

Arthropods



of

Canadian Forests



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Photos by S. Digweed

CONTENTS

WELCOME	3
CONTRIBUTIONS	3
PROGRESS REPORT	4
Biological Survey of Canada Forest Arthropods Project	4
PROJECT UPDATES	5
Diversity of Gall Wasps on Bur Oak in Southern Manitoba	5
Rove Beetles (Staphylinidae) in Canadian Forests and Their Value as Indicators of Changing Environmental Conditions	9
Recent Research on Forest Beetles in the Maritime Provinces	12
Coast Region Experimental Arthropod Project (CREAP) Pilot, Roberts Creek Study Forest on the Sunshine Coast of British Columbia	16
GRADUATE STUDENT FOCUS	17
Insect Community Structure as a Function of Tree Cohort Structure in the Mixedwood Forests of Northeastern Ontario	17
The Effect of Dead Wood on Mite Biodiversity in Quebec's Boreal Forest	18
Effects of Variable-Retention Harvesting of Mixedwood Forests on Ground-Dwelling Spider Assemblages in the Boreal Forest	19
Diversity of Parasitoids (Hymenoptera: Ichneumonidae) in a Boreal Forest Ecosystem	20
NEWS AND EVENTS	21
Ongoing Survey Initiatives in Canadian National Parks	21
Siricidae Needed	21
Arthropods of Newfoundland and Labrador	21
NEW PUBLICATIONS	22

WELCOME



Welcome to the fourth 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 (BSC)—Terrestrial Arthropods. The goal of the newsletter is to serve as a communication tool for encouraging 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 (as a pdf file) in April. If you wish to be placed on the distribution list, please contact David Langor (see below for contact information).

Newsletter content will include project updates (short articles that introduce relevant Canadian projects); feature articles (overviews, summaries, commentaries, or syntheses); a graduate student section featuring brief summaries of thesis research, funding opportunities, employment notices, and other items of interest; brief news articles concerning meetings, symposia, collaboration opportunities, collecting trips, and other activities; and new publications and websites. Please consider submitting items to the *Arthropods of Canadian Forests* newsletter—articles in either official language are welcome. We also welcome comments on how we can improve the content and delivery of this newsletter.

CONTRIBUTIONS

Contributions of articles and other items of interest to students of forests and forest arthropods are welcomed by the editor. Submission in electronic format by email or CD is preferred. The copy deadline for the next issue is 31 January 2009.

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Cette publication est également disponible en français sous le titre *Arthropodes des forêts canadiennes*.



PROGRESS REPORT

Biological Survey of Canada Forest Arthropods Project

In 2003, the Biological Survey of Canada (BSC) initiated a new project on arthropod faunistics and systematics 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. There has been notable progress with all current activities organized through this project.

Project Database

The BSC continues to maintain and update a list of forest arthropod biodiversity projects in Canada and adjacent parts of the United States (see <http://www.biology.ualberta.ca/bsc/english/forestprojectsummary.htm>). This database highlights current activity in Canada and the northern United States and facilitates contact between researchers with complementary interests. As of early 2008, 73 projects were listed. Researchers are encouraged to regularly update their project descriptions and progress and add new projects as they arise. This is a particularly good forum for graduate students to advertise their new work.

Communications

Volume 3 of the *Arthropods of Canadian Forests* newsletter, published in April 2007, was distributed electronically in English and French to over 230 recipients in 10 countries. The mailing list for the newsletter continues to grow rapidly. In addition, the project web pages (<http://www.biology.ualberta.ca/bsc/english/forests.htm>) continue to be maintained and updated.

Symposium Proceedings

Seven synthesis papers stemming from a BSC-sponsored symposium, entitled "Maintaining Arthropods in Northern Forest Ecosystems," held in 2005, have been completed and will be published in the July/August 2008 issue of *The Canadian Entomologist*.

Cerambycidae of Canada and Alaska

A collaboration between the Canadian Forest Service, the US Department of Agriculture Forest Service, Agriculture and Agri-Food Canada, the University of Cape Breton, and the BSC has the goal of producing a handbook to the Cerambycidae (Coleoptera) of Canada and Alaska. All large collections in Canada and Alaska and selected collections in the United States have now been examined, and specimens identified and entered into a database. Revisionary work is near completion for several genera, and other taxonomic work is under way. Most keys have already been developed, many color photographs have been prepared, and distribution maps are in preparation.

Diversity of Gall Wasps on Bur Oak in Southern Manitoba

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Introduction

Gall wasps (Hymenoptera: Cynipidae) comprise 1360 described species of gall formers and gall inquilines or “guests” worldwide (Ronquist 1994; Liljeblad and Ronquist 1998). Most species (almost 1000) attack oaks (Fagaceae: *Quercus* spp.), and in North America there are more than 485 described species of oak-galling cynipids (Burks 1979; Melika and Abrahamson 2002). The galls produced by these wasps are morphologically diverse and often structurally complex, and they host large communities of other insects that live in them or attack their occupants (Askew 1984; Meyer 1987; Stone and Schönrogge 2003). These communities comprise mostly inquilines or “guests” (mostly cynipids from the non-galling tribe Synergini) and chalcidoid parasitoids (Askew 1984).

Although many species of oak gall wasps have been described from North America, the family is still poorly understood, both taxonomically and biologically (Pujade-Villar et al. 1999). The main reason for this lack of understanding is the peculiar life history of most oak-galling cynipids: they are bivoltine, with adult males and females of the sexual generation (denoted by “♂♀”) active in early summer and adults of the female-only agamic generation (denoted by “♂”) active in late fall or early spring. Further, the two generations of a single oak-galling cynipid species often have morphologically different galls and adult wasps. At the time when most species were described, the prevalence of alternating generations in oak gall wasps was not well recognized. As a result, almost all species were originally described from only one generation, and in an unknown number of cases, the two generations of a single species have been described as separate species. Today, the most basic biological information is lacking for most species of North American oak-galling cynipids (Pujade-Villar et al. 1999), and little is known of their inquilines and parasitoids.

Bur oak, *Quercus macrocarpa* (Michx.), is the most widespread native “white” oak in Canada (Farrar 1995).

Stands of bur oak in southern Manitoba occur at the extreme northwest edge of the native range of this species (Harms 2002). Nothing is known about the cynipid galls and their communities of associated insects in these northern bur oak stands. Twenty-seven species of Cynipidae have been recorded from bur oak (Table 1), but none has been recorded in the literature from Manitoba (Burks 1979). Although parasitoids have been reared from cynipids in Canada (Peck 1963), the diversity of inquilines and parasitoids attacking cynipids galling bur oak in Manitoba is unknown.

The ongoing project described here was undertaken to document the diversity of oak gall wasps and their inquilines and parasitoids on bur oak in southern Manitoba. Work started in 2004 in Riding Mountain National Park (Digweed 2006), further collections were taken in 2005 and 2006, and more collections are planned for 2008 and beyond.

Methods

Bur oak galls in Manitoba (mostly south of 51°N) were surveyed during the period 2004–2006. Most collections were made in late August, when all galls of the current year are mature, but detachable galls have not yet dropped off the trees. In 2004, some galls were also collected in April and July. Oaks examined were all easily accessible from public roads and in public parks. All stands surveyed in Riding Mountain National Park in 2004 were along the eastern park boundary. At all locations, the aboveground parts of trees were searched extensively, and galls were collected up to 6 m above the ground using a pole pruner. Root galls were not sampled, although root-galling species may occur in Manitoba (Table 1). Representatives of all gall species found were collected, placed in labeled resealable plastic bags, and retained to allow rearing of gall occupants under ambient outdoor conditions in Edmonton, Alberta. All reared inquilines and parasitoids were identified to at least the genus level.

Table 1. Species of oak gall wasp (Hymenoptera: Cynipidae) recorded from bur oak (*Quercus macrocarpa*) by Felt (1940), Weld (1959)^a and Burks (1979)

Species	Location for bisexual gall	Location for agamic gall	In Manitoba ^b
<i>Acraspis macrocarpae</i> Bassett ^{c,d}	Bud scale ^e	Leaf	✓
<i>Acraspis villosa</i> Gillette	Bud scale ^e	Leaf	✓
<i>Andricus chinquapin</i> (Fitch)	Leaf	Unknown	✓
<i>Andricus dimorphus</i> (Beutenmueller)	Leaf	Unknown	✓
<i>Andricus foliaformis</i> Gillette	Leaf	Unknown	✓
<i>Andricus ignotus</i> (Bassett)	New shoot ^e	Leaf	✓
<i>Andricus pisiformis</i> Beutenmueller	Bud	Unknown	✓
<i>Andricus quercusfrondosus</i> (Bassett)	Unknown	Bud	✓
<i>Andricus quercuspetiolicola</i> (Bassett)	Leaf petiole	Unknown	✓
<i>Andricus quercustrobianus</i> (Osten Sacken) ^b	Unknown	Petiole base	✓
<i>Callirhytis flavipes</i> (Gillette)	Leaf midrib	Coarse twig bark ^e	✓
<i>Callirhytis glandulus</i> (Beutenmueller)	Unknown	Acorn cup	✓
<i>Callirhytis quercusfutilis</i> (Osten Sacken)	Leaf	Root	✓
<i>Disholcaspis bassetti</i> (Gillette)	Unknown	New twig	NC ^f
<i>Disholcaspis quercusmamma</i> (Walsh)	Bud ^e	New twig	✓
<i>Holocynips badia</i> (Bassett)	Unknown	Root	NS ^g
<i>Holocynips maxima</i> (Weld)	Unknown	Root	NS
<i>Loxaulus illinoisensis</i> (Weld)	Unknown	Root	NS
<i>Neuroterus fugiens</i> Weld	Leaf	Unknown	NC
<i>Neuroterus niger</i> Gillette ^h	New shoot ^e	Leaf	✓
<i>Neuroterus quercusverrucarum</i> Osten Sacken ^b	Unknown	Leaf	✓
<i>Neuroterus saltarius</i> Weld	Unknown	Leaf	✓
<i>Neuroterus umbilicatus</i> Bassett ^b	Unknown	Leaf	✓
<i>Neuroterus vescicula</i> (Bassett)	Unknown	Bud	NC
<i>Philonix fulvicollis</i> Fitch ^{b,i}	Unknown	Leaf	✓
<i>Phylloteras volutellae</i> (Ashmead)	Unknown	Leaf	NC
<i>Trigonaspis quercusforticorne</i> (Walsh)	Unknown	New stem or leaf	✓

^aDoes not include undescribed species associated with bur oak that were mentioned by Weld (1959).

^bCollected by the author from 2004 to 2007.

^cRecorded from Canada, according to Burks (1979) or Kinsey (1923, 1930).

^dIncludes references to *Acraspis gemula* (Bassett) ♂♀ (bisexual) and *Acraspis hirta* (Bassett) ♂ (agamic) and varieties within the latter species, which are treated here as synonymous with *A. macrocarpae* ♂♀ and ♂ on bur oak.

^eThis alternate generation has been experimentally determined by the author but awaits description.

^fNC = not collected.

^gNS = not sampled.

^hIncludes references to *Neuroterus vernus* Gillette ♂♀, which is the alternate generation of *Neuroterus niger* ♂ (unpublished data).

ⁱIncludes references to *Philonix gigas* (Weld) ♂, *Philonix insulensis* (Kinsey) ♂, and *Philonix nigra* (Gillette) ♂, which are treated here as synonymous with *Philonix fulvicollis* ♂ on bur oak.

Results and Discussion

So far, 20 species of oak-galling cynipids have been found on bur oaks in southern Manitoba (Table 1; Figures 1–5). This diversity represents 75% of the total oak-galling cynipid fauna recorded from bur oak throughout North America, and 83% of the 24 species expected on aboveground plant parts.

To date, 6 081 insects have been reared from galls of at least 15 species. Of these, 2453 were gall-makers; the remainder wereinquilines or parasitoids from the hymenopteran cynipoid genera *Ceroptres* and *Synergus* (Cynipidae: Synergini) and the following chalcidoid genera: *Ormyrus* (Ormyridae); *Eurytoma* and *Sycophila* (Eurytomidae); *Brasema* (Eupelmidae); *Pteromalus* and *Gastrancistrus*? (Pteromalidae); *Torymus* (Torymidae); *Closterocerus* (Eulophidae: Entedoninae); *Aulogymnus* (Eulophidae: Eulophinae); and *Quadrastichus*, *Aprostocetus* (subgenus *Aprostocetus*), *Aprostocetus* (subgenus *Quercastichus*), and *Baryscapus* (Eulophidae: Tetrastichinae). A few Diptera inquilines from the genus *Lasioptera* (Cecidomyiidae) were also reared.

This study revealed that a large proportion of the gall wasp species known from bur oak are present in Manitoba, which is near the extreme northwest limit of bur oak's native

range. Many of the oak-galling cynipids will represent new published records for Canada, and all represent new records for Manitoba. These galls support a diverse array of inquiline or parasitoid insects, most of which specialize on oak-galling hosts (e.g., *Ceroptres* and *Synergus*) and are therefore completely dependent on them for survival.

Current understanding of the insect community in cynipid galls on bur oak in Manitoba is rudimentary. Most gall wasps on bur oak still have unknown alternate generations (Table 1), and the trophic relationships between these gall wasps and their inquilines and parasitoids are not understood. For example, it is unknown which Synergini and chalcidoid species are guests, feeding on gall tissue, and which are parasitoids. Further, the competitive interactions among multiple parasitoid species within a single gall have not been investigated. Elucidating these relationships will take much additional detailed work. Well-studied oak-galling cynipids in Europe are model systems for studying fundamental questions in evolution and ecology (Stone et al. 2002; Stone and Schönrogge 2003). Further complex and interesting questions could be addressed if the more diverse North American cynipid fauna was also understood at a basic biological level.



Figure 1. *Acraspis macrocarpae* agamic galls (photo by S. Digweed).



Figure 2. *Andricus ignotus* agamic female ovipositing into bur oak bud (photo by S. Digweed).



▲ **Figure 3.** *Disholcaspis quercusmamma* agamic galls (photo by S. Digweed).



▲ **Figure 4.** *Philonix fulvicollis* and *Andricus ignota* galls (photo by S. Digweed).



▲ **Figure 5.** *Trigonaspis quercusforticorne* galls (photo by S. Digweed).

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Rove Beetles (Staphylinidae) in Canadian Forests and Their Value as Indicators of Changing Environmental Conditions

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The Staphylinidae, or rove beetle family, (Figure 6) is one of the largest and most biologically diverse of the beetle families (Klimaszewski 2000; Goux and Klimaszewski 2007). The world fauna consists of more than 46 200 known species classified in about 3 200 genera (Newton et al. 2001). In Canada and Alaska, nearly 1 400 rove beetle species in 23 subfamilies and 274 genera have been recorded (Klimaszewski 2000). Many species in Canada, however, remain undescribed, particularly within the largest rove beetle subfamily, Aleocharinae, which contains about 400 species. Rove beetles are very successful in competing with other arthropods because of several biological and morphological features: a shortened elytra, leading to a small, narrow, flexible body; well-developed wings (in most species), leading to very good dispersal abilities; and defensive glands (in many species, such as those of Aleocharinae), containing chemicals to deter predators (Klimaszewski 2000). The majority of adults are nocturnal, generally avoiding contact with light, and prefer moist habitats. Most rove beetles (e.g., Aleocharinae, Staphylininae, Paederinae) are general predators, preying on other arthropods, but some specialize in the use of other food resources. For example, Oxyporinae species are obligate inhabitants of fresh mushrooms, and species of the subtribe Gyrophaenina are exclusively mycetophagous, feeding on fungal spores and hyphae (Ashe 1984). All Scaphidinae species are obligate or facultative inhabitants and consumers of fungi (Newton 1984). Osoriinae and Oxytelinae feed mainly on decomposing organic material (Klimaszewski 2000). A number of species are saprophagous (e.g., some Oxytelinae) or phytophagous (e.g., some Omaliinae, Osoriinae, Oxytelinae, Paederinae) (Frank and Thomas 1991; Klimaszewski 2000). Larvae of *Aleochara* spp. are ectoparasitoids on pupae of cyclorrhaphous Diptera (Klimaszewski 1984). Some species occur under the bark of trees or logs (e.g., species of the genera *Homalota*, *Dexiogyia*, and *Gnathusa*). Many other species are affiliated with ants (some members of the tribe Athetini, as well as members of the tribe Oxypodini). The primary feeding modes (i.e., trophic affiliations) of several biological and morphological features rove beetles were presented and discussed by Klimaszewski (2000).

The rove beetles occur in most terrestrial habitats but are best represented in forest litter (Klimaszewski 2000). In a recent inventory of the beetle fauna of the boreal forest of

northwestern Quebec, rove beetles represented the highest proportion of overall species richness, totalling 29% (238 species) of all the beetle species collected (Paquin and Dupérré 2001). In a recent study in a yellow birch (*Betula alleghaniensis* Britt.) forest northwest of Québec, rove beetles were five times more abundant than ground beetles (Carabidae) (9424 and 1875 specimens, respectively), and there were three times as many species (116 and 38 species, respectively) for collections gathered according to the same experimental design and with the same sampling effort (Klimaszewski et al. 2005a, 2007). Rove beetles fill a larger number and variety of trophic and functional roles than ground beetles or spiders and occupy niches (e.g., mushrooms and fungal mats) that are not occupied by ground beetles, which accounts for this higher diversity and abundance (Pohl et al. 2008).

The composition of rove beetle assemblages differs across large geographic regions and, to a lesser extent, among forest types within localized areas (Paquin and Dupérré 2001; Klimaszewski et al. 2005b; Pohl et al. 2008). There have been relatively few inventories of staphylinid assemblages in boreal forests and even fewer in which species in the highly diverse and abundant subfamily Aleocharinae were identified. Klimaszewski et al. (2005b) recorded 134 rove beetle species (including 52 Aleocharinae species) from boreal forest dominated by red spruce (*Picea rubens* Sarg.) in New Brunswick. In comparison, 143 species were captured in boreal forest dominated by yellow birch in southeastern Quebec (Klimaszewski et al. 2008). The rove beetle faunas at sites dominated by red spruce (in New Brunswick) and yellow birch (in Quebec) shared only 72 species of the combined total of 205 species (Klimaszewski et al. 2005b, 2008). The 28 most numerous species occurred at both sites, but their relative dominance, with the exception of one species (*Oxypoda convergens*), differed between the sites (Klimaszewski et al. 2005b, 2008). The boreal forest, which covers much of Canada, is not a uniform forest region; rather, it exhibits high variability in soils, environmental conditions, and vegetation across its range (Rowe 1972). The two studies compared here were conducted at two completely different boreal forest sites, separated by about 500 km. Clearly, an immense amount of work is still required to fully characterize the rove beetle fauna of the boreal forest and its variation.

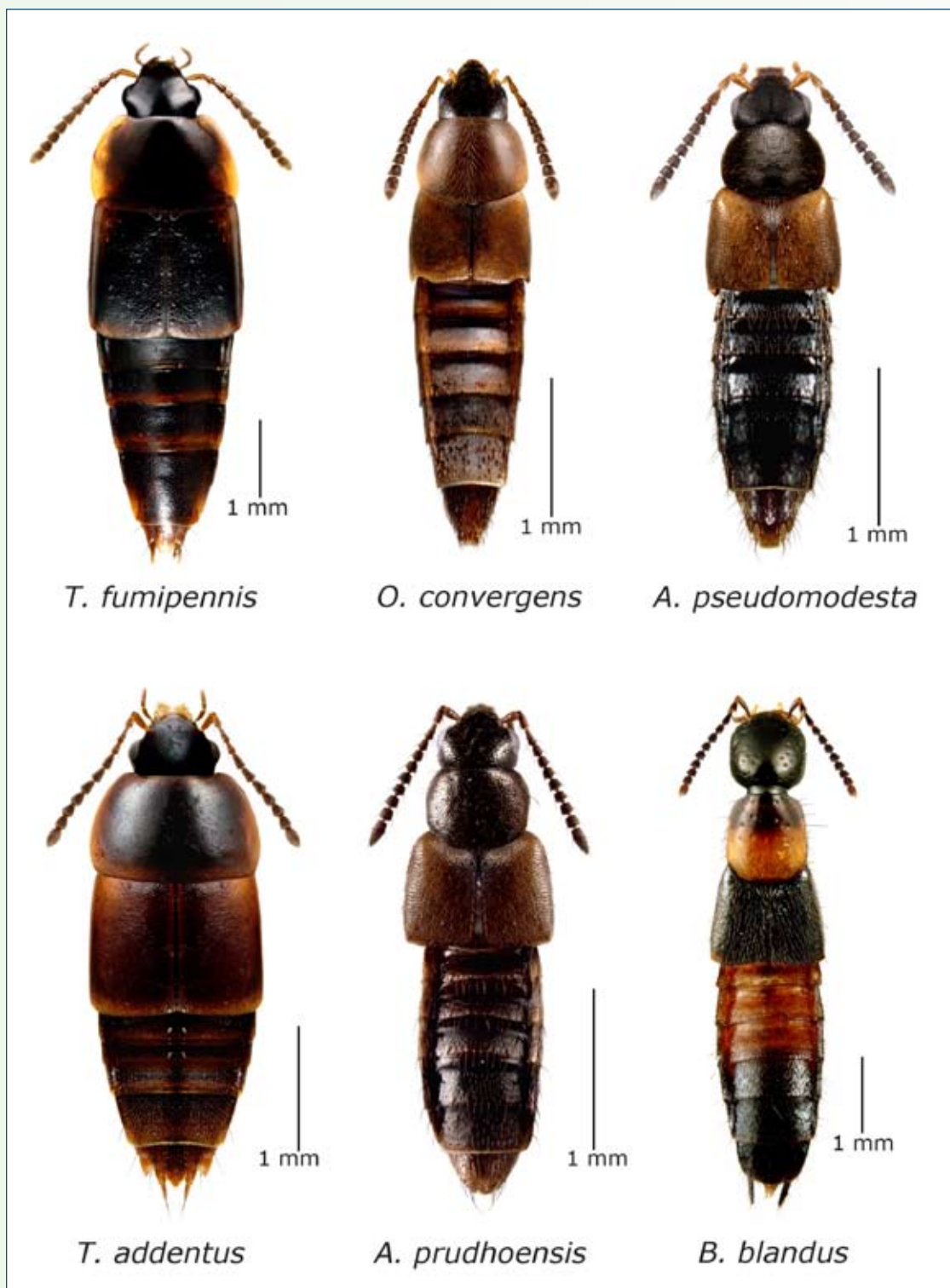


Figure 6. The dominant rove beetle species from yellow birch forests of southeastern Quebec (photo by J. Klimaszewski).

There is also much temporal variation in rove beetle assemblages within sites. The two sites in the yellow birch forest that were sampled in 2000 were also sampled in 1999 (the pretreatment year). Klimaszewski et al. (2008) recorded 143 species in total over both seasons. Sixty-one species were collected in both years, including all of the most common species, whereas 82 species, mostly uncommon or rare, were collected in only one of the two years (27 species only in 1999 and 55 species only in 2000). Some of the species collected in only one of the two years might have been influenced positively or negatively by forestry treatments. However, in the control stands, 62 of the total of 109 species were collected in only one of the two years (41 species in 1999 and 21 in 2000), which indicates that treatments alone cannot account for the variability. The variability in species abundance and species richness from year to year within sites is not well understood but may be attributable to species phenology, temporal variation in the availability of habitats (e.g., fungal fruiting bodies) and stochastic events (Klimaszewski et al. 2008).

The habitat affinities of rove beetles are quite different from those of other litter fauna such as ground beetles (Klimaszewski et al. 2005a). The rove beetle fauna is characterized by a large number of species that appear to have a strong affinity for unharvested forest and may be considered forest specialists. In the yellow birch forest study, of the 53 staphylinid species for which habitat affinity could be assessed, 24 appeared to be forest specialists. In comparison,

only 6 of the 38 carabid species collected according to the same experimental design were considered forest specialists (Klimaszewski 2005b, 2007). This difference shows that more rove beetles may be sensitive to forest disturbances than ground beetles and that, because of their greater sensitivity, rove beetles may be better indicators of ecological disturbance than ground beetles. About one-third of all carabid species collected at these sites were forest generalists, whereas only about one-fifth of rove beetles fit this category. Species that are adapted to open habitats were much more common among ground beetles (11 of 38 species) than among rove beetles (1 of 53 species) (Klimaszewski et al. 2007). It appears that, in contrast to ground beetles, few rove beetles were adapted to specialize in open habitats or could thrive on the exposed mineral soil typical of newly harvested sites. However, the notable absence of open-habitat specialists may be a phenomenon limited to the immediate post-harvest period. These specialists may become more abundant in subsequent years, as has been noted by Koivula and Niemelä (2003) for ground beetles in Europe.

Rove beetles have great potential for use as indicators of forest change, because of their sensitivity to any disruption of habitat. The difficulty of identifying selected rove beetle groups (e.g., Aleocharinae) should not deter researchers from choosing this taxonomically and trophically diverse group of forest insects for this purpose.

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Recent Research on Forest Beetles in the Maritime Provinces

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I first became conscious of the term “saproxylic” while reading Speight’s seminal booklet, *Saproxylic Invertebrates and their Conservation* (Speight 1989) more than a decade ago. It was a moment of awakening, when a panoply of ideas came together for me in a coherent pattern. *Deadwood – Living Forests*, the title of Dudley and Vallauri’s booklet written for the World Wildlife Fund, encapsulates an important paradox of forest biology: the processes of decomposition (of wood and other organic matter) are the *sine qua non* of forest ecosystems. Much of the forest biota is directly or indirectly reliant on such processes. As the Sammy Cahn song has it, “you can’t have one without the other.”

Another enlightening experience was reading the excellent survey by Langor et al. (2006) on maintaining saproxylic insects in Canada’s managed boreal forests. As a biologist working on Coleoptera in the Maritime provinces, I was struck by what the authors called the “paucity of research” on this topic and their remark that, “The seemingly low interest of the Canadian research community to pursue work on saproxylic faunas is enigmatic as the interest among forest managers in CWD [coarse woody debris] management for biodiversity conservation is very high.” Moreover, of the comparatively few Canadian studies that Langor et al. (2006) managed to marshal for their review, almost all came from Alberta or Quebec; none were from Atlantic Canada. Clearly, there were both challenges and opportunities in this region. In my previous research examining historical Coleoptera collections in the Maritime provinces, I had found relatively low representation of many forest (and particularly saproxylic) species. This reflected early interests in the region, which focused on beetles of open habitats, particularly those of agricultural or horticultural significance.

With the assistance of many collaborators at various institutions in the Maritime provinces, including students working on thesis projects, private collectors, and taxonomists upon whose assistance I have relied in my climb up the steep learning curve of Coleoptera systematics and taxonomy, I have endeavored to fill in at least some of the gaps. The resulting research initiatives have been in three principal areas: taxon-specific biodiversity studies that have surveyed families, or groups of families, of saproxylic beetles, reporting new species, mapping distribution, compiling bionomic information, and discussing these organisms in the context of the region’s forests and their management history; studies of forest beetle communities at particular localities; and specific

ecological investigations into forest beetle communities as they reflect forest stand types, ages, available coarse woody debris and forest management histories.

Biodiversity studies have resulted in a sizable number of papers surveying forest beetle families such as the Mycteridae, Boridae, Pythidae, Pyrochroidae, Salpingidae (Majka 2006b), Cleridae (Majka 2006a), Tetratomidae, Melandryidae, Synchroidae, Scraptiidae (Majka and Pollock 2006), Nitidulidae, Corylophidae (Majka and Cline 2006a, 2006b), Ciidae (Majka 2007a), Eucnemidae (Majka 2007d), Erotylidae, Endomychidae (Majka 2007c), Derodontidae, Bostrichidae, Anobiidae (Majka 2007b), Anthribidae, Curculionidae, Nemomychidae (Majka et al. 2007a, 2007b), Colydiidae (Majka et al. 2006), Cerambycidae (Majka et al. 2007c), Mordellidae (Majka and Jackman 2006), Ptiliidae (Majka and Sörensson 2007), and Elateridae (Majka and Johnson 2008) in the Maritime provinces (and survey results for the Latridiidae, Leiodidae, Tenebrionidae, and Phalacridae are in preparation). One important outcome of these surveys is that a large number of new provincial and regional records have been established (Figure 7). Overall, of the 647 species identified, 187 (29%) are newly recorded in the Maritimes, and 14 are new Canadian records. The records also include 489 new provincial records, a substantial increase in the known fauna of each province and in our knowledge of its distribution in the region.

Recent work in the Maritime provinces (e.g., several papers summarized in Majka 2007d) has revealed that a large proportion of the saproxylic fauna appears to be “rare,” i.e., species represented by five or fewer specimens (or no more than 0.005% of saproxylic specimens examined in total) (Figure 8). Fifty-nine (28%) of 208 species investigated thus far fall into this category. If bark beetles (Scolytinae), which are early colonizers of phloem, cambium, and sapwood, are excluded from the calculations, the proportion of “rare” species increases to 39%. The high proportion of rare species may be partly attributable to the long history of forest management in the region and should serve as an impetus for further research to assess the state of the saproxylic fauna and the impacts of anthropogenic and natural disturbances.

In recent years, several studies have examined the composition of forest beetle communities in the Maritime provinces. Although some of these studies are still unpublished, together they provide important insights into

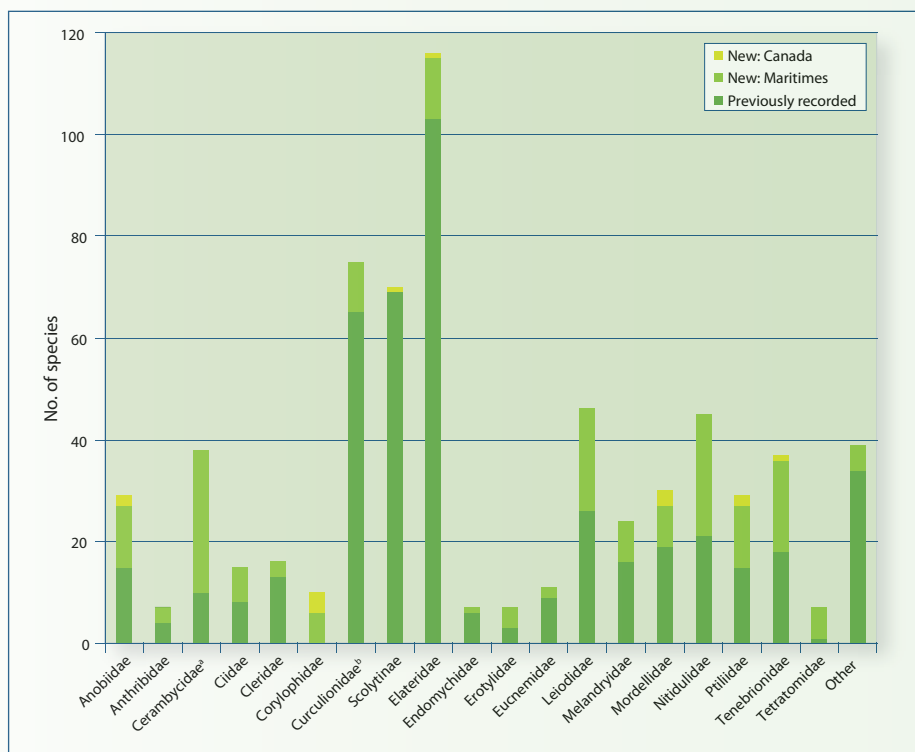


Figure 7. Records for selected families of forest Coleoptera in the Maritime provinces, including new records. For families that include nonforest species, only forest species are included in these counts. ^aPrince Edward Island only; ^bexcluding the Scolytinae.

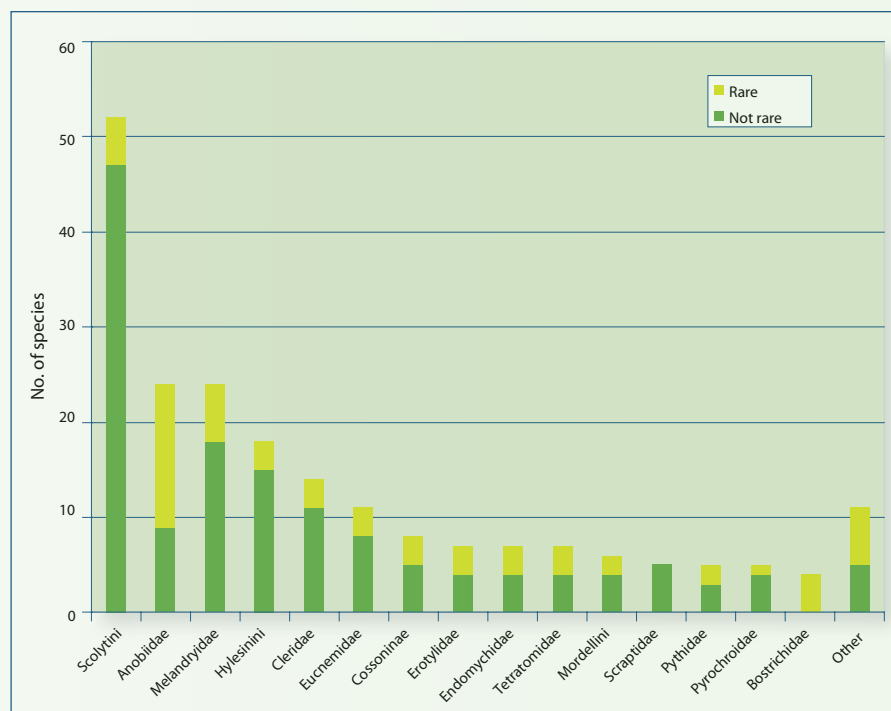


Figure 8. Rare species of native saproxylic Coleoptera in the Maritime provinces.

forest beetle communities of the region. Since 2000, I have been conducting research on forest beetles at a site in St. Patricks, Prince Edward Island. Between 2000 and 2004, I also surveyed the beetle fauna of Point Pleasant Park, a forested municipal park located at the southern tip of peninsular Halifax, Nova Scotia. During 2004–2005, Tatiana Rossolimo and her students at Dalhousie University, Halifax, conducted a study of the forest-floor Coleoptera at several sites in Kejimikujik National Park, Nova Scotia. They found 152 species of beetles as part of their investigation of the potential utility of forest-floor Coleoptera as indicators of environmental change. Figure 9 summarizes the findings of several studies of forest beetle communities in Nova Scotia. Kehler et al. (1996) and Bishop et al. (2008) used flight-intercept traps to survey several forest stands, whereas Dollin (2004) and Majka (unpublished data) used several trapping methods. Although the sampling methods, sampling effort, and number of sampled sites varied between studies, the number of forest beetle species found (ranging from 292 to 405) and the proportion of saproxylic fauna (ranging from 63% to 79% of species) give an indication of the scale and relative importance of this fauna in the province.

Three studies of saproxylic beetle communities in Nova Scotia deserve particular attention. In 1994–1995, Daniel Kehler and Christine Corkum (working with Søren

Bondrup-Nielsen at Acadia University, Wolfville, Nova Scotia) conducted an extensive study of forest beetle communities in 20 coniferous and deciduous forests. Some of the results of this research have been published (Kehler et al. 2004; Majka and Bondrup-Nielsen 2006), and additional analysis is in progress. In 1997, DeLancey Bishop (working with Stewart Peck of Carleton University, Ottawa, Ontario) studied saproxylic beetles in naturally and artificially disturbed forests in Nova Scotia (Bishop et al. 2008). Most recently, in 2003, Philana Dollin (working at Dalhousie University with Peter Duinker and C.G. Majka) examined forest beetle communities at 11 sites of various ages in southwestern Nova Scotia (Dollin 2004). Each of these studies has provided detailed information on saproxylic and forest beetle communities in relation to both forest age and disturbance history, as well as in relation to the characteristics of coarse woody debris. These are all important steps in addressing the “paucity” of information noted by Langor et al. (2006).

Although we have learned a considerable amount about the forest beetle faunas of the region, it is nonetheless clear that much remains to be done. Given the apparent rarity of many species, it is worth echoing the conclusion of Grove (2002), who wrote, with respect to European saproxylic fauna, “Many saproxylic species now survive ... only as relictual populations, ‘hanging on by the tips of their tarsi’ ... In the absence of positive management, the ultimate extinction of some such species (truly the ‘living dead’) is almost inevitable through stochastic events.”

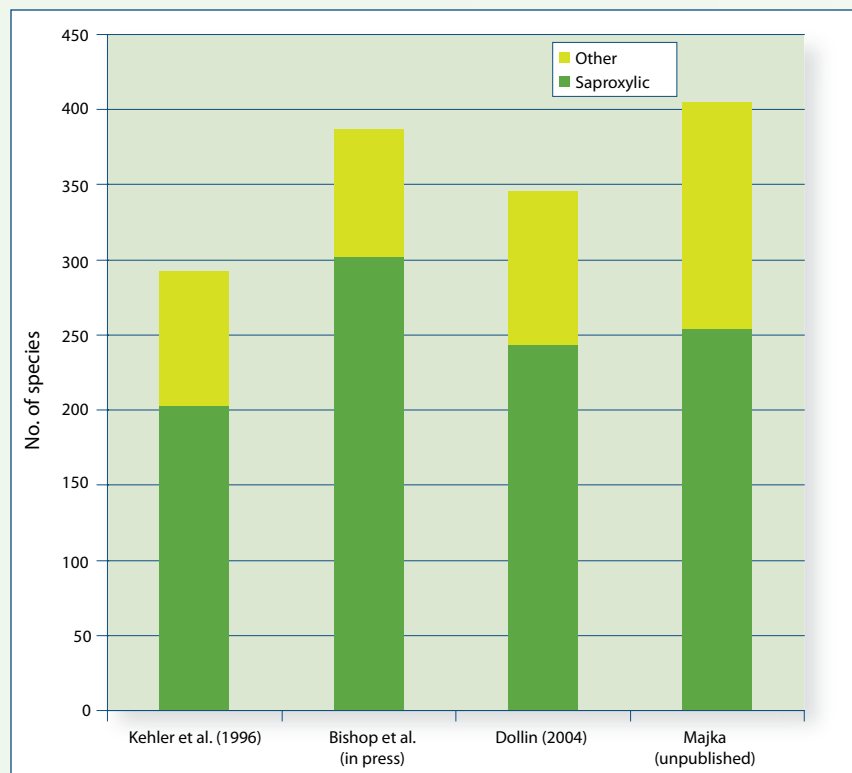


Figure 9. Diversity of forest Coleoptera assemblages in the Maritime provinces based on four independent studies.

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Coast Region Experimental Arthropod Project (CREAP) Pilot, Roberts Creek Study Forest on the Sunshine Coast of British Columbia

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In 2007, we initiated a pilot project to examine the utility of ground arthropod communities as suitable, sensitive indicators of the structural integrity of coastal forests. As ecologists and biologists interested in monitoring to evaluate the effects of structural retention practices on biodiversity and wildlife habitat and to determine the potential interactions of forest management with the effects of climate change, we have been exploring cost-effective ways of teasing out functionally representative biotic responses that reflect ecosystem resilience.

Effectiveness studies often focus on better-known indicator ground taxa, particularly the carabid and staphylinid beetles, and more recently ants and spiders. The ecosystem approach that we are exploring examines the responses of functional groups (e.g., according to trophic roles) to changing patterns in ecosystem structure and function resulting from different types and levels of disturbance. Functional rather than taxonomic diversity thus becomes the surrogate for biodiversity, with shifts in functional diversity and richness reflecting shifts in microhabitat and microclimate, either in direct response to changing conditions or through interaction with more dominant functional groups under those changed conditions.

We are using the Roberts Creek Study Forest in the dry Coastal Western Hemlock biogeoclimatic subzone, which is dominated by Douglas-fir (*Pseudotsuga menziesii* (Mirb.)), to

pilot methods of sampling in the field, sorting and identifying specimens, and interpreting data. The study forest offers a range of structural types and conditions created through alternative harvest systems applied between 1993 and 2002 (Figs. 10 and 11). Assisted by invertebrate ecologist Jeff Meggs, we have been employing pitfall traps as the primary sampling tool. Our goal is to determine if we can describe the responses (in terms of biomass, abundance, and diversity) of arthropod assemblages, identified to the level of morphospecies rather than to individual species or other taxonomic levels, to a suite of structural habitat attributes. We are doing this work in partnership with Dr. Staffan Lindgren from the University of Northern British Columbia, Prince George, British Columbia, who is exploring the responses of carabid beetles and ants to downed-wood retention practices in the interior of British Columbia, and Dr. Bruce Marcot of the U.S. Department of Agriculture Forest Service in Portland, Oregon, who is exploring a similar ecosystem approach in his study of old forest remnants in the Pacific Northwest.

Some degree of taxonomic identification will support a comparison of morphospecies with real species identities and will allow us to evaluate the reliability of using morphospecies as a basis for functional community analysis. To that end, we will be calling on taxonomic experts and exploring data-sharing opportunities. We will also resample the area in 2008.



Figure 10. Example of dispersed retention within the Roberts Creek Study Forest, Sunshine Coast, British Columbia (photo by J. Meggs).



Figure 11. Harvested gap within an extended-rotation block in the Roberts Creek Study Forest, Sunshine Coast, British Columbia (photo by J. Meggs).

GRADUATE STUDENT FOCUS



Insect Community Structure as a Function of Tree Cohort Structure in the Mixedwood Forests of Northeastern Ontario

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Emulation of natural forest dynamics has been suggested as a way to maintain biodiversity in managed forests. Short fire cycles in Ontario's boreal forest have traditionally justified a strategy of even-aged management by clear-cutting. However, some regions of the boreal forest have much longer fire cycles (>100 years), where even-aged management may not be ideal. Multicohort forest management is a new strategy that is being studied for its potential to allow for the natural stand variation occurring in these areas. My research attempts to identify how these two approaches (i.e., multi-aged versus even-aged) influence insect communities in the boreal forest.

Study sites representing three cohorts were established in Kapuskasing, Ontario, during spring 2006. At each site, 16 pitfall traps were used to sample the ground arthropod fauna and 2 malaise traps in the understory and canopy (Figure 12) were used to sample the aerial arthropod fauna. Samples are now being sorted and key taxa identified to the family level. Carabidae, Cerambycidae, Syrphidae, Mymaridae, Odonata, and various families of butterflies will be identified to species level. Additional taxonomic expertise is being sought for identification of other taxonomic groups. This is the only known study sampling canopy insect fauna with aerial malaise traps in Ontario's boreal forest, so many interesting records are anticipated.

This work will further our knowledge of how insect communities are vertically partitioned in the boreal forest and how they respond to anthropogenic changes in forest structure. Any cohort-sensitive taxa with the potential to act as indicators that are identified during this study might be useful for monitoring future forest conditions in Ontario.

If you are interested in contributing your taxonomic expertise to this project and in obtaining specimens, please contact Erica Barkley at erica.barkley@utoronto.ca.



Figure 12. Aerial malaise trap (photo by E. Barkley).

The Effect of Dead Wood on Mite Biodiversity in Quebec's Boreal Forest

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Fallen dead wood or downed woody material (DWM) accumulating on the forest floor provides habitat with high heterogeneity and structural complexity (Figure 13), which has the potential to support a large number of forest arthropod species. The abundance and distribution of many species that depend on decaying wood (i.e., saproxylic species) are reduced in managed forests because the DWM is removed, which may in turn influence decomposition and other soil processes. Ecosystem-based management, such as partial-cut harvesting, allows elements of the natural forest structure such as DWM to be maintained in managed forest, and several studies have shown that retention of DWM during harvesting may increase the biodiversity of arthropods, including microarthropods, on the forest floor. Oribatid mites constitute the most abundant taxon in decaying wood and contribute greatly to decomposition in DWM by fragmenting organic matter and stimulating microbial growth. Despite the importance of these mites for the decomposition of wood and the subsequent implications for many forest soil processes, patterns of their abundance, species richness, and composition in DWM at any stage of decay are not well known. The objective of this study was to examine how the presence of decomposing logs influences the vertical and horizontal distribution of oribatid mite assemblages on the forest floor in an aspen-dominated boreal mixedwood forest in northwestern Quebec.

In June 2006, the arthropod populations associated with each of six logs classified as decay class III–IV (ellipsoid shape, moss coverage 50%–80%, <50% bark) were sampled at three distances: directly on top of the log (ON), directly beside the log (ADJ), and at least 1 m away from the log and other fallen wood (AWAY). ON samples consisted of a litter-layer sample, an upper-wood sample (i.e., upper portion of log), and an inner-wood sample (i.e., loose woody material not connected to the outer wall of the log). ADJ and AWAY samples consisted of litter and soil samples. Samples were extracted with Tullgren funnels, and all adult oribatid mites were enumerated and identified to species or morphospecies.

More than 15 000 individual oribatids in more than 75 species were collected, although *Oppiella nova* (Oudemans, 1902) was the most abundant species in all layers. In litter, the highest species richness was found on logs (ON samples), and wood had greater species diversity than soil. Additionally, each layer of ON samples (i.e., litter, wood, and soil) exhibited a unique composition of mite species. Although the relative abundance of mites in ADJ and AWAY samples was not significantly different from that in ON samples, several species showed changes in abundance with increasing distance from the DWM. These results indicate that DWM such as logs increase the biodiversity of oribatid mites on the forest floor in boreal mixedwood forest.

DWM provides a critical resource for oribatids on the forest floor, and preservation of structural elements such as DWM will benefit oribatid biodiversity. In turn, the maintenance of oribatid biodiversity in managed forests may help to maintain key ecosystem processes such as decomposition and nutrient cycling. Oribatid mites offer a unique perspective for ecological work and great potential for the study of species with low dispersal abilities, particularly in association with specific habitats like DWM.



Figure 13. Downed woody debris on forest floor (photo by A. Dechene).

Effects of Variable-Retention Harvesting of Mixedwood Forests on Ground-Dwelling Spider Assemblages in the Boreal Forest

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Forest harvesting is one of the main resource extraction activities in Alberta, and many different management recommendations are being implemented to maintain biodiversity in the harvested landscapes. Some of the most common sustainable harvesting practices include protection of key habitats and retention of dead wood, prescribed burning, variable retention, single-tree retention, and aggregated retention. In addition, more sustainable harvesting operations are being implemented, with a shift from large clear-cuts to the practice of retaining 10%–20% standing trees on the landscape after harvesting. One important challenge is ascertaining the best way to distribute the retained trees (dispersed or clumped) to maintain overall biodiversity and ecosystem function. My research explores this issue by focusing on the effects of variable-retention harvesting on ground-dwelling spider assemblages. One of the main goals is to establish the function of retained patches as species refuges and to generate information that will allow an assessment of spider species as bioindicators of forest recovery.

The project is taking place in the boreal forest at the Ecosystem Management Emulating Natural Disturbance

(EMEND) site in northwestern Alberta. Spiders were collected in pitfall traps during the ice-free season of 2006. The spiders were sampled in areas with both clumped and dispersed retention (Figure 14) in deciduous (*Populus* spp.) and conifer (mainly *Picea*) stands. Uncut controls, clear-cuts, and stands with 10% and 75% retention were sampled.

A total of 9 234 adult spiders representing 15 families and 153 species were collected. Initial analysis suggests a clear effect of harvesting method and retention type on observed richness and abundance of spider species. Areas of high disturbance (clear-cuts and 10% retention) tended to have lower species richness but higher species abundance. Also, clumped retention was associated with higher species richness than dispersed retention, with the species composition of the former most similar to that of uncut control plots.

These preliminary results suggest the importance of retaining patches of trees (i.e., clumped retention) after harvest. Such patches seem to maintain some of the structural features and microhabitats found in undisturbed areas, thereby functioning as biological “lifeboats.”



Figure 14. Clumped and dispersed retention of *Populus* in a harvested stand (photo by J. Pinzon).

Diversity of Parasitoids (Hymenoptera: Ichneumonidae) in a Boreal Forest Ecosystem

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In recent years, there has been a shift in management goals for boreal forests. Instead of simply considering such forests as a source of timber, there is an increasing emphasis on intrinsic forest values, such as biodiversity. One harvesting technique that is rapidly gaining popularity is to emulate natural disturbances, such as fire, windthrow, or insect outbreaks. However, the relationship of these methods to biodiversity conservation remains hypothetical, and studies are needed to determine whether they are in fact capable of preserving biodiversity and ecosystem processes.

Because of their abundance and diversity and their important ecological roles in forest ecosystems, arthropods are useful for biodiversity studies. However, some of the most species-rich groups of arthropods have not been popular subjects for forest biodiversity studies, largely because taxonomic expertise and identification keys are lacking. These groups nevertheless perform essential ecosystem functions, and their responses to natural and anthropogenic disturbances must be understood if we are to assess the impacts of land-use strategies. One such group is the Ichneumonidae, a large family of parasitic Hymenoptera. The majority of ichneumonid species are solitary endoparasitoids of endopterygote larvae and pupae, particularly among the Lepidoptera and Symphyta. As such, they play a large role in regulating potential pest species and in maintaining the equilibrium of ecosystems in general. Because of their highly specialized life histories, they may also be particularly vulnerable to ecological disturbances. Nonetheless, they are rarely included in biodiversity or forest management studies, primarily because of difficulties of identification.

Throughout the summer of 2007, I used malaise traps (Figure 15) and sweep-netting to sample Ichneumonidae in a variety of boreal habitats throughout Alberta, with an emphasis on the Ecosystem Management Emulating Natural Disturbance (EMEND) research site, near Peace River, Alberta. These specimens (from at least 15 subfamilies) will be used to form a preliminary species list for the area, which will aid in assessing the impact of forestry on the ichneumonid community. I am performing a comparative community study at the EMEND site, using two malaise traps in each of two replicates of three different treatments (uncut, partial cut, and clear-cut). This will be among the first studies in North America to examine the response of the ichneumonid community to forest disturbance.



Figure 15. Malaise trap for sampling parasitic Hymenoptera (photo by M. Schwarzfeld).

One of the major obstacles to using Ichneumonidae in biodiversity studies is the lack of user-friendly identification keys or, for many groups, the lack of any keys at all. Interactive matrix-based keys have many advantages over traditional dichotomous keys, including the ability to quickly rule out certain taxa, to choose the order in which characters are examined, and to easily expand the key with new taxa. I will use Lucid software (Centre for Biological Information Technology, Brisbane, Australia) to create an interactive key to the most common ichneumonids of Alberta's boreal forest and thus to encourage further studies on this fascinating and ecologically important group of insects.



Ongoing Survey Initiatives in Canadian National Parks

In the wake of two successful Biological Survey of Canada (BSC) Bio-Blitzes, in Waterton Lakes National Park (2005) and Gros Morne National Park (2006), research permits have been obtained by the Canadian Forest Service and the BSC to engage in long-term arthropod surveys of both parks. The purpose of these surveys is to assess the composition, distribution, and habitat affinities of all arthropods and gastropods in both parks, thereby establishing a "biodiversity baseline" against which Parks Canada can assess progress in maintaining the ecological integrity of these parks. We invite scientists in Canada and abroad to help in cataloging the arthropod and gastropod species in these parks. To participate, please contact

the principal investigator, David Langor (dlangor@nrcan.gc.ca; +1-780-435-7330). Participants will be given a copy of the relevant permit. Participation requires that (1) vouchers of all species are placed in publicly accessible collections in Canada, (2) all species and locality data are submitted to the relevant databases within a reasonable period of time, (3) unwanted by-catch is provided to the principal investigator for dissemination to other interested scientists, and (4) other park-specific requirements articulated in the permit are met. Please consider participating in surveys of these diverse and beautiful parts of Canada.

Siricidae Needed

Henri Goulet (Agriculture and Agri-Food Canada, Ottawa, ON), Dave Smith (USDA, Washington, DC), and Nathan Schiff (USDA, Stoneville, MS) are doing a revision of the New World Siricidae. As part of this project, Henri is photographing live specimens of Siricidae and their parasites. He has images of *Sirex nigricornis*, *S. edwardsi*, *S. noctilio*, *Ibalia* spp., and *Rhyssa* spp. He would greatly appreciate help in getting live

specimens of *Xeris* (any species), *Urocerus* (any species), and other species of *Sirex* from anywhere. He would especially appreciate receiving specimens (preserved in 95% alcohol) of *Sirex cyaneus* from *Abies balsamea* (especially in the west) and *Xeris tarsalis* (difficult to find but possible in southwestern British Columbia).

Arthropods of Newfoundland and Labrador

One of the BSC's current initiatives is the Terrestrial Arthropods of Newfoundland and Labrador project. The goal of this project is to survey the province's arthropod fauna and make data accessible in the form of catalogs and databases. Illustrated keys to species will be developed for as many groups as possible. This project is being coordinated by David Langor and David Larson, but there are many participants. For more details, please consult the following web page: <http://www.biology.ualberta.ca/bsc/english/nfld.htm>.

Although collections are being made regularly in Newfoundland and Labrador as part of this project, we realize that many other collectors have sampled the fauna of the province over the past few decades and are continuing to do so. Many of these specimens have found their way into major Canadian collections (e.g., the Canadian National Collection of Insects) and have since been rediscovered and entered into the project database. However, many collectors pin and label only a portion of their collection (i.e., the taxa of most interest to them), with the "residual" material remaining in alcohol and placed in storage. Such residual material

usually contains many valuable specimens, including new provincial records and even new species. In addition, many pinned specimens remain in personal collections or smaller institutional collections and therefore remain unknown to those interested in the fauna.

The participants in this project are interested in discovering the locations of valuable material (pinned, papered, wet, or residual) that might be examined. If you have pinned or wet material from Newfoundland and Labrador in your collection, we would be grateful to hear from you and may be interested in borrowing it. If you have residual material, we would be pleased to accept it for preparation, labeling, and identification of specimens. If you are planning collecting trips to Newfoundland and Labrador in the future, please let us know, so that we can stay abreast of faunal surveys of the province. We will reimburse any shipping costs for material that you send to us.

Please contact David Langor at dlangor@nrcan.gc.ca or 780-435-7330.



NEW PUBLICATIONS

The following publications are as of February 2008

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- Huber, J.T.; Baquero, E. 2007. Review of *Eustochus*, a rarely collected genus of Mymaridae (Hymenoptera). *J. Entomol. Soc. Ont.* 138:3–31.
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- Lopardo, L.; Dupérré, N.; Paquin, P. 2008. Expanding horizons. The first report of the genus *Mysmena* (Araneae, Mysmenidae) from continental North America, with the description of a new species. *Zootaxa* 1718:36–44.
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- Majka, C.G. 2007. The Ciidae (Coleoptera: Tenebrionoidea) of the Maritime provinces of Canada: new records, distribution, zoogeography, and observations on beetle–fungi relationships in saproxylic environments. *Zootaxa* 1654:1–20.
- Majka, C.G. 2007. The Derodontidae, Dermestidae, Bostrichidae, and Anobiidae of the Maritime provinces of Canada (Coleoptera: Bostrichiformia). *Zootaxa* 1573:1–38.
- Majka, C.G. 2007. The Erotylidae and Endomychidae (Coleoptera: Cucujoidea) of the Maritime provinces of Canada: new records, zoogeography, and observations on beetle–fungi relationships and forest health. *Zootaxa* 1546:39–50.
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