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Abstract

Within the Lower Mississippi Alluvial Valley (LMAV), some lands cleared of bottomland hardwood forests have the potential to return to forest as a result of private sector and government interests in *Populus* cultivation. Specifically, monoculture plantings of eastern cottonwood (*Populus deltoides* Bartr.) represent an important component of many recent afforestation efforts in the region. The impact establishment of such monocultures will have on native insect communities in the LMAV is relatively unknown. To evaluate this, beetle (Coleoptera) diversity, abundance, and functional distribution were examined within an intensively managed eastern cottonwood plantation and nearby bottomland hardwood forest in southeastern Arkansas. Beetles were sampled in both settings over the summer of 2000 using Malaise traps. When compared to the heterogeneous bottomland hardwood forest, the beetle morphospecies assemblage collected from the plantation was one characterized by lower species diversity and a depauperate xylophagous and fungivorous beetle fauna. Over half of all beetles trapped in the eastern cottonwood plantation were species considered to be economic pests of *Populus*.

Introduction

The Lower Mississippi Alluvial Valley (LMAV) has undergone widespread deforestation as a result of clearing for agriculture, resulting in a loss of approximately 75% of the original forested wetlands that once occurred across this region (Stanturf et al., 2000). As a result of agricultural conversion, lands once covered by bottomland hardwood forests are now used to produce such crops as cotton and soybeans. However, some of this land has the potential to return to forest through developing private sector interest in the production of alternative timber/wood fiber resources and federal incentive programs (Wetlands Reserve Program) to restore bottomland hardwood forests (Stanturf and Portwood, 1999; Stanturf et al., 2000). Although seemingly divergent, both ventures share an intertwined interest in the cultivation of eastern cottonwood (*Populus deltoides* Bartr.).

Recently, economic interest has developed in the southern U.S. for fast growing tree species, such as eastern cottonwood, that can be intensively managed in monoculture settings (plantations, fiber farms) to produce a short rotation woody crop (Stanturf et al., 1998). Eastern cottonwood is the fastest growing commercial forest tree native to North America, with average rotations of only six to 12 years, and is well suited for use as a harvestable resource on former cropland in the LMAV (Stanturf and Portwood, 1999). Uses of eastern cottonwood range from fiber (pulp and paper), biomass energy, to carbon sequestration. Currently, several timber companies have established short rotation woody crop programs and pilot projects in areas across the south.

Plantings of eastern cottonwood have also been recognized as potentially effective tools in the afforestation of bottomland hardwood forests on marginal agricultural land (Stanturf et al., 2000). Traditional bottomland hardwood forest restoration has relied upon single species plantings of heavy-seeded oak based on the idea that light-seeded tree species would later colonize the plantation, enhance diversity, and provide suitable habitat for wildlife (King and Keeland, 1999). Research indicates that development of forest structure under such a system takes a long time (Twedt et al., 1999); colonization by other plant species is often unreliable (Allen, 1997); and opportunities to manipulate the developing stand are limited (Stanturf et al., 2000). In contrast, fast growing plantations of eastern cottonwood, interplanted with oak seedlings, have been shown to provide the forest structure required by some species much more rapidly than oak plantings alone (Twedt and Portwood, 1997).

Establishment of eastern cottonwood plantations on former agricultural lands does have the potential to provide habitat for a range of plant and animal species. Although plantations may provide more favorable habitat conditions for some species than cropland, studies have indicated that

eastern cottonwood plantations represent lower quality habitat when compared to natural bottomland hardwood forests (Christian et al., 1998; Twedt et al., 1999). As eastern cottonwood plantations may become a more common component of the LMAV landscape, studies need to be conducted to determine what other taxa might utilize these "new forests."

Terrestrial insects represent a fundamental, but understudied, component of the LMAV ecosystem. Insects are tied to a diverse array of microhabitats, are known to play a number of important roles (pollination, nutrient cycling) in forest systems (Janzen, 1987; Packham et al., 1992), and represent a vital food base for other organisms (Greenberg and McGrane, 1996). Excluding a few pest species, little research has been conducted regarding how land use and management affect terrestrial insect species diversity and abundance in the LMAV.

Although additional research concerning insects is needed within this region, there are obstacles to this kind of work. One such obstacle is the often overwhelming diversity of insect species that can be collected, making timely, cost effective processing and identification difficult (Disney, 1986). As an alternative to sampling all insect species, assemblages of select species representing different ecological or functional roles have been suggested for use as monitoring tools or indicators of habitat change (Kremen et al., 1993). Beetles (Coleoptera), in particular, are considered well suited for such uses as they display a wide range of functional roles (herbivores, predators, fungivores), are easily sampled through a variety of trapping methods, and good taxonomic information exists for many families (Hutcheson and Jones, 1999). In that light, the objective of this study was to compare the species diversity, abundance, and functional composition of beetles inhabiting an intensively managed eastern cottonwood plantation and adjacent bottomland hardwood forest in southeastern Arkansas.

Materials and Methods

Study Site.--This study was conducted from April to October 2000 on Choctaw Island, just west of Arkansas City, Arkansas (Desha County), along the flood-prone batture lands of the LMAV. A large, intensively managed eastern cottonwood plantation and nearby secondary bottomland hardwood forest on the island served as study sites. The plantation was established early in 1998 (February) on land previously used to produce soybeans. Eastern cottonwood cuttings, planted in rows on 3.6 x 3.6 meter spacing, were used to establish the plantation. During the summers of 1998 and 1999, workers disced and mowed between rows of trees to reduce the shading effects of competing vegetation. The plantation also received infrequent aerial applications of insecticide in an effort to control populations of the cottonwood leaf beetle (*Chrysomela scripta* F.), a major economic pest of *Populus* (Morris et al., 1975).

During the winter of 1999, the plantation was interplanted with oak seedlings in conjunction with a National Resources Conservation Service pilot project examining the feasibility of incorporating eastern cottonwood into bottomland hardwood afforestation efforts. Oak seedlings were planted along every other row of the plantation. Discing and mowing were discontinued in 2000.

At the time the study was conducted, the plantation was in its third growing season and contained trees ranging in height from 4 to 6 m. Other than eastern cottonwood and oak seedlings, vegetation within the plantation consisted mainly of trumpet creeper (*Campsis radicans* (L.) Seeman), passionflower (*Passiflora incarnata* L.) vines, and Johnson grass (*Sorghum halepense* (L.) Pers.). A mature bottomland hardwood forest, dominated by willow oak (*Quercus phellos* L.), cherrybark oak (*Q. falcata* Michaux), American sweetgum (*Liquidambar styraciflua* L.), sugarberry (*Celtis laevigata* Willd.), and red maple (*Acer rubrum* L.), adjacent to the plantation was also sampled.

Insect Sampling and Analyses.--Beetle sampling was conducted using Malaise traps. Malaise traps are tent-like structures that passively trap insects and funnel them up into a collecting head filled with a killing agent (Townes, 1972). Samples of Malaise trapped beetles have been shown to be characteristic of recognizable communities and strongly related to habitat variables up to 50 m from traps (Hutcheson, 1990; Hutcheson and Jones, 1999). Two Malaise traps, spaced 100 m apart, were placed in the plantation and forest. Malaise traps were placed at least 50 m into each site. Collecting containers were filled with 75% ethanol mixed with a small amount of ethylene glycol to reduce evaporation of the ethanol. All traps were operated continuously from April to October. Insects were removed from traps every two weeks. All beetles collected were identified to family and sorted to morphospecies. To compare beetle trophic structure, collected morphospecies were assigned to one of five functional groups: (1) predaceous, (2) herbivorous, (3) fungivorous, (4) xylophagous, or (5) omnivorous.

Beetle morphospecies diversity was evaluated using rarefaction. Rarefaction estimates the number of species in a random subsample to the entire sample (Simberloff 1972). The resulting value can then be interpreted as a measure of diversity because the technique takes into account both species richness and abundance (Niemelä et al., 1993; Spence et al., 1997). Over the course of our study, trap contents from both sites were lost at certain sampling periods due to vandalism and high winds. Rarefaction was used as it compensates for sampling errors and uneven catch

Table 1. Beetle families and number of morphospecies collected from an eastern cottonwood plantation and adjacent bottomland hardwood forest in southeastern Arkansas.

Family	Number of Morphospecies	
	Forest	Plantation
Staphylinidae (Rove beetles)	16	2
Cerambycidae (Long-horned beetles)	15	7
Elateridae (Click beetles)	14	9
Chrysomelidae (Leaf beetles)	13	7
Scarabaeidae (Scarab beetles)	13	4
Buprestidae (Metallic woodboring beetles)	7	4
Curculionidae (Snout beetles and true weevils)	7	2
Coccinellidae (Ladybird beetles)	5	9
Erotylidae (Pleasing fungus beetles)	5	0
Mordellidae (Tumbling flower beetles)	4	3
Cleridae (Checkered beetles)	4	1
Lampyridae (Firefly beetles)	3	2
Eucnemidae (False click beetles)	3	0
Bostrichidae (Horned poweder-post beetles)	2	0
Cantharidae (Soldier beetles)	1	1
Cucujidae (Flat bark beetles)	1	0
Melandryidae (False darkling beetles)	1	0
Oedemeridae (Pollen-feeding beetles)	1	0
Pyrochroidae (Fire-colored beetles)	1	0
Total	116	51

size (Simberloff, 1972). Similarities in beetle morphospecies composition between the sites were assessed using the Morisita-Horn index (Morisita, 1959; Wolda, 1981). This index produces a value of one when two samples possess identical faunas and a value of zero for two samples with completely different faunas. The Morisita-Horn index is based upon abundance data, rather than binary data, and therefore performs more effectively than some qualitative indices (Magurran, 1988). The index is also less dependent upon sample size and diversity than other quantitative indices (Wolda, 1981). Species abundance distributions were compared through the use of rank abundance plots (Feinsinger, 2001).

Results and Discussion

A total of 1,941 individuals representing 137 beetle morphospecies was collected from the two sites. Morphospecies representing nineteen beetle families were trapped, with the greatest number collected from the bottomland hardwood forest (Table 1). Staphylinidae, Cerambycidae, Elateridae, Scarabaeidae, and Chrysomelidae dominated trap samples from the bottomland hardwood forest. By comparison, trap samples from the eastern cottonwood plantation contained a less diverse complement of families, mostly dominated by Elateridae, Chrysomelidae, and Cerambycidae. Overall, most families collected from the plantation contained fewer morphospecies than their counterparts in the forest. The exception to this was the Coccinellidae, with trap samples from the plantation containing nearly twice the number of morphospecies as those from the forest.

Species diversity, as estimated by rarefaction, was higher in the bottomland hardwood forest than in the eastern cottonwood plantation (Fig. 1). Very few morphospecies were shared between the two sites, with the forest containing a larger, and more diverse, complement of morphospecies than the plantation, which was characterized by a smaller, but still unique assemblage. Dissimilarity in morphospecies assemblages between the two sites was underscored by the low Morisita-Horn value of 0.33.

Both sites, forest and plantation, also differed in terms of equability of species abundances. Dominance by a single morphospecies in the eastern cottonwood plantation is evident in the rank abundance plots comparing morphospecies abundance distributions (Fig. 2). The plot

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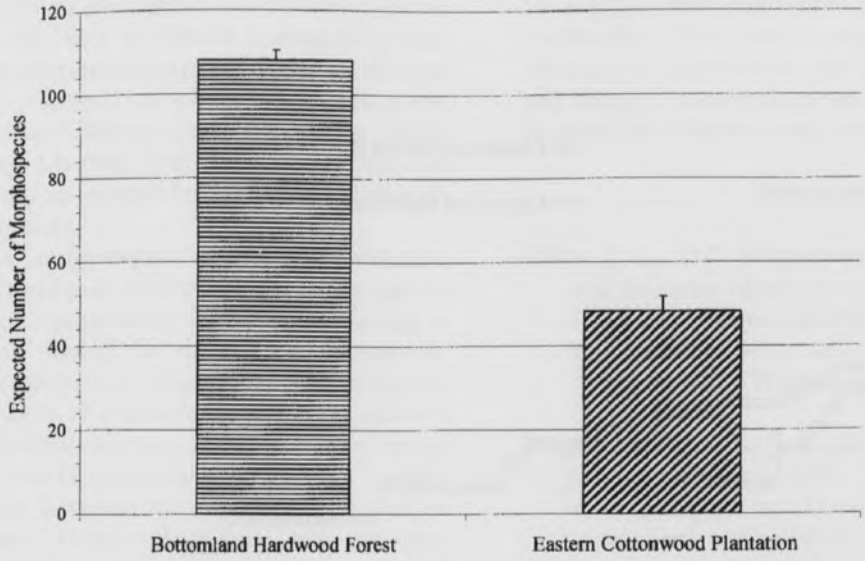

Fig. 1. Beetle morphospecies diversity, as estimated by rarefaction, in an eastern cottonwood plantation and adjacent bottomland hardwood forest.

for the plantation shows a high value at the intersect with the y-axis, indicating dominance by a single species and fewer morphospecies of intermediate abundance. The shallow slope of the forest plot indicates a greater degree of equitability among morphospecies abundance. Plot length further underscores the differences in numbers of morphospecies collected at both sites.

At both sites, predaceous and herbivorous beetles accounted for most of the morphospecies collected in Malaise traps (Table 2). Herbivorous beetles accounted for over 60% of the individuals collected from the plantation site, whereas that functional group only accounted for 38% of the total catch from the forest. Conversely, trap samples from the forest contained larger numbers of xylophagous beetles than samples from the plantation. Fungivorous beetles, although collected from the forest, were absent from plantation trap samples.

Research comparing forest plantations (conifer, broadleaved hardwood) to natural forest has often indicated a trend toward lower species diversity in the plantation setting (Deharveng, 1996; Fahy and Gormally, 1998; Ananthakrishnan, 2000). Herbivorous insects, pest species specifically, also tend to be more abundant in monocultures due to abundant food supplies and fewer natural enemies (Moore et al, 1991; Bragança et al., 1998; Zanuncio, 1998). These broad assertions are applicable to the results we obtained concerning beetle morphospecies diversity and abundance in the eastern cottonwood plantation.

During their first two years, intensively managed eastern cottonwood plantations are managed essentially as field crops. Areas surrounding the trees are cleared of competing vegetation (discing, mowing, herbicides), and outbreaks of insect pests are often treated with applications of insecticide. Based upon our personal observations of a number of plantations (newly planted to harvest age) in Arkansas and Mississippi, these areas tend to remain relatively simple habitats. During the first two to three years, plantations are generally characterized by little canopy cover and an open understory composed of grasses, forbs, and vines. Accumulations of leaf litter and dead woody material are scarce. On most sites, crown closure does not take place until the fourth or fifth growing season. After closure, ground vegetation tends to remain relatively simple. Dead woody material, outside of small diameter branches and the occasional wind-felled tree, is also limited.

Our results, especially those regarding species diversity, appear to be reflective of these structurally simple habitat conditions and are particularly applicable to the early stages of plantation development. Lack of certain habitat features within these plantation settings most likely played an important role in the absence of certain beetles from our trap samples. In particular, beetles known to be associated with dead wood for some portion of their life-cycle either occurred in much smaller numbers in plantation trap

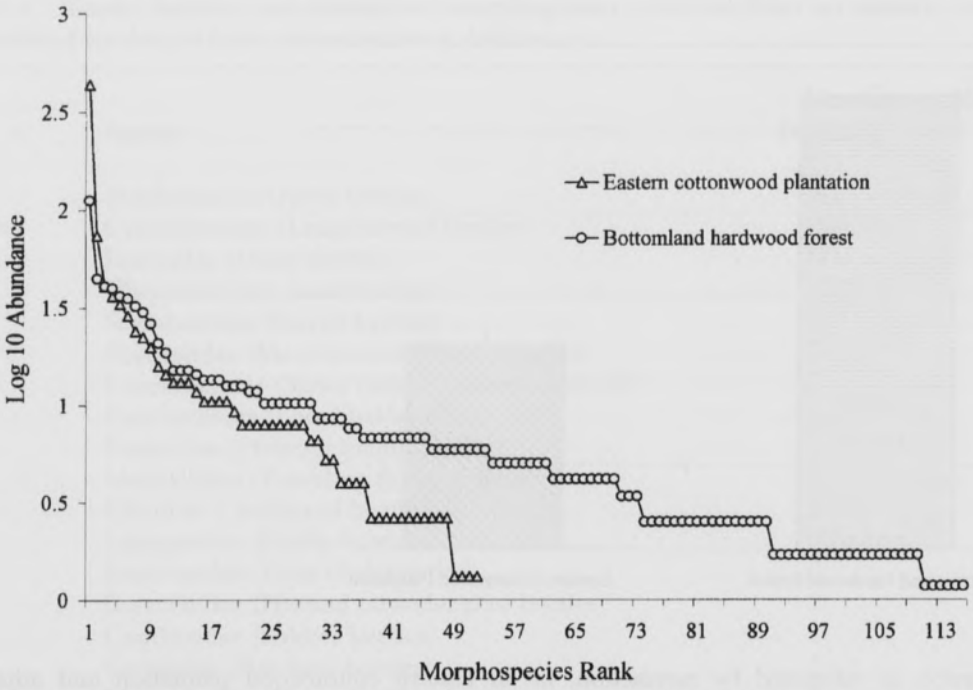

Fig. 2. Rank abundance plots for beetle morphospecies collected from an eastern cottonwood plantation and adjacent bottomland hardwood forest.

Table 2. Number of individuals, representing various trophic roles, collected from an eastern cottonwood plantation and adjacent bottomland hardwood forest in southeastern Arkansas.

Trophic Role	Forest	Plantation
Herbivorous	452 (38.2%)	459 (60.6%)
Predaceous	297 (25.1%)	200 (26.4%)
Xylophagous	283 (23.9%	95 (12.5%)
Fungivorous	125 (10.6%)	0 (0)
Omnivorous	26 (2.2%)	4 (0.5%)
Total	1183 (100.0%)	758 (100.0%)

samples, or were absent altogether. This includes such groups as the Eucnemidae (larvae in rotting wood), Melandryidae (adults and larvae in dry wood), and Oedemeridae (larvae in rotting stumps). Lack of dead wood in the plantation also appeared to have an impact upon those beetles that are known to feed upon wood-decaying fungi. Absent from plantation samples were members of the Erotylidae, many of whose members feed on a range of fungi, from mushrooms to hard bracket fungi (Goodrich and Skelley, 1994).

Since many xylophagous beetle species feed on dead wood, their presence in an area is based to a great extent upon the presence of suitable host material (Martikainen et al., 1999; Martikainen et al., 2000). Consequently, for diversity of these species to be maintained dead woody material, in various stage of decay, must be present. This is a resource that is often lacking in eastern cottonwood plantations, but is present in natural bottomland hardwood forests. Since trees within intensively managed plantations are often harvested after only 10 to 12 years, opportunities for increased loads of dead wood are minimal. In addition, following harvest, little wood often remains on site. Decreased diversity of dead wood associated organisms will potentially represent a long-term feature of intensively managed eastern cottonwood plantations.

Conversely, the homogeneous nature of the eastern cottonwood plantations provided highly suitable habitat for *Populus* pest species. Of the total number of herbivorous beetles trapped in the plantation, 73% were cottonwood leaf beetles. By comparison, trap samples from the bottomland hardwood forest contained twice as many herbivorous beetles, with numbers more equitably distributed among