Arthropods of Canadian Forests

Number 1 **April 2005**

Contents

Male forked fungus beetle, *Bolitotherus cornutus* (Tenebrionidae) (photo courtesy of CFS).

Welcome

Welcome to the first issue of *Arthropods of Canadian Forests*. This newsletter is a product of a collaboration between Natural Resources Canada, Canadian Forest Service and the Biological Survey of Canada, Terrestrial Arthropods (BSC). The goal of the newsletter is to serve as a communication tool to encourage information exchange and collaboration among those in Canada who work on forest arthropod biodiversity issues, including faunistics, systematics, conservation, disturbance ecology, and adaptive forest management. As well, the newsletter supports the Forest Arthropods Project of the BSC. This annual newsletter will be distributed electronically (pdf) in late March. If you wish to be placed on the distribution list, please contact David Langor.

Newsletter Content will include project updates (short articles that introduce ongoing relevant projects in Canada); feature articles (overviews, summaries, commentaries or syntheses); a graduate student section featuring brief summaries of thesis research, funding opportunities, employment notices, etc.; brief news articles concerning meetings, symposia, collaboration opportunities, collecting trips, etc.; and a listing of new publications and websites. Please consider submitting items to the *Arthropods of Canadian Forests* newsletter. We welcome articles in English or French, and we invite your comments on how we can improve the content and delivery of this newsletter.

Contributions of articles and other items of interest to students of forests and their arthropods are welcomed by the editor. Submission in electronic format by e-mail or CD is preferred. The final copy deadline for the next issue is January 31, 2006.

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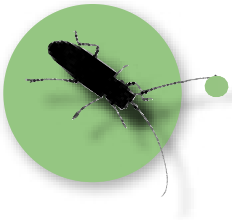


BSC Project – Forest Arthropods

In 2003, the Biological Survey of Canada (BSC) initiated a new project to focus on arthropod faunistics and systematics work related to forested ecosystems. The primary goal of this project is to coordinate research on the diversity, ecology, and impacts of the arthropods of Canadian forests.

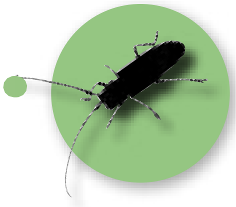
Arthropods represent 60–70% of all species in Canadian forests but are relatively little known despite their great importance (see boxed text at right). The current situation in Canada concerning research on diversity of arthropods in Canadian forests can be characterized as follows:

- There is much research activity across the country focusing on a wide variety of biodiversity issues, but most work is tightly focused on restricted faunistic inventories or localized testing of specific hypotheses.
- Information exchange is abysmal. Most groups work in relative isolation, and there is relatively little interchange of results or true collaboration.
- There is little scientific synthesis.
- Work is often criticized, poorly funded and noninfluential because there is no cohesive overall plan.

The BSC is well placed to offset some of these difficulties by serving as a clearing house for information, a coordinator and catalyst to foster research and synthesis on arthropod biodiversity, and a unifying voice to express matters of national concern and need. The BSC has, therefore, initiated efforts to build better communication, collaboration, and cohesion among those working on forest arthropod biodiversity issues, and to build on and integrate existing BSC activities related to forests.

The economic context

About 45% of Canada’s land area is forested, and 25% of the land area is represented by commercial forests. Fifteen terrestrial ecozones in Canada contain forest types, and two-thirds of Canada’s estimated 140 000 species of plants, animals, and microorganisms live in forests. Clearly, forests dominate life zones in the country to the extent that a study of their associated fauna is basic to a full understanding of the arthropod fauna of Canada. Forests also underpin a pillar of the Canadian economy, worth about $75 billion annually and contributing over 360 000 jobs directly, resulting in increased forest development activity. The search for a sustainable balance among ecological, economic, and social values of forests drives the national forest policy agenda. The ecological values and services provided by forests are not fully understood or appreciated, a critical information gap that impedes optimal decision-making. In the absence of detailed knowledge of the full range of forest ecosystem functions, biological diversity represents a generally accepted surrogate of functional ecosystem integration and, as such, is increasingly being included in the suite of forest management objectives for the Canadian forest industry. However, there is the realization that little is known about the vast majority of species, including arthropods, in forests and that improved knowledge (composition, variation, impacts of disturbances) of these groups is necessary to establish meaningful, operational biodiversity objectives as an essential component of sustainable forest management.



To fulfill these general roles the BSC has undertaken several new activities:

- Develop a continuously updated list of ongoing forest biodiversity projects in Canada (see www.biology.ualberta.ca/bsc/english/forestprojectssummary.htm). This product highlights current activity in Canada and helps facilitate contact between researchers with complementary interests.
- Sponsor and organize symposia and workshops on relevant topics. These events will serve to review progress and highlight important gaps and opportunities. The BSC is hosting a symposium, *Maintaining Arthropods in Northern Forest Ecosystems*, in Canmore, Alberta, in November 2005 (see details in News and Events section).
- Development of new communication vehicles. The BSC has developed a set of web pages (www.biology.ualberta.ca/bsc/english/forests.htm) to support and advertise the work on forest arthropods. The *Arthropods of Canadian Forests* newsletter is also expected to provide an important communication forum.

In its broader scientific roles, the developing project will involve a large number of specialists with expertise on different taxa, from various geographic regions, and with diverse research interests, embracing three general objectives on the nature of arthropods associated with Canadian forests:

1. Describe of the diversity (alpha, beta, gamma) of arthropods associated with Canadian forests.
2. Determine the ecological roles of arthropods in Canadian forests and the drivers that determine species distributions and assemblage structure.
3. Measure the impacts of natural and anthropogenic disturbances on forest arthropod communities, and identify mitigation measures to improve conservation.

To these ends, faunistic and taxonomic research on selected groups of forest arthropods will be pursued. There are two current research initiatives:

Geoff Scudder and Bob Foottit are assessing the guild of sucking insects on *Pinus banksiana* (Jack pine) and *P. contorta* (Lodgepole pine) by extracting data from collections and by field collecting.

David Langor, David McCorquodale, Serge Laplante, and Jim Hammond are preparing a handbook to the Cerambycidae (Coleoptera) of Canada and Alaska. This collaboration includes Canadian Forest Service, USDA Forest Service, Agriculture and Agri-Foods Canada, University College of Cape Breton, and the BSC. The book is expected to be completed in 2007.

Stay tuned as this project matures, and consider becoming involved.

Database of Forest Arthropod Biodiversity Projects

In late 2003, the BSC undertook a survey of active forest arthropod biodiversity projects in Canada to update a database compiled in 1997. The objective was to build a comprehensive and regularly updated on-line database to improve awareness of ongoing forest biodiversity research/survey projects in Canada. This product was expected to increase opportunities for data sharing and syntheses; exchange of experiences, expertise and information; collaboration; and better visibility for such activities. The database was made available on-line in January 2004, and now, one year later, includes 56 projects focusing on faunal surveys; assessment of natural and anthropogenic impacts on species abundance and genetic diversity; development of ecological indicators; and conservation of forest arthropods. The database does not include projects on pest management, population ecology, physiology, behavior, and systematics.

A majority of the projects are located in British Columbia (15 projects) and Alberta (16), with good clusters of activity in Manitoba (7), Ontario (6), Quebec (6) and the Atlantic Provinces (6). There is very little activity in Saskatchewan and in the north. Work in the north would be especially desirable as many areas remain poorly sampled, and it is predicted that these areas will be especially affected by climate change.

Most work has been focused on epigaeic arthropods, especially Carabidae (23 projects), spiders (23) and Staphylinidae (15), but also ants (4), myriapods (1) and tartigrades (1). The volume of data and analyses on some of these groups are sufficient to allow some worthwhile syntheses. Saproxylic arthropods, especially Coleoptera, have increasingly become the focus of research in recent years. Currently there are 13 projects, with 5 of those focused on bark- and wood-boring families (Buprestidae, Cerambycidae, Scolytidae). Lepidoptera, especially macro-moths, are also popular subjects for forest biodiversity work (15 projects). Other groups that are under current study include mites (9), Collembola (5), parasitic Hymenoptera (5), other Hymenoptera (6), Diptera (6), Coleoptera (8), Odonata (1) and Thysanoptera (1). In general, the groups receiving most attention are those that are relatively easy to identify, and for which good recent keys and expertise are available, e.g., Carabidae, Staphylinidae, Lepidoptera, and saproxylic beetles.

Most projects were initiated for the purpose of faunistic inventory (25 projects). Many projects (22) were initiated to assess the non-target impacts of forest management (e.g., harvesting, silviculture, pest management) and to assess the recovery of fauna following perturbations. Most of such projects aimed to identify practices that minimized impacts on biodiversity and a small number sought to contribute to adaptive management practices. Nine projects sought to provide insight into the relationship between fire and arthropod diversity and assemblage structure. Finally, 12 projects aimed to identify habitat associations of arthropods. Little attention (1 project) has been focused on the relationship between climate change and forest arthropod biodiversity. Such work is direly needed and should be encouraged.

There is bountiful evidence that this database is being used to facilitate information exchange and collaboration. Please continue to provide updates to this database as per instructions on the associated web page: http://www.biology.ualberta.ca/bsc/english/forestprojectssummary.htm.

Project Updates

Monitoring biodiversity close to home: collecting generalist arthropod predators from McGill University's research forests

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Introduction

The value of long-term biodiversity monitoring is well appreciated, but initiation of and continuing commitment to such efforts is far from simple. This work requires the proper techniques for data collection, motivated and qualified field assistants, good taxonomic skills, and a commitment to long-term data management. Additionally, the data are not immediately suitable for publication; consequently, biodiversity monitoring is often low on the research priority list when developing student projects and making plans for the field season. Despite these obstacles, however, the benefits of long-term arthropod monitoring are great. It is satisfying to become familiar with the arthropod fauna in a specific forest, and there exists the possibility of detecting shifts in species composition due to external environmental change, the introduction of invasive species, or human-caused disturbance to forest ecosystem. Arthropod biodiversity monitoring also provides a terrific opportunity to foster enthusiasm for entomology and arachnology and a positive educational experience.

My laboratory hosts a regular event called 'Biodiversity Blitz,' which provides an opportunity for biodiversity monitoring activities. Together with students and summer research assistants we tackle biodiversity monitoring of generalist arthropod predators in three different research forests, with 6 individual sampling plots. The Molson Reserve, the Morgan Arboretum, and the Gault Nature Reserve (Mont St. Hilaire) (Figure 1) are all located within 1.5 hours of McGill University. The forest composition at these forests is diverse and heterogeneous, but overall it is dominated by beech–maple–oak, with smaller coniferous components.

The objectives for the biodiversity monitoring are 1) to maintain ongoing inventories of generalist arthropod predators inhabiting specific habitats in McGill University's research forests; 2) to use the inventory data to assess changes in species composition in response to external environmental changes; 3) to foster and enhance enthusiasm for entomology and arachnology by providing students and research assistants with an interesting activity and the opportunity to collect arthropods using a variety of standard techniques; and 4) to make data accessible to the entomological and arachnological communities and to the general public.

Figure 1. View of Mont St. Hilaire, Quebec (photo by C. Buddle).

Study Taxa

The subjects of our biodiversity monitoring are generalist arthropod predators, mainly Coleoptera (e.g., Carabidae, Staphylinidae), Araneae, Pseudoscorpionida, and ants. We also collect other arthropods on a more opportunistic basis, depending on the interests of the participants and the possibilities of obtaining accurate species determinations. The reasons for focusing activities on generalist predators follow: first, my own personal expertise is with spider taxonomy, and thus the original design and inception of the monitoring had a certain arachnological bias; second, the selected arthropods are all currently part of student research projects, and thus the field assistants and students involved in the monitoring have an inherent interest and skill in finding these taxa in the field; third, the chances of good species determinations are high. One of the main limiting factors of monitoring invertebrates is sound taxonomy. There is little value to shelves of unidentified specimens; instead we collect specimens we can identify, with the assistance of taxonomists who help verify determinations.

Monitoring Plots

The monitoring occurs at six plots, three occurring at the Gault Nature Reserve (Mont St. Hilaire) (Figure 1), two at the Morgan Arboretum, and one at the Molson Reserve. In the first year of this project (2003), we sampled in May, June, and August, and focused efforts in the Gault Nature Reserve. We have now opted to include the two additional forests (the Molson Reserve and the Morgan Arboretum) but will collect only twice per year (i.e., June and August) in each forest. Sampling requires four full field-days per field season, plus time for sorting and identifications in the laboratory. Plot selection was completed in the spring of 2003, with plots established in habitats dominated by the main tree species in each forest. Where possible, we placed our plots close to the permanent EMAN (Ecological Monitoring and Assessment Network) plots to take advantage of environmental data (e.g., precipitation, temperature, and humidity) collected by the EMAN permanent monitoring stations.

The three plots at the Gault Nature Reserve are an old-growth, low-lying deciduous forest (dominated by beech, *Fagus grandifolia*, and maple, *Acer* sp.); a rocky and xeric hill-top plot, dominated by red oak, *Quercus rubra*, with shallow litter layer and high exposure (Figure 2); and a mesic area dominated by ferns, stinging nettle, and skirting a small creek (fern site), affectionately known by students as the 'mosquito plot!' At the Morgan Arboretum, we placed plots in an old-growth pure sugar maple, *Acer saccharum*, stand and on a ridge dominated by beech. The plot at the Molson Reserve is dominated also by sugar maple and beech. Unlike the other forest plots, the Molson Reserve is rocky with very little soil and meager leaf litter.

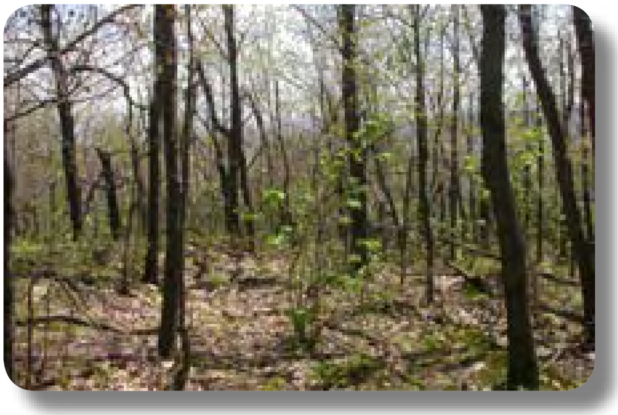

Figure 2. The hill-top plot, dominated by red oak, *Quercus rubra*, at the Gault Nature Reserve, Mont St. Hilaire (photo by C. Buddle).

Sampling Protocols

The sampling protocols are a combination of those suggested by EMAN – Arthropod Monitoring in Terrestrial Ecosystems (Finnamore et al. 2004), protocols used by spider specialists (Coddington et al. 1996), and protocols suggested by ant specialists (Agosti et al. 2000). Within a plot, a 10 m x 10 m area is flagged for sampling. This sample area will not be sampled again for at least 1 year (i.e., sample areas are alternated within a plot location). The group (at least four people are required) is split, with two teams of field collectors (A and B). The teams are instructed to collect any generalist arthropod predators (in the case of ant nests, 10 workers are collected). The sampling protocols are as follows:

One person collects two samples of about 0.2 m^2 of leaf litter in two separate pillow cases. The litter is returned to the laboratory where invertebrates are extracted using a Berlese apparatus.

For 15 minutes, Team A (two people) uses sweep nets or beat sheets (depending on habitat) to collect foliage-dwelling arthropods. Simultaneously, Team B (two people) actively search (visual survey) at knee level and below for arthropods; this includes searching in leaf litter, under rocks, and in and under dead wood (Figure 3).

Figure 3. Graduate student Michel Saint-Germain searching leaf-litter for arthropods (photo by C. Buddle).

For 15 minutes, Team B uses a litter sifter to sift sections of litter (about 0.2 m^2 in area) onto the beat sheet and arthropods are collected (Figure 4). Simultaneously, Team A collects arthropods (visual survey) above knee level, including on trees and foliage.

Figure 4. Graduate students Tara Sackett (left) and Alida Mercado (right) sifting litter, using a bucket with a screen at the base, onto a beat sheet for collecting leaf-litter arthropods (photo by C. Buddle).

For 15 minutes, Team A performs a visual survey at knee level and below, while Team B uses sweep net or beat sheets for foliage-dwelling arthropods.

For 15 minutes, Team A uses the litter sifters, while Team B performs a visual survey at knee level and above.

After each 15-minute period, the team regroups and places pre-made labels in all of the collection vials. Specimens are stored in 70% ethanol and later identified to species in the laboratory. The protocols are designed so that each participant has the opportunity to use each sampling method. Four person-hours within a 100 m^2 area represents a reasonable sampling effort, given the objectives of the monitoring project.

Preliminary Results

Jean-Philippe Lessard (Figure 5), an undergraduate student, has completed all ant identifications from our 2003 collection at the Gault Nature Reserve. The spider identifications (2003 and 2004) will be completed early in 2005, and the Coleoptera will be identified on an opportunistic basis in the future.

Figure 5. Jean-Philippe Lessard happily collecting ants at Mont St. Hilaire (photo by C. Buddle).

Twelve ant species were collected in the three plots at the Gault Nature Reserve in 2003 (Table 1). Eight species were collected in the beech–maple plot, 9 in the hill top plot, and 7 in the fern plot. Five species were found in all three habitats, including the ubiquitous carpenter ant, *Camponotus pennsylvanicus* (De Geer), and the common *Lasius alienus* (Foerster). One species was unique to the fern plot, 2 to the hill top plot and 2 to the beech–maple plot. All voucher specimens will be deposited in the Lyman Entomological Museum (Ste Anne de Bellevue, Quebec). We are also in the process of developing a website that will highlight the overall project and provide lists of species collected in the research forests.

Table 1. Ant species collected in three plots at the Gault Nature Reserve in 2003

Ant species	Beech–Maple	Hill top	Fern
Aphaenogaster picea Emery	*	*	*
Camponotus nearcticus Emery		*	*
Camponotus pennsylvanicus (De Geer)	*	*	*
Formica neogagates Emery	*	*	
Formica subanescens Emery		*	
Lasius alienus (Foerster)	*	*	*
Lasius nearcticus Wheeler	*		
Myrmica punctiventris Roger			*
Myrafant longispinosus (Roger)	*	*	*
Myrmecina americana Emery	*		
Stenamma diecki Emery	*	*	*
Stenamma impar Forel		*	
Total	8	9	7

Conclusions

Biodiversity monitoring of forest arthropods is possible, provided that detailed protocols are used in a consistent fashion, and accurate species identifications are completed. It is recognized that current methods will certainly miss many cryptic or rare species, but they will at least provide baseline information about which species are present in our plots during two key phenological periods. Preservation of voucher specimens and data accessibility will be key elements for success with this project. Additionally, the non-quantifiable value of enthusiastic field-collecting cannot be understated. Students and research assistants have come to love the Biodiversity Blitz days, and these collections allow us to be reacquainted with the reasons many of us first became enthused about arthropods. It's a chance to step out of heavily structured research projects and a chance to turn off the computer and microscope! The wealth of biodiversity in our own backyards is sometimes underappreciated. Even in an urban center like Montreal, it is possible to venture into old-growth forests within sight of the city and collect valuable data about arthropod biodiversity.

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Coddington, J.A., L.H. Young and F.A. Coyle. 1996. Estimating spider species richness in a southern Appalachian cove hardwood forest. Journal of Arachnology 24: 111–124

Finnamore, A.T.; Winchester, N.N.; Behan-Pelletier, V.M. (2004) Protocols for measuring biodiversity. Arthropod monitoring in terrestrial ecosystems. Ecological Monitoring and Assessment Network (EMAN). http://www.eman-rese.ca/eman/ecotools/protocols/terrestrial/arthropods/intro.html (accessed 22 December 2004).

Web Links:

The Molson Reserve: http://www.mcgill.ca/macdonald/resources/molson/

The Morgan Arboretum: http://www.morganarboretum.org/

The Gault Nature Reserve: http://www.mcgill.ca/gault/reserve/

The Forked Fungus Beetle as a Model System in Ecology

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Preface

I am a population biologist, and for years I used microtine rodents as model systems for investigating social organization, dispersal, and population demographics. Over time I developed an allergy to the urine of rodents, and my reaction became so severe that I had to accept that if I continued handling rodents I might die from anaphylactic shock. While attending a forestry conference in Sweden I met a colleague from Norway who worked on saproxylic beetles, and I asked him, half in jest, if he knew of an insect that I might use as an experimental model system to continue my research in population ecology. Without hesitation, he said *Bolitotherus cornutus*. We were at the Grimsö Field Station in central Sweden, and there was a small museum attached to the station. Although it was close to midnight, he managed to find a key and took me over to show me a display of a birch log with a fruiting body of the tinder fungus, *Fomes fomentarius* on it. Excitedly he told me about the forked fungus beetle and its reliance on fungal sporocarps. In the sporocarp was an emergence hole from a related beetle, *Bolitophagus reticulates*. I was convinced on the spot. Here was a system that was ideal for studying dispersal, population structure, and demographics. For the last few years, I have been studying a variety of population phenomena using this model system.

Background

The forked fungus beetle, *Bolitotherus cornutus* Panzer (Coleoptera: Tenebrionidae) is 8–12 mm in length and sexually dimorphic; only males possess two horns on the pronotum (Graves 1960) (Figure 1). Males use the horns to try to dislodge other males from the backs of females during courtship and mating. Although individuals have well-developed wings (Graves 1960), flight has only been observed in the lab (Teichert 1999a). The only evidence of flight in the wild is circumstantial and consists of a single individual, uniquely marked, found 852 m away from its initial capture, which occurred about 22.5 hours earlier. All of the other 27 beetles in that study were found an average of 6 times on the same log during a 1-month period (Heatwole and Heatwole 1968).

Figure 1. Male forked fungus beetle (photo by S. Bondrup-Nielsen).

Forked fungus beetles are strict fungivores and were once thought to complete their entire life cycle on a single piece of fungus (Liles 1956); however, they do move around among sporocarps on a single dead log and occasionally between logs tens of metres apart (Whitlock 1994; Lundrigan 1997; Kehler and Bondrup-Nielsen 1999; Teichert 1999b; Starzomski and Bondrup-Nielsen 2002). Forked fungus beetles are slow, deliberate walkers (Park and Keller 1932) and most active at night, with peak periods of activity between 8 p.m. to 4 a.m. (Liles 1956) and 12 a.m. to 7 a.m. (Conner 1989). Beetles can often be seen during the day, feeding or mating on the surface of their fungal hosts or on tree bark adjacent to the host.

Forked fungus beetle mating begins in spring and lasts until late summer. The ritual of mating begins when the male forked fungus beetle mounts the female so that the ventral surface of his abdomen lays on the dorsal surface of the female's thorax in a reverse position (Figure 2). Using his abdomen, the male rubs across the female's tubercles continuously for up to 3 hours (Conner 1989). This initiation may be followed by copulation, in which the male reverses his position on the female so that he may transmit his spermatophore to her. For successful transmission to occur, the female must open the plate at the tip of her abdomen, thereby allowing her to control successful mating by the male in question. If the male is successful, he may guard the female from other males for 2 to 5 hours (Conner 1988).

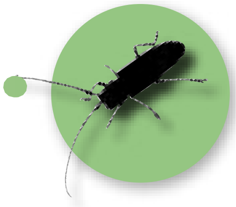
Figure 2. Male forked fungus beetle courting female (photo by S. Bondrup-Nielsen).

Up to 20 eggs per female are laid in early spring (May) until late summer (August) singly on the upper surface of the host fungi and covered with feces (Liles 1956). Eggs take 11 to 26 days (average 16 days) to hatch, at which time the larvae enter the sporocarp and construct tunnels (Liles 1956), eating the tissue as they tunnel (Pace 1967). Pupation occurs inside the sporocarp about 3 months after oviposition and, in more southern regions, larvae from earlier-laid eggs emerge as adults in the fall, while those from later-laid eggs emerge the following spring (Liles 1956). Before emerging as adults, the beetles remain in the pupal chamber for at least 4 days so that their exoskeleton may be completely melanized (Liles 1956). Adults can live for 5 years or more (Brown and Rockwood 1986).

The tinder fungus, *Fomes fomentarius*, is the fungus species most widely used by forked fungus beetles in Nova Scotia, probably due to its abundance (Figure 3) (Starzomski and Bondrup-Nielsen 2002). This fungus causes a white rot in the wood of living and dead hardwoods (Gilbertson 1984). Tinder fungus is circumboreal (Gilbertson 1984), commonly found on dead or dying white birch (*Betula papyrifera*) (Schwarze 1994), yellow birch (*Betula lutea*), large-toothed aspen (*Populus grandidentata*) and beech (*Fagus grandifolia*) in northern regions (Matthewman and Pielou 1971, Kehler and Bondrup-Nielsen 1999). The sporocarps are somewhat hoof-shaped and the crust or upper surface is a light-grey color when young, becoming darker with age (Matthewman and Pielou 1971), and they measure about 60–500 mm x 40–300 mm x 40–250 mm (Schwarze 1994). The under or pore surface of tinder fungus is light brown when the fungus is alive, and when the sporocarp dies it stays attached to the host tree and the pore surface darkens and becomes cracked (Matthewman and Pielou 1971). Pores measure about 2–4 per mm (Schwarze 1994). Basidiospores are released from late spring to early summer (Schwarze 1994). Tinder fungus is perennial, and it continues to sporulate and grow for up to 9 years, until it is eventually killed off by insects (Gilbertson 1984).

Figure 3. Tinder fungus on birch (photo by S. Bondrup-Nielsen).

The forked fungus beetle and its host is enticing as a model system for investigating questions in ecology for a number of reasons. The beetle is large enough that they can be individually and permanently marked (I use Testor model paint). The species is sexually dimorphic and males can easily be distinguished from females. The species is active from late May to end of August (at my location), and presence can be determined from visual observation of adults, the presence of unique emergence holes in sporocarps, and the presence of eggs on the surface of sporocarps. The adults are slow moving and do not escape capture. The habitat consists of fruiting bodies of *Fomes fomentarius, Ganoderma applanatum* and *Ganoderma tsugae*, and, finally, the habitat is discrete at several scales (the single sporocarp, sporocarps on a single dead log or snag, logs and snags with sporocarps within a forest stand or a forest fragment in an agricultural landscape).



Research Progress

To date my students and I have investigated a variety of questions including population dynamics (density, movement, survival), population genetic structure, habitat use, development, effect of isolation and sexual selection using a variety of approaches from pure observational studies to controlled laboratory experiments.

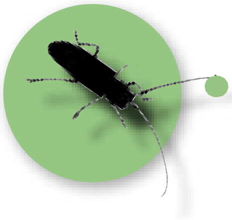
As a population biologist, the obvious starting point was to initiate a capture-mark-recapture study. Honours student, Janet Barlow, monitored two 1-hectare study areas where all dead logs and snags (standing dead trees) with sporocarps were located, mapped and each sporocarp was individually identified and tagged. All forked fungus beetles were uniquely marked. The two study areas were regularly monitored, noting the location of marked beetles on numbered sporocarps, and any new beetle was marked from late May until end of August when the beetles disappeared (aestivated). Thus, a huge data set was amassed of the number of beetles and their locations over time. Analysis of this initial data set revealed that emergence occurs throughout the summer, survival rate is high with many individuals having survived for 5 years, and there was greater movement of individuals between logs with sporocarps than expected from the literature.

The following year, Sonja Teichert, a Masters student, continued the monitoring initiated by Janet. Sonja was interested in detailed habitat use by the beetle. She used both observational data from the two 1-hectare study sites, as well as an experimental system where beetles could choose among sporocarps that were live, dead intact, and dead and decomposing. She found that adult beetles preferred to occupy live sporocarps and females preferentially laid eggs on live sporocarps. Trish Lundrigan, an Honours student, was interested in movement and approached her investigation experimentally. She constructed a spatial distribution of sporocarps and followed the movement of marked individual beetles. Movement was apparently slow, and it could take 2 to 3 days for the beetles to move a few metres. The study area was too small, however, to determine the extent of movement by the forked fungus beetle.

Daniel Kehler, a Masters student, investigated the effect of isolation on the prevalence of the forked fungus beetle. Using transects in continuous forests and in forest fragments in an agricultural landscape, he determined the prevalence of sporocarps on dead trees (white birch, beech, and poplar) and the prevalence of beetles on sporocarps using an indirect approach by looking for emergence holes or eggs on sporocarps. Daniel found evidence of isolation at all scales examined. That is, the greater the distance between sporocarps on a single log the greater the chance the sporocarp had not been used and the greater the distance among forest patches in a farm landscape the greater the chance sporocarps in the patch had not been used. He also made the intriguing observation that the probability of occupancy of sporocarps was greater in forest fragments that in continuous forests.

Brian Starzomski, a Masters student, was intrigued by movement. Daniel had found that the beetles occupied sporocarps in isolated forest patches but were not necessarily present all the time. Sonja had published her observation of flight by the forked fungus beetle, yet Trish's evidence was that the beetles walked to get from one sporocarp to another. Brian hypothesized that newly emerged beetles would fly but that after their emergence flight they would walk. Trish had laid sporocarps out in a circular area with a radius of 30 m, but this was too small. Further, Trish had found the sporocarps broken off logs soon went mouldy. Brian, ingeniously, cut sections of logs bearing sporocarps and distributed these in a 100 x 100 m area in a grid work with 10 m spacing. Brian released uniquely marked individual beetles and monitored their movements. To determine movement by newly emerged individuals, Brian brought sporocarps into the lab and collected individuals as they emerged and released them in the experimental field set up. To determine the importance of flight Brian glued the elytra together on some individuals thus preventing flight. This set up allowed him to compare movement between males and females, and newly emerged individuals and individuals at least a year old for individuals that had their elytra glued together or had not.

Surprisingly, there was no difference in movement patterns between individuals that could and could not fly and newly emerged individuals



tended to move less than older individuals. Not all individuals were recaptured, of course, and could have left the study area by flight; however, the proportion of individuals with glued elytra that were observed after releases was identical to the proportion of individuals without glued elytra observed.

Krista Thomas, a Masters student, wanted to investigate egg laying and development in the forked fungus beetle. Using a combination of observations in the wild and experiments in the lab, Krista discovered that larval development in Nova Scotia appears to take more than 1 year. Thus, eggs laid during the summer of one year do not produce adults that emerge from sporocarps until at least 2 years later. Further, larvae are more likely to survive the more eggs that have been laid on a live sporocarp. Krista hypothesized that the fungal sporocarps have some sort of chemical defence system that kills larvae as they burrow into the sporocarp, and the more eggs laid, and hence larvae that burrow in, the greater the chance of survival. The evidence here is not convincing, as of yet, and is currently being investigated further.

Erin O'Prey, an Honours student, is investigating sexual selection in the forked fungus beetle. Past research has primarily focused on the effect of size of males and successful mating. Larger males tend to dislodge smaller males from females. Erin is investigating the effect of female size and has hypothesized that males, regardless of their own size should mate selectively with larger females. To date, Erin has not been able to reject this hypothesis.

During a sabbatical I used isoenzymes to genetically characterize populations of the forked fungus beetle. Daniel had found that although there were isolation effects, sporocarps in forest fragments were more likely to be occupied by beetles than sporocarps in continuous forests. Thus, discovery and occupation was more likely in forest fragments than in continuous forests. This observation is counter to the traditional logic that as habitat becomes fragmented and isolated occupancy by any organism becomes less likely. This results in low genetic diversity within isolated habitat patches and greater diversity among patches. The results of the isoenzyme study supported the observation and logical conclusion made by Daniel; F_{st} values of populations of the forked fungus beetle were lower among forest fragments than among areas at the same scale in a continuous forests. This would suggest that movement by forked fungus beetles was greater among forest patches in an agricultural landscape than at a similar scale in continuous forest, although based on only two isoenzymes. This data was not convincing enough, and Laura Butler, an Honours student, tried to develop a molecular marker for the forked fungus beetle. Unfortunately Laura could not find molecular markers on the mitochondrial DNA that could be used to investigate the population genetics of the forked fungus beetle. Subsequent work to date has not been successful at finding a suitable molecular marker, and this work has been temporarily suspended.

Many questions remain to be answered. The issue of dispersal and the role of flight remains a huge challenge.

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The Ecosystem Management Emulating Natural Disturbance (EMEND) Project

David Langor[1], Tim Work[2] and John Spence[3]

Introduction

Under the “Natural Disturbance Paradigm,” boreal forest management moved away from the extensive clear-cutting and toward retention of residual trees and patches in an effort to leave structure on the landscape. This structure, in turn, is thought to promote non-fiber values, including conservation of biological diversity, desired in the context of sustainable forest management. Effects of size and distribution of residual patches have been reasonably well studied in Alberta and elsewhere. However, the important question of “how much residual is enough to preserve and protect critical aspects of ecosystem function?” has received scant attention. Thus, there is little scientific basis to guide management of stand structure in the extensive management zone. Patterns of retention of either green-tree or dead residual can have significant impact on forest regeneration by directing young stands down various successional pathways. Thus, in a modern context, sustainable management depends on linking harvest methods to forest regeneration procedures to promote holistic and ecologically sensitive silviculture that promotes forest values beyond simple sustained yield of fiber. New silvicultural procedures are required to meet the expanded objectives of sustainable management (including conservation of biodiversity) and to assist with evaluation of their implications for productivity (Spence 2001).

In the mid-1990s, an experiment, Ecosystem Management: Emulating Natural Disturbance (EMEND), was designed and implemented in Alberta to explore the responses of ecosystem parameters (structural and functional) to variable retention harvesting. The overall objectives of the EMEND project are

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- to determine how harvest with retention, and a range of regenerative practices, can be employed to optimize maintenance of biotic communities, spatial patterns of forest structure and functional ecosystem integrity in comparison with mixed-wood landscapes that have originated through wildfire and other inherent natural disturbances; and
- to evaluate these practices in terms of economical viability, sustainability, and social acceptability.

These objectives are to be achieved through the large-scale harvest-silviculture experiment and through modeling based on the results.

The Experiment

The EMEND research study site is located in the Clear Hills Upland, Lower Foothills Ecoregion of Alberta, about 90 km northwest of Peace River (56° 46′ 13″ N 118° 22′ 28″ W). The site area (elevation: 677 m to 880 m) is characteristic of the boreal mixedwood plains. EMEND in one of the largest projects of its kind in the world, covering over 1 000 ha (100 compartments of about 10 ha each). Major funding for the project has been provided by Canadian Forest Products Ltd. (CANFOR), Daishowa-Marubeni Ltd (DMI), Manning Diversified Forest Products Ltd., The Weyerhaeuser Company Ltd., the Government of Alberta through the Ministry of Sustainable Resource Development and the Alberta Forest Research Institute and the Sustainable Forest Management Network. The project is specifically designed to improve the ability of CANFOR and DMI to jointly manage a northern mixed-wood land base for sustainable production of both confer and hardwood fiber, while optimizing the conservation of other forest values and services. It has been clear to the scientists involved that the sponsors have the interest, will, and patience to develop management approaches based on scientific understanding of how these forest systems work. The project is a model partnership for how diverse interests can cooperate to realize large-scale and expensive science well beyond the means of any single agency.

Two main driving variables were manipulated in the experiment, with three replicates of each treatment and control:

Cover Type (Cover). Forest type was partitioned based on canopy composition of stands before harvest as follows: 1) conifer dominated (> 70% composition); 2) mixed (conifer and deciduous composition, each 35–65%); 3) deciduous-dominated with coniferous understory extensive and at least 50% of canopy height; 4) deciduous-dominated (> 70%). *Disturbance (Treatment).* Compartments (ca. 10 ha each) were harvested in stands of each cover type, leaving one of five proportions of residual material: 1) 0% (clear cut); 2) 10%; 3) 20%; 4) 50%; and 5) 75% (Figures 1–5). Harvesting treatments applied to EMEND Experiment, using conifer-dominated compartments as an example:

Figure 1. Clear cut compartment (photo by J. Spence).

Figure 2. Ten percent residual material (photo by J. Spence).

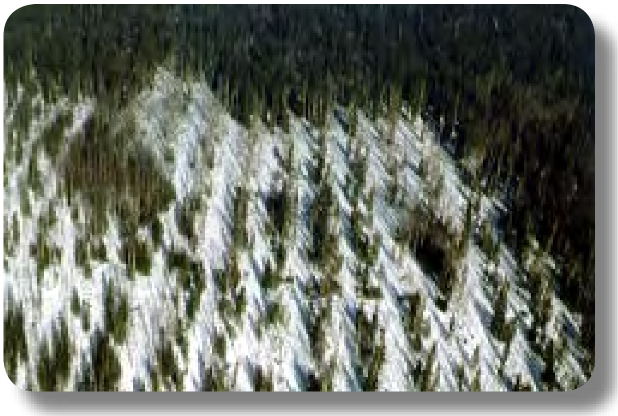


Figure 3. Twenty percent residual material (photo by J. Spence).

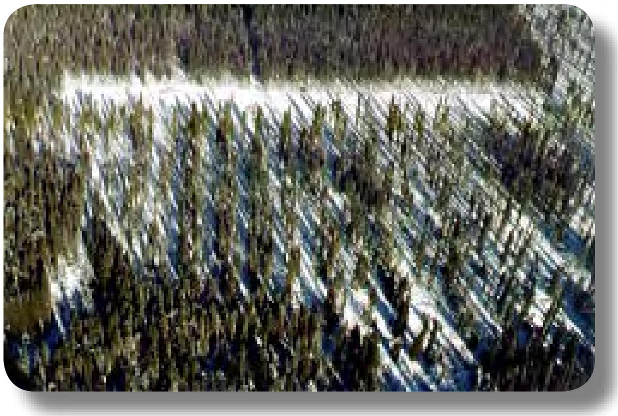


Figure 4. Fifty percent residual material (photo by J. Spence).

Figure 5. Seventy-five percent residual material (photo by J. Spence).

Treatment effects are interpreted in relation to two types of control treatments, each replicated spatially with harvesting treatments: either uncut compartments, or those burned experimentally under two prescriptions. The two prescriptions comprise 1) whole compartment ground fires; and 2) burns of distributed slash after harvesting. Comparisons of burned and unburned compartments reveal the extent to which harvest-silviculture combinations foster successional trajectories similar to those initiated by natural processes. Comparison to uncut compartments reveals if any species from a range of indicator groups are threatened by the truncation of stand age distribution implicit in a harvest rotation, and if residuals are old-growth islands that are effective sources for colonists.

After considerable discussion and preliminary research with alternative cutting plans, the pattern of harvest was prescribed in May 1998. Pre-treatment sampling occurred in the summer of 1998, and the EMEND site was harvested during January–March 1999 using a modified, 2-pass uniform shelterwood method with residual-harvest treatments applied to compartments about 10 ha each. Each compartment was harvested to retain two ellipse-shaped patches, one at 0.20 ha (40 x 60 m) and one at 0.46 ha (60 x 90 m). All operations (felling and skidding) were completed in 5-m wide machine corridors spaced 20 m (center to center) apart, leaving a 15-m wide retention strip between each corridor. Machine corridors account for 25% of net compartment area. Thus, retentions less than 75% (10, 20, 50%) were achieved by systematic tree removal from the retention strips.

Comparison to the burn treatments is at the heart of EMEND and that is what makes the project stand out relative to a host of large silvicultural trials. Although these are coming along more slowly than hoped, due to lack of suitable burning conditions when burning infrastructure was available, progress is being made.

Standing timber burns, with no harvesting before burning, have been difficult to achieve. The first standing timber burn, involving a conifer-dominated compartment, was conducted in early August 1999. The fire burned hot and with a medium rate of spread. The burn was patchy with some areas burnt to mineral soil and other areas with no evidence of burn. One deciduous-dominated compartment was burned in April 2000. The burn was typical of an aspen-dominated stand with low fire intensity and rate of spread. Some entomological studies have been conducted in these burns (Jacobs 2004).

Slash burns, where selected compartments were harvested to 10% residual and harvest slash was redistributed across the compartment and dried for a year before ignition. Eleven of 14 slash burns were completed in early October 2003. The three aspen-dominated slash–harvest compartments were not burned due to lack of sufficient ground fuels. Plans are in place to burn these in spring 2005.

Finally, a 1-ha silviculture plot is located in all clearcut, 50% and 75% treatments in conifer- and deciduous-dominated stands. Each plot is divided into 4 treatment quadrants, each of which was treated with one of the following site preparations: high-speed, horizontal bed mixing (meri-crusher); scalping; mounding; or no site preparation. Half of each quadrant was planted with 100 white spruce in July 1999. The other half of each quadrant was seeded with local white spruce seed.

Data Collection

The core of EMEND research focuses on how the various state variables and processes are affected by cover, treatment and their interaction, and how these effects vary with silvicultural prescription. These state variables include

1) succession and dynamics of biodiversity,
2) residual structures and nutrient cycling,
3) regenerated structures,
4) site productivity,
5) selected hydrological processes and indicators,
6) socioeconomic indicators.

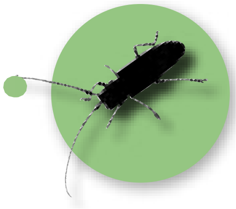
Six (40 x 2 m) permanent sample plots (PSPs) established in each compartment before treatment have been largely used for tree, snag, and dead wood mensuration purposes, and other sampling efforts are implemented near the PSPs, especially for experiment-wide biodiversity studies. These plots are supplemented by other plots, established to measure other response parameters. Standardized pre-treatment data about biotic and abiotic response variables, especially those related to site productivity and diversity, were collected from all compartments to be treated. These and subsequent data are held in a database accessible to all EMEND researchers.

Biodiversity responses to treatments have been measured for birds, bats, vascular and non-vascular plants, ectomycorhizae, and arthropods (soil mites, spiders, night flying macrolepidoptera, parasitoids, saproxylic beetles, bumble bees, ground-beetles, and rove beetles). Among arthropods, most work has focused on epigaeic spiders and beetles (carabids and staphylinids), and these have been consistently measured across the entire experimental design. Work on other arthropod groups has been of shorter duration or focused on only a sub-set of treatments.

Last year a large grant was secured from the Canadian Foundation for Innovation, co-funded by the Alberta Science and Research Investments Program and our two founding industrial partners (CANFOR and DMI) to build a permanent research camp to serve the EMEND site. Construction is now underway on a facility adequate to serve 35–40 investigators. We hope to be working from this new research camp by mid-July 2005. We welcome participation in EMEND by anyone wishing to use the site as a template to pursue biodiversity work on any aspect of the northern mixed-wood biota. Don't hesitate to contact either David Langor or John Spence about the possibility of working at EMEND if you are interested.

Arthropodological Results

Three M.Sc students from the University of Alberta (Julia Dunlop, Joshua Jacobs, and Louis Morneau) and two from the University of Calgary (Zoë Lindo and Jane Park) have completed their thesis on arthropod biodiversity projects at EMEND (Morneau 2002; Park 2002; Wesley 2002; Lindo 2003; Jacobs 2004). In addition, three Ph.D theses (Colin Bergeron, Esther Kamunya, and David Shorthouse) are underway at the University of Alberta. It is beyond the scope of this article to summarize this work, and some of it is published (e.g., Lindo and Visser 2003, 2004; Work et al. 2004) or in thesis-to-publication transition. Generally, the results from the initial post-harvest sampling of arthropods and other groups in 1999–2000 suggest



that even moderate levels of green tree retention are ineffective for maintaining species composition similar to that in uncut stands, and that moderate levels of harvesting effectively homogenize the differences in beetle composition that exist among the variety of successional stand types in the boreal mixedwood.

In 2005, the first significant post-harvest measurements for the arthropod biodiversity survey will be made. This effort marks the transition to longer-term biodiversity monitoring at EMEND. All experimental compartments will be re-sampled using pitfall traps to evaluate longer term changes in arthropod species composition among six different intensities of variable retention harvesting. In addition the responses of the macrolepidopteran community will be re-assessed through light trapping. We will also initiate significant studies of prescribed slash-burn harvesting aimed to show whether they can retain pyrophilic species like the carabid *Sericoda quadripunctata* in managed stands.

We are also moving now to compare results from sites on either end of the boreal forest between the arthropod biodiversity work at EMEND and at the SAFE (Sylviculture et Aménagement Forestier Ecosystémiques) experiment in western Québec. Both projects explore the value of partial-cut harvesting for protecting biodiversity and comparisons between the two will likely further our understanding of the natural and anthropogenic disturbances in the context of a larger cross-Canada perspective of the boreal mixedwood. In 2004, Elise Bolduc, Michelle St. Germaine, Chris Buddle (McGill University) and Tim Work began an intensive inventory of leaf-litter arthropods associated with aspen dominated stands at the SAFE experiment. This effort will be expanded to include mixedwood cover types in 2005, with an additional intensive sampling to quantify both the spatial heterogeneity and microhabitat associations of both adult and larval arthropods at SAFE.

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Feature Article

Spiders at the Hub of Canadian Forest Research

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Spiders (Figures 1–3) are one of the most common and ubiquitous groups of animals: they are found over the entire life-supporting landmasses of the world. Where any form of terrestrial life exists, it is safe to assume there will be spiders living close by. Spiders exist in the most northern islands of the Arctic (Leech 1966), the hottest and most arid of deserts (Cloudsley-Thompson 1962), at the highest altitudes of any living organism (Schmoller 1970; 1971a, b), and the wettest of flood plains (Sudd 1972). In all terrestrial environments spiders occupy virtually every conceivable habitat.

Spiders are the seventh most diverse order of animals on the planet, comprising 38 663 described species (Platnick 2004). Spider species outnumber all vertebrate species combined. The largest families are the jumping spiders (Salticidae) and the sheet-web weavers (Linyphiidae), which comprise over 5 000 and 4 260 species, respectively. This is of particular interest to those conducting invertebrate studies in Canadian forests because the bulk of global sheet-web weaver richness is in our northern forests. Jumping spider diversity, however, is concentrated in the tropics. Interestingly, there is a progression of spider composition from the tropics toward colder, northerly climes. Sheet-web weavers gradually usurp the dominance of jumping spiders (Figure 4). Wolf spiders (Lycosidae) do not appear in the top ten most species-rich families in the Neotropics, but they are the fifth most diverse family in the Nearctic. A similar trend was uncovered by Huhta (1965) in Finnish forests. Closer to home, Nordstrom and Buckle (2002) found that species of sheet-web weavers and wolf spiders far outnumbered all other spider families in some of the most northern wildland parks in Alberta. This interesting latitudinal gradient may, however, be an artifact of the boreal bias where more collecting has taken place and more expertise is found relative to tropical regions.

Figure 1. Typical posture of the alert wolf spider of the family Lycosidae (photo by D. Shorthouse).

Figure 2. Male *Pachygnatha xanthostoma* of the family Tetragnathidae (photo by D. Buckle).

Figure 3. Orb-weaving spider, *Larinioides cornutus*, of the family Araneidae (photo by D. Buckle).

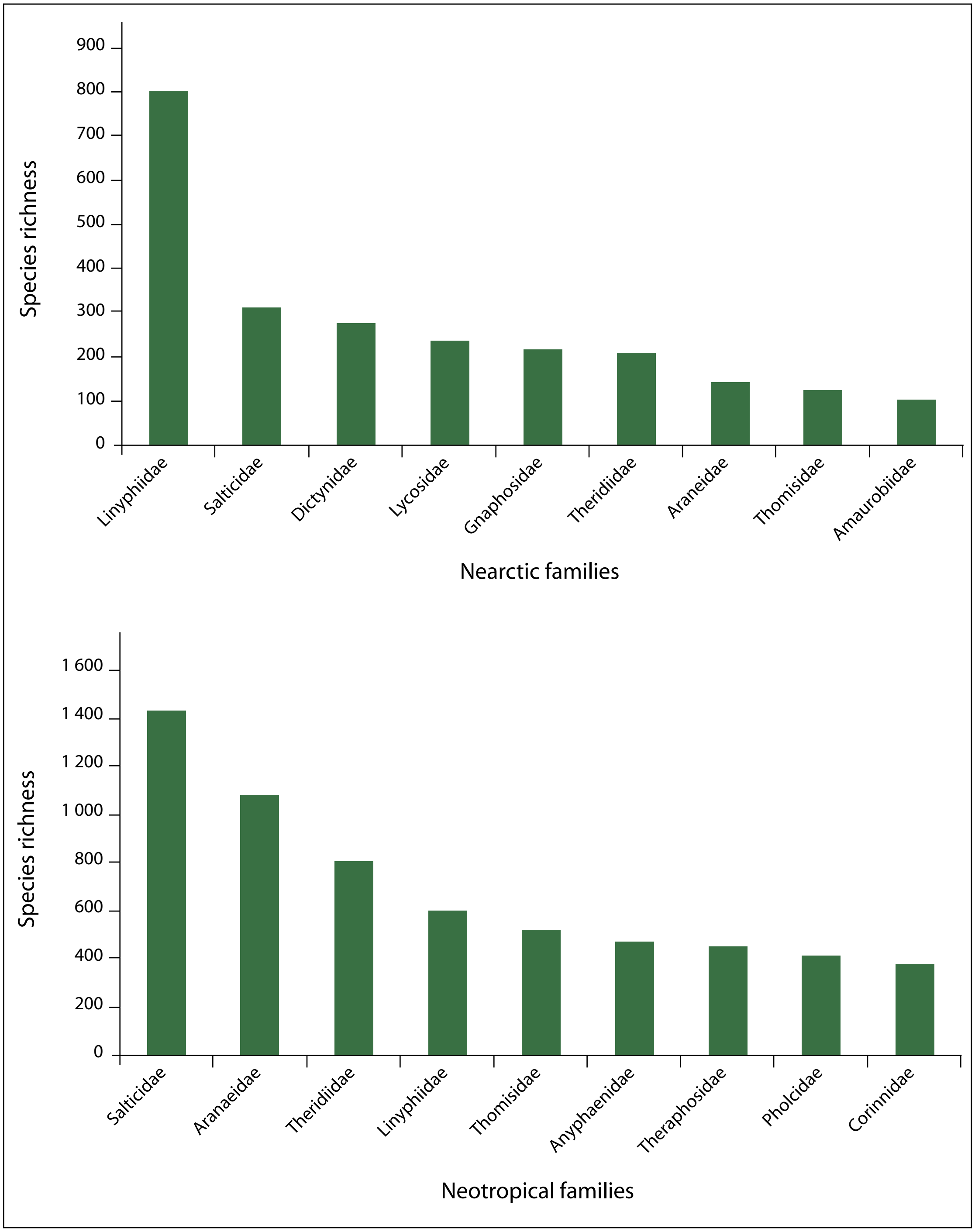


Figure 4. Species richness for the ten dominant Nearctic (top panel) and Neotropical (bottom panel) families. The known species richness of Linyphiidae (sheet-web weavers) far outnumber all other families in the Nearctic, whereas Salticidae (jumping spiders) dominate the Neotropics. Data compiled from the currently available database of global spider diversity (Platnick 2000).

Compilations of spider surveys undertaken throughout the Northern Hemisphere have shown low levels of endemism. However, there may exist a handful of pockets with unique assemblages, as is evident in forested regions close to the Bering Strait and in northeastern Siberia (Marusik and Koponen 2000, Marusik and Koponen 2002). While many species are widespread throughout large geographical regions, spider collections, such as those obtained via pitfall trapping, include a large number of species represented by one or two specimens. For example, more than one-third of the species collected by Buddle et al. (2000) were considered rare or uncommon. Likewise, only 11 species each had abundances in excess of 2% of the total number of spiders in a large study in northwestern Ontario (Pearce et al. 2004). Two-fifths of the species in large-scale and multi-year collections I made in forests northwest of Peace River, Alberta, were represented by fewer than three specimens (Figure 5).

While there are indeed a large number of uncommon spider species in Canada, work underway by some of Canada's arachnologists to completely catalog our country's known spider diversity is progressing rapidly. Spider species lists in Canada have been steadily gaining length and breadth (see Pearce 2004). Bennett (1999) and Dondale (1979) estimated that a mere 100 species await addition to the country-wide list. Many of these soon to be collected species will be members of the minute and cryptic sheet-web weavers in boreal forests. These are exciting times for spider ecologists in Canada because we almost have a complete picture of our country's entire spider diversity. This will certainly open the door for those who might have neglected spiders in their biodiversity studies because of a current unwarranted fear of not knowing how to identify them.

As with many organizations of spider enthusiasts in the world, Canada now has its own active, well-organized and -integrated core of spider systematists and ecologists. An annual newsletter entitled, *The Canadian Arachnologist* (see boxed text on following page) is published, and a dynamic website is maintained to encourage discussion and collaboration. Pearce (2003) has also posted an excellent overview of spider survey studies undertaken throughout Canada since the early 1900s.

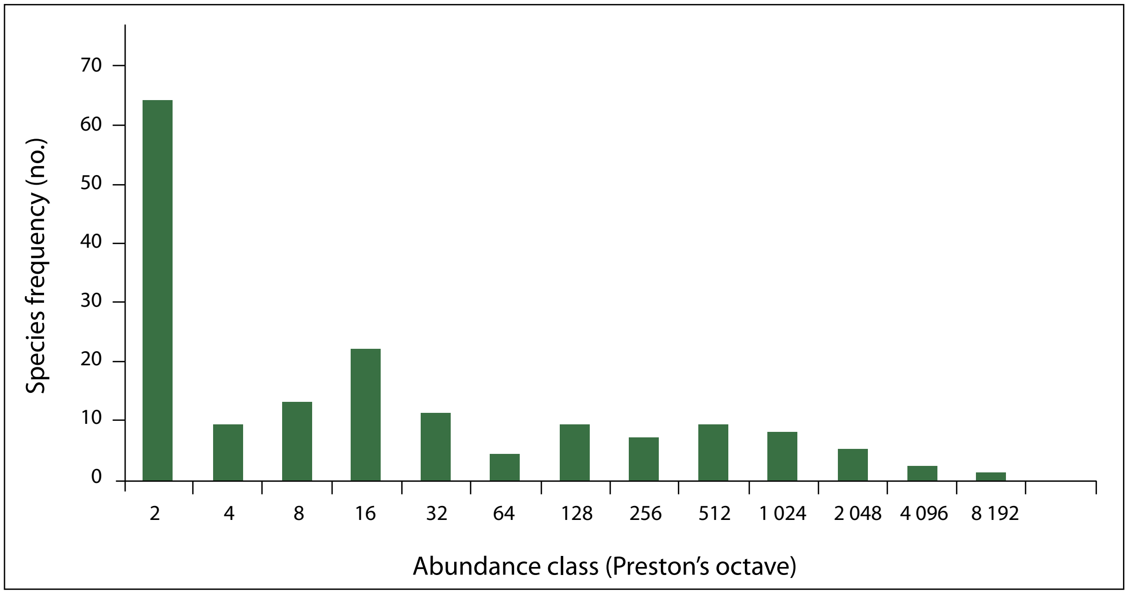
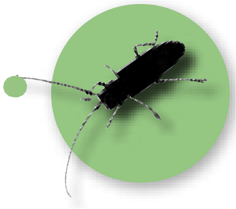


Figure 5. Frequencies of Preston's octave abundance classes for spiders collected via pitall trapping as part of a large-scale, multidisciplinary experiment northwest of Peace River, Alberta, in 1999 and 2000. Total number of species collected = 164 and total abundance = 33 412 from 720 pitfall traps maintained over two successive growing seasons.



The Canadian Arachnologist is an annual newsletter, freely distributed the first week of May. The goals of this newsletter and website are to profile Canadian arachnologists, publish feature articles, announce conference details and other news of value, help foster a sense of community and encourage collaboration. Species lists for various arachnid groups in Canada such as jumping spiders, pseudoscorpions, and mites found on Canadian birds are located on the website (http://canadianarachnology.webhop.net), and a rich list of introductory literature to aid your discovery of arachnids is included. This website is a dynamic forum for all Canadian arachnologists, amateur and professional alike and is continually updated with new information. You may create a password-protected account, a profile of your interests, provide a list of your creative works, and post announcements for all viewers. Contact the editor, David Shorthouse (dps1@ualberta.ca) if you would like to contribute species lists or other data of interest.

Spiders make an ideal indicator group. Numerous workers have shown that different environments can have specific spider faunas, and in gradient analyses, species are not evenly or randomly distributed. The general impression is that the spider fauna in any given region demonstrate a pattern similar to that of vascular plants (Allred 1975). This is not the same as saying the number of spider species fluctuates with the number of plant species. In fact, the two variables often do not correlate well but depend largely on the spatial structure and microclimate of the environment. Like plants, different spider species have different requirements. Many species and genera do have rather specific habitat associations. For example, among wolf spiders *Geolycosa* spp. are found in bare, sandy substrates; *Pardosa hyperborea* are often collected in sphagnum bogs; *Pirata* spp. in moist habitats, often close to open bodies of water; and species in the genera *Trochosa* and *Schizocosa* are usually collected in fields, meadows, and in deciduous forests (Dondale and Redner 1990). Because spiders are easy to collect in large numbers, they have been successfully used in many bio-indicator studies. Spiders on trees have been studied in relation to SO_2 pollution by Gilbert (1971); they have been analyzed in relation to heavy metals (Rabitsch 1995); and they have been intensively studied in relation to succession (Lowrie 1948; Huhta 1971; Peck and Whitcomb 1978; Duffey 1978; Bultman 1980; Bultman and Uetz 1982; Crawford et al. 1995) and others reviewed by Uetz (1991). They have also been studied in industrial landscapes (Luczak 1984, 1987), along pollution gradients (Koponen and Niemelä 1993; Koponen and Niemelä 1995), and even on reclaimed strip mines (Hawkins and Cross 1982). These studies aside, the spider research undertaken in forest and agricultural landscapes is arguably the richest body of spider literature.

Spider assemblages tend not to be strongly linked to the mix of tree species in a forest but are instead linked to structural features. In other words, at least in local regions, spider species compositions tend not to vary a great deal between stands with different tree species compositions. In addition, spiders as a group are very quick to respond to changes in their habitats. For example, the assemblages of ground-dwelling spiders collected from four forest types within in a large-scale, manipulative forestry experiment in northwest Alberta are much the same (Figure 6A). However, stands harvested at varying intensities within this template support very different assemblages (Figure 6B). These effects were observed the first summer immediately following winter logging and persisted into the second summer. Carabid beetles were collected in these same locales and, although assemblages were distinguishable between different stand types, it wasn't until the second growing season that numerical responses to harvesting intensity were apparent. Carabids and other invertebrates considered the staple of biomonitoring studies often have lengthy phonologies; and consequently, their response to stress lags that of the initial impact. Spiders have relatively simple phenologies; all instars of every species occupy roughly the same physical habitat and have roughly the same diet. All spiders are generalist predators and will consume almost any invertebrate provided it isn't too large to be tackled, swathed, or subdued. This presents an excellent opportunity to take rapid, snap-shot measures of the biological effects of athropogenic stressors and to uncover the reasons for shifts in abundance or in species composition.

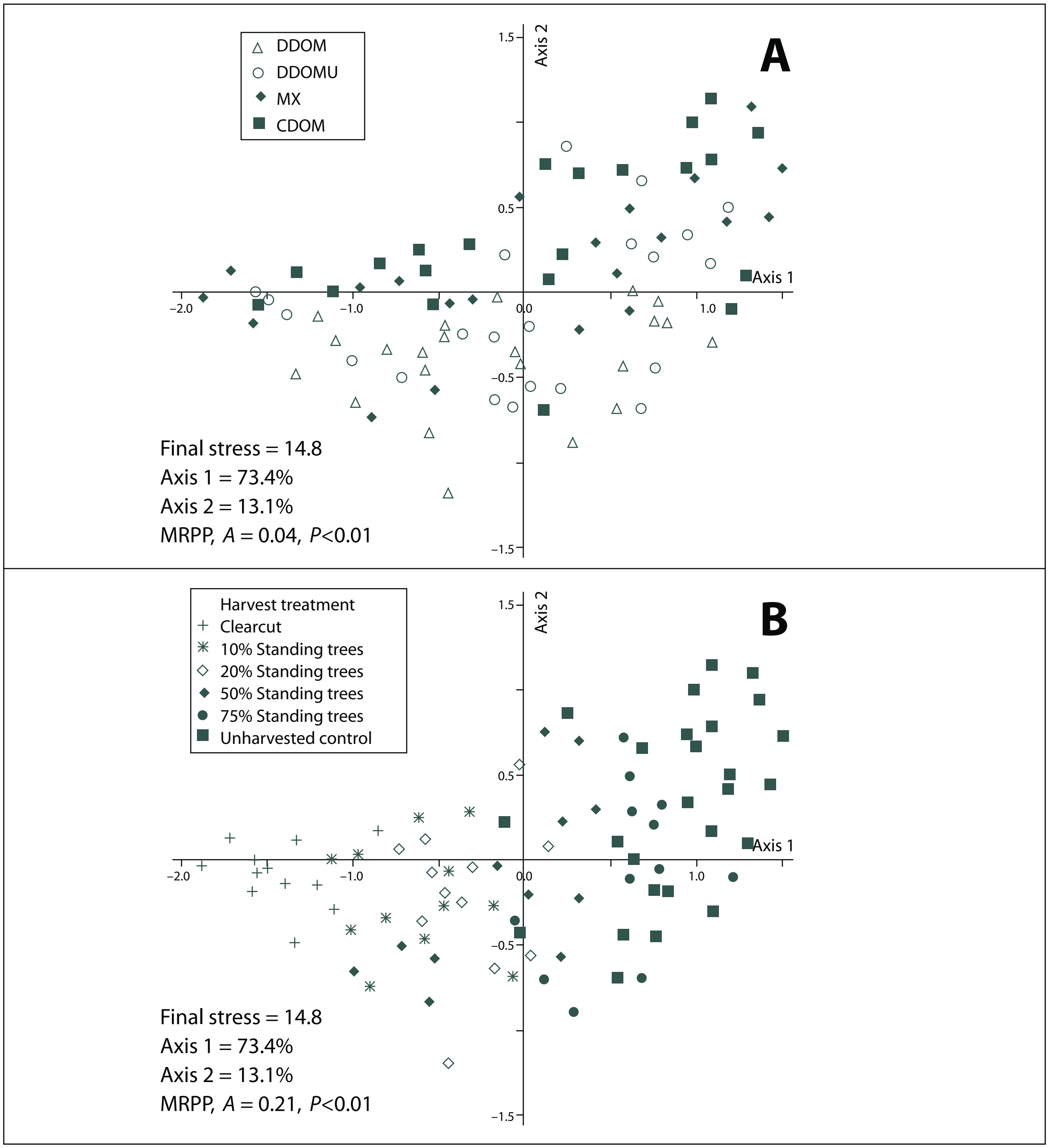
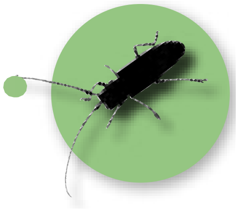


Figure 6. Nonmetric multidimensional scaling ordinations of spider assemblages within 100 10-ha compartments in the Ecosystem Management Emulating Natural Disturbance (EMEND) experiment, NW of Peace River, AB (Spence and Volney 1999) over 2 years of collecting post experimental harvesting. Stands, represented by the 100 points in each panel, are most similar to one another with respect to their spider compositions when closest in ordination space; points furthest apart indicate very different spider species compositions. There is merely a weak distinction between spiders assemblages when the 100 stands are coded for their tree compositions (Panel A) such as deciduous dominant (DDOM), deciduous dominant with a coniferous understory (DDOMU), mixed tree species (MX), or coniferous dominant (CDOM). However, there is a strong distinction between these same stands when coded for harvesting intensity (Panel B). Spider assemblage structure in clearcut stands is very different from those in unharvested control stands. MRPP = multiple range permutation procedure.



Buddle (2001) found that spider assemblages on coarse woody debris are different from those on the neighboring forest floor. Although the raw abundance of spiders was greater on the forest floor, their diversity was greatest on fallen logs and eleven species were collected almost exclusively on the surfaces of logs. The use of fallen logs by individual spiders may change over the course of their developmental, thus these types of associations may be missed if collecting regimes are not comprehensive. Pearce et al. (2004) found that spider richness and diversity can be linked to large-scale stand composition, but these linkages are largely due to microhabitat and microclimatic features. However, Work et al. (2004) found that these linkages can be weak to imperceptible. Uncovering these linkages will need more thorough, manipulative experiments. Regardless, current coarse-filter management approaches where broad, stand-level tree species compositions are the targets in favor of costly targets of fine forest structure, may lead to the eventual demise of boreal forest spider diversity, especially for members of the speciose family Linyphiidae. We simply don't know if the development and maintenance of fine structures will track large-scale manipulations of tree species composition. Instead, future forest management studies ought to direct effort at solving how best to maintain fine forest structures while continuing to harvest with cost-saving, coarse-filter strategies. We need only look at the outcome in Finland and other Slavic countries where multiple, coarse-filter strategy rotations have decimated invertebrate species richness and diversity to learn that attention to fine forest structures is critical.

There are a few species of opportunistic spiders that have counter-intuitive responses to harvesting intensity whereby they quickly colonize openings in what used to be contiguous forest. One species in particular, a wolf spider, *Pardosa moesta*, is found in large numbers after harvesting, yet is uncommon in forests with a closed canopy. Typically, large openings in the forest and the resultant increased variability in the microclimate on forest floors discourage the survival of spider species with narrow tolerance ranges in heat and moisture. This is likely why a few species of spiders (e.g., *P. moesta*) are able to tolerate extremes, rapidly displace, consume or out-compete less tolerant and uncommon species. Because spider assemblages shift in a roughly linear fashion with increased harvesting intensity (Figure 6B), it is difficult to determine the threshold at which we ought to limit harvesting. Instead, we must balance our desire to preserve naturally assembled biota with our economic needs.

Spiders are a rich and fascinating group, and deserve a prominent seat at the table when effort is undertaken to catalog or assess changes in invertebrate biodiversity in Canada's forests. Active spider enthusiasts have come close to assembling a list of all Canadian species, which will soon be made available. For progress on this endeavor, I encourage you to visit the *Canadian Arachnologist* website. While the richness of spiders in Canada is almost completely known, there remain large forested areas where spiders have never been collected. This is particularly true in the north. It is possible that some of these regions may harbor unique, endemic species, as appears to be the case close to the Bering Strait and northeastern Siberia.

Spiders often dominate invertebrate samples in generalized diversity and monitoring studies. Unlike many other groups, however, they tend to be more reliant on microhabitat and fine structural features rather than on plant or tree species identity. They also respond quickly to changes in these features. Reports on the mix of microhabitats that best maintain spider richness and diversity differ somewhat. Here, then, is an excellent opportunity for invertebrate biologists and their students, who might not have ordinarily considered using spiders in their ecological studies, to plunge into the world of araneology, and attempt to resolve these questions. Professional and amateur arachnologists in Canada are a congenial bunch, will provide taxonomic assistance when possible, and always welcome collaborative efforts.

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Graduate Student Focus

Host use patterns in saproxylic Coleoptera: explaining species succession along the wood decay gradient

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Host-plant selection in phytophagous insects has traditionally been explored through optimality theory, with the preference-performance hypothesis being one of the important derived hypotheses. This hypothesis states simply that an ovipositing female's host selection strategy should allow a maximization of its inclusive fitness. This approach has seldom been applied to wood-feeding insects, and never to saproxylic ones. We have little information about saproxylic insect species succession in dead wood as decay proceeds, nor about the mechanisms driving this succession. In the spirit of the preference-performance hypothesis, changes in factors having a direct influence on larval performance along the decay gradient should lead to different patterns of host choice in saproxylic wood-feeders. My Ph.D research, located in western Quebec (Abitibi), aims to describe host use patterns of saproxylic Coleoptera (Figure 1) in standing dead stems (snags) of aspen and black spruce, and to link changes in species composition to changes in nutritional and physical characteristics of the substrate.

Figure 1. *Xylotrechus undulatus* (Cerambycidae) (photo by M. Saint-Germain).

Relationships between species composition and these snag characteristics will be established using correlative analyses. Twenty-four natural snags covering 4 classes of decomposition, 4 mechanically killed trees (portraying fresh snags), and 4 living trees of both aspen and black spruce have been sampled for Coleoptera using sticky traps (Figure 2) (to collect landing insects) and snag dissection (to collect inhabitants). The same trees have been sampled for simple sugars, organic nitrogen compounds, secondary compounds (some volatile), wood density and water content. Causal relationships between any of these factors and insect performance will be established or rejected using larvae reared on selective artificial diets. Multiple side projects will also aim at testing important assumptions related to the preference-performance hypothesis on saproxylic wood-feeders. This project will increase faunistic knowledge of saproxylic insects significantly and lead to a better understanding of host selection processes in these species.

Figure 2. Sticky trap on snag (photo by M. Saint-Germain).

The Walbran Valley Canopy Arthropod Project

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This research examines oribatid mite (Acari: Oribatida) communities in forest canopies (suspended soil pockets 35 m above ground) and forest floors associated with ancient western red cedar (*Thuja plicata*) trees in the Walbran Valley on the southwest coast of Vancouver Island, British Columbia. Suspended soils (Figure 1) within the canopy system are thought to be interconnected islands through which random movement actively disperses individuals; however, the initial source pool of these resident arboreal fauna assemblages is unknown and theorized to be the forest floor. The objectives of this research are to 1) compare canopy and forest floor oribatid mite communities and decomposition processes; 2) elucidate factors and mechanisms that shape oribatid mite community structure in suspended soil pockets; and 3) determine whether canopy oribatid mite assemblages are colonized by forest floor source pools or whether the canopy community is a distinct meta-community linked through dispersal within the canopy system.

Figure 1. Suspended soil pocket 30 m above the ground in the forest canopy of the Walbran Valley (photo by Z. Lindo).

I will examine the physical, chemical and biological soil properties, decomposition dynamics, and the oribatid mite communities of suspended soils and in forest floors, using core sampling, litter bags, litter traps and extraction of micro-arthropods from soils. An observational and an experimental study utilizing natural and artificial soil pockets of different sizes at different heights in the canopy will test whether the forest floor is a colonizing source for canopy oribatid assemblages and explore oribatid mite meta-community dynamics within the canopy.

Species identification of oribatid mites collected in 2004 is in progress. New species descriptions are anticipated and at least one taxonomic re-description of an oribatid genus is proposed. During the next 2 years (2005–2006), I will implement and complete the observational and experimental aspects of this study.

Oribatid mite communities contribute significantly to forest biodiversity, and are functionally important components of forest ecosystems. This study complements other studies of soil fauna in temperate Canadian forest systems, and specifically other studies of canopy systems on Vancouver Island, such as the Carmanah Project, the Mt. Cain Project, and the MASS initiative.

Opportunities for Graduate Students

Recently Tim Work relocated from the University of Alberta to the Université du Québec à Montréal (UQAM) and began a research program focused on biodiversity, forest management, and natural disturbance. In the upcoming year, he anticipates being able to provide research opportunities and funding for enthusiastic students interested in ecology, conservation biology, entomology, and biodiversity. He will be starting several projects in the boreal mixedwood and northern black spruce zone of Western Québec, examining the interactions of partial cutting, insect biodiversity, and insect-fungal interactions in coarse woody debris. These projects will provide exciting opportunities to advance community ecology, particularly in the areas of diversity-stability relationships and landscape ecology, in an applied forest management context. For more information please contact Tim at work.timothy@uqam.ca or visit his website at http://www.unites.uqam.ca/gref/twork/.

News and Events

Bio-Blitz 2005

The 2005 Biological Survey of Canada Bio-Blitz will occur in Waterton Lakes National Park (WLNP), Alberta, from 7 to 12 July. This provides an exciting opportunity to collect in one of Canada's most scenic and biologically interesting natural areas, which is also a UNESCO Biosphere Reserve.

The park derives its name from the Waterton Lakes (Figures 1 and 2), a chain of lakes named in honor of a British naturalist, Squire Charles Waterton (1782–1865). The 525 km^2 WLNP represents the southern Rocky Mountains Natural Region, where some of the most ancient mountains in the Rockies abruptly meet the prairie. It is a landscape shaped by wind, fire, and flooding, with a rich variety of plants and wildlife. The townsite sits at 1 280 m above sea level and the park's highest peak, Mt. Blakiston, is 2 940 m above sea level. WLNP is located in the southwest corner of Alberta. It is bordered on the west by the province of British Columbia (Akamina-Kishinena Provincial Park and Flathead Provincial Forest); on the south by Glacier National Park, Montana; on the north and east by the Bow-Crow Forest, and private lands in the Municipal Districts of Cardston and Pincher Creek; and it includes a large timber reserve belonging to the Kainaiwa (Blood Tribe).

Figure 1. Aerial view of lower Waterton Lake and surrounding fescue grassland and aspen parkland (photo by C. Smith).

Several ecological regions meet in WLNP, with biota of the Great Plains, northern Rocky Mountain and Pacific Northwest all overlapping. The park's four natural subregions – foothills parkland, montane, subalpine, and alpine (Figures 1–3) – embrace 45 different vegetation types, including grasslands, shrublands, wetlands, lakes, spruce–fir, pine and aspen forests, and alpine areas. Sixteen of the vegetation types are considered rare or fragile and threatened. WLNP is the only Canadian national park that preserves foothills fescue grasslands. This rich collection of vegetation types in a small geographic area means that WLNP has an unusually rich and varied number of plants for its size, with more than 970 vascular plant species, 182 bryophytes and 218 lichen species (this represents more than half of Alberta's plant species, and more species than Banff and Jasper National Parks combined). About 179 of the vascular plant species in WLNP are rare in Alberta, and 22 of these are not found anywhere else in Alberta.

Figure 2. Middle and upper Waterton Lakes looking south, showing some montane forest (photo by C. Smith).

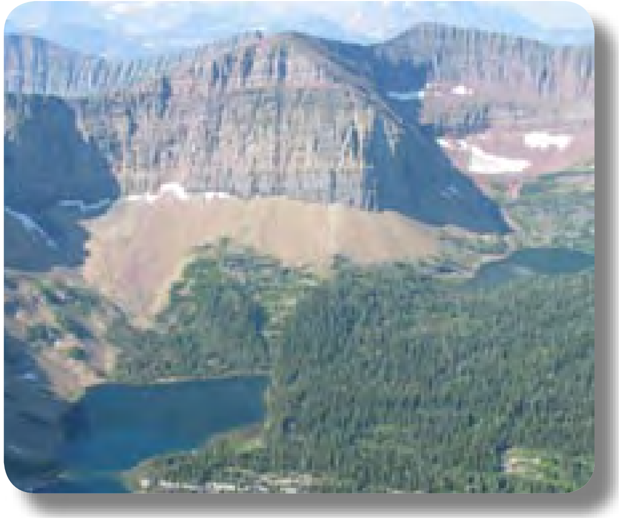


Figure 3. Lineham Lake, showing subalpine and alpine habitats (photo by C. Smith).

The park's variety of vegetation communities provides homes for many animals, including more than 60 species of mammals, over 250 species of birds, 24 species of fish, 10 species of reptiles and amphibians, and thousands of species of terrestrial arthropods. Large predators include wolf, coyote, cougar, grizzly bear, and American black bear. The grasslands are important winter range for ungulates such as elk, mule deer, and white-tailed deer. In the fall, the marsh and lake areas of the park are used extensively by migrating ducks, swans, and geese. Some animals found here are considered rare or unusual (e.g., trumpeter swans, Vaux's swifts, and vagrant shrews).

Historically, collection of arthropods in WLNP has been sporadic and usually focused on a few taxonomic or functional groups. Recent collecting by Rob Longair and students (University of Calgary) has contributed greatly to our knowledge of some groups. Many arthropod species found in WLNP are found nowhere else in Canada; some of these may be endemic and, for others, WLNP represents the northernmost limit of their distribution in North America. WLNP has a small collection of insects, much of which originates from the efforts of David and Margaret Larson collected during their honeymoon in WLNP. This collection, and other material (pinned and wet residuals) collected by the University of Calgary, are available for examination during Bio-Blitz 2005.

Thus, Bio-Blitz 2005 offers a unique opportunity to collect in the varied habitats of one of Canada's biologically rich areas. The Parks Canada staff is enthusiastic about and highly supportive of this event. They have offered the use of their research house, which has sleeping facilities for 8 and space for sorting and examination of samples and specimens. As well, group camping facilities will be provided. For those who prefer hotels, these are in abundant supply at the Waterton town site.

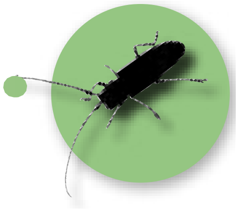
If you are interested in participating in Bio-Blitz 2005, or would like more details, please contact David Langor (dlangor@nrcan.gc.ca).

New Website

In 2004, Val Behan-Pelletier and Barbara Eamer completed the website on published records for Oribatida by province and territory. Many of the species are from forest habitats in Canada. This is the most complete list of references since Marshall et al. (1987). Check it out at http://www.cbif.gc.ca/spp_pages/mites/phps/index_e.php.

Meetings

- A Biological Survey of Canada (BSC) -sponsored symposium, *Maintaining Arthropods in Northern Forest Ecosystems*, will be held at the Annual Meeting of the Entomological Society of Canada, Canmore, Alberta from 2 to 5 November 2005. This symposium will feature 6 papers that synthesize what is known about structure and dynamics of selected arthropod assemblages (Carabidae, Staphylinidae, spiders, saproxylic arthropods, Lepidoptera, and aquatic arthropods) in managed boreal and north temperate forests. Speakers include Tim Work, Chris Buddle, Keith Summerville, John Richardson, John Spence, and David Langor. A second BSC-sponsored symposium, *Arthropods and Fire*, organized by Rob Roughley, will also include some focus on forest arthropod biodiversity.
- The 5th North American Forest Ecology Workshop will be held in Aylmer, Quebec, 12–16 June 2005. The theme is Ecosystem management: can we conserve the pieces while managing the matrix? Please consult



the following website for updates: http://www.sbf.ulaval.ca/rlq/nafew/callforpaper.htm.

Requests for Cooperation

- A group of Canadian entomologists (D. McCorquodale, S. Laplante, J. Hammond and D. Langor) are currently preparing an identification guide to the Cerambycidae of Canada and Alaska. If there are colleagues who have collections of cerambycids from interesting and restricted habitats in Canada, especially southern areas, or anywhere in Alaska and the Canadian north, we would be pleased to hear about them, and we may wish to borrow the material for a short period. Please contact David Langor (dlangor@nrcan.gc.ca).
- Most biodiversity sampling in forests (and other habitats) results in the collection of much 'non-target' arthropod material. Such material is sometimes preserved and is commonly referred to as 'residuals.' Residuals may be of great value to entomologists in Canada and elsewhere. If you have such material, or if you have a desire to access such material, please provide the editor with the necessary details, which will be publicized in future BSC Newsletters and on the BSC website. This request is not restricted to forested habitats.
- Two large, well-designed forest arthropod biodiversity experiments in central Alberta have resulted in collections of large numbers of epigaeic spiders across the entire experimental design. These spiders are available to interested arachnologists who are willing to do the identifications and utilize the data for publication. One experiment is a chronosequence study in foothills lodgepole pine forests, designed to assess the impacts of clear-cutting on epigaeic arthropods and the rate of assemblage recovery. The second experiment is located in boreal upland white spruce in northwest Alberta and was designed to assess the responses of arthropods to a variety of harvesting treatments that leave 0%, 25% or 50% residual trees on the landscape. Interested researchers can contact David Langor (dlangor@nrcan.gc.ca).
- Do you have an interest in pyrophilous beetles in the genus *Sericoda*? I am coordinating an effort to bring together all available knowledge of the ecology and distribution of the four species in the Canadian fauna. If you have unpublished data on biology, distribution and abundance or if you are about to undertake work on this group, I would be interested to correspond with you. Also, if you would like to participate in a national project on *Sericoda* distribution and abundance in burned forests of various types and locations, please contact Tyler Cobb (email: tcobb@ualberta.ca).

New Publications

Battigelli, J.P.; Spence, J.R.; Langor, D.W.; Berch, S.M. 2004. Short-term impact of forest soil compaction and organic matter removal on soil mesofauna density and oribatid mite diversity. Canadian Journal of Forest Research 34:1136–1149.

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