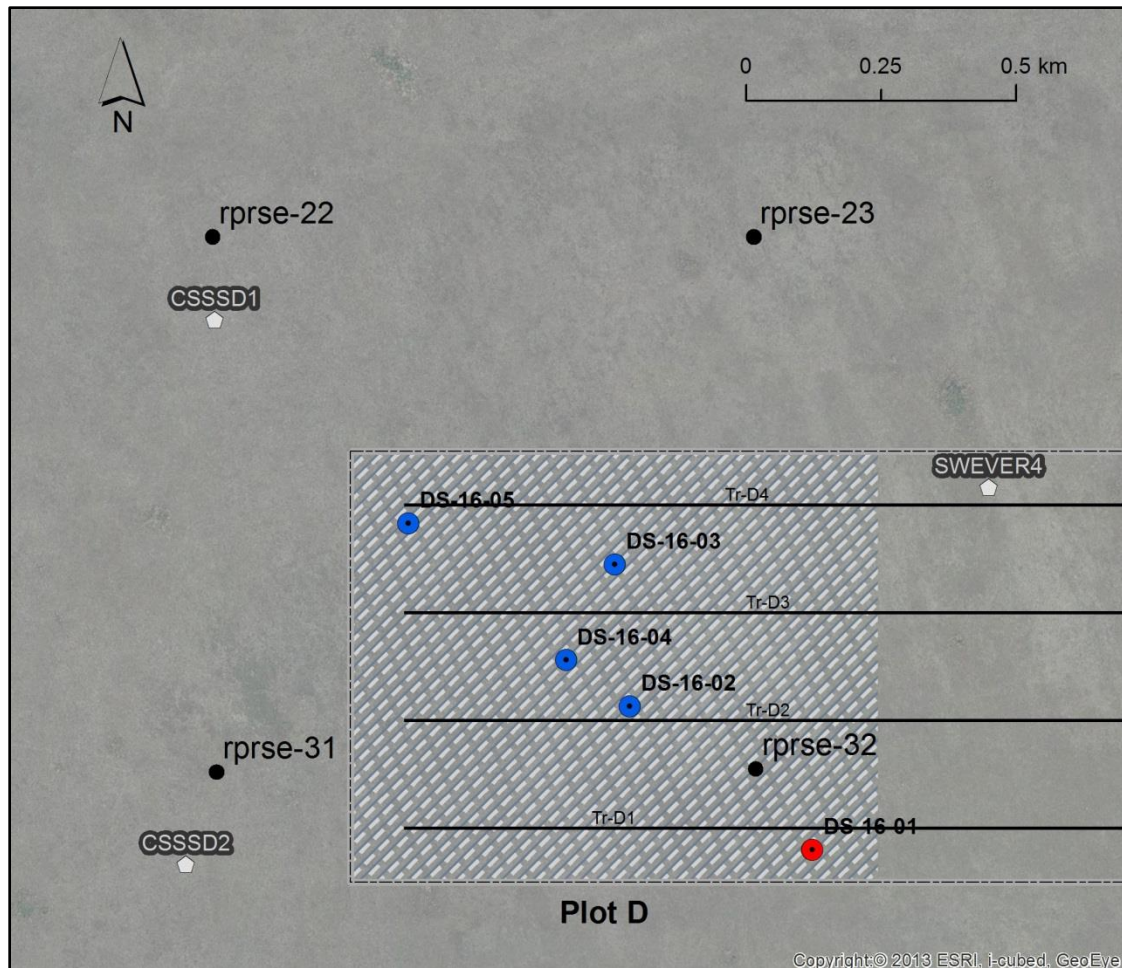


FIGURE 2.3: Location of Cape Sable seaside sparrow (CSSS) territories in subpopulation D during the 2016 breeding season. Black circles correspond to ENP helicopter survey sites. Five male sparrows were observed singing on apparent territories during 2016; only one of these males was paired and apparently nested (DS-16-01). Blue circles represent central locations of single male sparrow territories; red circle represents central location of the only paired male sparrow territory (female detected – possibly feeding fledglings). Hatched area represents area where survey effort was focused in 2016.

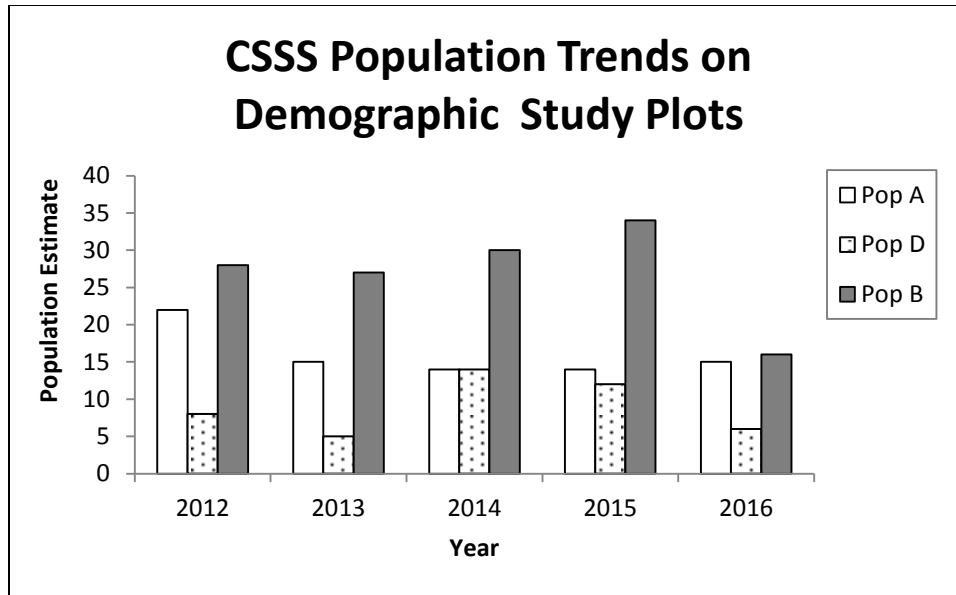


FIGURE 2.4: Number of Cape Sable seaside sparrows (CSSS) on demographic study plots in subpopulations A, B and D (2012-2016). Total area surveyed within each study plot was consistent from 2012-2014. In 2015, all study plots were reduced in size; however, core breeding areas from previous years were surveyed with similar effort making data comparable. Survey effort in 2016 was consistent in subpopulations A and B; however, effort was substantially reduced in subpopulation D due to difficult field conditions.

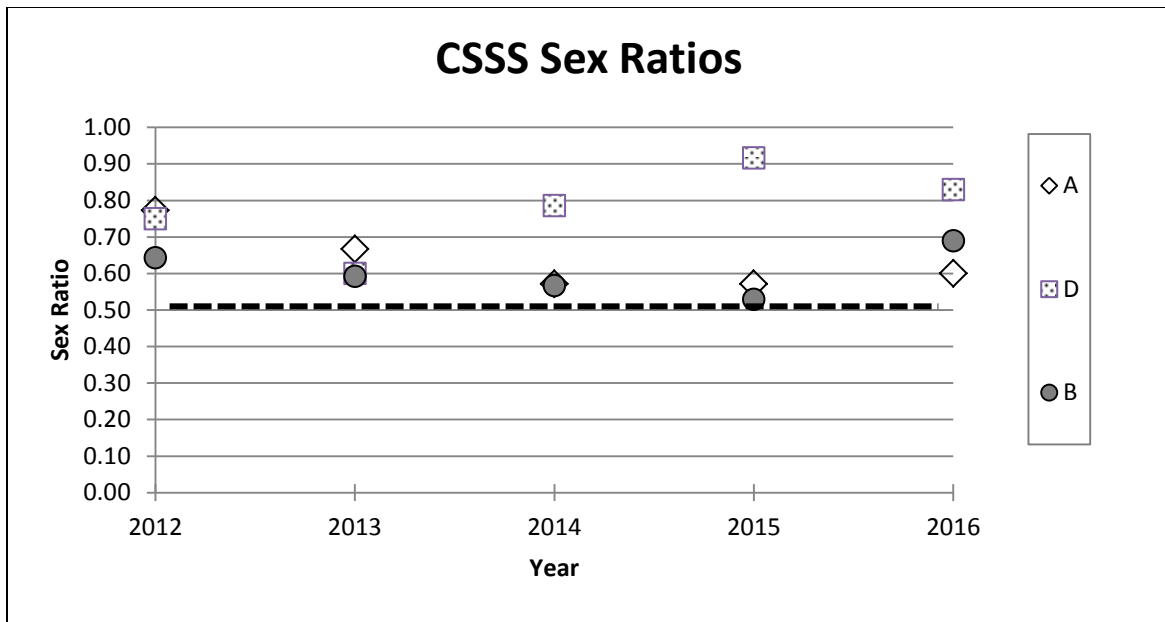


FIGURE 2.5: Cape Sable seaside sparrow (CSSS) sex ratios observed during the 2012-2016 breeding seasons in small subpopulations A and D compared to sex ratios observed in large subpopulation B. Ratios > 0.50 indicate male-biased sex ratios (black dashed line).

3.0 Spatially-explicit Population Estimator

3.1 Introduction

One of our main objectives in 2015-2016 was to develop a spatially-explicit population estimator to improve upon the current CSSS population estimator being used by agencies. At present, agencies continue to make significant management decisions based on a CSSS population estimate derived by multiplying the unadjusted count data from annual ENP rangewide helicopter surveys using a 16x multiplier (Pimm *et al.* 2002). This method has been shown to be invalid in small sparrow subpopulations where many of the assumptions about breeding sparrows relied upon to develop the estimator are not met (Virzi *et al.* 2016; Virzi *et al.* 2009). However, this multiplier may also not hold in large sparrow subpopulations for similar reasons despite previous evidence suggesting otherwise (Curnutt *et al.* 1998). The ENP rangewide survey data is still useful to examine trends, but the data was not intended to be used for population estimation the way that the surveys were originally designed. One recognized problem is the lack of error estimation surrounding any population estimate based on the current method (Walters *et al.* 2000). We believe that having a more reliable population estimate based on sound methods, with some estimate of precision, is paramount to understanding the current status of the CSSS across its range.

While we did not ultimately derive a new CSSS population estimate at this time, in 2016 we continued to make major strides towards the development of a spatially-explicit population estimator. During 2016, we conducted a pilot study to test new survey methods designed to improve precision of the population estimator. We plan to complete development of a preliminary population estimator in 2017, and to collect additional field data using new survey methods to provide recommendations to modify existing survey methods and improve sampling design. This report provides a summary of our current effort towards developing the spatially-explicit population estimator, and presents preliminary results of our pilot study; however, statistical analysis of results has not been conducted at this time.

3.2 Methods

Virzi *et al.* (2016) brought to light several issues using the historic 16x multiplier to estimate CSSS population size. First, CSSS detection probability is imperfect as should be expected, and the current multiplier assumes perfect detection. The issue of detectability is critically important to consider in any attempt to use count data to estimate population size (Murray *et al.* 2011; MacKenzie & Kendall 2002). The need to incorporate an estimate of detection probability directly into the ENP rangewide helicopter surveys has previously been suggested by both Cassey *et al.* (2007) and Walters *et al.* (2000) in past reviews of the surveys. Virzi *et al.* (2016) also suggested that detection probability may be density dependent with lower rates observed in low density (i.e., small) CSSS subpopulations. We hypothesize that detection probability may be reduced in part due to lower singing rates in low density subpopulations, possibly as a result of a limitation in the amount of conspecific cues available to induce singing at rates expected in a healthy sparrow subpopulation (Virzi *et al.* 2012). Second, territory sizes were found to be much larger in small CSSS subpopulations, which may also contribute to lower detection probability in these areas by reducing encounter rates as sparrows move across much larger areas on the landscape. The larger territory sizes further suggests that the historic 16x multiplier may not be valid in small CSSS subpopulations because the density component of the multiplier fails to hold in these areas. Finally, sex ratios were shown to be more imbalanced in small CSSS subpopulations so we cannot assume that for every male CSSS detected on surveys there is a female sparrow, as is the case with the current multiplier. In fact, in small CSSS subpopulations a large proportion of males encountered typically do not have a mate.

During 2016, we conducted a pilot study to test new survey methods to address two of the major deficiencies with the historic multiplier: 1) the effect of variable singing rates on CSSS detection probability, and 2) methods to better estimate sex ratios in CSSS subpopulations. We also tested two broad survey methods (point count surveys and line transect surveys) to see if there were benefits of either method in addressing these questions. Finally, we conducted repeat surveys at sites, the lack of which has previously been considered to be one of the major deficiencies with the ENP rangewide helicopter surveys (Walters *et al.* 2000). Thus, in 2016 we

selected survey sites presently used by ENP and conducted our own independent surveys (2-3 additional replicates per site). Repeat surveys are likely essential to derive an accurate and precise population estimate since the CSSS count data are highly zero-inflated.

Our broad survey design was developed for reasons besides acting as a pilot study to test new survey methods. We were also interested in surveying areas in close proximity to our existing demographic study plots to search for dispersing individuals. Early in our 2016 field season it became apparent that sparrow numbers were substantially lower on our demographic study plots. We hypothesized that the historically high water levels reported during the winter and early spring leading into the CSSS breeding season may have influenced sparrow behavior, distribution and breeding habitat selection (e.g., sparrows on our study plots may have moved off-plot to drier areas). Thus, we wanted to incorporate additional band resighting surveys off-plot to look for dispersing individuals. In summary, our pilot study not only included testing new survey methods to detect singing male sparrows, but also called for observers to detect females and previously color-banded individuals – both of which provide new information that current rangewide survey methods ignore.

3.2.1 Point Count Surveys

The current ENP rangewide helicopter survey protocol calls for observers to be dropped off at predefined survey sites by helicopter and conduct a 7-min point count survey recording all male CSSS detected singing within 200 m of points (Pimm *et al.* 2002). Recently, the ENP protocol was changed to include distance sampling at points with observers recording the estimated distance of all sparrows detected so that distance sampling procedures may be used to estimate CSSS detection probability and density. Points are visited only once per season, between 1 April and 31 May, with some surveys conducted into early June if necessary. The ENP protocol calls for all surveys to be completed by 09:00, and to be discontinued in high wind conditions or inclement weather. Our general survey protocols follow the ENP protocol for consistency, with several modifications as described below.

We systematically selected survey sites near our demographic study plots in CSSS subpopulation A ($n = 9$) and B ($n = 13$), plus sites in subpopulation C ($n = 9$) in an area where we anticipated adding a new demographic study plot in 2017 (**Figures 3.1 – 3.3**). Between 1 April and 10 June we conducted 1-3 repeated surveys at sites (some sites could not be surveyed multiple times), with repeated surveys separated by 7-14 days. Survey routes were changed between visits when possible in order to avoid a “time-of-day” effect. We also attempted to avoid conducting our surveys on the same days when ENP conducted their surveys so that we could obtain up to four replicates at each survey site.

Our point count survey protocol differed from the ENP protocol by allowing observers to record CSSS detected by site or sound; the ENP surveys are aural surveys only. Further, observers were instructed to record detections of all adult sparrows encountered during the survey (i.e., males and females); the ENP surveys only record detections of males. Observers were also instructed to record all CSSS detections at any distance from the survey point. This is in contrast to the ENP survey protocol which calls for observers to only record sparrows detected within 200 m; however, this protocol is not closely followed by ENP observers based on our review of past survey data. We allowed CSSS detections at any distance because: 1) we believe sparrows can be detected relatively easily at distances > 200 m, and 2) we wanted to maximize the number of detections on surveys, especially in low density areas, to obtain a large enough sample size for statistical analyses.

One of the most significant modifications to the current ENP survey protocol was the addition of time-of-detection sampling to our survey methods. Time-of-detection (TOD) sampling can be used to break down detection probability into separate components for encounter probability and singing rates, and analyzed together using methods such as n-Mixture models to improve precision of estimates (Cunningham & Lindenmayer 2005). Incorporating this information may substantially improve estimates if singing rates are expected to be different among populations, which is our prediction for CSSS subpopulations. Our TOD sampling protocol called for observers to break down each 7-min point count into distinct 1-min intervals, recording whether a focal individual was observed (singing, calling or visually) during each interval. TOD

sampling requires observers to follow multiple focal individuals during each survey (i.e., observers record TOD data for all male sparrows encountered rather than only counting birds). In order to avoid confusion during sampling and to improve accuracy of data collection, observers were instructed to only record TOD data for individuals first detected within 200 m of survey points. For an example datasheet used for our point count surveys see **Figure 3.4**.

Finally, our protocol also called for observers to attempt to resight previously color-banded individuals any time sparrows were detected on a survey; resight surveys occurred either immediately following the point count survey or on an additional return visit to the site.

3.2.2 Line Transect Surveys

Along with our point count surveys, during 2016 we conducted line transect surveys to compare methods for collecting data needed for development of the spatially-explicit population estimator. We have previously conducted line transect surveys for CSSS as part of our demographic monitoring and found them useful for estimating detection probability and plot density (Virzi *et al.* 2016). In addition, line transect surveys conducted on our demographic study plots appeared to be more useful for detecting female sparrows than point count surveys; however, detection probability for females remains quite low using either method. Our previous data, however, has been inconclusive as to which method provides more useful information. Thus, during 2016 we conducted line transect surveys immediately following point count surveys to compare these methods.

Our survey protocol called for observers to walk 300 m line transects, which begin at every point count survey site, and count all CSSS detected within 100 m perpendicular distance on either side of the line. Transect lines were not placed randomly; rather, the direction of the lines was chosen to maximize survey efficiency walking towards the next point count site along routes. We restricted CSSS detections to within 100 m to be consistent with protocols for surveys being conducted along existing transects on demographic study plots, to increase the speed at which surveys could be conducted, and to reduce distance estimation errors. Observers were instructed to walk lines at a pace that would allow completion of the survey in

15-20 min. Distance data was collected any time a sparrow was detected, similar to distance sampling protocols for our point count surveys, with modifications to allow later estimation of perpendicular distances from lines which is necessary for distance analysis (Thomas *et al.* 2010; Buckland *et al.* 2001).

We expected similar male CSSS counts on line transect surveys to those made on point count surveys. However, we suspected that we would detect more female sparrows on line transects due to the flushing of females from nests as observers walked the lines. We also anticipated that line transect surveys would be better for our resight surveys to detect previously color-banded sparrows.

3.3 Results

3.3.1 Point Count Surveys

We conducted repeated surveys at 31 sites in CSSS subpopulations A, B and C between 15 April and 10 June, 2016 (**Table 3.1**). One-three replicate surveys were conducted at each survey site; in total 84 repeated surveys were conducted. Sites/surveys were distributed among subpopulations as follows: A ($n = 9/27$); B ($n = 13/32$); C ($n = 9/25$). Some replicates could not be performed at certain sites due to difficult and/or hazardous field conditions as a result of high water levels throughout the 2016 field season. We had anticipated conducting surveys at additional sites; however, field conditions also limited our ability to cover more area. ENP conducted their own independent surveys at each of our survey sites, and these data provided an additional replicate at each site (i.e., all sites were visited 2-4 times in 2016).

In total, 52 CSSS were detected on our repeated point count surveys (1-3 replicates); ENP surveys detected 20 CSSS at the same sites (**Table 3.2**). The highest counts were recorded on the third replicate of our surveys ($n = 26$). Total counts on our earlier replicates ($n = 13$) were below counts recorded on the ENP surveys. The mean count of male sparrows per survey site recorded on our repeated surveys was 0.62; the mean count per site on ENP surveys was very similar at 0.65. Total CSSS counts and mean (μ) counts per survey site varied substantially

among subpopulations with A ($n = 3$; $\mu = 0.11$) reporting much lower counts compared to B ($n = 28$; $\mu = 0.88$) and C ($n = 21$; $\mu = 0.84$).

As expected, the count data were zero-inflated with the majority of surveys reporting no CSSS detections. Of the 27 repeated surveys conducted in subpopulation A, 89% reported zero counts. Zero-inflation continued in the other subpopulations, albeit at a lower level; 50% of surveys in B and 64% of surveys in C reported zero counts. Comparison of our results from repeated surveys to those from the ENP single surveys shows the necessity of conducting multiple replicates when count data are heavily zero-inflated and when detection probability is low. Sixteen of the 31 ENP surveys reported zero counts (52%), which is a similar rate to rates reported in our study. However, when we compared count data from our repeated surveys to data from the ENP surveys conducted at the same sites, we detected sparrows at almost half (44%) of the sites where ENP had reported zero counts. This suggests that relying upon raw count data from the ENP surveys may be leading to underestimation of CSSS occupancy rates and population size. Our sample size is small; however, we suspect that these results will hold over larger areas. Thus, we strongly recommend that the ENP surveys be modified to include repeated surveys in order to obtain a more accurate and precise population estimate.

Most CSSS detections were made at distances < 200 m from survey sites; however, sparrows were detected at much greater distances – approaching 400 m (**Figure 3.5**). Binning the distance data into 100 m intervals shows that most CSSS detections are actually occurring at distances between 100-200 m, and the distance function appears to be a relatively smooth curve that includes detections out to 400 m (**Figure 3.6**). These results support our prediction that singing male CSSS may be heard at much greater distances than 200 m, and suggests that previous population estimates based on the historic 16x multiplier may not be accurate. The historic multiplier includes an area adjustment based on the assumption that sparrows are only detected at distances up to 200 m. If sparrows are actually being detected at much greater distances, as our data suggests, then the historic population estimate based on the 16x multiplier is likely overestimated. Additional survey data is needed to accurately calculate the detection function and estimate CSSS detection probability, density and abundance.

3.3.2 Line Transect Surveys

During 2016, we conducted 72 repeated line transect surveys at the same 31 sites where we conducted point count surveys (**Table 3.3**). The total number of male CSSS detected on our line transect surveys ($n = 44$) was similar to the number detected on our point count surveys (**Table 3.4**). Further, the counts per replicate were very similar those from our point count surveys, as was the mean (μ) count per survey site ($\mu = 0.61$). Thus, there appears to be no apparent benefit to conducting line transect surveys over point count surveys for detecting male CSSS.

We had hoped that our line transect surveys might be better than point count surveys for detecting female sparrows and/or for resighting previously color-banded individuals. However, we found similar results from both survey methods. In total, few female CSSS were detected on line transect surveys ($n = 4$) or point count surveys ($n = 3$). These results suggest that the best way to survey for female CSSS, and subsequent calculation of sex ratios, may still be to obtain these data from intensively monitored demographic study plots. Additionally, we did not detect any previously color-banded sparrows on our off-plot line transect or point count surveys. Again, this suggests that intensively monitored demographic study plots may be the best way to obtain the mark-recapture data necessary for dispersal and survival analyses.

3.3.3 Singing Rates

Our point count surveys conducted in 2016 were modified to include time-of-detection sampling so that we could begin to examine the influence of variation in CSSS singing rates among subpopulations on detection probability and density estimates. We collected TOD data for 23 male CSSS detected during point count surveys in large subpopulation B and 22 male CSSS detected in small subpopulations A and C. There was no significant difference in the mean (μ) number of male CSSS detected singing per survey in large ($\mu = 1.7$) and small ($\mu = 2.0$) subpopulations (**Table 3.5**). However, there was a significant difference in the mean singing rate between large ($\mu = 0.71$) and small ($\mu = 0.36$) subpopulations (**Table 3.6**). Male sparrows in large subpopulation B sang twice as long as males in small subpopulations during the 7-min point count survey period despite having a similar number of individuals counter-singing during

surveys. In other words, male sparrows were available for detection twice as long during point count surveys conducted in a large CSSS subpopulation.

3.4 Conclusions

We did not conduct statistical analyses of our survey data this year due to a lack of sufficient data to perform distance analysis or to incorporate TOD data into n-Mixture models. However, the preliminary results from our pilot study show the importance of incorporating other factors into CSSS surveys that are currently not being considered. First, our data strongly suggests that the highly zero-inflated nature of CSSS survey data indicates that repeated surveys are necessary to accurately and precisely estimate CSSS abundance using these data. Detection probability for CSSS is already known to be imperfect with prior estimates ranging from 0.81 (Virzi *et al.* 2016) to as low as 0.60 (La Puma *et al.* 2010). Importantly, our results suggest that a zero count recorded on a single survey is likely not a good indication that there are no sparrows present at a site. We suggest that at least two repeated surveys are necessary to estimate detection probability with the precision necessary to derive a statistically valid population estimate. This does not necessarily mean that every survey point must be visited twice; a sampling design might be developed to survey a randomly-selected subset of sites multiple times to collect the data necessary for analyses. Second, our initial TOD sampling suggests that singing rates are lower in small CSSS subpopulations, which would affect detection probability in those areas. Thus, detection probability is likely lower in low density areas as previously suggested (Virzi *et al.* 2016; La Puma *et al.* 2010). We recommend that future CSSS surveys include TOD sampling so that variation in singing rates among subpopulations can be incorporated into statistical analyses.

The results of our pilot study show that distance sampling, and possibly other methods such as time-to-detection sampling or removal models (Alldredge *et al.* 2007a and 2007b; Farnsworth *et al.* 2002), should be incorporated into current survey methods. Repeated surveys are clearly needed to account for the zero-inflated nature of the ENP survey data and to obtain an adequate number of detections to model the detection function adequately, especially if

individual population estimates are desired for each of the remaining six CSSS subpopulations. This will likely require more advanced analysis techniques such as n-Mixture models, which requires large sample sizes because it is a heavily data dependent analysis (Cunningham & Lindenmayer 2005). In 2017, we recommend that additional surveys be conducted at more sites using the methods used in our pilot study in 2016 to obtain the data necessary to conduct these analyses.

We make one additional recommendation regarding the ENP rangewide helicopter survey here: we recommend that the sampling design for the survey be examined closely to determine if improvements can be made so that results provide better inference over the entire CSSS population. For example, presently there is no randomization in the study design for annual site selection which limits inference capabilities (MacKenzie *et al.* 2005). Additionally, the current method for removing survey sites between years may not be appropriate. Presently, sites are removed when there have been no CSSS detections for three consecutive years which would tend to consistently reduce survey effort over time and may lead to erroneous population estimates. We suggest that recent habitat suitability models be used to explore the possibility of adding new survey sites in previously unoccupied areas as habitat there becomes more suitable as a result of restoration efforts, which appears to be the case in some areas (Beerens *et al.* 2016).

3.5 Tables and Figures

Table 3.1: Dates of Cape Sable seaside sparrow (CSSS) point count and line transect surveys conducted by Ecotudies Institute (EI) in subpopulations A, B, and C during 2016 compared with dates of Everglades National Park (ENP) rangewide helicopter surveys conducted at the same locations. One-three replicate surveys were conducted by EI at each survey point between 15-Apr and 10-Jun 2016 ($n = 31$ sites and 84 surveys), and a single survey was conducted at each point by ENP between 12-Apr and 01-Jun 2016.

EI Surveys			Survey Dates			
Point	Pop	# Reps	Rep1	Rep2	Rep3	ENP
Shark-32	A	3	20-Apr	6-May	9-Jun	28-Apr
Shark-35	A	3	20-Apr	6-May	9-Jun	28-Apr
Shark-36	A	3	15-Apr	20-Apr	6-May	28-Apr
Shark-40	A	3	15-Apr	11-May	9-Jun	28-Apr
Shark-69	A	3	15-Apr	20-Apr	11-May	9-May
Shark-78	A	3	15-Apr	11-May	9-Jun	9-May
Shark-82	A	3	15-Apr	20-Apr	6-May	28-Apr
Shark-92	A	3	15-Apr	6-May	10-Jun	9-May
Shark-93	A	3	20-Apr	6-May	10-Jun	9-May
Mahog-17	B	3	28-Apr	13-May	25-May	20-May
Mahog-18	B	3	28-Apr	13-May	25-May	20-May
Mahog-25	B	2	28-Apr	13-May	na	20-May
Mahog-34	B	3	28-Apr	16-May	24-May	25-May
Mahog-35	B	3	21-Apr	5-May	20-May	25-May
Mahog-42	B	2	28-Apr	16-May	na	12-Apr
Mahog-43	B	3	28-Apr	10-May	24-May	12-Apr
Mahog-44	B	3	21-Apr	5-May	1-Jun	1-Jun ⁽¹⁾
Mahog-50	B	1	26-Apr	na	na	12-Apr
Mahog-51	B	2	26-Apr	3-Jun	na	12-Apr
Mahog-53	B	2	26-Apr	9-May	na	25-May
Mahog-59	B	2	26-Apr	9-May	na	31-May
Mahog-60	B	3	26-Apr	9-May	25-May	25-May ⁽¹⁾
LPK-29	C	2	25-Apr	9-May	na	27-Apr
LPK-30	C	3	25-Apr	9-May	23-May	27-Apr
LPK-32	C	3	25-Apr	9-May	23-May	1-Jun
LPK-33	C	3	25-Apr	9-May	23-May	1-Jun
LPK-35	C	3	26-Apr	10-May	24-May	1-Jun
LPK-36	C	3	26-Apr	10-May	24-May	1-Jun
RPRS-12	C	2	25-Apr	9-May	na	1-Jun
RPRS-16	C	3	25-Apr	9-May	24-May	1-Jun
RPRS-20	C	3	26-Apr	10-May	24-May	1-Jun

⁽¹⁾ EI and ENP surveys conducted on same day.

Table 3.2: Male Cape Sable seaside sparrow (CSSS) detections made on point count surveys conducted by Ecostudies Institute (EI) in subpopulations A, B, and C during 2016. One-three replicate surveys were conducted by EI at each survey point between 15-Apr and 10-Jun 2016. Dashes in Rep2-3 columns indicate surveys that were not completed. CSSS detections made on EI surveys compared to detections made on Everglades National Park (ENP) rangewide helicopter surveys during 2016. EI Count Summary reports total CSSS count (all replicates), min count, max count, mean count (μ), and SD (σ).

EI Surveys			CSSS Detections				EI Count Summary				
Point	Pop	# Reps	Rep1	Rep2	Rep3	ENP ⁽¹⁾	Total	Min	Max	μ	σ
Shark-32	A	3	0	0	0	0	0	0	0	0.0	0.0
Shark-35	A	3	0	0	0	0	0	0	0	0.0	0.0
Shark-36	A	3	0	0	1	0	1	0	1	0.3	0.6
Shark-40	A	3	1	0	0	0	1	0	1	0.3	0.6
Shark-69	A	3	0	0	1	0	1	0	1	0.3	0.6
Shark-78	A	3	0	0	0	0	0	0	0	0.0	0.0
Shark-82	A	3	0	0	0	1	0	0	0	0.0	0.0
Shark-92	A	3	0	0	0	1	0	0	0	0.0	0.0
Shark-93	A	3	0	0	0	0	0	0	0	0.0	0.0
Mahog-17	B	3	0	0	0	0	0	0	0	0.0	0.0
Mahog-18	B	3	1	0	3	0	4	0	3	1.3	1.5
Mahog-25	B	2	1	0	-	0	1	0	1	0.5	0.7
Mahog-34	B	3	0	0	1	1	1	0	1	0.3	0.6
Mahog-35	B	3	0	0	5	1	5	0	5	1.7	2.9
Mahog-42	B	2	3	2	-	0	5	2	3	2.5	0.7
Mahog-43	B	3	2	1	1	3	4	1	2	1.3	0.6
Mahog-44	B	3	1	1	2	1	4	1	2	1.3	0.6
Mahog-50	B	1	0	-	-	0	0	0	0	0.0	na
Mahog-51	B	2	0	0	-	1	0	0	0	0.0	0.0
Mahog-53	B	2	0	1	-	1	1	0	1	0.5	0.7
Mahog-59	B	2	0	0	-	1	0	0	0	0.0	0.0
Mahog-60	B	3	2	1	0	1	3	0	2	1.0	1.0
LPK-29	C	2	0	0	-	0	0	0	0	0.0	0.0
LPK-30	C	3	0	0	3	2	3	0	3	1.0	1.7
LPK-32	C	3	0	0	0	0	0	0	0	0.0	0.0
LPK-33	C	3	2	2	3	0	7	2	3	2.3	0.6
LPK-35	C	3	0	0	0	0	0	0	0	0.0	0.0
LPK-36	C	3	0	0	2	1	2	0	2	0.7	1.2
RPRS-12	C	2	0	4	-	1	4	0	4	2.0	2.8
RPRS-16	C	3	0	1	2	2	3	0	2	1.0	1.0
RPRS-20	C	3	0	0	2	2	2	0	2	0.7	1.2
Pooled		84	13	13	26	20	52	6	39	0.6	1.1

⁽¹⁾ CSSS detections made on ENP helicopter surveys conducted between 12-Apr and 01-Jun 2016.

Table 3.3: Male Cape Sable seaside sparrow (CSSS) detections made on line transect surveys conducted by Ecostudies Institute (EI) in subpopulations A, B, and C during 2016. One-three replicate surveys were conducted by EI at each survey point between 15-Apr and 10-Jun 2016. Dashes in Rep2-3 columns indicate surveys that were not completed. CSSS detections made on EI surveys compared to detections made on Everglades National Park (ENP) rangewide helicopter point count surveys during 2016. EI Count Summary reports total CSSS count (all replicates), min count, max count, mean count (μ), and SD (σ).

EI Surveys			CSSS Detections				EI Count Summary				
Point	Pop	# Reps	Rep1	Rep2	Rep3	ENP ⁽¹⁾	Total	Min	Max	μ	σ
Shark-32	A	3	0	0	0	0	0	0	0	0.0	0.0
Shark-35	A	3	0	0	0	0	0	0	0	0.0	0.0
Shark-36	A	0	-	-	-	0	na	na	na	na	na
Shark-40	A	3	2	0	0	0	2	0	2	0.7	1.2
Shark-69	A	3	0	0	0	0	0	0	0	0.0	0.0
Shark-78	A	3	0	0	0	0	0	0	0	0.0	0.0
Shark-82	A	0	-	-	-	1	na	na	na	na	na
Shark-92	A	3	0	0	0	1	0	0	0	0.0	0.0
Shark-93	A	3	0	0	0	0	0	0	0	0.0	0.0
Mahog-17	B	3	0	0	0	0	0	0	0	0.0	0.0
Mahog-18	B	3	1	1	5	0	7	1	5	2.3	2.3
Mahog-25	B	2	1	0	-	0	1	0	1	0.5	0.7
Mahog-34	B	3	1	1	1	1	3	1	1	1.0	0.0
Mahog-35	B	0	-	-	-	1	na	na	na	na	na
Mahog-42	B	2	0	2	-	0	2	0	2	1.0	1.4
Mahog-43	B	3	3	1	1	3	5	1	3	1.7	1.2
Mahog-44	B	0	-	-	-	1	na	na	na	na	na
Mahog-50	B	1	0	-	-	0	0	0	0	0.0	na
Mahog-51	B	2	2	0	-	1	2	0	2	1.0	1.4
Mahog-53	B	2	0	1	-	1	1	0	1	0.5	0.7
Mahog-59	B	2	0	0	-	1	0	0	0	0.0	0.0
Mahog-60	B	3	1	0	0	1	1	0	1	0.3	0.6
LPK-29	C	2	0	0	-	0	0	0	0	0.0	0.0
LPK-30	C	3	0	0	2	2	2	0	2	0.7	1.2
LPK-32	C	3	0	0	0	0	0	0	0	0.0	0.0
LPK-33	C	3	1	1	7	0	9	1	7	3.0	3.5
LPK-35	C	3	0	0	0	0	0	0	0	0.0	0.0
LPK-36	C	3	0	0	4	1	4	0	4	1.3	2.3
RPRS-12	C	2	1	2	-	1	3	1	2	1.5	0.7
RPRS-16	C	3	0	0	1	2	1	0	1	0.3	0.6
RPRS-20	C	3	0	1	0	2	1	0	1	0.3	0.6
Pooled		72	13	10	21	20	44	5	35	0.6	1.2

⁽¹⁾ CSSS detections made on ENP helicopter surveys conducted between 12-Apr and 01-Jun 2016.

Table 3.4: Comparison of male Cape Sable seaside sparrow (CSSS) detections made on line transect and point count surveys conducted by Ecostudies Institute (EI) in subpopulations A, B, and C during 2016. One-three replicate surveys were conducted by EI at each survey point between 15-Apr and 10-Jun 2016; however, some line transect surveys were not completed. Dashes in Rep columns indicate surveys that were not completed. #TR = number of replicates for line transect surveys; #PC = number of replicates for point count surveys.

EI Surveys				Line Transects				Point Counts			
Point	Pop	#TR	#PC	Rep1	Rep2	Rep3	Total	Rep1	Rep2	Rep3	Total
Shark-32	A	3	3	0	0	0	0	0	0	0	0
Shark-35	A	3	3	0	0	0	0	0	0	0	0
Shark-36	A	0	3	-	-	-	0	0	0	1	1
Shark-40	A	3	3	2	0	0	2	1	0	0	1
Shark-69	A	3	3	0	0	0	0	0	0	1	1
Shark-78	A	3	3	0	0	0	0	0	0	0	0
Shark-82	A	0	3	-	-	-	0	0	0	0	0
Shark-92	A	3	3	0	0	0	0	0	0	0	0
Shark-93	A	3	3	0	0	0	0	0	0	0	0
Mahog-17	B	3	3	0	0	0	0	0	0	0	0
Mahog-18	B	3	3	1	1	5	7	1	0	3	4
Mahog-25	B	2	2	1	0	-	1	1	0	-	1
Mahog-34	B	3	3	1	1	1	3	0	0	1	1
Mahog-35	B	0	3	-	-	-	0	0	0	5	5
Mahog-42	B	2	2	0	2	-	2	3	2	-	5
Mahog-43	B	3	3	3	1	1	5	2	1	1	4
Mahog-44	B	0	3	-	-	-	0	1	1	2	4
Mahog-50	B	1	1	0	-	-	0	0	-	-	0
Mahog-51	B	2	2	2	0	-	2	0	0	-	0
Mahog-53	B	2	2	0	1	-	1	0	1	-	1
Mahog-59	B	2	2	0	0	-	0	0	0	-	0
Mahog-60	B	3	3	1	0	0	1	2	1	0	3
LPK-29	C	2	2	0	0	-	0	0	0	-	0
LPK-30	C	3	3	0	0	2	2	0	0	3	3
LPK-32	C	3	3	0	0	0	0	0	0	0	0
LPK-33	C	3	3	1	1	7	9	2	2	3	7
LPK-35	C	3	3	0	0	0	0	0	0	0	0
LPK-36	C	3	3	0	0	4	4	0	0	2	2
RPRS-12	C	2	2	1	2	-	3	0	4	-	4
RPRS-16	C	3	3	0	0	1	1	0	1	2	3
RPRS-20	C	3	3	0	1	0	1	0	0	2	2
Pooled		72	84	13	10	21	44	13	13	26	52

⁽¹⁾ Correcting for survey effort since line transect surveys were not completed at four survey points, the total number of CSSS detected on point count surveys = 42.

Table 3.5: Comparison of mean number of male Cape Sable seaside sparrows (CSSS) detected singing at survey points during time-of-detection sampling. Two-sample t-test assuming equal variances ($\alpha = 0.05$) comparing samples from Large (high density; B) and Small (low density; A and C) CSSS subpopulations.

	<i>Large</i>	<i>Small</i>
Mean	1.7	2.0
Variance	0.7	1.0
Observations	14	11
Pooled Variance	0.8	
Hypothesized Mean Difference	0	
df	23	
t Stat	-0.78	
P(T<=t) one-tail	0.22	
t Critical one-tail	1.71	
P(T<=t) two-tail	0.44	
t Critical two-tail	2.07	

Table 3.6: Comparison of mean singing rates of male Cape Sable seaside sparrows (CSSS) observed singing at survey points during time-of-detection sampling. Two-sample t-test assuming equal variances ($\alpha = 0.05$) comparing samples from Large (high density; B) and Small (low density; A and C) CSSS subpopulations.

	<i>Large</i>	<i>Small</i>
Mean	0.71	0.36
Variance	0.07	0.08
Observations	23	22
Pooled Variance	0.07	
Hypothesized Mean Difference	0	
df	43	
t Stat	4.36	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.68	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.02	

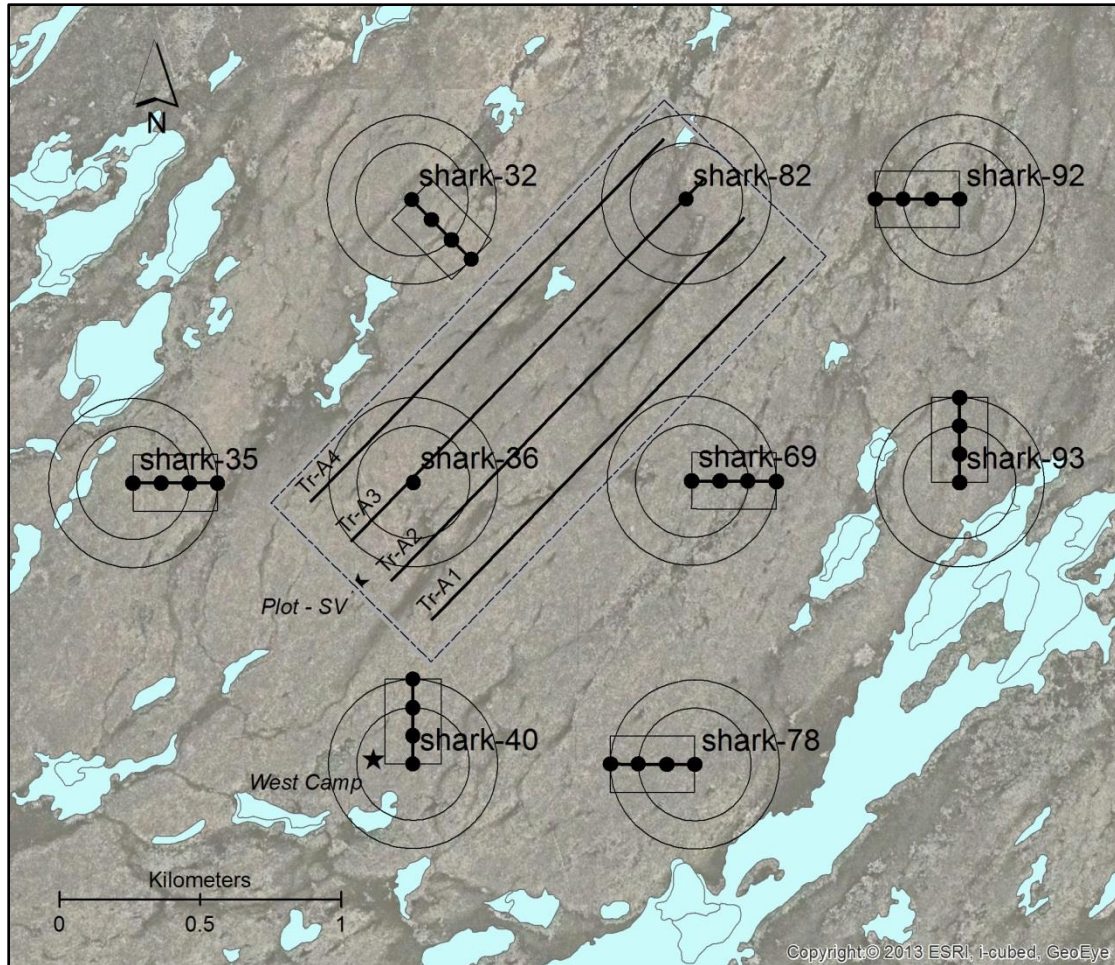


FIGURE 3.1: Survey sites for off-plot point count and line transect surveys for Cape Sable seaside sparrows conducted during the 2016 breeding season in small subpopulation A. Labeled black circles indicate location of ENP rangewide helicopter survey sites where Ecostudies Institute (EI) conducted repeated surveys using new survey methods. Outlines surrounding survey sites indicate 200 and 300 m buffers (aids for survey protocols). Line transect surveys were also conducted at these sites immediately following point count surveys for comparison of methods. Grey outlined rectangular area represents boundary of EI demographic study plot.

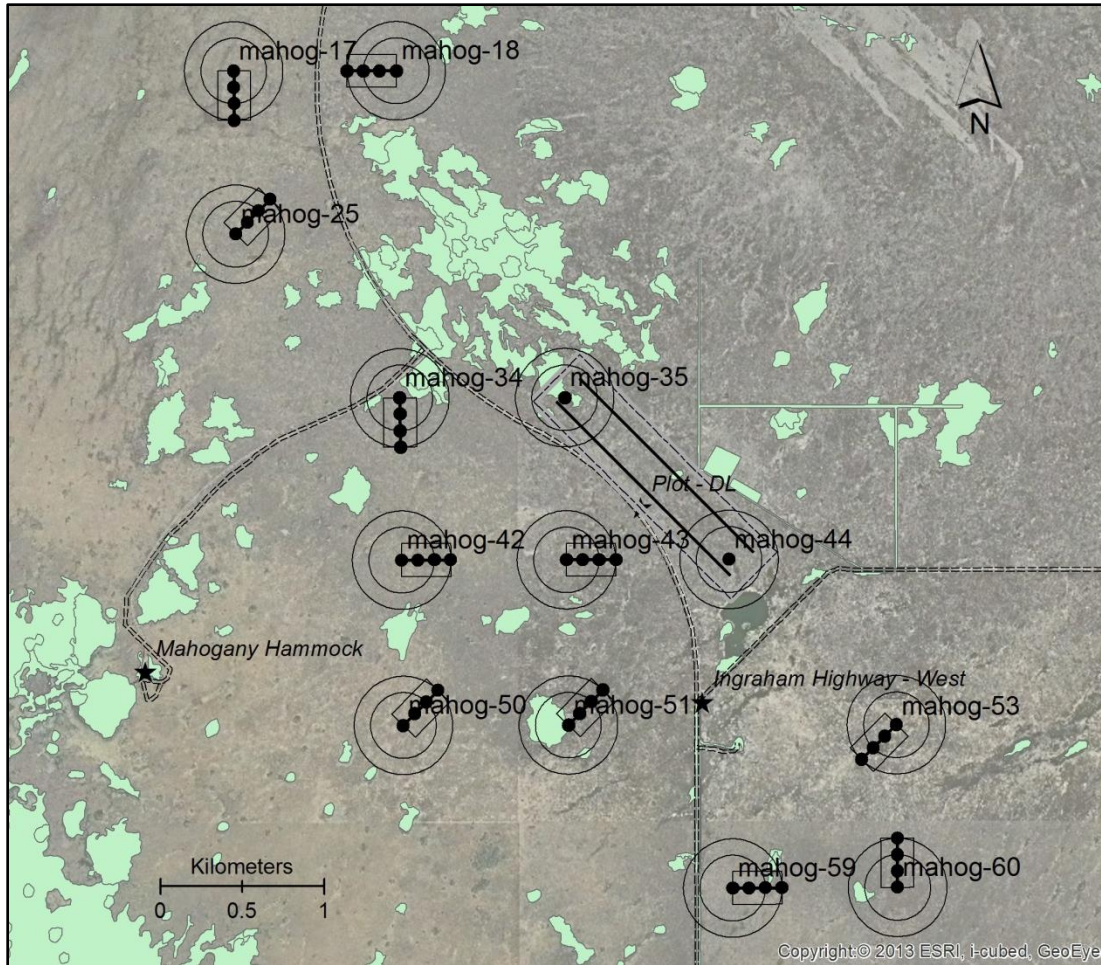


FIGURE 3.2: Survey sites for off-plot point count and line transect surveys for Cape Sable seaside sparrows conducted during the 2016 breeding season in large subpopulation B. Labeled black circles indicate location of ENP rangewide helicopter survey sites where Ecostudies Institute (EI) conducted repeated surveys using new survey methods. Outlines surrounding survey sites indicate 200 and 300 m buffers (aids for survey protocols). Line transect surveys were also conducted at these sites immediately following point count surveys for comparison of methods. Grey outlined rectangular area represents boundary of EI demographic study plot.

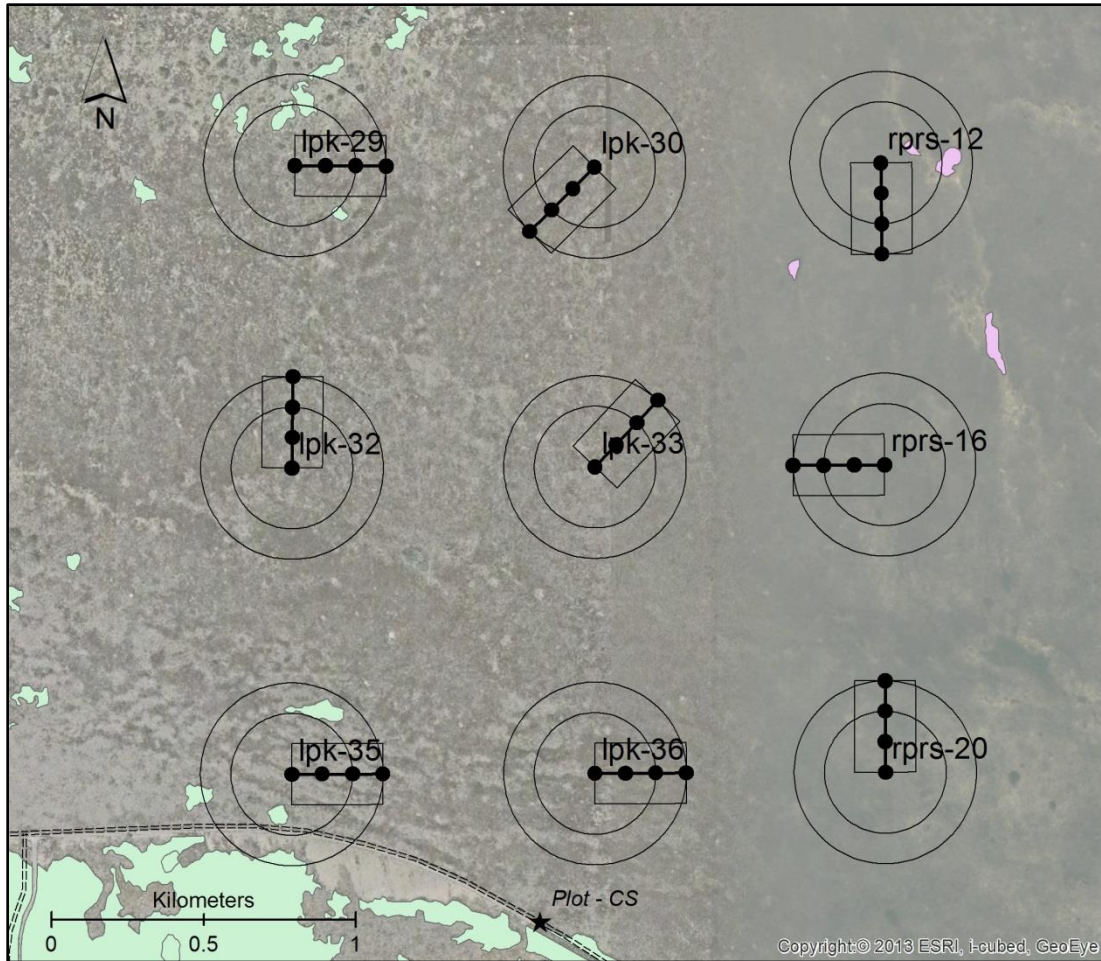


FIGURE 3.3: Survey sites for off-plot point count and line transect surveys for Cape Sable seaside sparrows conducted during the 2016 breeding season in small subpopulation C. Labeled black circles indicate location of ENP rangewide helicopter survey sites where Ecostudies Institute (EI) conducted repeated surveys using new survey methods. Outlines surrounding survey sites indicate 200 and 300 m buffers (aids for survey protocols). Line transect surveys were also conducted at these sites immediately following point count surveys for comparison of methods.

FIGURE 3.4: Example datasheet used by Ecostudies Institute in 2016 to conduct off-plot point count surveys at ENP rangewide helicopter survey sites incorporating distance sampling and time-of-detection sampling methods. Similar datasheets were used for line transect surveys conducted at the same sites.

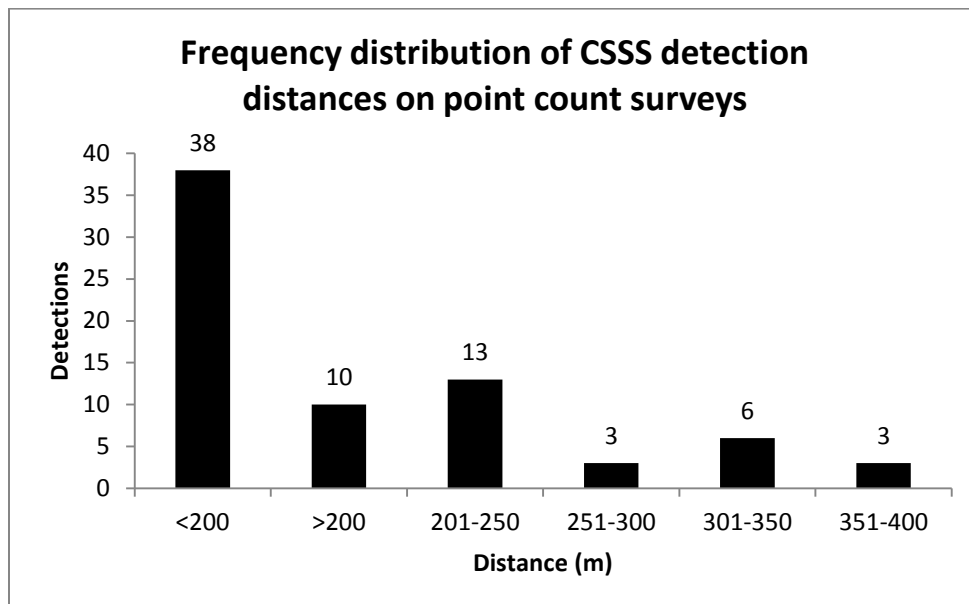


Figure 3.5: Frequency distribution of Cape Sable seaside sparrow (CSSS) detection distances for sparrows detected on point count surveys during 2016. Numbers above bars indicate sample size of detections within each distance bin. There were 10 CSSS detections where exact distances were not measured; these are included in the bin labeled “> 200” (i.e., all of these CSSS detections were estimated to be at distances > 200 m).

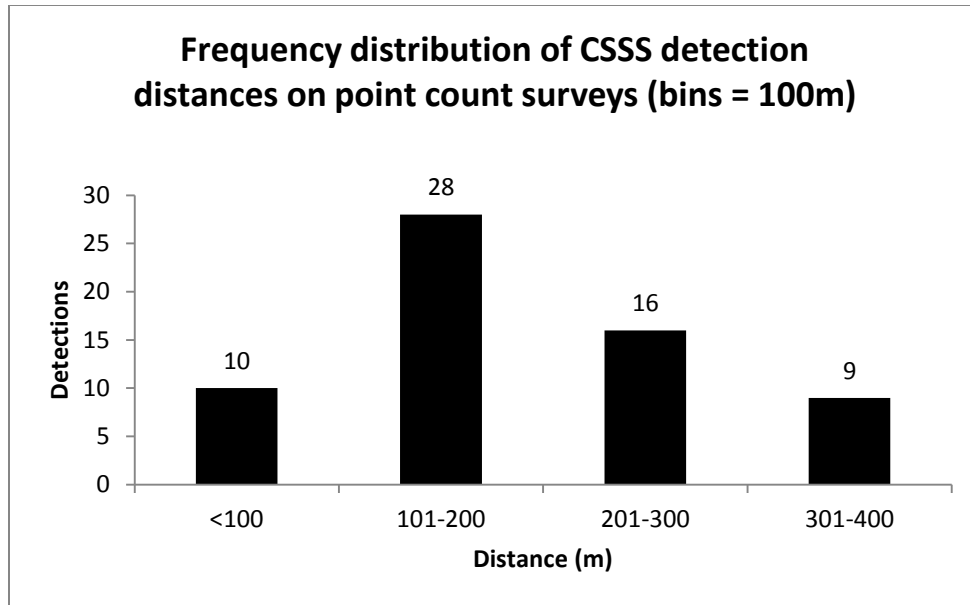


Figure 3.6: Frequency distribution of Cape Sable seaside sparrow (CSSS) detection distances for birds detected on point count surveys during 2016 (data bins = 100 m; detections without exact distances removed). Numbers above bars indicate sample size of detections within each distance bin.

4.0 Literature Cited

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