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Author: Bomar, Charles R.

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Comparison of grasshopper (Orthoptera: Acrididae) communities on remnant and reconstructed prairies in western Wisconsin

CHARLES R. BOMAR

Department of Biology University of Wisconsin - Stout Menomonie, 54751.
e-mail:BOMARC@UWSTOUT.EDU

Abstract

Grasshopper populations (Orthoptera: Acrididae) were surveyed on reconstructed and remnant prairies in Wisconsin. Twenty-seven species were observed on 17 different sites. Most sites ranged from dry to mesic habitats. Two species were very common, *Melanoplus femurrubrum* and *Chorthippus curtipennis*, being found at 15 and 14 sites respectively; 12 species were collected only at one site. Reconstructed prairies generally lacked the overall grasshopper species diversity observed on remnant prairies, with one exception, Lake Wissota – a 48 ha reconstructed dry site that contained 10 species of grasshoppers. Important factors for grasshopper conservation and prairie restoration may not be dependent on the age of the restoration, but the size and type of prairie being reconstructed as well as proximity to remnant sites. Management plans that include fire should also consider those species that overwinter as nymphs.

Key words

Prairie, grasshopper, restoration, species diversity

Introduction

The state of reconstructed prairies.— To account for the loss of prairie habitat, reconstruction and restoration have become popular investments for communities in the United States, returning patchworks of abandoned land to some pre-described 'native' state. The term 'native' is commonly defined as the historical condition of a piece of land prior to a disturbance [(*e.g.* agriculture, Berger 1991)]. Restorations are defined for the purpose of this research as any habitat treatment that utilizes human-intensive and intended management (*e.g.* fire, weeding, brushing) to enhance a prairie habitat. Reconstruction is defined as any habitat treatment that has utilized intensive management as well as planting of prairie plants to replace an agricultural or abandoned field.

Many restoration and reconstruction projects are placed on land of little or no economic value and managed by planting native ecotype plants and monitoring the growth of these plants over time, while other projects have been placed on well-defined portions of agricultural land. Native or 'remnant' prairies exist where they have coevolved with the surrounding environment. In many cases in western Wisconsin, these prairies have been ecologically compromised by urban sprawl, invasion of exotic plants (*e.g.* spotted knapweed, leafy spurge) and suppression of their primary regulatory force, fire.

Current prairie reconstruction practices are based on insufficient knowledge of the prairie ecosystem and its associated insect fauna, and generally lack long-term goals for restoration (Margules *et al.* 1988; Pressey *et al.* 1993). Evaluation of reconstructed sites has been generally one-dimensional, being based primarily on the establishment of the newly substituted plant community (Westman 1991).

Grasshoppers on remnant and reconstructed prairies.— Very little work has been completed at the next level, investigating which organisms are utilizing the newly reconstructed habitat. The primary-above ground herbivores in the system, the insects (Seastedt & Crossley Jr. 1984), have not been evaluated in this capacity. Only one previous study has been completed specifically on the insects of a reconstructed prairie (Panzer *et al.* 1987; Panzer 1988). Even Curtis Prairie in Madison, WI, USA, which was reconstructed in 1935 (Jordan *et al.* 1986), has not had a quantitative study of this nature done on its insect community (W. Jordan III, pers. comm). Curtis Prairie was the first reconstructed prairie in the world (Jordan *et al.*, 1987). Some work has been done on "grasshoppers through time" (Evans 1984, 1988; A. Joern, personal comm.), but each study was strictly based on one large (*e.g.* 3500 ha Konza Prairie, Evans 1984, 1988) remnant prairie. No research has assessed the assemblage of grasshopper communities in a prairie from time zero, its initial reconstruction. Understanding grasshopper communities from not only a secondary, but a primary succession stand point (defined in this case as a physical alteration of the non-prairie habitat to prairie) could provide valuable insights into future planning, development and management of these reconstructed sites.

There are two distinct problems when evaluating the insect fauna of remnant and reconstructed prairies. First, very little data exist as to which insect species are prairie specialists, and second, even less information is available on insects that invade and colonize reconstructed prairies (Taron 1997). Insects, because of their short life span (generally one summer or less), are highly susceptible to

Table 1. Site description from remnant (N), reconstructed (R) and N, R combination prairies in six Wisconsin counties.

Prairie	County	N, R (year)	ha	Type	Last Burn
Bergh	Pierce	N	4	dry	1997
Murray Tract	Pierce	N	3.5	dry	1997
Ross	St. Croix	N, R (1992)	1, 3.5	dry, mesic	1996
Hammond	St. Croix	N	<1	mesic	1997
Ogburn	St. Croix	N	12-16	dry-mesic	1997
Three Lakes	St. Croix	R (1993)	5	mesic	1995
Hartman	St. Croix	N	4	dry	Heavily grazed annually
USFWS	St. Croix	N, R (1996)	16, 16	dry, dry	1996
Hudson Terrace	St. Croix	N	1.5	dry	not burned
Lake Menomin	Dunn	R (1994)	16	mesic	1997
Larrabee	Dunn	N	16	mesic	1997
Rock Falls RW	Dunn	N	16	dry	1996
Lake Wissota	Chippewa	R (1975)	48	dry-mesic	1997
Little Red School	Eau Claire	N, R (1983)	4, 1.5	dry-mesic, mesic	not burned
Curtis	Dane	R (1936)	24	mesic	1997
W. Grady Tract	Dane	N	4	dry	1997
Greene	Dane	R (1945)	16	mesic-wet	1997

changes in the environment. Those insects that are prairie-restricted therefore are highly susceptible to local population fluctuations including local extinctions (Panzer 1988). For example, it is widely understood that burning plays an important role in determining insect fauna in prairie habitats (Evans 1984,1988; Panzer *et al.* 1987; Panzer 1988; Dunwiddie 1991; Reed 1995, 1997). This is an important point since fire is the primary management tool for maintaining the prairie (Leach & Givnish 1996). Without some level of recolonization of insects after each disturbance, many of these local extinctions have the potential to become permanent, unless local, undisturbed reservoirs are available.

The present research evaluated the grasshoppers of both reconstructed and remnant prairies in western Wisconsin. Its purpose was to develop an understanding of which grasshoppers inhabit remnant and reconstructed prairies, as well as establish baseline information on the ecological succession of grasshopper communities on prairies of various ages. Knowing the differences between remnant and reconstructed prairies will allow an understanding of what it truly means to be reconstructed, and at what point in time (in the context of grasshopper communities) a prairie reconstruction can be considered successful. Improved management decisions may result from this research concerning endangered species and the placement of future reconstructed prairies.

Methods

Site identification.— Eleven remnant (N), five reconstructed (R) and 2 remnant-reconstructed combination (N, R) prairies, in 6 counties in Wisconsin (Fig. 1) were identified by the presence of prairie plants, as described by Curtis (1959). Remnant-reconstructed prairies were sites where a small remnant prairie was increased in size by the construction of a prairie adjacent to it. Each site fell on or below Curtis's (1959) "tension zone" where northern boreal forests meet southern prairies. Once identified as prairie, each site was surveyed for primary plant community, and classified for type (*e.g.* wet/mesic/dry) based on descriptions of plant communities provided by Curtis (1959). Management histories were obtained when available. Prairies ranged in size from <1 ha to 48 ha, with the majority of the sites being over 4 ha (Table 1).

Collection.— Grasshoppers were collected from 1997-1999. Each site was collected for one or two years, optimizing the potential for collecting those species that overwinter as nymphs as well as those that mature throughout the summer and fall. Each prairie was surveyed a minimum of five times in a given year. Three methods were used to collect grasshoppers, including a standard sweep net (38 cm) used to take 100 sweeps along a permanent transect within each prairie. Second, since some grasshoppers are difficult to catch using a sweep net (*e.g. Psinidia fenestralis* (Serville) due to its elusive nature, *Melanoplus dawsoni* (Scudder) due to brachypterous wings), or because sweep nets do not function well in tall grass prairie, grasshoppers were individually

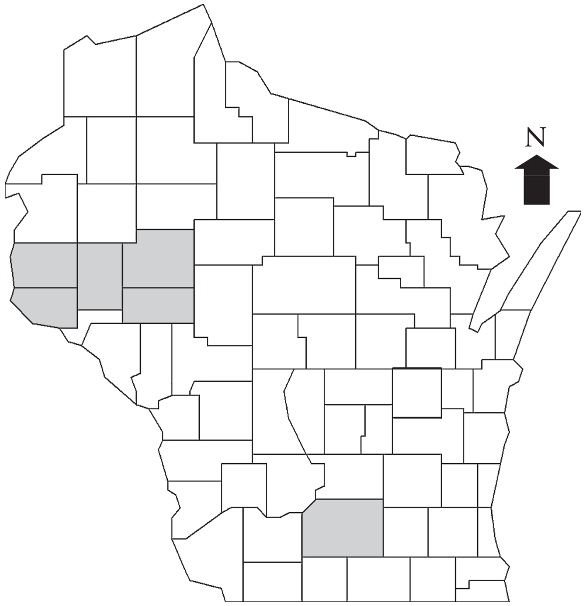

Fig. 1. Wisconsin Counties surveyed for grasshoppers (Orthoptera: Acrididae) associated with remnant and reconstructed prairies.

collected at each site using a 'flush and capture' method described by Pfadt (1994). Third, when available, malaise traps were used as permanent traps. Prairies were sampled between June and August; sites with malaise traps (Lake Wissota, Lake Menomin, Larrabee) were sampled bi-weekly. Samples were stored in a laboratory freezer (-10°C) until specimens were identified. Insects were collected under a Wisconsin Department of Natural Resources permit (# SCP-WD-86-C-98).

Identification.— Grasshoppers were identified to species using the keys of Vickery (1979), Otte (1981, 1984), Capinera & Sechrist (1982) and Pfadt (1994). Voucher specimens from each collection are maintained in the University of Wisconsin-Stout Research Collection.

Analysis.— Quality of individual prairies was inferred by assessing the grasshopper diversity present. This was calculated using the formula

$$\Sigma\left(1/(p/N)\right)$$

where p represents the number of prairies inhabited by a given species and N represents the total number of prairies (N=17). This formula minimized the importance of common species and favored those individuals that were less common. By summation of species present at a given site, a score was then generated. The highest scores represent the highest quality for grasshopper diversity and inferentially the highest quality prairie. This analysis is similar to that employed by Curtis (1959) who used plants to assess the quality of Wisconsin prairies. Sites were also clustered using a hierarchal cluster analysis (SPSS 1996) to determine categorical patterns of similarity as well as differentiation. Variables used in the cluster include prairie type, remnant or reconstructed, number of species present and presence/absence of each species at any site.

Results

A total of 17 different sites from 6 different counties in Wisconsin were surveyed. With the exception of the Dane County sites (Curtis, Greene and W. Grady Tract), all sites were in western Wisconsin (Fig. 1). Based on plant communities present, sites were classified dry-mesic-wet: most were classified as mesic. Sites ranged from <1 to 48 ha, but most sites were between 8-16 ha (Table 1). These prairie sites included a total of 27 species of grasshoppers from 4 subfamilies. The most abundant subfamily was the Melanoplinae (n = 12; Table 3), the least abundant was the Cyrtacanthacridinae (n = 1; Table 3). The Gomphocerinae (n = 6; Table 4) and Oedipodinae (n = 8; Table 5) were also represented. The most common species were *Melanoplus femurrubrum* (DeGeer) and *Chorthippus curtipennis* (Harris), being collected at fifteen and fourteen sites respectively.

Three sites with the highest grasshopper diversity Rock Falls RW, Lake Wissota, and Murray Tract (n = 12, 10, 9 respectively; Table 2) were all considered dry sites (Table 1). Two of these, Rock Falls RW and Murray Tract, are remnant prairies; Lake Wissota is a reconstructed prairie. Of the three lowest ranking sites, USFWS had one species of grasshopper (*C. curtipennis*) present and two sites, Bergh and Hammond, had two species (*C. curtipennis* and *M. femurrubrum*). Sites with 3-7 species had variable rankings, dependant upon the frequency of the species of grasshoppers present.

New reconstructed vs. old reconstructed.— Lake Wissota State Park, 25+ year-old reconstructed dry prairie, was the most diverse of the reconstructed prairies, with 10 species of grasshoppers being collected, primarily represented by those species that preferred dry sites, such as *M. keeleri* (Dodge), *M. gladstoni* Scudder, *M. sanguinipes* (F.) and *Spharagemon marmorata* (Harris).

No correlation appears to exist between age of reconstruction and species diversity (Table 2). Curtis Prairie at 65 years of age, contained only 5 species, whereas most of the other reconstructed prairies were younger, and contained at least as many species. The five species observed at Curtis Prairie were collected frequently in this survey with one exception: *Dissosteira carolina* (L.) was only collected at Curtis Prairie, yet it is a fairly common species throughout the United States. It is most commonly associated with roadside ditches, bare ground and railroad beds (Otte 1984; Vickery & Kevan 1985).

Of the four highest ranked reconstructed prairies (Lake Wissota, Ross, Lake Menomin and Curtis), only two species occurred in all four sites, *M. femurrubrum* and *C. curtipennis*.

Table 2. Rank, score, and species abundance of grasshoppers (Orthoptera: Acrididae) from remnant and reconstructed prairies in six Wisconsin counties.

Prairie	Rank	Score	No. of species
Rock Falls RW	1	87.3	12
Lake Wissota	2(t)	61.4	10
Murray Tract	2(t)	61.4	9
Ross	3	33.5	6
Lake Menomin	4	33.1	6
W. Grady Tract	5	30.7	7
Curtis	6	27.4	5
Little Red School	7	26.6	3
Ogburn	8	20.6	3
Greene	9	18.9	5
Three Lakes	10	15.3	3
Larrabee	11	13.3	5
Hartman	12	12.5	3
Hudson Terrace	13	10.8	3
Bergh	14(t)	2.3	2
Hammond	14(t)	2.3	2
USFWS	15	1.2	1

Table 3. Melanoplinae and Cyrtacanthacridinae (Orthoptera: Acrididae) associated with remnant and reconstructed prairies in six Wisconsin counties.

	Species												
Prairie	Mf	Ms	Md	Mk	Mb	Mc	Ma	Mp	Mg	Mflav	Mbor	Hv	Sa
Bergh	x	-	-	-	-	-	-	-	-	-	-	-	-
Murray Tract	x	-	-	x	x	-	x	-	-	-	-	x	-
Ross	x	-	-	x	-	-	-	-	-	-	-	-	-
Hammond	x	-	-	-	-	-	-	-	-	-	-	-	-
Ogburn	x	-	-	-	x	-	-	-	-	-	-	-	-
Three Lakes	x	-	-	-	-	-	-	-	-	-	-	-	-
Hartman	-	-	-	-	-	x	-	-	-	-	-	-	-
USFWS	-	-	-	-	-	-	-	-	-	-	-	-	-
Hudson Terr.	x	x	-	-	-	-	-	-	-	-	-	-	-
Lake Menomin	x	-	x	-	x	-	-	x	-	-	-	-	-
Lake Wissota	x	x	-	x	x	x	-	x	x	-	-	-	x
Larrabee	x	-	-	-	x	x	-	-	-	-	-	-	-
Little Red Sch.	x	-	-	-	-	-	-	-	-	-	x	-	-
Rock Falls RW	x	-	-	x	-	-	x	-	-	x	-	-	x
Curtis	x	-	x	-	x	-	-	-	-	-	-	-	-
W. Grady Tract	x	-	-	x	-	x	-	-	-	-	-	-	x
Greene	x	-	x	x	x	-	-	-	-	-	-	-	-

KEY: Mf = *Melanoplus femurrubrum* (DeGeer); Ms = *M. sanguinipes* (F.); Md = *M. dawsoni* (Scudder); Mk = *M. keeleri* (Dodge); Mb = *M. bivittatus* (Say); Mc = *M. confusus* Scudder; Ma = *M. angustipennis* (Dodge); Mp = *M. punctulatus* (Scudder); Mg = *M. gladstoni* Scudder; Mflav = *M. flavidus* Scudder; Mbor = *M. borealis* (Fieber); Hv = *Hesperotettix viridis* Scudder; Sa = *Schistocerca alutacea* (Harris)

Table 4. Gomphocerinae (Orthoptera: Acrididae) associated with remnant and reconstructed prairies in six Wisconsin counties.

	Species					
Prairie	Cc	Oo	Ad	Os	Pb	Ccon
Bergh	x	-	-	-	-	-
Murray Tract	x	-	x	-	-	-
Ross	x	-	-	x	-	x
Hammond	x	-	-	-	-	-
Ogburn	-	-	-	-	-	-
Three Lakes	-	-	-	x	x	-
Hartman	x	-	-	x	-	-
USFWS	x	-	-	-	-	-
Hudson Terr.	x	-	-	-	-	-
Lake Menomin	x	-	-	-	-	-
Lake Wissota	x	-	-	-	-	-
Larrabee	x	-	-	-	-	-
Little Red Sch.	-	-	-	-	x	-
Rock Falls RW	x	x	x	-	-	-
Curtis	x	-	-	-	-	-
W. Grady Tract	x	x	x	-	-	-
Greene	x	-	-	-	-	-

Key: Cc = *Chorthippus curtipennis* (Harris) Oo = *Opeia obscura* (Thomas) Ad = *Ageneotettix deorum* Scudder
Os = *Orphulella speciosa* (Scudder) Pb = *Pseudopomala brachyptera* (Scudder) Ccon = *Chloealtis conspersa* (Harris)

Table 5. Oedipodinae (Orthoptera: Acrididae) associated with remnant and reconstructed prairies in six Wisconsin counties.

	Species							
Prairie	Sb	Sc	Sm	Dc	As	Ac	Pa	Cv
Bergh	-	-	-	-	-	-	-	-
Murray Tract	x	-	-	-	x	-	-	-
Ross	-	-	-	-	x	-	-	-
Hammond	-	-	-	-	-	-	-	-
Ogburn	-	-	-	-	-	-	-	x
Three Lakes	-	-	-	-	-	-	-	-
Hartman	-	-	-	-	-	-	-	-
USFWS	-	-	-	-	-	-	-	-
Hudson Terr.	-	-	-	-	-	-	-	-
Lake Menomin	-	x	-	-	-	-	-	-
Lake Wissota	-	-	x	-	-	x	-	-
Larrabee	-	-	-	-	-	-	x	-
Little Red Sch.	-	-	-	-	-	-	-	-
Rock Falls RW	-	x	x	-	x	x	x	-
Curtis	-	-	-	x	-	-	-	-
W. Grady Tract	-	-	-	-	-	-	-	-
Greene	-	x	-	-	-	-	-	-

Key: Sb = *Spharagemon bolli* Scudder Sc = *S. collare* (Scudder) Sm = *S. marmorata* (Harris)
Dc = *Dissosteira carolina* (L.) As = *Arphia simplex* Scudder Ac = *A. conspersa* Scudder
Pa = *Pardalophora apiculata* (Harris) Cv = *Chortophaga viridifasciata* (DeGeer)

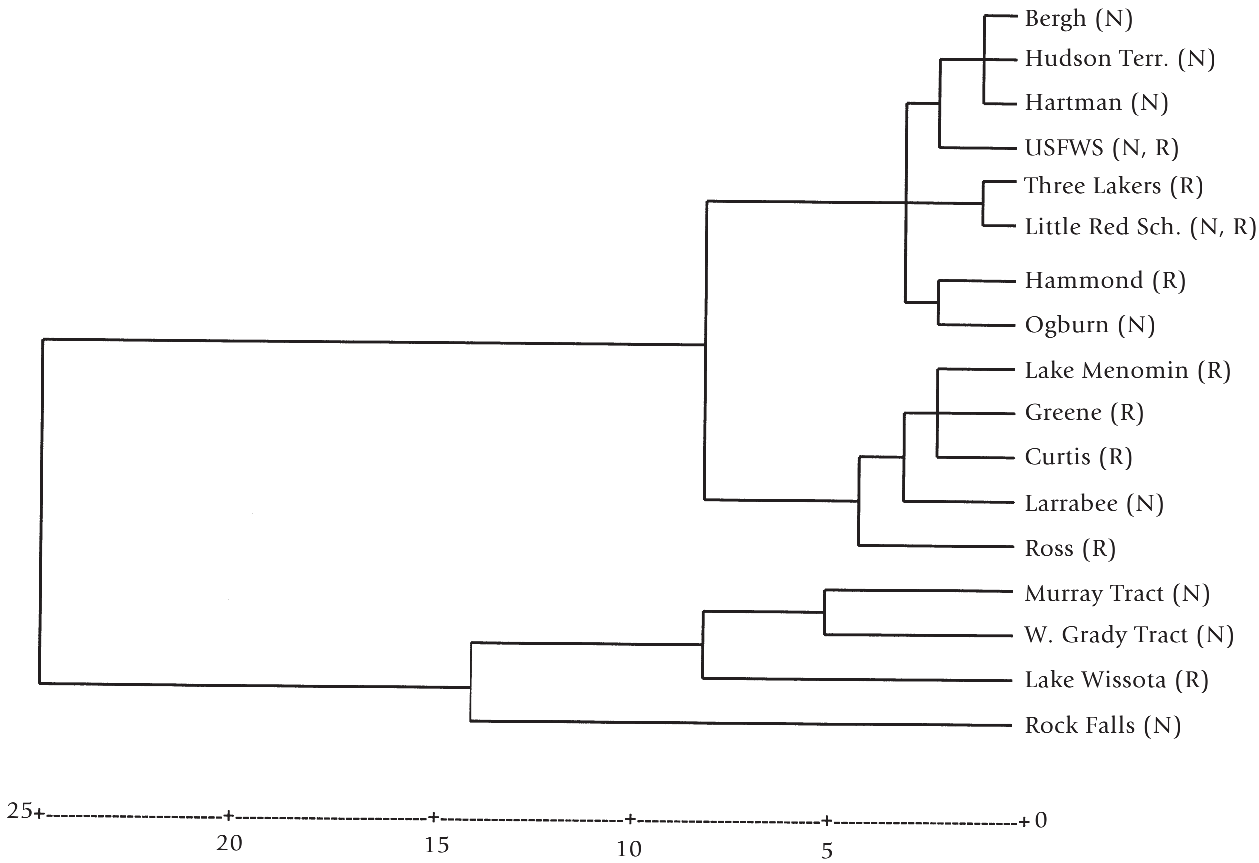

Fig. 2. Results of Hierarchal Cluster Analysis of remnant (N) and reconstructed (R) prairies in six Wisconsin counties.

Melanoplus bivittatus (Say) was collected at three sites; *M. dawsoni*, *M. punctulatus* (Scudder) and *M. keeleri* were collected at two sites. Ross Prairie contained two species not seen at the other reconstructed sites: *Orphulella speciosa* (Scudder) and *Chloealtis conspersa* (Harris). *O. speciosa* is commonly associated with dry short-grass sites (Otte 1981; Vickery & Kevan 1985) and thus more likely to be considered a prairie-associated species, whereas *C. conspersa* is more associated with thickets and woody edges (Otte 1981; Vickery & Kevan 1985).

Reconstructed vs. remnant.— Grasshoppers present at reconstructed sites represent a characteristic suite of species, with *M. femurrubrum* and *C. curtipennis* constituting the bulk of grasshoppers on these sites. From reconstructed sites, *M. femurrubrum* was generally taken in great quantities, commonly fifty or more specimens in a 100-sweep transect, while five or less *C. curtipennis* were collected in the same sample. While these two species were also present on the remnant sites, they were only collected in small quantities (generally < 5).

Many species were found only once in remnant prairies, and three were found only on reconstructed prairies: *M. dawsoni*, *S. collare* and *D. carolina*. The first species, *M. dawsoni*, is interesting, having long-winged and brachypterous forms (Pfadt 1994). The brachypterous forms were observed in this survey, but must have had a long-winged predecessor that colonized these reconstructed areas. Coincidentally the malaise trap allowed for the capture of the brachypterous form of *M. dawsoni* one year before any sweep-net samples at Lake Menomin Park. The remaining two species, *S. collare* and *D. carolina*, are both band-winged grasshoppers and are generally considered to be very mobile.

Hierarchal cluster analysis.— This analysis separated prairies into three distinct clusters (Fig.2), where the first cluster includes primarily remnants and two remnant-reconstructed sites. This cluster is distally related to the second cluster of primarily reconstructed prairie. The one exception is Larrabee Prairie: this site was under water for nearly 6 mo during a flood in 1992. This event most likely extirpated the grasshopper fauna, as well as most other terrestrial life forms. The third most distal cluster united 4 sites, Rock Falls RW, Lake Wissota, W. Grady Tract and Murray Tract, three of which were remnants, representing sites that contained the greatest species diversity. Three of these prairies, Rock Falls RW, Lake Wissota, and Murray Tract ranked highest in Table 2.

Species of interest.— While *M. femurrubrum* and *C. curtipennis* are very common, it is of greater interest to ask about those species collected only once (n = 12) or twice (n = 7) on remnant prairies. Of these species, six should be considered good indicators of dry prairies. They include *M. angustipennis, M. flavidus, M. gladstoni, H. viridis, S. bolli* and *O. speciosa*. One other species, *S. alutacea*, was collected at three of the dry sites, and should also be considered as an indicator of dry prairie. Other species that occur infrequently in these surveys were collected in edge areas (*e.g. M. borealis, M. punctulatas. C. conspersa)* or represent very mobile species (*e.g. D. carolina*) and are probably not good prairie representatives.

Other species that provide interesting information include three oedipodines: *Pardalophora apiculata* (Harris), *Chortophaga viridifasciata* (DeGeer) and *Arphia conspersa* Scudder. These species were found on three different sites and have one thing in common: all overwinter as nymphs. As such, these species represent an ecological drawback to the current management practice of spring burning. Since they overwinter in the duff layer, it is unlikely that they would survive any form of burning, whether spring or fall.

Discussion

There are some interesting patterns that are clear. First, on reconstructed sites it appears that *M. femurrubrum* and *C. curtipennis* are nearly immediate occupants, occurring at Lake Menomin Park. Once these species enter the reconstructed sites, it is also evident that they do not leave or get forced out by other species, since they were collected at Lake Wissota (25 yr), Greene Prairie (52 yr) and Curtis Prairie (65 yr). Two other species that arrive at various intervals are the brachypterous-winged *M. dawsoni* and the bandwing *Spharagemon collare*. While all four species are almost always present on newly reconstructed sites, these were also the primary species present on old reconstructed sites. These species serve as early colonizers and seem to persist as substantial populations. The mobility of *M. femurrubrum* and *C. curtipennis* suggests that they most likely reinvade from surrounding areas on an annual basis.

There are three primary differences between the Lake Wissota site and the other reconstructed sites. First, Lake Wissota is a very large site, at 48 ha much larger than any other site in this survey. This alone probably increased the rate at which mobile insects found this reconstructed area. Larger areas such as this also provide a greater diversity of microsites, thus increasing opportunities for recolonization. Second, Lake Wissota was not only large; it is also located in a very rural, uninhabited area with fewer unnatural barriers to disrupt local movement and migration, unlike sites such as Curtis and Greene Prairies. Third, this is a dry site, and dry sites seem to provide better habitat for a greater number of grasshopper species in western Wisconsin. As such, this site begins to approach diversity observed on western sites (*e.g.* Wyoming, Montana) where it is not uncommon to readily observe 12-15 grasshopper species at a given site (C. Bomar, unpublished data).

While the remnant sites were generally more species-rich than the reconstructed sites, they were not immune to the loss of species diversity. Remnant sites such as Hammond that were < 1 ha and surrounded by active agricultural production (*e.g.* corn and alfalfa) had no proximal external inputs. Over a period of time it can be assumed these 'meta-populations' become depleted (McCullough 1996) if nearby sources are not available. As for the overall process of restoration, it appears that important variables for success include not only size, as seen at Lake Wissota, but also the presence and proximity of nearby prairie sites. Further research assessing the influence of satellite remnant communities on reconstruction projects is a necessary next step in understanding the assembly of grasshopper communities. Those reconstruction projects that represent 'islands in an oasis' of urban development, agriculture, or other unnatural features, will only represent plant communities without their coevolved insect population. Thus no amount of time will make such reconstructed sites a successful representative of native prairie. Moreover, it appears the variables that create these 'island effects' are rather deterministic (Drake *et al.* 1996) and thus force these sites into a fixed equilibrium similar to that suggested by Friedel (1991), Laycock (1991), and Lockwood & Lockwood (1993). To the detriment of restoration ecology, it appears that urbanization and the resulting human-influenced landscape, drives the state of many of these sites in a reverse direction, toward a less stable ecological condition. As such it is unlikely that any amount of time, effort, or input will improve them for grasshopper or any other form of insect diversity. Improvement will require a much larger effort to link reconstructed sites or to reconstruct sites at the landscape level so that they are positioned in relative proximity to remnant sites.

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