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Decline of Iowa Populations of the Regal Fritillary (*Speyeria idalia*) Drury

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The Regal Fritillary butterfly, *Speyeria idalia* Drury (Lepidoptera: Nymphalidae, Argynninae), is a prairie endemic species which has exhibited a dramatic decline in Iowa during the last few decades. Tallgrass prairie is the primary habitat of *S. idalia* and the butterfly's presence is correlated with the presence of violets (*Violaceae*). Due to the extensive habitat fragmentation of Iowa prairies, both the butterfly and its host plant populations are limited primarily to unplowed, relatively pristine prairies. Thus, *S. idalia* is an excellent case study of a prairie endemic species. Here, we report on the results of a two-year survey of the insect and its host plants in Iowa. During 1995, we conducted extensive surveys of 52 prairies in southern Iowa and found *S. idalia* in 11 of those prairies. During 1996, we conducted more intensive surveys comparing eight Iowa prairies to prairies in Kansas, South Dakota, and North Dakota to examine the hypothesis that larval host plant limitation may be causing the decline of *S. idalia.* Our data show that Iowa prairies have lower hostplant availability and also have lower butterfly weights. We discuss the future prospects for the species and suggest various management scenarios that might aid in preserving the butterfly.

INDEX DESCRIPTORS: *Speyeria idalia,* butterfly, *Violaceae,* prairie, habitat fragmentation, extirpation

HISTORICAL PERSPECTIVE

Tallgrass prairies in the U.S. exemplify one of the most highly fragmented natural areas, with 1–12% of their original area remaining (Sampson and Knopf 1994). In Iowa, less than 0.02% of these habitats remain intact (Smith 1981). One of the most visible components of prairie biodiversity is the butterfly community, and the Regal Fritillary (*Speyeria idalia* Drury Lepidoptera: Nymphalidae, Argynninae) might well be considered a symbol of prairie endemic insects. Tallgrass prairie is the primary habitat of *S. idalia* (Hammond and McCorkle 1983, Opler and Krizek 1984, Schull 1987) and the butterfly's presence is correlated with the presence of violets (*Violaceae*). *S. idalia*'s larval host plants include *Viola pedata* (Bird's-foot Violet), *V. pedatifida* (Blue Prairie Violet), *V. papilionacea* (Common Blue Violet), *V. lanceolata* (Lance-leafed Violet) and *V. nuttallii* (Nuttall's Violet) (Schull 1987, Opler and Krizek 1984). Regions in Iowa where *S. idalia* is most abundant contain largely *V. pedatifida.* With the disappearance of prairie habitat, widespread populations of *S. idalia* also have declined in numbers and distribution. This trend is especially pronounced in Iowa due to the intensity of agriculture. Larger populations of *S. idalia* can be found in Great Plains states that have larger prairies remaining.

Historic records of the species in Iowa date back to Scudder's surveys in 1869. Records from 1869 to the present reveal that the species was known to occur in at least 51 of the 98 Iowa counties (Schlicht pers. com.). It may have been even more common. Population estimates of this insect in Iowa and across the nation have declined sharply over the last 50 years, primarily due to plowing of the remaining prairies. *S. idalia* was listed as a Category II species under the Endangered Species Act until 1996, when this category of protection was deleted by the U.S. federal government (USFWS 1996). Category II species were candidates for listing, but there was not sufficient knowledge regarding their status to warrant proposing them for listing as endangered or threatened. *S. idalia* currently is listed as a species of special concern in Iowa and in other prairie states (J. Fleckenstein, pers. com.).

METHODS

In 1995, we conducted an extensive survey of *S. idalia* and *V. pedatifida* populations in southern Iowa (Fig. 1). Using knowledge of the species' historic distribution and information regarding potential habitats remaining in southern Iowa, we surveyed 52 prairies. The butterfly was surveyed using standard mark-recapture techniques (Pollard 1977) and Lincoln-Peterson calculations (Davis and Winstead 1980). The violets were surveyed for presence/absence in all prairies, and *V. pedatifida* density was examined relative to prairie management history on 29 of the 52 prairies. In 1996, we conducted more intensive surveys of *S. idalia* populations and *V. pedatifida* densities, focusing on eight of the Iowa prairies that had large *S. idalia* populations and comparing these prairies to prairies in Kansas, Nebraska, and North and South Dakota.

In 1995, our *V. pedatifida* searches lasted for a minimum of 30 min, unless the habitat was obviously poor quality [e.g., solid *Panicum virgatum* (switchgrass), *Bromus* spp. (brome), etc.]. The densest patches of *V. pedatifida* were located at each prairie. A 10 x 10 m plot was centered in each of these areas, and three plots were surveyed in most prairies (except where prairie size limited sampling). *V. pedatifida* density was estimated by counting the number of plants (stems with a single root stalk) in every other square meter in each of 10 transects that made up the plot, and mean *V. pedatifida* density was calculated across all plots. To understand the effects of management on *V. pedatifida,* each prairie was ranked relative to the intensity at which it experienced a given land use (ranging from 0 to 3). Land use categories included mowing, burning, and grazing. Each prairie was also ranked according to its moisture level (dry, mesic, or wet).

In 1996, we examined the issue of host plant limitation more intensively by focusing our surveys on fewer, more high quality prairies (Fig. 2). We compared Iowa data on butterflies and host plants

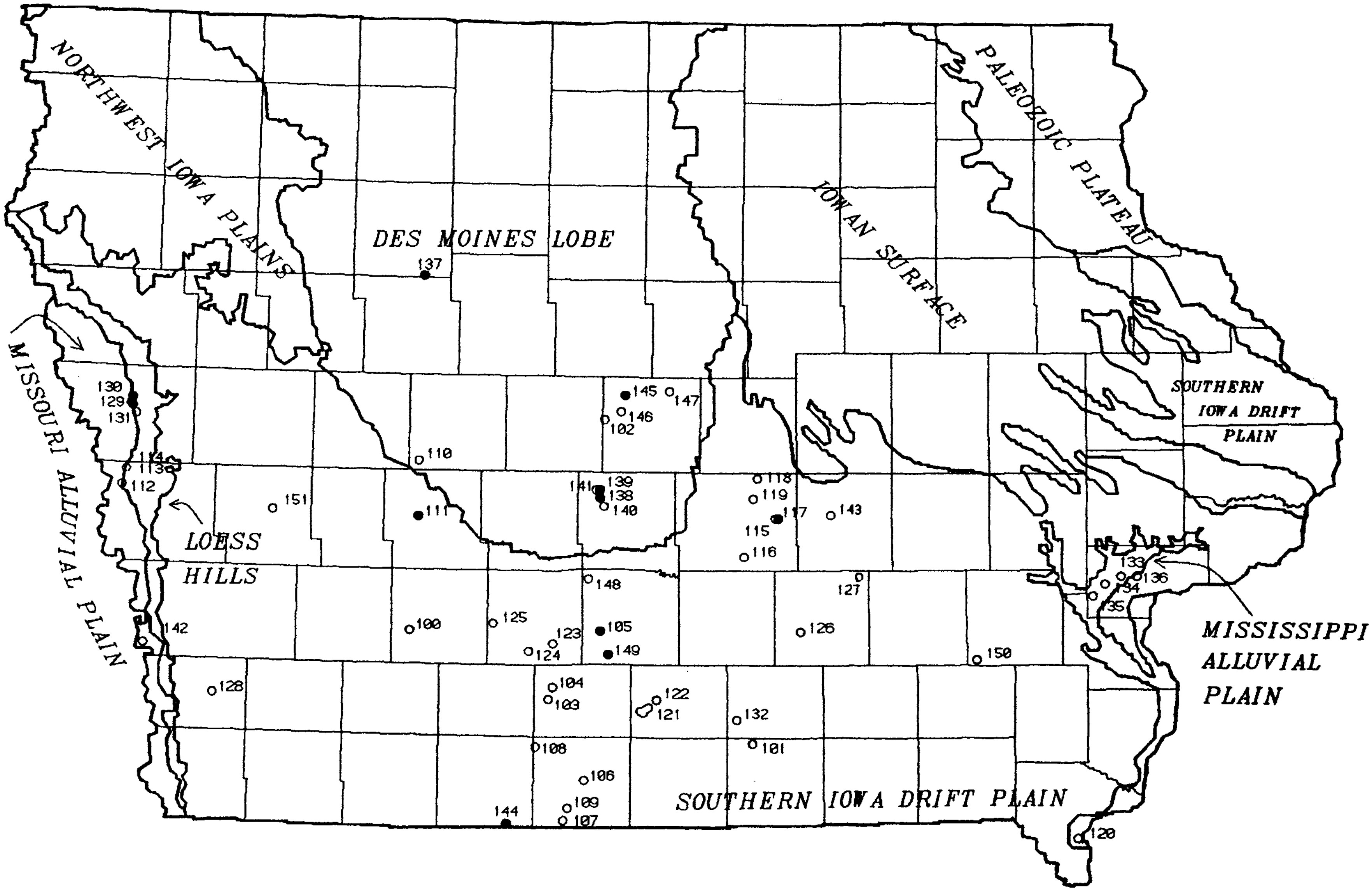

Fig. 1. Iowa prairies surveyed for *S. idalia* in 1995. Filled circles are sites where the species was found and open circles are sites where the species was not found. Site codes are as follows: 100: Adair Wildlife Area, 101: Honey Creek State Park, 102: Boone Railroad Prairie, 103: Troy Township Cemetery, 104: Flaherty Prairie, 105: Page Private Prairie, 106: Little River Recreation Area, 107: Nine Eagles State Park, 108: Sand Creek Wildlife Area, 109: Slip Bluff Park, 110: Howe Prairie, 111: Sheeder Prairie, 112: Gleason-Hubel Wildlife Area, 113: Pioneer State Forest, 114: Murray Hill Overlook, 115: Kellogg Wildlife Area, 116: Kish-ke-kosh State Preserve, 117: Reichelt Unit, 118: Potato Creek, 119: Morris Prairie, 120: Linger Longer Prairie, 121: Stephens State Forest, 122: Lucas Railroad Prairie, 123: Johnson Prairie, 124: Chris Cove Park, 125: Peebler Prairie, 126: Hull Wildlife Area, 127: Hawthorn Wildlife Area, 128: Wearin Prairie, 129: Loess Hills Wildlife Area, Section 21, 130: Loess Hills Wildlife Area, Section 9, 131: Loess Hills Wildlife Area, Section 34, 132: Melrose Cemetery, 133: Pike Run Wildlife Area, 134: Red Cedar Wildlife Area, 135: Highway 70 Prairie, 136: Shield Prairie, 137: Kalsow Prairie, 138: Polk City Cemetery, 139: Moekley Prairie, 140: Saylorville's Red Feather Prairie, 141: Big Creek Prairie, 142: Wabash Trace Railroad Trail, 143: Malcom Railroad Prairie, 144: Ringgold Wildlife Area, 145: Doolittle State Preserve, 146: Raymond-Rolling Prairie, 147: McCallsburg Railroad Prairie, 148: Cumming Railroad Prairie, 149: Rolling Thunder Prairie, 150: Lake Darling, 151: Denison Prairie.

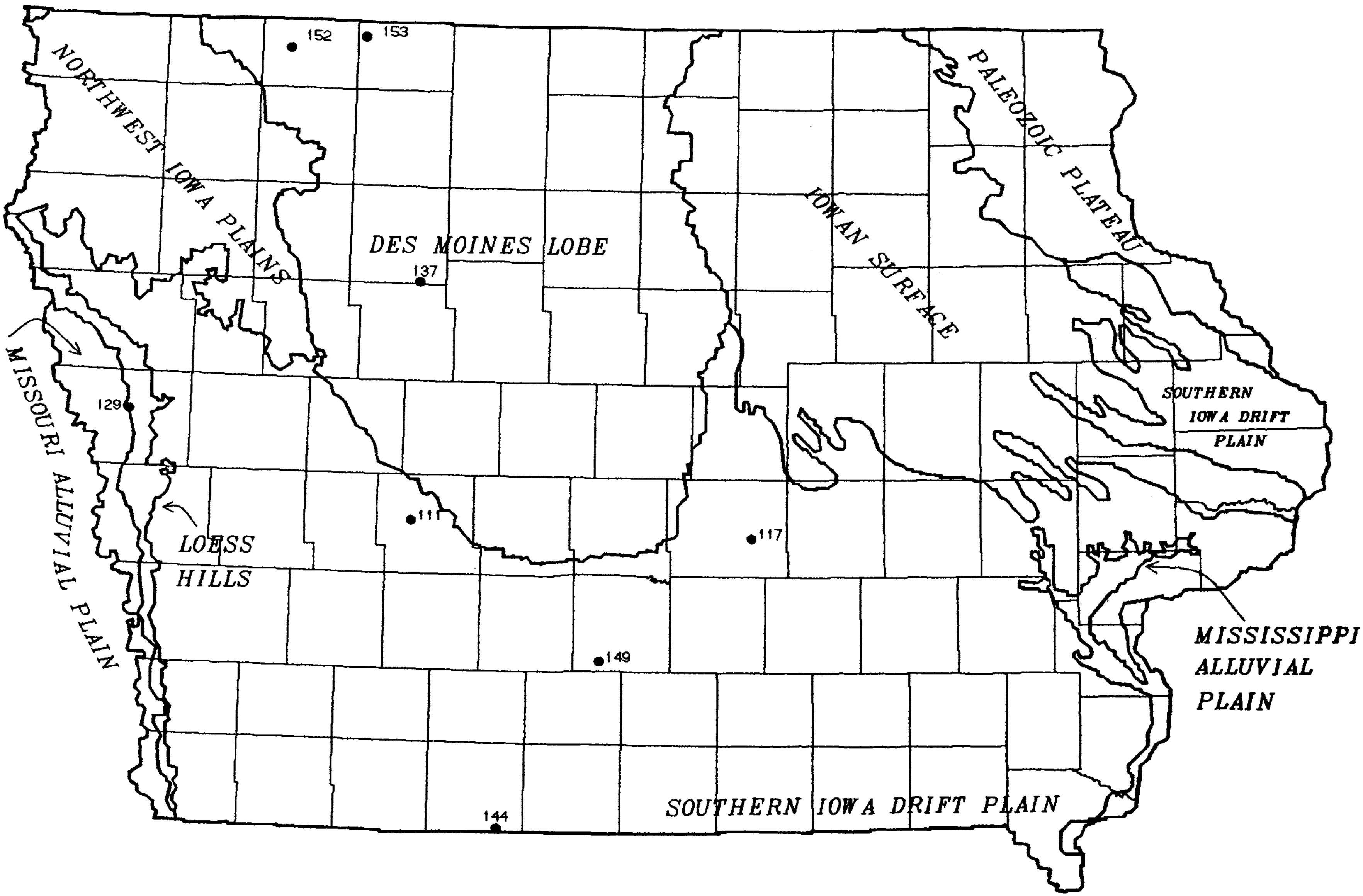

Fig. 2. Iowa prairies surveyed for *S. idalia* in 1996. The species was found in all sites and a more extensive survey of the butterfly and its host plant were conducted. Site codes are as follows: 111: Sheeder Prairie, 117: Reichelt Unit of Stephens State Forest, 129: Loess Hills Wildlife Area, Section 21, 137: Kalsow Prairie, 144: Ringgold Wildlife Area, 149: Rolling Thunder Prairie, 152: Cayler Prairie, 153: Anderson Prairie.

Table 1. *Speyeria idalia* population size estimates in 1995.

PRAIRIE NAME	POPULATION ESTIMATE	METHOD
Page Private Prairie	2	individuals observed
Sheeder Prairie	50	mark-recapture
Reichelt Unit of Stephens State Forest	4	individuals observed
Polk City Prairie	1	individuals observed
Moeckley Prairie	220	mark-recapture
Ringgold Wildlife Area	7	individuals observed
Doolittle Prairie	2	individuals observed
Rolling Thunder Prairie	120	mark-recapture
Kalsow Prairie	500	visual estimate[1]
Loess Hills Wildlife Area sect. 9	160	mark-recapture
Loess Hills Wildlife Area sect. 21	2	individuals observed

[1]P. C. Hammond's estimate

with data from Kansas, South Dakota, and North Dakota prairies, where host plant abundance is greater. We surveyed five plots, rather than three plots for violets, and included *V. pedatifida* as well as other *Viola* species because *V. nuttallii* is much more common as a host plant in the Dakotas. In addition, we measured the size and weight of *S. idalia* butterflies in Iowa prairies and compared these values to violet density (for details, see Kelly 1997).

RESULTS AND DISCUSSION

In 1995, *S. idalia* was found in 11 out of the 52 prairies (Fig. 1), but only five prairies had a population over 50 individuals (Table 1). We found *S. idalia* only on sites where *V. pedatifida* were found, and population sizes of the insect seemed correlated with the violet biomass. *V. pedatifida* was found in 18 prairies. We were able to obtain information regarding management history on 29 of the 52 prairies, and this included 16 of the 18 prairies with *V. pedatifida* (Table 2). No *V. pedatifida* were found in any of the areas that had been plowed. These data support the assumption that plowing has a negative impact on *V. pedatifida*. Interestingly, violet densities were highest in moderately grazed and recently burned prairies, and the correlation between violet density and grazing intensity was significant (Spearman rank correlation = 0.43, P = 0.02). Grazing and burning probably release the plant from competition with many of the tallgrass species, offering it an opportunity to flourish. Moisture and violet density were negatively correlated (Spearman rank correlation = −0.43, P = 0.06), which is not surprising, given that the plants are usually found on dry hillsides. There was no significant correlation between mowing or burning and violet density.

V. pedatifida densities on Iowa prairies were not very high, averaging 1.85 plants/m^2 in 1995 (Table 2). In contrast, *V. papilionacea* can be found in densities of up to 20 stems/m^2 in Iowa forests (Kelly and Debinski, unpublished data). *Speyeria cybele*, a woodland butterfly species whose larvae feed on *V. papilionacea*, is found throughout Iowa. Given the fact that both *S. idalia* and *S. cybele* are large insects and consume a large biomass of violet leaves during the larval stage, a tenfold difference in host plant abundance could explain the relative rarity of *S. idalia* on Iowa prairies as compared to the abundance of *S. cybele*.

Our investigation of hostplant availability relative to *S. idalia* population size provided mixed results. In 1996, we found that North and South Dakota and Kansas had much larger violet populations (Table 3). However, there was not a clear relationship between violet population size and *S. idalia* population size. Iowa prairies showed lower *S. idalia* population sizes and violet densities than the Dakotas. However, the Kansas populations of *S. idalia* were actually lower than the Iowa average, despite having a hostplant population that was six times larger.

Examining the hostplant limitation hypothesis from the perspective of insect weight provided support to our hypothesis. Iowa butterflies had statistically significant lower weights among both males and females, in contrast to the prairies we surveyed in Kansas, North Dakota, and South Dakota (Kelly 1997). Another striking result of these surveys was that we found adult sex ratios were almost 10 males to 1 female in Iowa prairies, whereas in other states the sex ratio was barely skewed. Because males emerge before females in this species (Opler and Krizek 1984), if males consume larval hostplant resources faster than females, females may lack sufficient resources to finish their larval stage. This may explain why the Iowa populations we observed had so few females. It may also be an important clue as to why Iowa *S. idalia* populations are declining. If prairie size limits the total violet biomass available, larval males may use up the resource in small prairies. Male populations of *S. idalia* were correlated (but not significantly) to area of habitat surveyed (r^2 = 0.75, P = 0.17, df = 11). Thus, there may be a prairie size threshold below which the populations are at a high risk of extirpation due to demographic problems precipitated by host plant limitation (e.g., Gilpin and Soule 1986).

FUTURE POSSIBILITIES AND POTENTIAL: CORRIDORS AND RESTORATION

Butterflies such as *S. idalia* are keenly affected by landscape patchiness and therefore provide a useful model system for examining the effects of prairie fragmentation in Iowa. Mechanisms resulting in such sensitivity include host plant specificity, physiological constraints, limited dispersal abilities of larvae, predator avoidance (Wood and Samways 1991, Litsinger et al. 1991, Thomas and Harrison 1992, Thomas et al. 1992, Rodrigues et al. 1993, Rodrigues et al. 1994), and even avoidance of crossing a prairie edge to move into a new habitat type (Ries and Debinski, unpublished data). These behavioral mechanisms lead to differential use and differing population sizes on prairie remnants. Subtle implications of these differences may even include effects on plant community dynamics such as altered herbivore loads, or changes in pollination (Hendrix, pers. comm.).

Although *S. idalia* is at less of a risk of extirpation across the entire Great Plains, our surveys of population sizes of the insect in Iowa during 1995 and 1996 suggest that it is at risk of extirpation in Iowa. Hammond and McCorkle (1983) attribute the decline of a number of *Speyeria* populations to the extent of environmental disturbances caused by humans. In Iowa prairies, the erratic distribution

Table 2. A synopsis of land use history and prairie characteristics of 29 Iowa prairies. Prairie violet density was calculated by averaging all plots from a prairie site. The number of plots taken from a site varied from 1 to 5 depending on the size of the prairie. Information on the soil moisture of the prairies was obtained from the Iowa Department of Natural Resources.

SITE NAME	AVERAGE VIOLET DENSITY ($\#/m^2$)	GRAZING	MOWING	BURNING	SOIL MOISTURE
Boone Railroad	0	none	none	accidental distant past	mesic
Little River Recreation	0	infrequent distant past	none	infrequent	mesic
9 Eagles State Park	0	distant past	none	infrequent	dry
Howe Prairie	1.9	intensive	none	none	dry
Sheeder Prairie	0.8	none	annual until 1965	once every three years	mesic
Gleason-Hubel	0	none	none	infrequent	dry
Pioneer State Forest	0	none	none	once every three years	dry
Murray Hill Overlook	0	infrequent distant past	none	infrequent	dry
Kellogg Wildlife	0	none	none	none	mesic
Kish-kekosh Prairie	6.7	lightly before 1976	none	once every four years	dry
Reichelt Unit Prairie	2.0	moderate in past	none	once (1994)	dry
Potato Creek Prairie	0	moderate to intensive	moderate	once every 5(+) years	mesic
Morris Prairie	0.1	none	none	once every 3–4 years	mesic
Hull Wildlife	0	none	none	none	mesic
Hawthorne Wildlife	4.5	none	none	once every five years	mesic
Loess hills Wildlife - 9	2.9	intensive	none	infrequent distant past	dry
Loess hills Wildlife-21	1.6	moderate in past	none	once every five years	dry
Loess hills Wildlife-34	0.1	none	none	infrequent distant past	dry
Polk City Cemetary	0.1	none	none	once every three years	dry
Moeckley Prairie	0.7	none	annual before 1987	once	wet
Saylorville Prairie	0	none	none	once every five years	wet
Big Creek Prairie	0	none	moderate in past	once every three years	mesic
Wabash Trace Trail	0	none	none	accidental distant past	mesic
Ringgold Wildlife	0.5	moderate	none	once every five years	dry
Doolittle Prairie	0.1	moderate	moderate	once every four years	wet
Raymond/Rolling	4.6	light	none	once every five years	dry
McCallsburg Railroad	0	none	none	once every 3–5 years	mesic
Cummings Railroad	1.1	none	none	once every 2–3 years	mesic
Rolling Thunder	1.9	intensive distant past	none	once every 3–4 years	dry

Note: Page Private Prairie and Kalsow Prairie are not included in the land use history survey, but they did have *V. pedatifida* present in 1995.

Table 3. *Speyeria idalia* population size estimates relative to violet densities in Iowa prairies as compared to North and South Dakota and Kansas Prairies in 1996.

	SURVEY LOCATIONS	HECTARES SURVEYED	VIOLET POPULATION ESTIMATE	VIOLET DENSITY PLANTS/m2	S. IDALIA 1996 POP. ESTIMATE	INSECT DENSITY EST. (INSECTS/HA)
Iowa	Loess Hills, Section 21	20.2	67,500	3,342	175	8.7
	Sheeder Prairie	10.1	22,600	2, 238	163	16.1
	Stephens State Forest	8.1	13,500	1,667	21	2.6
	Ringgold Wildlife Area	64.8	86,000	1,327	270	4.2
	Cayler State Preserve	64.8	57,500	887	319	4.9
	Anderson State Preserve	64.8	57,400	886	494	7.6
	Kalsow State Preserve	64.8	136,000	2,099	224	3.5
	Rolling Thunder	49.8	423,000	8,494	60	1.2
Iowa means	n = 8	43.4	107,938	2,617	216	6.1
Dakota means (North and South)	n = 6	64.8	1,086,500	16,767	431	6.7
Kansas means	n = 2	35.9	622,150	12,469	98	14.2

as well as low abundance of *V. pedatifida* is probably responsible for the small *S. idalia* populations. The primary cause of the restricted distribution of *V. pedatifida* in Iowa prairies is plowing. Plowing has caused serious fragmentation of prairie habitats, leaving *S. idalia* populations highly isolated. Grazing could actually have a positive, albeit indirect, effect on *S. idalia* populations via the effects on *V. pedatifida*. However, the intensity of the grazing would definitely have to be moderate. We cannot speculate here about effects of fire on *S. idalia,* but this is a research area that warrants further attention.

In the context of prairie management, many of the sites we surveyed in Iowa also had extensive areas of invasive brome with few if any violets. *S. idalia* adults often patrol these areas and feed at the nectar sources present in them. Such areas with no violets may be detrimental to female fecundity [i.e., sink populations (Pulliam 1988)] if adult females spend significant time searching there in vain for areas with host plants where they could deposit eggs.

In Iowa, we face three challenges in conserving this species. First, how do we manage and preserve the areas where the insect is consistently found? Second, how do we reconnect fragmented prairie remnants, and third, how do we enhance potential habitat for the insect where it once was found and/or could be reintroduced? In order to preserve the current populations of *S. idalia* in Iowa prairies, disturbances such as plowing and spraying on native prairies should be proscribed. Plowing destroys the root mass of violets, and additionally, *V. pedatifida* is a species that does not propagate well by seed (Debinski and Kelly, unpublished data). Unnecessary collecting of insects (especially females) should also be discouraged, since we found only 31 female insects across eight of the largest populations in the state in 1996.

There may be the potential to re-connect some prairie habitats through the use of corridors. One example of a possible corridor for *S. idalia* adults may be roadside planting of native prairie forbs and grasses. These roadsides could serve as important nectar sources and potentially aid in linking isolated prairie remnants. However, roadside plantings will probably never serve as good larval habitat due to the difficulty of establishing host plant populations from seed. Restoration of large prairies, such as the project at Walnut Creek National Wildlife Refuge, offers some hope for *S. idalia,* but in order to establish a viable population, a large amount of financial and human resources would need to be committed to restore tens of acres of the violet host plants. It is undeniably a difficult undertaking to transplant and physically improve prairie habitat, but we (the authors) have participated in this effort, and have seen some grasslands improve in quality.

Finally, we need to assess the extent of decline as well as the reasons why *S. idalia* populations are disappearing in our prairies. We should monitor larger areas to determine possible reasons for population fluctuations of this species and initiate a citizen-based monitoring effort. Some of the larger areas that should be monitored include Ringgold Wildlife Area, in Ringgold County, Steele Prairie, in Cherokee County, and Stephens State Forest (Reichelt Unit), in Jasper County. In Ringgold Wildlife Area, there are over 1,200 acres of wildflowers to support adult insects with nectar plants, but there is only a very small *V. pedatifida* population, since much of the area was once plowed or otherwise disturbed. For this reason, the Ringgold Wildlife Area could be a good candidate for restoring violet populations. In the Reichelt Unit of Stephens State Forest, the situation is the opposite: there is quite a large population of *V. pedatifida,* but few nectar sources to maintain adult insects at that site. It is puzzling to us that a large resource base of violets (hundreds of thousands of plants) would not result in populations of adult insects larger than the 50 or so that we estimated in 1995 and 1996. In Steele Prairie, a state preserve, previous state records indicate that hundreds of insects were found regularly in the 1980s, but during the last season we surveyed (1996), we found only a few insects despite extensive violet coverage. These interesting survey results continue to demand the attention of conservationists in Iowa. We hope to initiate a program in the near future to ask outdoor enthusiasts to report when and where they find *S. idalia.* This would aid in cultivating local appreciation of rare Iowa wildlife and it would provide a much more extensive database from which to evaluate the status of *S. idalia* in the next decade.

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