The Auk 116(1):109–115, 1999

HABITAT REQUIREMENTS OF HENSLOW'S SPARROWS WINTERING IN SILVICULTURAL LANDS OF THE GULF COASTAL PLAIN

SHELDON PLENTOVICH,[1,2,3] NICHOLAS R. HOLLER,[2] AND GEOFFREY E. HILL[1,4]

[1]*Department of Zoology and Wildlife Science, 331 Funchess Hall, Auburn University, Alabama 36849, USA; and* [2]*Alabama Cooperative Fish and Wildlife Research Unit, 331 Funchess Hall, Auburn University, Alabama 36849, USA*

ABSTRACT.—Henslow's Sparrow (*Ammodramus henslowii*) is one of several grassland bird species that has declined during the last several decades. Although several studies have characterized the habitat requirements of breeding Henslow's Sparrows, winter habitat requirements for the species remain poorly known. The purpose of our study was to identify habitat variables associated with occupancy by Henslow's Sparrow on silvicultural lands in the core of its winter range in the Gulf Coastal Plain. Forty-one study sites were chosen on lands managed for timber production in Baldwin County, Alabama. Henslow's Sparrows selected moist sites that occurred as pitcher plant bogs or as transition areas between wet pitcher plant bogs and drier upland areas. A multiple logistic regression model identified the density of the grass *Panicum verrucosum* and the density of pitcher plants as the variables best able to explain the presence of Henslow's Sparrows. Sites occupied by Henslow's Sparrows had higher herbaceous vegetation densities and had been disturbed by timber harvest and/or fire more recently than unoccupied sites. Within occupied sites, Henslow's Sparrows chose areas with higher densities of herbaceous vegetation, especially *P. verrucosum*. *Received 16 October 1997, accepted 9 June 1998.*

THE HENSLOW'S SPARROW (*Ammodramus henslowii* Audubon) is a shy and elusive bird that inhabits moist grasslands in the central and eastern United States (Hyde 1939, Robins 1971, Mirarchi 1986, Zimmerman 1988, Herkert 1994). Knowledge about the Henslow's Sparrow is limited. Recent studies have been conducted in breeding areas in Michigan, New York, Illinois, Kansas, and Oklahoma (Robins 1971, Peterson 1983, Zimmerman 1988, Reinking and Hendricks 1993, Herkert 1994). These studies show that Henslow's Sparrows inhabit moist grasslands with tall, dense vegetation (Herkert 1994), a deep litter layer, and a high density of standing dead forbs (Wiens 1969, Zimmerman 1988, Reinking and Hendricks 1993). They nest in grasslands with scattered shrubs but avoid areas with extensive woody vegetation (Wiens 1969, Peterson 1983, Zimmerman 1988). In Oklahoma, Reinking and Hendricks (1993) found Henslow's Sparrows nesting in an area of "dense, erect tallgrass prairie" and commented that the presence of a large disjunct breeding population in this area indicated that the absence of suitable habitat may be an important limiting factor.

Grassland area and the time elapsed since a major disturbance appear to be important factors in determining suitable habitat for Henslow's Sparrows. Henslow's Sparrows depend on transitional habitat. They are usually found in fields that have been free of major disturbances for several years (Zimmerman 1988, Volkert 1992). Thus, they use habitats that are temporarily unsuitable if disturbed but that also become unsuitable without disturbance owing to succession (Askins 1993). Peterson (1983) and Herkert (1994) found that the patch size of grasslands was the major factor influencing habitat selection by breeding Henslow's Sparrows, which occurred on only one grassland less than 100 ha in size in Illinois and in six sites with an average area of 66 ha in New York.

The winter range of Henslow's Sparrow extends from South Carolina to southern Florida, west to eastern and (rarely) southern Texas, and casually north to Illinois, Indiana, New England and Nova Scotia (AOU 1983). Within this range, Henslow's Sparrows are thought to use pitcher plant (*Sarracenia* sp.) bogs, open pine savannahs, old fields, and salt marsh bor-

[3] Present address: U.S. Fish and Wildlife Service, Rota Field Station, P.O. Box 1251, Rota, MP 96951. E-mail: aga@ite.cnmi.com

[4] Address correspondence to this author. E-mail: geoffrey.hill@acesag.auburn.edu

dering the Gulf Coast (Hyde 1939, Mirarchi 1986), but their winter habitat requirements have not been examined in detail.

The purpose of our study was to identify variables associated with occupancy by Henslow's Sparrows on silvicultural lands in the Southeastern Coastal Plain. In particular, we wanted to examine the importance of pitcher plant bogs as winter habitat for the species and to develop management recommendations for conservation of habitat on managed lands.

METHODS

Site selection.—The study was conducted on International Paper Company land in Baldwin County, Alabama, during the winters of 1995 and 1996. Sites were not chosen randomly because we had to ensure that at least some of the sites contained sparrows. Thus, in January 1995 we conducted preliminary surveys in open habitats that lacked a significant midstory until 15 sites occupied by Henslow's Sparrows were found. Seventeen more sites were then randomly drawn from a pool of 37 that included areas that had not been searched for Henslow's Sparrows. The 32 sites included pitcher plant bogs, pine plantations harvested less than five years previously, and areas where trees had recently been harvested; general habitat characteristics ranged from wet areas with pockets of standing water to dry upland areas. Within all sites, most vegetation occurred within 100 cm of the ground.

We resurveyed the original 32 sites in 1996 and added 9 additional sites. New sites were added because five of the study sites used in 1995 had been degraded by timber harvesting to the extent that they were no longer used by Henslow's Sparrows. The additional sites were added in the same manner that sites were chosen in 1995; three were chosen and six were selected randomly from a pool of 20 new sites.

Strip-transect surveys and vegetation sampling.— Henslow's Sparrows were surveyed along strip transects. Between 15 January and 10 March, each study site was censused on three occasions at varying times of day between sunrise and 1500 CST. Within each site, three 200-m transects were established side by side at 20-m intervals and marked with colored flagging every 20 m. A single observer walked each transect using a 1.5-m stick to disturb vegetation along the transect line and recorded all birds observed within a 5-m strip around the transect. All surveys were conducted by the same person. Each transect was censused in 8 to 10 min, depending on the number of birds observed. All points from which Henslow's Sparrows were flushed were marked so that vegetation could be sampled at these "flush sites." We strived to avoid double-counting birds. For instance, if a sparrow flew from transect A to transect B, and then another was flushed from the same general area of transect B later in the survey, the second bird was not recorded as a new individual.

Vegetation sampling was conducted in mid- to late March after Henslow's Sparrows began leaving for their breeding grounds. No obvious changes in vegetation structure were observed between the start of the study in January and the time of vegetation sampling in late March. All sites were sampled in both 1995 and 1996. We measured vegetation at flush sites and also every 10 m along each 200-m transect, which provided a minimum of 60 samples per site. We used a variation of the pole method (Mills et al. 1989) to measure heights and densities of vegetation. The pole method measures vegetation in a 10-cm radius cylinder at 5-cm intervals up to 20 cm, followed by 10-cm intervals up to 200 cm. At each point, we recorded the number of height intervals (5 or 10 cm) that contained vegetation. Plants were identified to genus and/or species and categorized as *Panicum verrucosum*, grass/sedge (other than *P. verrucosum*), fern, forb, pitcher plant, or shrub. *P. verrucosum* was separated from the other grasses because of the strong association we observed between the density of this grass and the presence of Henslow's Sparrows. Canopy cover was measured using a spherical densiometer, and the presence or absence of standing water was noted at each of the 60 points along the transect and at each flush site. International Paper Company provided information on the disturbance (timber harvest, site prepping, or prescribed burning) histories of each plot.

Statistical analysis.—We used multiple logistic regression (Hosmer and Lemeshow 1989) to determine which vegetation variables (i.e. densities of *P. verrucosum*, forbs, shrubs, pitcher plants, and grasses/sedges other than *P. verrucosum*) were able to explain the presence of Henslow's Sparrows. The dependent variable was binary, i.e. presence or absence of Henslow's Sparrows. To find the best model possible, backward elimination (Menard 1995) was used to eliminate variables one by one that did not improve the model's ability to correctly classify site occupancy by Henslow's Sparrows. Studies of breeding habitat of Henslow's Sparrows emphasize the importance of dense ground cover. Therefore, we examined vegetation density occurring at and below 1.0 m. Grasses and sedges were combined in our analysis because we were not confident in distinguishing between some grass and sedge species during the winter. Despite the obvious association between *P. verrucosum* density and the presence of Henslow's Sparrows, *P. verrucosum* was lumped with grass/sedge during preliminary analyses. We report the results of the model that correctly classified the largest number of sites; as expected, this model required the separation of *P. verrucosum* from other grasses and sedges. Density of herbaceous vegetation and the number of

TABLE 1. Stratified randomization tests comparing *Panicum verrucosum* density and total vegetation density at points where Henslow's Sparrows were located versus randomly selected points within each of 19 study sites in Baldwin County, Alabama.

Site	*P. verrucosum*	Total vegetation	No. of flush samples
ARMI	0.011*	0.604	5
ATTA	0.000*	0.044*	7
B6BO	0.365	0.768	2
BLAZ	0.049*	0.160	3
CAHI	0.025*	0.123	2
FATR	1.000	0.490	2
HAND	0.003*	0.002*	6
HELI	1.000	0.770	1
HESP	0.819	0.084	3
LONGS	0.004*	0.233	4
METH	0.084	0.001*	5
MFBB	1.000	0.538	1
NEWB	0.262	0.117	2
NHCH	0.070	0.056	5
OGLE	1.000	0.489	1
RESE	0.015*	0.740	1
SNAK	0.173	0.005*	7
STRE	0.200	0.139	1
WINT	0.014*	0.022*	5

*, $P < 0.05$.

growing seasons since the last disturbance were not used in the analysis because they were significantly correlated with *P. verrucosum* density and hence redundant. Analysis of habitat predictors was based on the 32 sites used in 1995 plus the 9 sites added in 1996, for a total of 41 sites.

We used t-tests to examine differences in total vegetation density and herbaceous vegetation density between sites with and without Henslow's Sparrows. The normal approximation to the Mann-Whitney test was used to compare the number of growing seasons since the last disturbance in sites with versus without Henslow's Sparrows.

Because habitat along the transects was heterogeneous, comparison of flush samples (i.e. vegetation samples on or near the transect from which sparrows were flushed) with transect samples (i.e. points along the transects from which Henslow's Sparrows were not flushed) within occupied sites ($n = 19$) allowed us to isolate habitat characteristics selected by Henslow's Sparrows. Flush samples separated by more than 50 m were considered independent. If two or more flush samples were clustered within 50 m of each other, we randomly selected one to use in the analyses. The normal approximation to the Mann-Whitney test was used to determine if there were differences in total vegetation density and density of *P. verrucosum* between flush samples and transect samples in occupied sites.

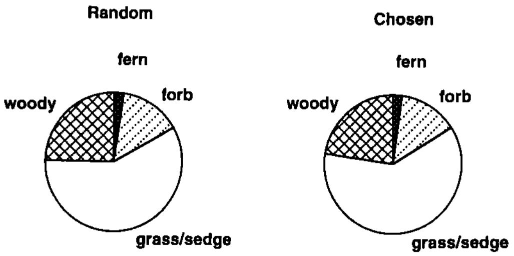

FIG. 1. Vegetation composition (all heights) at sites selected randomly ($n = 24$) and sites chosen because they were known to be occupied by Henslow's Sparrows ($n = 17$).

Randomization tests (Noreen 1989) were used to compare *P. verrucosum* density and total vegetation density (i.e. sum of all vegetation categories) of flush samples versus a random draw from all samples (i.e. transect samples and flush samples) within sites. Data were ranked from lowest to highest density at each site to control for varying vegetation densities among sites. Although transect sampling points were not strictly random, they were treated as randomly encountered non-flush samples in randomization tests.

The test statistics for the randomization tests were calculated as the sum of the rank densities of all flush samples. This was compared with a pseudo test statistic generated after shuffling the flush samples and transect samples within each site and randomly selecting a specified number of samples (i.e. the number of samples selected equaled the number of flush samples at that site). The pseudo test statistic was generated by summing the rank densities of randomly selected samples. The test statistic and pseudo test statistic were compared within sites (i.e. separate comparisons were made for all 19 sites; Table 1). The process was carried out 5,000 times. The computer program (written in QBASIC) is available from the authors upon request. Fisher's cumulative probability (Sokal and Rohlf 1981) was used to calculate an overall probability for all 19 sites.

RESULTS

Vegetation composition was virtually identical at chosen sites known to be occupied by Henslow's Sparrows and sites selected randomly (Fig. 1). According to our logistic regression analysis, *P. verrucosum* density and pitcher plant density were the variables that best explained the presence of Henslow's Sparrows (Table 2). Using logistic regression, we estimated the probability of occurrence of Henslow's Sparrows as:

TABLE 2. Likelihood-ratio test results. Data were gathered in 1995 and 1996 on intensively managed timberlands in Baldwin County, Alabama.

Variable	Chi-square[a]	df	P
P. verrucosum	27.79	1	<0.001
Pitcher plant	6.52	1	0.011
Forb	3.12	1	0.077
Woody	0.68	1	0.408
Grass/sedge[b]	1.46	1	0.226
Means and totals	34.09	2	<0.010

[a] Likelihood-ratio χ^2 value.
[b] Includes grasses and sedges other than *P. verrucosum*.

$$P = 1/1 + e^{-z}, \qquad (1)$$

where $z = -3.0264 + 0.0646$ (*P. verrucosum* density) + 0.0440 (pitcher plant density). The model correctly classified 87.8% of our 41 sites as to presence or absence of Henslow's Sparrows.

Total vegetation density below 1.0 m did not differ at sites with and without Henslow's Sparrows ($t = 1.61$, $n = 41$, $P = 0.116$). However, sites with Henslow's Sparrows had a higher density of herbaceous vegetation at and below 1 m ($t = 2.25$, $n = 44$, $P = 0.02$) and had undergone fewer growing seasons without a disturbance ($Z = 3.00$, $n = 38$, $P = 0.003$). The majority of sites occupied by Henslow's Sparrows had undergone one growing season without a disturbance, and no occupied sites had undergone more than six such growing seasons (Fig. 2). When the sparse vegetation above 1 m was examined, *P. verrucosum* was also denser in occupied sites versus unoccupied sites ($Z = 2.21$, $n = 41$, $P = 0.027$). The number of Henslow's Sparrows was positively correlated with the density of *P. verrucosum* ($r_s = 0.67$, $P < 0.0001$; Fig. 3).

When microhabitat within occupied sites was examined, flush samples had higher densities of total vegetation ($Z = 5.86$, $P < 0.0001$) and *P. verrucosum* ($Z = 6.627$, $P < 0.0001$) than non-flush samples (n = 1,203 in both cases). Conversely, pitcher plants were no more likely to be found in flush samples than in samples along transects ($Z = 1.40$, $P = 0.16$). Randomization tests showed that total vegetation and *P. verrucosum* were denser in flush samples than in randomly selected samples along transects ($P < 0.01$). To examine whether this result was due to extreme differences at a single site, we examined sites individually. *P. verrucosum* was more dense at flush samples than at samples se-

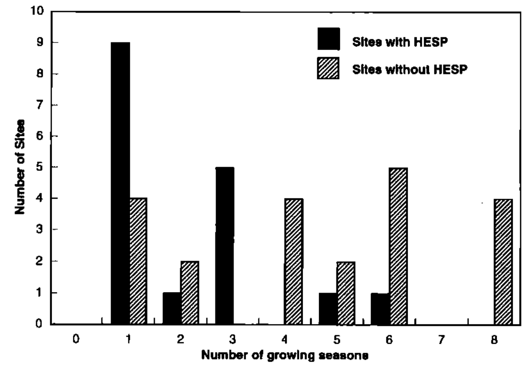

FIG. 2. Number of growing seasons since the last disturbance (i.e. clearcut, site preparation, and/or prescribed burn) in sites occupied versus unoccupied by Henslow's Sparrows in Baldwin County, Alabama, during the winters of 1995 and 1996.

lected randomly in 8 of 19 sites (Table 1). Eight of the 11 study sites that did not show a difference had three or fewer flush samples. In 5 of the 19 sites, flush samples had higher total vegetation density than randomly selected samples (Table 1). Eleven of the remaining 14 had three or fewer flush samples. *P. verrucosum* was present in 74.6% of flush samples and only 19.8% of non-flush samples. Correlation analysis showed that in both tests, as the number of flush samples in a site increased, the probabil-

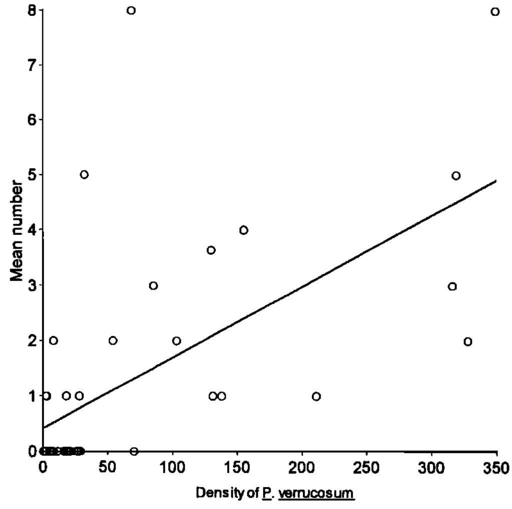

FIG. 3. Relationship between the average number of Henslow's Sparrows and *Panicum verrucosum* density in Baldwin County, Alabama, during the winters of 1995 and 1996.

ity of detecting a significant difference also increased ($P = 0.005$). Flush samples also had less standing water ($\chi^2 = 5.28$, df = 1, $P = 0.022$) than transect samples.

Discussion

Henslow's Sparrows were observed in habitat similar in structure to their breeding habitat (i.e. areas with dense ground cover), and they selected areas with high densities of herbaceous vegetation, particularly *P. verrucosum.* These areas had moist soil and usually were in pitcher plant bogs or in transition areas between wet pitcher plant bogs and drier upland habitats. On our study sites, *P. verrucosum* formed nearly pure stands in many moist areas soon after a mechanical disturbance such as clearcutting (Godfrey and Wooten 1979). The density of *P. verrucosum* was the variable that best explained the presence of Henslow's Sparrows, an association that likely is a function of the structure of the grass.

Wintering Henslow's Sparrows occur in high densities in the savannahs in Appalachicola National Forest, Florida (Plentovich pers. obs.), and the Mississippi Sandhill Crane National Wildlife Refuge, Mississippi (Chandler and Woodrey 1995), both of which are burned regularly (i.e. every 2 to 5 years). The soil in these areas is left undisturbed so that the natural understory assemblages are intact, and pioneering species like *P. verrucosum* are absent. The structure of these natural assemblages (which include species such as *Aristida stricta, Muhlenburgia capillaris,* and *Carex* sp.) is very similar to that of the dense stands of *P. verrucosum* on our study sites. In our study area, *P. verrucosum* provides what appears to be the best habitat for Henslow's Sparrow because regularly burned areas with a diverse understory of grasses and sedges are not present.

Vegetation structure is not necessarily a precise measure of habitat suitability. Henslow's Sparrows have needs other than adequate cover that may not be met in some areas. For example, some savannahs retain similar vegetation structure even though fire has been suppressed for many years. We observed single Henslow's Sparrows in three sites that had not been burned or harvested for more than four years. Because these individuals were detected only once at each site, they may not have been residents. It is possible that Henslow's Sparrows settle temporarily in areas with adequate vegetative structure but are forced to leave because of limited resources. Sparrows found in habitat that had been burned or harvested one to three years earlier were generally relocated in the same area of our sites throughout the winter (Plentovich et al. 1998). Many grasses that occur in the longleaf pine/wiregrass ecosystem will not produce seeds until a low-intensity fire has occurred in the area (Clewell 1981). To produce seeds, one of the most common grasses in our study area, wiregrass (*Aristida stricta*), needs frequent low-intensity burns that must occur in the warm season (Clewell 1981, Myers and Ewel 1990). Unburned pitcher plant bogs and other moist areas would likely become suitable for Henslow's Sparrows if a regular burning program was established in the area.

When variation in sparrow settlement pattern attributed to *P. verrucosum* was removed from the logistic regression model, pitcher plant density was the next variable that best explained the presence of Henslow's Sparrows. Unlike *P. verrucosum,* pitcher plants were no more likely to be found in flush samples than in non-flush samples along transects. Among sites occupied by sparrows, the density of *P. verrucosum* was negatively correlated with the density of pitcher plants ($r_s = 0.82$, $n = 19$, $P = 0.0002$). As previously mentioned, high densities of *P. verrucosum* are characteristic of mechanically disturbed soils. Thus, sites with high densities of pitcher plants (and therefore low densities of *P. verrucosum*) were generally less mechanically altered but still in the early stages of succession, which provided suitable habitat for Henslow's Sparrows. No prescribed burning had occurred on any of our study sites for four years unless timber had been harvested at the site. Because International Paper Company typically burns slash before replanting, fairly undisturbed areas with high densities of pitcher plants had not been burned for at least four years. Sites that had high densities of pitcher plants and were occupied by Henslow's Sparrows were usually areas where woody vegetation had been eliminated through regular burning. Because woody vegetation was almost completely eliminated in these areas, a diverse understory of grasses, sedges, and forbs persisted in the absence of recent prescribed burns.

Henslow's Sparrows seem to prefer certain habitat characteristics within apparently suitable habitat, which could explain their patchy distribution. The presence of pitcher plants indicated the presence of moist or wet soils. Henslow's Sparrows selected an intermediate moisture level that often occurred in drier pitcher plant bogs, or in transition areas between wet bogs and drier upland habitat. A wet pitcher plant bog could have Henslow's Sparrows along the edges and therefore would be considered suitable habitat in our analyses, even though Henslow's Sparrows were not actually using wet sections of the bog with the highest density of pitcher plants. Despite habitat structure that seemed similar in some areas, we never found Henslow's Sparrows in dry upland sites.

Our study area is an example of habitat that is used by Henslow's Sparrows but in which they are generally uncommon. Only 4 of the 24 randomly selected sites were occupied by Henslow's Sparrows. Henslow's Sparrows were observed only once in three of these four sites, indicating that the habitat was marginal. Henslow's Sparrows need moist grasslands with a dense herbaceous ground cover in the early stages of succession (i.e. one to four years). The suppression of wildfire, the destruction and alteration of wetlands, and the development of land for urban or agricultural use have dramatically reduced the number of areas that meet these criteria in the Southeastern Coastal Plain (Lewis and Harshbarger 1976, Clewell, 1981, Robbins and Meyers 1992).

Historically, Henslow's Sparrow wintering grounds were disturbed by fire every two to five years (Clewell 1981, Platt et al. 1988, Robbins and Meyers 1992, Waldrop et al. 1992, Horton 1995). Fire was the driving force in creating the longleaf pine/wiregrass ecosystem. The obvious way to manage for Henslow's Sparrows is to mimic the natural fire regime. In the Southern Coastal Plain, frequent fire will maintain a mosaic of early successional habitats dominated by herbaceous vegetation that is structurally similar the open savannahs in the Appalachicola National Forest (Plentovich pers. obs.) and the Mississippi Sandhills Crane Wildlife Refuge (Chandler and Woodrey 1995). On lands specifically managed for timber production, burning is useful in controlling invasion by woody vegetation and often results in increased growth of pines (USFS 1971). This is especially true when soil moisture is a limiting resource. Eliminating woody vegetation by prescribed burning increases the amount of water available for the overstory trees (USFS 1971). Warm-season prescribed burns have been shown to increase the number and density of herbaceous species (Lewis and Harshbarger 1976).

On our sites, Henslow's Sparrows selected areas associated with wetlands. It is estimated that relatively undisturbed pitcher plant bogs occupy less than 3% of their original area along the Southeastern Coastal Plain (Folkerts 1982), and little or no protection is afforded to many of the remaining pitcher plant bogs. Indeed, by the winter of 1996, more than half of the sites occupied by Henslow's Sparrows in our study area in 1995 had been significantly altered by management practices such as soil disturbance to create fire breaks (thus reducing the chances of any future burning in the wet areas) and attempts to drain wetlands.

In many forested areas of the southeastern United States, implementing a regular burning program is becoming increasingly difficult owing to restrictions placed on burning. Such regulations impede the ability of forest managers to maintain the integrity of ecosystems that rely on fire. Fire is an essential (vs. catastrophic) component of areas in which all species have evolved in its presence. Suitable Henslow's Sparrow habitat in the Southeastern Coastal Plain will persist only if fire suppression and the destruction and alteration of wetlands are halted.

ACKNOWLEDGMENTS

This study was supported by the Biological Resources Division of the U.S. Geological Survey, International Paper Company, and the Alabama Cooperative Fish and Wildlife Research Unit. We thank G. Hepp, J. Grzybowski, and an anonymous reviewer for comments on previous drafts of the manuscript, and Robert Reed, Rick Fredland, and Deanna Harris for help in the field.

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Associate Editor: R. L. Hutto