SUSTAINABLE FOREST MANAGEMENT NETWORK
RÉSEAU DE GESTION DURABLE DES FORÊTS
Networks of Centres of Excellence
Réseaux de centres d'excellence

SFM Network
Research Note Series
No. 42

Deadwood-associated insect biodiversity in mixedwood forests

Highlights

- Deadwood-associated insects are essential to the healthy functioning of forests, but can be threatened by harvesting of timber, slash and deadwood.
- Decay stage and species of snags are important determinants of deadwood-associated insect communities in northern Alberta mixedwood forests.
- Fire creates a unique habitat that attracts species absent from harvested and undisturbed stands.
- Increased harvesting intensity (i.e. lower retention levels) decreases the number of snags available for habitat, resulting in significant changes of species composition in fungus-feeding and predator species.

The Ecosystem Management Emulating Natural Disturbance (EMEND) Project is a multi-partner, collaborative forest research program. The EMEND project documents the response of ecological processes to experimentally-delivered variable retention and fire treatments. The research site is located in the western boreal forest near Peace River, Alberta, Canada, with monitoring scheduled for an entire forest rotation (i.e. 80 years). Individual research projects evaluate which forest harvest and regenerative practices best maintain biotic communities, spatial patterns of forest structure, and functional ecosystem integrity, compared to mixedwood landscapes created by natural disturbances. Furthermore, economic and social analyses evaluate the long-term viability and acceptability of these practices. This research note, part of a series about the EMEND Project, summarizes research on deadwood-associated insects in mixedwood forests.

Figure 1. Deadwood associated beetle (*Schizotus cervicalis*) emerging from aspen log. Photo courtesy of Charlene Wood.

Deadwood-associated beetles

Deadwood-associated (or saproxylic) species play important roles in nutrient cycles and the healthy functioning of forests. They also comprise a large proportion of the biodiversity in forests. For example, in Finland, 20-25% of the 19 000 known animal, plant and fungus species in the boreal forest are thought to be associated with deadwood. These deadwood-associated species received little attention until Siitonen and Martikainen (1994) provided strong evidence implicating industrial forest harvesting in the endangerment and extinction of many saproxylic beetles in Finland.

Now it is recognized that over half of the threatened forest species in Finland and Sweden are due to the reduction of deadwood as a result of industrial forest harvesting. These discoveries inspired much work on conservation of saproxylic arthropods in other forests around the world, including in Canada.

The EMEND project

The EMEND project used an experimental template where six levels of dispersed green-tree retention (0-2%, 10%, 20%, 50%, 75% and 100% or uncut) were applied to whole forest stands 10 ha in size. These retention treatments were replicated 3 times over 4 dominant stand types (deciduous-dominated canopy—primarily aspen and balsam poplar; deciduous canopy with developing understory of white spruce; mixed deciduous-conifer canopy; and conifer-dominated canopy—primarily white spruce). Two types of fire treatments were also applied to selected stands: burning of stands that were first harvested to 10% retention, with logging slash left on site (three replicate stands in each cover type; completed in 2003-2005); and burns of uncut standing timber (five stands completed 1999-2007).

Methods of beetle sampling

Figure 2. Flight intercept trap attached to a girdled tree. Photo courtesy of Josh Jacobs.

Saproxylic insects inhabiting standing deadwood (snags) were sampled at EMEND using flight intercept traps (Figure 2). The traps were placed in control stands of all four cover types, all harvesting treatments of the conifer-dominated sites, and a standing timber burn from 1999. Traps were attached to girdled and standing dead trees that naturally release chemicals which attract saproxylic insects. These traps yielded over 31 000 saproxylic beetles and 262 species, representing a considerable proportion of the beetle biodiversity found at the EMEND site.

Snag characteristics and beetle succession

Snag species and degree of decomposition influenced the presence and abundance of saproxylic insects. Many saproxylic species, especially those that feed within the tree phloem, have very narrow host preferences, and often do better in a single species of tree. At EMEND, half of the beetle species specialized on either aspen or spruce. However, this is considered to be an underestimate of host specificity as many beetle species known to specialize on conifers were also collected commonly in traps on recently killed aspen snags. The apparent attraction of some beetles to non-hosts is likely a result of similar chemicals (especially ethanol) released from aspen and spruce trees shortly after death.

A distinct succession of beetles inhabits trees after death. Fresh snags are initially colonized by bark beetles and other species requiring fresh phloem, along with their predators. Three years following tree death, later-successional bark beetles arrive and feed on the phloem layer, using the entrance and emergence holes of the initial colonizers. During this period fungivores (fungi-feeding) also begin to appear, feeding on fungi that have colonized the dead trees. Many of these fungi arrived within the digestive tract or attached to the exterior of early colonists. Therefore, to maintain this successional progression of colonizers, forests must be managed to ensure a diversity of decay stages and species of dead wood in the forest to provide habitat for a full suite of saproxylic insect species.

Figure 3. Maintaining a range of snag decay stages in a forest promotes beetle diversity. Photo courtesy of Charlene Wood.

Fire

Historically, fire has been an important factor shaping age class distributions in the boreal forest. It creates unique habitats for fire-adapted organisms. Many beetle species seek recently-burned areas to take advantage of the newly-created deadwood. One species, *Melanophila acuminata* (DeGeer) has been shown to possess a special sensory device that allows it to detect and orient its flight pattern to smoke and heat from a burning forest. Burned patches of the prescribed fire at EMEND supported a higher diversity of beetles than unburned patches. Thirteen species were significant indicators of burned areas. Two ground beetle (Carabidae) species were found only in these areas (*Sericoda quadripunctata* (DeGeer), *Sericoda bembidioides* Kirby). These pyrophilic (fire-loving) species are assumed to have habitat requirements that are not emulated in any of the harvesting treatments, although the specific nature of these requirements is not yet fully understood. Clearly, it is important to maintain some level of fire on the landscape to support this unique group of insects.

Figure 4. Fire is an important landscape element for some species. Photo courtesy of Matthew Pyper.

Variable retention harvesting

Fire-created habitats typically contain a much larger volume of dead wood than harvested areas. In Fennoscandia, long term extensive harvesting in the boreal forest has resulted in a 90-98% decrease in the amount of dead wood in managed stands. General species-area relationships predict that such a reduction in

habitat could lead to a loss of 50% of the original species over the long term. In contrast, fire does not typically kill all trees in a stand, but leaves aggregated patches of unburned trees and sometimes single trees. As the forest regenerates, these residual trees die, creating a continuous supply of dead wood in various stages of decomposition.

Emulation of these natural patterns is one approach for managing dead wood in harvest stands. Two harvesting approaches were used at EMEND to emulate natural patterns found after fire. First, five levels of variable dispersed retention were left following harvesting (see details above). Second, small (0.2ha) and large (0.46ha) aggregated patches of living trees were left in each variable retention treatment. Although the real benefits of these two practices will require several years or even decades to be fully assessed, our early work on saproxylic beetles has provided some initial insights.

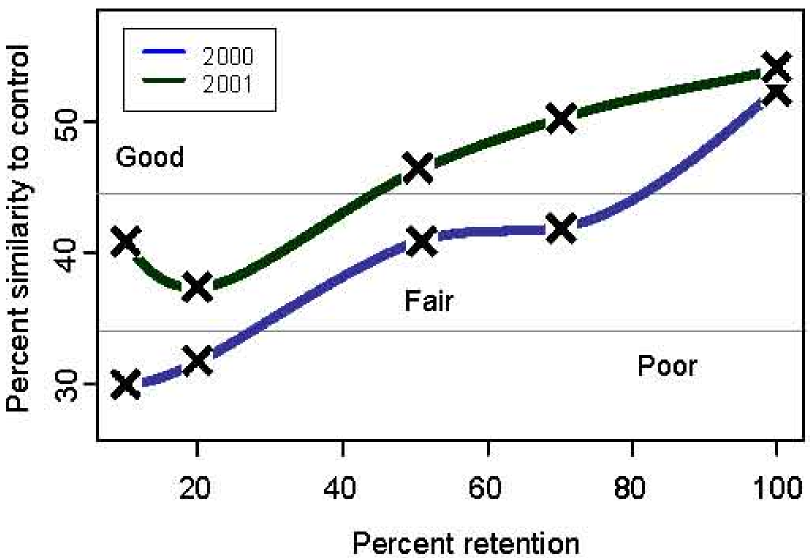

Figure 5. Similarity of fungivorous beetle assemblages to the uncut control stands 1.5 years following harvest (2000) and 2.5 years following harvest (2001).

Harvesting treatments were evaluated by monitoring changes in beetle assemblages in the treatments relative to control stands (Figure 5). Similarity of beetle assemblages to control stands decreased with lower retention levels 1.5 years following harvest (2000) for all feeding groups. The following year (2001) this trend was observed only in the fungivores and predator species, although both groups show signs of recovery. These reductions in similarity also correspond to a decrease in snags in the lower retention treatments.

Three species of fungivorous beetles were found only in the 75% retention stand and uncut controls of conifer dominated stands, but not in lower retention stands. It is possible that treatments that open stands to sun exposure beyond a certain threshold will cause sufficient drying limiting fungal growth, possibly altering fungal communities and the insects feeding on them. These species require mature, intact forest and appear susceptible to any degree of harvesting.

Clearly, deadwood-associated beetles at EMEND are closely related to habitat quality and quantity. Management to ensure a diversity of habitats will provide the best conservation value for these insects.

Further reading

Jacobs, J., J. R. Spence, and D. Langor. 2007a. *Variable retention harvest of white spruce stands and saproxylic beetle assemblages.* Can. J. For. Res. 37: 1631-1642.

Jacobs, J., J. R. Spence, and D. Langor. 2007b. *Influence of boreal forest succession and dead wood qualities on saproxylic beetles.* Agric. For. Entom. 9: 2-15.

Saint-Germain, M., P. Drapeau and C. Buddle. 2007. *Host-use patterns of saproxylic wood-feeding Coleoptera adults and larvae along the decay gradient in standing dead black spruce and aspen.* Ecography 30: 737-748.

Siitonen, J., and P. Martikainen. 1994. *Occurrence of rare and threatened insects living on decaying* Populus tremula: *a comparison between Finnish and Russion Karelia.* Scand. J. For. Res. 9: 185-191.

Siitonen, J. 2001. *Forest management, coarse woody debris and saproxylic organisms: Fennoscandian boreal forests as an example.* Ecol. Bull. 49: 11-41.

EMEND website: www.emend.rr.ualberta.ca

Management Implications

- Deciduous-dominated stands support many deadwood insect species not found in coniferous stands, and vice versa. Management strategies should aim to maintain a diversity of stand types on the landscape. This will best support conservation of the full range of species dependent on dead wood.
- Fire creates microhabitats not present in harvested stands. The changes to the natural fire cycles as a result of fire suppression may require the use of controlled burning as part of forest management to maintain pyrophilic species.
- Variable retention harvesting, using large patches down to single tree retention, promotes a continuous supply of dead wood in forests. This provides habitat for saproxylic species. However, further research is needed to determine the optimal amount and configuration of retention across large landscapes.
- Ongoing research on saproxylic species will aid our understanding of their responses to natural and harvesting disturbances. Such work will provide better predictive powers and create insights into improved forest management strategies to minimize impacts on forest health and biodiversity.

Written by: Joshua Jacobs[1] and David Langor[2]

[1] Department of Renewable Resources, University of Alberta,Edmonton Canada
[2] Canadian Forest Service, Northern Forestry Centre, Edmonton, Canada

Ecosystem Management Emulating Natural Disturbance

A Partnership Committed to a Long Look at Boreal Ecosystems
Canadian Forest Products • Canadian Forest Service • Daishowa-Marubeni International • Government of Alberta • Manning Forestry Research Fund • Sustainable Forest Management Network • University of Alberta • University of British Columbia • University of Calgary • Université du Québec à Montréal • Weyerhaeuser

For more information on the SFM Network Research Note series and other publications, visit our website at http://sfmnetwork.ca or contact the Sustainable Forest Management Network
University of Alberta, Edmonton, AB. Tel: 780-492-6659. Email: info@sfmnetwork.ca

Coordinating editor: M. Pyper
Graphics & Layout: K. Kopra

ISSN 1715-0981