Newsletter

Arthropods of Canadian Grasslands

Number 7 **2001**

Contents

The Grasslands Newsletter of the Biological Survey of Canada (Terrestrial Arthropods) supports the Survey's grasslands project by providing information relevant to the study of grassland arthropods in Canada.

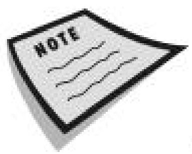
Band-winged grasshoppers are characteristic species in the semi-arid grasslands of North America. Read interesting observations about these species on page 5

Contributions welcome

Please consider submitting items to the Grasslands Newsletter

Grassland site descriptions

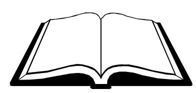
Current research - project reports



Short news items

Feature articles

Grassland species accounts



Selected publications

Contributions such as these, as well as other items of interest to students of grasslands and their arthropods, are welcomed by the editor. The Newsletter appears annually in March; final copy deadline is February 15.

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Articles without other accreditation are prepared by the Editor.

The web site of the Biological Survey is at: http://www.biology.ualberta.ca/esc.hp/bschome.htm

Grasslands news

First key site chosen

In addition to ongoing work in various places, the Survey plans to focus study in one key grassland site each year, to ascertain its diversity, acquire specimens for study, encourage exchange of ideas, and so on. The first such site, Onefour range in Alberta, is introduced on page 3.

Informal conference

The informal conference on grasslands at the 2000 joint entomological societies' meeting in Montreal was successful in bringing together a range of presentations and ideas about Canadian grasslands and how to study them. For details see page 2.

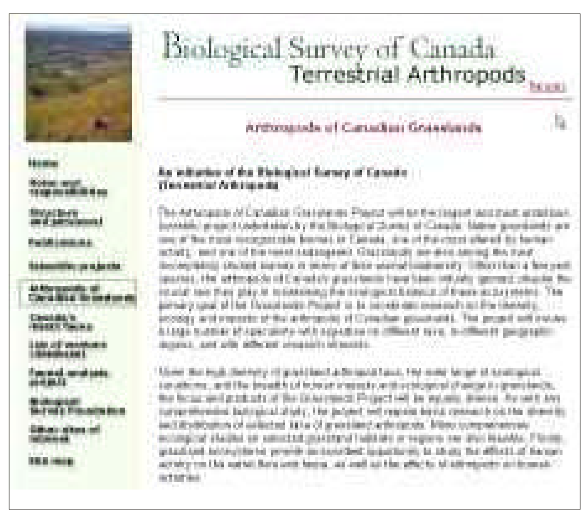
2002 Grasslands symposium

One of the proposed products of the Grasslands Project is a volume on ecological or habitat-based studies. This volume will include chapters on arthropod ecology and diversity in particular grassland habitats, and analyses of selected species assemblages or guilds, for example. A formal symposium on this theme is being planned for the 2002 Annual Meeting of the Entomological Society of Canada in Winnipeg. Some potential symposium speakers and chapter authors have already been contacted, and others will be approached to fill out the volume.

Anyone who would like more information on the symposium or ecology volume, especially those who would like to contribute chapters, should contact Terry Wheeler [wheeler@nrs.mcgill.ca] or Joe Shorthouse [jshortho@nickel.laurentian.ca].

Biological Survey of Canada (Terrestrial Arthropods) website: Grasslands project

A section of the Biological Survey's website highlights the Grasslands Project. The site currently includes background information on the project, all issues of the Grasslands Newsletter, and a summary of research projects on grassland arthropods. More information will be added as the project progresses.



The Biological Survey website is at: www.biology.ualberta.ca/esc.hp/bschome.htm. Follow the 'Arthropods of Canadian Grasslands' menu item.

Grasslands project action

Informal Conference on Arthropods of Grasslands (ESA/ESC/SEQ Joint Annual Meeting 2000)

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An Informal Conference entitled "Arthropods of Grasslands: Current Status and Future Directions" was held at the Joint Annual Meeting of the Entomological Societies of America, Canada and Quebec in Montreal in December 2000. The primary goals of the session were to update some of the ongoing research projects associated with the Grasslands Project, to encourage discussion about future directions and possible interactions between workers, and to inform the broader entomological community about the Project.

The conference was organized by Terry Wheeler of McGill University and, considering the early hour (8:00 a.m.) and the predictable presence of several concurrent sessions of great interest to all involved, the session was well attended, with attendance peaking during the formal papers at 50 people, many of whom stayed to participate in the open discussion following the presentations.

Kevin Floate (Agriculture and Agri-Food Canada, Lethbridge) opened the session with an appropriately broad talk entitled "Canada's Grasslands". Kevin outlined the great geographic range and diversity of grassland ecosystems in Canada and discussed some of the human-mediated effects on native grasslands. This paper set the stage for subsequent talks on specific research projects.

Rob Roughley (University of Manitoba, Winnipeg) presented a paper co-authored with Darren Pollock on "The use of fire as a biodiversity and conservation management tool in tallgrass prairies", which summarized their ongoing research on the effects of prescribed burns on beetle diversity in the tallgrass prairies of southern Manitoba.

Terry Wheeler (McGill University, Ste-Anne-de-Bellevue), gave a talk entitled "Diversity of *Meromyza* (Diptera: Chloropidae) in Canadian native grasslands". Collections of this abundant genus across Canada are showing unexpected patterns of diversity in different grassland habitats, with implications for the distribution and species limits of some well-known pest species.

Andy Hamilton (Agriculture and Agri-Food Canada, Ottawa) closed the formal part of the session with a talk on "Endemism and dispersal of short-horned bugs (Homoptera: Auchenorrhyncha) in Pacific Northwest intermontane grasslands", which underlined the great potential value of these insects in reconstructing the history of grassland habitats.

The presentations were followed by a brief summary of the history and present structure of the Grasslands Project, and an open discussion of the status and needs of the Project. Some useful concrete suggestions came out of the discussion, which included topics such as current research, cooperative effort and sampling standards that will reappear on the pages of this newsletter.

Grasslands project key site 2001: Collecting grassland arthropods in Alberta

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What:	Prairie Insect Collecting at Onefour, Alberta, summer, 2001
Where:	Onefour, Alberta (substation of Lethbridge Agriculture and Agri-Food Canada Research Station)
When:	June 23- July 8, 2001 (or any part of that time that you can make it)
How:	Register (details below), bring your camping and collecting gear and get busy!

At a recent meeting of the grasslands subcommittee of the Biological Survey of Canada (Terrestrial Arthropods), it was suggested that we organize a series of field excursions for entomologists with interests in prairie insects and related arthropods. The main, long-term goal of these gatherings is to generate collections of prairie arthropods in selected prairie habitats that will help to document their fauna. We encourage an exchange and sharing of information about various taxonomic groups, field tactics, methods, techniques, observations, and social interaction. We hope that it will allow students and professionals the opportunity to see techniques and to exchange information about prairie insects. Over the next few years, a different field location for these collecting excursions will be chosen each year in a different kind of prairie ecozone.

Southern Alberta showing the Onefour area

Photo by D. Johnson

The first of these will be in the southeast corner of Alberta at Onefour, Alberta. The Lethbridge Research Centre has a substation there. Onefour is a 17,000 ha parcel of what Alberta Forestry, Lands and Wildlife call the ‘dry mixed grass’ ecoregion. Historically, the land has been used only for grazing, so could be considered to be in relatively pristine condition. The area is unique in that it represents the most northerly distributions of some species including yucca plants and their pollinators. The southern boundary of the property is bounded by the Milk River Valley, which is the deepest valley on the Canadian prairies and the substation is surrounded by ‘badlands’ country.

The strategy for the trip is to have a two-week window of opportunity and the proposed dates are from June 23 to July 8, 2001. Some people would come for the entire two-week period and others would use the Onefour research station as a base of operations with forays to the Cypress Hills and surrounding areas, and still others might be able to visit only on the weekend. Attendance would be open to anyone with an interest to learn about and collect prairie insects. However, registration is mandatory.

On the substation is a small laboratory that would be suitable for sorting and processing insect samples. We can setup microscopes, Berlese funnels, etc. in this facility. Further details will be provided to people registered for the field collecting excursion.

On site there is room for only 15 people to camp at one time. There are larger campgrounds (e.g. Cypress Hills Provincial Park, Milk River Provincial Park) more or less nearby.

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The Milk River valley near Onefour
Photo by K. Floate

Band-winged grasshoppers of the Canadian Prairies and Northern Great Plains

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The band-winged grasshoppers (subfamily Oedipodinae of the family Acrididae; also referred to as subfamily Locustinae, Tribe Oedipodini) are a characteristic feature of semi-arid grasslands in North America. These insects are generally found in open short-grass prairie, and often frequent rough terrain, preferring bare or heavily eroded cliffs or surfaces (and even adopting summer fallow fields as choice territory).

Their large, lobed hindwings, usually with spots and bands, are features that distinguish the band-winged grasshoppers from the other grasshopper subfamilies anatomically. The hindwings are also the basis on which many people who are not familiar with insect taxonomy can distinguish the group by their behaviour. Many species of band-winged grasshoppers snap the hindwings as they fly (crepitation) so loudly that they can be heard across a pasture or field. The red-winged grasshopper (*Arphia pseudonietana*) is well-known across Canada for its startle reaction, exploding in a red and black flash out of the grass ahead of a hiker and clacking loudly away.

Although the band-winged grasshoppers are a coherent group and clearly belong together, the subfamily contains extreme diversity. While this subfamily contains mainly species that are economically harmless (and should be distinguished from other grasshoppers to avoid unjustified control actions), it also contains the clear-winged grasshopper (*Camnula pellucida*), among the most devastating grasshopper pests in Canada. In fact, the oldest genus of Oedipodinae is *Locusta*, the ultimate in devastation. Some band-wings are small and even delicate, like the light-weight Kiowa range grasshopper (*Trachyrhachys kiowa*), but the Oedipodinae is also home to the most massive grasshoppers we have: the black-winged grasshopper (*Dissosteira carolina*), red-shanked grasshopper (*Xanthippus corallipes latefasciatus*), and three-banded range grasshopper (*Hadrotettix trifasciatus*) all outweigh the two-striped grasshopper (*Melanoplus bivitattus*), which holds the title in the subfamily Cyrtacanthacridinae (spur-throated grasshoppers). The flashiest occur in Oedipodinae, like the red wings of *A. pseudonietana* mentioned above, or the nearly cobalt colour of the bluelegged grasshopper

(*Metator pardalinus*), but also some of the most cryptic. Most Canadians have watched a black-winged grasshopper (or “roadduster”) fly lilting back and forth with large black and yellow wings and then disappear before the eyes as it lands and fades into the ground. *T. kiowa* sitting and absolutely disappearing into the pattern and colour of a grey-green prairie lichen testifies to millenia of life with grassland birds.

The following notes provide a brief look at some of the band-winged grasshoppers that I have collected and observed on grassland of Alberta and Saskatchewan. The list is not complete, but I have included the more interesting species of Oedipodinae (Locustinae) that would be seen by collectors visiting sites such as the National Wildlife Area at Suffield, AB, the Research substation at Onefour, AB, the Milk River valley, or southern Alberta grazing reserves.

(All collections and photographs are by D. Johnson)

Aerochoreutes carlinianus (Thomas)
(= _Circotettix carlinianus_)

Carlinian snapper grasshopper

Fig. 1. Adult male

This species is one of the most interesting to be encountered, because of its very active and noisy behaviour while displaying and defending territory. The males hover in flight over bare (usually sun-warmed) ground, swooping and buzzing intermittently. The breaks between each buzz are somewhat temperature dependent, but usually about a half second. They are so loud that a common but unofficial name is rattlesnake grasshopper. Their preference for bare, rough and (unlike *C. rabula* below) flat terrain has caused them to readily adopt summer fallow fields as prime habitat for male displays. I have seen groups of hundreds spaced roughly 5 m apart buzzing up and down between about 1 and 8 m for much of a warm afternoon. They often sit and bask, waiting for a move by another male, and then when it happens, on cue all of the males within 50 m or so will take to the air and buzz. They hover so close to one spot that I have had no trouble videotaping this behaviour.

This grasshopper is normally gray to tan, but I have found them in chalky pink and chalky blue forms that seem best described as pastel.

Arphia conspersa Scudder

Speckled range-land grasshopper

This charcoal-coloured grasshopper is common on native short grass (for example, blue grama, needle-and-thread and June grass), especially where sand ridges, dunes, bare ground and small blowouts occur. It winters as late nymphal instars that can be easily found whenever the snowcover disappears during January through April. They become adults early, usually in May, and are mostly gone before the end of the summer.

Arphia pseudonietana **(Thomas)** **Red-winged grasshopper**

Fig. 2. Adult female

I have already mentioned the loud crepitation of this species. Although it looks like *A.conspersa*, it overwinters in the egg and therefore appears as late nymphal instars in June, and as adults in late summer. Both species feed on grass, and may prefer wheatgrass.

Fig. 3. Red wing exposed

Camnula pellucida **(Scudder)** **Clear-winged grasshopper**

Fig. 4. Male and female

At one time this serious pest of wheat and barley was thought to be a strict graminovore, but in recent years it has appeared as a significant pest of young canola plants. We found that although it will not feed on the leaves of safflower, it will nibble the stem under the head until it nods over, and thereby do more damage to final yield than the more voracious *Melanoplus* species. This species is commonly found hanging dead on vegetation, in some cases with visible conidiophores of fungi of the *Entomophaga grylli* complex (Entomophthorales: Entomophthoraceae). An outbreak of this species that covered much of Prairie Canada was stopped by this fungus in 1962.

No grasshopper species in Canada exhibits such extreme fluctuations in abundance. The clear-winged grasshopper went from dominance in some sites in southern Alberta, Saskatchewan and B.C. in 1984, to being an endangered species by 1993-4 when we found only a few specimens in collections that totalled well over 15,000 grasshoppers (Johnson and Andrews, unpublished). In the same years, it accounted for an outbreak in northern regions (for example, Peace River,

Fig. 5. Greenish male form

Cache Creek, Dawson Creek). This is the only grasshopper I have seen that has mass matings so thick that they can be seen from several hundred m, in which several males may be simultaneously attempting to copulate with a female.

Chortophaga viridifasciata **(DeGeer)** — Northern green-stripe grasshopper

Although never abundant, it is usually possible to find one of these very green grasshoppers on a hike in grassland in April or May. They overwinter as nymphs, one of about seven species that do so. The keeled shape of the pronotum and the small dots of other colours make it a beautiful insect.

Circotettix rabula **Rehn and Hebard** — Wrangler grasshopper

Fig. 6. Male resting

This angular and bugged-eyed species is the most seemingly aggressive grasshopper, difficult to approach for a photo but not easily scared off either. They will actually charge a collector, pass to the side, and come back to reclaim the territory. They can be captured with a net snapped quickly down with tension, but rarely by normal sweeping.

Fig. 7. Male sitting in observing/basking spot

***Cratypedes neglectus* (Thomas)** **Pronotal range grasshopper**

This is another crepitating grasshopper that never becomes very abundant, and can sometimes be heard before it is seen.

***Dissosteira carolina* (Linnaeus)** **Black-winged grasshopper**

Fig. 8. Pair in copulo

This very large and familiar grasshopper occurs right across Canada and the northern U.S., and can be found in most habitats that have dry, bare ground. They appear to be very sensitive to soil type and weather. In Alberta they appear in large numbers (I have seen 40 per sq. m.) only when several years in a row have a dry spring, and then only in certain areas. Elsewhere typical densities are around one per 10 sq. m. We have found this species to be an excellent lab animal (meaning that it has good survival in a cage and seems to feed and grow normally).

***Encoptolophus costalis* (Scudder)** **Western clouded grasshopper**

This is another good example of the changes that can occur in species composition. *E. costalis* seems to prefer slightly moist conditions, and I have observed it feeding on forbs. It was a common early hatching species in Alberta until the hot, dry period that so encouraged the melanoplines. Now it is very rare.

***Hadrotettix trifasciatus* (Say)** **Three-banded range grasshopper**

There are two ways to camouflage, to match the background colour or to break up the outline. *H. trifasciatus* takes the second approach and does it very well. When this grasshopper lands and sits at rest, the bars on the femur and tegmen line up perfectly to make a stripe that cancels the grasshopper shape.

Fig. 9. Adult female alighting and closing the band pattern

***Metator pardalinus* (Saussure)** **Bluelegged grasshopper**

This was once a common grassfeeder on native and semi-native pastures in southern Alberta, but like many band-winged grasshoppers it became rare during the wet years, 1991-99. During the drought of 2000 it quickly made a comeback at sites such as Onefour and Lost River, AB. The blue of the leg of this grasshopper is as bright and striking as any I have seen on beetles.

Fig. 10. Adult male

***Spharagemon collare* (Scudder)** **Mottled sand grasshopper**

This species is similar to *S. equale*, but not as well defined. It is associated with sandy grassland and feeds on grasses.

***Spharagemon equale* (Say)** **Barren ground grasshopper**

Fig. 11. Adult male

I would chose this species for the official Alberta grasshopper if there were such a contest. It is a beautiful insect that thrives in dry conditions, increasing in both prominence and abundance as others drop out due to extreme drought or heat. It is a common grasshopper that can be collected in the southeast corner of the province, but also occurs in most of the short grass of the southern region. It has been reported to feed on crucifers, but I have found both forb and grass remains in the gut of this species. It is a very good flier, and its relative abundance can be underestimated by using a standardized, inflexible sweep-sampling method.

Trachyrhachys k. kiowa (Thomas)
Kiowa range grasshopper

This lovely little grasshopper has a head that seems too big for the body, and a line of fringe hairs on the femur so that you can never go wrong identifying it. This is a helpful feature, because it occurs in colours from pastel green to tan to gray.

Fig. 12. Brown adult male and green female (colour is not determined by sex)

Trimerotropis species

Trimerotropis species are fascinating in that some of them have such specific habitat preferences that one can look at a landscape and see where to go to find a particular species. I will illustrate their appearance with only one species, and leave the group for a separate description another time, as it deserves.

Trimerotropis suffusa Scudder
Crackling forest grasshopper

Fig. 13. Adult male found flying back and forth between subalpine grass meadow and edge of wooded area

I selected this species to illustrate because it is unusual in that it is a forest species that inhabits grassy alpine meadows but also moves out on to the plains. I realized this only after chasing them down in unexpected places (they are fast and hard to catch).

Other species are:

Trimerotropis agrestis McNeill
Toothed field grasshopper

Trimerotropis campestris McNeill
Campestral grasshopper

Trimerotropis latifasciata Scudder
Broad-banded grasshopper

Trimerotropis pallidipennis salina McNeill
Alkaline pallid-winged grasshopper

Trimerotropis pistrinaria Saussure
Barren lands grasshopper

Trimerotropis sparsa (Thomas)
Great basin grasshopper

Trimerotropis sordida E.M.Walker
Walker's dingy grasshopper

Trimerotropis verruculata (W.Kirby)
Cracker grasshopper

Xanthippus corallipes latefasciatus (Scudder) Red-shanked grasshopper

Fig. 14. Fifth-instar female sitting on snow in March

This species is our largest grasshopper, and looks almost the size of a wren while flying. It overwinters as a toad-like nymph (which is often heavily parasitized by flies, as shown by T. Danyk in my lab) and matures quickly in the spring. I have seen these grasshoppers impaled on barbed wire or on prickly pear cactus, apparently by shrikes. We have also found them to be a common constituent of coyote dung in spring and early summer, and the hind femora and tegmina are common refuse around the holes of burrowing owls, or beneath posts used by kestrels.

Selected references

I recommend the following references for anyone who would like to identify and read further about this group:

Brooks, A.R. 1958. Acridoidea of southern Alberta, Saskatchewan, and Manitoba (Orthoptera). Canadian Entomologist Supplement 9: 3-32.

Otte, D. 1984. The North American Grasshoppers. Vol. 2. Oedipodinae. Harvard Univ. Press, Cambridge, MA. 366 pp.

Vickery, V.R. and D.K. McE. Kevan. 1986. The insects and arachnids of Canada. Part 14. The grasshoppers, crickets and related insects of Canada and adjacent regions. Ulonota: Dermaptera, Cheleutoptera, Notoptera, Dictyoptera, Grylloptera and Orthoptera. Agriculture Canada Publication 1777. 918 pp.

[Production of this article with colour illustrations was supported by a contribution from the author's educational fund, administered at the University of Lethbridge and the Lethbridge Research Centre.]

Fact file

The prairie grassland of North America is characterized by relatively limited rainfall, ranging from about 100 cm at the forested eastern edge to less than 30 cm at the western edge. On the plains, May and June are the months with the greatest amounts of precipitation, and about 40% of the annual total falls as snow during the winter. Closer to the Cordillera, due to Chinooks, the duration and the depth of snow cover are reduced. At Lethbridge, for example, snow depths greater than 25 cm are rare even with an annual snowfall of 140 cm.

Buried treasure: Mining the residues from grassland sampling programs

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Residues from insect sampling programs are both a blessing and a curse. They are a source of large numbers of taxonomically and ecologically valuable specimens from regions and habitats that a particular specialist might not have the opportunity to visit, but locating, sorting, processing and storing those residues can create logistic and financial nightmares. The Grasslands Project has already generated, and will continue to generate, large numbers of residues containing specimens of interest to most collaborators in the project.

This note is a preliminary attempt to establish a residue network for the Grasslands Project that will allow us to derive the maximum benefit from our collecting efforts, while minimizing the amount of valuable material that is lost or overlooked. Some groundwork will be required before this effort can become a reality, and the main purpose of this note is to solicit the input from the community that will lay that groundwork. Several questions need to be addressed:

Who are the collectors?

If those who already have residues from grassland sampling programs, or are planning to acquire them, contact me (a short email is fine, I can then follow up with a list of questions), I will generate a list of potential participants and sources of material. This list can then be expanded into a database that will provide the information needed to answer the subsequent questions.

Who is equipped to deal with residues?

Many people collect using trap methods that generate large volumes of material, but lack the funding, personnel or facilities to deal with the residues beyond extracting their own taxa of interest. Others are equipped to deal with residues if the samples find their way to them. We need to establish who is in each of these categories. Input and suggestions would be appreciated.

Where are the residues?

The answers to the first question will partially deal with this one as well. However, it will be useful to know where the bulk of the material is, and in approximately what quantities. There are a few more centralized storage areas, like the Canadian National Collection, but many workers have smaller residue collections from individual projects. Information on the current location of residues, and the locality and collecting method of the material, will be necessary to build a useful database of residues.

What is being extracted?

We can assume that each collector will extract their own taxa of interest first from residues. Coordinating efforts to extract other taxa will save a lot of sorting work in the long run. Is there a way to combine sorting efforts to extract, for example, all Diptera at the same time, for subsequent routing to specialists? Should we try to ensure that delicate insects are removed before the samples reach people who potentially can use harsh techniques to retrieve their specimens (beetles, for example)?

How will the network be monitored?

Two problems with a sorting network are that residues are easily lost in the system and that it often takes people a long time to deal with the material. In order for this network to work on a large scale, it will have to be monitored. Perhaps the simplest approach would be to assign an identification code to each batch of residues before it enters the system; this code could be transmitted to the person or institution monitoring the network, and they could then track the material. As each batch moves through the cooperating laboratories, the monitor could be informed and the material tracked. If FedEx can do this, surely a group of systematists can manage it. An email list would serve the purpose well, and allow more immediate contact than an annual or semi-annual newsletter. Using this system, we can also identify laboratories where residues are being held up from time to time, and route the rest around that node until everything is caught up.

Where will the residues be stored?

Proper storage is always an issue with residues. Unlike identified and curated material, residues tend to spend more time in potentially leaking whirlpaks or containers that may allow alcohol to evaporate, and with fading labels. We should endeavour to follow at least minimal standards for labelling and storing residues while they are actively in the network. There is also the issue of long-term storage for residues that are not active. Is it feasible to try to establish a few centralized locations where residues can be refrigerated, and monitored from time to time to ensure that they are not deteriorating? These locations might also be a logical place to decide when a particular set of residues has been mined to the point that it is no longer worth storing.

Anyone with thoughts on the residue issue, or with answers to any or all of the above questions should contact Terry Wheeler (wheeler@nrs.mcgill.ca).

Web watch: The Alberta Prairie Conservation Forum

http://www.albertapcf.ab.ca

K.D. Floate

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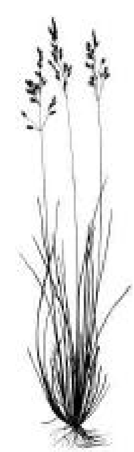
The Alberta Prairie Conservation Forum is a voluntary coalition of about 40 organizations whose members are interested in the conservation of native prairie and parkland environments in Alberta. The three broad objectives of the PCF are: 1) to develop and implement broad strategies and focused initiatives for conserving native prairie ecosystems, 2) to encourage information exchange among member organizations and, 3) to raise public awareness of management issues pertaining to prairie landscapes, habitats and species. The PCF is currently hosting a vote to elect a provincial grass with the 'winning' species being announced in April.

The PCF typically meets three times a year (January, May-June, and September) in various locations within prairie and parkland Alberta. All meetings are open to the public. Detailed information on the Forum, its membership, its past accomplishments and current initiatives is on the Internet at: http://www.albertapcf.ab.ca/



Aerial fallout on a grassland reserve after fire

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Abstract. Aerial fallout was measured by yellow pan-trap collectors on the Haynes Lease Ecological Reserve near Osoyoos, British Columbia immediately following fire that devastated the vegetation in 1993. The fallout was recorded at a rate of 1.766 billion insects/sq. km/24 hrs. It contained no rare species, and constituted a pioneer aeolian community, subject to predation by other mobile invaders.

Introduction. The Haynes Lease Ecological Reserve, adjacent to the north end of Osoyoos Lake, 6 km NNW of Osoyoos, British Columbia, at 49°05′N 119°31′W, is a 101 ha tract of land within the hot, dry subzone of the Bunchgrass biogeoclimatic zone in the Southern Interior of the province (Meidinger and Pojar 1991). The sandy terraces which make up the bulk of the reserve supported three communities, which over the past 100 years have been greatly influenced by livestock grazing. These three communities were (i) sand dropseed (*Sporobolus cryptandrus* (Torr.) A. Gray) – prickly pear cactus (*Opuntia fragilis* (Nutt.) Haus.) – cheatgrass (*Bromus tectorum* L.), (ii) antelope brush (*Purshia tridentata* (Pursh.) DC) – sand dropseed – red three-awn (*Aristida longiseta* Stend.) – needle-and-thread grass (*Stipa comata* Trin. & Rupr.) and (iii) Ponderosa pine (*Pinus ponderosa* Dougl.) – antelope brush.

Five communities, mostly of limited extent, have been reported on the rocky slopes and summit of Throne Mountain. Small benches, especially the “seat” of the “throne”, from which the mountain gets its name, have been inaccessible to cattle and thus support essentially pristine communities dominated by bluebunch wheatgrass (*Elymus spicatus* (Pursh.) Gould) and alkali bluegrass (*Poa secunda* J.S. Presl.), or ponderosa pine – bluebunch wheatgrass.

Shrubby thickets dominated by sumac (*Rhus glabra* L.), poison ivy (*Rhus radicans* L.), and mock-orange (*Philadelphus lewisi* Pursh.) occur on talus slopes at the foot of the mountain. The lower riparian parts of the reserve, bordering Osoyoos Lake, are dominated by *Scirpus*.

The reserve was established in 1980 to protect an example of the near-natural communities of the Bunchgrass ecosystem. At the time of designation it was noted that the reserve provided habitat for many rare species. These include Red (endangered or threatened) or Blue (vulnerable) provincially listed species, plus species listed as at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Most noteworthy were the pallid bat (*Antrozous pallidus* (LeConte)), pocket mouse (*Perognathus parvus* (Peale)), western harvest mouse (*Reithrodontomys megalotis* (Baird)) and Nuttall’s cottontail (*Sylvilagus nuttalli* (Bachman)) among the mammals, the Canyon wren (*Catherpes mexicanus* (Swainson)), sage thrasher (*Oreoscoptes montanus* (Townsend)) and burrowing owl (*Athene cunicularia* (Molina)) among the birds, and the Great Basin spadefoot toad (*Scaphiopus intermontanus* (Cope)) among the Amphibia; the burrowing owl is now extirpated in the area. In the arthropods, some 29 rare species have been recorded on the reserve, including the northern boreal scorpion (*Paruroctonus boreus* (Girard)), the sun-spider (*Eremobates gladiolus* Muma) and the native mantid (*Litaneutria minor* (Scudder)). At least 13 rare plants have also been recorded on the reserve.

The Haynes Lease Ecological Reserve was considered to probably harbour in total, more rare plants, vertebrates and invertebrates than any other ecological reserve in the province. Covering 101 ha, it is the largest protected area of the endangered antelope-brush community in the South Okanagan, and has been subject to intensive study by many scientists over the years. Indeed, intensive pitfall trap sampling of ground-dwelling arthropods had been carried out for several years, and so the general characteristics of this fauna were known.

In the middle of this pitfall trap research, a fire of unknown cause swept through the reserve at noon on July 9, 1993. Because the reserve had been ungrazed by livestock for some 13 years, there was considerable accumulation of dry ground litter. As a result, the fire burned fast and hot. In fact, the polyvinyl chloride plastic trap covers over the pitfall traps were melted at the edges.

By 1500 hrs. on July 9, almost all the vegetation on the sandy areas of reserve had been destroyed, along with most of the resident fauna. Most of the scattered ponderosa pine trees were killed and have subsequently fallen down, and virtually all of the antelope brush was consumed. The surface of the reserve, after the fire, was essentially bare sand, covered in patches with charred plant debris.

In the end, the majority of the sandy benches on the reserve were burnt, together with much of the adjacent grazing lease to the west, which originally had similar vegetation. However, because the grazing lease had little dry litter accumulated on the ground, the fire was less intense, and more shrubs survived.

Fortunately, fire-fighters from the BC Ministry of Forests were able to put a fire-break through the grazing lease, and so part of this remained unburnt. Unfortunately, only a small area (5m x 30m) of antelope-brush community on the reserve was saved.

Immediately after the fire, a study of recolonization of the reserve was initiated. This paper reports on a study on the aerial fall-out on the reserve and the adjacent grazing lease during the first four weeks following the fire. During this period, the bunchgrasses started to shoot, so providing the first vegetation available for colonization.

Material and Methods. Following receipt of a permit to conduct research on the reserve (received by fax on July 14, 1993), 12 pan traps were set up in the north and south parts of the flat area of the reserve at 352-357 m elevation, and within 210-370 m of the rock and talus slopes to the east. Three pairs of traps were set up at intervals across the width of this part of the reserve, so as to cover the whole area in both the north and south. In the northern transect the first pair of traps was 70 m from the rock cliffs, and then other pairs were at approximately 160 m intervals. In the southern transect, the first pair was 25 m from the rocks, and others then at approximately 75 m intervals. Simultaneously, 5 pan traps were also set up in both the burnt and unburnt parts of the grazing lease at 349-351 m elevation, 20 m apart, and within 800 m of the reserve. The northern and southern transects on the reserve and the trap series on the burnt and unburnt parts of the grazing lease were some 750 m apart.

Pan traps were 298 mm x 235 mm x 38 mm (11¾" x 9¼" x 1½") EZ Foil®Brand aluminum Casserole/Lasagna Pans (EZ Por®, Division of Packing Corporation of America, Wheeling, Illinois), sprayed with Holland Yellow Rust Coat Gloss Enamel. They were placed on the ground, and filled almost to the brim with saturated road salt solution, to which a few drops of detergent were added.

The pan trap results reported herein were from 24 hr. samples taken after an initial 12 hrs. sampling period. The trapping period for the present results was from 1900 hr. one day, to the same time the next day, with trapping at weekly intervals. The sample dates were July 16-17, July 22-23, August 5-6 and August 12-13, 1993. The first trapping period was one week after the fire, and already at this time, the tufts of bunchgrass were evident as bright green spots across the landscape. By July 16, the bunchgrass tufts were some 5 cm high.

The weather was fine during most of the sampling periods, with maximum temperatures as follows: July 11-17 25°C, July 22-23 20°C, August 5-6 35°C and August 12-13 35°C. There was 3 hrs. of rain on August 13. No traps were disturbed during the sample period, but the traps had to be topped up around noon because of excessive evaporation.

Trap contents were filtered through a fine-mesh nylon net, and then preserved in 70% ethanol for later study. Subsequently, all arthropods were counted and identified to order and family (where possible). All Heteroptera were identified to species, and all samples were surveyed for the presence of rare species listed by Scudder (1994).

Total numbers for each trap were recorded and pan-trap totals averaged for the burnt reserve, and burnt and unburnt areas of the grazing lease. The averages per trap (surface area 700.3 sq. cm) were then multiplied to five figures for fall-out per km^2/day. Percentage composition of the catches was also calculated.

Results. Fig. 1 records the aerial fall-out on the burnt reserve, and the burnt and unburnt parts of the grazing lease during the 4 sample periods. The highest fall-out on the reserve was recorded on July 22-23, when the rate was calculated at 1.768 billion/sq. km/24 hrs. The fall-out in both the burnt and unburnt parts of the adjacent grazing lease was also highest at this sampling period.

The pooled data for the sample periods (Fig. 2) showed that aphids dominated the fall-out on the reserve, whereas on the burnt and unburnt parts of the grazing lease, Hymenoptera were the dominant element in the fall-out. Diptera constituted about the same percentage on all three sites, but were the second highest component on the burnt reserve, and on the unburnt part of the grazing lease. The burnt area of the grazing lease had aphids as the second most common component. Other Hemiptera were minor components at all three sites.

None of the species trapped belonged to species considered rare in the area. All appear to be common, widely distributed, often pioneer colonizing species. The lygaeid *Nysius niger* Baker was the most common heteropteran intercepted.

Discussion. There have been several similar studies on arthropod aerial fall-out; many of these were summarized by Edwards (1987). Collectively these studies provide a quantifiable index of the immense biomass of wind-borne arthropods, be they dispersers, migrants or accidentals. The sample data provide a measure of the recruitment of arthropod populations to a wide variety of ecosystems.

In particular, Edwards and Sugg (1993) have shown that over 140 arthropod families from 17 orders were represented in the fall-out at 1000-1200 m elevation on Mount St. Helens in the first 5 years following the major eruption in May 1980. Fragments or whole Diptera, Hymenoptera and Homoptera predominated in the fall-out samples. The fall-out collectors were 0.1 m^2 wooden frames containing a single layer of close-packed uniform spheres (usually golf balls). Edwards and Sugg (1993) calculated that arthropod fall-out was as high as 18 mg/m^2/day. On Mount St. Helens, there was no vegetation in the study area, other than a few short-lived seedlings and very localized patches of moss. The principal source of material for the fall-out was the distant fertile lowlands to the west, which consisted of agricultural land and a mosaic of forested and logged areas, although the nearby margins of the Pumice Plain provided some habitat for a diverse arthropod fauna.

Thornton et al. (1988) studied air-borne arthropod fall-out on Anak Krakatau in 1985. This island suffered a sterilizing eruption in 1952, and another severely damaging one in 1972: over 90% of the island consists of bare ash and lava. Sea-water-filled square white plastic pan-traps were utilized as collectors, and were placed at 2-8 m above sea level on lava flows partly covered by ash. Diptera far outnumbered other orders in the fall-out, with more than twice as many individuals as the second most common group, the Coleoptera. Of the other orders, only Hymenoptera, Orthoptera, Hemiptera and Araneae reached double figures.

Thornton et al. (1988) found that fall-out amounted to about 20 individuals per square metre per day. Extrapolation suggested an upper limit for the 2.34 km^2 area of Anak Krakatau of 50 million per day, or some 21.38 million/ km^2/24 hrs. The main source of colonists was likely the vegetated islands to the southwest, namely Rakata 4 km to the south, and Sertung about the same distance to the west. The site chosen for study mini-

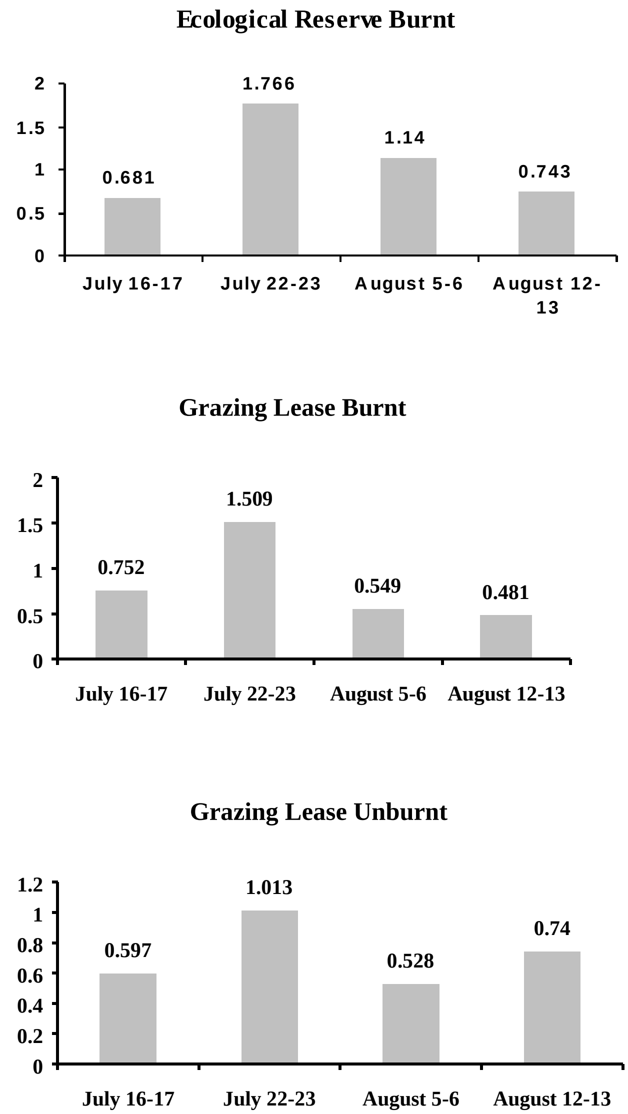

Fig. 1. Airborne insect fall-out at Osoyoos 1993 (billion/sq. km/24hrs.).

mized the likelihood that trapped arthropods were from Anak Krakatau's own vegetation, which occurs on the north and east forelands, and consists of grassland within which there are a few casuarinas (Thornton 1996).

The extremely high fall-out recorded on the Haynes Lease Ecological Reserve, and the adjacent grazing lease, is several orders of magnitude higher than reported in previous studies, and no doubt is related to the close proximity of sources. These undoubtedly were the unburnt grassland and shrub-steppe habitats within 500 m. Prevailing winds during the sampling period were mostly upslope from Antelope brush, Great Basin Sage (*Artemisia tridentata* Nutt.) communities, agricultural lands and riparian areas downslope.

Trap colour can markedly affect catch, and it is well known that yellow coloured traps are particularly attractive to aphids and other insects (Kennedy et al. 1961; Prokopy and Owens 1978; Kieckhefer et al. 1976; Hardie 1989), although not all aphid species are equally sensitive to yellow (Eastop 1955; Heathcote 1957). Nevertheless, the fact that fresh green bunchgrass shoots were present throughout the pan-trapping period means that such coloured trapping is not totally without context.

The magnitude of the fall-out measured in this study, like previous studies, indicates that the first community established in denuded habitats is an aeolian one (Edwards 1987; Thornton et al. 1988). The earliest true residents are dependent on aeolian debris for their survival, not the photosynthetic plants in situ. The earliest dispersers to the Haynes Lease Ecological Reserve were predatory wasps (*Vespula* sp.) and Say's Phoebe (*Sayornis saya* (Bonaparte)). Coincident pitfall trapping research also showed that carabid beetles and spiders were the first permanent inhabitants (Scudder, unpublished).

Acknowledgements. This research was supported by grants from the Natural Sciences and Engineering Research Council of Canada. BC Parks kindly provided permits to allow studies in the Haynes Lease Ecological Reserve. I thank my wife and daughter for their help.

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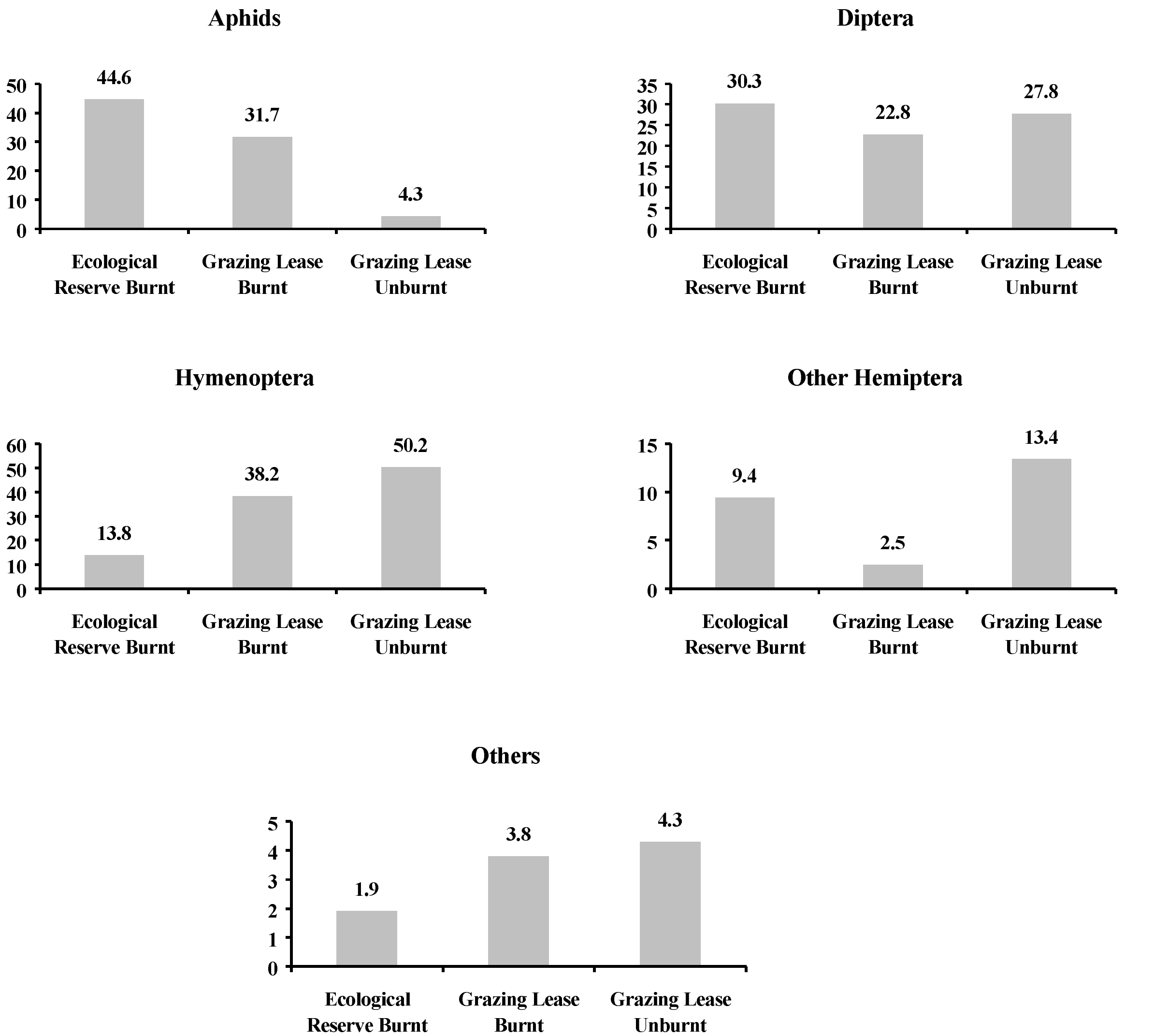

Fig. 2. Percentage composition of aerial fall-out at Osoyoos, 1993.

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Grassland site: Ross Lake Natural Area

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The Ross Lake Natural Area (RLNA) is 1,943 hectares of relatively pristine foothill grasslands located approximately 60 km south of Lethbridge, AB. Foothill grasslands occur at relatively high elevations resulting in warmer winters, long cool summers and more precipitation than normally expected in grassland habitats. Elevations at RLNA range from 1220 to 1700+ m, with average January and July temperatures of about 8 and 19 ^{o}C, respectively. Average annual precipitation is about 430 mm.

Figure 1. Glacial moraine in Ross Lake Natural Area. Photo by K. Floate

The local landscape is diverse with glacial moraines, outwash features, coulees and swales. Upland areas are drained by two main streams with seeps and springs in several locations. Water is held behind dams on these streams with additional standing water in dugouts and in depressions that fill with water in the spring. The latter usually are dry by late summer. Grazing by cattle has caused extensive disruption of native plant communities in coulee bottoms. However, plant communities on upland areas remain intact. Under provincial legislation, grazing at RLNA is still permitted, but now is managed to restore and (or) maintain the native vegetation.

The dominant vegetation type is fescue grassland with a lesser representation of mixed grass and forb meadow, sage prairie, graminoid meadow, and shrub thickets. More than 220 species of plants are present including montane species such as perennial lupine, *Lupinus sericeus*, sticky purple geranium, *Geranium viscosissimum*, and common yarrow, *Achillea millefolium*. Of particular interest are the rare plant species thoroughwax, *Bupleurum americanum*, tufted hymenopappus, *Hymenopappus filifolius*, nodding microseris, *Microseris nutans*, and harefooted locoweed, *Oxytropis lagopus*.

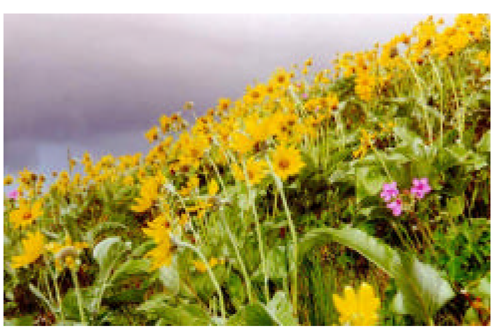

Figure 2. Balsam root (*Balsamorhiza sagittata*) and sticky purple geranium (*Geranium viscosissimum*) in May at Ross Lake Natural Area. Photo by K. Floate

Surveys at RLNA in the 1980's identified 83 species of birds and 31 species of mammals at or likely to visit the site, including a relatively substantial population of badgers. Such populations are becoming increasingly rare in grassland habitats. Systematic surveys of arthropods have yet to be performed.

Special features of RLNA include bison wallows, teepee rings, and a group of unusually large erratics – boulders deposited far from their points of origin by glacial movement.

Details of RLNA are provided in a 1986 report, titled "*Biophysical features and land use. Ross Lake. Candidate Ecological Reserve*", by G. Brown, E. Gasser and P. McIsaac, submitted to Alberta Recreation and Parks.

The effect of a grassland fire on a prairie arthropod community

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Summary. The purpose of the study presented here was to examine the effect of a grassland fire on the trophic structure of a prairie arthropod community. For this purpose specimens were identified to the family level, for classification as herbivore, predator, or parasitoid. The intent of this article is to provide an overview of the differences in abundance on burned and unburned sites. This work does not represent a survey of biodiversity, but rather a summary of what happened to overall arthropod abundance following a prairie fire. The specimens collected in this study are from an area not previously surveyed so intensively, and the collections are still available for species level classification.

Introduction. Fire is a common form of disturbance that affects communities of prairie arthropods (Rice 1932; Nagel 1973; Anderson et al. 1989; reviewed by Warren et al. 1987). However, due to various factors, including the timing and intensity of burn, little progress has been achieved in understanding the generality of these effects in different communities. This is an important shortcoming, considering the role of fire in maintaining prairie biodiversity.

Here, I summarize the results of a study that addressed the effects of a grassland fire on a community of prairie arthropods in western Canada. In particular, I asked "What was the effect of this fire on the total abundance and family richness?" This research was performed as part of the requirements of a M.Sc. thesis at the University of Lethbridge.

Methods. On December 13, 1997 a wildfire swept across the prairie in the foothills of southern Alberta. Approximately 200 square kilometers of prairie were burned in an area that had not experienced a fire for at least 20 years (Fig. 1). The affected area is part of the foothills fescue natural subregion. Strong (1992) reports that soils in this region are dark brown and black chernozems, precipitation varies from 400 to 480 mm per annum, and that the dominant grasses are rough fescue (*Festuca campestris*), Idaho fescue (*F. idahoensis*), sedges (*Carex* spp.) and Western wheat grass (*Agropyron smithii*). To assess the effects of this fire on prairie arthropods, two study plots (Site 1, Site 2) were set up in the Porcupine Hills, southwest of the town of Granum (Fig. 1). Site 1 was approximately 19 km N of Brocket, Alberta (49°43′N 113°45′W), at an elevation of 1410 m. Site 2 was approximately 18 km NNW of Brocket, (49°41′N 113°54′W), at an elevation of 1350 m.

Arthropods were collected using pitfall traps and pantraps. A pitfall trap consisted of two nested, 450 ml

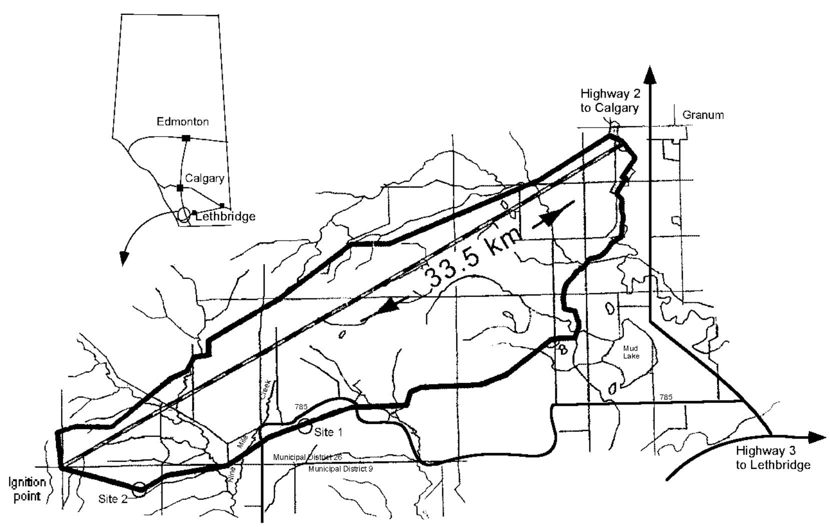

Figure 1. Map of the area burned in southern Alberta Canada (Dec. 1997). The locations of study sites 1 and 2 are indicated.

plastic cups (9 cm in diameter at lip) sunk in the ground so that the lip of the top cup was level with the substrate. Traps were covered with a gray-white, 15 cm square ceramic tile, supported 2.5 cm over the trap by four galvanized nails. The cups were half-filled with 50% ethylene glycol. Pantraps were aluminum food trays (22.5x15x5 cm) which were painted yellow (RGB colour scale: 250, 200, 0) to increase trap rates. The pans were laid level on the ground and filled to approximately 2cm depth with 90% ethylene glycol. Pantraps were also covered with 30 x 30 cm chicken wire mesh to prevent large vertebrates from drinking the ethylene glycol. Servicing of the traps and processing of the specimens followed standard protocols (Martin, 1978).

I sampled along the southern edge of the Granum burn, comparing adjacent regions on and off the burn. The edge of the burn was actually the firebreak that was ploughed at the time of the fire. Four transect lines were set up at each site, perpendicular to the firebreak (approximately 2.5 to 3 m wide) and positioned 25m apart. The mid-point in the width of the firebreak was treated as the center point for the transects. Sampling stations were positioned at 10 and 50 m from the center point on both the unburned (control) side of each transect and the burned side.

At each sampling station, three pitfalls and three pantraps were laid in a 2 m diameter circle (alternating trap type) around a center stake. Samples from the six traps at each station were pooled. Arthropod collections were resolved to the level of site, burn treatment, distance from burn edge, and date. In 1998, the traps were laid out on 6 July at Site 1 and 11 July at Site 2. At Site 1, all traps were emptied and reset on July 10, 15, and 18. Traps at Site 2 were emptied and reset on July 15, 18, and 22. All traps were reset on August 6, then emptied and reset on August 10, 14, and 18. Traps were removed for the winter then reset on July 8, 1999 and emptied and reset on July 12, 16, and 20. By limiting sampling to these restricted periods, seasonal differences in arthropod taxa largely were eliminated as a confounding factor. Also, collection and processing of a greater number of samples was possible, which increased the probability of detecting subtle differences between treatments.

Vegetation measurements were made on August 13, 1998 and August 19, 1999. Percent cover of common plant species was estimated using a $1m^2$ quadrat. These measurements were made at each trap, centering the quadrat over the trap. This allowed a view of the microhabitat structure immediately surrounding each trap. Mean height estimates were made using a meter stick. Cattle were excluded from the two sites during the study to eliminate grazing as a confounding factor.

Most individuals were counted and identified to the family level. Arthropods from the orders Phalangida, Chilopoda, and Thysanoptera were not keyed to family but, with exception of Thysanoptera, were rare. Only analyses of abundance by order are reported here. Specimen identifications were confirmed by comparison with known specimens and with the help of technicians at the Strickland Museum, University of Alberta and at the Provincial Museum of Alberta.

Samples from all pitfalls and pantraps at each distance were pooled for each four-day sampling period, and a mean was calculated for all sampling dates. Differences between vegetation measurements and taxon abundances on the unburned and burned prairie were analyzed using Wilcoxon/Kruskal Wallis tests. Data were analyzed using JMP® (v4.0, 2000). Variations due to site, year, burn treatment, and distance were analyzed with mixed-model ANOVA. Total arthropod abundance and family richness were the response variables measured and were transformed to normality using Box Cox transformations. Family richness was measured as the total number of taxa (family for all but four orders not keyed to family) that occurred in each sample. The mean abundances of each order were calculated using all of the 1998 samples. However, because samples were not collected in August 1999, only the July samples from 1998 were used in the ANOVA analyses to make the two years comparable. Least square means were plotted for the highest order interactions in which variables were significantly involved. A posteriori differences between treatment means were assessed using Tukey-Kramer HSD tests (P=0.05).

Results. Approximately 120,000 individual specimens were collected in July of 1998 and 1999, from 137 taxa. Approximately 62,000 and 58,000 specimens, respectively, were collected from unburned and burned prairie. In 1998 the percent cover of vegetation was 17.3 % less on the burn than on the unburned prairie (Table 1; Wilcoxon test, $\chi^2 = 145.44$, $P < 0.0001$). In 1999, the vegetation cover on the burn was 8.9 % lower than that on the unburned prairie (Table 1; Wilcoxon test, $\chi^2 = 105.56$, $P < 0.0001$).

The effect of burning varied by taxa and year (Table 2). In 1998, many taxa showed no significant difference in abundance between burned and unburned treatments (e.g. Diptera, Heteroptera). However, some taxa were more abundant on the unburned prairie (e.g. Homoptera, Lepidoptera), whereas Thysanoptera were more abundant on the burned prairie. In 1999, fewer taxa showed significant differences between burned and unburned treatments. However, the Phalangida, Araneae and Neuroptera were more abundant on the unburned prairie, and the Orthoptera were more abundant on the burned area.

Total abundance was affected by a 3-way interaction involving site, year, and treatment. At Site 1, there was no difference in total abundance between burned and unburned prairie in 1998 or 1999 (Fig. 2). However, the abundance at Site 1 was higher in 1999 than in 1998 (Fig. 2). At Site 2, there was no difference between total abundance on and off the burn in 1998 or 1999 (Fig. 2).

Mean family richness was affected by a 2-way interaction between site and treatment, and also by year. Family richness was the same on

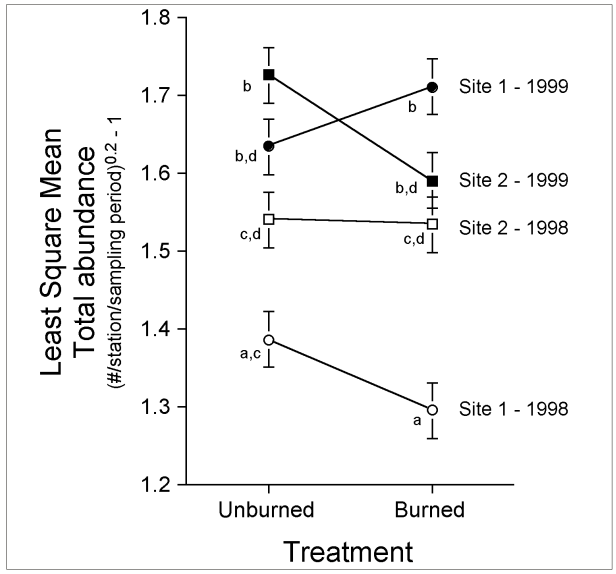

Figure 2. Relationship between total abundance and treatment on Sites 1 and 2 in each year (1998 and 1999). Means +/- one standard error are given. Letters indicate groups of means that are not significantly different from each other (Tukey-Kramer HSD test. P<0.05)

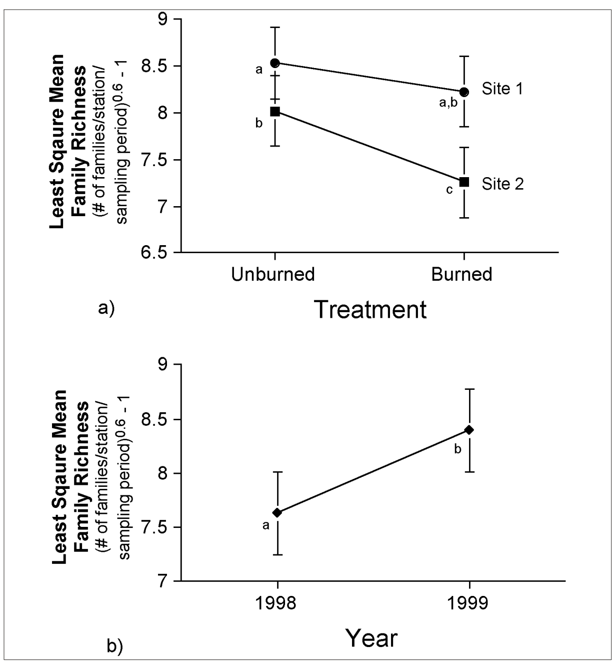

Figure 3. Relationship between family richness and a) treatment at each site, and b) year. Means +/- one standard error are given. Letters indicate groups of means that are not significantly different from each other (Tukey-Kramer HSD test, P<0.05).

both unburned and burned prairie at Site 1 (Fig. 3a). At Site 2, the family richness was significantly higher on the unburned prairie than on the burned prairie (Fig. 3a). Family richness was also significantly higher in 1999 than it was in 1998 (Fig. 3b).

Discussion. Results from this study was consistent with results from previous studies (Cancelado and Yonke 1970; Warren et al. 1987; Anderson et al. 1989) that showed fire to have a varied effect on the abundance and richness of arthropod taxa. This varied response is likely due to a number of factors. The timing and rate of burning can greatly affect how fires will affect given insect groups (Reed 1997). Life history may also influence how a fire will affect arthropod taxa; e.g. pupae overwintering in the soil are less likely to be affected by a winter burn than eggs overwintering on vegetation (Algren 1974).

Total abundance and family richness were significantly affected by combinations of year, site, and burn treatment. This study shows that there are many factors that influence the abundance and richness of arthropods in prairie communities. The area studied, the year, and the effects of disturbance all had an impact on this grassland arthropod community. Factors such as these are what make finding generality among studies dealing with arthropod responses to disturbance difficult.

Conservation of biodiversity is a popular topic in community ecology (e.g. Morowitz 1991; Ehrlich 1992; Tilman 1999) and the search for management practices that allow preservation of the highest diversity is just beginning. This study indicates that it is difficult to determine how common management practices affect arthropod communities and that generality is difficult to attain without extensive effort. The best approach may be to conserve arthropod diversity indirectly, by using fires to manage the associated plant communities, whose response to fire is easier to predict.

Acknowledgements. Funding for this research was provided by the Southern Applied Research Association, the Challenge Grants in Biodiversity Program (Dept. of Biological Sciences, University of Alberta), the Alberta Conservation Association, and NSERC of R. Cartar. Many thanks go to my supervisory committee, field assistants, and the land owners who allowed me to work on their property.

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Table 1. Percent cover and diversity of vegetation on unburned and burned prairie in 1998 and 1999. Rank means (% or D/station) ± 1 SE are given. *P* values are Bonferroni-corrected.

Measurement	Unburned	Burned	Wilcoxon test statistics
% cover – 1998	96.69± 1.00	68.18 ± 1.25	$c^2 = 39.92$ $P < 0.0004$
% cover – 1999	93.57 ± 1.06	78.23 ± 0.86	$c^2 = 105.56$ $P < 0.0004$
Diversity – 1998	0.18 ± 0.014	0.51 ± 0.014	$c^2 = 126.15$ $P < 0.0004$
Diversity – 1999	0.24 ± 0.014	0.32 ± 0.018	$c^2 = 6.03$ $P = 0.056$

Table 2. Mean abundance of all orders collected on unburned and burned prairie in 1998 and 1999. * indicates significant difference between burned and unburned rank means in each year (Wilcoxon test, $P < 0.05$). P values were Bonferroni corrected, for each year comparison.

Family	Unburned 1998 *n*=94	Burned 1998 *n*=141	*P*< .05	Unburned 1999 *n*=44	Burned 1999 *n*=66	*P*< .05
Acarina	4.24±0.92	0.13±0.04	*	0.27±0.07	0.16±0.10	
Phalangida	5.10±0.51	4.90±0.72		0.42±0.07	0.17±0.04	*
Araneae	12.16±1.39	4.97±0.59	*	3.16±0.39	1.59±0.18	*
Diptera	146.73±5.77	146.11±4.84		40.24±2.27	37.26±1.53	
Hymenoptera	125.3±19.61	166.9±23.33		24.18±3.43	25.70±2.57	
Homoptera	86.44±3.18	67.78±2.79	*	34.77±4.08	30.72±7.09	
Heteroptera	4.03±0.31	5.48±0.36		0.64±0.11	1.02±0.15	
Lepidoptera	18.73±0.26	8.26±0.45	*	5.36±0.42	6.15±0.76	
Coleoptera	5.95±0.46	7.76±0.44		0.62±0.04	1.99±0.30	
Neuroptera	8.36±1.67	1.40±0.82	*	0.66±0.11	0.23±0.03	*
Thysanoptera	57.71±5.95	100.91±8.29	*	24.62±1.94	27.17±1.77	
Collembola	2.71±0.53	0.60±0.13	*	0.77±0.42	0.13±0.03	
Orthoptera	7.78±0.56	9.01±0.51		1.00±0.16	2.70±0.38	*
Strepsiptera	0.15±0.06	0.03±0.01		0.03±0.01	0.01±0.00	
Chilopoda	0.00	0.04±0.02		0.00	0.01±0.01	

Recent publications

Grassland Ecosystems

White, R.P., Murray, S. and Rohweder, M. 2000. Pilot analysis of global ecosystems: Grassland Ecosystems. World Resources Institute, U.S.A.

Pilot Analysis of Global Ecosystems (PAGE): Grassland Ecosystems summarizes key findings about the condition of the world's grasslands, as well as the quality and availability of data. Among the conditions and trends identified are the following:

- Grasslands cover some 40 percent of the earth's surface (excluding Greenland and Antarctica).
- Of 136 terrestrial ecoregions identified as outstanding examples of the world's diverse ecosystems, 35 are grasslands, supporting some of the most important grassland biodiversity.
- The five countries with the largest grassland areas are Australia, the Russian Federation, China, the United States, and Canada.
- Grasslands are found most commonly in semi-arid zones (28 percent of the world's grasslands), followed by humid (23 percent), cold (20 percent), and arid zones (19 percent).
- Temperate grasslands, savannas, and shrublands have experienced heavy conversion to agriculture, more so than other grassland types including tropical and subtropical grasslands, savannas, and woodlands.

For many other details, see the report, which is available also on the web at http://www.wri.org/wr2000/grasslands_page.html

Notes on arthropods in grassland agroecosystems

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Researchers recently reported two new species of pest insects in Canada's grassland agroecosystems, and have reported populations of two other pest, or potential pest, species on the rise. Information on these species is summarized below to generate awareness of species of particular interest in grassland agroecosystems.

The cabbage seedpod weevil, *Ceutorhynchus obstrictus* (Marsham), is specific to crucifers, including canola, brown mustard, wild mustard, cabbage and flixweed. It was first collected in North America near Vancouver in 1931, with populations being established in the BC interior since the 1930s. It was first detected on the prairies in 1995 when a larva was recovered near Lethbridge. The weevil has rapidly increased in abundance to become a major pest of canola crops in southern Alberta. It is expected to spread throughout the canola growing regions of Canada.

The pea leaf weevil, *Sitona lineatus* (L.), is a serious pest of pea and other legumes in the United States and Europe. Prior to 1997, it was known in Canada only from the southern interior of British Columbia. In 2000, adults were recovered from several fields in southern Alberta where they were observed feeding on pea seedlings. The potential for this weevil to affect Alberta's expanding pulse crop industry is unknown.

Populations of wheat stem sawfly, *Cephus cinctus* Norton, have increased dramatically in southern Alberta since 1998, with up to 90 percent damage to wheat stems observed in some fields. Larval feeding within stems can reduce yields from 5-15 percent and decreases grain quality. Stems girdled by mature larvae are susceptible to lodging, further reducing yields.

Populations of wheat head armyworm, *Faronta diffusa* Walker, increased 10-fold in southern Alberta from 1999 to 2000. Although this increase did not warrant control measures, it has raised awareness of the species as a potential pest. Larvae crawl partially into wheat heads to feed on developing kernels from mid-July to late August.

Populations of wheat stem sawfly and wheat head armyworm likely have benefitted from the warm, dry conditions of recent years. Adoption of reduced tilling methods also likely favors survival of these species. Because no pesticides have been registered for control of either pest, research on their natural enemies may be of particular interest.

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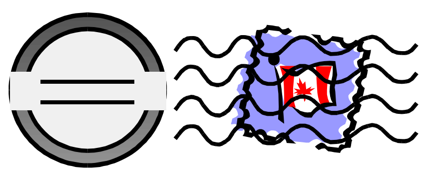

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