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IMPLICATIONS OF FIELD MANAGEMENT FOR HENSLOW'S SPARROW  
HABITAT AT SARATOGA NATIONAL HISTORICAL PARK, NEW YORK

By

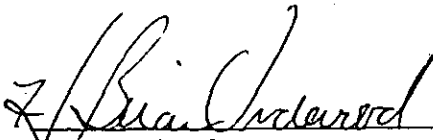
Rachel Mazur

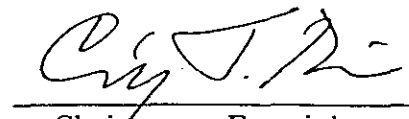
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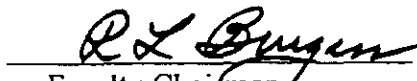
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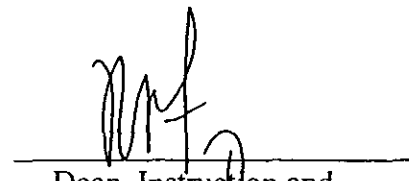
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## ABSTRACT

The early successional nature of Henslow's sparrow habitat requires rotational field management, but certain types of management preclude occupancy. To determine appropriate management of Henslow's sparrow habitat, components of adequate habitat and the influence of field management on their development and maintenance were studied at Saratoga National Historical Park, New York.

In 1994 and 1995, all Henslow's sparrow territories were mapped, resulting in 14 territories in 1994 and 15 territories in 1995. Habitat was then sampled in August of 1994, and May and August of 1995, in occupied and unoccupied fields, as well as territorial and non-territorial sections of occupied fields. Measured habitat variables included overall field morphology, vegetation structure, the extent of woody growth, and vegetation composition.

Henslow's sparrows occupied large ( $> 8$  ha), flat ( $< 7\%$  slope) fields that had tall, dense vegetation, a litter layer, and a low density of woody-stemmed plants. Dominant plant genera did not predict Henslow's sparrow occupancy, but all occupied fields were dominated by plant genera with tall, strong-stemmed representative species that provided perches and cover.

The appropriate frequency of management depends on whether one uses mowing, haying, burning, or grazing. Management in late summer precludes Henslow's sparrow

occupancy the following spring through its effects on the structure of the vegetation. The fields will not be suitable for occupancy until mid-summer, when the vegetation has grown. To allow for rotational management and constant habitat availability, total managed land area should be a minimum of 30 ha. All managed lands should be located near or contiguous to each other because Henslow's sparrows tend to occupy adjacent territories in available habitat.

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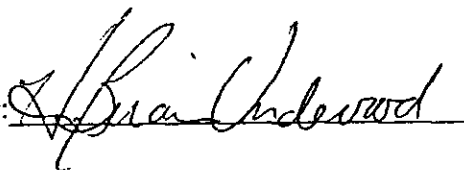
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A handwritten signature in dark ink, appearing to read "H. Brian Underwood", written over a horizontal line.

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## INTRODUCTION

There is growing evidence of a decline of grassland-dependent birds, including the Henslow's sparrow (*Ammodramus henslowii*), in both northeastern and midwestern North America (Askins 1993). Results from the Breeding Bird Survey between 1965 and 1994 show a decline in the Henslow's sparrow population of 8.2% continent-wide, and 12.1% in New York State (Hines et. al 1995). The Henslow's sparrow is currently under review by the U.S. Fish and Wildlife Service for consideration as a candidate for listing as endangered or threatened under the Endangered Species Act (USFWS 1991), and in New York State it is listed as a species of special concern (Andrle and Carroll 1988).

Grassland habitat was fragmented with the introduction in the 1950's of row-cropping and alfalfa monocultures. Pesticides, mechanical cropping, mowing during nesting, forest regeneration, and residential and commercial development on farmland are additional threats to breeding grassland-dependent birds (Cody 1985, Andrle and Carroll 1988, Warner 1994). As habitat on the midwestern prairies rapidly disappears, the role of eastern grasslands has increased in importance in sustaining dwindling populations continent-wide (Askins 1993). Any remaining habitat must be maintained through careful management (Askins 1993, Smith and Smith 1992).

Research on Henslow's sparrows indicates a narrow range of habitat use (Wiens 1969, Rotenberry and Wiens 1980). Henslow's sparrows generally occur in small groups, and their territories are < 0.4 ha (Robins 1971a, 1971b). Claims of minimum field size requirements differ among studies (Samson 1980, Zimmerman 1988, Herkert 1994) and need to be resolved. There is also disagreement about the effect of grassland management on Henslow's sparrow occupancy in the following year (Zimmerman 1988, Smith and Smith 1992, Herkert 1994, Bollinger 1995). Fields with low woody stem density are preferred (Peterson 1983, Zimmerman 1988), but the tolerable extent is unknown.

Vegetation inside territories is consistently found to be taller than outside, with more dead forb stalks, higher litter depth, higher overall density, and higher vertical density (Wiens 1969, Zimmerman 1988, Smith and Smith 1992, Herkert 1994). Typically, studies have not quantified vegetation composition, and limited published accounts are inconsistent in this area (Robins 1971a, Hanson 1994).

To date, most grassland bird habitat research has been conducted in the Midwest, where grassland birds were abundant historically (Herkert 1991, Renken and Dinsmore 1987, Wiens 1969). However, some research has been conducted in the Northwest (Wittenberger 1980), and in the East (Vickery 1993, Whitmore 1979, Whitmore 1981, Wray et. al 1982). Few studies have focused on the Henslow's sparrow, and populations that have been studied contained small numbers of birds (Wiens 1969, Robins 1971a, 1971b, Smith and Smith 1992), or looked at limited aspects of habitat use. Due to the dearth of knowledge regarding Henslow's sparrow ecology, additional information is needed for sound habitat management.

At Saratoga National Historical Park (SNHP) in Stillwater, New York, the presence of several grassland-dependent bird species was documented in 1985 during the NYS Breeding Bird Atlas Project (Appendix A). Among them was the Henslow's sparrow, the only known population in the Albany-Saratoga region. SNHP has been mandated by Congress to preserve its historic battlefields, and park personnel want to consider the habitat needs of grassland birds in future management planning. In the past, management was accomplished by periodic mowing and, more recently, by prescribed fire. By evaluating current field conditions and avian composition of this particular site, an appropriate management plan can be developed and implemented (Maurer 1986).

The goal of this research project was to determine components of adequate Henslow's sparrow habitat and the factors most influential in its development. To accomplish this goal, my objectives were to: (1) enumerate and map the population of Henslow's sparrow at

SNHP; (2) quantify vegetation characteristics of Henslow's sparrow territories in the spring and post-fledging; and (3) explore factors that affect field occupancy by Henslow's sparrows.

### HENSLow'S SPARROW BIOLOGY

Although Henslow's sparrows are conventionally called "grassland-dependent birds," they nest in fields dominated by forbs as well. The term "grassland" is therefore used here to refer to all types of occupied fields, and not to the strict grassland definition of fields with graminoid cover greater than 50% as defined by Barbour et. al (1980). The eastern subspecies of the Henslow's sparrow, *A. h. sussurans*, ranges from southeastern Ontario, northern New York, and central New England south to Kentucky and North Carolina. Henslow's sparrows winter between the coast of South Carolina and Florida (Bull 1974). Males arrive in New York in late April and females arrive soon after.

Because of the secretive nature of this uncommon and little known species, they are usually located by their two-note song (Wiens 1969, Bull 1974). They are generally double and occasionally triple brooded. The first nest is completed by the end of May and the second one may extend into September (Smith 1992). Males defend territories primarily through song while females incubate, feed, and brood the young. Females stop brooding on the fourth or fifth day post-hatch (Robins 1971a). While only the female incubates, males will also feed the young (Wiens 1969). In Kalamazoo, observers using blinds discovered that Henslow's sparrows commonly fed on the larvae of both lepidopterans and scarab beetles; however, only 2% of their total feedings were spent on grasses (Robins 1971b). I know of only one study where hatching success was reported. In Michigan, of 46 eggs, seventeen young were produced, giving a 37% success rate (Robins 1971a).

## STUDY AREA

The study was conducted at Saratoga National Historical Park from mid-April through late August, 1994-95. The park is located in Stillwater, New York, 32 km north of Albany (latitude 43 00', longitude 73 78'). The area of the park is about 1100 ha, encompassing over 335 ha of fields (Austin 1992). These fields have a variety of management histories including haying, burning, and manual shrub removal. While all fields are managed by the park, certain fields are under a mutually beneficial contract with local farmers who hay them for profit. Precipitation in 1994 was average while 1995 was a dry summer. The vegetation within park fields is dominated by *Centaurea* spp., *Bromus* spp., and *Galium* spp. Plant genus nomenclature follows Gleason and Cronquist (1991).

## METHODS

### FINDING AND MAPPING BIRDS

To enumerate Henslow's sparrows and mark their territories, I used spot mapping supplemented with the territory flush technique described by Wiens (1969). This involved traversing fields at 50 m intervals to locate birds and then flushing them up to 10 times to delineate their territories. The territorial area and perches used by each bird were marked on maps made from enlarged aerial photos (scale 1:12,000). Additional details were supplemented by topography, historic structures, and natural features. In 1994 and 1995, censuses were conducted at least 10 times throughout the breeding season (May-August), twice in the evening and eight times in the morning. Birds found in the same area on three visits were considered territory holders (Johnsgard and Rickard 1957). Fields bordering the park were surveyed from roadside listening points for presence/absence. Each field was

visited at least five times during the breeding season between 0600 and 1000 hours for 5 minute listening counts.

## STRUCTURAL ANALYSIS OF HABITAT

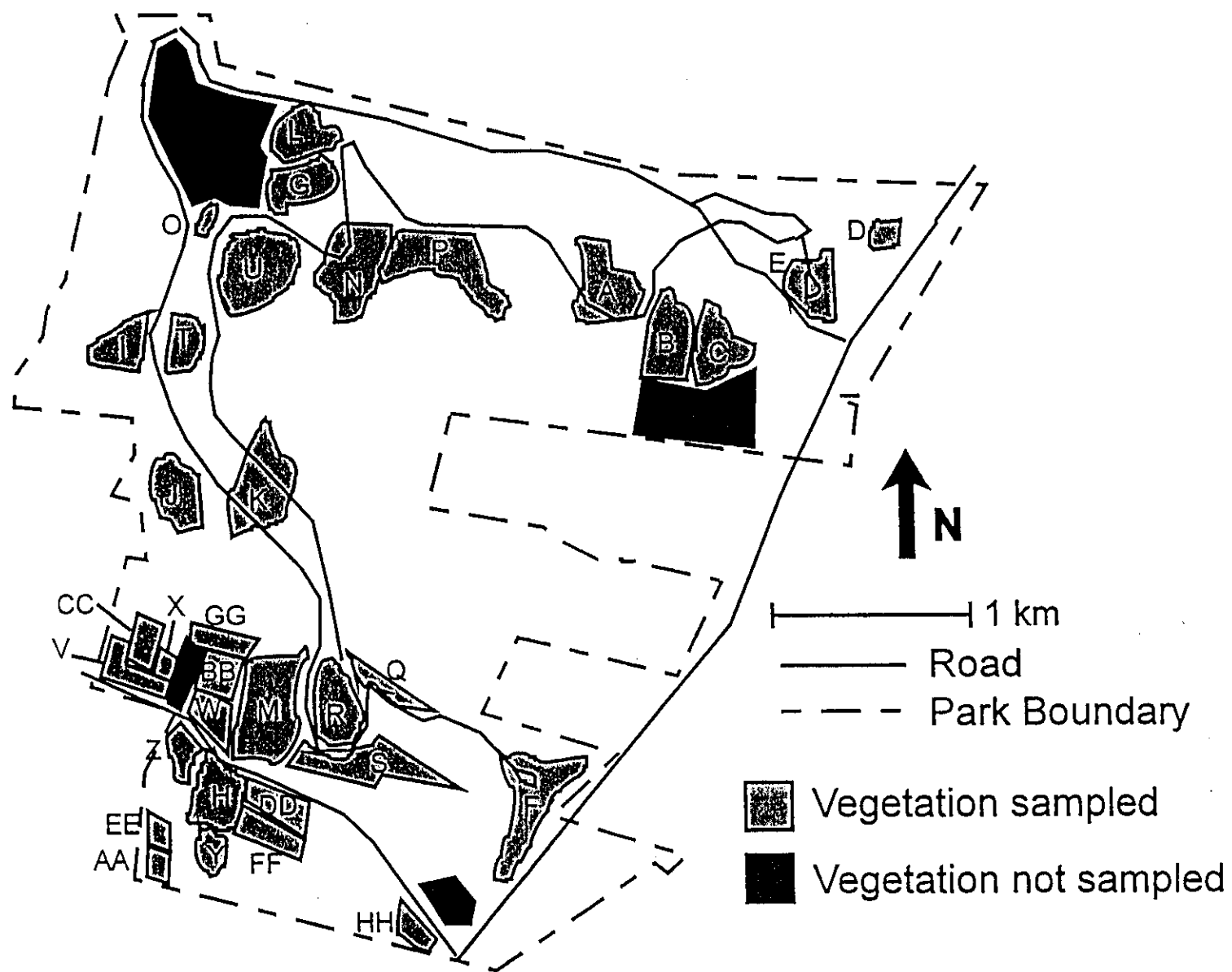
To quantify vegetation characteristics associated with Henslow's sparrow habitat, I sampled features of field morphology, vegetation structure, and vegetation composition. I used randomly placed, 1m<sup>2</sup> quadrats to sample the vegetation. Quadrats were located by using computer generated random compass directions and pacing distances.

*Fields sampled in August.* To determine field characteristics associated with Henslow's sparrow presence, I first compared occupied and unoccupied fields. Toward that end, all park fields were sampled at least once in 1994 and 1995. In 1994, 6 of the 8 occupied fields were sampled, as well as 15 of the unoccupied fields. In 1995, all of the 8 occupied fields were sampled, as well as the remaining 11 fields that were not sampled in 1994 (Fig. 1). In both years, sampling was done in late July and August, when the vegetation was fully grown. A total of 30 quadrats was sampled in large fields, and 15 quadrats in small fields.

At each quadrat location, % slope, effective vegetation height, litter depth, % ground cover, and vertical vegetation density were measured. Density usually describes the number of individuals of a vegetation type per unit area (Barbour et. al 1980), but in this study, it describes the number of individual contacts of a vegetation type intercepted at a vertical or horizontal point as used by Wiens (1969) and Whitmore (1981). Finally, field size and management history were recorded for each field.

Effective height was the height of the tallest vegetation in each plot (Whitmore 1981). Litter depth was measured with a piece of 1-1/4" dia. PVC pipe dropped over a randomly placed meter stick. The length of the meter stick below the pipe, which was supported by

Figure 1. Map of fields in Saratoga National Historical Park where vegetation was sampled in 1994 and 1995.



litter, was recorded. The extent of ground cover was visually estimated as the percentage of the plot covered by herbaceous or woody material and assigned a value between 0-5 (Braun-Blanquet 1932). Vertical vegetation density was measured with a 7mm dia. rod, 1 meter in length and marked off in 10 cm increments. At a randomly placed point in the plot, the number of live vegetation contacts at each increment was recorded. All ten measurements were then summed to give the total vertical density (Whitmore 1981). The percent vertical vegetation density within the first 10 cm was the total number of hits in that increment divided by the total vertical density. Field size was measured from park maps, and management history was recorded by classifying how many years a field had been idle since it was last mowed or burned. Fields idle for > 3 years were coded with a four.

*Territories sampled in August.* To determine characteristics of fields associated with territorial versus non-territorial areas, I sampled inside and outside of territories within occupied fields. The territory was used to designate suitable habitat based on the assumption that it is a reflection of the owner's habitat preference, given the choices available (Wiens 1969). Within each field, all territories were combined into a collective "territorial" area. Sampling was done in August, after vegetation had fully developed and nestlings had fledged. In 1994, 20 samples (1 m<sup>2</sup> plots) were taken within each territorial area and 10 outside. In 1995, these numbers were revised to 20 and 20, respectively.

At each quadrat, I measured the same structural variables as in the previous section, with the addition of horizontal density. Horizontal density was measured with a second 1 meter rod, held perpendicular to the first at each 10 cm increment on the vertical rod. The number of live vegetation contacts at each horizontal, 10 cm increment was recorded. The total vegetation density was the total number of hits (Whitmore 1981). Based on observations of perch use, I divided horizontal density measures into contacts of woody plants, dead grass, dead forbs, dead *Andropogon*, live grass, and live forbs in 1995 (Wiens 1969). *Andropogon* is classified separately because unlike the other genera of grasses,

*Andropogon's* structure does not create a suitable perch for Henslow's sparrows. I also measured mean height, which was the average of the highest hit at each 10 cm increment along the horizontal rod (Whitmore 1981).

*Fields and territories sampled in May.* To explore Henslow's sparrow habitat characteristics immediately following spring migration, I sampled both occupied and unoccupied fields and territorial and non-territorial areas in late May. In both cases, I measured the same variables as in the territorial sampling in August of 1995.

To compare occupied and unoccupied fields, variables were measured in all four occupied fields and 10 randomly chosen unoccupied fields within the southwest corner of the park. I chose this area due to the presence of Henslow's sparrow territories there during the previous year. Based on preliminary sampling, 28 quadrats were measured in occupied fields and 28 in unoccupied fields, and 25 quadrats were measured inside and outside of territories, within occupied fields.

*Frequency and height of woody stems.* To compare the quantity of woody plants in occupied versus unoccupied fields, the percent of quadrats containing woody stems was calculated in occupied and unoccupied fields in August of each year. The effective height of woody plants in the leftmost  $1/5 \text{ m}^2$  of each quadrat was also measured in occupied and unoccupied fields in August of each year. Simple comparisons were made to explore field occupancy as a function of the percent of quadrats containing woody stems and the mean effective height of woody plants in each field.

## ANALYSIS OF VEGETATION COMPOSITION

Vegetation composition of the fields and territories was sampled at the generic level. One species of grass that did not bloom during the sampling period could not be identified, and was therefore referred to as "Grass". Sampling was done in August in the quadrats

previously described. A genus was counted as present in a quadrat when at least one specimen was rooted within the quadrat. The percent frequency of each genus was the number of quadrats containing the genus as a percentage of the total number of quadrats sampled (Causton 1988). A cover value based on a scale of 0-5 was assigned to each genus present in a quadrat (Braun-Blanquet 1932). The percent cover value for each genus was the total cover of that genus over all samples as a percentage of the total cover of all genera over all samples. The percent frequency and percent cover value of each genus were summed into an index of ecological importance (IV; Bray and Curtis 1957). The IVs of all genera were then used to compute the dissimilarity among fields, and among territorial and non-territorial areas within fields (Pielou 1984).

## STATISTICAL ANALYSIS

*Vegetation structure.* Occupied fields were compared to unoccupied fields in each sampling period using t-tests. Within occupied fields, paired comparison t-tests were used to assess the significance of differences between territories and non-territories. In effect, this controls for error variance across fields (SAS Institute Inc. 1989). Because of an unexpected drought in 1995, the data from each year were analyzed separately.

In statistics, a small sample size reduces the power of significance tests, increasing the likelihood of a type 2 error; therefore fewer significant results will be found than with a large sample (Ott 1988). Because my objective was to identify predictors of occupancy, I adopted a significance level of  $p = 0.10$ , decreasing the likelihood of a type 2 error, but correspondingly increasing the likelihood of a type 1 error.

In each sampling period, if there were multiple significant predictors of Henslow's sparrow occupancy, multiple regression techniques were used to examine their interrelationships. Logistic regression is the standard method when modeling the relationship

subjectively grouped, and the IVs of their collective generic content were averaged. The three genera with the highest IVs were used to describe their respective group, or single field.

## RESULTS

### HENSLOW'S SPARROW DENSITY

In 1994, there were seven Henslow's sparrow territories in four fields by 31 May, and 14 territories in eight fields by 31 July. Females were assumed to be present when two adult birds were flushed together within a territory. Using this criterion, females were observed in 13 territories. In 1995, there were 11 Henslow's sparrow territories in four fields by 31 May, and 15 territories in eight fields by 31 July. Females were observed in eight territories and fledglings were seen in four territories. With the exception of the last arriving male in 1995, males invariably established territories within audible singing distance of other males (Figs. 2, 3).

Over both years, four fields had virtually all early arriving occupants, those arriving by 31 May, and four fields had all late arriving occupants, those arriving after 31 May. In one exception, a late arriving bird established his territory in a field already occupied by early arriving birds. In neither year were any Henslow's sparrows detected within a two mile corridor outside the park boundary (Appendix B).

### STRUCTURAL ANALYSIS

*Occupied versus unoccupied fields in August.* In August 1994, the only significant predictor of occupancy was % cover ( $p = 0.04$ ). On average, occupied fields had greater cover than unoccupied fields, but in all fields, most quadrats contained 100% cover (Table 1).

Figure 2. Map of fields in Saratoga National Historical Park occupied by Henslow's sparrows in 1994. Early occupants arrived by 31 May and late occupants arrived by 31 July.

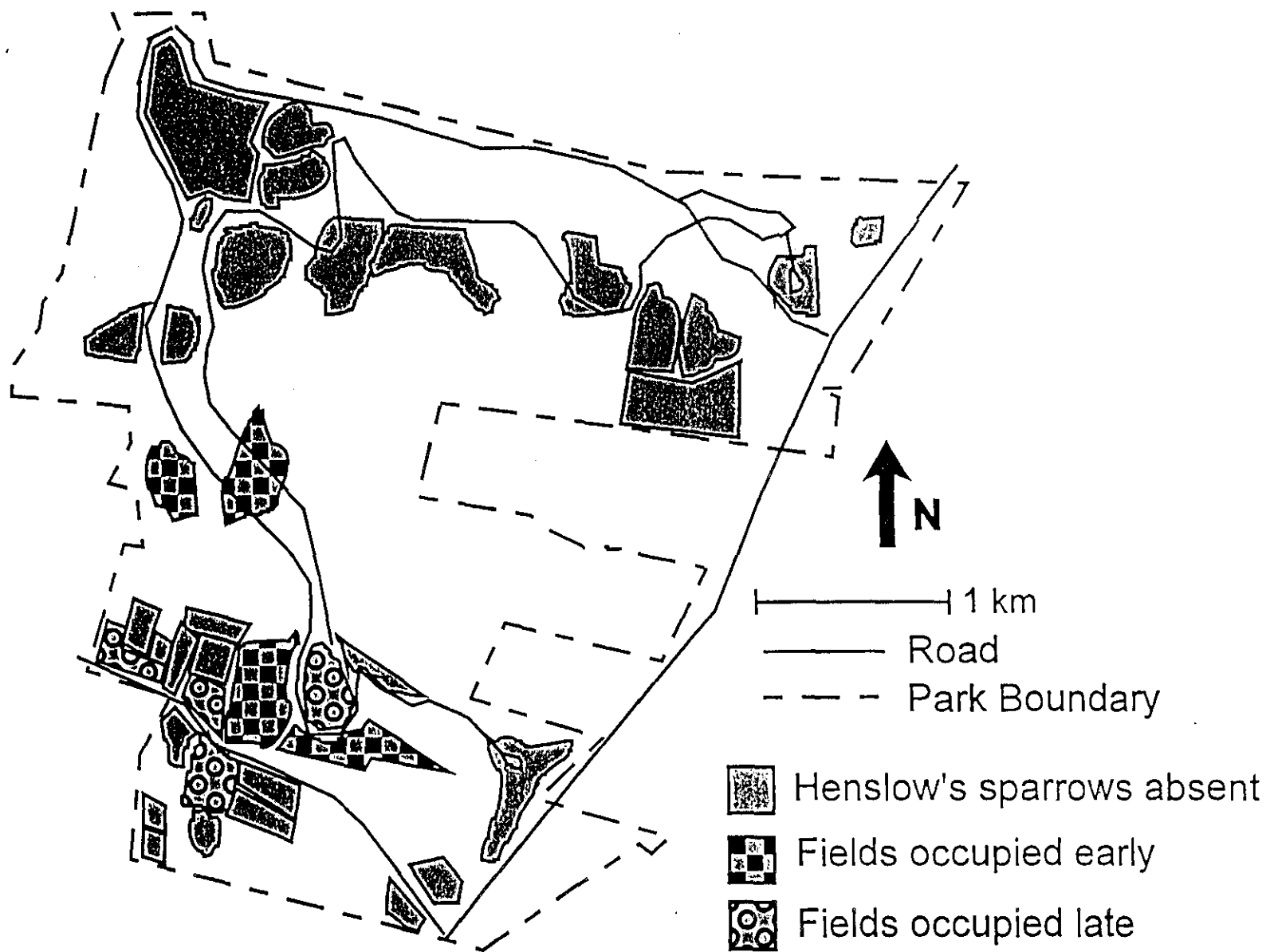


Figure 3. Map of fields in Saratoga National Historical Park occupied by Henslow's sparrows in 1995. Early occupants arrived by 31 May and late occupants arrived by 31 July.

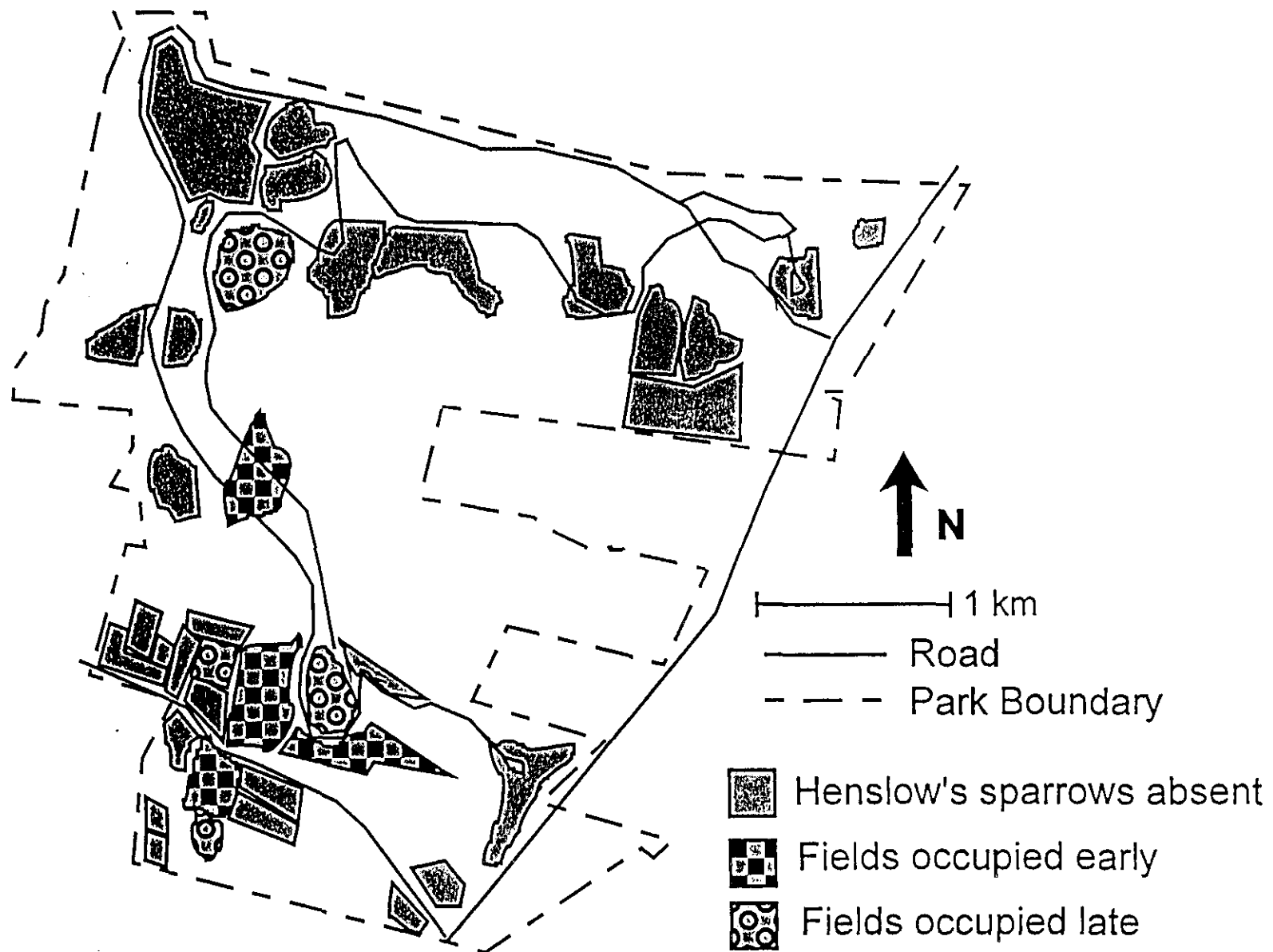


Table 1. Mean ( $\pm$  SE) of measured variables in fields occupied and unoccupied by Henslow's sparrows in Saratoga National Historical Park in 1994 and 1995.

| Variable                              | Aug-94           |                 | Aug-95           |                 | May-95            |                 |
|---------------------------------------|------------------|-----------------|------------------|-----------------|-------------------|-----------------|
|                                       | Occupied (6)     | Unoccupied (15) | Occupied (8)     | Unoccupied (11) | Occupied (4)      | Unoccupied (10) |
| Slope (%)                             | 5.3 $\pm$ 0.7    | 5.2 $\pm$ 0.7   | 4.7 $\pm$ 0.5    | 4.9 $\pm$ 0.8   | 6.2 $\pm$ 0.5     | 7.0 $\pm$ 0.8   |
| Effective height of veg. (cm)         | 100.4 $\pm$ 4.5  | 97.6 $\pm$ 3.2  | 95.4 $\pm$ 3.63* | 108.3 $\pm$ 5.1 | 78.9 $\pm$ 4.1**  | 61.8 $\pm$ 6.8  |
| Litter depth (cm)                     | 3.1 $\pm$ 0.2    | 2.7 $\pm$ 0.2   | 3.3 $\pm$ 0.44** | 2.1 $\pm$ 0.3   | 4.9 $\pm$ 0.6     | 4.0 $\pm$ 0.6   |
| Total vertical density <sup>a</sup>   | 14.1 $\pm$ 1.4   | 13.6 $\pm$ 0.6  | 10.2 $\pm$ 0.96* | 7.8 $\pm$ 1.0   | 7.1 $\pm$ 0.6     | 6.4 $\pm$ 0.4   |
| Vertical density < 10 cm (%)          | 19.0 $\pm$ 2.0   | 23.0 $\pm$ 2.0  | 16.0 $\pm$ 2.0   | 14.0 $\pm$ 3.0  | 35.0 $\pm$ 4.0**  | 49.0 $\pm$ 4.0  |
| Ground cover (1-5 scale)              | 5.0 $\pm$ 0.02** | 4.8 $\pm$ 0.1   | 5.0 $\pm$ 0*     | 4.9 $\pm$ 0.1   | 4.7 $\pm$ 0.1     | 4.5 $\pm$ 0.1   |
| Total vegetation density <sup>a</sup> |                  |                 |                  |                 | 124.0 $\pm$ 6.1** | 91.7 $\pm$ 4.6  |
| Density of dead stems <sup>a</sup>    |                  |                 |                  |                 | 28.8 $\pm$ 4.4**  | 8.4 $\pm$ 2.9   |
| Density of live stems <sup>a</sup>    |                  |                 |                  |                 | 94.0 $\pm$ 6.0    | 80.3 $\pm$ 6.3  |
| Density of woody stems <sup>a</sup>   |                  |                 |                  |                 | 0.7 $\pm$ 0.2     | 0.3 $\pm$ 0.1   |
| Mean height of veg. (cm)              |                  |                 |                  |                 | 3.8 $\pm$ 0.1**   | 2.7 $\pm$ 0.2   |
| Management history <sup>b</sup>       | 3.2 $\pm$ 0.5    | 2.2 $\pm$ 0.4   | 3.1 $\pm$ 0.4**  | 1.7 $\pm$ 0.4   | 3.5 $\pm$ 0.5*    | 2.1 $\pm$ 0.4   |
| Field size (ha)                       | 11.1 $\pm$ 1.7   | 8.9 $\pm$ 1.3   | 9.9 $\pm$ 2.0**  | 3.4 $\pm$ 0.6   | 11.1 $\pm$ 2.8*   | 4.5 $\pm$ 0.8   |

\* different ( $p < 0.1$ ) from unoccupied fields, \*\* different ( $p < .05$ ) from unoccupied fields (t-test).

<sup>a</sup> Measured as the number of vegetation contacts.

<sup>b</sup> Measured as the number of years a field was idle. Any field idle for > 3 years was given a rating of 4.

Neither management history nor field size was significant, but a graphical display shows that occupied fields tended to be larger and were idle longest (Fig. 4).

In August 1995, there was a tendency for birds to occupy large ( $p = 0.01$ ), unmanaged fields ( $p = 0.02$ ). The pattern is shown graphically in Figure 5. Both graphs indicate that fields occupied before 31 May are larger and idle longer than those occupied later.

In 1995, cover was significantly greater in occupied than unoccupied fields ( $p = 0.06$ ). Litter depth ( $p = 0.04$ ), effective height of the vegetation ( $p = 0.06$ ), and total vertical vegetation density ( $p = 0.10$ ) were all greater in occupied than unoccupied fields.

Structural variables may explain the relationship observed in August 1995 between management history and occupancy. In other words, the effect of management history on occupancy may totally depend upon its modification of vegetation structure. This possibility was tested with a logistic regression analysis (Table 2). When occupancy was regressed on management history (model 1), the concordance (agreement of prediction with observation) was 69%. When occupancy was regressed on three of the significant structural variables (model 2), the concordance was 90%. Cover, the fourth significant structural variable, was rejected from the logistic regression due to quasi-complete separation, a common problem with small samples (Hosmer and Lemeshow 1989). In model 3, management was added to the structural variables, producing a concordance of 91%, barely higher than in model 2. Therefore, structural variables alone explain occupancy that is attributable to management.

*Occupied versus unoccupied fields in May.* In May of 1995, field size ( $p = 0.09$ ) and management history ( $p = 0.07$ ) were significant predictors of Henslow's sparrow presence. The percent of vertical vegetation density in the first 10 cm was lower in occupied than unoccupied fields ( $p = 0.03$ ), and the effective height of the vegetation was higher in occupied than unoccupied fields ( $p = 0.05$ ).

Additional variables measured only in May proved to be important predictors of Henslow's sparrow occupancy. Total horizontal density was significantly greater in occupied

Figure 4. Relationship of field size and management history to Henslow's sparrow presence in Saratoga National Historical Park in 1994. Management history is recorded as the number of years a field has been idle. Any field idle for over three years is designated by a four. Late arriving birds are those establishing territories after 31 May.

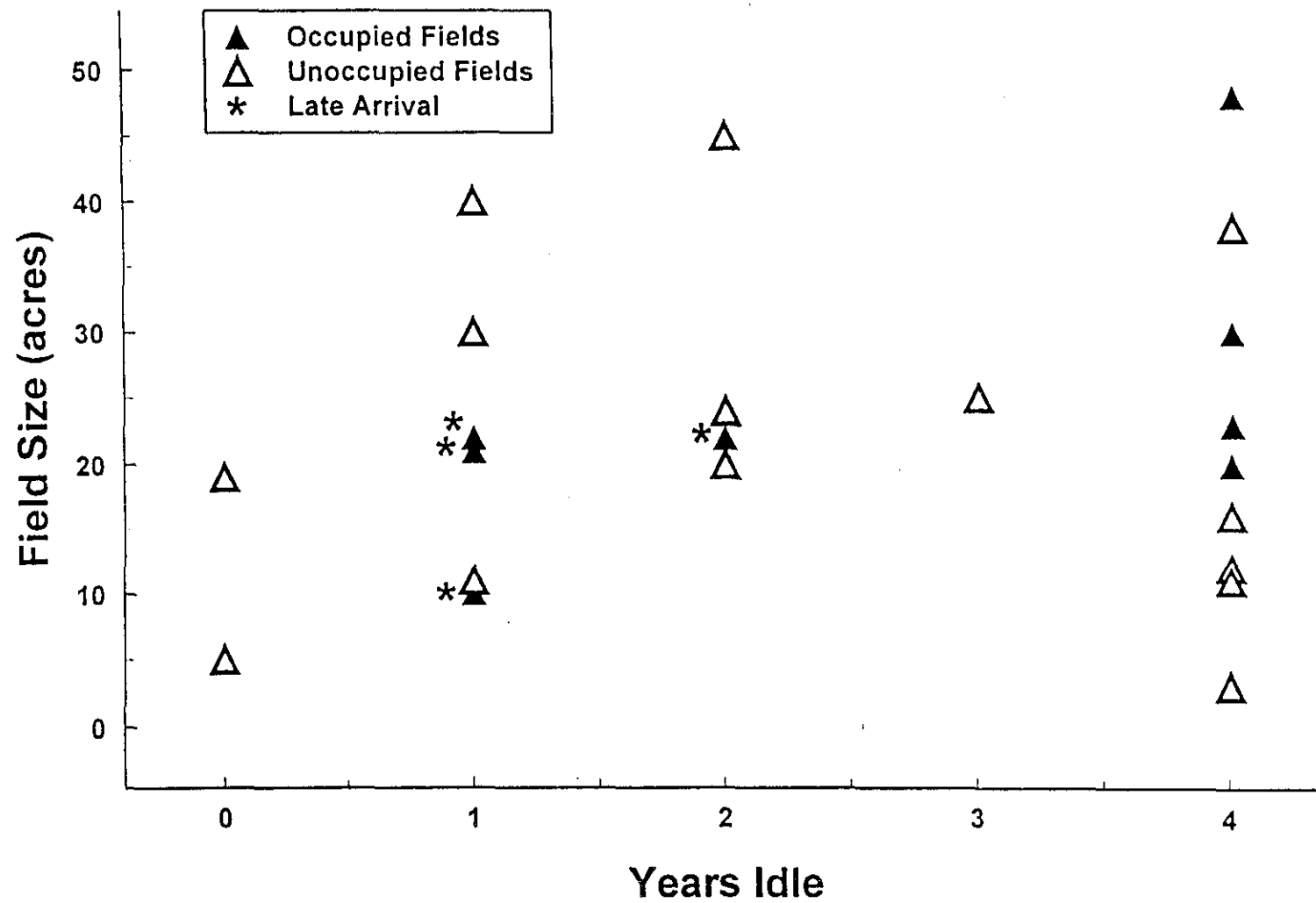


Figure 5. Relationship of field size and management history to Henslow's sparrow presence in Saratoga National Historical Park in 1995. Management history is recorded as the number of years a field has been idle. Any field idle for over three years is designated by a four. Late arriving birds are those establishing territories after 31 May.

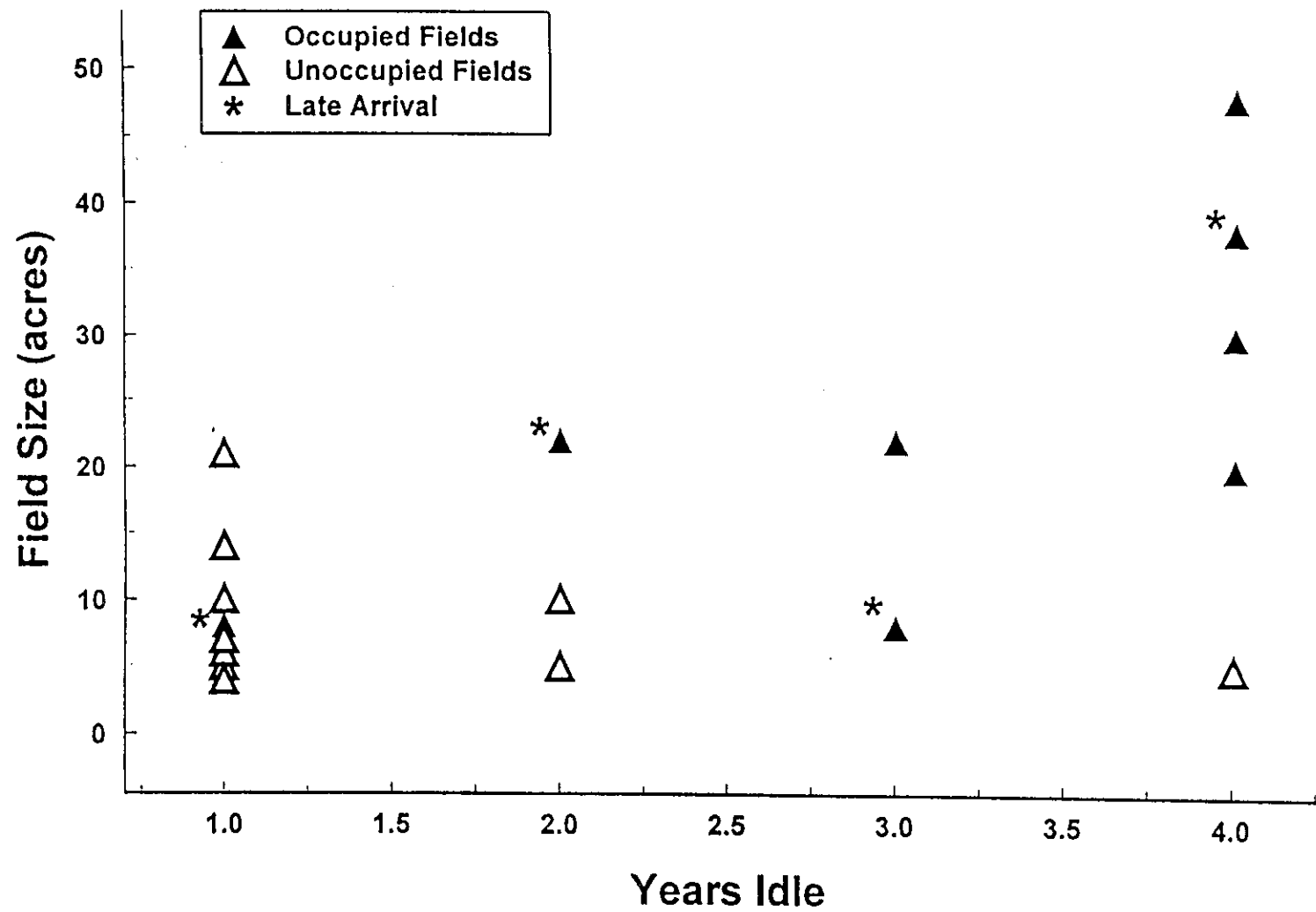


Table 2a. Logistic regression models of the relative contribution of management history and structural vegetation characteristics to predicting Henslow's sparrow presence at Saratoga National Historical Park in August 1995.

| Variable                            | Model # 1         |         | Model # 2 |         | Model # 3 |         |
|-------------------------------------|-------------------|---------|-----------|---------|-----------|---------|
|                                     | Beta <sup>a</sup> | p-value | Beta      | p-value | Beta      | p-value |
| Management history <sup>b</sup>     | -0.69             | 0.03    |           |         | 0.47      | 0.48    |
| Effective height of veg. (cm)       |                   |         | -0.82     | 0.06    | -1.19     | 0.10    |
| Litter depth (cm)                   |                   |         | 0.90      | 0.06    | 1.29      | 0.09    |
| Total vertical density <sup>c</sup> |                   |         | 0.43      | 0.29    | 0.63      | 0.24    |
| Significance of the model           |                   | 0.02    |           | 0.01    |           | 0.02    |
| Concordance                         |                   | 69%     |           | 90%     |           | 91%     |

<sup>a</sup> Beta is the standardized regression coefficient.

<sup>b</sup> Measured as the number of years a field was idle. Any field idle for > 3 years was given a rating of 4.

<sup>c</sup> Measured as the number of vegetation contacts.

Table 2b. Ordinary least squares regression models of the relative contribution of management history and structural vegetation characteristics to predicting Henslow's sparrow presence at Saratoga National Historical Park in May 1995.

| Variable                            | Model # 1         |         | Model # 2 |         | Model # 3 |         |
|-------------------------------------|-------------------|---------|-----------|---------|-----------|---------|
|                                     | Beta <sup>a</sup> | p-value | Beta      | p-value | Beta      | p-value |
| Management history <sup>b</sup>     | 0.49              | 0.08    |           |         | 0.42      | 0.03    |
| Effective height of veg. (cm)       |                   |         | 1.30      | 0.001   | 1.58      | 2E-04   |
| Litter depth (cm)                   |                   |         | 0.60      | 0.02    | 0.51      | 0.02    |
| Total vertical density <sup>c</sup> |                   |         | -1.45     | 1E-04   | -1.47     | 1E-04   |
| Significance of model               |                   | 0.08    |           | 2E-04   |           | 1E-04   |
| Adjusted R-squared                  |                   | 0.24    |           | 0.8     |           | 0.87    |

<sup>a</sup> Beta is the standardized regression coefficient.

<sup>b</sup> Measured as the number of years a field was idle. any field idle for > 3 years was given a rating of 4.

<sup>c</sup> Measured as the number of vegetation contacts.

than unoccupied fields ( $p = 0.004$ ). However, only the number of dead stems was significantly greater in occupied versus unoccupied fields ( $p = 0.01$ ). Mean height was significantly greater in occupied than unoccupied fields ( $p = 0.001$ ).

In the May 1995 data set, logistic regression produced either infinite parameters or insignificant models. Therefore, I used ordinary least squares regression to approximate general relationships among structural variables and occupancy (Table 2). While the structural characteristics alone accounted for 80% of the variation, when management was included, adjusted explained variance rose to 87%. This indicated that management alone, or some unmeasured covariate, retained some explanatory value.

*Territorial versus non-territorial areas.* In August of both 1994 and 1995, % slope was a significant ( $p = 0.09$ ) predictor of territorial areas, with the birds establishing territories in flatter areas of fields (Table 3). Mean height of the vegetation, although not measured in 1994, was significantly higher in territories than non-territories in 1995 ( $p = 0.04$ ).

In May, effective height of the vegetation was significantly taller in territorial than non-territorial areas ( $p = 0.07$ ). Total vegetation density was significantly ( $p = 0.05$ ) greater in territorial areas, while the number of dead stems was the most significant ( $p = 0.04$ ) component. Finally, mean height was significantly taller in territorial than non-territorial areas ( $p = 0.06$ ).

*Frequency and height of woody stems.* In 1994, less than 50% of quadrats in occupied fields contained woody stems, and the maximum height of woody stems was below 70 cm. The unoccupied fields had up to 80% of plots containing woody stems and had maximum heights up to 115 cm. In 1995, occupied and unoccupied fields were not differentiated; less than 40% of plots contained woody stems and both had maximum heights below 55 cm.

Table 3. Mean ( $\pm$  SE) of measured variables in Henslow's sparrow territories and non-territories in Saratoga National Historical Park in 1994 and 1995.

| Variable                              | Aug-94           |                   | Aug-95           |                   | May-95            |                   |
|---------------------------------------|------------------|-------------------|------------------|-------------------|-------------------|-------------------|
|                                       | Territory (8)    | Non-territory (8) | Territory (8)    | Non-territory (8) | Territory (4)     | Non-territory (4) |
| Slope (%)                             | 4.5 $\pm$ 0.4*   | 6.1 $\pm$ 1.0     | 4.8 $\pm$ 0.5*   | 6.0 $\pm$ 0.8     | 6.0 $\pm$ 1.1     | 6.2 $\pm$ 0.4     |
| Effective height of veg. (cm)         | 101.5 $\pm$ 5.1  | 101.5 $\pm$ 5.4   | 95.7 $\pm$ 3.0   | 92.4 $\pm$ 4.1    | 88.7 $\pm$ 5*     | 77.4 $\pm$ 4.6    |
| Litter depth (cm)                     | 3.6 $\pm$ 0.3    | 3.4 $\pm$ 0.4     | 3.7 $\pm$ 0.2    | 3.5 $\pm$ 0.3     | 4.7 $\pm$ 0.5     | 4.9 $\pm$ 0.6     |
| Total vertical density <sup>a</sup>   | 13.6 $\pm$ 0.9   | 14.2 $\pm$ 0.7    | 9.8 $\pm$ 0.8    | 8.7 $\pm$ 0.5     | 7.7 $\pm$ 0.6     | 6.5 $\pm$ 0.3     |
| Vertical density < 10cm (%)           | 26.0 $\pm$ 2.0   | 29.0 $\pm$ 3.0    | 29.0 $\pm$ 1.0   | 30.0 $\pm$ 1.0    | 37.0 $\pm$ 3.0    | 45.0 $\pm$ 7.0    |
| Ground cover (1-5 scale)              | 5.0 $\pm$ 0.0    | 5.0 $\pm$ 0.0     | 5.0 $\pm$ 0.0    | 5.0 $\pm$ 0.0     | 4.7 $\pm$ 0.07*   | 4.7 $\pm$ 0.1     |
| Total vegetation density <sup>a</sup> | 191.1 $\pm$ 12.6 | 204.8 $\pm$ 12.8  | 148.9 $\pm$ 12.8 | 138.7 $\pm$ 6.2   | 131.8 $\pm$ 5.2** | 111.4 $\pm$ 8.9   |
| Density of dead stems <sup>a</sup>    |                  |                   | 10.7 $\pm$ 3.4   | 5.5 $\pm$ 1.1     | 39.3 $\pm$ 5.6**  | 17.3 $\pm$ 5.9    |
| Density of live stems <sup>a</sup>    |                  |                   | 137.5 $\pm$ 11.4 | 131.7 $\pm$ 6.3   | 92.1 $\pm$ 4.4    | 92.9 $\pm$ 5.4    |
| Density of woody stems <sup>a</sup>   |                  |                   | 0.7 $\pm$ 0.2    | 0.8 $\pm$ 0.1     | 0.7 $\pm$ 0.1     | 0.8 $\pm$ 0.1     |
| Mean height of veg. (cm)              |                  |                   | 5.2 $\pm$ 0.2*   | 4.8 $\pm$ 0.2     | 4.5 $\pm$ 0.3*    | 3.7 $\pm$ 0.2     |

\* Different ( $p < .1$ ) from non-territories, \*\* different ( $p < .05$ ) from non-territories (paired t-test).

<sup>a</sup> Measured as the number of vegetation contacts.

## ANALYSIS OF VEGETATION COMPOSITION

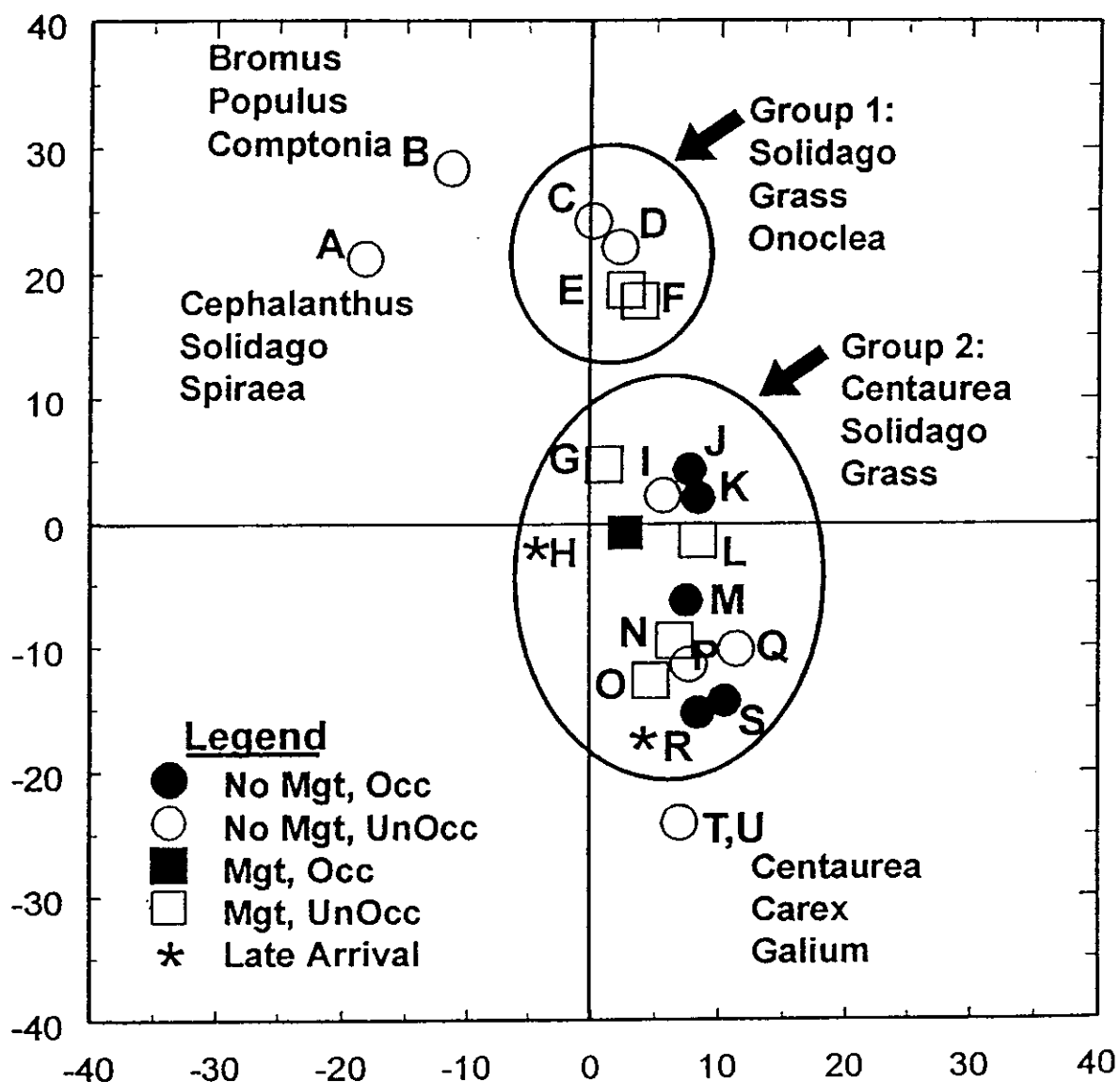
*Occupied versus unoccupied fields.* In 1994, the PCO of occupied versus unoccupied fields reveals a clustering of occupied fields at the center of the graph where the dominant genus was *Centaurea*, with two species commonly found at SNHP (Fig. 6.A, Group 2). The unoccupied fields varied widely in generic composition. Field A was dominated by *Cephalanthus*. Field B was dominated by *Bromus* and *Populus*. The fields in group 1 were dominated by *Solidago*.

The 1995 ordinations of occupied versus unoccupied fields differ from the 1994 ordinations partly due to the sampling of different fields (Fig. 6.B). The dominant genus in five of the occupied fields was again *Centaurea*, but two other occupied fields were dominated by *Phalaris* and one by *Bromus*. Of the unoccupied fields, four were dominated by *Bromus*, four by *Phalaris*, two by *Centaurea*, and one by *Potentilla*.

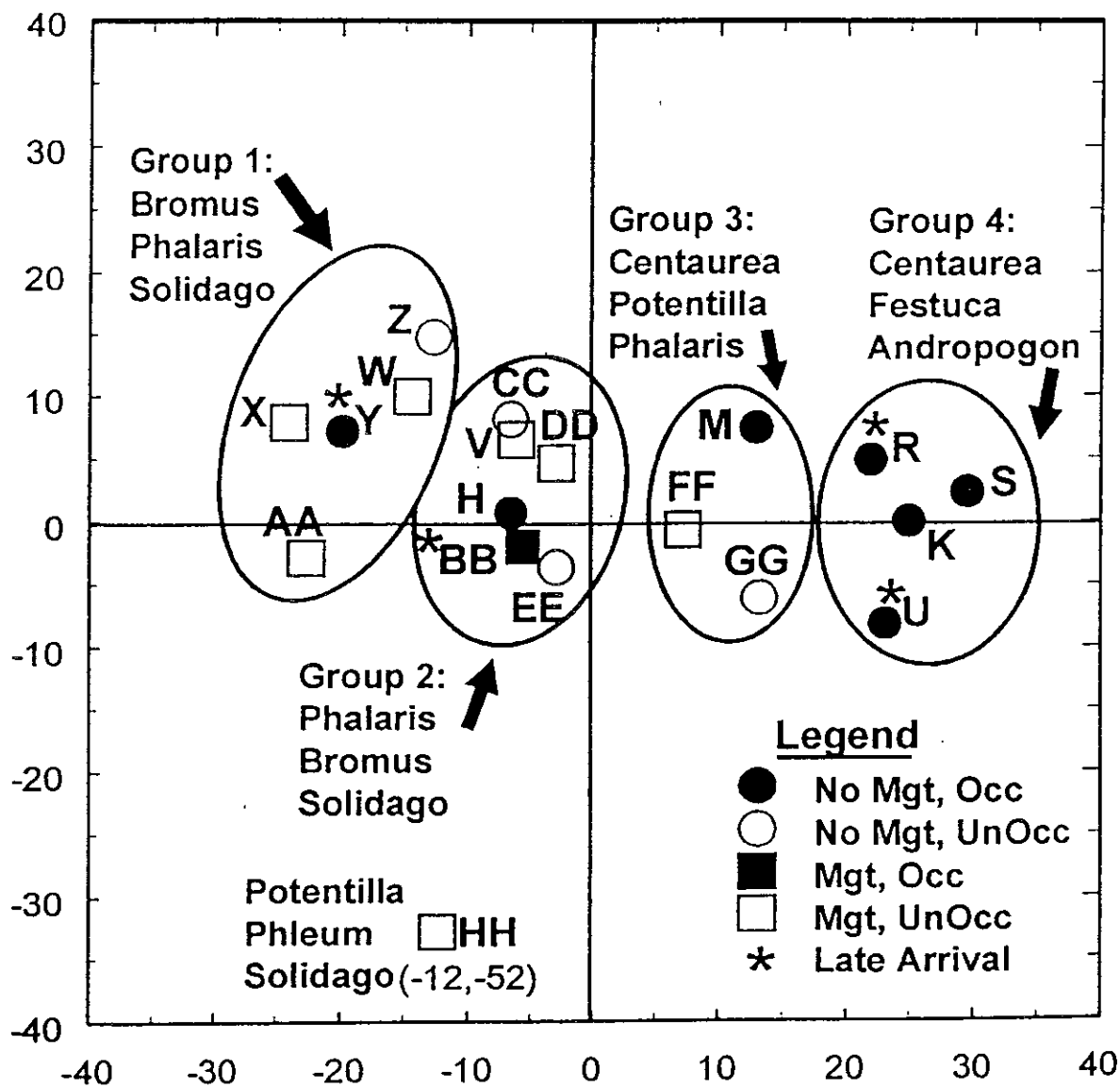
*Territorial versus non-territorial areas.* At this spatial scale, there is clearly variation in vegetation composition among occupied fields, but little separation between territorial and non-territorial areas within those fields (Fig. 6.C and 6.D). In each year, all five managed, occupied fields were occupied late in the season and are shown on the left side of each figure. Four were primarily or secondarily dominated by *Bromus*, the fifth by *Galium*. Of the unmanaged, occupied fields, nine of 11 are located on the right side of each graph, and all are dominated by *Centaurea*. There were also two unmanaged, occupied territories on the left of the 1995 graph. One was dominated by *Phleum*. The other was dominated by *Solidago* and was occupied by a late arriving male.

The underlying environmental gradients of all four ordinations appear to be moisture along the y-axis and the number of years a field has been idle along the x-axis.

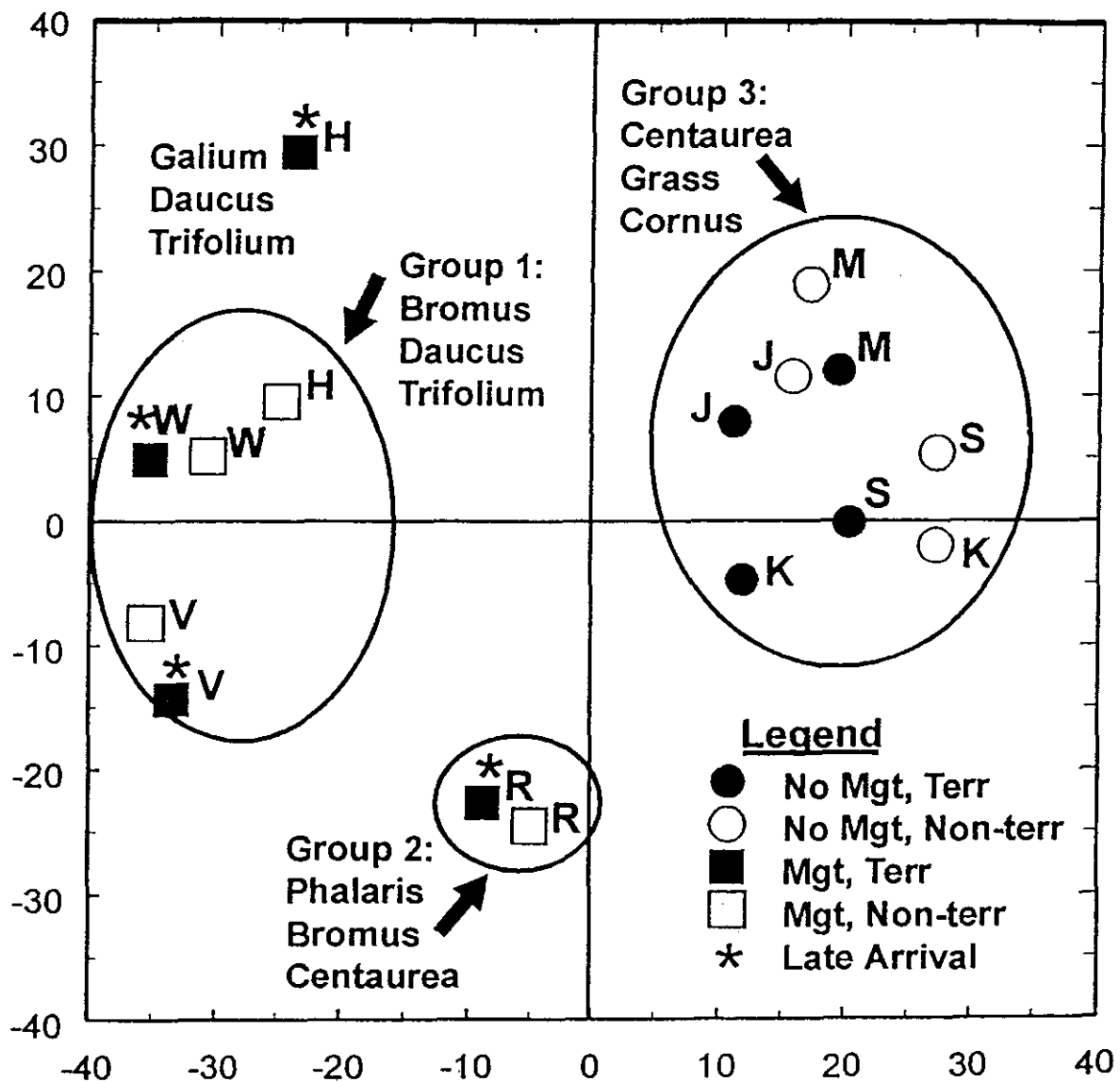
## A. Occupied Versus Unoccupied Fields (1994)



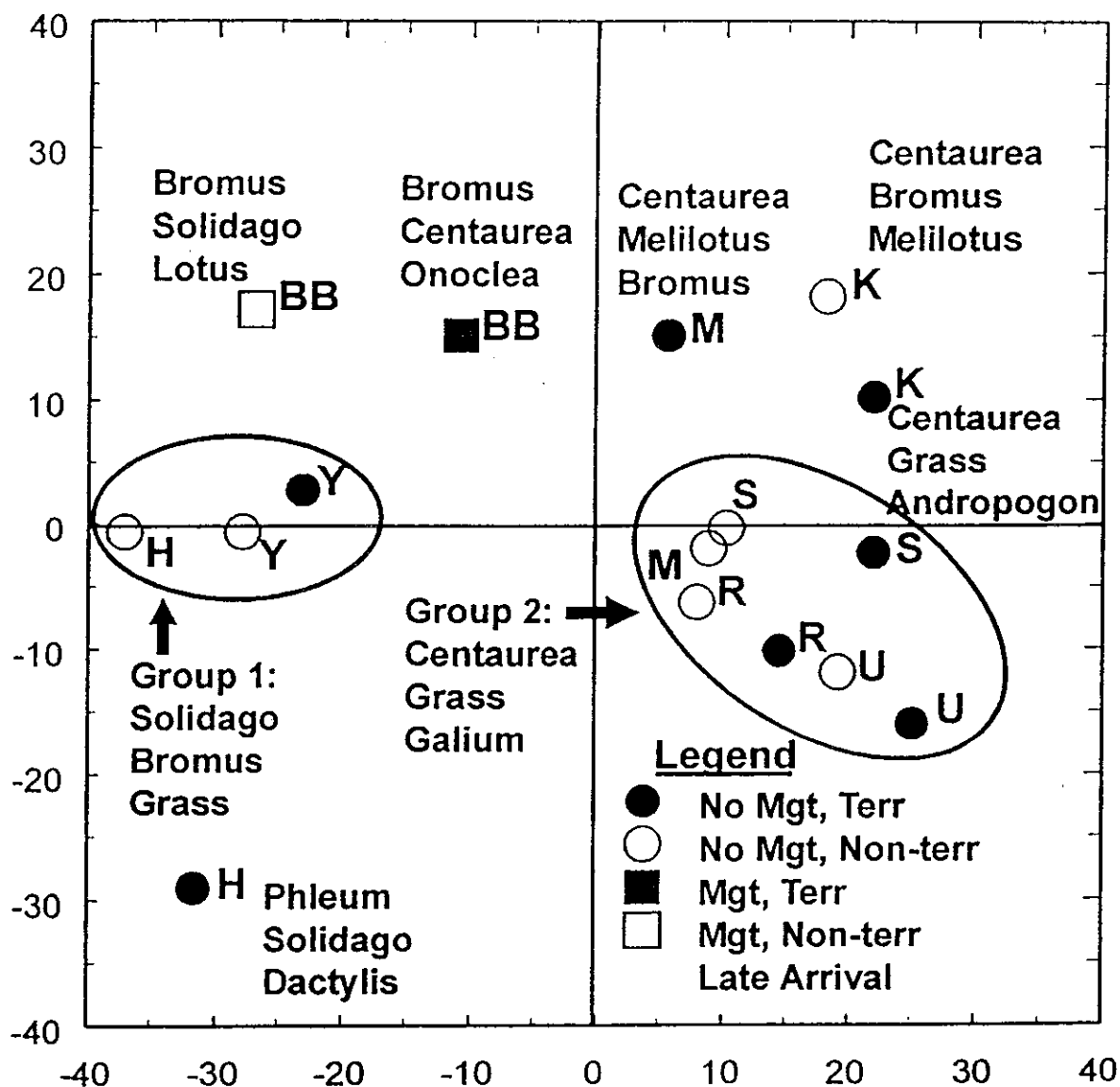
## B. Occupied Versus Unoccupied Fields (1995)



### C. Territorial Versus Non-territorial Areas (1994)



# D. Territorial Versus Non-territorial Areas (1995)



## DISCUSSION

*Territory establishment.* Once established territories were stable throughout both years of my study, as was found by Robins (1971a). The presence or absence of Henslow's sparrows and their time of occupancy can be explained by structural and field characteristics and the behavior of the birds. Territories established by 31 May were located within singing distance of another Henslow's sparrow in seemingly suitable habitat (i.e., relatively flat areas in fields unmanaged the previous year, of at least 8 ha with tall, strong-stemmed vegetation). One late arriving male established his territory in similar habitat. All other late arriving males were relegated to other areas, but they still established territories, found mates, and exhibited at least some evidence of successful breeding in both wet (1994) and drought (1995) years.

*Field size and slope.* Some recent studies suggest that a minimum field size of at least 10 ha is required to provide adequate habitat for the Henslow's sparrow (Zimmerman 1988, Herkert 1994). In other studies, Henslow's sparrows have been found in smaller fields (Graber 1968, Hanson 1994). At SNHP, occupied fields ranged from 3-20 ha, with most larger than 8 ha. Of those with suitable habitat, the largest fields were occupied first, an observation consistent with other studies (Smith and Smith 1992, Herkert 1994). Even birds in the smallest fields found mates and had evidence of nesting activity. It therefore seems that while larger fields are more predictive of occupancy, smaller fields are capable of providing nesting habitat. At SNHP, slope was also predictive of occupancy. Henslow's sparrows consistently established territories within the flatter part of the fields.

Some suggest that Henslow's sparrows use large fields because the birds occupy territories in close proximity to each other (Hyde 1939, Graber 1968). But this pattern of Henslow's sparrow occupancy may occur simply because available habitat is not uniformly distributed across the landscape (Wiens 1969, Smith 1992). At SNHP, Henslow's sparrows

were found in the southwest corner of the park where they frequently countersang. The large fields were occupied first, and successively arriving birds chose territories next to birds already present. Later arriving birds chose smaller fields adjacent to the occupied fields and sang with the residents rather than occupying larger suitable fields that were farther away. This suggests that Henslow's sparrows exhibited clustered occupancy regardless of the distribution of the habitat.

*Effect of time of sampling on density and height as predictors of adequate habitat.*

Research consistently points to dense, tall vegetation as an essential component of Henslow's sparrow habitat (Zimmerman 1988, Herkert 1994). This is consistent with the behavior of the bird (Wiens 1969). When Henslow's sparrows first arrive in the spring, they use the standing dead vegetation as perches from which to establish territories and find mates. Otherwise, they are secretive birds and they spend most of their time concealed in the vegetation (Forbush 1929, Hyde 1939, Wiens 1969).

In May 1995, total vegetation density was greater in occupied versus unoccupied fields, and also in territories versus non-territories within those fields, largely due to differences in the density of dead standing stems. Similar results were found by Wiens (1969), Zimmerman (1988), and Herkert (1994). Also in May 1995, the effective height of vegetation was taller in occupied versus unoccupied fields and in territories versus non-territories.

The presence of dead stems and the effective height of the vegetation are both functions of the previous year's management. When I sampled vegetation in August of each year, the effect of management on the structure of the vegetation had diminished after a full season of growth. The only real difference was in August 1995, when the effective height was actually shorter in occupied than in unoccupied fields. While most studies do not report effective height, the mean height of occupied areas in this and other studies has often been reported to be about 50 cm or more (Smith 1992, Herkert 1994).

In 1994, three fields that would have excluded Henslow's sparrows in the spring, because they were managed the previous year, were occupied by later arrivals. By that time the vegetation had apparently grown into suitable habitat. In 1995, only one field that had been managed the previous year was occupied late, possibly because the drought slowed vegetation growth. Other research reports that Henslow's sparrows are absent in June from areas managed the previous year (Zimmerman 1988, Herkert 1994). Seemingly contradictory findings by other researchers, in which managed fields were occupied the following year, can be reconciled because observations of occupancy were made late in an unusually wet summer (Smith and Smith 1992).

I found a general trend of deeper litter in occupied than unoccupied areas, but differences were generally small and insignificant. The range of litter depth found at SNHP of 2.5 to 5 cm in occupied areas contains values reported by Wiens (1969) and Herkert (1994), but Hanson (1994) reported an average litter depth of 7.1 cm. Presence of litter is important for nesting, escaping predators and foraging (Hyde 1939). Consistent with other sites (Wiens 1969), Henslow's sparrows at SNHP were not found in areas with bare patches.

At SNHP, Henslow's sparrows were restricted to fields where less than 50% of plots contained woody stems, and the maximum height was below 70 cm. In Peterson's (1983) study in New York, woody stems in occupied fields were also less than 1 m tall. Other researchers have observed that Henslow's sparrows occupy fields with scattered shrubs, but are absent from fields with high woody stem density (Wiens 1969, Peterson 1983, Zimmerman 1988). At SNHP, the birds used woody stems that were at the height of the vegetation (<1 meter) as perches. Although larger woody plants were generally avoided, one male frequently sang from the tops of trees (>10 m) bordering the field he occupied.

*Effect of vegetation composition on adequate habitat.* There has been a lot of anecdotal evidence regarding the importance of plant composition to Henslow's sparrow occupancy, and results are inconsistent. Dominant genera cited in the literature include

*Dactylis*, *Carex*, and *Scirpus* (Smith 1992). Other research points to a dominance of either grasses (Robins 1971a, Herkert 1994) or forbs (Hanson 1994). Still others claim that vegetation composition is irrelevant (Wiens 1969).

The ordinations of occupied and unoccupied fields at SNHP indicate that occupancy does not fall out on a plant compositional gradient. The dominant genera vary across occupied fields and are not clearly different from those of unoccupied fields (Figure 7.B). The commonality among occupied fields is the dominance of plant genera with tall, strong-stemmed representative species that provide perches for Henslow's sparrows. Unoccupied fields dominated by the same genera had confounding factors such as small field size (< 8 ha) or a steep slope (> 7 %).

In the ordinations of territorial and non-territorial areas within occupied fields, the time of occupancy at first appears to fall out on a plant compositional gradient - fields dominated by *Centaurea* were occupied first and fields dominated by grasses were occupied last. The actual gradient is the time since the fields were last managed. However, it is masked because management history affects the time of occupancy through changes in the structure of the vegetation. In managed fields, grasses are cut in the autumn and do not provide cover and perches for the Henslow's sparrows that arrive in the spring. Once the grasses grow tall enough to provide cover and perches for Henslow's sparrows in the summer, they are occupied by late arrivals. Grasses generally provided cover and perches after 31 May. The only field dominated by grasses that was occupied before 31 May was one that was left idle the previous year. In unmanaged fields, *Centaurea*, an invasive genus, is not cut in the autumn and does provide cover and perches for the Henslow's sparrows that arrive in the spring.

Some clusters of fields on the ordinations were noticeably absent of Henslow's sparrows. For instance, in 1994 there were no Henslow's sparrows in fields dominated by *Solidago* (Fig. 6.A, Group 1). This finding supports Hanson (1994), who hypothesized that

because *Solidago* is a genus with many common and colonial species, patches of the plants tend to be homogenous and provide little ground cover. Consequently use by Henslow's sparrows is unlikely. There were no occupants in field A which was dominated by ferns growing in stagnant water, or in field B, which was also wet and had a high density of woody-stemmed plants. Finally, in 1995 there were no Henslow's sparrows in field HH, which was dominated by *Potentilla*, a genus that does not provide perches or adequate cover. Thus, all these effects are consistent with the importance of structure rather than plant composition in determining occupancy.

One additional observation, not evident at the scale of the ordination, was the Henslow's sparrows' avoidance of areas with dense, grassy vegetation, as found by Wiens (1969). While dense vegetation is important, I hypothesize that vegetation that is too dense prevents movement within the habitat, which is essential to foraging behavior (Morrison et. al 1992).

## MANAGEMENT RECOMMENDATIONS

Appropriate management of Henslow's sparrow habitat promotes tall, dense vegetation, a litter layer, and a low density of woody-stemmed plants. Managed fields should be large ( $> 8$  ha) and flat ( $< 7\%$  slope). Mowing, haying, and grazing can all be used to maintain habitat. In some fields, additional work is needed to create habitat suitable for occupancy, such as when woody stems are so numerous that they must be mechanically removed.

The minimum size and configuration of the land that should be maintained is dictated by temporal and spatial concerns. Because of the temporary nature of this early successional habitat and the need for constant habitat availability, rotational management is needed. To do this, at least 20 % more land is needed than is occupied by Henslow's sparrows at any given

time, given that each field is managed approximately every four years. Based on my observations as well as those of Herkert (1994), Smith and Smith (1990), and Zimmerman (1988), the total managed land area should be a minimum of 30 ha. The managed area can be made up of a few large fields, or a mix of large and small fields, as long as each field is larger than 8 ha, which is the smallest field that was occupied at SNHP. All managed fields should be located near or contiguous to each other because at SNHP Henslow's sparrows tended to establish adjacent territories in available habitat.

The frequency of management depends on whether one uses mowing, haying, burning, or grazing. In order to protect nests, fields must be managed either before the birds arrive in the spring (15 April), or after the young have fledged (15 September). While all management techniques are used with the intention of ensuring tall, dense vegetation, moderate litter depth, and limited frequency of woody stems, they do so at different rates. Based on my results, a good rule of thumb is that management is needed when the woody vegetation is taller than the fully grown herbaceous vegetation.

Mowing in the autumn avoids nest destruction and leaves a litter layer, but no standing vegetation for birds arriving the following spring. The area will not be suitable for sparrow occupancy until mid-summer of the following year and should then be mowed every four or five years. Although spring mowing would allow for re-growth and therefore the presence of standing dead vegetation for birds arriving the following spring, there is a danger of nest destruction. Mowing is a cost-effective management technique, but is dangerous in fields with uneven terrain.

Haying removes both the litter and standing vegetation. Burning also removes litter and standing vegetation, but stimulates the development of both as well (Zimmerman 1988). Due to the loss of litter, I found that areas that are hayed or burned are not suitable for occupancy until late the following summer, or in spring of the second year. A longer management rotational cycle is therefore needed - perhaps once every five or six years.

Grazing, which leaves the litter layer intact and some of the standing vegetation, may be done annually, but overstocking may preclude use in the spring (Zimmerman 1988). In the Finger Lakes National Forest, Smith and Smith (1992) found the stocking rate of 0.12 to 0.25 head of cattle per ha to allow for occupancy in the summer, but may have precluded use in the spring. Grazing should be either maintained annually at low stocking rates, or at higher stocking rates on a rotational basis.

Some types of management may be inappropriate for maintenance of Henslow's sparrow habitat. The prospects for habitat management on intensively hayed farmland are poor. Farmers cut their fields every spring when the nutrient value of grasses is highest. This ensures high quality feed for cattle, and a higher resale profit. There is a danger that males will select these areas in early spring, and then females will lose their nests when the fields are cut (Smith 1992). When farmers attempt a second cutting in August, the habitat is unsuitable the following spring, and as a result, the sparrows will not occupy the fields.

While the management techniques described above will be adequate for most fields, other fields require additional work before they are appropriate for Henslow's sparrow occupancy. Some fields, although appropriately large and flat, are dominated by vegetation that is too short or sparse for occupancy. If resources permit, these fields could be seeded with vegetation that grows tall (height > 95 cm) and dense (total vegetation density > 150 vegetation contacts) and provides perches for Henslow's sparrow such as *Phleum*, or *Dactylis*. Although *Centaurea* is tall and dense and provides perches at SNHP, it is an invasive genus, and should be avoided. If small (< 2 ha) areas are dominated by plants that are beneficial to other grassland birds (such as *Solidago* which is commonly used by grasshopper sparrows), the areas will benefit avian community diversity and should be maintained. In other appropriately large and flat fields, the frequency (> 50 % of quadrats contain woody stems) and height (> 70 cm) of woody stems may preclude Henslow's

sparrow occupancy. In these fields, mechanical cutting or re  
appropriate.

Finally, in managing for Henslow's sparrows, it is in  
size and breeding success of the population (Smith 1992). A  
should be conducted three times in early May for early arriv  
for late arrivals, at sunrise or sunset. At SNHP, all males sa  
about half of the population would sing on any given day, m  
While some Henslow's sparrows sang consistently througho  
indicator of presence for the majority of birds and should no

Breeding activity can be monitored by locating nests  
easily damaged by searching activities, or by observing terri  
feeding activities, and fledged young. Possible sources of p  
include cowbird (*Molothrus ater*) parasitism, predation, met  
interspecific competition (especially at the time of territory c  
Destruction and degradation of wintering grounds and migra  
investigated.

While areas such as Saratoga National Historical Par  
Forest are protected, and will provide habitat for Henslow's  
future, other areas, such as abandoned farmland, are often lo  
ecological succession (Smith 1992). If populations of Hens  
few, isolated patches of habitat, normal population fluctuati  
to their local extinction (Smith 1992). Active protection, ac  
large patches of habitat are therefore critical to the conserva  
Smith 1990, Herkert 1994).

Appendix A. Grassland bi  
1995.

ishn.

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Appendix A. Grassland bird species found in Saratoga National Historical Park in 1994 and 1995.

| Common name         | Scientific name                  |
|---------------------|----------------------------------|
| Upland Sandpiper    | <i>Bartramia longicauda</i>      |
| Northern Harrier    | <i>Circus cyaneus</i>            |
| Red-tailed Hawk     | <i>Buteo borealis</i>            |
| American Kestrel    | <i>Falco sparverius</i>          |
| Eastern Bluebird    | <i>Sialia sialis</i>             |
| Bobolink            | <i>Dolichonyx oryzivorus</i>     |
| Eastern Meadowlark  | <i>Sturnella magna</i>           |
| Grasshopper sparrow | <i>Ammodramus savannarum</i>     |
| Savannah Sparrow    | <i>Passerculus sandwichensis</i> |
| Henslow's Sparrow   | <i>Ammodramus henslowii</i>      |

Appendix B. Summary of Henslow's sparrow occupancy in Saratoga National Historical Park in 1994 (1) and 1995 (2).

Appendix B.1. Summary of Henslow's sparrow occupancy in Saratoga National Historical Park in 1994.

| Field | Number of males by May 31 | Number of males by July 31 | Number of males with mate |
|-------|---------------------------|----------------------------|---------------------------|
| H     | 0                         | 2                          | 2                         |
| J     | 1                         | 1                          | 1                         |
| K     | 4                         | 4                          | 3                         |
| M     | 2                         | 3                          | 3                         |
| R     | 0                         | 1                          | 1                         |
| S     | 1                         | 1                          | 1                         |
| V     | 0                         | 1                          | 1                         |
| W     | 0                         | 1                          | 1                         |

Appendix B.2. Summary of Henslow's sparrow occupancy in Saratoga National Historical Park in 1995.

| Field | Number of males by May 31 | Number of males by July 31 | Number of males with mate |
|-------|---------------------------|----------------------------|---------------------------|
| H     | 3                         | 3                          | 2                         |
| K     | 2                         | 2                          | 1                         |
| M     | 4                         | 4                          | 3                         |
| R     | 0                         | 1                          | 0                         |
| S     | 2                         | 2                          | 1                         |
| U     | 0                         | 1                          | 1                         |
| Y     | 0                         | 1                          | 0                         |
| BB    | 0                         | 1                          | 0                         |

Appendix C. Relative importance values of genera in fields occupied and unoccupied by Henslow's sparrows in Saratoga National Historical Park in 1994 and 1995. Only the top five genera are shown in each area.

Appendix C. Relative importance values of genera in fields occupied and unoccupied by Henslow's sparrows in Saratoga National Historical Park in 1994 and 1995. Only the top five genera are shown in each area.

| 1994 Occupied Fields |                   |       | 1994 Unoccupied Fields |                   |       | 1995 Occupied Fields |                   |       | 1995 Unoccupied Fields |                       |       |
|----------------------|-------------------|-------|------------------------|-------------------|-------|----------------------|-------------------|-------|------------------------|-----------------------|-------|
| Field                | Genera            | IV    | Field                  | Genera            | IV    | Field                | Genera            | IV    | Field                  | Genera                | IV    |
| J                    | <i>Andropogon</i> | 41.09 | T                      | <i>Apocynum</i>   | 37.79 | K                    | <i>Andropogon</i> | 35.93 | HH                     | <i>Potentilla</i>     | 38.70 |
|                      | <i>Melilotus</i>  | 37.87 |                        | <i>Centaurea</i>  | 36.46 |                      | <i>Centaurea</i>  | 34.45 |                        | <i>Solidago</i>       | 37.24 |
|                      | <i>Rubus</i>      | 31.05 |                        | <i>Carex</i>      | 25.88 |                      | <i>Rubus</i>      | 21.97 |                        | <i>Phleum</i>         | 35.68 |
|                      | <i>Centaurea</i>  | 29.76 |                        | <i>Galium</i>     | 21.35 |                      | <i>Cornus</i>     | 20.50 |                        | <i>Aster</i>          | 23.66 |
|                      | <i>Solidago</i>   | 29.42 |                        | <i>Melilotus</i>  | 18.44 |                      | <i>Festuca</i>    | 17.89 |                        | <i>Rumex</i>          | 19.29 |
| K                    | <i>Andropogon</i> | 38.90 | I                      | <i>Eupatorium</i> | 37.98 | M                    | <i>Phalaris</i>   | 50.66 | GG                     | <i>Andropogon</i>     | 31.15 |
|                      | <i>Solidago</i>   | 32.59 |                        | <i>Onoclea</i>    | 25.48 |                      | <i>Centaurea</i>  | 38.58 |                        | <i>Potentilla</i>     | 27.44 |
|                      | <i>Grass</i>      | 31.76 |                        | <i>Cornus</i>     | 25.26 |                      | <i>Potentilla</i> | 16.64 |                        | <i>Centaurea</i>      | 25.61 |
|                      | <i>Centaurea</i>  | 31.11 |                        | <i>Galium</i>     | 25.17 |                      | <i>Cornus</i>     | 15.21 |                        | <i>Solidago</i>       | 20.35 |
|                      | <i>Bromus</i>     | 24.59 |                        | <i>Andropogon</i> | 24.45 |                      | <i>Bromus</i>     | 14.97 |                        | <i>Bromus</i>         | 19.19 |
| M                    | <i>Melilotus</i>  | 62.84 | F                      | <i>Solidago</i>   | 37.29 | R                    | <i>Festuca</i>    | 38.63 | V                      | <i>Phalaris</i>       | 62.79 |
|                      | <i>Grass</i>      | 29.16 |                        | <i>Galium</i>     | 34.57 |                      | <i>Centaurea</i>  | 30.91 |                        | <i>Centaurea</i>      | 50.58 |
|                      | <i>Centaurea</i>  | 28.16 |                        | <i>Grass</i>      | 34.38 |                      | <i>Rubus</i>      | 25.07 |                        | <i>Bromus</i>         | 31.68 |
|                      | <i>Rubus</i>      | 25.68 |                        | <i>Cornus</i>     | 30.47 |                      | <i>Galium</i>     | 22.62 |                        | <i>Carex</i>          | 20.06 |
|                      | <i>Bromus</i>     | 23.78 |                        | <i>Rhus</i>       | 28.30 |                      | <i>Cornus</i>     | 21.64 |                        | <i>Potentilla</i>     | 17.48 |
| R                    | <i>Grass</i>      | 60.38 | C                      | <i>Solidago</i>   | 62.14 | U                    | <i>Centaurea</i>  | 37.42 | CC                     | <i>Phalaris</i>       | 34.70 |
|                      | <i>Galium</i>     | 45.47 |                        | <i>Phalaris</i>   | 55.73 |                      | <i>Galium</i>     | 26.28 |                        | <i>Cornus</i>         | 31.38 |
|                      | <i>Lotus</i>      | 38.34 |                        | <i>Leptoloma</i>  | 49.52 |                      | <i>Carex</i>      | 24.80 |                        | <i>Solidago</i>       | 28.15 |
|                      | <i>Arctium</i>    | 37.92 |                        | <i>Andropogon</i> | 32.73 |                      | <i>Cornus</i>     | 20.95 |                        | <i>Lotus</i>          | 18.04 |
|                      | <i>Bromus</i>     | 37.23 |                        | <i>Cornus</i>     | 30.22 |                      | <i>Potentilla</i> | 15.00 |                        | <i>Asclepias</i>      | 17.69 |
| S                    | <i>Grass</i>      | 44.31 | E                      | <i>Grass</i>      | 87.82 | S                    | <i>Centaurea</i>  | 32.59 | X                      | <i>Bromus</i>         | 58.29 |
|                      | <i>Centaurea</i>  | 36.01 |                        | <i>Solidago</i>   | 40.63 |                      | <i>Festuca</i>    | 27.50 |                        | <i>Lotus</i>          | 16.48 |
|                      | <i>Galium</i>     | 27.93 |                        | <i>Onoclea</i>    | 38.13 |                      | <i>Andropogon</i> | 26.11 |                        | <i>Viburnum</i>       | 13.55 |
|                      | <i>Lotus</i>      | 18.81 |                        | <i>Galium</i>     | 38.13 |                      | <i>Rubus</i>      | 25.74 |                        | <i>Parthenocissus</i> | 13.55 |
|                      | <i>Solidago</i>   | 16.23 |                        | <i>Thymus</i>     | 32.15 |                      | <i>Cornus</i>     | 18.17 |                        | <i>Phleum</i>         | 13.52 |

Appendix C (cont.)

| 1994 Occupied Fields |        |    | 1994 Unoccupied Fields |                     |       | 1995 Occupied Fields |        |    | 1995 Unoccupied Fields |        |    |
|----------------------|--------|----|------------------------|---------------------|-------|----------------------|--------|----|------------------------|--------|----|
| Field                | Genera | IV | Field                  | Genera              | IV    | Field                | Genera | IV | Field                  | Genera | IV |
|                      |        |    | N                      | <i>Centaurea</i>    | 31.80 |                      |        |    |                        |        |    |
|                      |        |    |                        | <i>Spiraea</i>      | 26.46 |                      |        |    |                        |        |    |
|                      |        |    |                        | <i>Pycnanthemum</i> | 26.15 |                      |        |    |                        |        |    |
|                      |        |    |                        | <i>Fraxinus</i>     | 23.14 |                      |        |    |                        |        |    |
|                      |        |    |                        | <i>Rhamnus</i>      | 21.59 |                      |        |    |                        |        |    |
|                      |        |    | L                      | <i>Onoclea</i>      | 38.41 |                      |        |    |                        |        |    |
|                      |        |    |                        | <i>Centaurea</i>    | 34.62 |                      |        |    |                        |        |    |
|                      |        |    |                        | <i>Carex</i>        | 29.12 |                      |        |    |                        |        |    |
|                      |        |    |                        | <i>Solidago</i>     | 28.36 |                      |        |    |                        |        |    |
|                      |        |    |                        | <i>Galium</i>       | 26.99 |                      |        |    |                        |        |    |
|                      |        |    | G                      | <i>Andropogon</i>   | 41.84 |                      |        |    |                        |        |    |
|                      |        |    |                        | <i>Rubus</i>        | 30.14 |                      |        |    |                        |        |    |
|                      |        |    |                        | <i>Solidago</i>     | 29.50 |                      |        |    |                        |        |    |
|                      |        |    |                        | <i>Galium</i>       | 29.45 |                      |        |    |                        |        |    |
|                      |        |    |                        | <i>Cornus</i>       | 25.77 |                      |        |    |                        |        |    |
|                      |        |    | O                      | <i>Galium</i>       | 48.17 |                      |        |    |                        |        |    |
|                      |        |    |                        | <i>Ambrosia</i>     | 38.26 |                      |        |    |                        |        |    |
|                      |        |    |                        | <i>Lotus</i>        | 38.26 |                      |        |    |                        |        |    |
|                      |        |    |                        | <i>Robinia</i>      | 38.26 |                      |        |    |                        |        |    |
|                      |        |    |                        | <i>Bromus</i>       | 31.97 |                      |        |    |                        |        |    |

Appendix D. Relative importance values of genera in territorial and non-territorial areas within fields occupied by Henslow's sparrows in Saratoga National Historical Park in 1994 and 1995. Only the top five genera are shown in each area.

Appendix D. Relative importance values of genera in territorial and non-territorial areas within fields occupied by Henslow's sparrows in Saratoga National Historical Park in 1994 and 1995. Only the top five genera are shown in each area.

| 1994 In Territory |                   |       | 1994 Out of Territory |                   |       | 1995 In Territory |                   |       | 1995 Out of Territory |                   |       |
|-------------------|-------------------|-------|-----------------------|-------------------|-------|-------------------|-------------------|-------|-----------------------|-------------------|-------|
| Field             | Genera            | IV    | Field                 | Genera            | IV    | Field             | Genera            | IV    | Field                 | Genera            | IV    |
| J                 | <i>Cornus</i>     | 51.49 | J                     | <i>Thymus</i>     | 40.30 | K                 | <i>Centaurea</i>  | 98.37 | K                     | <i>Centaurea</i>  | 80.38 |
|                   | <i>Solidago</i>   | 38.62 |                       | <i>Viburnum</i>   | 38.37 |                   | <i>Grass</i>      | 16.02 |                       | <i>Bromus</i>     | 32.32 |
|                   | <i>Centaurea</i>  | 28.93 |                       | <i>Cornus</i>     | 36.85 |                   | <i>Andropogon</i> | 13.04 |                       | <i>Melilotus</i>  | 20.47 |
|                   | <i>Viburnum</i>   | 25.88 |                       | <i>Centaurea</i>  | 32.94 |                   | <i>Viburnum</i>   | 13.04 |                       | <i>Thymus</i>     | 16.44 |
|                   | <i>Andropogon</i> | 20.98 |                       | <i>Andropogon</i> | 31.78 |                   | <i>Cornus</i>     | 12.49 |                       | <i>Cornus</i>     | 15.55 |
| K                 | <i>Centaurea</i>  | 71.00 | K                     | <i>Centaurea</i>  | 48.21 | M                 | <i>Centaurea</i>  | 88.48 | M                     | <i>Centaurea</i>  | 89.70 |
|                   | <i>Bromus</i>     | 23.20 |                       | <i>Grass</i>      | 41.07 |                   | <i>Melilotus</i>  | 37.99 |                       | <i>Grass</i>      | 69.81 |
|                   | <i>Lotus</i>      | 21.43 |                       | <i>Andropogon</i> | 27.38 |                   | <i>Bromus</i>     | 33.97 |                       | <i>Solidago</i>   | 30.92 |
|                   | <i>Rhamnus</i>    | 18.98 |                       | <i>Galium</i>     | 26.88 |                   | <i>Cornus</i>     | 21.57 |                       | <i>Cornus</i>     | 20.76 |
|                   | <i>Galium</i>     | 18.98 |                       | <i>Cornus</i>     | 21.15 |                   | <i>Solidago</i>   | 20.30 |                       | <i>Carex</i>      | 17.54 |
| M                 | <i>Centaurea</i>  | 41.10 | M                     | <i>Galium</i>     | 41.63 | R                 | <i>Centaurea</i>  | 95.79 | R                     | <i>Centaurea</i>  | 75.38 |
|                   | <i>Grass</i>      | 39.11 |                       | <i>Centaurea</i>  | 35.01 |                   | <i>Galium</i>     | 50.30 |                       | <i>Onoclea</i>    | 62.90 |
|                   | <i>Galium</i>     | 19.96 |                       | <i>Solidago</i>   | 19.85 |                   | <i>Grass</i>      | 47.57 |                       | <i>Grass</i>      | 46.62 |
|                   | <i>Solidago</i>   | 15.36 |                       | <i>Grass</i>      | 15.80 |                   | <i>Cornus</i>     | 20.06 |                       | <i>Cornus</i>     | 39.27 |
|                   | <i>Vicia</i>      | 13.65 |                       | <i>Cornus</i>     | 15.80 |                   | <i>Vicia</i>      | 16.33 |                       | <i>Galium</i>     | 36.07 |
| R                 | <i>Bromus</i>     | 62.38 | R                     | <i>Phalaris</i>   | 88.80 | U                 | <i>Centaurea</i>  | 79.56 | U                     | <i>Centaurea</i>  | 78.01 |
|                   | <i>Centaurea</i>  | 42.27 |                       | <i>Centaurea</i>  | 68.03 |                   | <i>Galium</i>     | 63.04 |                       | <i>Galium</i>     | 39.49 |
|                   | <i>Fraxinus</i>   | 38.00 |                       | <i>Galium</i>     | 63.80 |                   | <i>Cornus</i>     | 20.67 |                       | <i>Eupatorium</i> | 37.96 |
|                   | <i>Phalaris</i>   | 38.00 |                       | <i>Bromus</i>     | 58.07 |                   | <i>Asclepias</i>  | 13.04 |                       | <i>Rhus</i>       | 37.96 |
|                   | <i>Lotus</i>      | 27.73 |                       | <i>Trifolium</i>  | 38.80 |                   | <i>Phleum</i>     | 9.37  |                       | <i>Andropogon</i> | 37.96 |
| S                 | <i>Centaurea</i>  | 55.36 | S                     | <i>Grass</i>      | 49.49 | S                 | <i>Centaurea</i>  | 92.72 | S                     | <i>Centaurea</i>  | 78.93 |
|                   | <i>Solidago</i>   | 15.25 |                       | <i>Centaurea</i>  | 47.20 |                   | <i>Galium</i>     | 37.91 |                       | <i>Grass</i>      | 42.12 |
|                   | <i>Rosa</i>       | 14.03 |                       | <i>Thymus</i>     | 20.75 |                   | <i>Grass</i>      | 33.27 |                       | <i>Andropogon</i> | 38.07 |
|                   | <i>Vitis</i>      | 13.54 |                       | <i>Solidago</i>   | 19.38 |                   | <i>Potentilla</i> | 16.82 |                       | <i>Melilotis</i>  | 38.07 |
|                   | <i>Grass</i>      | 12.88 |                       | <i>Trifolium</i>  | 16.83 |                   | <i>Rhamnus</i>    | 14.41 |                       | <i>Solidago</i>   | 32.94 |

## Appendix D (cont.)

| 1994 In Territory |                  |       | 1994 Out of Territory |                  |       | 1995 In Territory |                  |       | 1995 Out of Territory |                 |       |
|-------------------|------------------|-------|-----------------------|------------------|-------|-------------------|------------------|-------|-----------------------|-----------------|-------|
| Field             | Genera           | IV    | Field                 | Genera           | IV    | Field             | Genera           | IV    | Field                 | Genera          |       |
| V                 | <i>Bromus</i>    | 48.25 | V                     | <i>Phalaris</i>  | 56.87 | BB                | <i>Bromus</i>    | 76.76 | BB                    | <i>Bromus</i>   | 53.86 |
|                   | <i>Phalaris</i>  | 45.21 |                       | <i>Lotus</i>     | 35.35 |                   | <i>Centaurea</i> | 63.44 |                       | <i>Solidago</i> | 37.75 |
|                   | <i>Daucus</i>    | 32.65 |                       | <i>Trifolium</i> | 31.98 |                   | <i>Onoclea</i>   | 37.97 |                       | <i>Lotus</i>    | 31.10 |
|                   | <i>Lotus</i>     | 26.65 |                       | <i>Daucus</i>    | 29.70 |                   | <i>Lotus</i>     | 30.15 |                       | <i>Grass</i>    | 23.58 |
|                   | <i>Trifolium</i> | 25.75 |                       | <i>Bromus</i>    | 22.00 |                   | <i>Grass</i>     | 29.61 |                       | <i>Phleum</i>   | 17.39 |
| W                 | <i>Carex</i>     | 42.97 | W                     | <i>Asclepias</i> | 38.51 | H                 | <i>Phleum</i>    | 66.11 | H                     | <i>Grass</i>    | 74.97 |
|                   | <i>Dactylis</i>  | 38.02 |                       | <i>Bromus</i>    | 29.04 |                   | <i>Solidago</i>  | 42.59 |                       | <i>Bromus</i>   | 63.02 |
|                   | <i>Juncus</i>    | 30.01 |                       | <i>Trifolium</i> | 28.65 |                   | <i>Dactylis</i>  | 36.15 |                       | <i>Phleum</i>   | 61.13 |
|                   | <i>Phleum</i>    | 20.61 |                       | <i>Lotus</i>     | 26.89 |                   | <i>Lotus</i>     | 32.81 |                       | <i>Lotus</i>    | 36.93 |
|                   | <i>Daucus</i>    | 20.40 |                       | <i>Daucus</i>    | 17.95 |                   | <i>Galium</i>    | 30.30 |                       | <i>Agrostis</i> | 35.52 |
| H                 | <i>Galium</i>    | 37.93 | H                     | <i>Bromus</i>    | 38.33 | Y                 | <i>Asclepias</i> | 63.06 | Y                     | <i>Solidago</i> | 70.55 |
|                   | <i>Daucus</i>    | 28.90 |                       | <i>Phleum</i>    | 25.93 |                   | <i>Solidago</i>  | 60.77 |                       | <i>Grass</i>    | 38.11 |
|                   | <i>Trifolium</i> | 25.98 |                       | <i>Solidago</i>  | 23.01 |                   | <i>Dactylis</i>  | 38.06 |                       | <i>Phleum</i>   | 26.81 |
|                   | <i>Phleum</i>    | 24.03 |                       | <i>Trifolium</i> | 22.55 |                   | <i>Centaurea</i> | 38.06 |                       | <i>Bromus</i>   | 25.16 |
|                   | <i>Solidago</i>  | 24.02 |                       | <i>Daucus</i>    | 22.20 |                   | <i>Bromus</i>    | 30.80 |                       | <i>Cornus</i>   | 15.66 |

Appendix E. Relative importance values of genera in field and territory groupings in ordinations of Saratoga National Historical Park in 1994 and 1995. Only the top five genera are shown in each group.

Appendix E. Relative importance values of genera in field and territory groupings in ordinations of Saratoga National Historical Park in 1994 and 1995 (Fig. 6). Only the top five genera are shown in each group.

| Ordination A |                     |       | Ordination B |                   |       | Ordination C |                  |       | Ordination D  |                  |       |
|--------------|---------------------|-------|--------------|-------------------|-------|--------------|------------------|-------|---------------|------------------|-------|
| Group        | Genera              | IV    | Group        | Genera            | IV    | Group        | Genera           | IV    | Group         | Genera           | IV    |
| Group 1      | <i>Solidago</i>     | 59.07 | Group 1      | <i>Bromus</i>     | 56.33 | Group 1      | <i>Bromus</i>    | 27.52 | Group 1       | <i>Solidago</i>  | 43.77 |
|              | <i>Grass</i>        | 30.55 |              | <i>Phalaris</i>   | 49.71 |              | <i>Daucus</i>    | 24.58 |               | <i>Bromus</i>    | 39.66 |
|              | <i>Onoclea</i>      | 19.08 |              | <i>Solidago</i>   | 16.40 |              | <i>Trifolium</i> | 21.79 |               | <i>Grass</i>     | 37.69 |
|              | <i>Andropogon</i>   | 15.88 |              | <i>Lotus</i>      | 10.53 |              | <i>Phalaris</i>  | 20.42 |               | <i>Phleum</i>    | 21.98 |
|              | <i>Cornus</i>       | 14.76 |              | <i>Carex</i>      | 10.33 |              | <i>Lotus</i>     | 17.78 |               | <i>Asclepias</i> | 21.02 |
| Group 2      | <i>Centaurea</i>    | 19.93 | Group 2      | <i>Phalaris</i>   | 28.97 | Group 2      | <i>Phalaris</i>  | 63.40 | Group 2       | <i>Centaurea</i> | 84.30 |
|              | <i>Solidago</i>     | 16.70 |              | <i>Bromus</i>     | 24.94 |              | <i>Bromus</i>    | 60.22 |               | <i>Grass</i>     | 34.20 |
|              | <i>Grass</i>        | 15.64 |              | <i>Solidago</i>   | 13.37 |              | <i>Centaurea</i> | 55.15 |               | <i>Galium</i>    | 32.40 |
|              | <i>Galium</i>       | 15.63 |              | <i>Carex</i>      | 12.98 |              | <i>Galium</i>    | 31.90 |               | <i>Cornus</i>    | 14.39 |
|              | <i>Andropogon</i>   | 11.25 |              | <i>Lotus</i>      | 9.47  |              | <i>Trifolium</i> | 19.40 |               | <i>Solidago</i>  | 9.12  |
| Field A      | <i>Cephalanthus</i> | 62.84 | Group 3      | <i>Centaurea</i>  | 21.40 | Group 3      | <i>Centaurea</i> | 44.34 | Field H(in)   | <i>Phleum</i>    | 66.11 |
|              | <i>Solidago</i>     | 38.07 |              | <i>Potentilla</i> | 20.11 |              | <i>Grass</i>     | 19.79 |               | <i>Solidago</i>  | 42.59 |
|              | <i>Spiraea</i>      | 30.11 |              | <i>Phalaris</i>   | 16.89 |              | <i>Cornus</i>    | 15.66 |               | <i>Dactylis</i>  | 36.15 |
|              | <i>Vaccinium</i>    | 29.48 |              | <i>Bromus</i>     | 11.39 |              | <i>Solidago</i>  | 13.56 |               | <i>Lotus</i>     | 32.81 |
|              | <i>Osmorhiza</i>    | 24.07 |              | <i>Andropogon</i> | 10.38 |              | <i>Galium</i>    | 13.43 |               | <i>Galium</i>    | 30.30 |
| Field B      | <i>Bromus</i>       | 59.04 | Group 4      | <i>Centaurea</i>  | 33.84 | Field H(in)  | <i>Galium</i>    | 37.93 | Field BB(out) | <i>Bromus</i>    | 53.86 |
|              | <i>Populus</i>      | 47.15 |              | <i>Festuca</i>    | 21.00 |              | <i>Daucus</i>    | 28.90 |               | <i>Solidago</i>  | 37.75 |
|              | <i>Comptonia</i>    | 38.26 |              | <i>Cornus</i>     | 20.31 |              | <i>Trifolium</i> | 25.98 |               | <i>Lotus</i>     | 31.10 |
|              | <i>Spiraea</i>      | 33.75 |              | <i>Rubus</i>      | 18.19 |              | <i>Phleum</i>    | 24.03 |               | <i>Grass</i>     | 23.58 |
|              | <i>Cornus</i>       | 33.27 |              | <i>Andropogon</i> | 15.51 |              | <i>Solidago</i>  | 24.02 |               | <i>Phleum</i>    | 17.39 |
| Fields T,U   | <i>Centaurea</i>    | 39.41 | Field HH     | <i>Potentilla</i> | 38.70 |              |                  |       | Field BB(in)  | <i>Bromus</i>    | 76.76 |
|              | <i>Carex</i>        | 30.31 |              | <i>Solidago</i>   | 27.24 |              |                  |       |               | <i>Centaurea</i> | 63.44 |
|              | <i>Galium</i>       | 25.57 |              | <i>Phleum</i>     | 35.68 |              |                  |       |               | <i>Onoclea</i>   | 37.97 |
|              | <i>Apocynum</i>     | 18.89 |              | <i>Aster</i>      | 23.66 |              |                  |       |               | <i>Lotus</i>     | 30.15 |
|              | <i>Viburnum</i>     | 9.65  |              | <i>Rumex</i>      | 19.29 |              |                  |       |               | <i>Grass</i>     | 29.61 |

Appendix E (cont.)

| Ordination A |        |    | Ordination B |        |    | Ordination C |        |    | Ordination D |                  |       |
|--------------|--------|----|--------------|--------|----|--------------|--------|----|--------------|------------------|-------|
| Group        | Genera | IV | Group        | Genera | IV | Group        | Genera | IV | Group        | Genera           | IV    |
|              |        |    |              |        |    |              |        |    | Field K(out) | <i>Centaurea</i> | 80.38 |
|              |        |    |              |        |    |              |        |    |              | <i>Bromus</i>    | 32.32 |
|              |        |    |              |        |    |              |        |    |              | <i>Melilotus</i> | 20.47 |
|              |        |    |              |        |    |              |        |    |              | <i>Thymus</i>    | 16.44 |
|              |        |    |              |        |    |              |        |    |              | <i>Cornus</i>    | 15.55 |
|              |        |    |              |        |    |              |        |    | Field K(in)  | <i>Centaurea</i> | 98.37 |
|              |        |    |              |        |    |              |        |    |              | <i>Grass</i>     | 16.02 |
|              |        |    |              |        |    |              |        |    |              | <i>Andropogo</i> | 13.04 |
|              |        |    |              |        |    |              |        |    |              | <i>Viburnum</i>  | 13.04 |
|              |        |    |              |        |    |              |        |    |              | <i>Cornus</i>    | 12.49 |
|              |        |    |              |        |    |              |        |    | Field M(in)  | <i>Centaurea</i> | 88.48 |
|              |        |    |              |        |    |              |        |    |              | <i>Melilotus</i> | 37.99 |
|              |        |    |              |        |    |              |        |    |              | <i>Bromus</i>    | 33.97 |
|              |        |    |              |        |    |              |        |    |              | <i>Cornus</i>    | 21.57 |
|              |        |    |              |        |    |              |        |    |              | <i>Solidago</i>  | 20.30 |

Appendix F. Plant genera found in Saratoga National Historical Park during Henslow's sparrow study in 1994 and 1995.

Appendix F. Plant genera\* found in Saratoga National Historical Park during Henslow's sparrow study in 1994 and 1995.

| Family          | Common name           | Genus                   | Common name                     |
|-----------------|-----------------------|-------------------------|---------------------------------|
| Equisetaceae    | Horsetail Family      | <i>Equisetum</i> L.     | Horsetails and scouring rushes. |
| Onocleaceae     | Sensitive Fern Family | <i>Onoclea</i> L.       | Sensitive fern.                 |
| Ranunculaceae   | Buttercup family      | <i>Anemone</i> L.       | Anemone, windflower.            |
|                 |                       | <i>Clematis</i> L.      | Clematis.                       |
|                 |                       | <i>Ranunculus</i> L.    | Buttercup, crowfoot, spearwort. |
| Ulmaceae        | Elm Family            | <i>Ulmus</i> L.         | Elm.                            |
| Urticaceae      | Nettle Family         | <i>Parietaria</i> L.    | Pellitory.                      |
| Myricaceae      | Bayberry Family       | <i>Comptonia</i> L'Her. | Sweet fern.                     |
| Fagaceae        | Beech Family          | <i>Quercus</i> L.       | Oak.                            |
| Betulaceae      | Birch Family          | <i>Betula</i> L.        | Birch.                          |
| Caryophyllaceae | Pink Family           | <i>Cerastium</i> L.     | Mouse-ear chickweed.            |
|                 |                       | <i>Stellaria</i> L.     | Chickweed.                      |
|                 |                       | <i>Silene</i> L.        | Catchfly, campion.              |
| Polygonaceae    | Smartweed Family      | <i>Rumex</i> L.         | Dock, sorrel.                   |
|                 |                       | <i>Polygonum</i> L.     |                                 |
| Clusiaceae      | Mangosteen Family     | <i>Hypericum</i> L.     | St. John's-wort.                |
| Violaceae       | Violet Family         | <i>Viola</i> L.         | Violet.                         |
| Salicaceae      | Willow Family         | <i>Populus</i> L.       |                                 |
| Ericaceae       | Heath Family          | <i>Vaccinium</i> L.     |                                 |
| Primulaceae     | Primrose Family       | <i>Lysimachia</i> L.    | Loosetrife                      |
| Grossulariaceae | Gooseberry Family     | <i>Ribes</i> L.         |                                 |
| Crassulaceae    | Stonecrop Family      | <i>Sedum</i> L.         | Stonecrop.                      |
| Saxifragaceae   | Saxifrage Family      | <i>Saxifraga</i> L.     | Saxifrage.                      |
| Rosaceae        | Rose Family           | <i>Spiraea</i> L.       | Spiraea.                        |
|                 |                       | <i>Fragaria</i> L.      | Strawberry.                     |
|                 |                       | <i>Potentilla</i> L.    | Cinquefoil or five-fingers.     |
|                 |                       | <i>Geum</i> L.          | Avens.                          |
|                 |                       | <i>Rubus</i> L.         | Bramble.                        |
|                 |                       | <i>Agrimonia</i> L.     | Agrimony, harvest-lice.         |
|                 |                       | <i>Rosa</i> L.          | Rose.                           |

\* Nomenclature follows Gleason and Cronquist (1991).

Appendix F (cont.)

| Family         | Common name          | Genus                        | Common name                  |
|----------------|----------------------|------------------------------|------------------------------|
| Fabaceae       | Pea or Bean Family   | <i>Prunus</i> L.             |                              |
|                |                      | <i>Crataegus</i> L.          | Hawthorn.                    |
|                |                      | <i>Robinia</i> L.            | Locust.                      |
|                |                      | <i>Lotus</i> L.              |                              |
|                |                      | <i>Trifolium</i> L.          | Clover.                      |
|                |                      | <i>Melilotus</i> Miller.     | Sweet clover.                |
|                |                      | <i>Vicia</i> L.              | Vetch.                       |
| Cornaceae      | Dogwood Family       | <i>Cornus</i> L.             | Dogwood.                     |
| Rhamnaceae     | Buckthorn Family     | <i>Rhamnus</i> L.            | Buckthorn.                   |
| Vitaceae       | Grape Family         | <i>Parthenocissus</i>        |                              |
|                |                      | Planchon, nom. conserv.      |                              |
|                |                      | <i>Vitis</i> L.              | Grape.                       |
| Polygalaceae   | Milkwort Family      | <i>Polygala</i> L.           | Milkwort.                    |
| Aceraceae      | Maple Family         | <i>Acer</i> L.               | Maple.                       |
| Anacardiaceae  | Cashew Family        | <i>Rhus</i> L.               | Sumac.                       |
|                |                      | <i>Toxicodendron</i> Miller. |                              |
|                |                      |                              |                              |
| Oxalidaceae    | Wood sorrel Family   | <i>Oxalis</i> L.             | Wood-sorrel.                 |
| Geraniaceae    | Geranium Family      | <i>Geranium</i> L.           | Wild geranium, crane's bill. |
| Apiaceae       | Carrot Family        | <i>Osmorhiza</i>             | Sweet cicely.                |
|                |                      | Raf., nom. conserv.          |                              |
|                |                      | <i>Daucus</i> L.             |                              |
|                |                      | <i>Zizia</i> Koch.           | Golden alexanders.           |
|                |                      | <i>Cicuta</i> L.             | Water-hemlock.               |
| Apocynaceae    | Dogbane Family       | <i>Apocynum</i> L.           | Dogbane.                     |
| Asclepiadaceae | Milweed Family       | <i>Asclepias</i> L.          | Milkweed.                    |
| Solanaceae     | Nightshade Family    | <i>Solanum</i> L.            | Nightshade.                  |
| Convolvulaceae | Morning-glory Family | <i>Convolvulus</i> L.        |                              |
|                |                      | <i>Ipomoea</i> L.            | Morning-glory.               |
| Polemoniaceae  | Phlox Family         | <i>Phlox</i> L.              | Phlox; Sweet William.        |
| Verbenaceae    | Vervain Family       | <i>Verbena</i> L.            | Vervain.                     |

\* Nomenclature follows Gleason and Cronquist (1991).

Appendix F (cont.)

| Family            | Common name        | Genus                                | Common name                   |
|-------------------|--------------------|--------------------------------------|-------------------------------|
| Lamiaceae         | Mint Family        | <i>Satureja</i> L.                   |                               |
|                   |                    | <i>Thymus</i> L.                     | Thyme                         |
|                   |                    | <i>Pycnanthemum</i>                  | Mt.-mint.                     |
|                   |                    | Michx., nom. conserv.                |                               |
| Lamiaceae (cont.) |                    | <i>Mentha</i> L.                     | Mint.                         |
|                   |                    | <i>Lycopus</i> L.                    | Water-horehound; bugle-weed.  |
|                   |                    | <i>Glechoma</i> L.,<br>nom. conserv. | Ground-ivy.                   |
|                   |                    | <i>Prunella</i> L.                   | Self-heal.                    |
|                   |                    | <i>Lamium</i> L.                     | Dead nettle.                  |
|                   |                    | <i>Monarda</i> L.                    | Bee-Balm.                     |
| Plantaginaceae    | Plantain Family    | <i>Plantago</i> L.                   | Plantain.                     |
| Oleaceae          | Olive Family       | <i>Fraxinus</i> L.                   | Ash.                          |
| Scrophulariaceae  | Figwort Family     | <i>Penstemon</i> Schmidel.           | Beard-tongue.                 |
|                   |                    | <i>Linaria</i> Miller.               | Toadflax.                     |
|                   |                    | <i>Digitalis</i> L.                  | Foxglove.                     |
|                   |                    | <i>Veronica</i> L.                   | Speedwell.                    |
| Campanulaceae     | Bellflower Family  | <i>Lobelia</i> L.                    | Lobelia.                      |
| Rubiaceae         | Madder Family      | <i>Cephalanthus</i> L.               |                               |
|                   |                    | <i>Galium</i> L.                     | Bedstraw; cleavers.           |
| Caprifoliaceae    | Honeysuckle Family | <i>Viburnum</i> L.                   |                               |
|                   |                    | <i>Sambucus</i> L.                   | Elder.                        |
| Asteraceae        | Aster Family       | <i>Rudbeckia</i> L.                  | Conefl.                       |
|                   |                    | <i>Ambrosia</i> L.                   | Ragweed.                      |
|                   |                    | <i>Xanthium</i> L.                   | Cocklebur.                    |
|                   |                    | <i>Achillea</i> L.                   | Yarrow.                       |
|                   |                    | <i>Chrysanthemum</i> L.              | Chrysanthemum.                |
|                   |                    | <i>Solidago</i> L.                   | Goldenrod.                    |
|                   |                    | <i>Aster</i> L.                      | Wild aster; Michaelmas-daisy. |
|                   |                    | <i>Erigeron</i> L.                   | Daisy; fleabane.              |

\* Nomenclature follows Gleason and Cronquist (1991).

Appendix F (cont.)

| Family             | Common name  | Genus                         | Common name                       |
|--------------------|--------------|-------------------------------|-----------------------------------|
| Asteraceae (cont.) |              | <i>Inula</i> L.               |                                   |
|                    |              | <i>Antennaria</i> Gaertner.   | Pussytoes.                        |
|                    |              | <i>Eupatorium</i> L.          |                                   |
|                    |              | <i>Arctium</i> L.             | Burdock.                          |
|                    |              | <i>Cirsium</i> Miller.        | Thistle.                          |
|                    |              | <i>Centaurea</i> L.           | Star-thistle; knapweed.           |
|                    |              | <i>Hieracium</i> L.           | Hawkweed.                         |
|                    |              | <i>Taraxacum</i>              | Dandelion.                        |
|                    |              | Wiggers, nom. conserv.        |                                   |
|                    |              | <i>Cichorium</i> L.           | Chicory.                          |
| Juncaceae          | Rush Family  | <i>Juncus</i> L.              | Rush.                             |
| Cyperaceae         | Sedge Family | <i>Carex</i> L.               | Sedge.                            |
| Poaceae            | Grass Family | <i>Festuca</i> L.             | Fescue.                           |
|                    |              | <i>Lolium</i> L.              |                                   |
|                    |              | <i>Poa</i> L.                 | Bluegrass.                        |
|                    |              | <i>Dactylis</i> L.            | Orchard-grass.                    |
|                    |              | <i>Holcus</i> L.              | Velvet-grass.                     |
|                    |              | <i>Anthoxanthum</i> L.        | Sweet vernal grass.               |
|                    |              | <i>Phalaris</i> L.            |                                   |
|                    |              | <i>Agrostis</i> L.            | Bent-grass; bent.                 |
|                    |              | <i>Phleum</i> L.              |                                   |
|                    |              | <i>Bromus</i> L.              | Brome, brome-grass; chess, cheat. |
|                    |              | <i>Elymus</i> L.              | Wild rye.                         |
|                    |              | <i>Agropyron</i> Gaertn.      | Crested wheatgrass.               |
|                    |              | <i>Danthonia</i>              | Wild oatgrass                     |
|                    |              | Lam. & DC., nom. conserv.     |                                   |
|                    |              | <i>Muhlenbergia</i> Schreber. | Muhly.                            |
|                    |              | <i>Panicum</i> L.             | Panic-grass.                      |
|                    |              | <i>Leptoloma</i> Chase.       | Fall witch-grass.                 |
|                    |              | <i>Andropogon</i> L.          | Bluestem.                         |

\* Nomenclature follows Gleason and Cronquist (1991).

Appendix F (cont.)

| Family    | Common name | Genus              | Common name           |
|-----------|-------------|--------------------|-----------------------|
| Liliaceae | Lily Family | <i>Allium</i> L.   | Onion.                |
|           |             | <i>Uvularia</i> L. | Bellwort, merrybells. |

Unknown thick, grassy vegetation was collectively referred to as "Grass".

\* Nomenclature follows Gleason and Cronquist (1991).

## VITA

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## EDUCATION:

|              | <u>Name and location</u>                                                   | <u>Dates</u> | <u>Degree</u>   |
|--------------|----------------------------------------------------------------------------|--------------|-----------------|
| High School: | Nottingham High School<br>Syracuse, New York                               | 1983-1987    | H.S.<br>Diploma |
| College:     | Penn State University<br>State College, Pennsylvania                       | 1987-1992    | B.S.            |
|              | Syracuse University<br>Academic semester abroad<br>Madrid, Spain           | Fall 1989    | N/A             |
|              | State University of New York<br>Syracuse, New York                         | 1993-1996    | M.S.            |
|              | Maxwell School of Citizenship<br>Syracuse University<br>Syracuse, New York | 1994-1996    | M.P.A.          |

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|----------------------------------------------------------|-------------|--------------------------------------------------------|
| Kings Canyon National Park                               | 1996        | Ranger - Lead Interpretive<br>Naturalist (Cedar Grove) |
| The Nature Conservancy                                   | 1995        | Conservation Biology Intern                            |
| Edna Bailey Sussman Fund                                 | 1995        | Field Technician                                       |
| State University of New York                             | 1993-1995   | Teaching Assistant                                     |
| Kings Canyon and Sequoia<br>National Parks               | 1991-1993   | Ranger - Interpretive Naturalist                       |
| The Learning Center                                      | 1988-1992   | Computer Lab Attendant                                 |
| Zion National Park<br>Student Conservation Association   | 1990        | Naturalist                                             |
| Denali National Park<br>Student Conservation Association | 1989        | Naturalist                                             |