

Reintroduction of Regal Fritillary (*Speyeria idalia*) to a Restored Prairie

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Photo by Rod Van Nimwegen.

The tallgrass prairie is one of the most fragmented ecosystems in North America. In Iowa only 0.1 percent of the original tallgrass prairie remains because of extensive land conversion to agricultural practices (Smith 1998). A consequence of this loss is the imperiled existence of prairie-associated organisms, such as butterflies (Pullin 1996, Schlicht and Orwig 1998). In Iowa, Schlicht and Orwig (1998) classified nine prairie endemic butterflies as endangered (existing on fewer than 20 sites) and 11 more as threatened (existing on 21 to 100 sites).

One strategy for conserving declining butterfly species is the preservation or restoration of existing prairie habitat (Launer and Murphy 1994, Smallidge and Leopold 1997, Marttila and others 2000, O'Dwyer and Attiwill 2000, Schultz 2001). However, restoration of disturbed natural areas does not always alleviate the problem of habitat fragmentation. Because many endangered Lepidoptera (golden sun moth [*Synemon plana*], chequered blue butterfly [*Scolitantides orion*] and Fender's blue butterfly [*Icaricia icarioides fenderi*], to name a few) exist in relatively small areas of suitable habitat isolated in a much larger matrix of unsuitable habitat (Pullin 1996, Marttila and others 1997, O'Dwyer and Attiwill 2000, Schultz 2001), connectivity and size of habitat may be as important as habitat quality (Moilanen and Hanski 1998, Dennis and Eales 1999).

A second technique used to restore rare butterfly populations is their reintro-

duction into restored areas of formerly degraded habitat (Dempster and Hall 1980, Williams 1995, Pullin 1996, Marttila and others 1997, Witkowski and others 1997, Wynhoff 1998, Barascud and others 1999). This includes reintroductions into former croplands that have been restored to some semblance of their historic past, which in Iowa generally means tallgrass prairie. Such reintroductions are necessary because they provide more possibilities for increasing the amount and connectivity of habitat in a landscape. However, some prairie entomologists (Panzer and others 1995) question whether a habitat-sensitive butterfly will thrive in such a restored habitat. Here we describe and discuss the potential of reintroducing the regal fritillary (*Speyeria idalia*), a prairie-endemic butterfly species, into areas of former cropland that have been restored to tallgrass prairie.

Life History, Habitat Requirements, and Status of Regal Fritillary

Life History

The regal fritillary is a large, sexually dimorphic, univoltine butterfly. Females are especially long-lived. Males emerge in mid-June about two weeks before the females. Females mate immediately after their emergence, but enter a reproductive diapause until mid-August or early September (Scott 1986, Kopper and others 2001), at which time they begin deposit-

Keywords: *Speyeria idalia*, prairie, Iowa, insect reintroduction

ing up to 2,500 eggs (Wagner and others 1997) in the vicinity of their host plant species—one of the prairie violets (Kopper and others 2000). Larvae hatch in about one month, eat the chorion of their egg and enter diapause in the leaf litter (Kopper and others 2000). They become active again in early May and search for a host plant.

Habitat Requirements

Regal fritillaries are most often associated with tallgrass and midgrass prairie. Because they prefer wetter grasslands (Scott 1986, Opler and Krizek 1984, Wagner and others 1997), they have primarily been found in prairies that include moist, low areas and drier areas for the host plant on the uplands (Swengel 1997, Zercher 2001). The regal fritillary seems to be restricted in its habitat requirements by the availability of its larval host plants, which include a number of prairie-endemic violet species (Wagner and others 1997, Debinski and Kelly 1998, Opler and Krizek 1984). Prairie violet (*Viola pedatifida*) and bird's-foot violet (*V. pedata*) are the most commonly utilized host plants in Iowa (Figure 1), and are primarily restricted to well-drained, drier soil in prairie habitat (Shirley 1994). Nectar preferences do not seem to be a limiting factor for the regal fritillary. They have been recorded nectaring on a variety of mid- to late-summer blooming flowers including dotted blazingstar (*Liatriis punctata*), thistles (*Cirsium* spp.), beebalm (*Monarda fistulosa*), and black Sampson (*Echinacea angustifolia*) (Kopper and others 2001, Mason 2001, personal observation).

Another apparent requirement for the regal fritillary is prairie size (Debinski and Kelly 1998, Zercher 2001). For example, managers at the Fort Indian-town Gap National Guard Training Center in central Pennsylvania suggest 257 acres (104 ha) as the minimum required area to sustain a viable population of regal fritillaries (Zercher 2001). Our research has shown that in Iowa, the largest populations of regal fritillaries are found exclusively on prairies exceeding 165 acres (67 ha) (Debinski and Kelly 1998 personal observation). We specu-



Figure 1. Bird's-foot violet (above) and prairie violet serve as the plant hosts for regal fritillary.

late that because of the large body size of the butterfly and the small biomass of its host plants, larger prairie areas may be required to provide sufficient host plant resources for a viable population.

Status

The regal fritillary has experienced a severe contraction across its entire range, with its disappearance in the eastern United States and Canada occurring mainly in the last 60 years (Hovanitz 1963, Opler and Krizek 1984, Scott 1986, Barton 1995, Gochfeld and Burger 1997, Wagner and others 1997, Zercher 2001). Their historic range once extended across at least 30 states and Canadian provinces, from New Brunswick south to northwestern North Carolina, and west to northeastern Colorado (Scott 1986, Opler and Krizek 1984, Hovanitz 1963, Mason 2001). Today, only two populations remain east of Illinois—one in Virginia and another in Pennsylvania (Swengel 1993, Wagner and others 1997, Zercher 2001). There are, however, several significant populations in each of the following states: Colorado, Kansas, western Missouri, Nebraska, North Dakota, and South Dakota (Mason 2001). In many of the other states where it is still present, such as Illinois, Iowa, Minnesota, northeastern Missouri and Wisconsin, regal fritillary occurrence is

local and rare (Debinski and Kelley 1998, Zercher 2001).

The regal fritillary was listed as a species of concern in Iowa (Iowa Administrative Code 2002) after being classified as threatened in Iowa by Schlicht and Orwig (1998). In 1995, Debinski and Kelly (1998) surveyed 52 Iowa prairies and found only 11 that hosted the regal fritillary; only seven of those contained more than 50 individuals. Despite these low population numbers, the regal fritillary is an ideal candidate for reintroduction because it is still abundant enough in some areas of Iowa to allow capture and transportation of individuals from extant populations.

Methods

Reintroduction Area

Neal Smith National Wildlife Refuge (NSNWR), which is located about 20 miles (32 km) east of Des Moines, Iowa, encompasses about 5,145 acres (2,083 ha), 3,088 acres (1,250 hectares) of which are former cropland that has been restored to tallgrass prairie (Figure 2A). Prior to restoration, a majority of the refuge property was in agricultural production, although a few small, scattered remnant prairie patches remained (Drobney 1994). Surveys prior to the refuge establishment in 1991 reported 51 species of butterflies,

apart in a 9-m by 11-m grid. All plots were located in the interior portion of the refuge (Figure 2B). Violet plots were surveyed for survivorship each spring from 1998 to 2002.

Regal Fritillary Introduction

Many butterfly reintroduction projects involve releasing larvae or adults that have been bred in the lab (Hammond and McCorkle 1991, Witkowski and others 1997, Nicholls and Pullin 2000). Others have introduced wild-caught adult butterflies with some success (Marttila and others 1997, Wynhoff 1998). Unfortunately, lab rearing of regal fritillaries is very difficult (Wagner and others 1997, personal observation) and, as a result, we decided to introduce wild-caught, gravid females.

The U.S. Fish & Wildlife Service, the agency in charge of the refuge, requires that all introduced organisms, including butterflies, be local ecotype species from a 38-county region of Iowa with similar vegetation, soil, and topography relative to the refuge (P. Drobney pers. comm.). The primary source population for regal fritillary females we introduced was Ringgold Wildlife Area, a 1,235-acre (500-ha) prairie within the local ecotype region for NSNWR (Figure 2A). Debinski and Kelly (1998) determined the population at Ringgold was relatively large, and subsequent surveys confirmed the presence of a thriving population. Our second source for regal fritillary females was Rolling Thunder State Preserve, a 291-acre (118-ha) prairie south of NSNWR (Figure 2A).

We transported the females to NSNWR in late July 2000 and mid-August to early September 2001. We removed only one in every ten females caught to minimize effects on the source populations. These gravid females were transported from the source to NSNWR within two hours of capture. All individuals were successfully transported inside a cooler in glassine envelopes to minimize overheating and maximize survival.

In 2000, we moved four females from Ringgold to NSNWR and individually placed them in small, 0.6-m by 0.6-m mesh cages directly over violet plots.

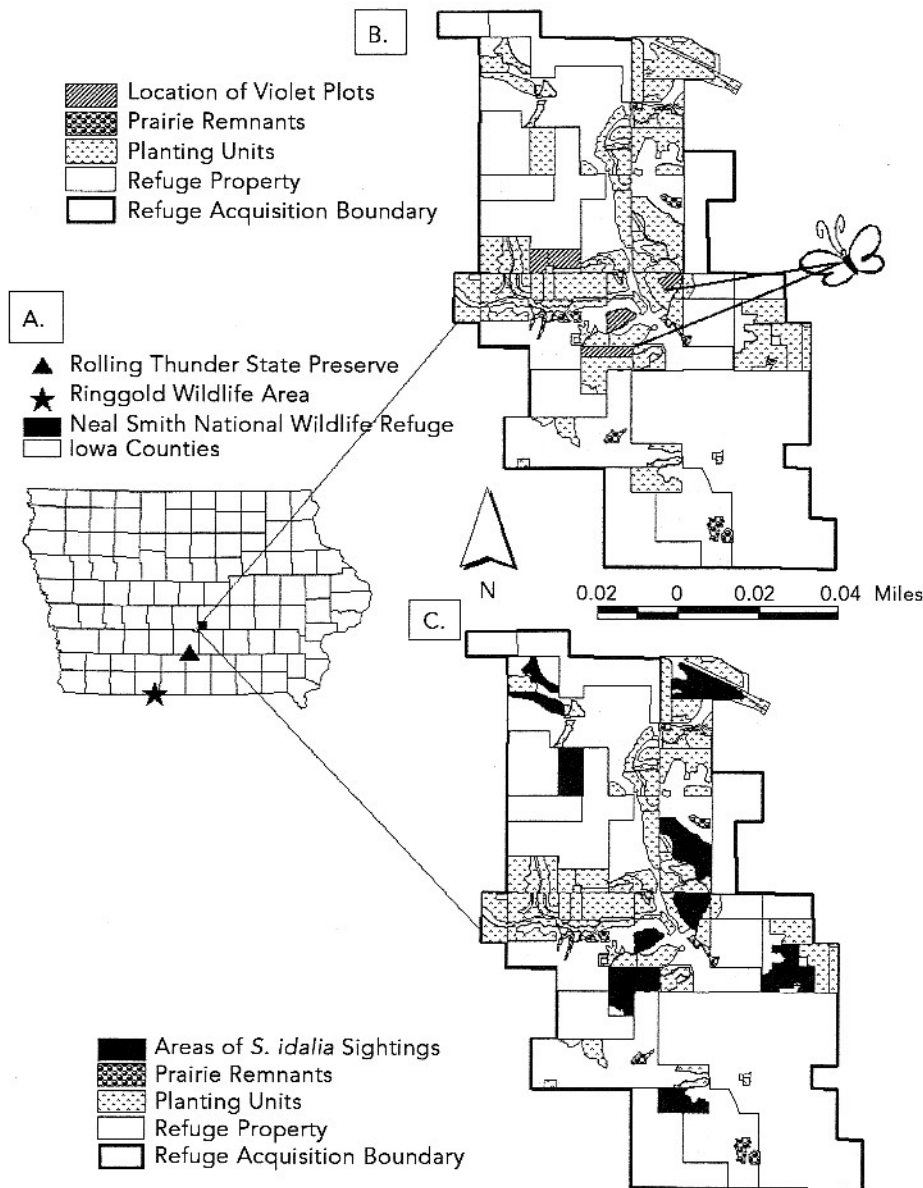


Figure 2. Maps showing the locations of regal fritillary (*Speyeria idalia*) source population and reintroduction locations in Iowa. Figure 2A: The primary source population was located at Ringgold Wildlife Area. A total of seven female regal fritillary were moved from Ringgold to Neal Smith National Wildlife Refuge (NSNWR). The secondary source population was located at Rolling Thunder State Preserve. One female regal fritillary was moved from this location to NSNWR. Figure 2B: Map of NSNWR showing the location of remnants, violet plots, and regal fritillary reintroduction areas in the summer of 2000 and 2001. Figure 2C: Map of NSNWR showing locations on the refuge where regal fritillary were observed in the summer of 2002.

but no regal fritillary (Klaas and Bishop 1995). However, within 15 miles (24 km) of the refuge, there are two native prairie sites of about 124 acres (50 ha)—Kish-Ke-Kosh State Preserve and an adjacent privately owned prairie—that support small populations of regal fritillary.

Host Plant Establishment

In 1998 and 1999, a total of 1,980 local ecotype prairie violet plants were planted at NSNWR. Violets were planted in four planting units, each with five plots. Each plot contained 99 violets planted 1 m

Every day, the reintroduced females were provided with nectar from the cut flowers of species that were in bloom, such as beebalm (*Monarda didyma*) and thistles. Females and cages were also moved daily to new violet plants to maximize the distribution of eggs. Survivorship of the females ranged from 3-19 days (normal survivorship after egg deposition is unknown).

In 2001, we shifted the date of introduction to mid-August/early September (August 19 and September 1) to more closely coincide with oviposition. We transported two females from Ringgold and one from Rolling Thunder to two violet plots at NSNWR in the same manner as 2000. Instead of small cages, we placed these butterflies in larger, 1.83-m by 1.83-m cages that covered several violet plants (Figure 3). Survivorship ranged from 16 to 20 days.

Regal Fritillary Survey Methods and Techniques

In the spring of 2001 and 2002, we surveyed caged violet plants for larvae and evidence of herbivory. We surveyed for adult regal fritillaries at NSNWR beginning in mid-June, focusing our efforts on the planting units where introductions were conducted. In 2002, when adult regal fritillaries were observed at the refuge, we initiated a mark-release-recapture program to estimate population size. On July 23 through July 25, July 28 and July 29, August 1 and August 7, two people, walking steadily 10 meters apart for 40 minutes, surveyed each of the three units where regal fritillaries were most abundant. They marked butterflies on the wings with a unique pattern using a felt tip marker (Opler and Krizek 1984) and immediately released them after recording the gender, activity, amount of wing wear, and UTM (Universal Transverse Mercator) coordinates (Figure 4). Surveys were only conducted on warm sunny, calm days between 9:30 in the morning and 4:30 in the afternoon. The surveyors used a stopwatch to keep track of time. They turned it off while processing regal fritillaries.



Figure 3. Co-author Stephanie Shepherd in one of the larger regal fritillary cages.

Results Host Plant Establishment

Total violet survival for 2002 was 72.9 percent with a range from 55 to 92.3 percent. Nine new violet plants were recorded within and adjacent to the plots, indicating that the violets were spreading. Violets persisted well after 2002, but we did not collect detailed survival data after that year.

Regal Fritillary Reintroduction

We found no larvae in the violet plots, although that is not surprising because regal fritillary larvae are notoriously challenging to observe in the field. Some herbivory of violet plants was noted, but we were unable to identify the herbivore. No adult regal fritillaries were observed in 2001. The following year, we observed the first regal fritillary at NSNWR on July 5 and then observed 83 other individuals during seven days in late July and early August (Table 1, Figure 2C). Fourteen individual regal fritillaries—all males—were caught, marked, and released in three planting units (Table 1). There were also 64 sightings of uncaptured individuals in the three planting units used for the

mark-release-recapture study. We did not confirm the presence of a female regal fritillary, although two individuals observed near violet plots on August 25 were probably female given the late date of observation and the likelihood that most males were no longer alive (Kopper and others 2001, Zercher 2001).

During 2003-2004, our surveys were not as extensive. In 2003, on July 14 and 17, we surveyed two violet plots and two other areas on the refuge where the species had been seen in 2002. We observed 11 regal fritillaries in two violet planting areas and two other sites on the refuge. We did not confirm the presence of females at the refuge because many of the butterflies were not netted or seen closely enough to identify their gender. In 2004, the first regal fritillary of the season was observed on June 24. On July 7, we surveyed our plots and captured 12 regal fritillaries, including one female. Regal fritillaries were observed in three of the four violet planting areas and in one area that had not been planted, where they had been seen in 2003. From June 25 to July 26 of that year, Robert Woodward, an entomologist examining seed production plots, observed regal fritillaries on 15 different dates. His counts ranged from 1 to

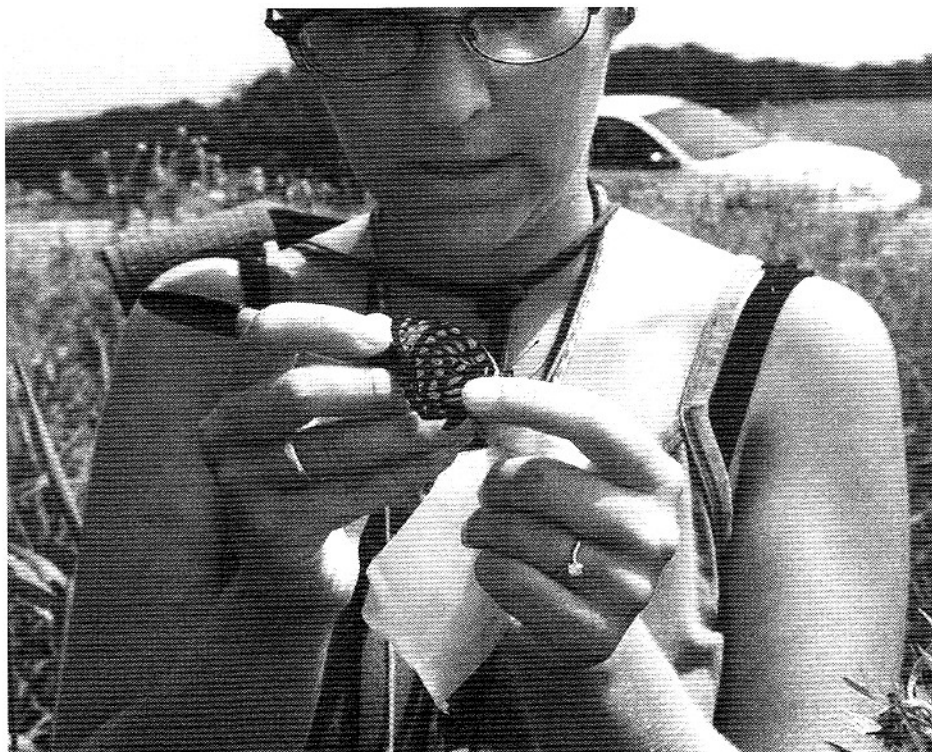


Figure 4. Summer 2002. Jessica Skibbe marking the first regal fritillary caught at Neal Smith National Wildlife Refuge, following reintroduction of the habitat-limited butterfly species in 2000.

23 individuals, with an average of 7.6 regal fritillaries sighted per day.

Frequent sightings at NSNWR for three subsequent years indicate that a regal fritillary population has been established. Whether this population will persist and increase in number remains to be seen, but it is clear that the butterfly is able to successfully use the restored prairie habitat.

Discussion

We encountered several obstacles during the course of this reintroduction experiment. The first problem was the inability to rear individual regal fritillaries for release and the problems associated with transporting wild-caught butterflies. Other studies have transported wild-caught adults (Marttila and others 1997, Wynhoff 1998), but this procedure makes some assumptions. If moving wild-caught males and females, one must assume they will mate when released. If only females are moved, as we did, one assumes that the butterflies will have mated soon after emergence at the capture site and that the females will be gravid. Then, it becomes a

matter of scheduling their release at the reintroduction site to maximize survival until oviposition. Introducing large numbers of individuals can compensate for the uncertainties involved with transporting wild-caught adults as well as complications associated with the loss of genetic diversity, such as inbreeding (Barascud and others 1999). However, for the regal fritillary, large-scale introduction presents some formidable barriers.

One primary difficulty is that females tend to be less numerous than males

and/or more difficult to find and catch, especially in Iowa (Nagel and others 1991, Kelly and Debinski 1998, Kopper and others 2001). In intensive surveys of eight sites in Iowa, Kelly and Debinski (1998) found only 31 females but 479 males. In the same study, surveys on prairies in Kansas and South Dakota produced higher numbers of females (210 and 296, respectively) than males (150 and 126, respectively). These biased gender ratios continued to plague us during the course of several years, suggesting that the low number of females found in Iowa prairies was not due to sampling too early.

Modern standards for restoration using local ecotypes can also present challenges in finding enough individuals to serve as colonists. We did not collect females outside of Iowa because of U.S. Fish & Wildlife ecotype regulations. The local ecotype concept is an enormously important development in restoration ecology and was established to prevent haphazard mixing of different locally adapted gene complexes, but it severely limited the numbers of individuals we could move each year. Therefore, we modified our goal by extending the number of years we expected to continue the reintroductions. We felt this plan also served to encourage a genetically and numerically robust population at the refuge without compromising donor populations.

The appearance of regal fritillaries at the refuge and on other unexpected sites during 2002 changed our plans, yet again, and made assessment of our reintroduction success more challenging. In 2002, we observed regal fritillaries at 14 of 24

Table 1. Data from a mark-release-recapture study of regal fritillary at Neal Smith National Wildlife Refuge. Surveys were performed at three sites on the refuge where regal fritillary appeared most abundant on sunny, calm days. Data were collected on seven days in late July and early August 2002. Numbers of regal fritillary seen and marked at other locations on the refuge are also reported. Numbers are the total across all sampling days.

Site	Observed	Captured and Marked	Recaptured
Planting Unit 21	22	5	0
Flaherty	23	6	0
Planting Unit 25	19	3	2*
Other sites	20	3	0
TOTAL	84	17	2

* Both recaptures were of the same individual.

other sites within a 75-mile (120-km) radius of the refuge. Five of these were restored cropland sites where regal fritillaries had not previously been seen, and four did not support populations of either prairie violet or bird's-foot violet. Prior to this time (1995-2001), we had never observed regal fritillaries on what might be considered "poor quality" habitat. It is not clear whether these immigrants came from the refuge or from other prairies in the area. However, given the large numbers of regal fritillaries observed at NSNWR, we decided that there was no need to continue our reintroduction efforts there.

One explanation for the appearance of regal fritillaries at NSNWR is that they dispersed from other prairies, although the closest known population is 13 miles (8 km) away. While this may be the case, the fact remains that the regal fritillary's dispersal abilities are not fully understood. For example, Ries and Debinski (2001) found that, in Iowa, regal fritillaries were reluctant to disperse out of a prairie across tree, crop, and field edges. On the other hand, Zercher (2001) reports that surveys at Fort Indiantown Gap National Guard Training Center indicate that regal fritillaries are capable of dispersing up to 6 miles (9.7 km) in two hours across inhospitable habitat. The majority of the dispersing individuals in this case were males. Zercher (2001) feels that the most plausible explanation for regal fritillary dispersal is to search for nectar resources. However, despite our observations in 2004, long-distance dispersal appears to be rather rare.

Lessons Learned

In conclusion, our regal fritillary reintroduction project points to the importance of having detailed information about the demography, habitat requirements, and dispersal abilities of Lepidoptera species. The problems associated with the regal fritillary's poor ability to reproduce in captivity and the difficulty we have in Iowa of locating abundant females emphasized that species constraints can profoundly affect the length of a reintroduction effort. We have learned that it is not safe to assume

introductions of insects will be on a shorter time scale than large animals with longer generation times, simply because insects generally reproduce more quickly.

We also learned that monitoring may be more important than ever. Our surveys of regal fritillary populations surrounding the reintroduction area were extremely helpful in understanding population dynamics and habitat use of the species. If we had not been surveying several other prairies in the vicinity several years before and after the reintroduction, we may have assumed the reintroduction success was entirely due to our efforts. Although our reintroductions may be the source of regal fritillary populations at NSNWR, we will never know this for sure. Long-term data were also instrumental in highlighting how rare events may allow this species to maintain itself.

This article details some of the problems we encountered in this butterfly reintroduction project, but more importantly our findings suggest that restored croplands may provide critical habitat linkages for connecting and enhancing populations of rare prairie species, such as regal fritillary.

ACKNOWLEDGMENTS

We would first like to thank Pauline Drobney, Nancy Gilbertson, and all the staff at Neal Smith National Wildlife Refuge for being very supportive of this project. In addition, thanks to Mel Moe and the Warren County Conservation Board for allowing us to remove regal fritillary females from Ringgold Wildlife Area and Rolling Thunder State Preserve. Iowa State's E.L.V.I.S. lab group and the members of GREBE provided many helpful thoughts and ideas. We are indebted to Amanda Hetrick for comments on this manuscript. Finally, thanks to the numerous volunteers, and Sarah Franklin, Jessica Skibbe, and Amanda Hetrick for their assistance in the field. The Iowa Department of Natural Resources, the United States Fish & Wildlife Service, and the National Fish and Wildlife Foundation provided funding for this project.

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