

Evaluation of Leafhoppers and Their Relatives (*Insecta: Homoptera: Auchenorrhyncha*) as Indicators of Prairie Preserve Quality.

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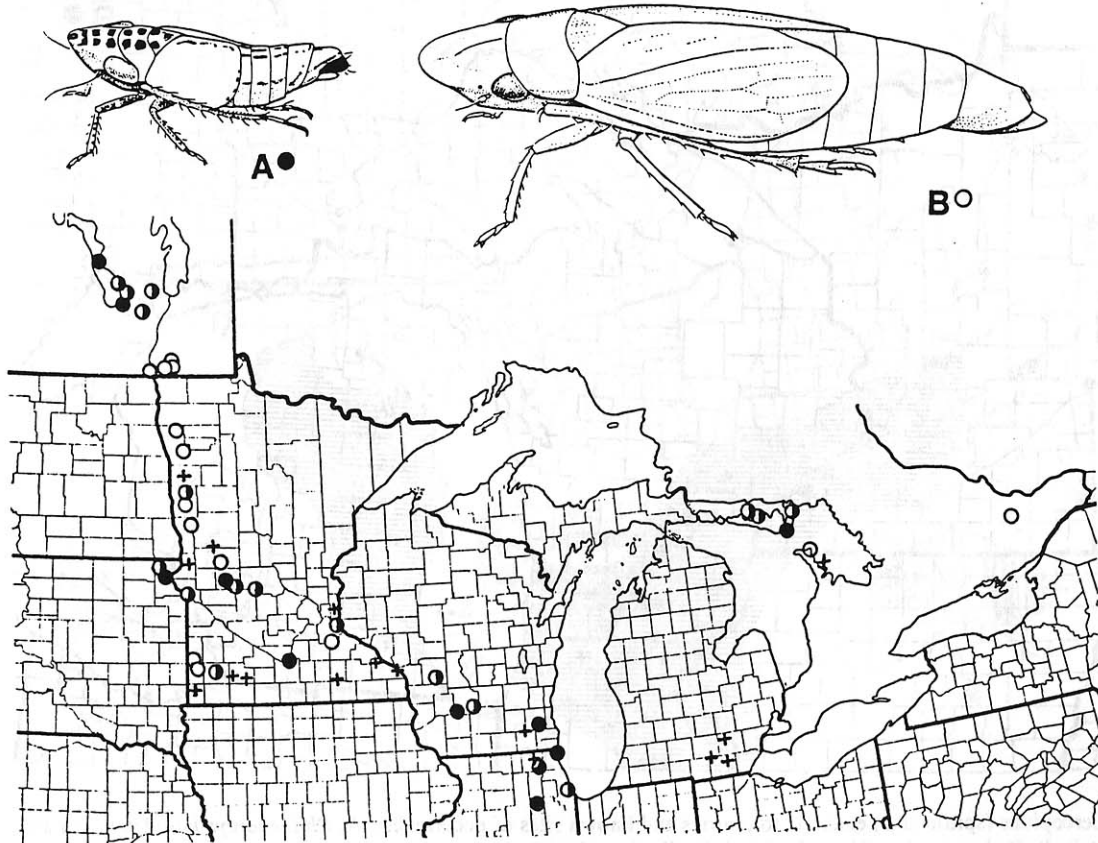
Abstract. Sampling insects in 100 northern "tallgrass" prairies and alvars yielded many Auchenorrhyncha that are unknown from other ecosystems. Those species hypothesized as endemic to prairies include 72 leafhoppers (Cicadellidae), 2 spittlebugs (Cercopidae) and 7 planthoppers (Caliscelidae) including 30 species recorded for the first time in Minnesota, 21 in Wisconsin, 14 in Manitoba, 3 each in North Dakota and Ontario, 2 in Illinois and 1 from Michigan. Spittlebugs are distributed on the prairies chiefly by habitat and apparently are affected little by prairie management practices. Their persistence in disturbed habitats makes them chiefly useful as markers of prehistorical prairie extent. The number of prairie-endemic species of leafhoppers and caliscelids can be used as a test for satisfactory faunal preservation within the study area. The presence of at least 4 of the 9 most common prairie-endemic species can provide a quick test. One-third of the "best" sites (with 9-24 prairie-endemic

species) are managed only by haying and/or by infrequent use of fire. Full faunal regeneration after a fire takes at least 4 years.

Key words: Caliscelidae, Cercopidae, Cicadellidae, faunal diversity, fire management, leafhopper, planthopper, prairie, spittlebug

Introduction

Prairie preserve management strategies are based largely on easily observed effects. As a consequence, moths and butterflies are usually the only insect fauna that are considered when establishing prairie management practices. Thus, smaller prairie insects are little utilized and seldom sampled intensively.



FIGs. 1A-B. Cicadellid (leafhopper) specialists on prairie dropseed. A, *Aflexia rubranura*, male; B, *Memnonia* nr. *grandis* Shaw, female. Dots, *Aflexia* only; circles, *Memnonia* only; split circles, both species together; crosses, prairie dropseed common, but without either leafhopper species.

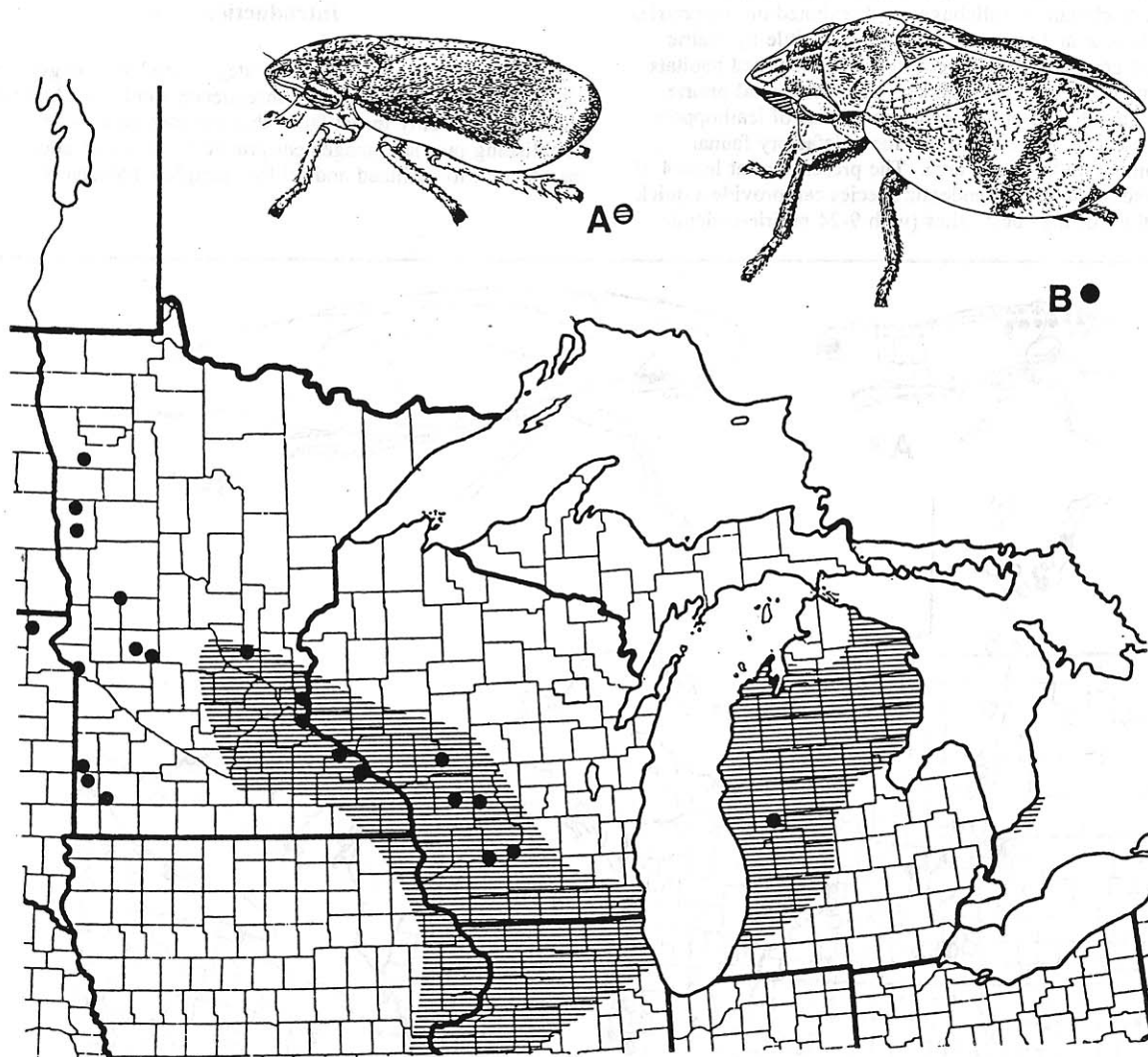
Here I report on leafhoppers (Fig. 1) and related "short-horned" bugs, the Auchenorrhyncha, of northern prairies. These are plant feeding insects of the suborder Homoptera with tiny, inconspicuous antennae. They are common in prairie situations. They include spittlebugs (Cercopoidea), cicadas (Cicadoidea), planthoppers (Fulgoroidea), and leafhoppers and treehoppers (Membracoidea). No prairie-endemic cicadas and treehoppers occur in the northeast, and most planthoppers show no such endemism.

Although easily collected, Auchenorrhyncha are hardly ever reported from northern "tallgrass" prairies (prairies east of 100°W and north of 41°N in Illinois, the vicinity of Chicago, to 43°N in South Dakota, the vicinity of Sioux Falls). Most published reports from this area are of a single prairie-endemic species per site, with the exception of Little Rock, Iowa in the southwest corner of this area (43°N 96°W), and around Chicago (DeLong 1948) and adjacent Indiana (Panzer *et al.* in press) where leafhoppers have been collected intensively.

Unreported material in collections are equally sparse. Only 1 hillside at Arena, Wisconsin (sampled in 1965 by Stannard and Smith of the Illinois Natural History Survey) yielded specimens of more than 1 prairie-endemic species. There were 3 species, each representing a different family: *Philaenarcys killa* (Cercopidae), *Bruchomorpha dorsata* (Caliscelidae), and *Laevicephalus vannus* (Cicadellidae). These 3 families are the subject of this study.

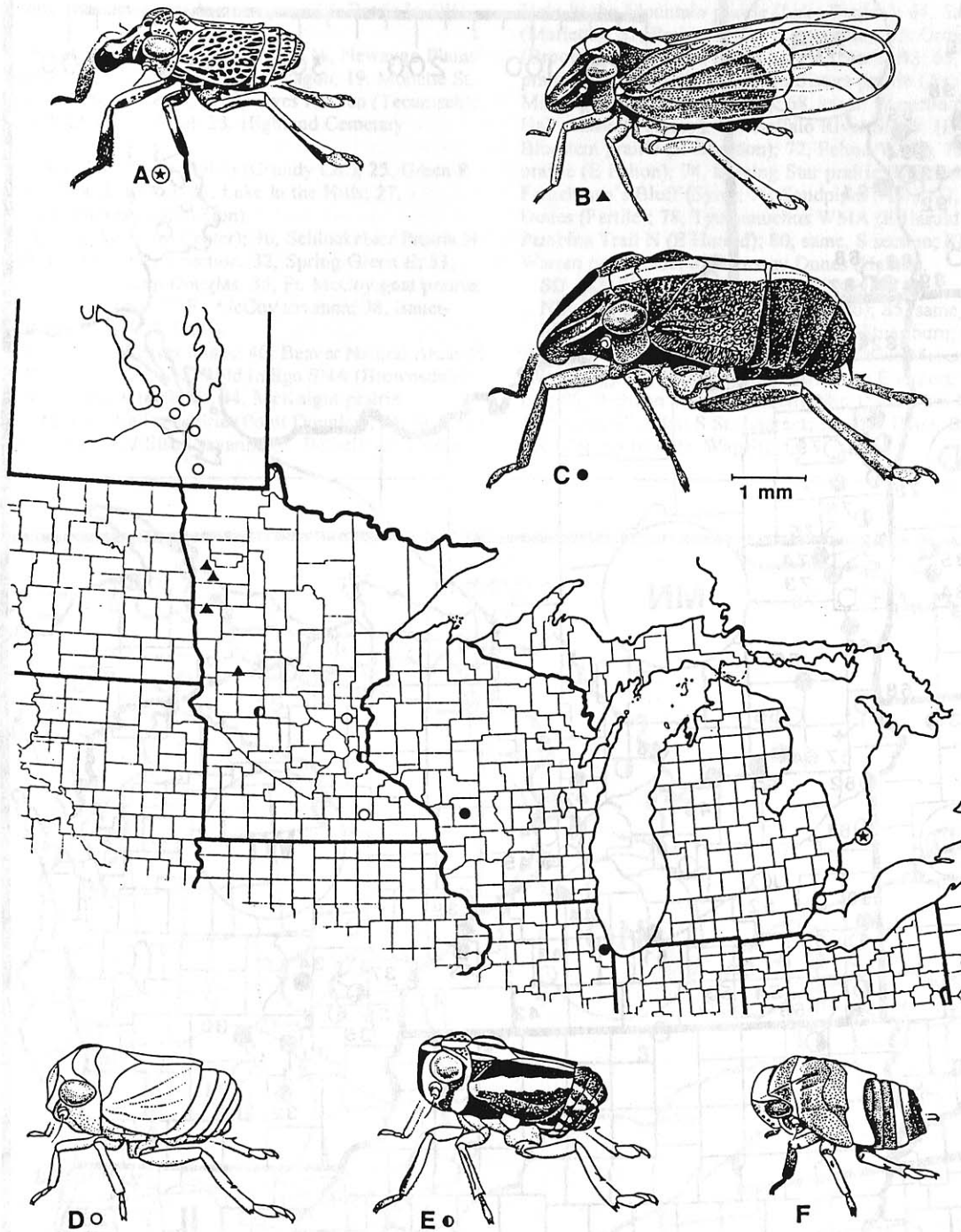
Cercopoidea: Cercopidae

Spittlebugs or froghoppers (Figs. 2 A-B) include about 50 North American species (Hamilton 1982) of which 19 occur in Michigan (Hanna and Moore 1966). These include 4 species in northern prairies, of which 3 feed on grasses; 2 appear to be prairie-endemic.

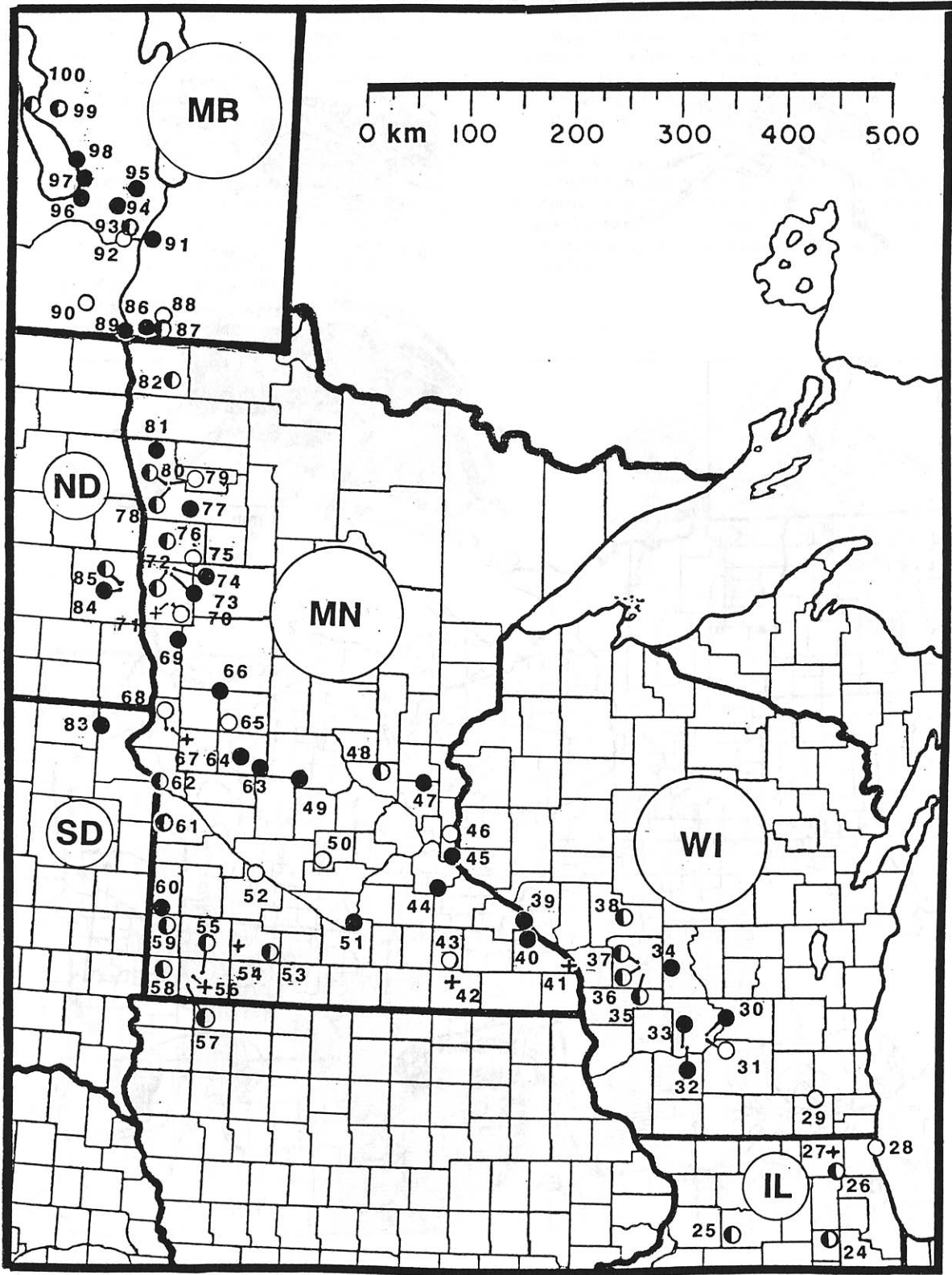


FIGS. 2A-B. Cercopidae (spittlebugs) endemic to prairies and known sites of occurrence. A, *Philaenarcys killa* Hamilton and distribution (hatched); B, *Lepyrionia gibbosa* Ball and distribution (dots).

* "Tallgrass" in the traditional sense, being dominated by grasses that can attain heights of over 0.5 m. Within most of the study area, dominant grasses form extensive tall swards only following a fire; at other times, their growth usually is stunted.



FIGS. 3 A-F. Calisceline Fulgoroidea and known sites of occurrence. A, *Fitchiella robertsoni*, male; B, *Bruchomorpha beameri*, long-winged female; C, *B. extensa*, female; D, *Aphelonema simplex*, male; E, *Peltonotellus bivittatus*; F, same, nymph. Species A, B, C, D, and E represented by star, triangle, dot, circle, and split circle, respectively.



FIGS. 4 A-B. Prairie sites sampled in U.S.A., Ontario, and southern Manitoba; A, western half; B, eastern half. Dot: best sites (9-19 prairie-endemic cicadellid and calicellid species); split circle: average sites (4-8 such species); circle, poor sites (1-3 such species); cross, no prairie-endemic Homoptera found.

ON - 1 Ramsay alvar (Almonte); 2, Point Anne alvar (Belleville); 3, Brantford Golf Club; 4, Matchette Road half of Ojibway Prairie (Windsor); 5, Walpole Is.; 6, Watson Nature Trail (Sarnia); 7, Prairie Point (Cape Croker I.R.); 8, Cabot Head; 9, Little La Cloche Is.; 10, Great La Cloche Is.; 11, Goat Is.; 12, Wikwemikong I.R.; 13, Barrie Is. causeway; 14, Barrie Is. (W extremity).

MI - 15, Maxton Plains (Drummond Is.); 16, Newaygo Plains (9 km E Newaygo); 17, Fennville; 18, Pokagon; 19, Monette St. fen (Cassopolis); 20, Cement City; 21, Ives Rd. fen (Tecumseh); 22, Pinckney SRA (N Chelsea); 23, Highland Cemetary (Ypsilanti).

IL - 24, Goose Lake State Prairie (Grundy Co.); 25, Green R. Conservation Area (Lee Co.); 26, Lake in the Hills; 27, Woodstock; 28, Illinois Beach (Zion).

WI - 29, Lulu Lake (Troy Center); 30, Schluckebier Prairie N (Prairie du Sac); 31, same, S section; 32, Spring Green E; 33, same, W section; 34, Camp Douglas; 35, Ft. McCoy goat prairie; 36, Ft. McCoy drop zone; 37, Ft. McCoy savanna; 38, Bauer-Brockway Prairie (Black R. Falls).

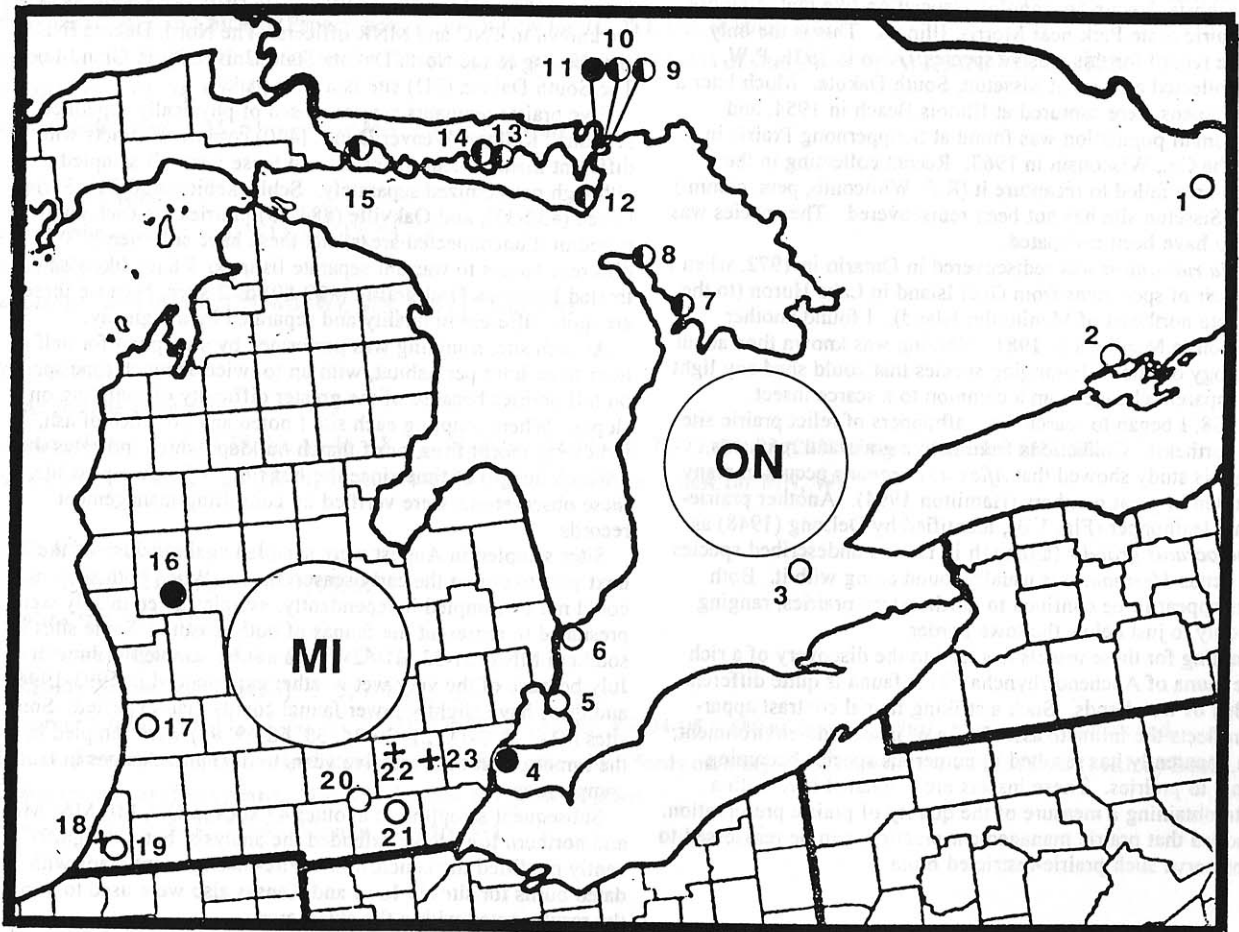
MN - 39, Kellogg-Weaver dunes; 40, Beaver Natural Area; 41, King's Bluff (Winona Co.); 42, Wild Indigo SNA (Brownsdale); 43, Iron Horse prairie (Hayfield); 44, McKnight prairie (Randolph); 45, Lost Valley prairie (Point Douglas); 46, St. Croix savanna (Bayport); 47, Allison savanna (E. Bethel); 48, Uncas

Dunes (Orrock); 49, Roscoe prairie; 50, Schaefer prairie (Brownton); 51, Kasota prairie (St. Peter); 52, Delhi prairie; 53, Mountain Lake; 54, Expandere WMA; 55, Lundblad prairie (Slayton); 56, 3 km W Chandler; 57, 7 km W Chandler; 58, Blue Mounds St. Pk. (Luverne); 59, Prairie Coteau (Holland); 60, Hole-in-the-Mountain prairie (Lake Benton); 61, Salt Lake WMA (Marietta); 62, Prairie WMA (Ortonville); 63, Ordway prairie (Brooten); 64, Glacial Lakes St. Pk. (Starbuck); 65, Staffanson prairie (Kensington); 66, Seven Sisters prairie (Ashby); 67, Miller prairie E (NE Dumont); 68, same, W section; 69, Town Hall prairie (Rothsay); 70, Buffalo River St. Pk. (E Glyndon); 71, Bluestem prairie (E Glyndon); 72, Felton WMA; 73, Bicentennial prairie (E Felton); 74, Blazing Star prairie (E Felton); 75, Frenchman's Bluff (Syre); 76, Sandpiper (Ada); 77, Agassiz Dunes (Fertile); 78, Tympanuchus WMA (E Harold); 79, Pembina Trail N (E Harold); 80, same, S section; 81, Crookston-Warren rwy. grade; 82, Norway Dunes (Halma).

SD - 83, Sica Hollow St. Pk. (N Sisseton).

ND - 84, Oakville Prairie S (Emerado); 85, same, N section.

MB - 86, Tolstoi; 87, Gardenton; 88, Stuartburn; 89, Emerson; 90, Myrtle; 91, Transcona; 92, Living Prairie Museum (Winnipeg); 93, Winnipeg, industrial site E airport; 94, Grosse Isle; 95, Brennan prairie (N Stony Mtn.); 96, 7 km E St. Ambrose; 97, 8 km S St.-Laurent; 98, Oak Point, B; 99, Camper; 100, The Narrows (E Wapah).



Fulgoroidea: Caliscelidae

These insects, unofficially called "piggy bugs", are usually very robust insects without obvious wings and often with a snout-like head process (Figs. 3 A-F). There are about 60 North American species in 4 genera, mostly characteristic of the southwestern plains (Doering 1940, 1941); their reported hosts are grasses. These tiny insects were placed previously in the family Issidae, but are related more closely to Dictyopharidae such as *Rhaphiophora*.

Membracoidea: Cicadellidae

Leafhoppers are abundant and diverse, with over 3000 North American species, of which 800 are associated with grasses and sedges. More than 200 of these are endemic to prairies (Hamilton & Whitcomb 1993), and there are smaller numbers of other prairie-endemic species on broadleaved hosts.

Historical

This study began as an attempt to identify prairie sites that still retain populations of a leafhopper of northeastern prairies that was thought to have been extirpated: *Aflexia rubranura*, a bug easily recognized by the bricklike spots on the head and the bright red "tail" spot on the male abdomen (Fig. 1 A). It is the only species in its genus.

This species was collected first by H.H. Ross and colleagues in 1935-1936 in the vicinity of Chicago, Illinois, where it once occurred in large numbers on wet black-soil prairie dominated by short grasses (DeLong 1935, as *Flexamia rubranura*), probably in an *Eleocharis-Juncus-Sporobolus* association like that at Goose Lake Prairie State Park near Morris, Illinois. This is the only literature record for this elusive species. Also in 1936, P.W. Oman collected a series at Sisseton, South Dakota. Much later a few specimens were captured at Illinois Beach in 1954, and another small population was found at Scuppernong Prairie in Waukesha Co., Wisconsin in 1963. Recent collecting in the Chicago area failed to recapture it (R.F. Whitcomb, pers. comm.) and the Sisseton site has not been rediscovered. The species was feared to have been extirpated.

Aflexia rubranura was rediscovered in Ontario in 1972, when I took a pair of specimens from Goat Island in Lake Huron (to the immediate northeast of Manitoulin Island). I found another population in Manitoba in 1981. Nothing was known then about the biology of this wide-ranging species that could shed any light on its apparent change from a common to a scarce insect.

In 1988, I began to search for leafhoppers of relict prairie sites in the northeast. Collections from native grassland remnants during this study showed that *Aflexia rubranura* occurs in many sites, often in great numbers (Hamilton 1994). Another prairie-endemic leafhopper (Fig. 1 B), identified by DeLong (1948) as *Parabolocratus grandis* (although in fact an undescribed species of the genus *Memnonia*) is usually found along with it. Both species appear to be confined to northeastern prairies, ranging south only to just below the Iowa border.

Sampling for these insects has led to the discovery of a rich prairie fauna of Auchenorrhyncha. This fauna is quite different than that of woodlands. Such a striking faunal contrast apparently reflects the intimate association of insect and environment, which apparently has resulted in numerous species becoming endemic to prairies. These insects are evaluated here with a view to obtaining a measure of the quality of prairie preservation. It is hoped that prairie management practices can be reassessed to help preserve such prairie-restricted biota.

Methods

The sample area chosen extends from southern Ontario to the Red River valley of the Dakotas, northwest to Lake Manitoba (Figs. 4 A-B). This is believed to comprise the majority of northern "tallgrass" prairie areas from presettlement days and includes "prairie peninsula" relict prairies and alvars (Hamilton 1994).

Sites

Sites were deemed to be "prairie" that had stands of cordgrass (*Spartina* spp.), prairie dropseed (*Sporobolus heterolepis*), grama (*Bouteloua* spp.), June grass (*Coeleria* spp.) or porcupine grass (*Stipa spartea*). Bluestems (*Andropogon* spp.) and Indian grass (*Sorghastrum* spp.) were not used to define sites, because these prairie-dominant grasses are not limited to prairies and similar arid grasslands, being found in southeastern woodlands or invading roadsides.

One hundred sites were sampled (Figs. 4 A-B). This does not pretend to be an exhaustive survey of relict prairie sites in the study area, and the work is on-going. Sites were selected mainly on the advice of botanists at Agriculture Canada and personnel involved in prairie conservation with The Nature Conservancy (TNC) and state (DNR) or provincial (MNR) agencies. Some additional sites were discovered during collecting trips.

Grassland sites in Ontario (ON) and Michigan (MI) have been sampled and mapped recently (Hamilton 1987, 1990). Most of the Minnesota (MN) sites have been described and mapped (Wendt 1984). Most sites in Wisconsin (WI) and Manitoba (MB) are known to TNC and MNR officers. The North Dakota (ND) sites belong to the North Dakota State University in Grand Forks. The South Dakota (SD) site is a state park.

Five prairie remnants are composed of physically separated sections. Kellogg-Weaver Dunes (#40) comprise 3 tracts with different management histories, and these were all sampled although not itemized separately. Schluckebier (#30-31), Spring Green (#32-33), and Oakville (#84-85) prairies are each composed of 2 unconnected areas, and these have sufficiently different faunas to warrant separate listings. I have likewise treated Pembina Trail prairie (#79-80) as 2 sites, because these are quite different in quality and separated by a highway.

At each site, sampling was performed by sweep net for half an hour to an hour per habitat, with up to twice as much time spent on hill prairies because of the greater difficulty of sampling on slopes. When sampling each site I noted any presence of ash, indicating recent fires, or of thatch buildup, which indicates the probable length of time since the last fire. Wherever possible, these observations were verified by consulting management records.

Sites sampled in August were sampled again in June of the next year to obtain the early season fauna. When both seasons could not be sampled independently, samples taken in July were presumed to represent the faunas of both seasons. Some sites in southern MN (#51-53, 61-62) could not be sampled in June or July because of the very wet weather experienced in 1993-1994, and these have slightly lower faunal counts than expected. Some sites (#1-2, 4, 7-11, 21, 30-34, 53, 68-69, 94) were sampled in the same season in successive years to note any changes in faunal composition.

Subsequent sampling in another 47 sites in ON, MI, MN, MB and northern Iowa have extended the analysis, but not significantly modified the conclusions. Fire-management maps with dated burns for sites in Iowa and Kansas also were used to verify the results noted within the study area.

For analysis, prairie habitats were divided into 6 categories: (A) alvars (limestone plains that are wet in spring and very dry in summer); (B) bottom (wet) land (dominated by cordgrass, sedges and/or mat muhly, *Muhlenbergia richardsonis*); (C) common prairies (deep-soil mesic plains); (D) dry prairies (on sandy soil; on coteaux, moraines, or limestone ridges; "goat prairie" on steep hillsides; "dolomite prairie" on lower ridges); and (E) railway embankments and associated ditches. The last of these differs from the others in having been burned annually during the era of steam locomotives, although such practices have long been discontinued.

Fauna

Total leafhopper faunas have been recorded for Minnesota (Medler 1942), Illinois (DeLong 1948), Ontario (Beirne 1956), and Manitoba (Hamilton 1972). In particular, bugs of forested

habitats in this area are well studied. Much material is deposited in the Canadian National Collection of insects, housed by Agriculture Canada in Ottawa.

Bugs sampled in prairies but not known from the forest fauna are presumed to represent prairie endemics. This is assumed to apply even if they are found occasionally in nonprairie native grasslands. For example, both forest-glade and prairie-inhabiting species may be found on native grasses on sandy sites such as beach dunes. A few species that are dominantly prairie-inhabiting may be found occasionally in other nonprairie sites. If these are encountered rarely (e.g. *Limotettix urnura* in an alkaline swale in woods), they may still be considered as prairie-endemic. However, if they are carried by wind over long distances, as is *Balclutha neglecta*, or tend to invade old meadows, as does *Stirellus bicolor*, then they are not "endemic" even if characteristic of plains.

TABLE 1 - Caliscelidae, Cercopidae, and Cicadellidae of prairie sites. Numbers refer to sites listed in Table I and located on Fig. 1 (ON=1-14, MI=15-13, IL=24-28, WI=29-38, MN=39-79, SD=80, ND=81-82, MB=83-100). Common (>12%) nonendemic taxa listed by state/province only. Records by DeLong (1948) are marked with an asterisk (*).

CALISCCELIDAE

A: prairie endemics

Aphelonema simplex: 4-5, 43, 47, 86, 91, 94-95, 97-98 (10% of sites); **new for MN.**

Bruchomorpha beameri: 66, 73, 77-78; **new for MN.**

B. dorsata: 9, 21, 32, 35, 37-40, 47, 49, 51, 57, 62, 64, 69, 73-74, 77, 83-84, 86, 92, 96-97 (24% of sites); **new for ON, MN, MB.**

B. extensa: 36; also Chicago (Panzer, pers. comm.); **new for IL, WI**; rare in study area.

B. jocosca: 16, 30-31, 36, 51, 60, 63, 73, 77, 83-84, 86, 89, 94, 96-97 (16% of sites); **new for WI, MN, ND, SD, MB.**

B. keidensia: 87, 94, 97; rare.

Peltonotellus bivittatus: 45, 63; **new for MN**; rare in study area.

B: other species

Bruchomorpha oculata: 1-3, 9-13, 16, 47, 63, 74.

B. pallidipes: 16, 38; rare.

Peltonotellus histrionicus: ON, MI, WI, MN, MB (15% of sites).

CERCOPIDAE

A: prairie endemics

Lepyronia gibbosa: 16, 30-39, 40, 45-46, 48, 57, 59-60, 62-64, 66, 70, 72-73, 77, 83 (27% of sites); **new for MN, SD.**

Philaenarcys killa: 16, 25-26, 28-34, 36-40, 44-45, 48, 51 (18% of sites); **new for MN, WI.**

B: other species

Aphrophora spp.: 21-22, 37, 43, 77, 94, 97.

Clastoptera spp.: 18, 21, 33.

Lepyronia quadrangularis: 4, 18-19, 21, 70, 94.

Neophilaenus lineatus (European): 3, 5, 7-9, 11, 15.

Philaenarcys bilineata: 9-11, 57, 60, 63, 70-71, 73, 75, 77, 83, 87, 89, 94-95 (16% of sites). On little bluestem on alvars and prairies; possibly subspecifically distinct from northern race which feeds on bluejoint, *Calamagrostis canadensis* (Michx.) Beauv.

Philaenus spumarius (European): ON, MI, IL, MN, SD (49% of sites).

Prosapia ignipectus: 5, 32-33, 43, 62; **new for MN, WI.**

TABLE 1 contd.

CICADELLIDAE

Aceratagallia nanella: 70; new for MN; rare in study area.

A. n. sp. A: 40; new for MN; rare.

A. n. sp. B: 2, 11-14, 16, 32, 39, 47, 75 (10% of sites); new for ON, MN, WI.

A. n. sp. C: 7, 10-11, 15-16, 34, 48, 63, 69, 72, 81, 83, 86, 88, 90-91 (16% of sites); new for ON, WI, MN, SD, MB.

Aflexia rubranura: 9-14, 24, 26, 28, 30, 32, 35, 45, 49, 51, 55, 62-64, 73-74, 83, 94-98, 100 (27% of sites); new for WI, MN, SD, MB.

Amblysellus punctatus: 32, 38, 97, 100; new for WI, MB.

Athysanella attenuata: 44, 93; new for MN.

A. terebrans: 77, 82, 95.

Attenuipyga sp.: 94, 97-98; new for MB; rare.

Auridius helvus: 16, 32, 34, 38, 47; new for WI.

Chlorotettix brevidus: 28*; rare.

C. spatulatus: 4, 59; also reported (DeLong 1948) from 28.

Commellus colon: 32, 47, 57, 60, 62-63, 73-74, 83-84, 91, 94, 97 (13% of sites); new for WI.

C. comma: 16, 25, 28*, 34, 37, 39, 43-44, 51, 60, 74, 80, 83 (12% of sites); new for WI.

C. sexvittatus: 77, 82, 93; new for MB.

Cuerna sayi: 33, 36, 40, 69.

Deltocephalus n. sp.: 69; new for MN; unique specimen.

Dikraneura arizona: 44; new for MN; rare in study area.

Dorycara platyrhynchus: 34, 45, 47; new for WI.

D. minor: 60, 74, 77, 80, 82, 85, 89-91.

Dorydiella kansana: 4, 7, 28.

Driotura robusta: 38, 59-60, 68, 73, 75, 78, 84; new for ND, WI

Extrusanus oryssus: 16, 24, 26, 28, 32, 34, 45, 47, 49-50, 53, 58, 60, 63, 65, 69, 74, 76-77, 80, 82, 84-86, 89, 91-95, 97-98, 100 (33% of sites).

Flexamia abbreviata: 30, 32, 39, 47, 60, 63-64, 66, 73-74, 77 (11% of sites).

F. albida: 33, 40, 45, 51, 57-60, 62-64, 66, 83 (13% of sites); new for WI.

F. atlantica: 32; new for WI; rare in study area.

F. dakota: 69; new for MN; rare in study area.

F. decora: 85, 94-100.

F. delongi: 8-16, 30, 34, 36-38, 40, 94-98 (20% of sites); new for MN.

F. graminea: 52, 55, 73, 81, 84; new for MN.

F. pectinata: 26, 29, 32-33, 40, 44-45, 48, 51, 60, 63, 66 (12% of sites); new for WI.

F. prairiana: 21, 28*, 43, 49, 52-53, 55, 69, 72-73, 77, 78-81, 86-89, 91-92, 94, 96-97, 100 (24% of sites); new for MI.

F. serrata: 45, 63, 69, 84, 86-87, 94-95, 97-98; new for MN.

F. stylata: 25, 45, 59-60, 63; new for IL.

Graminella mohri: 8, 28*, 81; new for MN.

G. oquaka: 4-5, 28*, 47, 51; new for MN, WI.

G. pallidula: 4.

Gypona contana: 89, 91, 94, 96.

Gyponana vincula: 30, 33, 49, 57, 60, 62, 64, 69, 72-73, 81 (11% of sites); new for MN.

Hecalus viridis: 28*, 34, 39, 44, 47, 77, 83, 86, 89; recorded as *Parabolocratus* (DeLong 1948).

Hebecephalus signatifrons: 28*; rare; needs confirmation.

Laevicephalus minimus: 2-3, 26, 32-33, 35, 40, 43-45, 47, 51, 57-58, 60, 63, 66, 73, 83 (19% of sites).

L. poudris: 86, 94-97.

L. saskatchewanensis: 93; rare in study area; new for MB.

TABLE 1 contd.

- L. unicoloratus*: 4, 6-11, 13, 16, 20-21, 23-26, 28, 30-34, 36-40, 44-49, 51, 53, 55, 57-66, 68-70, 72-74, 76-83, 86-87, 89, 94-95, 97-99 (67% of sites).
- L. vannus*: 36, 40; rare in study area.
- Limotettix elegans*: 4; rare.
- L. urnura*: 2, 4, 7-13, 15, 28*, 43, 53, 94.
- Lonatura megalopa*: 44, 60, 63, 66; new for MN.
- L. salsura*: 61, 94, 97; new for MN.
- L. teretis*: 94, 97; new for MB; rare in study area.
- Memnonia nr. grandis*: 1, 8-11, 13-14, 30, 33, 35, 44-45, 49, 55, 57, 59-60, 62-63, 65, 69, 72-74, 76, 80-81, 83, 86-89, 94-95, 97-98 (36% of sites); new for WI, SD, MB.
- M. n. sp.*: 49, 69, 76, 84, 86, 94-95, 97-98, 100 (10% of sites); new for MN, ND, MB.
- Mesamia ludoviciana*: 47, 77, 83, 89, 94; new for MB.
- Mocuellus americanus*: 9-11, 58, 74, 76, 80, 83-85, 91, 94-100 (18% of sites); new for MN.
- Neohecalus nr. lineatus*: 17, 19, 28*, 55, 61, 69, 72, 80-81, 97-98 (10% of sites); recorded (DeLong 1948) as *Hecalus lineatus*.
- Orocastus perpusillus*: 73, 77; new for MN; rare in study area.
- Paraphlepsius altus*: 28*, 36, 44, 60, 63, 66.
- P. lobatus*: 11, 15, 30, 49, 52, 64, 94; new for MB.
- P. lupalus*: 28*; rare; recorded (DeLong 1948) as *P. turpiculus*.
- P. nebulosus*: 55, 58; new for MN; rare in study area.
- P. umbrosus*: 33, 35, 37-38, 47, 94.
- Pendarus magnus*: 94, 97-98; new for MB.
- Polyamia caperata*: 16, 30, 32-33, 39-40, 44-47, 49, 51, 60, 63-64, 66, 69, 81, 83, 91, 94, 97 (22% of sites).
- P. dilata*: 32, 35, 40; new for MN, WI; rare.
- P. rossi*: 25, 32; new for WI.
- Prairiana cinerea*: 33, 58, 60, 82, 85, 97; new for WI.
- P. nr. kansana*: 32-34, 39, 47-48, 55, 60, 63-64, 86-87, 95, 99 (14% of sites).
- Psammotettix knullae*: 61; new for MN.
- Rosenus cruciatus*: 16, 28*, 32, 36, 39, 44, 47, 73, 75-76; reported (DeLong 1948) as *Hebecephalus*; new for WI.
- Texanus cumulus*: 28*; rare in study area.
- T. marmor*: 9.
- Unoka gillettei*: 77; new for MN; rare in study area.

B: other species

- Aceratagallia humilis*: 11, 25-26, 30, 33-34, 43, 77, 80.
- A. sanguinolenta*: ON, MI, WI, MN, SD, ND, MB (27% of sites)
- A. n. sp. D*: 2, 16, 25, 28*, 31-34, 77; recorded (DeLong 1948) as *A. sanguinolenta*.
- Acinopterus sp.*: 32.
- Agalliopsis sp.*: 28*.
- Agalliota spp.*: 4, 21, 28*, 43, 48, 55, 63-64, 69, 72; recorded (DeLong 1948) as *Agallia*.
- Amplicephalus inimicus*: ON, MI, IL, WI, MN, ND, MB (52% of sites).
- Anoscopus spp. (European)*: 59-60, 81, 94, 97.
- Aphrodes spp. (European)*: ON, MI, IL, WI, MN (16% of sites).
- Athysanella acuticauda*: 28*
- A. longicauda*: 1-3, 16.
- Athysanus argentarius (European)*: ON, MI, IL, WI, MN, ND, MB (66% of sites).
- Balclutha spp.*: ON, MN, SD, ND, MB (36% of sites).

TABLE 1 contd.

- Chlorotettix fallax*: 4; rare in study area.
- C. galbanatus*: 4.
- C. obsenus*: 28*; rare; possibly a damaged form of *C. unicolor*.
- C. tergatus*: 55.
- C. unicolor*: ON, MI, IL, WI, MN, MB (48% of sites).
- Cicadula* spp.: ON, MI, IL, WI, MN, MB (15% of sites).
- Colladonus clitellarius*: 28*.
- Commellus cedilla*: 34, 49, 86, 94-96, 98.
- Cosmotettix* spp.: 10.
- Cribrus shingwauki*: 28*; recorded as *Laevicephalus* (DeLong 1948).
- Cuerna striata* complex: 3, 47, 75, 78, 97.
- Deltocephalus balli*: 4, 28*, 100.
- Dikraneura angustata*: 30, 53.
- D. hungerfordi*: 91; new for MB.
- D. mali*: 2, 59, 61, 75.
- D. urbana*: 49.
- D. variata*: 94, 96.
- Diplocolenus configuratus*: ON, IL, WI, MN, ND, MB (44% of sites).
- D. evansi*: 2, 7-8, 10-11, 13-14, 93, 95.
- Doratula stylata* (European): ON, MI, IL, WI, MN, SD, ND, MB (58% of sites).
- Draeculacephala* spp.: ON, MI, IL, WI, MN, MB (30% of sites).
- Driotura gammaroides*: ON, MI, IL, WI, MN, ND, MB (21% of sites).
- Elymana sulphurella* (European): 1, 8.
- Empoasca* spp.: 2, 7, 63, 75, 82.
- Erythroneura ziczac*: 55.
- Euscelis* sp.: 28*.
- Exitianus exitiosus*: IL, WI, MN (17% of sites); recorded (DeLong 1948) as *E. obscurinervis*.
- Flexamia inflata*: 2, 4, 24, 91, 95.
- F. picta*: 24; rare in study area.
- F. reflexa*: 4, 21; new for MI; rare in study area.
- Forcipata* spp.: ON, MI, IL, WI, MN, SD, MB (21% of sites).
- Graminella fitchii*: 28*
- G. nigrifrons*: 16, 19, 22.
- Graphocephala* spp.: 32, 37.
- Gypona melanota*: ON, MI, MN (16% of sites).
- Gyponana ortha*: 28*; recorded as *G. conferta* (DeLong 1948).
- Gyponana serpenta*: 15, 92, 94, 97.
- Hecalus major*: 28*, 39, 41, 69, 74, 82, 84, 89, 95, 100.
- H. montanus*: 28*, 34, 83-84, 89-91, 93; recorded as *H. rotundus* (DeLong 1948).
- Helochara communis*: 53, 84.
- Idiocerus* spp.: 1, 11, 24, 28*, 34, 43, 81, 94.
- Idiodonus* sp.: 7.
- Jikradia olitoria*: 4, 32.
- Laevicephalus sylvestris*: 70.
- Latalus* spp.: ON, MI, IL, WI, MN, SD, MB (61% of sites).

TABLE 1 contd.

Limotettix balli: 8-9, 13, 15, 21.
L. ferganensis: 28*, 43, 53, 97; recorded (DeLong 1948) as *L. striolus*.
L. kryptus: 24, 69, 79.
L. osborni: ON, MI, IL, WI, MN, MB (27% of sites).
L. plutonius: 10, 34, 99.
L. sphagneticus: 13, 86.

Macropsis spp.: 28*, 43.
Macrosteles spp.: ON, MI, IL, WI, MN, SD, MB (51% of sites).
Memnonia flvida: 4.
Menosoma cincta: 33; **new for WI**.
Mesamia nigradorsum: 4, 24, 28*, 38, 40, 69, 72, 81, 89, 94, 97.
Neocoelidia tumidifrons: ON, IL, WI, MN, ND, MB (20% of sites).
Neokolla hieroglyphica: ON, MI, IL, WI, MN, MB (15% of sites).
Norvellina sp.: 28*.
Paluda gladiola: 12, 69, 74, 76, 84, 86, 91, 94-95, 97.
Paraphlepsius fulvidorsum: 1, 7.
P. irroratus: ON, MI, IL, WI, MN, SD, MB (20% of sites).
P. solidaginis: 28*, 94, 97.
P. truncatus: 1-2, 6-7, 9-11, 13.
Pendarus punctiscriptus: 4, 15, 31, 80, 94.
Platymetopius spp.: 1, 10, 37, 46, 62, 69, 77-78, 80, 94, 96.
Polyamia apicata: 1, 8-9, 25, 28*, 32, 34, 46-47, 66.
P. compacta: ON, IL, WI, MN (21% of sites).
P. obtecta: 47; rare in study area.
P. weedi: 25, 33-34.
Prescottia lobata: 28*.
Psammotettix lividellus complex: ON, MI, IL, WI, MN, ND, MB (32% of sites).
Scaphoideus spp.: 2, 4, 10, 15, 28*, 37, 47, 94.
Scaphytopius spp.: ON, MI, IL, WI, MN, SD, MB (32% of sites).
Sorhoanus spp.: ON, MI, IL, WI, MN, MN, ND, MB (20% of sites).
Stirellus bicolor: MI, WI, MN, MB (13% of sites); **new for WI**.
Texananus arcostaphylag: 1, 11, 15, 47, 92, 96.
T. decorus: 94; **new for MB**.
Tylozygus bifidus: 4, 32.
Xerophloea major: 4, 24-25, 32.
Xestocephalus spp.: 2, 8, 15, 23, 83, 91-92, 94.

Results

Overall endemic species diversity

Total prairie-endemic species included 72 leafhoppers, 7 caliscelids, and 2 spittlebugs (Table I). This includes 30 species recorded for the first time in MN, 21 in WI, 14 in MB, 3 each in ND and ON, 2 in IL and 1 in MI. By contrast, the nonendemic fauna of these prairies is more diverse (over 100 species) but includes only 7 new state and provincial records of such leafhoppers.

Two prairie-endemic bugs have been collected on beach dunes in ON and MI (Hamilton 1990) but were not found on prairie sites during this study: the caliscelid *Fitchiella robertsoni* (Fig. 3 A) and the leafhopper *Macropsis quadrimaculata*, a reddish bug that is a specialist on sand cherry, *Prunus pumila*. These insects should be expected in northeastern prairies.

Spittlebugs

Four species of spittlebugs associated with grasslands were found in this survey. Two appear to represent prairie endemics.

The spittlebug *Philaenarcys killa* (Fig. 2 A) occurs east of the Red River valley in sandy or gravelly areas, where it feeds exclusively on little bluestem, *Andropogon scoparius*. It is usually flightless, but 5 long-winged individuals were taken at Schluckebier N (site 30).

The spittlebug *Lepyronia gibbosa* Ball (Fig. 2 B) feeds on a very wide variety of plants, both grasses and forbs, but is limited to well-drained soils. Therefore it is found on both sand plains and moraine hills east to MI. It also used to inhabit sandy areas near Boston, Massachusetts.

Leafhoppers and caliscelid bugs

The other 2 families of bugs show little bias in favor of habitat (Table I). The most commonly encountered species, *Laevicephalus unicoloratus*, a generalist on bluestem grasses, was found in fully 67% of sites sampled. This was as abundant on prairies as the most aggressive of introduced leafhoppers, *Athysanus argentarius* (in 66% of sites). Frequency of occurrence for 9 other common species are:

- 36% for *Memnonia* nr. *grandis* on prairie dropseed;
- 33% for *Extrusanus oryzzus* on blunt sedge, *Carex obtusata*;
- 27% for *Aflexia rubranura* on prairie dropseed;
- 26% for *Bruchomorpha dorsata* on little bluestem;
- 25% for *Laevicephalus minimus* on side-oats grama, *Bouteloua curtipendula*;
- 24% for *F. prairiana* on big bluestem, *Andropogon gerardii*;
- 22% for *Polyamia caperata* on little bluestem;
- 20% for *Flexamia delongi* on little bluestem;
- 18% for *Mocuellus americanus* on slender wheatgrass, *Agropyron trachycaulum*.

The last of these leafhoppers occupies 33% of the sites in the Red River valley (sites #56-100); otherwise, it is known in the study area only from the La Cloche Islands in Lake Huron (#9-11). *Laevicephalus minimus* is common in the south of the study area, whereas *Flexamia delongi* is common in the north; these 2 species have a narrow range overlap. All of the other species may be found in each of the habitat types throughout most of the study area. All other prairie-endemics are found in 16% or fewer of the sites.

Fauna of prairie dropseed

Only the leafhoppers *Aflexia rubranura* and *Memnonia* nr. *grandis* are found on prairie dropseed. Both have been collected repeatedly on this host but only rarely on any other plant, demonstrating that they are host-specific. These 2 leafhopper species occurred together in 18 sites. Two other sites (Sisseton, SD, 1936; Scuppernong, WI, 1963) once supported *Aflexia*, but until these sites can be reinvestigated, there is no way to determine whether *Memnonia* was also present. Only 9 sites supported *Aflexia* alone, but 18 prairie sites supported *Memnonia* alone (Fig. 1 B). Many of the latter are fire-managed prairies or railway embankments.

Discussion

Diversity

Faunal diversity is rather low in alvars, "dolomite" and "goat" prairies, which have a lower floral diversity than deep-soil prairies. The richest alvar faunas are those of the La Cloche Islands (sites #9-11), with 7-9 prairie-endemic species.

Up to 10 such species may be encountered on "goat" prairies (site #40) and 12 on "dolomite" prairies (#45). Wet prairies may have 13-14 species (#69, 95), whereas xeric deep-soil prairies have 17-19 species each (#28, 32, 47, 60, 63). Mesic deep-soil prairies are more variable, with up to 15-16 species in Minnesota (#73, 97) and up to 24 in Manitoba (#94, 97).

The absence of *Aflexia rubranura* in 7 frequently burned prairies and along most railway rights-of-way, where prairie dropseed is common, points towards fire-depopulated sites. *Memnonia* nr. *grandis* on the same host is abundant even in sites that are burned repeatedly, such as Ramsay alvar (site #1), locally known as "The Burnt Lands". Panzer (pers. comm.) has found that it is much more resistant to prairie fires than *Aflexia*, recovering to full populations within a single generation. By contrast, *Aflexia* requires 4 or more generations for full recovery (Panzer 1992), probably largely by overland migration of individuals from unburned areas with some assistance from wind. It may produce a second generation during the year, but only in the south of its range. Thus, it takes 2-4 years to recover from fire, depending on the number of its broods.

The reason for this different response to fire probably lies in the seasonality of these 2 species. *Memnonia* lays its eggs in summer; adults appear early in the spring, suggesting that nymphs hatch out before the fall. Thus, this species is active during the fall and spring when grass fires are most common and probably can escape burns by living on root crowns. By contrast, *Aflexia* apparently overwinters as eggs in exposed stems, which are highly vulnerable to fire.

It might be thought that winged females of *Aflexia* would permit this species to disperse more readily than *Memnonia*, with flightless females. Fully winged forms are usually very rare in the midsummer brood, but in Illinois, where an early summer brood also occurs, as much as 10% of females are fully winged (Panzer 1992), although males are always brachypterous. Fully winged forms occur only in unburned areas and do not appear to invade adjacent burned areas (Panzer, pers. comm.); therefore, they are probably also flightless. A burned site separated from an unburned site by a paved highway initially failed to regain its *Aflexia* population (Panzer 1992), although small populations eventually were found there (Panzer, pers. comm.), probably brought in by wind dispersal.

Both of these dropseed-specialist leafhoppers were absent or rare on high hills. Presumably these flightless insects are not active dispersers up steep slopes. By contrast, low hills (e.g., sites #45, 63, 64) had some of the heaviest populations of *Aflexia*.

Categories

The prairies sampled can be divided into 6 roughly equal portions (Table II): *depauperate*, 0-1 endemic species; *poor*, 2-3 such species; *fair*, 4-5 such species; *good*, 6-8 such species; *very good*, 9-11 such species; *excellent*, 12-24 such species. Thus, half the maximum number of species (or more) per site occur in only the top 1/6th of the sites.

No sites in the "depauperate" to "poor" categories support populations of *Aflexia rubranura*. Many of these sites have been burned heavily (e.g. railway embankments) or were burned too recently for the fauna to recover. The "fair" category shows 25% of sites that support *Aflexia*; most are alvars. Of the sites rated "good" to "very good", over 40% support *Aflexia*. For sites in the "excellent" category the comparable figure is 63%.

Similar results may be obtained by grouping prairie sites according to the 9 most common leafhoppers and caliscelids (Table III). Overall, 56% of the sites received the same rating, whereas only 4% changed by more than 1 level, and these only by 2 levels. Because of the smaller number of species considered, the groups are larger and, therefore, less accurately divided into 6ths; thus 27 received a higher rating, whereas only 17 receive a lower one. The results of such a rating compensate for regional faunal diversity, thus lowering the rating of Manitoban prairies and raising that of Ontario alvars. Such a rating system has the further advantage in being easier to apply, because only 9 target species must be sampled and identified.

Another alternative system ranks prairie sites by the presence of species considered rare in the sample area (Table IV). Only 22% of the sites sampled contained such species; these correspond fairly well with Table III except in 4 cases. This is a rather subjective method, because "rare" may refer to sampling defects rather than to actual scarcity. It also relies upon intensive collecting to disclose insects that may be very difficult to find. Nevertheless, it helps to draw attention to localities of special scientific interest, such as Zion, IL (site #28) which has by far the largest number of rare, prairie-endemic species.

Table 2. Sites (numbered as in Fig. 4) ranked by numbers of prairie endemic cicadellid and caliscelid species.

DEPAUPERATE: poorest 1/6th

0 spp. B-22, 54; C-27, 67, 71; DG-41; DM-56; E-18, 42
1 sp. A-1; B-17, 19, 20; C-50; DM-23, 29; DS-3; E-6

POOR: second 1/6th

2 spp. B-5, 70; C-68, 79; DM-46; DS-31; E-90
3 spp. A-2; B-21, 52, 65; C-88, 92; DM-75; E-43

FAIR: third 1/6th (below average)

4 spp. A-7, 12*, 14*, 15; B-53, 61, 99; C-78; DS-25; E-93
5 spp. A-8; B-24*, 85; DM-26*; DS-37, 48

GOOD: fourth 1/6th (above average)

6 spp. A-13*; B-72; C-76, 87; DG-35*; DM-59; DS-82
7 spp. A-10*; C-38, 57, 62*; DD-58, 100*
8 spp. A-9*; B-80; C-55*; DS-4, 36

VERY GOOD: fifth 1/6th

9 spp. A-11*; B-30*, 84, 91; C-89, 96*; DM-64*, 66; DS-34; E-81
10 spp. C-49*, 51*, 74; DS-16, 39
11 spp. DG-40; DM-33

EXCELLENT: top 1/6th

12 spp. DD-45*, DM-44
13 spp. B-95*, C-86, 98*
14 spp. B-69, C-73*, DM-83*, DS-77
17 spp. DS-32*, 47
18 spp. DM-63*, DS-28*
19 spp. DM-60
24 spp. C-97*; E-94*

* the 27 sites with *Aflexia*.

A--alvar.

B--bottom (wet) land.

C--common (mesic) prairie.

D--dry prairie: DD, "dolomite" prairie; DG, "goat" prairie; DM, moraine hill or coteau; DS, sand plain.

E--railway embankment.

Table 3 - Sites ranked according to occurrence of 9 most common prairie-endemic species: *Aflexia rubranura*, *Bruchomorpha dorsata*, *Extrusanus oryessus*, *Flexamia delongi*, *F. prairiana*, *Laevicephalus minimus*, *L. unicoloratus*, *Memnonia nr. grandis*, and *Polyamia caperata*.

DEPAUPERATE: poorest 1/6th

0 spp. 5, 17, 18, 19, 22, 27, 29, 41, 42, 54, 56, 67, 71, 75, 90

POOR: second 1/6th

1 sp. 1, 2, 3, 4=, 6, 7-, 15-, 20, 23, 25-, 31, 48-, 50, 52, 61-, 68, 70, 85-, 93-, 99-

FAIR: third 1/6th (below average)

2 spp. 12, 36-, 43+, 46+, 59-, 78, 79, 82-, 84= (ND), 88+, 92+

GOOD: fourth 1/6th (above average)

3 spp. 8+, 14+, 21, 24+, 34-, 37+, 38, 39-, 44+, 53+, 58, 65, 66-, 72, 76, 87, 100

VERY GOOD: fifth 1/6th

4 spp. 10+, 11, 13+, 16 (MI), 26++ (IL), 28-, 33, 35+, 55+, 57+, 62+, 64, 77, 80+, 81, 89, 91, 96

EXCELLENT: top 1/6th

5 spp. 9++ (ON), 30+, 40+, 47+, 51+, 60+, 74+, 86, 95, 98

6 spp. 32+ (WI), 45, 63, 69, 73 (MN), 83 (SD)

7 spp. 49+ (MN), 94

8 spp. 97 (MB)

- () best site in each state and province.
+/- sites with different rating than in Table II.
++ sites with higher rating by 2 levels.
= sites with lower rating by 2 levels.

Table 4 - Sites ranked according to occurrence of prairie-endemic species considered rare in the study area.

DEPAUPERATE to GOOD:

0 spp. 1-3, 5-15, 17-31, 33-34, 37, 39, 41-43, 46-54, 56-57, 59-62, 64-68, 71-72, 74-76, 78-86, 88-92, 95-96, 99-100

VERY GOOD: top 22%

1 spp. 4+++ , 16, 35, 38+, 44+, 45-, 55, 58+, 63-, 70+++ , 73-, 77, 87+, 93+++ , 98-

EXCELLENT: top 7%

2 spp. 32, 36++ , 69, 94, 97

3 spp. 40

5 spp. 28

+/- sites in 2 top categories with different rating than in Table III.

++ sites rated "fair" in Table III

+++ sites rated "depauperate" in Table III.

Special cases

Some sites are far from uniform and present interesting contrasts in management styles.

Ojibway Prairie PNR (site #4). This is composed of 2 tracts separated by an unpaved road. The smaller, N section is largely unburned sand prairie with a mixture of prairie and southeastern leafhopper species. The S section has a wet prairie that is burned annually, with virtually no leafhopper fauna remaining.

Schluckebier (#30). This sand prairie is composed of 2 tracts, both fire-managed by TNC. The S section has dropseed on flat surfaces near a small gully (which probably survived plowing in the gully), whereas the N section has dropseed growing on a steep northwest-facing slope. *Aflexia* and other prairie endemics are limited to the northern site. Because fires do not burn as hot and close to the ground on steep slopes as on flat areas, the leafhopper might survive there.

Spring Green (#32). This TNC-managed sand prairie is extensive, with detailed fire management records dating back to 1978. The best areas had not been burned in 3 years, and only the "old field" areas were burned less than 4 years apart. Sand "blowout" areas afforded particularly fine collecting. *Aflexia* leafhopper nymphs but no adults were found; they probably were taken on clumps of dropseed near the base of the bluffs at the eastern section of the preserve, where the dense rank growth made collecting difficult by August.

Kellogg-Weaver dunes (#39). This extensive sand plain is under multiple ownership. TNC and State Natural Areas (SNA) were burned within 1-2 years before sampling (1993); McCarthy Lake State Wildlife Management Area (SWMA) is apparently unburned. Most of the TNC and SNA tracts were sampled, plus the roadside (dune) area of SWMA. The prairie leafhopper fauna was confined mostly to SWMA, or along the highway adjacent to SWMA, and in "blowout" areas in SNA where fire probably did little damage.

Iron Horse Prairie SNA (#43). The land in a triangle surrounded by the railway "wye" (3-way junction), apparently heavily burned, has strikingly different vegetation than the area south of the tracks adjacent to a cornfield. The limited fauna of prairie leafhoppers on this site occurs mostly in the latter area, which is mesic to wet and dominated by shorter grasses. Wild rye, *Elymus canadensis*, and its leafhopper specialist *Commellus comma* were confined to the roadbed.

McKnight Prairie (#44). This site has 2 moraine hills with sandy slopes. The westernmost was burned recently by Carleton College and showed limited prairie fauna; the other has its best fauna around a sand "blowout" area.

Lost Valley (#45). This is the finest "dolomite prairie" sampled. Its low vegetation is dominated by prairie dropseed, bluestems, and sideoats grama, *Bouteloua curtipendula*. This is the easternmost site for the calisceline bug *Peltonotellus bivittatus* Ball on its host prairie muhly, *Muhlenbergia cuspidata*, on an unburned limestone ridge W of the site entrance. Many *Aflexia* also were found there and on the N tip of the access area, which was burned by DNR in the 1-2 years before sampling (1993). No prairie leafhoppers were found on a recently burned ridge N of the site entrance.

Kasota Prairie (#51). The entire site has been burned by TNC, probably in 1992. No prairie-endemic leafhoppers were found there. A small, unburned parcel of land outside the prairie boundary has a thriving population of *Aflexia* and other interesting species adjacent to a 10' high cedar.

Hole-in-the-Mountain Prairie (#60). This is a fine coteau prairie with "old field" vegetation in low areas, mostly managed by TNC using mowing. The central and eastern sections, plus hillsides outside the preserve boundary north of the site, have a rich prairie fauna. Special mention must be made of stands of hairy grama, *Bouteloua hirsuta*, and prairie muhly on "saddles" between low hills near railway tracks, which have their own fauna of prairie leafhoppers.

Town Hall Prairie SNA (#69). This wet, black-soil prairie is the best such site sampled, probably typical of the Red River Valley, and rich in floral and faunal diversity. A third was burned by TNC that spring (1993) and was without prairie insects; 1/3rd was burned a few years previously and had a limited fauna; and 1/3rd (adjacent to the preserve sign) was burned after sampling was complete. The best collecting was from the vicinity of the sign. An adjacent, unburned field is wetter and has a lower species diversity than the prairie preserve.

Bicentennial Prairie (#73). This is an extensive, deep-soil prairie on a low morainal "bench". This TNC prairie preserve is surrounded by much semiarid, unprotected land, pocked with gravel pits, and dominated by *Stipa* and little bluestem. The best collecting is outside the preserve or immediately adjacent to the preserve sign.

Blazing Star Prairie (#74). This prairie is situated adjacent to site #73. It has an access trail down the middle, which apparently serves as a burn boundary. Of the prairie endemics, only the fire-resistant *Memnonia* nr. *grandis* was dispersed generally; others were mostly, or exclusively, within 10' of the road, especially on the grass strip in its middle.

Crookston-Warren railway grade (#81). This unprotected prairie has an unusually high species diversity for a railway grade, possibly because it has a 30' wide strip of land between the railway ditches and highway that may not have been burned as frequently as the railway grade itself. The Crookston end is wider and is partly hayed. The end closest to Warren has the greatest floral and faunal diversity, including the state's most abundant population of the leafhopper *Flexamia graminea* on little bluestem.

Grosse Isle railway grade (#94). The "wye" where the Prairie Dog Express (a steam excursion train) turns on its run back to Winnipeg encloses an unprotected triangle of land that was burned twice a year until recently. There is also a 20' wide strip between the railway and the highway. Amazingly for such a small, frequently burned site, there is one of the richest prairie faunas occurs there. Flightless leafhoppers are confined to the strip along the roadside (*Attenuipyga* sp.) and to the wettest area along the return "wye" track (*Aflexia rubranura*). Perhaps these parts have been burned not so often as the verges of the main lines. Much of the area next to the highway was reduced to a mud bath when heavy construction equipment was parked on it in 1991.

Conclusions

Family differences

Spittlebugs do not correlate with prairie quality, being found on both recently burned prairie and prairie densely overgrown with European grasses and weedy plants. However, their persistence in degraded sites can show the extent of prehistoric prairie vegetation. The spittlebug *Philaenarctus killa*, usually flightless and unlikely to be wind-dispersed, is particularly good for this. Its occurrence on sand plains as far east as Ontario (Fig. 2 A) may indicate the extent of prairies during the Hypsithermal (6000-8000 years ago) when world temperatures were higher than today.

Leafhoppers and caliscelids together can be used to determine the state of faunal preservation on a site. Sampling must not be carried out until at least 3 years after burning, to allow the fauna to propagate and reach observable levels. Then sampling for the 9 most common prairie-endemic species should yield a standardized assessment of the site: at least 3 such species should be present and preferably 5 or more for well-managed sites within the study area.

Management

In sand prairies (e.g., sites #32, 39, 44), the prevalence of interesting prairie leafhoppers around sand "blowout" areas where fire would not burn completely suggests faunal degradation elsewhere from fire.

Leafhoppers are most abundant in sites where fire has been used only at wide intervals or not at all. A 4-year firing cycle seems to be the greatest frequency that will not damage their populations. In this regard, it is noteworthy that the best (least burned?) faunas are associated with wooden property signs (e.g., at sites #69, 73).

Fire is probably not highly destructive to leafhoppers on slopes and hill prairies (e.g., sites #30, 63-64, 66), because the fire goes up the slope too quickly to burn close to the ground. Hill prairies thus have some of the richest of prairie faunas. On the other hand, some flightless leafhoppers (e.g., *Aflexia*) apparently do not migrate readily up steep slopes.

Mowing seems to have little, if any, effect on prairie insects. Some of the most productive sites have been managed exclusively (site #97) or mostly (#60, 64) by mowing.

The extensive (40 km long!) prairie along the Warren-Crookston railway grade (site #81) is uniform enough and has enough prairie species to serve as a "test plot" for fire/mowing management strategies.

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