

EFFECTS OF BURNING ON HENSLOW'S SPARROW (*AMMODRAMUS  
HENSLOWII*) DENSITY AND HABITAT QUALITY IN LOUISIANA

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Laura M. Palasz  
B.S. University of Illinois Urbana-Champaign, 2002  
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## ABSTRACT

The Henslow's Sparrow (*Ammodramus henslowii*) is a grassland species of concern that winters in prairies and open pine savannas across the Gulf Coastal Plain. Previous studies have indicated that these birds occur at higher densities in recently burned habitats in winter, but this has never been examined over a large geographic area containing multiple habitat types. The objectives of the study were to identify areas of important winter habitat in Louisiana, to examine the relationship between time since burn, bird density, and bird condition, and to determine vegetation structure and composition used by birds. We found most of the new potential habitat and the highest numbers of birds in two specific ecoregions, the Lower West Gulf Coastal Plain and the East Gulf Coastal Plain ("east" and "west") suggesting that these may be most important for wintering Henslow's Sparrows. Time since burn explained little variation plot selection overall. Bird densities in the east peaked in the first winter after burn, while densities in the west were higher 1-2 years post burn, indicating that habitats in these regions may respond differently to fire. Vegetation measurements were not helpful in interpreting bird abundance patterns across plots, suggesting that characteristics of suitable habitat may vary widely across ecoregions. However, within a plot the probability of flushing a bird increased with increasing herbaceous density at ground level, and with increasing cover of the plant genera *Andropogon* and *Rhynchospora*, so Henslow's Sparrows may be responding to structural components of the habitat on a small scale. Sex ratios and bird body condition, including mass, fat storage, and feather growth, did not vary with burn year. Therefore I found no evidence for any sex-related winter hierarchy. Results of this research will help land managers make decisions with

appropriate consideration for the larger variation in bird abundance and vegetation associations found across a regional scale. We recommend a two year rotation of prescribed fire to maintain high numbers of Henslow's Sparrows, and caution against more frequent fire rotations in the west.

## INTRODUCTION

Many bird species throughout North America are declining (Sauer et al. 2007) or at risk due to habitat destruction, introduction of non-native species, and pollution (Wilcove et al. 1998). Detailed understanding of the natural history, ecology, and habitat requirements of such species is necessary in order to identify and assess threats specific to each one. This information could then be used to implement management techniques that might help prevent or slow population declines.

Migratory bird species present an additional set of management problems because they depend on habitat and resources spread out over large spatial and temporal scales. A thorough understanding of ecology, habitat requirements, and population dynamics is necessary at all stages including breeding, wintering, and migration if an effective conservation strategy is to be designed (Sherry and Holmes 1996, Norris et al. 2004, Holmes 2007).

The Henslow's Sparrow (*Ammodramus henslowii*), a species of high concern due to overall population decline, is both a migratory species and a grassland specialist. It is a short distance migrant, breeding on open grasslands in the United States from Kansas east to New England and north into Ontario, and wintering in pine savannas and pitcher plant bogs along the Gulf Coastal Plain from east Texas to the Carolinas (Herkert et al. 2002) (Figure 1). The North American Breeding Bird Survey documented a population decline at a rate of 8.6% per year between 1966 and 1984, making the Henslow's Sparrow one of the fastest declining species in the United States during that time. Since 1985 the population is no longer in decline, but the species is still of high conservation concern (Sauer et al. 2007). It is threatened or endangered in a total of 16 states across its

breeding range, and it is federally endangered in Canada (Burhans 2002). Habitat loss due to development, agriculture, and fire suppression has likely played a major role in the decline of this species (Askins 1993, Plentovich et al. 1999, Herkert et al. 2002). Only 1% of former grassland habitat still exists within the breeding range of the Henslow's Sparrow, and less than 3% of longleaf (*Pinus palustris*) pine savannas remain in the southeast—an area which once contained 25-36 million ha of longleaf pine savanna (Frost 1993, Noss et al. 1995, Varner and Kush 2004).

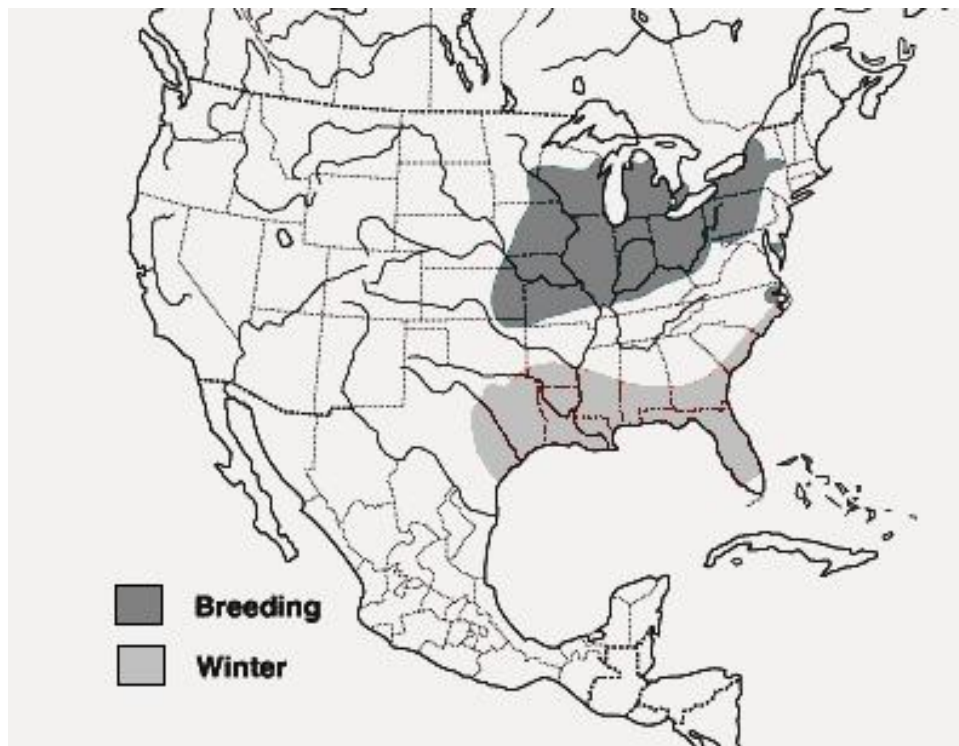


Figure 1. Henslow's Sparrow range map. Taken from Herkert et al. 2002.

While most study to date has taken place on the breeding grounds, a number of recent studies in Louisiana, Mississippi, Alabama, and Florida have added knowledge about Henslow's Sparrow winter ecology. A strong relationship exists between fire

regime and Henslow's Sparrow abundance, with Henslow's Sparrows being most abundant during the winter immediately following a burn, and numbers dropping sharply by three years after burn (Carrie et al. 2002, Tucker and Robinson 2003, Bechtoldt and Stouffer 2005, Johnson 2006). In addition, one study showed that birds had higher survival rates on recently burned savannas (Thatcher et al. 2006). Unlike results from studies on the breeding grounds, where Henslow's Sparrows are often associated with grasslands >100 ha in area (Herkert 1994), in the winter these birds may occupy habitat patches as small as 0.06 ha (Tucker and Robinson 2003). Indeed, in southeastern Louisiana the mean home range size was estimated at 0.3 ha for Henslow's Sparrows (Bechtoldt and Stouffer 2005). However most burned habitat exists as large patches; therefore larger tracts of habitat are more likely to be suitable for the birds in the winter.

Results of studies attempting to identify important characteristics of Henslow's Sparrow habitat have been variable, likely due to differences in habitat types and great distance between study areas. Recent studies in Louisiana, Mississippi, Alabama, and Florida have investigated Henslow's Sparrows in upland pine savannas, savannas in silvicultural lands, seepage (pitcher plant) bogs, and flatwood savannas, all of which have different soils properties and plant communities. Some studies of winter habitat characteristics found Henslow's Sparrows associated with lower vegetation density at ground level (Bechtoldt and Stouffer 2005, Johnson 2006), while others found higher numbers of birds associated with higher vegetation density (Plentovich 1999, Carrie et al. 2002). Some correlations were also documented between Henslow's Sparrows and the presence of specific plant species such as the grass *Panicum verracosum* and pitcher

plants (*Sarracenia* spp.) (Plentovich 1999), or abundance of seed stalks (Tucker and Robinson 2003, Bechtoldt and Stouffer 2005).

While all of these results add to knowledge of Henslow's Sparrow winter ecology, it is difficult to condense the information in a way that is conducive to forming general land management recommendations. There are several reasons for this. First, most winter studies were carried out within a relatively small land area, and therefore the study areas only contained a subset of possible grassland habitat types that Henslow's Sparrows may use. Conclusions based on study results from a particular type of habitat may not apply to others. Second, studies were scattered widely throughout the Gulf Coastal Plain, and there is potential for regional variation in habitats and plant communities. Third, with the exception of Plentovich (1999) and Tucker and Robinson (2003), sampling methods were different for each study, making comparison between them difficult. For these reasons, there is need for research on winter ecology of Henslow's Sparrows using consistent methods over a broad scale that will incorporate regional variation in grassland habitats.

Habitat associations such as plant structure, herbaceous species composition, and seed abundance have been identified as important variables associated with Henslow's Sparrow presence or abundance (Plentovich 1999, Carrie et al. 2002, Tucker and Robinson 2003, Bechtoldt and Stouffer 2005), so including these in a broad scale study should help clarify which, if any, are applicable to more than just a single habitat or region. Further, because Henslow's Sparrows are known to occupy small home ranges and patch sizes in the winter (Tucker and Robinson 2003, Bechtoldt and Stouffer 2005),

assessment of these variables within microhabitats chosen by birds may be more meaningful than examining habitat characteristics of the larger study area as a whole.

Just as important as connecting Henslow's Sparrows with preferred habitat characteristics is assessing the quality of the habitat. Habitat quality may directly influence the health of the birds, which in turn can affect both survival on the wintering grounds, and success during the breeding season (Marra et al. 1998, Norris et al. 2004). Bird density itself can be one indicator of habitat quality, assuming that high densities of birds indicate high quality habitat (Johnson et al. 2006). The actual physical condition of birds is another way to assess habitat quality. Multiple measures of body condition, including body mass, body fat, and feather growth rate (ptilochronology), can be measured and used as indicators to compare the physiological condition of birds and thus habitat quality between study sites (Grubb 1989, Gosler et al. 1995, Strong and Sherry 2000, Johnson et al. 2006).

Mass when corrected for body size is a common measure of body condition, as is the amount of subcutaneous body fat (Lima 1986, Strong and Sherry 2000). In addition, such measurements are easy to obtain from captured birds. The length of the wing chord can be used as a proxy for body size, and fat can be estimated by blowing the feathers aside and viewing subcutaneous fat deposited in the furcular hollow below the bird's throat. Higher body mass in general usually indicates a healthy bird, but that is not necessarily true of larger amounts of fat. Many small passerines carry less fat in the winter if food resources are predictable, presumably in order to maximize their ability to escape from predators (Lima 1986, Rogers 1987, Gosler et al. 1995). Brown et al. (2002)

found high feather growth rates in Hermit Thrushes (*Catharus guttatus*) with lower body fat, providing further evidence that passerines with low body fat in the winter are healthy.

Ptilochronology, which is the method employed to estimate feather growth rate, is also widely used as a measure of body condition (Grubb and Yosef 1994, Brown et al. 2002, Hogstad 2003). During times of stress or adverse conditions, feathers will grow in at a slower rate because more of the bird's energy is being allocated to elsewhere. By measuring the lengths of the visible growth bars on a feather that has grown in while the bird was occupying a specific habitat, one can estimate growth rate and link it directly to habitat quality (Grubb 1989).

Although previous studies found no difference in Henslow's Sparrow body condition between burn year (high bird density) and non burn year (low bird density) savannas (Bechtoldt and Stouffer 2005, Johnson 2006), body condition has never been compared across different regions or latitudes over a larger scale.

Henslow's Sparrows are not sexually dimorphic (Pyle 1997), nor do they sing in the winter (Herkert et al. 2002), so they must be sexed genetically. Therefore little information is available on sex distribution from the wintering grounds. Unequal sex ratios, if detected, could indicate that some level of sexual segregation is occurring on the wintering grounds. In the case that segregation does exist, an effective conservation strategy would need to consider winter habitat for both sexes (Cristol et al. 2001). One study in southeastern Louisiana in which birds were sexed found that the ratio of male to female Henslow's Sparrows captured there was not different from 0.50 (E. Johnson, unpublished data). However, additional sampling over a larger area would be helpful in detecting evidence for sexual segregation.

There are different types of sexual segregation shown by different species of migratory songbirds in the winter. Latitudinal clines in sex distribution are not uncommon during the non-breeding season, with higher proportions of males farther north. For species in which this trend has been documented, such as the well-studied Dark-eyed Junco (*Junco hyemalis*), it is hypothesized that this is beneficial to males because it enables them to arrive earlier on the breeding territories, but there may be a fitness tradeoff due to harsher conditions in more northern areas of the winter range (Ketterson and Nolan 1976, Kelly 1998). In contrast, rather than latitudinal gradients in sex ratio, American Redstarts (*Setophaga ruticilla*) exhibit inter-sexual competition during the winter in which males tend to out compete females for higher quality habitat. This results in poorer body condition for females on average, and can affect their survivorship or productivity during the breeding season (Marra and Holmes 2001).

The goals of this study are to identify important areas of habitat, describe vegetation associations, assess body condition, and determine sex ratios of wintering Henslow's Sparrow across the state of Louisiana. Utilization of consistent sampling methods across a broad geographical range incorporating multiple habitat types will allow us to make better recommendations to land managers overseeing large and often heterogeneous land areas.

Specific research questions are as follows:

- What areas of Louisiana support significant numbers of wintering Henslow's Sparrows?
- How does Henslow's Sparrow abundance vary with time since burn and region within Louisiana?

- Which habitat associations are correlated with overall bird densities, and which are correlated with preferred microhabitat within study plots?
- Does Henslow's Sparrow condition differ between fire treatment, ecoregion, or sex and age of birds?
- Are there trends in sex ratios across the state?

## **METHODS**

### **Study Sites**

I studied Henslow's Sparrows during the winters of 2005-2006 and 2006-2007 on nineteen 2.25 ha study plots across Louisiana. Ten of the plots were previously established in the fall of 2000 as described in Bechtoldt & Stouffer 2005 and Bechtoldt 2002 in the Florida Parishes of southeastern Louisiana, and have been sampled for Henslow's Sparrows each winter since that time. Three of these ongoing study plots (SH01, SH02, CWP) are located in eastern upland longleaf pine forest, and the remaining seven are located in eastern longleaf pine savanna (Lester et al. 2005). Nine new plots were established in a variety of grassland habitats including western longleaf pine savanna, western longleaf pine forest, and calcareous prairie across other regions of the state during the winter of 2005-2006 (Figure 2, Table 1).

### **Fire Treatment**

All but one of the study plots had been managed to some extent using prescribed fire. The exception, BD1, had been mowed regularly, but no fire documentation could be found. Season and frequency of burn varied widely between plots due to different management approaches and logistical consideration for appropriate conditions for controlled burns (Table 1). The management plans for all study plots (except BD1) called for burning at least every 2-3 years.

### **Statewide Surveys**

From October 2005-March 2006 we searched for Henslow's Sparrow habitat across Louisiana, resulting in the addition of nine new study plots for a total of 19. A few additional locations were searched during the winter of 2006/2007.

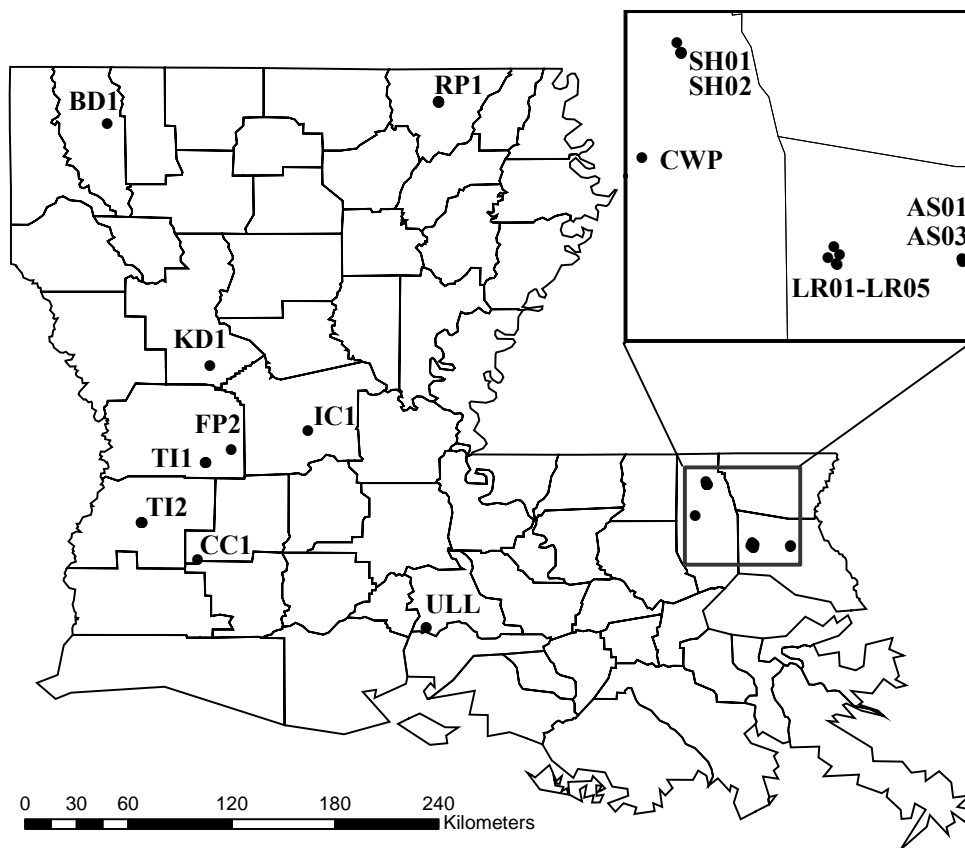


Figure 2. Henslow's Sparrow study plots.

Searching began by generating a list of locations containing potential suitable habitat in Louisiana. First, we included any locations where Henslow's Sparrow were reported to have been found in the winter. Sources included data from prior Henslow's Sparrow research (Carrie et al. 2002), data from the Audubon Society's Christmas Bird Count (2002), documentation from the Shreveport Bird Study Group, and personal communication with birdwatchers throughout the state via LABIRD listserv.

Table 1. List of all study plots, exact locations, and relevant burn dates.

Plot	Location	Parish	Ecoregion	Owner	Location	Burn Dates
AS01	serve	St. Tammany	East Gulf Coastal Plain (East)	The Nature Conservancy	30°31'N 89°58'W	May 2004
AS03	Abita Creek Flatwoods Preserve	St. Tammany	East Gulf Coastal Plain (East)	The Nature Conservancy	30°31'N 89°58'W	Apr 2005
BD1	Bodcau WMA	Bossier	Upper West Gulf Coastal Plain (NW)	U.S. Army Corps of Engineers	32°43'N 93°32'W	fall 2005 (mowed)
CC1	CC Road Savanna	Allen	Lower West Gulf Coastal Plain (West)	The Nature Conservancy	30 °27'N 93 °03'W	Oct 2004
CWP	Camp Whispering Pines	Tangipahoa	East Gulf Coastal Plain (East)	Girl Scouts of America	30 °40'N 90 °27'W	spring 2003 spring 2006
FP2	Ft. Polk WMA	Vernon	Lower West Gulf Coastal Plain (West)	U.S. Army/U.S. Forest Service	31 °01'N 92 °53'W	June 2004 Feb 2007
IC1	Alexander State Forest	Rapides	Lower West Gulf Coastal Plain (West)	LA Dept of Agriculture	31 °07'N 92 °29'W	Winter 04/05
KD1	Kisatchie District, Kisatchie NF	Natchitoches	Lower West Gulf Coastal Plain (West)	USDA Forest Service	31 °27'N 92 °59'W	Jan 2004 May 2005
LR01	Lake Ramsey WMA	St. Tammany	East Gulf Coastal Plain (East)	LA Dept Wildlife & Fisheries/TNC	30 °30'N 90 °09'W	May 2005
LR02	Lake Ramsey WMA	St. Tammany	East Gulf Coastal Plain (East)	LA Dept Wildlife & Fisheries/TNC	30 °30'N 90 °09'W	June 2005
LR03	Lake Ramsey WMA	St. Tammany	East Gulf Coastal Plain (East)	LA Dept Wildlife & Fisheries/TNC	30 °30'N 90 °09'W	June 2005 Jan 2007
LR04	Lake Ramsey WMA	St. Tammany	East Gulf Coastal Plain (East)	LA Dept Wildlife & Fisheries/TNC	30 °32'N 90 °10'W	May 2005 Feb 2007
LR05	Lake Ramsey WMA	St. Tammany	East Gulf Coastal Plain (East)	LA Dept Wildlife & Fisheries/TNC	30 °31'N 90 °10'W	May 2004
RP1	Private Land	Morehouse	Mississippi River Alluvial Plain (NE)	Private		spring 2005
SH01	Sandy Hollow WMA	Tangipahoa	East Gulf Coastal Plain (East)	LA Dept Wildlife & Fisheries	30 °50'N 90 °24'W	Apr 2003 Mar 2006 winter 06/07
SH02	Sandy Hollow WMA	Tangipahoa	East Gulf Coastal Plain (East)	LA Dept Wildlife & Fisheries	30 °50'N 90 °24'W	April 2004 March 2006 winter 06/07
TI1	Private Land	Vernon	Lower West Gulf Coastal Plain (West)	Temple Inland Timber Co.		Aug 2004
TI2	Private Land	Beauregard	Lower West Gulf Coastal Plain (West)	Temple Inland Timber Co.		Sept 2004
ULL	UL Research Farm	St. Martin	Gulf Coastal Prairie (South)	University of Louisiana-Lafayette	30 °05N 91 °52W	2001 +grazing Mar 2006

Next, we added any sites that also met at least one of the following criteria: presence of open pine savanna, prairie, pitcher plant bogs, or Red-cockaded Woodpeckers (Lester et al. 2005). The above criteria were chosen based on what we currently know of preferred Henslow's Sparrow winter habitat associations (Plentovich et al 1999, Carrie et al 2002, Thatcher et al 2003, Tucker & Robinson 2003, Bechtoldt & Stouffer 2005, Johnson 2006).

We used descriptions of state lands from the Louisiana Department of Wildlife & Fisheries, federal lands from the U.S. Forest Service, and some private lands from the Nature Conservancy and the Louisiana Natural Heritage Survey to select locations meeting one or more criteria. Due to research showing that habitat suitability declines significantly three years after a burn (Bechtoldt and Stouffer 2005, Johnson 2006), only sites meeting the above-mentioned criteria that had also been burned or otherwise managed to reduce litter density within the last five years were left on the final list. The only exception was a small saline prairie, which is a prairie associated with nutrient-poor soils that does not require burning (Lester et al. 2005). The original list of potential sites was continuously updated as new information on potential habitat was acquired.

The above selection criteria resulted in a list of 18 sites with potential for Henslow's Sparrows. All 18 locations were visited and further assessed between the months of October 2005 and March 2006, when there was a possibility that some wintering Henslow's Sparrows would be present. First, visual assessment was made by driving to all sites on the list and inspecting the habitat. All areas searched were documented, and notes were made regarding the thickness of the herbaceous layer, the density of shrubs and trees, and the presence of specific species of grasses and birds.

As Henslow's Sparrow is a grassland species, any areas within each of those locations that had a grassy understory were also investigated on foot by a group of people methodically walking through the habitat and attempting to flush and capture Henslow's Sparrows (see Methods: Relative Abundance Sampling for a detailed description of this technique). Due to the extreme size range of grasslands and savannas encountered, no specific amount of area was covered while searching for sparrows on foot. If the area was small, it was covered in its entirety. If the area was extensive, we covered as much of it as time allowed and surveyed sufficiently to detect any Henslow's Sparrows if they were present. Many marginal or mediocre areas, described as such if they had only sparse herbaceous layers or denser shrub cover, were also inspected on foot.

We used a GPS unit to document the locations where Henslow's Sparrows were either captured or positively identified. If no Henslow's Sparrows were found at a location, but the habitat quality looked comparable to areas where we did find them, it was noted as a comment.

### **Plot Selection**

If Henslow's Sparrows were present at a location, and the area of suitable habitat was large enough, we established a 2.25 ha study plot at the site for relative abundance sampling. We established nine plots (included in the 19 total plots mentioned in Methods: Study Sites), recorded their locations with a GPS unit, and marked the corners with plastic or metal pipes.

### **Relative Abundance Sampling**

We conducted bird surveys between 08:00 and 17:00 to estimate Henslow's Sparrow abundance from early November to early April of 2005-2006 and 2006-2007.

Each plot was surveyed at least once during the winter of 2005-2006, and most plots were surveyed three times during 2006-2007. Some plots could not be sampled three times the second season due to winter fire treatments.

Plots were sampled using a technique called flush netting, which requires 5-10 people spaced approximately three meters apart in a line to methodically cover a plot (Chandler and Woodrey 1995). We took compass bearings to ensure the line stayed on course and no area of the plot was covered more than once during a single sampling event.

For any suspected Henslow's Sparrows flushed, we marked the spot it originally flushed from with a plastic PVC pole, and the bird was pursued. The bird usually landed a short distance away in the grass or a low shrub, allowing us to surround it. Two people then cooperated to stretch out a 6 m mist net which had been carried with them on poles, and the remaining people attempted to flush the surrounded bird in to the net. If the bird was not captured on the first attempt, it was pursued until it was either captured or it disappeared. These methods follow Bechtoldt and Stouffer (2005) and Johnson (2006).

Whether a bird was captured or not, its original flush point and species, if known, was documented. Every attempt was made to identify all birds to the species level, but some birds could only be identified to the level of genus. Sparrows in the genus *Ammodramus* are cryptic and can be difficult to identify, but birds in this genus are often distinguishable from other genera by their weak flight and the way they drop back down in to the grass. *Ammodramus* sparrows that could not be identified to species were recorded as "*Ammodramus* sp." Birds that could not be captured but were positively identified as Henslow's Sparrows were included in density calculations.

All Henslow's Sparrows captured were banded on the right leg with a uniquely numbered U.S. Fish & Wildlife leg band. All Grasshopper Sparrows, LeConte's Sparrows, and Bachman's Sparrows were also banded (Appendix 2). We recorded the mass ( $\pm 0.25$  g), tail and unflattened wing chord length ( $\pm 0.5$  mm), fat score (0-8) using the Kaiser (1993) scale, gape color, and age (hatch year/second year, after hatch year/after second year) as determined by plumage and/or skull ossification described in Pyle (1997) for each Henslow's Sparrow captured. A tail feather, the right outer rectrix (R6), was pulled from every bird, and if the same tail feather was nearly or fully regrown upon recapture it was also collected. We stored feathers in coin envelopes at room temperature for later use in ptilochronology and sex determination. During the second winter, we also drew blood samples from the brachial vein for sex determination. Birds were banded on-site, and released at the location of capture after measurements and samples were taken.

During the first winter of the study, we recorded original flush locations of Henslow's Sparrows by taking a waypoint with a Garmin eTrex Global Positioning System unit (GPS; Garmin International Inc., Olathe, Kansas). For the second winter, in addition to GPS waypoints, flush locations were also marked with short sprinkler flags labeled with the corresponding bird's band number, date, and waypoint. We only marked accurate flush locations in this way, so if the exact spot the bird came from was uncertain, only a GPS location was taken. These flags were used so that we could return to the spot at a later date and document the vegetation structure and composition. Research using radio telemetry has shown that Henslow's Sparrows remain sedentary until flushed by the

line of people, so we were confident that the flush location represented where the bird was before being disturbed by us (Bechtoldt 2002).

### **Ptilochronology**

Ptilochronology is a way of quantifying feather growth rate by measuring the growth bars of a feather. This technique was performed on any regrown tail feathers collected from birds that had been captured previously during the same winter. Feather growth rate has been shown to be correlated with the overall health of an individual bird as growth rate is reduced during periods of inadequate nutrition or physical stressors (Grubb 1989, Grubb 1991, Takaki and Eguchi 2001). Thus feathers that have grown in while the bird was in a location of interest can be measured to assess habitat quality—lower daily growth rate indicates poorer quality habitat. We followed protocol by Grubb (1989), which called for measuring the length of a known number of growth bars on a feather with digital calipers ( $\pm 0.01$  mm), and calculating a mean growth bar length for that feather. To do this, both the original and regrown feathers were taped to index cards, and a pin was used to mark the most proximal and distal growth bars visible on each. We then measured the distance between the pins with the calipers, and recorded the number of growth bars between the pins.

### **Sex Determination**

It is not possible to sex the birds by any morphological characters during winter (Pyle 1997), so we determined the sex of Henslow's Sparrows using DNA extracted out of a blood sample or a feather. Blood samples were used preferentially for this purpose, and feathers were used to determine the sex of birds only if blood samples were unavailable or inadequate for the process.

Between 50 and 150  $\mu$ l of blood was drawn from the brachial vein in the wing of the birds. A small puncture to the vein with a sterile 26G 5/8" needle caused blood to well up, and it was then drawn into a non-heparinized capillary tube. The blood was stored in sterile microcentrifuge tubes containing 500  $\mu$ l Queens Lysis Buffer (QLB), and was kept refrigerated until processing (Seutin et al. 1991). Blood was not collected from birds that appeared stressed, particularly on cold days.

We followed a protocol modified from Sambrook and Russell (2001) and used by Johnson et al. (in review) to isolate the DNA. First, 500  $\mu$ l of whole blood in QLB buffer was added to a solution of 5 ml 8 M Guanidine-HCl and 50  $\mu$ l 2 M potassium acetate ( $\text{CH}_3\text{COOK}$ ). We then added 10 ml (approximately 2 volumes) of 100% ETOH and inverted the vial several times in order to allow the DNA to precipitate out. The DNA was removed with a glass rod and dissolved in 100-400  $\mu$ l 1x TE buffer at 4° C for at least 24 hours.

Two primers, CHD-P2 (Griffiths et al. 1996) and CHD-P8, were used to amplify DNA, which allows us to determine the presence or absence of the female-specific W-chromosome (Griffiths 1998). We used PCR methodology derived from Long and Stouffer (2003), and followed the altered procedure described in detail by E. Johnson (unpublished data). The procedure was performed in the same laboratory at Louisiana State University under the supervision of Mary Bowen, Senior Specialist Research Associate, LSU, and is described by Johnson et al. (in review) as follows:

Our PCR methodology for DNA extracted from whole blood follows Long and Stouffer (2003); however, we reduced the reaction volume from 50  $\mu$ l to 25  $\mu$ l. Reaction specifics are: 1x Green GoTaq Flexi Buffer (Promega Corp., Madison, Wisconsin), 1.5 mM  $\text{MgCl}_2$ , 200  $\mu$ M dNTP, 2.0-2.5 units GoTaq Flexi DNA polymerase (Promega Corp., Madison, Wisconsin) in 4  $\mu$ l for blood and 5.5  $\mu$ l for feathers, which contained 4-20 ng DNA. Polymerase chain reaction (PCR)

was performed with a MJR PTC-100 thermocycler, which was first set to 94° C for 90 seconds and followed by 30 cycles for blood or 40 cycles for feathers (Harvey et al. 2006) of 94° C for 30 seconds, 50° C for 45 seconds, and 72° C for 90 seconds. The final run was for 72° C for 5 minutes (J. Long, personal communication). PCR products were separated by electrophoresis for 18 hours at 1 V/cm in a 3% agarose gel in TBE.

Small amounts of bird DNA may be found in the proximal end of the feather shaft (Taberlet and Bouvet 1991). To isolate DNA from feathers, the proximal end of the calamus below the barbed rachis was severed from the feather, and then sliced lengthwise to allow maximum surface area exposure for extracting DNA. A Qiagen DNeasy Blood and Tissue Kit (Qiagen, Inc., Valencia, California) was then used to extract the DNA, and the rest of the sexing process was much the same as described above for the blood samples.

### **Habitat Structure and Plant Species Composition**

Data for habitat structure and species composition were only collected during the second year of the study. We gathered data on habitat structure from multiple variables using protocol described by Bechtoldt (2002) and Johnson (2006) for ease of comparison. Nine 6 m radius non-overlapping circular vegetation subplots were randomly selected in each 2.25 ha study plot. We then estimated percent herbaceous cover, bare ground/litter cover, and shrub cover for each subplot.

Within each subplot, we placed a modified Robel pole 3 cm diameter, 2 m tall pole down at nine predetermined points in order to measure vegetation density (Robel et al. 1970). These points were located at the center of the circle, and 3 m apart in each cardinal direction. The pole was divided into 10 cm increments, and the numbers of herbaceous “hits” were recorded on a scale of 1-10+ by a single individual holding the pole. A hit was a blade of dead or living vegetation that contacted the pole. In addition

maximum vegetation height, defined here as the tallest contact within a 30 cm radius from the pole, was recorded at each of the nine points within the subplot.

We determined plant species composition by placing a  $m^2$  frame on the ground at four predetermined points within each subplot—one at the center, and one 3 m away in each cardinal direction. Species making up a substantial portion of the cover were identified within the frame, and the percent cover was estimated for each. Percent cover over 100% was possible within the frame due to overlapping species cover at different vertical heights. Plants were identified at least to genus.

For data collected on trees, including species, diameter at breast height, and canopy cover, the vegetation subplot radius was extended by three meters in order to sample enough area of the plot overall to provide estimates for the entire plot. Species and diameter at breast height (to 9 m radius) were recorded for all trees  $\geq 3$  cm dbh. Basal area was then calculated from the diameter at breast height for each vegetation plot. Canopy cover was estimated using a vertical canopy densitometer (Geographic Resource Solutions, Arcata, CA), which resembles a T-shaped section of pipe containing a mirror on the inside and two levels. Canopy cover is measure with the densitometer by looking through the eyepiece while keeping both levels balanced, and checking to see if the dot in the center of the lens is covered by canopy from above. We took measurements of canopy cover by walking concentric circles 3, 6, and 9 m from the center of each subplot and recording a “hit” or “miss” at intervals of approximately 2 m for a total of 41 measurements (including the centerpoint). Thus the percent canopy for each subplot was calculated as the number of canopy “hits” divided by the total number of points (369 for

the whole plot). The same methods were used to collect structure data for locations flagged as bird flush points.

## STATISTICAL ANALYSES

### **Bird Density**

For analysis of bird density, the 2.25 ha study plot was the experimental unit, and the sampling event was the observational unit. Bird densities, given in Henslow's Sparrow detections per hectare, were adjusted prior to analysis to account for a number of observations in which a flushed bird could only be identified to genus (*Ammodramus*). The proportion of known Henslow's Sparrows to other *Ammodramus* species (Le Conte's Sparrow, *Ammodramus leconteii*; Grasshopper Sparrow, *Ammodramus savannarum*) identified on each plot was used to assign unknowns to a species. For example, if four Henslow's and one Le Conte's Sparrow were captured, but an additional bird flushed was identified as an *Ammodramus* sp. but not captured, I added 0.8 (4/5) of the unknown to the Henslow's Sparrow abundance estimate. This adjustment did not cause drastic change in raw densities, and was done to maintain consistency with previous studies (Bechtoldt 2002, Johnson 2006). Densities were then log-transformed to meet assumptions of parametric statistics.

I used a Generalized Linear Mixed Model to test the affects of time since burn (in number of growing seasons passed since burn), ecoregion, and basal area in the plot on bird densities (Proc Mixed, SAS Institute 2002). Louisiana is divided into six ecoregions characterized by distinctive ecological traits and plant and animal communities (Figure 3). As such, they can be used as a meaningful way to group study plots for comparison. For this analysis, I only used bird densities from plots that were located in the East Gulf Coastal Plain and the Lower West Gulf Coastal Plain ecoregions due to paucity of data from other ecoregions. Henceforth these ecoregions will be referred to as "east" and

“west”. Basal area ( $m^2/ha$ ) was estimated for each plot and tested as an independent variable because it was observed during initial site exploration that sites with high densities of trees rarely contained high numbers of birds.

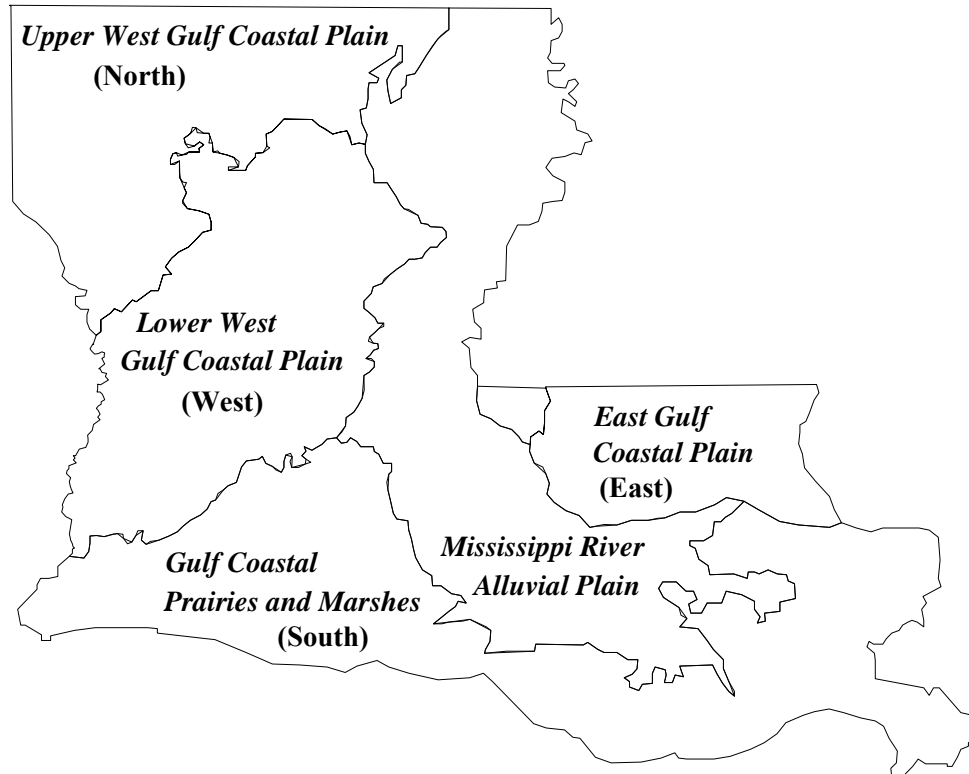


Figure 3. Louisiana ecoregions as designated by The Nature Conservancy.

Fixed effects included time since burn, ecoregion, and basal area, and plot was included as a random effect. The month of sampling, up to and including fourth order polynomials and interactions with time since burn at each level ( e.g. month\*month, month\*month\* burn, etc.), were placed in the model as covariates to account for fluctuating trends in bird densities through the winter due to migratory movement

(J. Geaghan, personal communication). Residuals were tested for normality using the Shapiro-Wilk test, and for homogeneity of variance using a scatter plot of the residuals plotted against the predicted values.

Akaike's Information Criterion (AIC), a model selection approach, was then used to identify the most meaningful model(s) out of all selected models. Anderson and Burnham (2002) recommend use of AICc values, which are used in place of AIC values for cases of smaller sample size. Using the AICc values calculated by SAS for each model, I utilized a selection process to eliminate variables that were not improving the overall fit of the model (Burnham & Anderson 2002 section 3.6.3). Starting with the full model, variables were removed one by one as long as the model AICc value continued to improve (lower AICc score) (SAS version 9.3.1 Service Pack 4 Documentation). If removal of a variable caused the AICc value to rise, that variable was passed over and the removal continued until the most parsimonious model was obtained. I also tested a null model, in which all independent variables were excluded and the response variable was tested against the intercept only. The null model is used as a type of benchmark to compare the validity of the best model(s). If the best model does not surpass the null model, it suggests that none of the selected models are a particularly good fit (Burnham and Anderson 2002).

In addition I conducted a separate analysis on bird densities using an ANOVA in Proc Mixed because I was interested in the variation in bird densities for each plot. In this case, I used the means of Henslow's Sparrow densities for each plot over a single winter instead of the densities for each sampling event. Therefore the plot was both the experimental unit and the observational unit. Fixed effects tested were burn and

ecoregion, again using only the east and west ecoregions. I did not use a model selection approach for this test.

### **Habitat Associations**

I tested bird density and vegetation associations with a Generalized Linear Mixed Model by specifying the Poisson distribution in Proc Glimmix (June 2006, SAS Institute) because the data did not meet assumptions of normality. The Poisson distribution is commonly used for count data. Only bird densities from the second winter of study were used because no vegetation measurements were collected during the first season. Once again plots were the experimental units, and sampling events were the observational units. Bird densities were not transformed for this analysis.

Vegetation measurements of interest fell into two main divisions: plant species composition recorded as percentages of each species, and habitat structure, which included all other measurements regarding the habitat (Table 2).

Table 2. Variables measured for habitat structure associations.

<b>Habitat Variables</b>
% Canopy Cover
% Herbaceous Cover
% Litter + Bare Ground
% Shrub Cover
Basal Area (m <sup>2</sup> /ha)
Max Herbaceous Height (cm)
Herbaceous Density 0-10 cm
Herbaceous Density 10-20 cm
Herbaceous Density 20-30 cm
Herbaceous Density 30-40 cm
Herbaceous Density 40-50 cm

Due to the high number of species identified and the potential for multicollinearity among many habitat structure measurements, I did two separate principle component analyses in order to condense the variables. The first PCA was for only species data with the original list of 67 species pared down to 32 after removing species that appeared in only one plot (Table 3, Appendix 3), and the second was for habitat structure.

Table 3. Reduced species list for use in PCA.

<b>Ground Cover Species</b>	
<i>Andropogon virginicus</i>	<i>Mimosa</i>
<i>Aristida purpurescens</i>	<i>Muhlenbergia expansa</i>
<i>Aristida</i>	<i>Panicum anceps</i>
<i>Aster</i>	<i>Panicum verrucosum</i>
<i>Carex</i>	<i>Panicum virgatum</i>
<i>Ctenium aromaticum</i>	<i>Paspalum</i>
<i>Dichantherium scaburiusculum</i>	<i>Pinus palustris</i> (“grass stage”)
<i>Dichantherium</i>	<i>Pityopsis graminifolia</i>
<i>Eragrostis refracta</i>	<i>Pteridium aquilinum</i>
<i>Eragrostis</i>	<i>Rhynchospora elliotii</i>
<i>Eriocaulon</i>	<i>Rhynchospora</i>
<i>Eupatorium</i>	<i>Sarracenia alata</i>
<i>Euthamia</i>	<i>Schizachyrium scoparium</i>
<i>Helianthus angustifolius</i>	<i>Schizachyrium tenerum</i>
<i>Hypericum</i>	<i>Solidago</i>
<i>Lycopodium</i>	<i>Tridens ambiguus</i>

The resultant PCA factors became the dependant variables in this analysis (Appendix 4). AIC model selection was again utilized as with the previous analysis, but with the comparable pseudo-AICc values calculated by Proc Glimmix for non-normal distributions (Glimmix 2006).

A separate vegetation analysis was performed for bird microhabitat selection by comparing vegetation measurements from bird flush locations to those of random locations within the plots used in the previous analysis. As described above, two separate

principle component analyses were used to condense species data and habitat structure data separately (Appendix 5).

I used logistic regression to test whether the probability of flushing a bird is correlated with any species or habitat variables; vegetation subplots were categorized as zeros for random points, and ones for bird flush points. The vegetation subplot was the experimental unit, and the measurement points within each subplot were the observational units. Any random subplots that fell too close to bird flush subplots were eliminated from this analysis. The logistic regression was done in Proc Glimmix so that the random effect for plot could be incorporated in the model. A nested random statement was used to specify that the vegetation points (both random and flush) were being compared within plots. AIC model selection was performed on the resultant set of models as well.

### **Bird Condition**

Three measures of body condition were used to assess possible effects of burn on the health of Henslow's Sparrows: mass, body fat, and feather growth rate. Bird body condition can be used as an indicator of fitness and habitat quality as it is thought to be directly related to survival (Newton 1993). For these analyses, the plot was the experimental unit. For all parametric tests in Proc Mixed, assumptions of normality were confirmed using the Shapiro-Wilk test for normality of residuals, and a plot of residuals\*predicted values for homogeneity of variance.

I analyzed bird mass using Analysis of Covariance (Proc Mixed, SAS Institute 2002). Fixed effects included burn, ecoregion, and a burn\*ecoregion interaction as well as age (HY/SY vs. AHY/ASY), sex, and an age\*sex interaction. Random effects

included plot, and covariates included wing chord length, month of capture, a month\*month interaction to account for possible nonlinear changes in fat deposition throughout the winter, and time of capture (minutes since sunrise). Wing chord was used as proxy for bird body size in order to account for the correlation between bird weight and overall body size (Piersma and Davidson 1991). We included month of capture and time of capture because the amount of fat a bird carries can fluctuate both within a day and within a season (Haftorn 1989, Gosler 1996), and variation in fat levels contribute to a bird's overall mass. Because age and sex were not known for all birds, two separate models were run using different data sets—one for the complete data set disregarding age and sex effects, and another on a restricted data set from which all birds of unknown age and sex were eliminated.

The amount of fat a bird carries can sometimes be used as an indicator of habitat quality for wintering birds (Rogers 1987). I examined the effects of burn on body fat using a multcategory logit regression, which allows for testing of a categorical dependant variable (Proc Glimmix, June 2006, SAS Institute 2002). Body fat was placed in categories of 0-8 for each bird (Kaiser 1993). As with body mass, I conducted two separate analyses in order to test age and sex effects without loss of data. Fixed and random effects were the same as with the bird mass analysis, but I added latitude as a fixed effect to determine if birds farther north carry more fat due to potentially harsher climate conditions (Rogers and Reed 2003).

Feather growth rate was analyzed using Analysis of Variance (Proc Mixed, SAS Institute 2002). Feather regrowth measurements were only available for 13 Henslow's Sparrows because birds had to be recaptured to have a second tail feather pulled. All

birds from which regrowth feathers were obtained were from either the east or the west ecoregion. Fixed effects included burn, ecoregion, burn\*ecoregion, and sex. Due to low sample size, we did not test age in this analysis. The dependant variable used was a ratio of the mean growth bar length of the induced feather to that of the original feather. This ratio was used in order to account for differing growth rates for individual birds (Grubb 1989).

### **Sex Ratios**

Finally, I used the G-test of Independence to test for differences in the proportion of male and female Henslow's Sparrows by number of growing seasons since burn, and the Cochran-Mantel-Haenszel test (used for repeated G-tests of Independence) to test for significant differences in sex ratios between ecoregions while accounting for variation between years (Proc Freq, SAS Institute 2002). I was unable to use the Cochran-Mantel-Haenszel test to test burn due to low sample size in certain categories within years, so for burn the years were lumped together. The null hypothesis for the G-test of Independence states that the relative proportions of males and females do not differ between burn categories. The null hypothesis for the Cochran-Mantel-Haenszel test is that for each year, there is no difference in the proportion of males and females between ecoregions. For the ecoregion analysis, I was only able to test the East Gulf Coastal Plain and the Lower West Gulf Coastal Plain (East and West) because there were too few birds sexed (n=9) in other ecoregions.

A final G-test was used to test for possible differences in sex ratios in the east ecoregion among all four winters of study utilizing data sex collected by Erik Johnson

from 2003-2005 in addition to sex data from this study. Once again, birds captured in November, March, and April were eliminated from this analysis.

## **RESULTS**

### **Statewide Survey**

We searched for Henslow's Sparrows in six Wildlife Management Areas, three National Wildlife Refuges, five districts of National Forest, one state forest, and eight private landholdings for a total of 23 major sites (Appendix 6). Henslow's Sparrows were present in 11 of these areas, and were found in a variety of grassland habitats including pine savanna, upland pine forest, pitcher plant bogs, open prairies, and pasture. On the Evangeline Unit of Kisatchie National Forest, we caught a single Henslow's Sparrow in a remnant prairie <2 ha in total area, but no other suitable habitat was found in the rest of the National Forest so the site was not included in the 11 mentioned above.

Most of the areas containing significant numbers of Henslow's Sparrows were located in the East Gulf Coastal Plain of southeastern Louisiana, and the Lower West Gulf Coastal Plain ecoregion of west-central Louisiana (Figure 4), both of which were historically dominated by longleaf pine forests and savannas (Frost 1993, Outcalt 1997). The western ecoregion currently contains four out of the five districts of Kisatchie National Forest, which combined make up over 244,000 hectares dominated by pine forests and savannas. Very little potential Henslow's Sparrow habitat exists in northern Louisiana, but nevertheless some suitable areas there did contain relatively high densities of birds.

### **Bird Density**

A total of 219 individual Henslow's Sparrows were, including birds captured during initial exploration for new study plots. During actual density sampling events, we

captured 190 individual Henslow's Sparrows a total of 214 times (Table 4). Recaptured birds were always recaptured on the same plot where they had been originally banded.

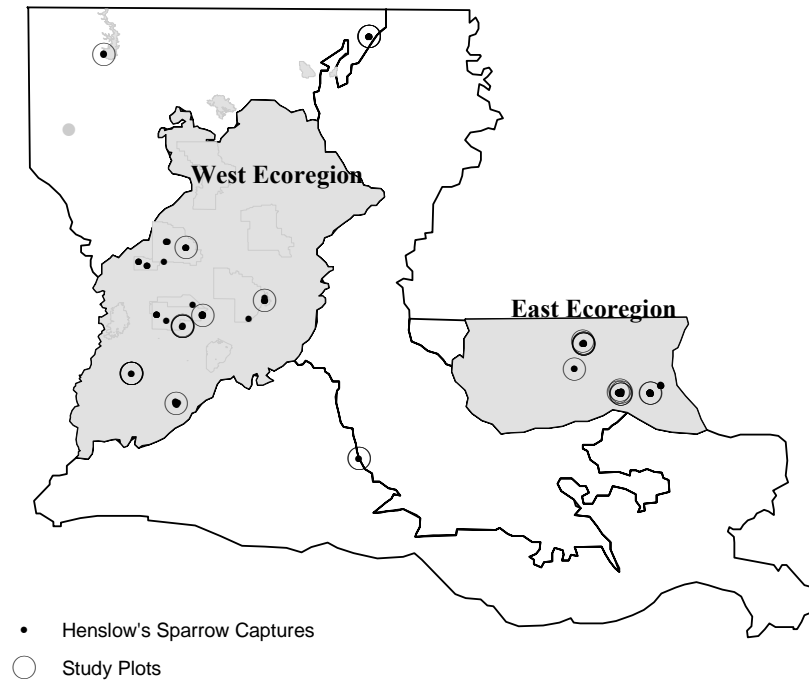


Figure 4. Study plots and bird captures during the first winter (2005/2006).

We recaptured 28 individual birds 35 times; 15 recapture events were due to birds being recaptured within the same year, and 20 were due to birds originally captured during a previous winter. Two birds were originally captured more than one year previous—one of those was originally banded at the same location in November 2001 during Henslow's Sparrow research conducted by Ross Carrie (Carrie et al. 2002) and was subsequently recaptured during this project in December 2005 on the same plot. Another individual had been captured for three winters in a row on the same plot as the original capture (LR01) in southeastern Louisiana.

Table 4. Summary of Henslow's Sparrow captures, recaptures, and means of all sampling events by ecoregion.

<b>Ecoregion</b>	<b>Sampling Events</b>	<b>Plots</b>	<b>Captures</b>	<b>Recaptures</b>	<b>Mean Birds/ha</b>	<b>Standard Error</b>
North	8	2	17	3	.91	± 0.23
East	43	10	125	21	1.61	± 0.24
West	23	6	70	10	1.47	± 0.27
South	4	1	2	1	0.11	± 0.11
Totals	78	19	214	35	1.42	± 0.16

Five different models were used to assess the importance of time since burn, ecoregion, and basal area on Henslow's Sparrow densities using AIC model selection (Table 5). The best model included all variables except for basal area, and it also included an interaction term between ecoregion and time since burn. The respective importance of the variables in the best model were calculated by summing the weights ( $\omega_i$ ) of all models that include that variable (Table 6).

Table 5. AIC rankings of all models chosen to estimate bird densities during both winters (2005/06, 2006/07). k=number of parameters,  $\omega_i$ =model weight. The model with a  $\Delta AIC \leq 2.0$  show substantial support and are indicated in bold. NULL model is the model run on the intercept only and is included for comparison purposes.

<b>Model</b>	<b>k</b>	<b>AICc</b>	<b><math>\Delta AICc</math></b>	<b><math>\omega_i</math></b>	<b>Model Likelihood</b>
Burn Ecoregion <b>Burn*Ecoregion</b>	3	127.7	<b>0</b>	0.939	1
Burn Ecoregion	2	133.4	5.7	0.054	0.058
Ecoregion	1	138.9	11.2	0.003	0.004
Burn	1	140.6	12.9	0.001	0.002
Burn Ecoregion <b>Burn*Ecoregion BA</b>	4	141.7	14	<0.001	<0.001
NULL		108.7			

Table 6. Relative variable importance for best model for estimating bird densities. Importance is calculated as the sum of the model weights of those that contain the variable of interest on a scale of 0-1, 1 being higher importance.

<b>Variable</b>	<b>Importance (<math>\Sigma \omega_i</math>)</b>
Burn	0.994
Ecoregion	0.994
Burn*Ecoregion	0.939

The second ranked model contained ecoregion and time since burn without the interaction. There was no strong support for the remainder of the models. However, the null model was substantially lower than any of them, which suggests that none of these models were satisfactory for explaining the variation in bird density.

Although time since burn was not shown to be an important variable overall in the AIC selection, previous studies have all shown that Henslow's Sparrows abundance strongly declines as time since burn increases (Carrie et al. 2002, Tucker and Robinson 2003, Bechtoldt and Stouffer 2005). However, a plot of predicted bird densities on time since burn for each ecoregion revealed a strong negative trend in the east ecoregion, and a strong positive trend in the west ecoregion (Figure 5).

Results of the ANOVA for means of bird densities for each plot revealed a trend very similar to the preceding analysis, and there was a significant interaction for Burn\*Ecoregion using an alpha value of 0.05 (Table 7).

Table 7. Results of ANOVA on bird densities tested with means for each plot within a single winter.

<b>Effect</b>	<b>df<sub>effect</sub></b>	<b>df<sub>error</sub></b>	<b>F</b>	<b>Pr &gt; F</b>
Burn	2	19.9	0.90	0.4219
Ecoregion	1	15.4	0.21	0.6562
Burn*Ecoregion	2	19.9	4.14	<b>0.0315</b>

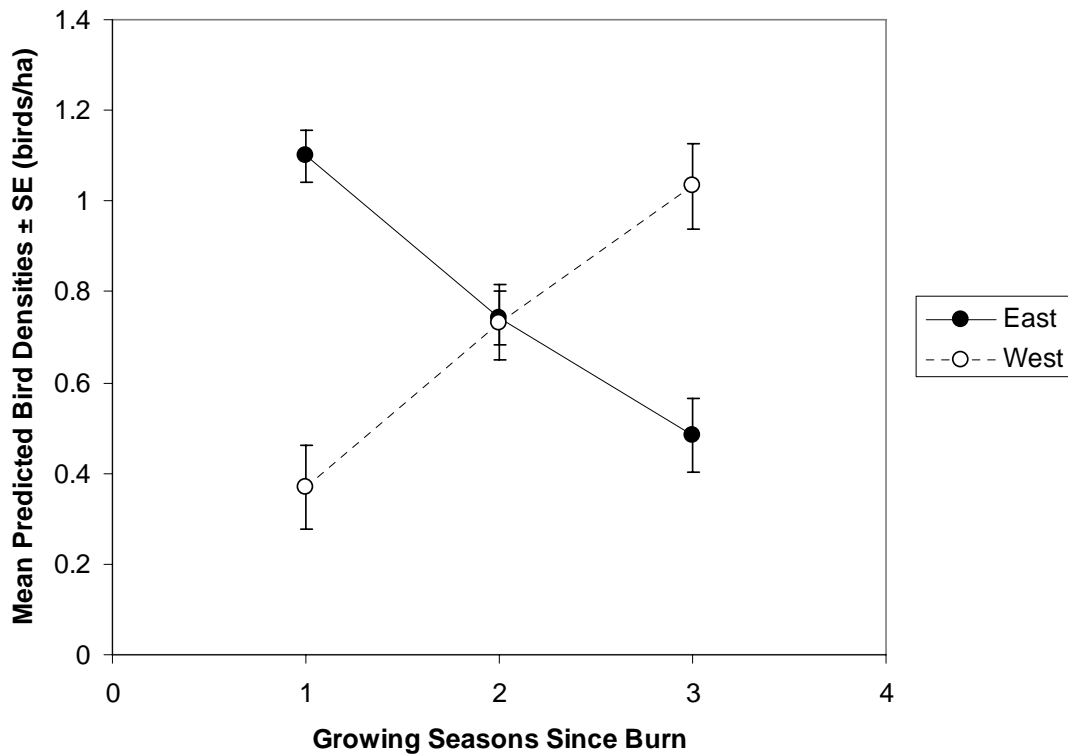


Figure 5. Means of predicted bird densities by ecoregion against time since burn. Predicted bird densities represent densities that have been adjusted (in SAS) for all other variables and covariates in the model.

### Habitat Associations

AIC values of selected models were used in a stepwise variable selection process in order to identify habitat variables that may be associated with bird density at the level of the study plot. Because vegetation data was only collected during the second year of the study, this analysis was restricted to bird densities from the second year as well. I was unable to test time since burn in this analysis because of the plots we were able to collect vegetation data from, only one had been burned the same year. Five plots were

burned before habitat data could be collected (LR03, LR04, SH01, SH02, IC1) so those were excluded from this analysis as well.

The habitat data were condensed into PCA factors prior to being entered in the model. For the plant species PCA, six factors were kept based on the accepted eigenvalue of 1. For the habitat structure, 17 variables went in to the analysis, and three good factors came out (Appendix 4). Therefore the full model included a total of 9 variables (Table 8).

[condense]After the variable selection process was complete, the top ranked model based on  $\Delta AIC$  score included eight out of the nine possible variables (Table 8). The next five models all had  $\Delta AIC$  values within 2.0 of the top ranked model, and all models fell within 5.0  $\Delta AIC$  of the top ranked model. Differences of two or less indicate that the models all have “substantial support”, and one would hope to see a difference of 6-10  $\Delta AIC$  to safely conclude the lesser models have no merit (Burnham and Anderson 2002). In this case the models were too close in score to be able to differentiate between them, and even the most parsimonious models contained almost all of the nine variables tested. Calculations of the importance for each variable revealed very little variation, which further supports the conclusion that none of the individual variables were very influential (Table 9). Furthermore, when compared to the null model, the top ranked model was not substantially better.

Vegetation structure was compared between random points and bird flush points within each plot. The PCA used to condense the herbaceous species data resulted in seven species factors and three habitat structure factors for a total of ten variables

(Appendix 5). Logistic regression was used to compare points, and the top two ranked models both showed substantial support with  $\Delta AICc$  values between 0-2 (Table 10).

Table 8. AIC rankings of all models of habitat associations chosen to estimate bird densities during the second winter only(2006/07).  $k$ =number of parameters,  $\omega_i$  =model weight. Models with a  $\Delta AIC \leq 2.0$  show substantial support and are indicated in bold. NULL model is the model run on the intercept only and is included for comparison purposes.

<b>Model</b>	<b>k</b>	<b>AICc</b>	<b><math>\Delta AICc</math></b>	<b><math>\omega_i</math></b>	<b>Model Likelihood</b>
sp1 sp2 sp3 sp4 sp5 sp6 hab2 hab3	8	116.4	<b>0</b>	0.226	1
sp1 sp2 sp3 sp4 sp6 hab2 hab3	7	117.59	<b>1.19</b>	0.124	0.552
sp2 sp3 sp4 sp5 sp6 hab2 hab3	7	117.65	<b>1.25</b>	0.119	0.535
sp1 sp2 sp3 sp4 sp5 sp6 hab1 hab2 hab3	9	117.68	<b>1.28</b>	0.102	0.527
sp1 sp2 sp4 sp5 sp6 hab2 hab3	7	117.99	<b>1.59</b>	0.088	0.452
sp1 sp2 sp3 sp5 sp6 hab2 hab3	7	118.28	<b>1.88</b>	0.062	0.391
sp1 sp2 sp3 sp4 sp5 sp6 hab1 hab3	8	118.99	2.59	0.059	0.274
sp1 sp3 sp4 sp5 sp6 hab2 hab3	7	119.08	2.68	0.052	0.262
sp1 sp2 sp3 sp4 sp5 hab2 hab3	7	119.35	2.95	0.025	0.229
sp1 sp2 sp3 sp4 sp5 sp6 hab1 hab2	8	120.78	4.38	0.025	0.112
NULL		120.89	4.49		

Table 9. Relative variable importance for best models of habitat associations for estimating bird densities. Importance is calculated as the sum of the model weights of those included in the models  $< 2 \Delta AIC$  that contain the variable of interest.

<b>Variable</b>	<b>Importance (<math>\omega_i</math>)</b>
hab3	0.952
sp6	0.900
sp2	0.893
hab2	0.890
sp4	0.864
sp3	0.850
sp1	0.831
sp5	0.827
hab1	0.181

Table 10. AIC rankings of all models of habitat associations chosen to estimate probability of flushing a Henslow’s Sparrow within a plot during the second winter (2006/07).  $k$ =number of parameters,  $\omega_i$ =model weight. Models with a  $\Delta AIC \leq 2.0$  show substantial support and are indicated in bold. NULL model is the model run on the intercept only and is included for comparison purposes.

Model		k	Pseudo AICc	$\Delta AICc$	$\omega_i$	Model Likelihood
sp1	hab1	2	4495.3	<b>0</b>	0.674	1
	hab1	1	4496.75	<b>1.45</b>	0.326	0.484
sp1	hab1hab2	3	4512.44	17.14	<0.001	<0.001
sp1		1	4518.67	23.37	<0.001	<0.001
sp1	hab1 hab2hab3	4	4519.76	24.46	<0.001	<0.001
	hab1 hab2 hab3	3	4521.57	26.27	<0.001	<0.001
sp1 sp2	hab1 hab2hab3	5	4534.96	39.66	<0.001	<0.001
sp1 sp2 sp3	hab1 hab2 hab3	6	4550.54	55.24	<0.001	<0.001
sp1 sp2 sp3 sp4	hab1 hab2 hab3	7	4565.62	70.32	<0.001	<0.001
sp1 sp2 sp3 sp4 sp5	hab1 hab2 hab3	8	4569.31	74.01	<0.001	<0.001
sp1 sp2 sp3 sp4 sp5 sp6	hab1 hab2 hab3	9	4573.69	78.39	<0.001	<0.001
sp1 sp2 sp3 sp4 sp5 sp6 sp7	hab1 hab2 hab3	10	4579.31	84.01	<0.001	<0.001
NULL			4524.1	28.8		

All other models had essentially no support with  $\Delta AICc$  values greater than 10 (Burham and Anderson 2002). The two top-ranked models therefore made up the confidence set for this analysis. These models contained the variable hab1, a habitat structure relationship, and sp1, a species relationship (Table 11). In comparison with the best models, the null model was extremely poor, with a  $\Delta AIC$  of 28.8.

Table 11. Relative variable importance for best models of habitat associations for estimating probability of flushing a bird. Importance is calculated as the sum of the model weights of those included in the confidence set of models that contain the variable of interest.

Variable	Importance ( $\Sigma \omega_i$ )
hab1	0.999
sp1	0.674

The hab1 factor is best described as the overstory-understory relationship in the savanna (Appendix 5). This factor indicated that where canopy cover, basal area, shrub cover, and leaf litter density on the ground were high, percent herbaceous cover (grasses and forbes) and herbaceous density within 10 cm of the ground were low. This variable appeared in both of the top ranked models, and the averaged model coefficient was -0.52. This indicates that as canopy cover and its correlates increased and herbaceous cover and density decreased, the probability of flushing a Henslow's Sparrow decreased. (Figure 6).

The sp1 factor included only two significant herbaceous species—a positive relationship between *Andropogon virginicus*, a bluestem grass, and *Rhynchospora*, a genus of beak sedge. *Rhynchospora* species were only classified to genus due to difficulties identifying them to species in the winter. This variable appeared in only one of the top ranked models, and the coefficient was 0.046, indicating that as percentages of these two plants increased, the probability of flushing a sparrow increased (Figure 6).

The consensus model for this analysis is  $\text{Flush} = (-0.52)\text{hab1} + (0.046)\text{sp1}$ . The parameter estimates in this case are difficult to interpret beyond general trends because they consist of PCA factors.

### **Bird Condition**

We obtained body mass and estimates of body fat for 210 Henslow's Sparrows over two years, and we successfully determined both the age and the sex of 176 of those birds. Results of analysis of bird body condition revealed no significant effect of burn, ecoregion, or age on mass or amount of fat of birds (Tables 12-15). As expected (Pyle 1997), sex did have a significant effect on mass of birds ( $p=0.007$ ) with females lighter

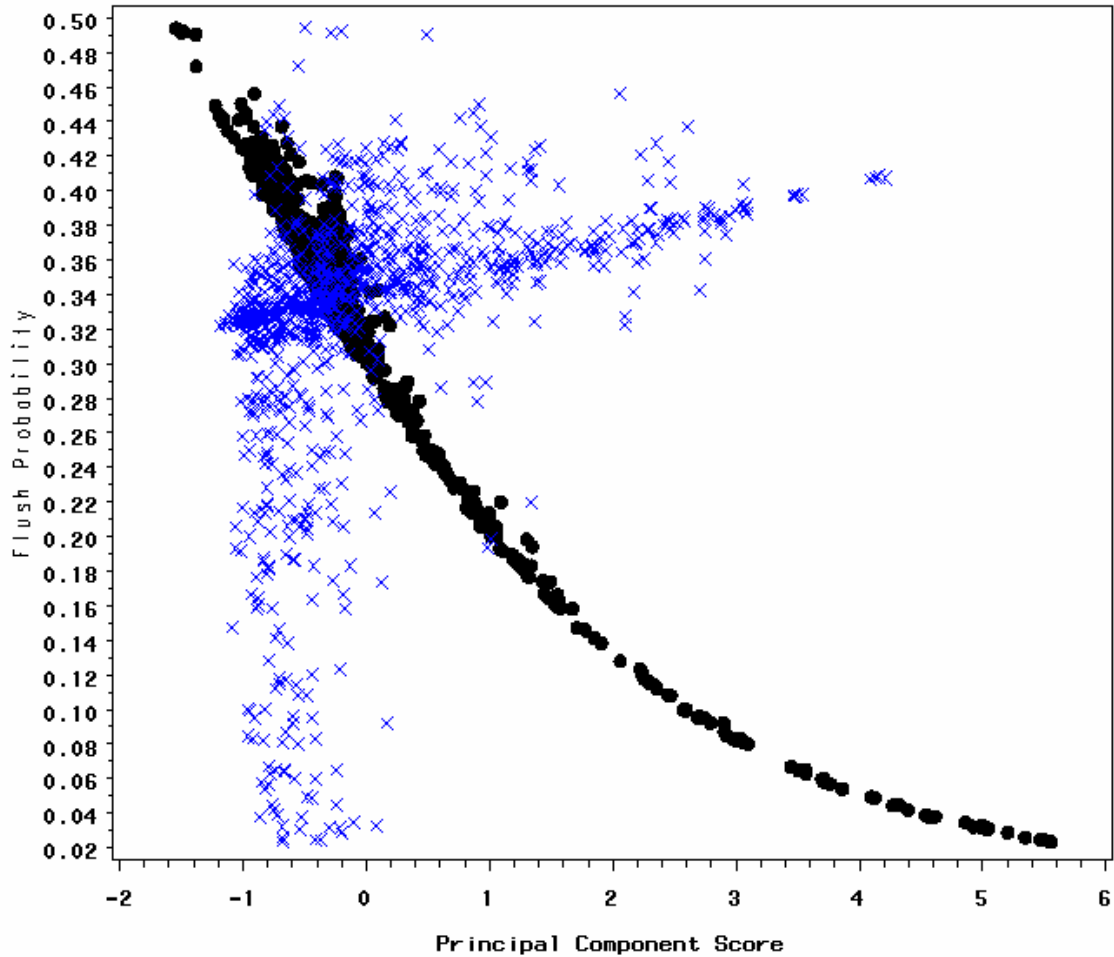


Figure 6. PCA scores of sp1 variable (crosses) and hab1 variable (circles) compared to probability of flushing a Henslow's Sparrow. When the herbaceous species associated with sp1 increase to a certain degree, the probability of flushing a sparrow increases. When basal area and its correlates decrease and the associated herbaceous cover and herbaceous density increase (hab1), the probability of flushing a sparrow increases.

than males. Fat or feather growth rate did not differ by sex or latitude. Likewise, feather growth rates did not vary significantly for burn, ecoregion, or sex (Table 16). I was unable to test the effect of age on feather growth rate due to small sample size (n=13).

Table 12. Effects of burn and ecoregion on bird mass with Month, Month\*Month, Minutes, and Wing length as covariates using all birds.

<b>Effect</b>	<b>df<sub>effect</sub></b>	<b>df<sub>error</sub></b>	<b>F</b>	<b>Pr &gt; F</b>
Burn	1	193	0.02	0.0898
Ecoregion	2	51.2	2.51	0.0909
Burn*Ecoregion	2	66.6	1.50	0.2307
Month	1	134	13.50	0.0003
Month*Month	1	123	12.61	0.0005
Minutes	1	170	7.55	0.0066
Wing	1	189	16.21	<.0001

Table 13. Effects of burn, ecoregion, age, and sex on bird mass with Month, Month\*Month, Minutes, and Wing length as covariates. Analysis used only birds of known age and sex.

<b>Effect</b>	<b>df<sub>effect</sub></b>	<b>df<sub>error</sub></b>	<b>F</b>	<b>Pr &gt; F</b>
Burn	1	160	0.31	0.5802
Ecoregion	2	160	0.38	0.6812
Burn*Ecoregion	2	160	0.09	0.9130
Age	1	160	0.64	0.4235
Sex	1	160	8.52	<b>0.0040</b>
Age*Sex	1	160	1.65	0.2008
Month	1	160	11.95	0.0007
Month*Month	1	160	9.92	0.0020
Minutes	1	160	2.52	0.1145
Wing	1	160	6.99	0.0090

Table 14. Effects of burn, ecoregion, and latitude on bird fat with Month, Month\*Month, and Minutes as covariates using all birds.

<b>Effect</b>	<b>df<sub>effect</sub></b>	<b>df<sub>error</sub></b>	<b>F</b>	<b>Pr &gt; F</b>
Burn	1	178	1.70	0.1936
Ecoregion	2	178	0.66	0.5201
Burn*Ecoregion	2	178	0.33	0.7199
Latitude	1	178	1.25	0.2656
Month	1	178	11.70	0.0008
Month*Month	1	178	9.64	0.0022
Minutes	1	178	0.88	0.3508

Table 15. Effects of burn, ecoregion, latitude, age, and sex on bird fat with Month, Month\*Month, and Minutes as covariates. Only birds of known age and sex were used in this analysis.

<b>Effect</b>	<b>df<sub>effect</sub></b>	<b>df<sub>error</sub></b>	<b>F</b>	<b>Pr &gt; F</b>
Burn	1	144	0.06	0.7996
Ecoregion	2	144	0.32	0.7273
Burn*Ecoregion	2	144	0.02	0.9820
Age	1	144	0.66	0.4186
Sex	1	144	0.98	0.3241
Age*Sex	1	144	1.35	0.2467
Month	1	144	11.00	0.0012
Month*Month	1	144	9.30	0.0027
Minutes	1	144	1.80	0.1824

Table 16. Effects of burn, ecoregion, and sex on feather growth rate (ptilochronology).

<b>Effect</b>	<b>df<sub>effect</sub></b>	<b>df<sub>error</sub></b>	<b>F</b>	<b>Pr &gt; F</b>
Burn	1	8	0.16	0.6979
Ecoregion	1	8	2.46	0.1557
Burn*Ecoregion	1	8	2.08	0.1873
Sex	1	8	3.40	0.1024

## Sex Ratios

Of 192 Henslow’s Sparrows sexed over two years for this study, 93 were male and 99 were female. DNA was successfully extracted from 100% of blood and feather samples. Birds captured in November, March, and April were excluded from analyses because birds during those months are likely to be showing movements associated with migration, and I wanted to test proportions of birds likely to have wintered on the study sites (Johnson et al. in review). In analysis of ecoregion effects, data were further limited to only those birds captured in the east and west ecoregions due to insufficient sample size in the other two regions, leaving 104 samples for this test.

The G-test of Independence for proportions of males and females on sites that had 1, 2, and 3 growing seasons since burn was non-significant ( $\chi^2=0.74$ ,  $p=0.69$ ), so the proportions for each did not differ (Table 17).

The Cochran–Mantel–Haenszel test on proportions of males and females within each sampling year was significant ( $\chi^2=6.84$ ,  $p=0.009$ ); therefore the proportions of males and females in the east and west were not equal (Table 18; Table 19). During both years, there was a higher proportion of males in the west, and a higher proportion of females in the east (Table 20).

Table 17. Proportions of male and female Henslow’s Sparrows by burn for both years combined (2005/06, 2006/07). Top values within cells are counts, bottom value are row percentages. Birds captured in November, March, and April were excluded from this analysis.

<b>Burn</b>	<b>Female</b>	<b>Male</b>
<b>1</b>	20 46.51%	23 53.49%
<b>2</b>	17 56.67%	13 43.33%
<b>3</b>	16 51.61%	15 48.39%

Table 18. Proportions of male and female Henslow’s Sparrows by ecoregion for Year 1 (2005/06). Top values within cells are counts, bottom value are row percentages. Birds captured in November, March, and April were excluded from this analysis.

<b>Ecoregion</b>	<b>Female</b>	<b>Male</b>
<b>East</b>	34 59.65%	23 40.35%
<b>West</b>	7 30.43%	16 69.57%

Table 19. Proportions of male and female Henslow’s Sparrows by ecoregion for Year 2 (2006/07). Top values within cells are counts, bottom value are row percentages.

<b>Ecoregion</b>	<b>Female</b>	<b>Male</b>
<b>East</b>	7 63.64%	4 36.36%
<b>West</b>	14 42.42%	19 57.58%

Table 20. Proportions of male and female Henslow’s Sparrows by ecoregion for both years combined. Top values within cells are counts, bottom value are row percentages.

<b>Ecoregion</b>	<b>Female</b>	<b>Male</b>
<b>East</b>	41 60.29%	27 39.71%
<b>West</b>	21 37.50%	35 62.50%

Results of the G-test for sex ratios in the east using data combined from this study and prior research by E. Johnson from 2003-2006 revealed no significant differences in ratios among years, indicating that proportions of males and females were consistent across all four study years in the east ecoregion ( $\chi^2=1.56$ ,  $p=0.67$ ) (Table 21).

Table 21. Proportions of male and female Henslow’s Sparrows in the east for birds captured in this study combined with those captured from 2003-2005. Top values within cells are counts, bottom value are row percentages.

<b>Year</b>	<b>Female</b>	<b>Male</b>
<b>2003/04</b>	56 50.91%	54 49.09%
<b>2004/05</b>	36 55.38	29 44.62
<b>2005/06</b>	34 59.65	23 40.35
<b>2006/07</b>	7 63.64	4 36.36

## DISCUSSION

### Statewide Survey

Henslow's Sparrows were found in many sites over a variety of grassland types throughout the state of Louisiana, including upland pine savanna, flatwoods savanna, pitcher plant bogs, pasture, and native prairie. The highest numbers of birds were located in the East Gulf Coastal Plain ecoregion of southeastern Louisiana, and the Lower West Gulf Coastal Plain of west-central Louisiana (Figure 4), and these two regions also contained the largest amount of potential habitat. Suitable habitat in the northern part of the state was very scarce. In spite of this, 2 areas (BD1, RP1) did contain moderate densities of birds, suggesting that sparrows are finding habitat even if it is somewhat isolated. In addition, birds were occasionally found in very small patches of habitat less than 1 ha in total area, as long as it was sufficiently grassy. We were not interested in examining very small patches of habitat for this study; therefore we cannot say how important they might be for wintering sparrows. Given these findings, it appears that Henslow's Sparrows are generalists in at least certain aspects of their habitat requirements, and that they are not greatly limited by region, grassland type, habitat area, or habitat isolation in the winter.

In spite of extensive searching in the vast areas of pine-dominated habitat in the west ecoregion, consisting mostly of Kisatchie National Forest, Henslow's Sparrows were not encountered as frequently as expected. Even so, the west ecoregion still contained the largest amount of potential habitat overall compared with the other ecoregions. Large areas of pine habitat did not necessarily contain a large amount of pine savanna; often it was dominated instead by moderately dense pine forest with a thick,

shrubby understory. Even less of that was determined to be suitable for Henslow's Sparrows after extensive ground surveys failed to turn up birds.

Many of these grasslands I classified as marginal or even poor in suitability for Henslow's Sparrows were areas being actively managed for Red-cockaded Woodpeckers, an endangered species, through prescribed fire and tree thinning. Such areas were often characterized by a notably sparser herbaceous layer, higher percentage of shrub cover, and often contained substantial numbers of trees. Pine savannas managed for Red-cockaded Woodpeckers are purported to be beneficial to other species of rare and declining plants and animals, such as Bachman's Sparrows (*Aimophila aestivalus*), Northern Bobwhite (*Colinus virginianus*), and the Louisiana pine snake (*Pituophis ruthveni*) (Conner 2002, U.S. Fish and Wildlife Service 2003). Indeed, the reason we searched so many of the sites was due to known Red-cockaded Woodpecker management techniques including prescribed fire, which also benefits wintering Henslow's Sparrows (Tucker and Robinson 2002, Bechtoldt and Stouffer 2005).

We confirmed presence of significant numbers of Henslow's Sparrows within approximately half of the sites searched that actively managed for Red-cockaded Woodpeckers, but they were generally restricted to a few small patches of suitable habitat within the larger landscape occupied by the woodpeckers. RCW sites within the Kisatchie District and the Vernon Unit of Kisatchie National Forest did contain a large amount of Henslow's Sparrow habitat interspersed throughout, but such areas were the exception rather than the rule. Cram et al. (2002) found that savannas managed for Red-cockaded Woodpeckers in Arkansas were not necessarily adequate for wintering Northern Bobwhite, either. This suggests that it should not be assumed that management

plans geared towards sustaining Red-cockaded Woodpeckers will result in habitat that is suitable for Henslow's Sparrows.

### **Bird Density**

During the two years of this study, we captured 190 individual Henslow's Sparrows and recaptured 28 individuals, including some from previous years. The most parsimonious model resulting from the AIC model selection process for bird density contained the variables burn (number of growing seasons passed since burn), ecoregion, and a burn\*ecoregion interaction. When compared with the null model the "best" model was inferior, however it did appear to have some support in light of bird density patterns we had observed (Table 5; Figure 5).

In the AIC selection the full model, which contained the variables mentioned above in addition to basal area, was the one with the least support. Once basal area was removed, the model was substantially improved. Thus, it does not seem that basal area is useful in explaining bird densities over a larger scale, though our results suggest it may be a very important factor with regard to preferred microhabitat conditions (Figure 6). Other studies have looked at effects of tree density/basal area on Henslow's Sparrows and found them to be insignificant, so this would not be surprising (Carrie et al. 2002, Johnson 2006). However, we felt it would be useful to examine this variable again in light of the large regional scale of this study and the high variation in overstory among study plots.

In spite of the lack of confidence in the model relating bird density and ecoregion with respect to the null model, there was a visible interaction between time since burn and ecoregion, with bird densities decreasing over time in the east and increasing over

time in the west (Figure 5). In addition, the ANOVA run as a separate analysis did reveal a significant interaction between burn and ecoregion (Table 7). As numerous studies in the wintering ground of this species have already illustrated, burn is critically important to Henslow's Sparrow habitat (Plentovich et al. 1999, Carrie et al. 2002, Bechtoldt and Stouffer 2005, Johnson 2006). However, it is not yet clear if prescribed fire has the same effect on different habitat types. There is some evidence that upland pine savannas respond differently to fire in comparison to other habitat types such as flatwoods, specifically relating to the way the vegetation responds (Drewa et al. 2002, Glitzenstein et al. 2003, Johnson 2006). A strong decrease in Henslow's Sparrow density after the first winter following a burn was observed by Bechtoldt and Stouffer (2005) and Tucker and Robinson (2003). Bechtoldt and Stouffer (2005) focused on eastern longleaf pine savanna and eastern upland longleaf pine forest, and Tucker and Robinson (2003) focused on hillside seepage (pitcher plant) bog habitat. However Carrie et al. (2002) found that more sparrows were detected in areas that had undergone at least one growing season since burn on western longleaf pine savannas and western hillside seepage (pitcher plant) bogs.

Seven out of ten study plots in the east ecoregion were eastern longleaf pine (flatwoods) savannas, and the remaining three were eastern upland longleaf pine forest. Eastern longleaf pine savannas are typically low-lying and often wet (Lester et al. 2005). In contrast, the majority of study plots in the west were located in western upland longleaf pine forest, with the occasional inclusion of hillside seepage (pitcher plant) bogs (Lester et al. 2005). Given the differences in these habitats types and the potential for differing responses to fire, it is not surprising that bird densities in the east dropped off

strongly after burn year one, while densities in the west did not. However, although bird densities in the west actually increased as time since burn progressed, we cannot infer that prescribed fire is unnecessary in upland pine savannas—it has been well established that the opposite is true for plants (Frost et al. 1986). It is possible that upland pine savannas remain suitable for Henslow's Sparrows for a longer period of time following fire treatment than has been shown in other habitat types, or that the peak densities of sparrows do not occur in the first winter following a fire.

Even though the trend in the west indicates that bird densities increase with time since burn for a time, densities would undoubtedly drop off again as more time passes without fire treatment and the understory shrubs increase. During initial site surveys, we observed a large amounts of pine savanna that hadn't been burned in  $\geq 5$  years, and usually by then the understory was so thick with shrubs it was obviously unsuitable to Henslow's Sparrows.

### **Habitat Associations**

As with the model selection results above, the most parsimonious models for the relationship between bird densities and habitat characteristics were not particularly meaningful. The six models with the most support were all within 2.0  $\Delta AICc$  of one another, meaning that they were all equally parsimonious (Burham and Anderson, 2002). In addition, this confidence set of six models all retained at least seven of the nine variables possible. Although the confidence set of models were better supported than the null model, it was not a very large distinction, so it is questionable how well the selected variables actually help to explain variation in bird densities (Table 8).

These results indicate that there is a large amount of variation in plant species and vegetation structure characteristics among plots overall (Appendix 7), which would lend further weight to the notion that the birds are probably not restricted to grasslands containing specific plant species or overall structural characteristics as long as the habitat otherwise meets their needs. It is not known precisely how the birds are choosing habitat, but these results suggest that structural characteristics of microhabitat may be important. Given the area covered for this study and the variety of habitat types and plant communities observed, it is not surprising that many habitat variables were included in the best supported models.

Previous studies have shown that vegetation structure, particularly herbaceous density at ground level, is useful for explaining bird densities (Plentovich et al. 1999, Carrie et al. 2002, Bechtoldt and Stouffer 2005, Johnson 2006). Yet the PCA factor containing this measurement (Appendix 4) was of low importance for explaining variation in bird densities between different plots. Given the heterogeneity of among study plots, particularly in upland pine savanna where small pitcher plant bogs were often interspersed within more tree-dense pine savanna, it is possible that overall plot means for habitat structure measurements were not very helpful in pinpointing what is driving Henslow's Sparrow habitat selection.

Therefore, we also assessed habitat preferences within plots by comparing the random vegetation points used in the above analysis to vegetation points from which birds had actually flushed. Results from model selection of habitat associations for bird flush points resulted in two equally parsimonious and highly supported models which included two PCA factors used as variables—hab1 and pc1 (Table 10). Hab1 was a

vegetation structure relationship that can be explained as the well-documented relationship between the overstory and the understory at vegetation points, e.g. when canopy cover and basal area are high, herbaceous cover and vegetation density at ground level are low (Jameson 1967, Harrington and Edwards 1999, Platt et al. 2006). Sp1 was an herbaceous species relationship between *Andropogon virginicus* and *Rhynchospora* spp., which were positively correlated with one another (Appendix 5). Hab1 had a negative coefficient value, which means that as canopy cover and basal area increase and herbaceous cover and density decrease, the probability of flushing a bird decreases. Sp1 had a positive coefficient, so birds were more likely to flush in areas where those species were present.

These results, then, suggest some level of microhabitat selection by Henslow's Sparrows within plots. A similar conclusion was reached in a study of microhabitat characteristics by Plentovich et al. (1990), but this has never been repeated across such a large regional area with different habitat types. Hab1 was the more important variable of the two (Table 11) in the averaged model, and it contained the structural characteristic of herbaceous density and ground level, (leaf) litter, and overall herbaceous cover—elements that have been found to be important in predicting Henslow's Sparrow presence/abundance in other studies (Plentovich et al. 1999, Carrie et al. 2002, Bechtoldt and Stouffer 2005, Johnson 2006). Like Plentovich et al. (1999) and Carrie et al. (2002), we found Henslow's Sparrows associated with higher herbaceous density at ground level (0-10 cm from ground), and research took place in large part on upland pine savannas. Conflicting results came from sites in southeastern Louisiana (Bechtoldt and Stouffer 2005, Johnson 2006) where Henslow's Sparrows were more abundant in plots with lower

herbaceous density near the ground. Although this discrepancy may seem confusing, there are several interpretations that might help explain this.

First, research conducted previously in southeastern Louisiana was not examining microhabitat at bird flush points but rather the means of vegetation measurements across the plot. Therefore it is not known specifically if birds were choosing microhabitat that differed from the mean characteristics of the overall site (Appendix 7). Second, unlike western upland longleaf pine forest, the eastern longleaf pine (flatwoods) savannas are characterized by wet soils, dense herbaceous vegetation, and naturally sparse tree cover (Lester et al. 2005). It seems plausible that if herbaceous density is particularly high in flatwoods savannas of the east, the birds may select less dense areas; yet in the west, where there is more overstory and the herbaceous cover in general is often more sparse, the birds may select microhabitat that is more dense. In other words, birds may actually be selecting an optimum herbaceous density at ground level that falls somewhere in between the more sparse cover of upland pine areas, and the thick dense cover of the lower-lying eastern longleaf pine savannas.

The second variable, Sp1 is also challenging to interpret. *Andropogon virginicus*, a bluestem grass, was a fairly common species across the state. *Rhynchospora* is a genus of low growing beak sedge also found across Louisiana. Although we cannot say that Henslow's Sparrows specifically selected microhabitat based on presence of these species, we can use what we know of the plants to suggest likely possibilities. The most obvious explanation for the relationship between bird flush locations and these two specific plants would be food oriented. However, in a study on diet preference of Henslow's Sparrows, DiMiceli (2007) showed that sparrows consumed few *Andropogon*

or *Rhynchospora* seeds—*Andropogon* seeds are elongated and hairy, and *Rhynchospora* seeds are very tiny, making them impractical as food items.

A second possibility is that these two plant species contribute to a desirable herbaceous structure for Henslow's Sparrows. *Andropogon* is a tall, slender grass, and *Rhynchospora* is a very fine, low growing sedge. Based on the PCA results these two species are highly correlated with one another, and in combination they may have structural attributes attractive to Henslow's Sparrows due to predator avoidance, foraging efficiency, or both. It is also possible that these two species, being widespread across the state, are associated with other plant species desirable to sparrows. Species that are not common across the state would be unlikely to show up in the best AIC model, but they still may be important as food sources for Henslow's Sparrows in certain areas.

### **Body Condition**

No significant difference in body mass, fat score, or feather growth was detected between different burn treatments or bird age classes (Tables 12-16). The only significant correlation of dependant variables was between overall body mass and bird sex (Table 13), which was to be expected due to males being slightly larger in general (Pyle 1997). These results are consistent with those found by Johnson (2006), and do not provide any support for age or sex related social hierarchy in winter (Gauthreaux 1978, Marra 2000).

Covariates month of capture, a month\*month interaction to account for curvature, and minutes since sunrise at the time of capture were incorporated into the analyses for bird mass and fat. Both month and month\*month were significant for all analyses on bird mass and fat, showing higher mass and fat storage during the midwinter months.

Surprisingly, minutes since sunrise was only a significant covariate in one model—when bird age was not considered, minutes was a significant covariate for body mass.

### **Sex Ratios**

There was no difference in sex ratio of birds among plots burned 1, 2, and 3 years prior to sampling. Thus, if we assume recently-burned habitat is higher quality, there is no reason to suspect that Henslow's Sparrows exhibit intra-sexual competition during the winter. This is also supported by results from bird body condition analyses.

Although we captured a significantly higher proportion of males in the west and a significantly higher proportion of females in the east, it is unlikely that this can be explained by birds of a specific sex being more likely to choose one region over another. Prior research on the same study plots in the eastern ecoregion during winters from 2003-2005 showed approximately equal proportions of males and females (E. Johnson, unpublished data), but even equal proportions would likely be significantly different than the proportions found in the west ecoregion for this study.

If proportions of males and females are different among east and west portions of the state, it is unclear why. Longitudinal clines, to our knowledge, have never been described in other bird species. Sexing many Henslow's Sparrows across a larger portion of the winter range may help elucidate any reasons for this trend.

## CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Henslow's sparrows winter throughout Louisiana across a range of grassland habitats. They were most often found in pine savanna and associated pitcher plant bogs, but may also occupy open prairies and pastures (study plot ULL1) when conditions in such habitats meet their needs. The highest numbers and densities of birds were located in the East Gulf Coastal Plain ecoregion of southeastern Louisiana, and the Lower West Gulf Coastal Plain ecoregion of western-central Louisiana (Figure 4). Not only did these two regions contain the most birds, but they also contained the largest amount of suitable habitat due to presence of multiple National Forest districts and Wildlife Management Areas in which prescribed fire is used to maintain pine savanna. Both the east and west ecoregions were historically dominated by longleaf pine savannas (Frost and Walker 1986). Therefore management aimed at benefiting the Henslow's Sparrow should focus on these two important regions in Louisiana.

In spite of the large amount of pine savanna in the west ecoregion in particular, relatively little of it was found to be suitable habitat for the sparrow. Areas being managed for Red-cockaded Woodpeckers were specifically targeted during initial surveys because of compatible management techniques like tree thinning and regular prescribed fires, but only a fraction of the ones we searched contained Henslow's Sparrows in detectable numbers. More research in this area could help land managers determine what might be limiting Henslow's Sparrow abundance on such sites and help them to make adjustments that might make the areas more suitable for both species.

Results of vegetation analysis on a plot-wide scale revealed little correlation with Henslow's Sparrow densities, but results from vegetation analysis of bird flush points

within a plot showed that the birds are more likely to flush from areas with lower canopy cover, basal area, shrub cover, and litter, and correspondingly high herbaceous cover and herbaceous density at ground level. This suggests that grasslands inhabited by the Henslow's Sparrows are likely to be very heterogeneous, but the birds are selecting microhabitat within larger areas that meet their needs.

Two herbaceous species, *Andropogon virginicus* and *Rhynchospora* spp. were also associated positively correlated with the likelihood of flushing a bird. Although Henslow's Sparrows appear to consume seeds from a variety of plant species, exhibiting preference for *Muhlenbergia expansa* and *Dichanthelium*, they avoid seeds from *Andropogon virginicus* or *Rhynchospora* (DiMiceli 2007). As they do not appear to be food sources, it is possible these plants are associated with structurally suitable microhabitat or other plant species that are preferred as food sources.

Bird body condition, mass corrected for body size, fat deposition, and feather growth rate, did not vary significantly by time since burn, ecoregion, sex, or age class of the birds (Tables 12-16). These results were in agreement with those of Johnson (2006). Based on this, we found no evidence to suggest that inhabiting newly burned sites or different ecoregions provides health benefits to birds. Sex ratios of Henslow's Sparrows did not differ between burn year either, but a significantly higher proportion of males was found in the west, and a significantly higher proportion of females was found in the east (Tables 18-20). However, given that these differences were regional, there does not support the existence of any sex-related social hierarchy or intrasexual competition.

Henslow's Sparrows are known to have highest winter densities the first winter after a burn (Tucker and Robinson 2003, Bechtoldt and Stouffer 2005), however results

of this study suggest that this general pattern may not be true for all regions in Louisiana (Figure 5). Consistent with previous results from studies in southeastern Louisiana, bird densities in the East Gulf Coastal Plain declined drastically as years passed since prescribed fire, but the opposite trend was displayed in the west. Other researchers have alluded to the possibility that upland pine savanna sites, like those predominant in the west, respond differently to fire than other grassland habitats. I speculate that the herbaceous vegetation in upland pine areas recovers more slowly post burn than more lowland habitats such as flatwoods savanna, and this dynamic could mean that optimum conditions for the Henslow's Sparrow occurs at different intervals post-burn for different habitat types. If this is true, then burning more frequently than every two years may actually make the savanna less suitable for high numbers of birds.

We conclude that a two-year prescribed fire rotation would adequately meet the needs of Henslow's Sparrows in a wide variety of grassland habitats. In the west ecoregion in particular more frequent burns would be undesirable. The two year fire rotation was also recommended by Johnson (2006), Bechtoldt and Stouffer (2005), and Thatcher et al. (2006). Tucker and Robinson (2003) recommended a 1-2 year rotation of prescribed fire, but cautioned that effects of persistent annual burning should be addressed before large-scale application because long-term effects of fire were not considered in this study.

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**APPENDIX 1. LIST OF VOLUNTEERS WHO ASSISTED WITH BIRD SAMPLING.**

Laura Alexander	Justin Hite	Kate Spivey
Jen Anderson	Jess Hite	Nicholle Stephens
Nicola Anthony	Margo Holst	Phil Stouffer
Lisa Appelbaum	Rector Hopgood	Paul Stouffer
Austin Arabie	Chuck Hughes	Antoinette Taylor
Eric Baka	Jay Huner	Jaime Thibodeaux
Nathan Banfield	Jim Ingold	Lindsey Torbett
Dee Baum	Caleb Izzdepski	Scarlett Vallaire
Phred Benham	Rick Jacob	Phillip Vasseur
Jerry Bertrand	Erik Johnson	Rachel Villani
Chris Blocker	Bill Kelly	Adrienne Viosca
Devin Bosler	Scot King	Bill Wayman
Justin Bosler	Scotty King	Bonnie Whitehead
Jessica Brauch	James King	Meg Williamson
Matt Brooks	Peggy Kuhn	Adam Wood
Bill Brown	Lainie LaHaye	
Joan Brown	Peter Markos	
Camille Burson	Mark McConnell	
Julie Burson	Nancy Menasco	
Zac Burson	Christina Mertz	
Jonathon Carpenter	Larry Mertz	
Philip Chandler	Nicole Michel	
Deborah Clark	Melissa Miller	
Mark Cox	Larry Minor	
Ashleigh Cullen	Kevin Morgan	
Jon Dale	Jenny Norris	
Terry Davis	Jessica O'Connell	
David DeSha	Mitch Overby	
Margaret DeSha	Roselie Overby	
John Dillon	Steve Pagans	
Jennifer DiMiceli	Jane Patterson	
Melanie Driscoll	Dave Patton	
Jackie Duncan	Adriann Pedroza	
Beth Erwin	Katie Percy	
Katie Faust	Marie Perkins	
Katrina Florek	Charles Pfeiffer	
Marty Floyd	John Quinn	
Dave Fox	Paula Russel	
Richard Gibbons	Philip Saksa	
Ken Hackman	Jacob Saucier	
Margaret Hebert	Lindsay Schober	
Erin Herbez	Carl Sheely	

**APPENDIX 2. DETAILS OF OTHER BIRD SPECIES CAPTURED.**

<b>Species</b>	<b>Scientific Name</b>	<b>Date</b>	<b>Site</b>	<b>Parish</b>	<b>Latitude</b>	<b>Longitude</b>
Marsh Wren	<i>Cistothorus palustris</i>	11/4/2005	UL Teaching and Research Farm	St. Martin	30.09	-91.87
Sedge Wren	<i>Cistothorus platensis</i>	11/20/2006	Abita Creek Flatwoods Preserve	St. Tammany	30.51	-89.96
Sedge Wren	<i>Cistothorus platensis</i>	2/10/2007	Abita Creek Flatwoods Preserve	St. Tammany	30.51	-89.96
Sedge Wren	<i>Cistothorus platensis</i>	3/25/2007	Abita Creek Flatwoods Preserve	St. Tammany	30.51	-89.96
Sedge Wren	<i>Cistothorus platensis</i>	3/25/2007	Abita Creek Flatwoods Preserve	St. Tammany	30.51	-89.96
Sedge Wren	<i>Cistothorus platensis</i>	12/4/2005	Lake Ramsey WMA	St. Tammany	30.51	-90.16
Sedge Wren	<i>Cistothorus platensis</i>	2/3/2007	Lake Ramsey WMA	St. Tammany	30.51	-90.16
Sedge Wren	<i>Cistothorus platensis</i>	3/3/2007	Private Land	Morehouse		
Sedge Wren	<i>Cistothorus platensis</i>	2/12/2006	Sandy Hollow WMA	Tangipahoa	30.84	-90.4
Sedge Wren	<i>Cistothorus platensis</i>	11/19/2006	Sandy Hollow WMA	Tangipahoa	30.84	-90.4
Sedge Wren	<i>Cistothorus platensis</i>	11/4/2005	UL Teaching and Research Farm	St. Martin	30.09	-91.87
Bachman's Sparrow	<i>Aimophila aestivalis</i>	1/10/2006	Jackson Bienville WMA	Jackson & Bienville		
Bachman's Sparrow	<i>Aimophila aestivalis</i>	2/3/2006	Kisatchie District KNF	Natchitoches		
Bachman's Sparrow	<i>Aimophila aestivalis</i>	2/12/2006	Sandy Hollow WMA	Tangipahoa	30.84	-90.4
Bachman's Sparrow	<i>Aimophila aestivalis</i>	4/1/2006	Temple Inland Timber Co.	Beauregard		
Grasshopper Sparrow	<i>Ammodramus savannarum</i>	11/19/2006	Camp Whispering Pines	Tangipahoa	30.68	-90.46
Grasshopper Sparrow	<i>Ammodramus savannarum</i>	12/4/2005	Lake Ramsey WMA	St. Tammany	30.51	-90.16
Grasshopper Sparrow	<i>Ammodramus savannarum</i>	11/11/2005	Sandy Hollow WMA	Tangipahoa	30.84	-90.4
Grasshopper Sparrow	<i>Ammodramus savannarum</i>	11/19/2006	Sandy Hollow WMA	Tangipahoa	30.84	-90.4
LeConte's Sparrow	<i>Ammodramus leconteii</i>	12/11/2005	Abita Creek Flatwoods Preserve	St. Tammany	30.51	-89.96
LeConte's Sparrow	<i>Ammodramus leconteii</i>	11/20/2006	Abita Creek Flatwoods Preserve	St. Tammany	30.51	-89.96
LeConte's Sparrow	<i>Ammodramus leconteii</i>	11/20/2006	Abita Creek Flatwoods Preserve	St. Tammany	30.51	-89.96
LeConte's Sparrow	<i>Ammodramus leconteii</i>	11/18/2005	Bodcau WMA	Bossier	32.72	-93.53
LeConte's Sparrow	<i>Ammodramus leconteii</i>	3/25/2006	Bodcau WMA	Bossier	32.72	-93.53
LeConte's Sparrow	<i>Ammodramus leconteii</i>	3/25/2006	Bodcau WMA	Bossier	32.72	-93.53
LeConte's Sparrow	<i>Ammodramus leconteii</i>	3/25/2006	Bodcau WMA	Bossier	32.72	-93.53
LeConte's Sparrow	<i>Ammodramus leconteii</i>	3/25/2006	Bodcau WMA	Bossier	32.72	-93.53
LeConte's Sparrow	<i>Ammodramus leconteii</i>	3/25/2006	Bodcau WMA	Bossier	32.72	-93.53
LeConte's Sparrow	<i>Ammodramus leconteii</i>	3/25/2006	Bodcau WMA	Bossier	32.72	-93.53
LeConte's Sparrow	<i>Ammodramus leconteii</i>	3/25/2006	Bodcau WMA	Bossier	32.72	-93.53

**APPENDIX 2. CONTINUED.**

LeConte's Sparrow	<i>Ammodramus leconteii</i>	12/3/2006	Bodcau WMA	Bossier	32.72	-93.53
LeConte's Sparrow	<i>Ammodramus leconteii</i>	12/3/2006	Bodcau WMA	Bossier	32.72	-93.53
LeConte's Sparrow	<i>Ammodramus leconteii</i>	12/3/2006	Bodcau WMA	Bossier	32.72	-93.53
LeConte's Sparrow	<i>Ammodramus leconteii</i>	1/28/2007	Bodcau WMA	Bossier	32.72	-93.53
LeConte's Sparrow	<i>Ammodramus leconteii</i>	3/4/2007	Bodcau WMA	Bossier	32.72	-93.53
LeConte's Sparrow	<i>Ammodramus leconteii</i>	3/4/2007	Bodcau WMA	Bossier	32.72	-93.53
LeConte's Sparrow	<i>Ammodramus leconteii</i>	11/19/2006	Camp Whispering Pines	Tangipahoa	30.68	-90.46
LeConte's Sparrow	<i>Ammodramus leconteii</i>	2/25/2007	CC Road Savanna	Allen	30.45	-93.06
LeConte's Sparrow	<i>Ammodramus leconteii</i>	11/6/2005	Clear Creek WMA	Vernon	30.90	-93.48
LeConte's Sparrow	<i>Ammodramus leconteii</i>	11/6/2005	Clear Creek WMA	Vernon	30.90	-93.48
LeConte's Sparrow	<i>Ammodramus leconteii</i>	12/14/2005	Ft. Polk WMA	Vernon	31.03	-93.18
LeConte's Sparrow	<i>Ammodramus leconteii</i>	12/14/2005	Ft. Polk WMA	Vernon	31.03	-93.18
LeConte's Sparrow	<i>Ammodramus leconteii</i>	11/12/2006	Ft. Polk WMA	Vernon	31.03	-93.18
LeConte's Sparrow	<i>Ammodramus leconteii</i>	11/12/2006	Ft. Polk WMA	Vernon	31.03	-93.18
LeConte's Sparrow	<i>Ammodramus leconteii</i>	11/12/2006	Ft. Polk WMA	Vernon	31.03	-93.18
LeConte's Sparrow	<i>Ammodramus leconteii</i>	11/12/2006	Ft. Polk WMA	Vernon	31.03	-93.18
LeConte's Sparrow	<i>Ammodramus leconteii</i>	2/3/2006	Kisatchie District KNF	Natchitoches	31.38	-93.11
LeConte's Sparrow	<i>Ammodramus leconteii</i>	12/4/2005	Lake Ramsey WMA	St. Tammany	30.51	-90.16
LeConte's Sparrow	<i>Ammodramus leconteii</i>	12/4/2005	Lake Ramsey WMA	St. Tammany	30.51	-90.16
LeConte's Sparrow	<i>Ammodramus leconteii</i>	12/4/2005	Lake Ramsey WMA	St. Tammany	30.51	-90.16
LeConte's Sparrow	<i>Ammodramus leconteii</i>	2/11/2006	Lake Ramsey WMA	St. Tammany	30.51	-90.16
LeConte's Sparrow	<i>Ammodramus leconteii</i>	2/11/2006	Lake Ramsey WMA	St. Tammany	30.51	-90.16
LeConte's Sparrow	<i>Ammodramus leconteii</i>	12/10/2005	Private Land	Morehouse		
LeConte's Sparrow	<i>Ammodramus leconteii</i>	1/14/2007	Temple Inland Timber Co.	Beauregard		
LeConte's Sparrow	<i>Ammodramus leconteii</i>	1/14/2007	Temple Inland Timber Co.	Beauregard		
LeConte's Sparrow	<i>Ammodramus leconteii</i>	3/10/2007	Temple Inland Timber Co.	Beauregard		
LeConte's Sparrow	<i>Ammodramus leconteii</i>	11/4/2005	UL Teaching and Research Farm	St. Martin	30.09	-91.87
LeConte's Sparrow	<i>Ammodramus leconteii</i>	1/15/2006	UL Teaching and Research Farm	St. Martin	30.09	-91.87
LeConte's Sparrow	<i>Ammodramus leconteii</i>	2/5/2007	UL Teaching and Research Farm	St. Martin	30.09	-91.87
Common Yellowthroat	<i>Geothlypis trichas</i>	11/4/2005	UL Teaching and Research Farm	St. Martin	30.09	-91.87

**APPENDIX 3. GLOBAL LIST OF PLANT SPECIES IDENTIFIED ON STUDY PLOTS (SPECIES NAMES FROM USDA).**

**Woody Species**

Altingiaceae  
*Liquidambar styraciflua*

Anacardiaceae  
*Rhus glabra*

Aquifoliaceae  
*Ilex opaca*  
*Ilex vomitoria*

Asteraceae  
*Baccharis halimifolia*

Caprifoliaceae  
*Lonicera japonica*

Clusiaceae  
*Hypericum* sp

Cornaceae  
*Nyssa biflora*  
*Nyssa sylvatica*

Cyrillaceae  
*Cyrilla racemiflora*

Ericaceae  
*Lyonia lucida*  
*Vaccinium* sp

Euphorbiaceae  
*Triadica sebifera*

Fabaceae  
*Gleditsia triacanthos*

Fagaceae  
*Quercus falcata*  
*Quercus nigra*  
*Quercus pogada*  
*Quercus* sp  
*Quercus stellata*  
*Quercus virginiana*

Gelsemiaceae  
*Gelsemium sempervirens*

Juglandaceae  
*Carya* sp

Lauraceae  
*Sassafras albidum*  
*Persea* sp

Magnoliaceae  
*Magnolia virginiana*

Myricaceae  
*Morella cerifera*  
*Myrica heterophylla*

Onagraceae  
*Gaura longiflora*

Pinaceae  
*Pinus echinata*  
*Pinus elliotii*  
*Pinus palustris*  
*Pinus* sp  
*Pinus taeda*

Rosacea  
*Aronia arbutifolia*  
*Rubus* sp

Sapindaceae  
*Acer rubra*  
*Aesculus pavia*

Smilacaceae  
*Smilax glauca*  
*Smilax laurifolia*  
*Smilax* sp

Symplocaceae  
*Symplocos tinctoria*

Ulmaceae  
*Ulmus alata*

**Ferns and Fern Allies**

Lycopodiaceae  
*Lycopodium*

Polypodiaceae  
*Pteridium aquilinum*

**Herbaceous Species**

**Monocots**

Poaceae  
*Andropogon gerardii*  
*Andropogon glaucopsis*  
*Andropogon gyrans*  
*Andropogon virginicus*  
*Anthaenantia villosa*  
*Aristida purpurescens*  
*Aristida ramosissima*  
*Aristida* sp  
*Chasmanthium laxum*  
*Chasmanthium sessiliflorum*  
*Ctenium aromaticum*  
*Dichantheium scaburiusculum*

### APPENDIX 3. CONTINUED.

#### Monocots continued

*Dichantherium* sp  
*Dichantherium* sp1  
*Digitaria ciliaris*  
*Digitaria filiformis*  
*Digitaria ischaemum*  
*Digitaria* sp  
*Eragrostis elliottii*  
*Eragrostis refracta*  
*Eragrostis* sp  
*Eragrostis spectabilis*  
*Gymnopogon brevifolius*  
*Panicum anceps*  
*Panicum* sp  
*Panicum verrucosum*  
*Panicum virgatum*  
*Paspalum floridanum*  
*Paspalum praecox*  
*Paspalum setaceum* var.  
*muhlenbergii*  
*Paspalum* sp  
*Paspalum urvillei*  
*Muhlenbergia expansa*  
*Saccharum aplopecuroidum*  
*Schizachyrium scoparium*  
*Schizachyrium tenerum*  
*Setaria pumila*  
*Setaria pumila pumila*  
*Setaria* sp  
*Sporobolus cernuus*  
*Sporobolus indicus*  
*Sporobolus neglectus*  
*Tridens ambiguus*  
*Tridens flavus*

Cyperaceae  
*Carex* sp  
*Cyperus* sp  
*Fuirena* sp  
*Rhynchospora elliottii*  
*Rhynchospora* spp  
*Scleria ciliata*  
*Scleria oligantha*  
*Scleria pauciflora*  
*Scleria reticularis*  
*Scleria* sp

Eriocaulaceae  
*Eriocaulon* spp

Juncaceae  
*Juncus* spp

Xyridaceae

*Xyris* spp

#### "Dicotyledons"

Apiaceae

*Eryngium integrifolium*

Asteraceae

*Aster adnatus*

*Aster dumosus*

*Aster* spp

*Boltonia diffusa*

*Chaptalia* sp

*Chaptalia tomentosa*

*Coreopsis* sp

*Eupatorium capillifolium*

*Eupatorium* sp

*Euthamia* sp

*Helianthus angustifolius*

*Liatris* sp

*Pityopsis graminifolia*

*Rudbeckia* sp

*Solidago rugosa*

*Solidago* spp

*Symphyotrichum patens*

Droseraceae

*Drosera* sp

Fabaceae

*Desmodium* sp

*Lespedeza* sp

*Mimosa microphylla*

Linaceae

*Linum medium*

*Linum* sp

Melastomataceae

*Rhexia alifanus*

*Rhexia lutea*

Onagraceae

*Ludwigia hirtella*

*Ludwigia* sp

Rubiaceae

*Diodia teres*

*Diodia virginiana*

*Hedyotis* sp

Sarraceniaceae

*Sarracenia alata*

Verbenaceae

*Verbena brasiliensis*

**APPENDIX 4. RESULTS OF PCA FOR HABITAT ASSOCIATIONS WITH  
RELATION TO BIRD DENSITIES.**

<b>Species</b>	<b>Sp1</b>	<b>Sp2</b>	<b>Sp3</b>	<b>Sp4</b>	<b>Sp5</b>	<b>Sp6</b>
<i>Andropogon virginicus</i>	<b>88</b>	-25	9	28	-11	-23
<i>Pteridium aquilinum</i>	10	-5	-9	1	6	-1
<i>Aster</i>	10	3	8	-1	-7	-5
<i>Helianthus angustifolius</i>	5	-1	3	-4	-2	-5
<i>Schizachyrium tenerum</i>	<b>-54</b>	<b>-52</b>	-14	<b>42</b>	-23	<b>-44</b>
<i>Schizachyrium scoparium</i>	-15	<b>83</b>	-13	<b>49</b>	7	-19
<i>Mimosa microphylla</i>	-2	26	-6	7	-2	-10
<i>Eragrostis</i>	0	10	-1	3	-1	-4
<i>Aristida</i>	0	5	1	0	0	0
<i>Euthamia</i>	-1	4	-2	-1	2	-1
<i>Aristida purpurescens</i>	1	-14	-6	0	3	-3
<i>Rhynchospora</i>	24	-5	<b>90</b>	<b>33</b>	-11	5
<i>Dichanthelium scabriusculum</i>	8	7	<b>30</b>	-3	-8	-3
<i>Eriocaulon</i>	2	1	23	-1	-4	-1
<i>Paspalum</i>	-2	-2	16	-4	2	2
<i>Hypericum</i>	-3	-1	14	-2	2	2
<i>Solidago</i>	0	0	1	-5	0	0
<i>Eupatorium</i>	-1	-2	1	-6	4	1
<i>Panicum verrucosum</i>	0	-4	-4	-11	1	-2
<i>Carex</i>	-1	-2	0	-11	-1	1
<i>Panicum anceps</i>	3	-2	15	-16	-3	-2
<i>Panicum virgatum</i>	0	-1	1	-20	-4	1
<i>Dichanthelium</i>	8	-25	-9	<b>34</b>	<b>87</b>	21
<i>Rhynchospora elliotii</i>	0	-5	3	-6	9	3
<i>Tridens ambiguus</i>	-1	3	-2	2	8	0
<i>Pityopsis graminifolia</i>	-3	1	-3	-6	7	-1
<i>Muhlenbergia expansa</i>	-16	-9	-17	<b>49</b>	<b>-37</b>	<b>75</b>
<i>Sarracenia alata</i>	-3	-4	1	0	-4	18
<i>Ctenium aromaticum</i>	-2	-2	2	1	12	17
<i>Eragrostis refracta</i>	0	-2	2	-1	1	5
<i>Pinus palustris</i>	-1	-3	-2	-2	2	4
<i>Lycopodium</i>	0	0	0	0	0	0
Percent Variance Explained	23%	21%	15%	12%	10%	4%

<b>Habitat Variables</b>	<b>Hab1</b>	<b>Hab2</b>	<b>Hab3</b>
% Canopy Cover	<b>89</b>	-12	-10
% Litter + Bare Ground	<b>89</b>	-8	-29
Basal Area (m <sup>2</sup> /ha)	<b>87</b>	-15	-16
% Shrub Cover	<b>55</b>	-10	5
% Herbaceous Cover	<b>-88</b>	7	30
Herbaceous Density 30-40 cm	-5	<b>75</b>	24
Herbaceous Density 40-50 cm	-7	<b>75</b>	-5
Max Herbaceous Height	-24	<b>68</b>	4
Herbaceous Density 10-20 cm	-12	19	<b>84</b>
Herbaceous Density 0-10 cm	-27	-11	<b>78</b>
Herbaceous Density 20-30 cm	-6	<b>52</b>	<b>61</b>
Percent Variance Explained	41%	16%	11%

**APPENDIX 5. RESULTS OF PCA FOR HABITAT ASSOCIATIONS WITH  
RELATION TO FLUSH POINTS.**

<b>Species</b>	<b>Sp1</b>	<b>Sp2</b>	<b>Sp3</b>	<b>Sp4</b>	<b>Sp5</b>	<b>Sp6</b>	<b>Sp7</b>
<i>Andropogon virginicus</i>	<b>98</b>	-12	-6	2	-3	10	-4
<i>Aster</i>	10	4	-2	-6	5	-6	-1
<i>Eragrostis refracta</i>	9	-3	0	2	3	0	1
<i>Lycopodium</i>	7	-4	-1	1	-2	1	-3
<i>Schizachyrium scoparium</i>	-11	<b>90</b>	-16	-14	-3	<b>36</b>	0
<i>Mimosa microphylla</i>	-1	25	-3	-5	-6	2	-2
<i>Tridens ambiguus</i>	-1	8	-1	4	1	5	-1
<i>Eragrostis sp</i>	-1	7	-1	-2	6	-1	0
<i>Euthamia</i>	-1	4	-1	1	-1	-1	-1
<i>Panicum verrucosum</i>	-1	-3	<b>97</b>	-16	-9	14	2
<i>Aristida purpureascens</i>	-2	-11	14	9	-5	4	-1
<i>Eupatorium</i>	-2	-2	13	-1	0	-1	-2
<i>Dichanthelium sp.</i>	0	-14	-2	<b>80</b>	9	<b>57</b>	12
<i>Pteridium aquilinum</i>	5	-3	1	9	-7	-5	-2
<i>Rhynchospora elliotii</i>	-3	-2	0	9	2	-5	0
<i>Pinus palustris</i>	2	-7	-2	7	-4	2	1
<i>Pityopsis graminifolia</i>	-5	2	-1	6	-2	-4	-4
<i>Aristida</i>	1	0	0	4	-1	0	0
<i>Rhynchospora</i>	<b>39</b>	-3	-7	-24	<b>85</b>	21	10
<i>Ctenium aromaticum</i>	-15	-3	-4	9	<b>32</b>	7	11
<i>Dichanthelium scaburiusculum</i>	7	7	-3	-10	28	-10	1
<i>Eriocaulon</i>	3	1	-1	-6	15	-5	0
<i>Hypericum</i>	-2	-2	0	3	10	-1	0
<i>Paspalum</i>	3	-3	0	1	9	-5	0
<i>Solidago</i>	-1	0	0	0	1	-6	0
<i>Helianthus angustifolius</i>	4	2	1	-2	-1	-7	-3
<i>Carex</i>	-2	-2	-1	1	0	-11	-1
<i>Panicum anceps</i>	2	-2	0	2	10	-16	0
<i>Panicum virgatum</i>	0	-2	-2	0	1	-18	-1
<i>Muhlenbergia expansa</i>	-19	-27	-22	<b>-35</b>	-21	<b>38</b>	<b>73</b>
<i>Sarracenia alata</i>	-4	-3	-3	3	8	4	12
<i>Schizachyrium tenerum</i>	-26	<b>-39</b>	-21	<b>-40</b>	-20	<b>45</b>	<b>-58</b>
Percent Variance Explained	25%	18%	15%	12%	10%	5%	4%

<b>Habitat Variables</b>	<b>Hab1</b>	<b>Hab2</b>	<b>Hab3</b>
% Canopy Cover	<b>89</b>	-6	-13
% Litter + Bare Ground	<b>87</b>	<b>-32</b>	-4
Basal Area (m <sup>2</sup> /ha)	<b>86</b>	-12	-15
% Shrub Cover	<b>62</b>	-1	-8
% Herbaceous Cover	<b>-86</b>	<b>33</b>	3
Herbaceous Density 10-20 cm	-16	<b>84</b>	8
Herbaceous Density 20-30 cm	-5	<b>72</b>	<b>36</b>
Herbaceous Density 0-10 cm	<b>-39</b>	<b>70</b>	-7
Herbaceous Density 40-50 cm	-5	0	77
Max Herbaceous Height	-22	4	<b>69</b>
Herbaceous Density 30-40 cm	1	<b>39</b>	<b>65</b>
Percent Variance Explained	41%	16%	11%

**APPENDIX 6. ALL SITES SURVEYED FOR HENSLOW'S SPARROWS IN LOUISIANA.**

<b>Site</b>	<b>Henslow's Sparrows</b>	<b>Public Land</b>	<b>Parish</b>
<b>Alexander State Forest</b>	<b>Yes</b>	Yes	Rapides
Arabie's Savanna	No		Beauregard
Black Bayou Lake NWR	No	Yes	Morehouse
<b>Bodcau WMA</b>	<b>Yes</b>	Yes	Bossier
<b>CC Road Savanna</b>	<b>Yes</b>		Allen
Clear Creek WMA	No	Yes	Vernon
<b>Conrad's Savanna</b>	<b>Yes</b>		Allen
D'Arbonne NWR	No	Yes	Ouachita/Union
Dickson Saline Prairie	No		DeSoto
<b>Ft. Polk WMA</b>	<b>Yes</b>	Yes	Vernon
Jackson-Bienville WMA	No	Yes	Jackson/Bienville
Kisatchie-Catahoula District	No	Yes	Grant
Kisatchie-Evangeline Unit	No (1-Palustris Prairie)	Yes	Rapides
<b>Kisatchie-Kisatchie District</b>	<b>Yes</b>	Yes	Natchitoches
<b>Kisatchie-Vernon Unit</b>	<b>Yes</b>	Yes	Vernon
Kisatchie-Winn District	No	Yes	Winn
<b>Peason Ridge WMA</b>	<b>Yes</b>	Yes	Vernon
Plum Creek	No		Morehouse
<b>Rector's Prairie</b>	<b>Yes</b>		Morehouse
<b>Temple Inland (3)</b>	<b>Yes</b>		Vernon/Beauregard
<b>ULL Farms</b>	<b>Yes</b>		St. Martin
Upper Ouachita NWR	No	Yes	Union/Morehouse
West Bay WMA	No	Yes	Allen

**APPENDIX 7. MEANS OF HABITAT CHARACTERISTICS FOR EACH STUDY PLOT ON WHICH VEGETATION DATA COULD BE COLLECTED.**

<b>Plot</b>	<b>% <i>Andropogon</i></b>	<b>% <i>Rhynchospora</i></b>	<b>% Canopy</b>	<b>% Herbaceous Cover</b>	<b>% Litter/ Bare Ground</b>	<b>% Shrub Cover</b>	<b>Basal Area (m<sup>2</sup>/ha)</b>
<b>AS01</b>	33.47	54.80	0.53	90.89	6.89	8.56	1.24
<b>AS03</b>	4.33	14.69	19.78	90.00	10.22	14.11	442.94
<b>BD1</b>	0.00	0.00	0.00	95.00	5.00	1.00	0.00
<b>CC1</b>	9.60	11.24	5.98	91.56	5.89	6.89	99.69
<b>CWP</b>	0.00	0.56	9.59	84.89	15.11	11.56	304.86
<b>FP2</b>	0.00	3.78	25.90	91.67	7.78	13.89	669.11
<b>KD1</b>	0.00	0.00	47.97	47.22	52.56	40.56	1482.39
<b>LR01</b>	0.00	14.64	21.05	90.50	9.63	46.88	487.76
<b>LR02</b>	0.00	12.13	22.78	96.88	3.13	15.00	563.18
<b>LR05</b>	5.13	8.29	4.61	98.50	0.13	10.75	84.04
<b>RP1</b>	1.29	0.00	2.44	97.22	3.00	12.78	121.79
<b>TI1</b>	15.82	12.44	2.16	97.22	2.00	8.33	37.37
<b>TI2</b>	1.02	0.87	45.78	64.44	33.89	6.56	1483.14
<b>ULL1</b>	0.00	0.00	0.00	94.89	5.11	0.33	0.00

## VITA

Laura Palasz was born in the town of Batavia in the Chicago suburbs of Illinois to parents Mark and Mary. She developed a love of wildlife from a young age that was strengthened by frequent family camping trips as a child. In 1998 she graduated from Batavia High School, and continued on to college at the University of Illinois in Urbana-Champaign majoring in ecology, ethology, and evolution. During her college studies, she also participated in various wildlife research projects working with birds and mammals before obtaining a Bachelor of Science in 2002. From 2002 through 2005 she worked as a seasonal field technician on bird research projects in Nevada, Hawaii, Alaska, Costa Rica, Oregon, and Kentucky, before beginning graduate work at Louisiana State University in the fall of 2005. Laura is a candidate for a Master of Science degree in wildlife.