THE EFFECTS OF THINNING ON BEETLES (COLEOPTERA: CARABIDAE, CERAMBYCIDAE) IN BOTTOMLAND HARDWOOD FORESTS

Michael D. Warriner, T. Evan Nebeker, Theodor D. Leininger, and James S. Meadows[1]

Abstract— The responses of two groups of beetles, ground beetles (Carabidae) and longhorned beetles (Cerambycidae), to a partial cutting technique (thinning) applied to major and minor stream bottom sites in Mississippi were examined. Species diversity of ground beetles and longhorned beetles was greater in thinned stands than unthinned stands two years following thinning. Higher diversity of ground beetles in thinned stands was primarily attributable to the presence of species that prefer open, disturbed conditions. Longhorned beetles that use dead wood as larval host material dominated collections in thinned stands. Although the two beetle groups examined seemed to favor certain habitat conditions brought about by thinning, how other invertebrates (litter fauna, herbivores) respond will require additional investigation.

INTRODUCTION

Terrestrial insects represent an integral component of bottomland hardwood forests yet they have rarely been considered in light of their response to forest management. Insects are known to play a number of important roles (pollination, nutrient cycling, predation) in forest systems and represent a vital food source for other organisms (Janzen 1987; Packham and others. 1992). Although little studied in these settings, insects have the potential to provide a great deal of information regarding bottomland hardwood forests. However, an obstacle confronting many insect-related projects is the overwhelming diversity of species that can be collected (Disney 1986).

As an alternative to sampling all insects, assemblages of select species representing different ecological or functional roles have been suggested for use as monitoring tools or indicators of environmental change (Kremen and others 1993). Beetles (Coleoptera) are considered well suited for such purposes as they display a wide range of functional roles (herbivores, predators, fungivores), are easily sampled through a variety of passive-trapping methods, and good taxonomic information exists for many families (Hutcheson and Jones 1999).

In bottomland hardwood forests, studies evaluating beetles as indicators of environmental change are rare. Most studies conducted thus far have taken the form of faunal surveys (Allen and Thompson 1977; Goff 1952; Grey 1973; Shelford 1954) or examined the influence of natural disturbances on beetles and other terrestrial arthropods (Gorham and others 1996; Uetz and others 1979). In one of the few examples, Thompson and Allen (1993) investigated the response of ground beetles (Carabidae) to different site preparation techniques applied to a clearcut bottomland hardwood stand. In their study, they identified ground beetle species considered to be indicative of disturbed conditions in bottomland hardwood forests.

The objective of this study was to investigate the impact of the partial cutting technique, thinning, on species diversity and abundance of two beetle families in bottomland hardwood forests. Ground beetles were included as one of the target taxa. Ground beetles have generally been regarded as a good group through which to evaluate habitat change (Gardner 1991; Niemelä and others 1993; Thiele 1977). The majority of ground beetle species are predaceous feeding on other invertebrates. Through patterns in their diversity and abundance, ground beetles can provide indirect information regarding the status of their prey and how alterations in habitat conditions affect them (Day and Carthy 1988).

To gauge the impact of thinning from another ecological perspective, longhorned beetles (Cerambycidae) were selected as the second target group. Most longhorned beetle species are xylophagous, feeding on trees, shrubs, and woody vines. While some longhorned beetles feed on healthy woody plants, most species feed on dying or dead woody material, playing important roles in the fragmentation and breakdown of dead wood (Fellin 1980). Due to their dependence upon dead wood, longhorned beetles have the potential to serve as potentially sensitive indicators of forest conditions (Yanega 1996). Evaluation of how both of these groups of beetles respond to the thinning process should provide insight into how their respective habitats are effected, and what that might portend for other members of the bottomland fauna.

[1]Research Associate II and Professor, Department of Entomology and Plant Pathology, Mississippi State University, Mississippi State, MS 39762-9775; Principal Research Plant Pathologist and Principal Silviculturist, USDA Forest Service, Southern Research Station, Stoneville, MS 38776-0227; respectively.

Citation for proceedings: Outcalt, Kenneth W., ed. 2002. Proceedings of the eleventh biennial southern silvicultural research conference. Gen. Tech. Rep. SRS–48. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 622 p.

METHODS

Study Site

This study was conducted in bottomland hardwood stands within major and minor stream bottom sites in Mississippi. The major stream bottom site was located in the Delta National Forest (Sharkey County) in west-central Mississippi. Dominant tree species included sweetgum (*Liquidambar styraciflua*), willow oak (*Quercus phellos*), Nuttall oak (*Q. nuttallii*), sugarberry (*Celtis laevigata*), and various elms (*Ulmus* spp.). Treatments at this site consisted of a commercial thinning applied in 1997 and an unthinned control. The minor stream bottom site was located on private land in Monroe County in northeastern Mississippi. Dominant tree species consisted of willow oak (*Q. phellos*), sweetgum (*L. styraciflua*), and elms (*Ulmus* spp.) Treatments applied at the minor stream bottom site also consisted of a commercially thinning applied in 1997 and an unthinned control. Thinnings applied at both sites removed poorly formed, diseased, and otherwise unmerchantable tree species and favored well-formed sweetgum and oaks to improve quality of the residual stand.

Beetle Sampling

Sampling for ground beetles and longhorned beetles was conducted in 1999, two years post-thinning. Ground beetles were sampled using pitfall traps. Twelve pitfall traps were placed along transects in each thinned and unthinned stand. Individual pitfall traps were placed 10 meters apart and consisted of two 1.8 liter plastic containers. One container was sunk flush with the ground as a liner and the second container placed into it. Traps were filled with 4-6 centimeters of propylene glycol as a preservative and killing agent. A number of holes were punched in the bottom of the second plastic container to serve as a sieve for removal of insects from traps. A 0.1 meter2 wooden roof supported by nails was placed over each pitfall trap to prevent flooding by rainwater. Traps were operated continuously from April to October 1999. Captured ground beetles were removed from pitfall traps every two weeks and stored in vials containing 70 percent ethanol. All collected specimens were identified to species.

Longhorned beetles were sampled using Malaise traps and barrier 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 (Townes 1972). Collecting containers were filled with 70 percent ethanol. One Malaise trap was placed in each thinned and unthinned stand. Traps were oriented in a north-south direction with collecting heads facing south.

Barrier traps, modified from Økland (1996), consisted of two perpendicular clear plastic sheets (35 centimeters x 40 centimeters) attached to a collecting container (33 centimeters in diameter). Collecting containers were filled with 3-5 centimeters of propylene glycol. A clear plastic roof was placed on top of the intersecting sheets to prevent rainfall from entering the collecting container. Individual traps were hung between two trees at a height of approximately 1.5 meters. Five barrier traps were placed in each thinned and unthinned stand with 10 meters between individual traps. Malaise and barrier traps were operated continuously from April to October 1999. Insects from both trap types were collected every two weeks. Longhorned beetles were removed from trap catches, stored in 70 percent ethanol, and identified to species.

To evaluate longhorned beetle activity in thinned and unthinned stands, we determined the larval host preferences of collected species. Species were assigned to one of four host groups; 1) healthy hosts – species feeding on healthy woody plants, 2) weakened/stressed hosts – species feeding on woody plants weakened by disease, injuries, or other causes, 3) dead/decaying hosts – species feeding on downed or standing dead trees and branches in various stages of decay, and 4) unknown hosts – species for which larval host preference is unknown. Host preferences were compiled from Craighead (1923), Hanula (1996), Solomon (1995), and Yanega (1996).

Statistical Analyses

Species diversity of ground beetles and longhorned beetles 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. Numbers of individuals were compared among treatments and study sites using analysis of variance (ANOVA). For longhorned beetles, distribution of numbers of individuals representing each functional group was compared between thinned and unthinned stands (pooled data) using a Chi-square test.

RESULTS AND DISCUSSION

Ground Beetle Diversity and Abundance

Overall, 13 species of ground beetles were collected from the major stream bottom site. Eight species were collected from the minor stream bottom. Species diversity, as estimated by rarefaction in a sample of 50 individuals, was greater for thinned stands than unthinned stands in both major and minor stream bottoms (figure 1). Higher diversity in the thinned stands is mostly reflective of the presence of a number of ground beetles species typical of open, disturbed habitats. The large, predatory ground beetles *Calosoma scrutator* and *Pasimachus punctulatus*, along with *Harpalus pennsylvanisus* were only collected from thinned stands. *Calosoma scrutator* is a species generally found in open hardwood forests, while *P. punctulatus* and *H. pennsylvannicus* are species typical of open, grassy fields.

Thompson and Allen (1993) suggest that finding ground beetles species such as these in bottomland hardwood forests is indicative of disturbance. Presence of these species suggests that the thinning operation did alter habitat conditions in these stands. With the removal of large number of trees, thinned stands are more open than unthinned stands, possessing a sparse understorey. As a result, more sunlight reaches the forest floor, leading to somewhat drier conditions and promoting increased growth of grasses and herbaceous vegetation. There are a number of published examples where disturbances created by silvicultural practices increases ground beetle species diversity by increasing habitat complexity (Beaudry and others 1997; Niemelä and others 1988; Parry and Rodger 1986). In those cases, as well as here, much of that increase is attributable to the colonization or increased activity of species characteristic of open, dry conditions.

However, thinning operations did not appear to effect habitat conditions so severely that species from unthinned stands were restricted from thinned stands. *Brachinus alternans* is a species common in closed-canopy bottom-land hardwood forests and has been considered to be indicative of undisturbed stands (Thompson and Allen 1993). This species was the most commonly collected ground beetle at all sites and was present in larger numbers in thinned stands. In addition, total ground beetle abundance did not differ significantly between thinned and unthinned stands ($F = 1.426$; d.f. = 1,24; $P = 0.2440$). Based on this, the supposition can be made that the thinnings conducted two years prior did not negatively impact populations of the ground beetle species examined.

Longhorned beetle Diversity and Abundance

A total of 17 species of longhorned beetle were collected from the major stream bottom site, while 23 species were collected from the minor stream bottom. Species diversity, as estimated by rarefaction in a sample of 50 individuals, was greater for thinned stands than unthinned stands in both major and minor stream bottoms (figure 2). Unlike ground beetles, abundances of longhorned beetles were significantly higher in the thinned stands ($F = 4.757$; d.f. = 1,46; $P = 0.0343$) than unthinned stands.

All longhorned beetle species collected at both sites feed on woody plant tissue as larvae. When compared to unthinned stands, thinned stands contained significantly higher numbers ($\chi^2 = 26.803$; d.f. = 2; $P = <0.0001$) of species that feed on dead/decaying wood and weakened/dying woody plants (figure 3). Thinned stands also contained fewer numbers of species that feed on healthy hosts. The most commonly trapped longhorned beetle in both thinned and unthinned stands was *Elaphidion mucronatum*. *Elaphidion mucronatum* feeds on the dead branches of a variety of hardwood species and was collected more frequently in thinned stands. Other dead wood feeders present in higher numbers in the thinned stands included *Typocerus zebra*, *Stenosphenus notatus*, *Doraschema cinereum*, and *Enaphalodes atomarius*. Thinning operations at both major and minor stream bottom sites left behind large amounts of logging slash in the form of branches and harvest tops. Such material represents suitable host material for these species, as well as other beetles (Buprestids, Scolytids, Platypodids) that rely on dead wood as food or habitat.

The most commonly collected species feeding on weakened/dying hosts were *Neoclytus acuminatus* and *Xylotrechus colonus*. *Neoclytus acuminatus* feeds on the sapwood of weakened, dying, and recently dead hardwood trees, while *X. colonus* feeds on phloem of a number of hardwood tree species. These species were also collected in unthinned stands but in lower numbers. Higher abundances of these beetles in thinned stands again most likely reflects input of dying and dead woody material from the thinning operation. Higher abundances of these species may also be attributable to damages to the residual stand resulting from logging wounds.

During thinning operations, damage to the residual stand may result. Wounding to the residual trees generally occurs when a harvested tree falls into a residual tree, or when logging equipment causes damage to the residual stems. At the major stream bottom site, logging wounds were especially high in the thinned stand, with 84 percent of the

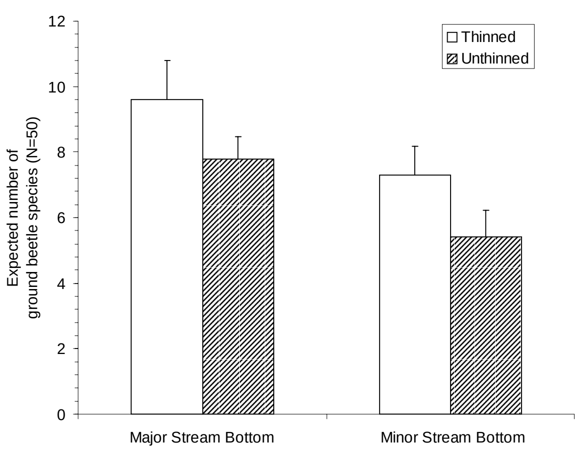

Figure 1—Ground beetle species richness, as estimated by rarefaction, in thinned and unthinned stands at major and minor stream bottom sites in Mississippi.

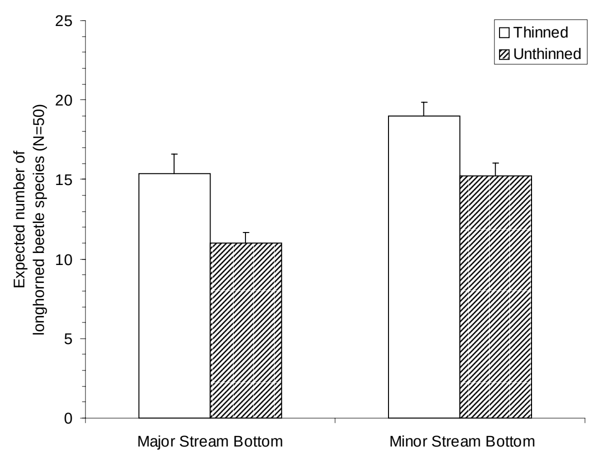

Figure 2—Longhorned beetle species richness, as estimated by rarefaction, in thinned and unthinned stands at major and minor stream bottom sites in Mississippi.

residual stems damaged in some way (Nebeker and others 1999). Wounds to the bole, roots, and branches can provide places for insects to enter and serve as infection courts for pathogens. Post-thinning surveys at this site have since shown that borer wounds have increased in the thinned stand, with many of these occurring on logging wounds (Nebeker and others 1999). In the case of insects, wounded trees are known to release volatile compounds that attract certain wood-boring beetles (Dunn and others 1986). Reduction of logging wounds might be expected to have a concomitant effect on reducing wood-boring beetle activity.

Longhorned beetle species feeding on healthy hosts were few in number. All species collected were twig pruners and borers, such as *Anelaphus parallelus*, *Oberea tripunctata*, and *Psyrassa unicolor*. These species were present in similar numbers in thinned and unthinned stands.

CONCLUSIONS

Both groups of beetles exhibited some response to thinning. Certain ground beetles responded to habitat changes brought about by the thinning process (open, disturbed conditions), whereas longhorned beetles responded to the input of dying and dead wood in the form of logging slash. Intermediate levels of disturbance are thought to enhance species diversity by increasing habitat structural complexity (Connell 1978). In the case of both of these beetle families, species diversity and abundance were increased to some degree. Increased diversity and abundance of these insects could be expected to have ramifications for other faunal groups. Other invertebrates that prefer open, disturbed conditions would also be expected to increase in thinned stands, along with species that use dead wood as habitat or a food source. In addition, those insect species that take advantage of weakened or wounded trees clearly benefit if logging damage to the residual stand is great. With increases in certain insect populations, predators (birds, reptiles) of these groups might also be expected to increase their foraging activity in thinned stands.

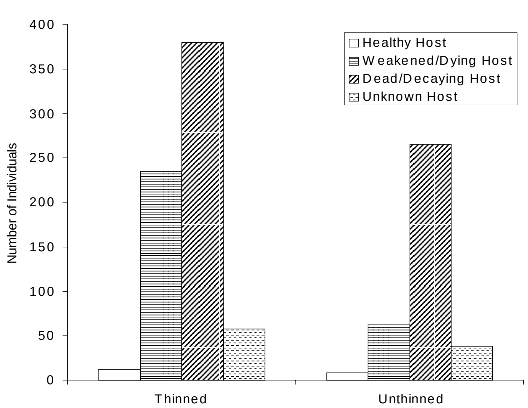

Figure 3—Larval host preferences of longhorned beetles collected in thinned and unthinned stands (pooled data) at major and minor stream bottom sites in Mississippi.

However, how long certain groups can maintain higher abundances is uncertain. Although longhorned beetles were present in higher numbers in the thinned stand, presumably due to the increased amount of host material (dead wood). The majority of dead wood left behind by the thinning operation was not large diameter material, rather it was smaller diameter branches. This material will eventually decay and reach stages where it is no longer useful to many of the longhorned beetles we collected. The thinning operation was designed to improve the quality of the residual stand and therefore diseased and undesirable trees were removed leaving a healthier stand. Those trees that were removed were trees that could have contributed to dead wood volume in the future. Consequently, dead wood input might be expected to be lower in thinned stands than unthinned stands over time. If that is true then longhorned beetle numbers in thinned stands may reach numbers comparable to or lower than unthinned stands.

ACKNOWLEDGMENTS

We are grateful for the cooperation of Larry Moore, District Ranger and Ralph Pearce, Timber Officer of the Delta National Forest in establishing plots and facilitating the thinning. Appreciation is also extended to John Hart for access to the site in northeastern Mississippi. William D. Jones provided a great deal of assistance in collection and processing of insect samples. The contributions of Terry Schiefer of the Mississippi Entomological Museum at Mississippi State University in beetle identification were invaluable. This project was funded in part by the Mississippi Agricultural and Forestry Experiment Station and the U.S. Forest Service, Southern Research Station, Center for Bottomland Hardwoods Research, Southern Hardwoods Laboratory through cooperative agreement no. SRS30-CA-96-061.

REFERENCES

Allen, R.T.; R.G. Thompson. 1977. Faunal composition and seasonal activity of Carabidae (Insecta: Coleoptera) in three different woodland communities in Arkansas. Annals Entomology Society of America. 70(1): 31-34.

Beaudry, S.; L.C. Duchesne; B. Côté. 1997. Short-term effects of three forestry practices on carabid assemblages in a jack pine forest. Canadian Journal of Forest Research. 27: 2065-2071.

Connell, J.H. 1978. Diversity in tropical rainforests and coral reefs. Science. 199: 1302-1310 .

Craighead, F.C. 1923. North American cerambycid larvae. Candada Deptartment of Agriculture Bulletin. 27 p.

Day, K.R.; J. Carthy. 1988. Changes in carabid beetle communities accompanying a rotation of Sitka spruce. Agricultural Ecosystems and Environment. 24: 407-415 .

Disney, R.H.L. 1986. Inventory surveys of insect faunas: discussion of a particular attempt. Antennae. 10(3): 112-116 .

Dunn, J. P.; T. W. Kimmerer; G. L. Nordin. 1986. Attraction of the twolined chestnut borer,*Agrilus bilineatus* (Weber) (Coleoptera: Buprestidae), and associated borers to volatiles of stressed white oak. Canadian Entomology. 118(6): 503-509.

Fellin, D.G. 1980. A review of some interactions between harvesting, residue management, fire, and forest insects and diseases. In Environmental consequences of timber harvesting in Rocky Mountain coniferous forests, symposium proceedings. General Technical Report INT-90: U.S. Department of Agriculture, Forest Service.

Gardner, S.M. 1991. Ground beetle (Coleoptera: Carabidae) communities on upland heath and their association with heathland flora. Journal of Biogeography. 18: 281-289 .

Goff, C.C. 1952. Floodplain animal communities. American Midland Naturalist. 57(2): 478-486 .

Gorham, L.E.; B.D. Keeland; S. Mopper; S.L. King; D.J. Johnson. 1996. Effects of canopy gap dynamics on arthropod abundance in a bottomland forest in northeast Arkansas. In: Flynn, K.M., ed. Proceedings of the Southern Forested Wetlands Ecology and Management Conference. Consortium for Research on Southern Forested Wetlands, Clemson University: Clemson, SC.

Grey, W.F. 1973. An analysis of forest invertebrate populations of the Santee-Cooper Swamp, a floodplain habitat. Columbia, SC: University of South Carolina. M.S. Thesis

Hanula, J.L. 1996. Relationship of wood-feeding insects and coarse woody debris. In: McMinn, J.W. and D.A. Crossley, Jr. eds. Biodiversity and coarse woody debris in southern forests, proceedings of the workshop on coarse woody debris in southern forests: effects on biodiversity; 1993 October 18-20; Athens, GA. Gen. Tech. Rep. SE-94 Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 55-81.

Hutcheson, J.; D. Jones. 1999. Spatial variability of insect communities in a homogeneous system: measuring biodiversity using Malaise trapped beetles in a *Pinus radiata* plantation in New Zealand. Forest Ecology Management. 118: 93-105.

Janzen, D.H. 1987. Insect diversity of a Costa Rican dry forest: why keep it and how. Biological Journal. Linn. Soc. 30: 343-356.

Kremen, C.; R.K. Colwell; T.L. Erwin; D.D. Murphy; R.F. Noss; M.A. Sanjayan. 1993. Terrestrial arthropod assemblages: their use in conservation planning. Conservation Biology 7(4): 796-808.

Nebeker, T.E.; T.D. Leininger; J.S. Meadows. 1999. Silvicultural practices in forests of the southeastern United States: insect and disease considerations. In: Haywood, J.D. ed. Proceedings of the tenth biennial southern silvicultural research conference; 1999 February 16-18; Shreveport, LA. Gen. Tech. Rep. SRS-30. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 555-559.

Niemelä, J.; D. Langor; J.R. Spence. 1993. Effects of clear-cut harvesting on boreal ground-beetle assemblages (Coleoptera: Carabidae) in western Canada. Conservation Biology. 7(3): 551-560 .

Økland, B. 1996. A comparison of three methods of trapping saproxylic beetles. European Jorunal of Entomology. 93: 195-209 .

Packham, J.R.; D.J.L. Harding; G.M. Hilton; R.A. Stuttard. 1992. Functional ecology of woodlands and forests. London: Chapman Hall.

Parry, W.H.; D. Rodger. 1986. The effect of soil scarification on the ground beetle fauna of a Caledonian pine forest. Scottish Forestry. 40: 1-9 .

Shelford, V.E. 1954. Some lower Mississippi Valley floodplain biotic communities: their age and elevation. Ecology 35(2): 126-142.

Simberloff, D.S. 1972. Properties of the rarefaction diversity measurement. American Nature. 106: 414-418.

Solomon, J.D. 1995. Guide to insect borers of North American broadleaf trees and shrubs. U.S. Forest Service: AH-706.

Thiele, H.U. 1977. Carabid beetles in their environments: a study on habitat adaptation, physiology and behavior. Springer-Verlag, Berlin.

Thompson, L.C.; R.T. Allen. 1993. Site preparation affects ground beetles in a clearcut bottomland hardwood forest in southeastern Arkansas. In: Brissette, J.C., ed. Proceedings of the Seventh biennial southern silvicultural research conference; 1992 November 17-19, Mobile, AL. Gen. Tech. Rep. SO-93. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 57-64.

Townes, H. 1972. A light-weight malaise trap. Entomology News. 83: 239-247.

Uetz, G.W.; K.L. Van der Laan; G.F. Summers; P.A.; Gibson; L.L. Getz. 1979. The effects of flooding on floodplain arthropod distribution, abundance and community structure. American Midland Naturalist. 101(2): 286-299.

Yanega, D. 1996. Field guide to northeastern longhorned beetles (Coleoptera: Cerambycidae). Natural History Survey Manual. 6.