

Butterflies (Lepidoptera) on Hill Prairies of Allamakee County, Iowa: A Comparison of the Late 1980s With 2013

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Abstract

In the late 1980s, several hundred butterflies were collected by John Nehnevaj from hill prairies and a fen in Allamakee County, Iowa. Nehnevaj's collection included 69 species, 14 of which are currently listed in Iowa as species of greatest conservation need (SGCN). The goal of this study was to revisit sites surveyed in the 1980s and survey three additional sites to compare the species present in 2013 to the species found by Nehnevaj. A primary objective was to document the presence of rare prairie specialist butterflies (Lepidoptera), specifically the ottoe skipper (*Hesperia ottoe* W.H. Edwards; Hesperidae), which was thought to be extirpated from Iowa. Twelve sites were surveyed 4 to 7 times between June and September 2013 using a meandering Pollard walk technique. A total of 2,860 butterflies representing 58 species were found; eight of these species were SGCN's, including the hickory hairstreak (*Satyrrium caryaevorum* McDunnough; Lycaenidae), and Leonard's skipper (*Hesperia leonardus* Harris; Hesperidae), species not collected in the 1980s, and the ottoe skipper and Baltimore checkerspot (*Euphydryas phaeton* Drury; Nymphalidae), both species also found by Nehnevaj. Species richness for the sites ranged from 14 to 33 species, with SGCNs found at 11 of the 12 sites. Significant landscape changes have occurred to hill prairies in Allamakee County over the past 25 years. Invasion by red cedar (*Juniperus virginiana*) has reduced hill prairie an average of 55.4% at these sites since the 1980s, but up to 100% on some of the sites surveyed by Nehnevaj. These changes in habitat may have contributed to the overall decrease in species richness. This study provides valuable information about the current status of butterflies present on northeastern Iowa hill prairies that can be used in directing future land management and conservation efforts.

Hill prairies are steep, south or southwest facing slopes in the Upper Midwest composed of native prairie plant species surrounded by woodland (Robertson et al. 1996, Iowa Association of Naturalists 2001). They are dry habitats with rocky outcrops, sandy soils, and generally shorter vegetation than their flatland tallgrass prairie counterparts, frequently exhibiting discontinuous sod (Vestal 1918, Robertson et al. 1996, Swengel and Swengel 2013). Hill prairies provide ideal habitat for some prairie-specialist butterfly species, as their steep slopes often remain untouched by human agricultural disturbance. Free from disturbance, these steep prairie refuges still host the native forbs and grasses required as host plants and nectar sources for specialist butterflies (Cross 2007).

Butterflies (Lepidoptera) are important members of the hill prairie ecosystem. They act as pollinators and are food for animals like birds that aid in the dispersal of prairie seeds (Davis et al. 2007, Davis et al. 2008). Butterflies also function well as bioindicators because they depend on a small range of resources throughout their life cycles (Schlicht and Orwig 1992). Butterflies commonly

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rely on a narrow range of larval host plants and as adults require a variety of forbs as nectar sources (Schlicht and Orwig 1992). This is particularly true of prairie specialist butterflies, such as many species of skippers (Hesperiidae). Larval host specificity demands that a strict set of conditions be present for a butterfly to occupy an area (Schlicht and Orwig 1992). A high diversity of butterfly species therefore indicates a healthy ecosystem capable of fulfilling the needs of a variety of species.

Hill prairies in Allamakee County, Iowa have been rapidly disappearing since the 1930s largely due to the rapid expansion of red cedar (*Juniperus virginiana*) and sumac (*Rhus* sp.). Photos taken in Allamakee County that were published in 1913 show wide expanses of hill prairie on many of Northeast Iowa's south and southwest facing slopes (Hancock 1913). Today, those same slopes exhibit only small hill prairie fragments or are entirely covered with woody species like red cedar. Historically, dry climate, grazing by large herds of bison (*Bison bison*) and other herbivores, and periodic fire are thought to have kept woody species from invading prairies (Stebbins 1981, Axelrod 1985). However, the absence of fire and large grazing herds has allowed *J. virginiana* to invade (Stebbins 1981, Axelrod 1985). In addition, Allamakee County hill prairies are currently imperiled by the threat of hydraulic fracturing (frac) sand mining in the area. Frac sand mining eliminates hill prairie habitat and has the potential to further fragment and degrade the surrounding habitat by introducing pollution, and causing erosion and sedimentation (Minnesota Environmental Quality Board 2013). Habitat fragmentation resulting from frac sand mining or expansion of *J. virginiana* can endanger butterfly populations by changing the prairie's microclimate (Karlsson and Van Dyck 2005). Rare butterflies are especially vulnerable to fragmentation (Summerville and Crist 2001).

Between 1986 and 1990, John Nehnevaj, a local butterfly enthusiast, collected over 345 butterflies representing 69 species from hill prairies and a fen in Allamakee County. Nehnevaj's collection included a number of rare butterfly species, 14 of which are currently listed as species of greatest conservation need (SGCN) by the Iowa Department of Natural Resources (IDNR) as part of its Wildlife Action Plan (IDNR 2007). Of particular interest, Nehnevaj's collection included 41 ottoe skippers (*Hesperia ottoe* W.H. Edwards; Hesperidae), a species listed as rare in Iowa, and recently declared as extirpated from the state (D. Schlicht personal communication). The goal of this study was to revisit many of the sites surveyed by Nehnevaj to determine which butterfly species could still be observed on those sites and in what abundance. A specific goal was to search for the ottoe skipper and other rare prairie-specialist species such as the SGCN species found by Nehnevaj. This information could be used to track population abundance over time, dictate site-specific management activities, and aid in choosing optimal sites for conservation.

According to Schlicht et al. (2007), 83 species of butterflies have been documented in Allamakee County over the past 34 years. A 1998 survey of neighboring Winneshiek County yielded 52 butterfly species, compared to 58 species present in a Winneshiek County collection from 90 years earlier in 1908 (Larsen and Bovee 2001). The 1908 collection contained 3 species on the current SGCN list, while the 1998 survey documented only two SGCN species (Larsen and Bovee 2001). Given the trend observed in Winneshiek County and predicted changes in habitat, we expected a decrease in the number of butterfly species in Allamakee County over the past 25 years.

Materials and Methods

Nehnevaj's 1980s collection. John Nehnevaj collected over 345 butterflies from 13 hill prairie sites and one fen in Allamakee County between 1986 and 1990. We surveyed nine of those sites in 2013 (Table 1). We were unable to survey the other five of Nehnevaj's sites in 2013 because four of those hill prairie sites were too covered by red cedars (three were 100% covered) to allow

Table 1. Sites in Allamakee County, Iowa surveyed for butterflies during the late 1980s, in 2013, or both, including geographic coordinates, length of survey transect, area surveyed, and habitat type within the transect. Sites partially or entirely managed by the Iowa DNR or INHF are marked with an asterisk (*), all other sites are on private property.

Site Name	Latitude	Longitude	Transect Length (meters)	Area Surveyed (acres)	Habitat
<i>1980s only sites:</i>					
Hwy 76 Waterloo Creek*	43°25.89'N	91°30.98'W	-	-	hill prairie
McLaughlin	43°25.23'N	91°13.31'W	-	-	hill prairie
Mt. Hosmer	43°21.96'N	91°32.52'W	-	-	hill prairie
Riverside Drive	43°25.63'N	91°31.20'W	-	-	hill prairie
Sunflower Drive	43°23.22'N	91°27.36'W	-	-	hill prairie
<i>2013 only sites:</i>					
Bear Creek Drive	43°25.94'N	91°31.63'W	1500	29	hill prairie, old field
Heritage Valley*	43°22.25'N	91°34.73'W	610	7.6	hill prairie
Prairie Song Farm	43°28.93'N	91°31.31'W	1100	17	riparian tallgrass prairie restoration
<i>1980s and 2013 sites:</i>					
Black Hawk Point*	43°27.59'N	91°17.85'W	1300	7.2	hill prairie, agricultural field, woods
Chimney Rock	43°28.05'N	91°19.50'W	850	7.8	hill prairie, woods
Clear Creek Fen*	43°26.94'N	91°25.20'W	1200	16	fen, old field
Honeywell	43°26.01'N	91°17.70'W	1000	7.7	hill prairie, woods
Potter's Prairie	43°28.95'N	91°24.74'W	550	3.5	hill prairie, woods
Solitaire Ridge East*	43°24.37'N	91°33.04'W	1100	13.6	hill prairie
Solitaire Ridge West*	43°24.39'N	91°33.83'W	1200	8.7	hill prairie, agricultural field, woods
Weymiller	43°27.26'N	91°18.21'W	1500	12	hill prairie, agricultural field
Zoll's Mountain	43°26.36'N	91°19.89'W	1700	7.7	hill prairie, agricultural field, woods

for surveys and a fifth (Mt. Hosmer) was not visited because it was simply too far out of the way for regular visits. Nehnevaj's collection included 69 species and was donated to Luther College in December 2012.

2013 Survey Sites. We surveyed twelve sites in 2013: eight hill prairies and Clear Creek Fen, which were visited by Nehnevaj, plus two other hill prairie sites in the area and a riparian tallgrass prairie restoration (Table 1). Sites varied in management history, quality of prairie, size, and steepness (Table 1). Five sites are currently owned and managed by the IDNR or the Iowa Natural Heritage Foundation (INHF), while the other seven sites are privately owned (Table 1).

2013 Survey Methods. Each site was surveyed by walking a meandering transect on a roughly biweekly basis from mid-June through September 2013 using a modified Pollard technique (Pollard 1975, Pollard 1977). Surveys occurred between 0930 and 1530 h CDT on days with winds less than 12.5 mph, temperatures between 20-31°C, and cloud coverage less than 90%. Walking pace was dictated by the difficulty of the terrain with the goal of maintaining a consistent pace throughout. All butterflies seen within a 10m distance of the observers were recorded. Two or three observers conducted each survey. Photographs were taken regularly for vouchering purposes and as aids in identification. Butterflies were identified on the wing or netted for closer examination and released if possible. Identification was made using Schlicht et al. (2007) or Glassberg (1999) and names standardized using Opler and Warren (2004). If species identity could not be confirmed in the field, voucher specimens were collected and identification verified in the lab. Collected voucher specimens are housed in the Research Insect Collection in the Hoslett Museum of Natural History, Luther College, Decorah, Iowa.

Overall butterfly abundance, species richness, and community diversity were calculated for each site. Community diversity was quantified for each site using the Shannon Diversity Index (H') and Peilou's Evenness Index (J') using log base 2 (Eckblad 1998). Survey time and number of observers were used to calculate butterflies observed per observer minute for each site to account for differences in survey time or number of observers present.

Aerial Photo Analyses. Aerial photos from the late 1980s and 2013 were analyzed to show how landscape changes in hill prairies in the last 25 years may have affected the diversity and abundance of butterflies found at each site. Aerial photos were downloaded from the Iowa Geographic Map server (<http://ortho.gis.iastate.edu>). Each hill prairie site's acreage in the 1980s and 2013 was determined using ArcMap10 (ESRI, Redlands, CA). Percent change in acreage was then calculated. Clusters of red cedar (*J. virginiana*) or sumac (*Rhus* sp.) present within the prairie interior were included in the total prairie area as long as they were scattered and ground was visible around the individual trees.

Results

Between 1986 and 1990, John Nehnevaj collected 345 butterflies from 13 hill prairies and a fen in Allamakee County, Iowa. In the summer of 2013, we observed 2,860 butterflies and identified 58 species from 10 hill prairies, Clear Creek fen, and a riparian prairie planting in Allamakee County. Butterfly species, common names, and family names are summarized in Table 2. The great spangled fritillary (*Speyeria cybele* Fabricius) was the most frequently observed butterfly in the 2013 survey ($n = 750$). Between the combined 1980s and 2013 studies, 80 species were observed with 47 species in common between the late 1980s and 2013. Eleven species were found in 2013 that had not been collected by Nehnevaj, while 22 species collected by Nehnevaj were undetected in the 2013 surveys (Table 2).

Of the 69 species collected by Nehnevaj, 14 are on the IDNR's current SGCN list (Table 2). Six of those same SGCN species were also found in 2013

Table 2. Number of butterflies of each species in John Nehnevaj's late 1980s collection and total number of butterflies of each species observed at 12 sites in Allamakee County Iowa in 2013 from mostly the same sites and habitats. Species listed by the Iowa DNR as species of greatest conservation need (SGCN) are indicated with an asterisk (*).

Family	Species	Common Name	Nehnevaj 1980s	2013 Survey Total
Hesperiidae	<i>Epagyreus clarus</i> (Cramer, 1775)	Silver-Spotted Skipper	2	62
Hesperiidae	<i>Thorybes pylades</i> (Scudder, 1870)	Northern Cloudywing	4	1
Hesperiidae	<i>Thorybes bathyllus</i> (Smith, 1797)	Southern Cloudywing	3	0
Hesperiidae	* <i>Erynnis brizo</i> (Boisduval & Leconte, [1837])	*Sleepy Duskywing	8	0
Hesperiidae	<i>Erynnis juvenalis</i> (Fabricius, 1793)	Juvenal's Duskywing	12	9
Hesperiidae	* <i>Erynnis baptisiae</i> (Forbes, 1936)	*Wild Indigo Duskywing	23	47
Hesperiidae	* <i>Erynnis lucilius</i> (Scudder & Burgess, 1870)	*Columbine Duskywing	10	0
Hesperiidae	<i>Pyrgus communis</i> (Grote, 1872)	Common Checkered-Skipper	8	1
Hesperiidae	<i>Pholisora catullus</i> (Fabricius, 1793)	Common Sootywing	6	0
Hesperiidae	<i>Ancyloxypha numitor</i> (Fabricius, 1793)	Least Skipper	7	20
Hesperiidae	<i>Thymelicus lineola</i> (Ochsenheimer, 1808)	European Skipper	0	2
Hesperiidae	<i>Hylephila phyleus</i> (Drury, 1773)	Fiery Skipper	2	0
Hesperiidae	* <i>Hesperia ottoe</i> Edwards, 1866	*Ottoe Skipper	41	34
Hesperiidae	* <i>Hesperia leonardus</i> Harris, 1862	*Leonard's Skipper	0	7
Hesperiidae	<i>Polites peckius</i> (Kirby, 1837)	Peck's Skipper	10	0
Hesperiidae	<i>Polites themistocles</i> (Latreille, [1824])	Tawny-edged Skipper	4	5

Table 2. Continued.

Family	Species	Common Name	Nehnevaj 1980s	2013 Survey Total
Hesperiidae	<i>Polites origenes</i> (Fabricius, 1793)	Crossline Skipper	10	0
Hesperiidae	<i>Polites mystic</i> (Edwards, 1863)	Long Dash	1	0
Hesperiidae	<i>Wallengrenia egeremet</i> (Scudder, 1864)	Northern Broken-Dash	4	8
Hesperiidae	<i>Pompeius verna</i> (Edwards, 1862)	Little Glasswing	4	2
Hesperiidae	<i>Anatrytone logan</i> (Edwards, 1863)	Delaware Skipper	9	5
Hesperiidae	<i>Poanes hobomok</i> (Harris, 1862)	Hobomok Skipper	8	1
Hesperiidae	<i>Euphyes conspicua</i> (Edwards, 1863)	Black Dash	1	0
Hesperiidae	* <i>Euphyes bimacula</i> (Grote & Robinson, 1867)	*Two-spotted Skipper	1	0
Hesperiidae	<i>Euphyes vestris</i> (Boisduval, 1852)	Dun Skipper	4	0
Hesperiidae	* <i>Atrytonopsis hianna</i> (Scudder, 1868)	*Dusted Skipper	8	0
Hesperiidae	* <i>Amblyscirtes hegon</i> (Scudder, 1864)	*Pepper and Salt Skipper	3	0
Hesperiidae	* <i>Amblyscirtes vitalis</i> (Edwards, 1862)	*Common Roadside-Skipper	4	9
Papilionidae	<i>Papilio polyxenes</i> Fabricius, 1775	Black Swallowtail	3	36
Papilionidae	<i>Papilio glaucus</i> Linnaeus, 1758	Eastern Tiger Swallowtail	1	12
Papilionidae	<i>Papilio cressphontes</i> Cramer, 177	Giant Swallowtail	0	61
Pieridae	<i>Pieris rapae</i> (Linnaeus, 1758)	Cabbage White	2	51
Pieridae	<i>Colias philodice</i> Godart, 1819	Clouded Sulphur	1	119

Table 2. Continued.

Family	Species	Common Name	Nehnevaj 1980s	2013 Survey Total
Pieridae	<i>Colias eurytheme</i> Boisduval, 1852	Orange Sulphur	9	39
Pieridae	<i>Colias cesonita</i> (Stoll, 1790)	Southern Dogface	7	0
Pieridae	<i>Phoebis sennae</i> (Linnaeus, 1758)	Cloudless Sulphur	0	7
Pieridae	<i>Eurema lisa</i> (Boisduval & Leconte [1830])	Little Sulphur	2	1
Lycaenidae	<i>Lycaena phlaeas</i> (Linnaeus, 1761)	American Copper	3	7
Lycaenidae	<i>Lycaena dione</i> (Scudder, 1868)	Gray Copper	3	0
Lycaenidae	<i>Lycaena hyllus</i> (Cramer, 1775)	Bronze Copper	4	4
Lycaenidae	<i>Callophrys gryneus</i> (Hübner [1819])	'Olive' Juniper Hairstreak	4	8
Lycaenidae	<i>Satyrrium titus</i> (Fabricius, 1793)	Coral Hairstreak	3	13
Lycaenidae	* <i>Satyrrium caryaeorum</i> (McDunnough, 1942)	*Hickory Hairstreak	0	3
Lycaenidae	* <i>Satyrrium edwardsii</i> (Grote and Robinson, 1867)	*Edward's Hairstreak	3	2
Lycaenidae	<i>Satyrrium calanus</i> (Hübner [1809])	Banded Hairstreak	9	8
Lycaenidae	* <i>Satyrrium tiparops</i> (Leconte, 1833)	*Striped Hairstreak	5	0
Lycaenidae	<i>Strymon melinus</i> (Hübner [1813])	Gray Hairstreak	0	1
Lycaenidae	<i>Everses conynitas</i> (Godart [1824])	Eastern Tailed-Blue	8	437
Lycaenidae	<i>Celastrina ladon</i> (Cramer, 1780)	Spring Azure	2	5
Lycaenidae	<i>Celastrina neglecta</i> (Edwards, 1862)	Summer Azure	2	1

Table 2. Continued.

Family	Species	Common Name	Nehnevaj 1980s	2013 Survey Total
Lycaenidae	<i>*Echinargus isola</i> (Reakirt [1867])	*Reakirt's Blue	4	0
Nymphalidae	<i>Libytheana carinenta</i> (Cramer, 1777)	American Snout	2	0
Nymphalidae	<i>Danaus plexippus</i> (Linnaeus, 1758)	Monarch	1	101
Nymphalidae	<i>Euptoieta claudia</i> (Cramer, 1775)	Variagated Fritillary	4	25
Nymphalidae	<i>Speyeria cybele</i> (Fabricius, 1775)	Great Spangled Fritillary	4	750
Nymphalidae	<i>*Speyeria aphrodite</i> (Fabricius, 1787)	*Aphrodite Fritillary	1	14
Nymphalidae	<i>Boloria selene</i> (Denis & Schiffermüller, 1775)	Silver-bordered Fritillary	5	1
Nymphalidae	<i>Boloria bellona</i> (Fabricius, 1775)	Meadow Fritillary	5	34
Nymphalidae	<i>Chlosyne gorgone</i> (Hübner [1810])	Gorgone Checkerspot	8	0
Nymphalidae	<i>Chlosyne nycteis</i> (Doubleday, [1847])	Silvery Checkerspot	3	11
Nymphalidae	<i>Phyciodes tharos</i> (Drury, 1773)	Pearl Crescent	9	230
Nymphalidae	<i>*Euphydryas phaeton</i> (Drury, 1773)	*Baltimore Checkerspot	2	17
Nymphalidae	<i>Junonia coenia</i> Hübner, [1822]	Common Buckeye	3	52
Nymphalidae	<i>Polygonia comma</i> (Harris, 1842)	Eastern Comma	0	5
Nymphalidae	<i>Polygonia progne</i> (Cramer, 1775)	Gray Comma	1	1
Nymphalidae	<i>*Nymphalis vaualbum</i> (Denis & Schiffermüller, 1775)	*Compton Tortoiseshell	1	0
Nymphalidae	<i>Aglais milberti</i> (Godart, 1819)	Milbert's Tortoiseshell	1	0

Table 2. Continued.

Family	Species	Common Name	Nehnevaj 1980s	2013 Survey Total
Nymphalidae	<i>Nymphalis antiopa</i> (Linnaeus, 1758)	Mourning Cloak	0	22
Nymphalidae	<i>Vanessa atalanta</i> (Linnaeus, 1758)	Red Admiral	2	18
Nymphalidae	<i>Vanessa cardui</i> (Linnaeus, 1758)	Painted Lady	1	29
Nymphalidae	<i>Vanessa virginiensis</i> (Drury, 1773)	American Lady	0	5
Nymphalidae	<i>Limenitis arthemis arthemis</i> (Drury, 1773)	White Admiral	1	0
Nymphalidae	<i>Limenitis arthemis astyanax</i> (Fabricius 1775)	Red-Spotted Purple	0	15
Nymphalidae	<i>Limenitis archippus</i> (Cramer, 1775)	Viceroy	2	17
Nymphalidae	<i>Asterocampa celtis</i> (Boisduval & Leconte, [1835])	Hackberry Emperor	3	30
Nymphalidae	<i>Asterocampa clyton</i> (Boisduval & Leconte, [1835])	Tawny Emperor	6	1
Satyridae	<i>Enodia anthedon</i> Clark, 1936	Northern Pearly-eye	1	2
Satyridae	<i>Satyrodes eurydice</i> (Linnaeus, 1763)	Eyed Brown	0	2
Satyridae	<i>Megisto cymela</i> (Cramer, 1777)	Little Wood-Satyr	2	9
Satyridae	<i>Cercyonis pegala</i> (Fabricius, 1775)	Common Wood-Nymph	5	441
	Total Butterflies:		345	2860
	Species Richness:		69	58
	# SGCN butterflies:		114	133
	# SGCN species:		14	8

(Table 2). Eight SGCN species found by Nehnevaj were not found in 2013: the sleepy duskywing (*Erynnis brizo* Boisduval and Leconte), columbine duskywing (*Erynnis lucilius* Scudder and Burgess), striped hairstreak (*Satyrium liparops* Leconte), two-spotted skipper (*Euphyes bimacula* Grote and Robinson), dusted skipper (*Atrytonopsis hianna* Scudder), Compton's tortoiseshell (*Roddia vaualbum* Denis and Schiffermüller), Reakirt's blue (*Echinargus isola* Reakirt), and pepper and salt skipper (*Amblyscirtes hegon* Scudder) (Table 2). Six SGCN species were found both in the 1980s and summer of 2013: ottoe skipper (*H. ottoe*), wild indigo duskywing (*Erynnis baptisiae* Forbes), Baltimore checkerspot (*E. phaeton*), common roadside skipper (*Amblyscirtes vialis* W.H. Edwards), aphrodite fritillary (*Speyeria aphrodite* Fabricius), and the Edward's hairstreak (*Satyrium edwardsii* Grote and Robinson). Two SGCN species were found in 2013 that were not collected by Nehnevaj: the hickory hairstreak (*S. caryaevorum*) and Leonard's skipper (*H. leonardus*).

In 2013, SGCN species were found at all of the sites surveyed except for Heritage Valley. The ottoe skipper (*H. ottoe*) ($n = 34$) was found on six hill prairie sites (Table 2). Leonard's skipper ($n = 7$) and Baltimore checkerspot ($n = 17$) were each found on a single site. The wild indigo duskywing ($n = 47$) was found on seven sites. The Edward's hairstreak ($n = 2$), hickory hairstreak ($n = 3$) and common roadside skipper ($n = 9$) were each found on three sites. The aphrodite fritillary ($n = 14$) was found on four sites.

Sites surveyed in 2013 varied in species richness from 31 species at Black Hawk Point to 14 species at Heritage Valley (Table 3). Shannon Diversity Index values for 2013 ranged from 3.796 at Zoll's Mountain to 1.971 at Bear Creek Hill Prairie (Table 3). The site with the highest evenness was Zoll's Mountain ($J' = 0.790$) while Bear Creek had the lowest evenness at ($J' = 0.505$) due to a large number of *S. cybele* (Table 3). Bear Creek had the largest number of butterflies observed per observer minute (0.566) while Chimney Rock Hill Prairie had the fewest (0.139) (Table 3).

Analysis of aerial photos revealed an overall loss of 55.4% of the hill prairies since the late 1980s. Nehnevaj's 1980s sites (Table 1) decreased in area by an average of 64.0% since the 1980s (Table 3). Three of his sites had 100% area loss, or complete cedar cover (McLaughlin Drive, Riverside Drive, Sunflower Drive), and one exhibited 78% loss (Hwy 76 Waterloo Creek). None of these four sites were sampled in 2013. Of the ten hill prairie sites surveyed in 2013 (Table 3), there was a 39.7% average area loss from the 1980s. All hill prairies surveyed in 2013 have lost area since the 1980s except Heritage Valley, which was manually cleared of *J. virginiana* in 2009 by the INHF intern crew. The eight hill prairie sites (Table 1) collected in the 1980s by Nehnevaj and surveyed by us in 2013 had an average area loss of 48.7%.

Discussion

Collections are a valuable tool for analyzing butterfly populations. They provide physical identification confirmation and locality data that can be used in future years for comparison, review, and genetic analysis. However, several difficulties arise in attempting to compare a collection to a single-season survey. It is important to note that though Nehnevaj's collection provides evidence of which species were present during his collection period, it does not provide abundance information, and absence of a species in a collection cannot be used to prove that a species was not present. It is impossible to tell whether a species was truly absent from a specific site at that time, if the collector simply missed that species, or if a decision was made not to include that species in the collection. For example, it is likely that the Leonard's skipper was present on Allamakee County hill prairies in the 1980s as well as 2013, but was simply not collected by Nehnevaj, even though his collections overlapped with the Leonard's skipper's flight period.

Table 3. Summary of number of butterflies, butterfly observation rate, species richness, species of greatest conservation need (SGCN) as designated by the IDNR, Shannon diversity index (H'), Pielou's Evenness Index (J'), and % change in acreage since the 1980s at twelve sites in Allamakee County, Iowa surveyed during 2013. Total acreage change refers to the average percent loss on the combined Nehnevaj and 2013 sites since the 1980s.

Site	Total	Butterflies/ minute	Species Richness	# SGCN butterflies	# SGCN species	Shannon Index (H')	H' variance	Evenness (J')	Acreage Change (%)
Bear Creek	360	0.566	15	9	1	1.971	0.011	0.505	-23.1
Black Hawk Point	312	0.347	31	5	2	3.406	0.012	0.688	-62.3
Chimney Rock	114	0.139	21	12	3	3.112	0.026	0.709	-56.8
Clear Creek Fen	394	0.359	26	19	2	3.581	0.005	0.762	n.a.
Heritage Valley	183	0.406	14	0	0	2.854	0.009	0.750	15.8
Honeywell	279	0.311	28	13	3	3.736	0.009	0.777	-57.3
Potter's Prairie	143	0.252	18	2	1	3.014	0.020	0.723	-74.8
Prairie Song Farm	193	0.350	20	1	1	3.115	0.014	0.721	n.a.
Solitaire Ridge East	262	0.297	30	9	3	3.345	0.014	0.682	-38.3
Solitaire Ridge West	218	0.377	23	6	2	3.317	0.012	0.733	-24.0
Weymiller	169	0.278	21	29	4	3.172	0.018	0.722	-19.8
Zoll's Mountain	233	0.165	28	28	4	3.796	0.011	0.790	-56.6
2013 Total	2860	0.304	58	133	8	3.850	0.001	0.657	-39.7
Nehnevaj 1980s	345	unknown	69	114	14	5.535	0.005	0.906	-64.0

An added complication in comparing a collection to our 2013 survey is that Nehnevaj's collection was amassed over a series of years, which would account for yearly fluctuations in abundance. In our 2013 survey, butterfly populations were widely rumored to be low, and flooding hindered our ability to access sites to make surveys in late June. Notably absent from the 2013 survey were two butterflies typically common in Northeast Iowa: the question mark, *Polygonia interrogatoris* (Fabricius), and Milbert's tortoiseshell, *Aglais milberti* (Godart). These species were previously listed as uncommon and common, respectively, in neighboring Winneshiek County, also based on a one-year survey (Larsen and Bovee 2001). Both species have been shown to undergo yearly fluctuations in abundance, which could account for their scarcity (Cassie 1986-1990, Walton 1986-1990). Surveys spanning several years would provide a more complete picture of which butterflies actually occupy Allamakee hill prairies and other habitats.

Survey time may also have limited the number of species observed in 2013. Surveys did not begin until mid-June, potentially bypassing the flight periods of the dusted skipper (*A. hianna*) and pepper and salt skipper (*A. hegon*), which fly primarily from mid-May to late June, and mid-May, respectively (Schlicht et al. 2007). Additional surveys might also be conducted in the late summer. A limited number of surveys occurred during the Leonard's skipper flight time, making it possible that this species resides on other sites that were either not surveyed during its late-August to October flight period, or were surveyed infrequently (Schlicht et al. 2007). More species might be detected by conducting additional surveys in spring and fall when we were unable to survey during 2013.

Decreased species richness from the late 1980s to our survey in 2013 could also be attributed to the significant decrease in hill prairie habitat in Allamakee County over the last 25 years. Encroachment by *J. virginiana* fragments butterfly habitat, decreases light availability to prairie plants, increases moisture, and hinders seed dispersal, preventing growth of grassland species beneath the canopy (Briggs et al. 2002). Red cedar is native to northeastern Iowa and its encroachment onto open areas and grassland is part of the natural cycle of succession (Briggs et al. 2002). However, changes to the landscape have interrupted the regular disturbances that limit the spread of *J. virginiana*, making management necessary for the maintenance of high quality open prairie (Swengel and Swengel 2001).

Fire has been shown to be a part of the historic prairie landscape and controlled burns have proven to be an effective method for removing fire intolerant species like *J. virginiana* from the landscape (Briggs et al. 2002). However, fire in the absence of refugia is a potential cause for the extirpation of prairie specialist butterflies (Swengel and Swengel 2007). Fire can diminish butterfly populations by burning up eggs and larvae on the host plants that they occupy. In this way, management activities can potentially have a negative effect on prairie butterflies (Swengel et al. 2011). Setting aside enough prairie refugia that butterflies can repopulate after burns appears to be vital in maintaining their populations on fire-managed sites (Swengel and Swengel 2007). Alternative management techniques, like cutting of woody invaders, light grazing, rotational mowing or haying, and spot herbicide applications have been offered as less impactful alternatives (Swengel and Swengel 2007, Swengel et al. 2011).

It had been assumed that many prairie-dependent butterfly species had been extirpated from Iowa due to the loss of prairie habitat and the excessive use of fire as a management tool (Schlicht et al. 2007). This study provides evidence that some rare prairie-dependent butterflies like the ottoe skipper and Leonard's still inhabit some isolated and unmanaged hill prairie sites in Northeast Iowa and are not yet extirpated from the state.

Hill prairies are ideal habitat for the ottoe skipper, as they have been shown to prefer habitats with discontinuous sod, such as the bare rocky outcrops and sandy patches on hill prairies (Selby 2005, Swengel and Swengel 2013).

The ottoe skipper is classified as having the highest level of prairie dependence because it is found significantly more often on undegraded prairies (Swengel and Swengel 2013).

The Iowa Wildlife Action Plan (IDNR 2007) has designated the ottoe skipper an imperiled species (S2) with declining populations and given it a special concern (SC) protection status (Selby 2005). On a national level, the ottoe skipper is listed as vulnerable to extirpation (N3), a rank attributed to species with a restricted range, few populations, or other factors (Selby 2005). The ottoe skipper is currently listed globally as vulnerable to apparently secure (G3G4) (Selby 2005).

A relationship can be observed between Shannon Diversity Index and evenness values and estimation of prairie quality. Sites noted to have high quality prairie like Zoll's Mountain and Honeywell possessed the highest Shannon Diversity Index and evenness values and also possessed high numbers of SGCN butterflies. Degraded prairie like Bear Creek, which was made up of hill prairie and degraded old-field habitat, had the lowest Shannon Diversity Index and evenness. This was expected, as higher quality prairie can support a larger variety of butterflies, including prairie specialists (Schlicht and Orwig 1992).

We believe five of our surveyed sites should be specifically designated as "hot spots" for conservation consideration because of their SGCN butterfly species richness. All five of these sites are currently privately owned, appear to have high-quality hill prairie habitat, and host a relatively large number of SGCN butterflies. These sites included Zoll's Mountain (4 SGCN species), Chimney Rock (3 SGCN species), Honeywell (3 SGCN species), Solitaire East (3 SGCN species) and Weymiller (4 SGCN species) hill prairies. The ottoe skipper and wild indigo duskywing were found all five of these sites. Each of these sites experienced a large decrease in acreage from the 1980s, averaging 45.8% loss. Area loss ranged from 57.3% at Honeywell hill prairie to 19.8% at Weymiller hill prairie. Small privately-owned and often unmanaged sites are not regularly surveyed for butterflies, however these private sites in Allamakee County appear to harbor a number of rare species not observed in larger, publically-owned and managed sites. Privately-owned lands may be important sites for locating species previously thought to be extirpated from the state.

For butterflies and other hill-prairie specialist insects to be effectively conserved, surveys like this must be conducted to locate populations and monitor the impact of habitat change. Current threats to Allamakee County hill prairies are removal by mining for frac sand and invasion by red cedar. It is crucial to protect and manage these vulnerable, privately-owned sites for appropriate conservation efforts as they are small biodiversity "hot spots" for these rare hill prairie butterflies. The continued disappearance of hill prairie habitat due to environmental change or destruction by frac sand mining will further reduce hill prairie habitat and likely lead to the extirpation of these hill prairie specialist butterfly species from Iowa.

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