COMPARISON OF SAPROXYLIC BEETLE (COLEOPTERA) ASSEMBLAGES IN UPLAND HARDWOOD AND BOTTOMLAND HARDWOOD FORESTS

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Abstract—Insects dependent upon dead wood, wood-decaying fungi, or other organisms within dead wood for some portion of their life cycle have been termed saproxylic. Beetles comprise a large component of the saproxylic fauna within forests and play vital roles in the initial fragmentation and breakdown of dead woody debris. To evaluate the influence of forest type on saproxylic beetle assemblages, we surveyed upland and bottomland hardwood stands in east-central Mississippi. Overall, the two forest types shared a number of similarities in terms of their saproxylic beetle faunas. However, ecological differences between these two forest types were evident, most notably in diversity and abundance of beetle species dependent upon wood-decaying fungi.

INTRODUCTION

Dead, decaying wood is known to play a number of important roles in terrestrial ecosystems from nutrient cycling, moisture retention, to habitat complexity (Harmon and others 1986). Due to involvement in such diverse ecological functions and processes, dead wood has been recognized as an important forest resource (Stevens 1997). With this recognition, has come a growing awareness of the contribution dead wood makes to forest biodiversity (Lofroth 1998).

Of the various organisms that make use of dead wood, insects represent one of the most species-rich and abundant components (Hanula 1996). Some insects spend the majority of their life cycle living within, and feeding on, dead wood. Once dead wood is fragmented by wood-boring species, other insects enter, feeding on the decaying wood or the hyphae of wood-decaying fungi. These species, in turn, represent prey for a variety of predaceous insect species.

Speight (1989) termed insect species dependent upon dead wood, wood-decaying fungi, or other organisms within dead wood for some portion of their life cycle as saproxylic. Saproxylic insects represent a fundamental component of most forest ecosystems, playing vital roles in the initial fragmentation and breakdown of dead woody debris (Ausmus 1977, Edmonds and Eglitis 1989) as well as comprising a food base for other organisms (Beckwith and Bull 1985).

Saproxylic insects, beetles in particular, have received much attention in Europe as regards their diversity, conservation, and potential to serve as indicators of forest condition (Hågvar and Økland 1997, Nilsson and others 1995, Väisänen and others 1993). A number of European studies have noted variations in saproxylic beetle faunas in relation to forest structure (Barbalat 1998), successional stage (Gutowski 1995), and management practices (Barbalat 1996).

Outside of insects considered to be pests of wood products, little base-line information exists regarding species composition and status of saproxylic insects in forests of the southeastern U.S. Though little studied, there has been a call for additional research concerning the role dead wood plays in the maintenance of southern forest biodiversity (McMinn and Crossley 1996). Basic assemblage-level data concerning the community composition and structure of saproxylic species within different forest types, and across successional stages, could provide a standard by which disturbances, human-induced or natural, could be evaluated (Kaila and others 1997). In that light, our objective in this study was to compare and characterize the saproxylic beetle assemblages of upland and bottomland hardwood forests. Both upland and bottomland hardwood forests are characterized by significant ecological differences in moisture, tree species composition, and site conditions. Such factors may play important roles in shaping the saproxylic beetle fauna of both forest types.

STUDY SITES

This study was conducted at the Noxubee National Wildlife Refuge in east-central Mississippi (Noxubee County). Study sites were established in two upland hardwood and two bottomland hardwood stands on the refuge. Dominant tree species in both upland hardwood stands included white oak (*Quercus alba* L.), mockernut hickory (*Carya tomentosa* (Poir.)), and black oak (*Q. velutina* (Ell.)). A number of large shortleaf pine (*Pinus echinata* (Mill.)) occurred in one of the upland hardwood stands. Dominant tree species in the bottomland hardwood stands included willow oak (*Q. phellos* L.), cherrybark oak (*Q. falcata* var. *pagodifolia* Ell.), red maple (*Acer rubrum* L.), and American sweetgum (*Liquidambar styraciflua* L.). The bottomland hardwood stands occurred along the floodplain of the Noxubee River and flooded for four to six days in early April 2000 when the Noxubee River overflowed its banks. All four stands used as study sites ranged in age from 45 to 60 years of age.

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MATERIALS AND METHODS

Insect Sampling Protocol

Saproxylic beetles were sampled using Malaise traps and window traps (flight-intercept traps). Malaise traps are large tent-like structures that passively trap low-flying insects and collect them in a container filled with a preservative/killing agent. Collecting containers were filled with 70 percent ethanol. One Malaise trap was placed in each upland hardwood and bottomland hardwood stand.

Window traps were also deployed at each study site. Window traps, modified from Økland (1996), consisted of two perpendicular clear plastic sheets (35 cm x 40 cm) attached to a collecting container (33 cm diameter). Collecting containers were filled with propylene glycol. A roof was placed on top of the intersecting clear plastic sheets to prevent rainfall from flooding the collecting container. Window traps were hung between two trees at a height of 2 m. A total of six traps, spaced 20 m apart, were operated at each study site.

All traps were operated continuously from May to October 2000. Malaise and window traps were serviced, and collected insects removed, on a biweekly basis. Beetles collected from both trap types were sorted to morphospecies and stored in 70 percent ethanol.

Selection of Target Saproxylic Groups

One obstacle confronting insect-related projects is the overwhelming diversity of species that can be collected (Disney 1986). As an alternative to identifying all insects, assemblages of select species representing different functional groups have been suggested for use as monitoring tools or indicators of environmental change (Kremen and others 1993). Based upon that rationale, we identified target groups for use in our analyses. The groups selected comprised saproxylic beetles representing major functional groups within dead wood. The represented functional groups, and associated beetle taxa, used in our analyses were as follows:

Xylophagous beetles
  Coleoptera: Cerambycidae (longhorned beetles)

Predaceous beetles:
  Coleoptera: Cleridae (checkered beetles)

Fungivorous beetles:
  Coleoptera: Erotylidae (pleasing fungus beetles)

Longhorned beetles include a number of species that feed as larvae within trees and shrubs. A small number of species feed on healthy hosts, however, most species feed on dead, decaying wood (Yanega 1996). Most checkered beetles feed on the larvae of wood-boring beetles (Cerambycidae, Scolytidae) as both larvae and adults. Pleasing fungus beetles are a group of mostly fungivorous species, many of which feed on wood-decaying fungi.

Data Analysis

Species diversity between sites was evaluated using rarefaction (Simberloff 1972). Rarefaction estimates the number of species in a random subsample to the entire sample. The resulting value can then be interpreted as a measure of diversity because the technique takes into account both species richness and abundance. The main advantage of using rarefaction is that it is independent of sample size. Abundances of target taxa were compared between upland and bottomland hardwood stands using t-tests. Similarities in faunal composition among study sites were assessed using the Morisita-Horn index. The Morisita-Horn index was chosen because sample size and diversity of the sample have little influence on its calculation (Morisita 1959, Wolda 1981). Distribution of numbers of species and individuals representing each functional group (xylophagous, predaceous, fungivorous) were compared among upland hardwood and bottomland hardwood stands using a Chi-square test.

RESULTS AND DISCUSSION

Saproxylic Beetle Diversity and Abundance

Overall, a total of 56 saproxylic beetle species were collected from the bottomland hardwood study sites and a total of 48 species from the upland hardwood sites. Species diversity, as measured by rarefaction, varied between the forest types for two of our three target saproxylic groups (fig. 1). For longhorned beetles, predicted diversity was slightly higher in the bottomland hardwood stands than in the upland hardwood sites. Species diversity of pleasing fungus beetles

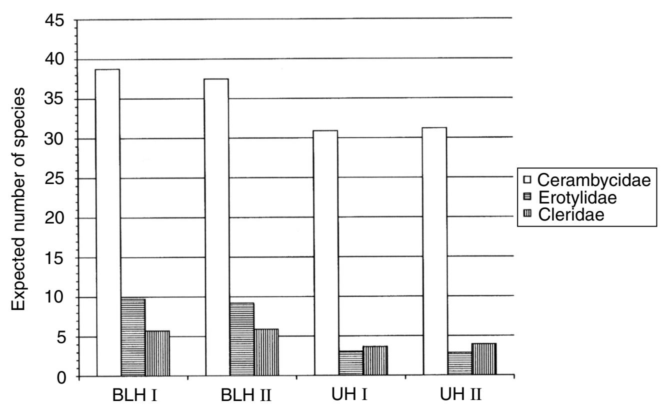

Figure 1—Species richness of target saproxylic beetle groups, as estimated by rarefaction, in upland and bottomland hardwood study sites.

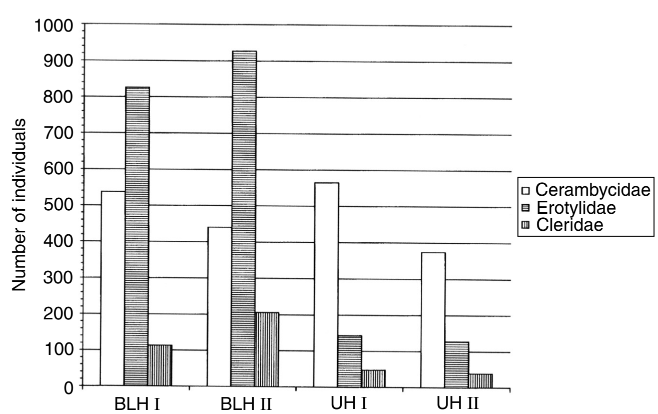

Figure 2—Abundances of target saproxylic beetle groups in upland and bottomland hardwood study sites.

was considerably higher in bottomland hardwood stands, reflecting the presence of a number of species not present in the upland hardwood sites. Checkered beetle species diversity was relatively equitable across all four study sites. Abundances of longhorned beetles were found to be relatively similar (t=-0.36, df=145, P=0.3597) in bottomland hardwood and upland hardwood forests (fig. 2). Conversely, pleasing fungus beetle (t=1.71, df=29, P=0.0489) and checkered beetle (t=1.75, df=21, P=0.04735) abundances varied significantly in relation to forest type, with larger numbers of both groups present in bottomland hardwood forests.

Comparisons of saproxylic beetle assemblages between stands of the same forest type displayed relatively high degrees of complementarity. The Morisita-Horn value calculated for saproxylic beetle assemblages from the two bottomland hardwood sites indicated a high level of similarity at 0.92. A similar level of congruence was found to exist between the two upland hardwood sites as well (0.91). Comparisons between upland hardwood and bottomland hardwood forest types yielded lower values (BLHI/UHI=0.77, BLHI/UHII=0.75; BLHII/UHI=0.72, BLHII/UHII=0.68), indicating a lesser degree of similarity in saproxylic beetle species composition. Analysis of numbers of species representing each functional group revealed no major differences among the four study sites (χ^2=2.29, df=6, P=0.8912). Differences were noted when abundances of each functional group were compared across study sites. Upland hardwood stands were characterized by significantly lower numbers of individuals from predaceous and fungivorous functional groups (χ^2=672.80, df=6, P=<0.001). Numbers of xylophagous individuals did not differ across the four study sites.

Of the three target groups, longhorned beetles exhibited the smallest amount of variation between the two forest types. The most commonly collected longhorned beetle species from both forest types included *Strangalia luteicornis* (Fabricius), *Neoclytus acuminatus* (Fabricius), *S. bicolor* (Swederus), and *Elaphidion mucronatum* (Say). *Strangalia luteicornis*, and *S. bicolor* are known to feed on decaying hardwoods. *Neoclytus acuminatus* is known to prefer recently dead, as well as weakened and dying hardwoods. *Elaphidion mucronatum* feed primarily on the branches of dead hardwoods.

Although both upland hardwood and bottomland hardwood forests contained different tree species, larval host preference did not seem so specific as to limit large numbers of longhorned beetle species to one forest type. Many of the longhorned beetles collected possess relatively broad larval host preferences in terms of hardwood trees, with individual species known to feed on a range of hickory (*Carya*), oak (*Quercus*), elm (*Ulmus*), and/or ash (*Fraxinus*) species. Notwithstanding that, both forest types did contain species either trapped only within a specific forest type or characterized by higher abundances in one forest type. For instance, *Orthosoma brunneum* (Forster) occurred in larger numbers in bottomland hardwood stands than in upland hardwood stands. This species is known to prefer well-decayed wood in moist conditions. Higher numbers within a moist, flood-prone forest type is understandable. Likewise, *Parandra polita* Say were only collected from upland hardwood stands. The larvae of *P. polita* feed on the heartwood of hickory and beech, tree species common in our upland hardwood study sites. The pine component of one upland hardwood stand was also evident in the presence of *Prionus pocularis* Dalmeister, a species known to feed on dead pine logs, and *Typocerus zebra* (Olivier), a species that mines dead pine roots.

Checkered beetles exhibited some variation between upland and bottomland hardwood forests. Although number of species did not differ significantly between the two forest types, numbers of individuals did. This difference was largely attributable to much larger numbers of *Enoclerus ichneumoneus* (Faricius) in the bottomland hardwood stands than in the upland hardwood stands. *Enoclerus inchneumoneus* is a checkered beetle known to feed on a variety of wood-boring beetle larvae, particularly those under the bark of hardwood trees.

Although upland and bottomland hardwood stands could not be strictly differentiated based upon longhorned beetle and checkered beetle species composition, they could based upon trap collections of pleasing fungus beetles. Both species composition and abundance of pleasing fungus beetles differed between the two forest types. Upland hardwood stands contained only four of the 10 species collected in the bottomland hardwood stands. The most commonly collected species from both forest types were *Tritoma biguttata* (Say) and *T. thoracica* (Fabricius). Both species were collected in numbers four to seven times higher in bottomland hardwood stands than in upland hardwood stands. Species only collected from bottomland hardwood stands included *Ischyrus quadripunctatus* (Olivier), *Megalodacne heros* (Say), *T. pulchra* (Say), and *T. punticeps* (Fabricius). These beetles are all known to feed on the fruiting bodies of fungi. *Megalodacne heros*, for instance, feeds on bracket fungi (*Ganoderma* spp.), while the various *Tritoma* and *Triplax* species feed on gilled fungi (*Amanita* spp., *Polyporus* spp.). Upland hardwood stands were largely characterized by a lack of these beetle species. Upland stands were also characterized by lower numbers of pleasing fungus beetles (406), when compared to bottomland stands (2024).

The pleasing fungus beetle fauna of bottomland hardwood stands is likely a reflection of the mesic conditions of these forests. Although we did not quantify number of fruiting bodies, the supposition can be made that the warm, humid conditions of bottomland hardwood forests may be more conducive to fungal growth and development than the drier conditions found in upland sites. Availability of wood-decaying fungi has been demonstrated to be an important factor affecting the diversity of saproxylic beetles in Europe (Økland and others 1996). Quantification of wood-decaying fungi fruiting bodies, in relation to pleasing fungus beetle diversity and abundance, could aid in elucidating any similar relationships in forests of the southeastern U.S.

CONCLUSIONS

Pleasing fungus beetles represent a saproxylic group that could be potentially sensitive to changes in forest condition, particularly as it pertains to suitable levels of moisture for fungal growth and availability of dead wood for wood-decaying fungi. These beetles are easily sampled with Malaise traps (Goodrich 1997) and relatively easy to identify. Their use as potential indicators seems especially appropriate for mesic forest types, such as bottomland hardwood stands, where they may be more diverse and abundant. Overall, longhorned beetles and checkered beetles did not appear to be a defining group in terms of either forest type. However, longhorned beetles have been shown to respond to changes in forest condition brought about by certain silvicultural practices (Warriner and others 2002). In that sense, they represent a potentially useful group when evaluating the impact forest management practices have upon dead wood resources within a stand.

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