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Responses of arthropod biodiversity to variable green-tree retention at the EMEND experiment

Highlights

- Ground beetle composition is not effectively preserved by low levels of variable retention (0-20%) in the first 5 years after harvesting.
- Changes in ground beetle assemblages result from the loss of individual species that demonstrate strong affinities for specific habitats which are removed during harvesting (e.g. coarse woody material).
- Variable retention harvesting is not intended to produce short term recovery, and thus longer term monitoring will be required to fully evaluate recovery potential in lower retention harvests (10-50%).

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 is one of a series about the EMEND project.

Evaluating forest management with biodiversity

One of the principal goals of the EMEND (Ecosystem Management Emulating Natural Disturbance) project is to evaluate whether 'greener' forestry practices such as dispersed green-tree retention are effective for maintaining the native flora and fauna at the stand level. If some benefits for native plants and animals exist under such an approach to forest management, these benefits could then be evaluated against economic demands such as the need for a continued supply of wood fiber and the need for socially acceptable forest conditions as perceived by the public. However, characterizing individual responses of all organisms in an ecosystem as complex as a forest is not feasible. Given this constraint, it is necessary to monitor subsets of bioindicators, that either accurately reflect changes in overall ecosystem functions or at least are representative of a large proportion of species within the ecosystem. Forest arthropods satisfy both these criteria.

Forest arthropods outnumber by far all other terrestrial animals both in terms of absolute numbers but perhaps more importantly in terms of the number of species. Furthermore, because of their short life-cycles (typically 1-2 years), arthropod populations may respond quickly to environmental changes. The combined responses of numerous species then can be used as a synthetic, high-resolution measure to evaluate the effects of specific forest management practices on arthropod biodiversity.

Monitoring changes in biodiversity & impacts of dispersed green-tree retention

The EMEND experiment provides 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. 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). In total 72 experimental stands were monitored 1, 2 and 5 years post-harvest. Within each stand, forest arthropods were sampled using pitfall trapping, a simple and inexpensive method that targets ground arthropods (mostly beetles and spiders). Monitoring at the EMEND site will continue for the length of an entire forest rotation.

Figure 1. Aerial view of 10% dispersed green tree retention at EMEND. Photo courtesy of Jason Edwards.

Arthropod responses to green-tree retention

This research note concentrates on the response of one dominant family of ground dwelling beetles, the Carabidae. These animals are typically predators as both larvae and adults and can be found throughout leaf-litter, in forest soils, and under bark of coarse woody material (CWM). The 1, 2 and 5-year post harvest beetle sampling captured over 45,000 individuals representing 59 species of carabid beetles. We detected a significant change in arthropod species composition resulting from harvesting treatments. This response differed among forest cover-types; later successional stages (conifer and mixed forest stands) experienced a larger overall effect than earlier successional, deciduous dominated stands.

Initially following harvesting (1 year post-harvest), we did not observe any significant difference in species composition as a result of the harvesting. We attribute this to many individuals which were present within stands as larvae during this first year and were unable to disperse from these blocks. However in the following year (2 years post-harvest), species composition in the lowest retention levels (0-2% and 10% retention) differed from uncut controls. This pattern became more pronounced in the 5 years post-harvest samples where species composition in treatments with up to 20% retention differed from 75% retention treatments as well as uncut controls.

We did not observe any signs of 'recovery' of beetle communities within the first 5 years post-harvest. This suggests that lower, presumably commercially viable, levels of retention harvesting still have a

significant impact on resident biodiversity in mixedwood stands in the short term. It also indicates that signs of recovery should not be expected within 5 years. However, it is important to remember the goal of variable retention harvesting is to expedite longer term recovery patterns, thus future recovery monitoring will provide a more complete evaluation of variable retention success. It is equally important to recognize that this period corresponds to approximately 5 generations of beetles. For species with slower generation times (including nearly all vertebrates) and/or limited capacity to disperse, recovery may take much longer.

The effects of harvesting were demonstrably greater for species in conifer and mixed stands than in deciduous dominated stands. This is consistent with what we expect given forest succession in this region. Typically vegetative growth and suckering by deciduous species is common following harvesting in this region. Thus after harvest, deciduous stands re-establish as deciduous stands. In contrast, conifer stands experience a greater 'net' change in terms of forest composition as they too return with a much larger deciduous component. Thus resident biodiversity in conifer and mixed stands may face an overall larger, and more long-term, environmental change than resident biodiversity in deciduous stands.

Figure 2. Coniferous dispersed retention harvest at EMEND. Photo courtesy of Jason Edwards.

Figure 3. Regeneration in a low retention harvest at EMEND. Photo courtesy of Jason Edwards.

Individual species responses

The generalized responses of individual species provide insight into how harvesting treatments affect beetle species composition. A key element in determining species composition is the relative amount of preferred habitats in a stand. Among the four stand-types at EMEND, we do not observe stands that are entirely deciduous or entirely coniferous. Typically even in the earliest and latest stages of stand-development there is always a small proportion of non-dominant tree species.

Understanding how these generalized species responses are manifested among stand-types is important to understanding the implications of variable retention. We have classified arthropod

associations into 5 categories related to harvesting: 1) open-habitat species, 2) forest generalists, 3) mature deciduous species, 4) mature conifer species and 5) old growth specialists (Figure 4).

Open-habitat species are promoted by harvesting and increase in abundance after partial cutting. Forest generalist species are found across all stand-types and persist following harvest even if in smaller populations. Mature and old-growth species are those taxa whose abundance reflects in some way the relative proportion of preferred habitats that remain following harvest. These species are typically abundant in a given stand-type but can be found in lower abundance across the gradient of stand-types.

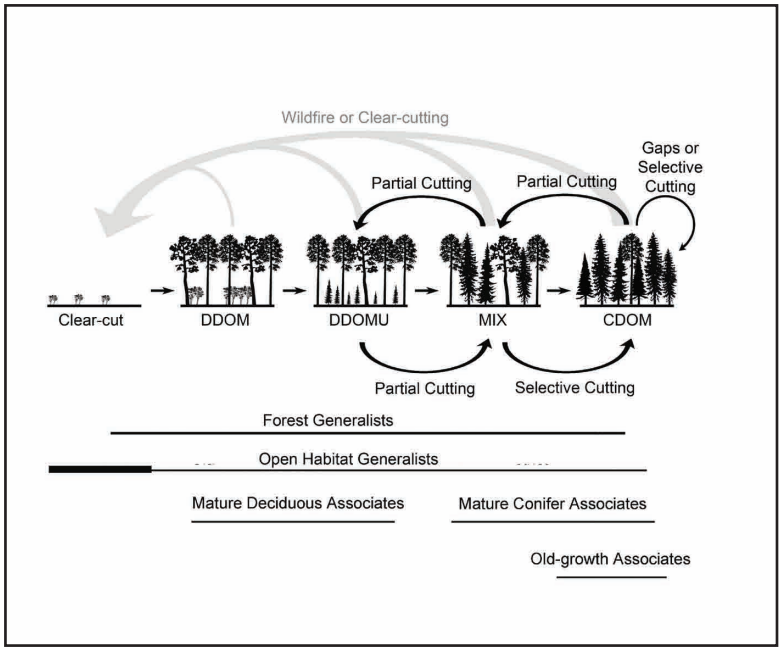

Figure 4. Schematic depicting generalized responses of biodiversity within the context of the natural disturbance model of forest management (adapted from Jacobs 2008 and Bergeron 2000).

Along this gradient of stand types, where individual species may use either deciduous or conifer dominated stands as preferred habitats, a species abundance changes with the relative proportion of preferred habitat. Thus, as we rarely see stands dominated by a single tree species, we rarely find ground beetle species absent from a given stand-type even if it is a non-preferred habitat. We call these species 'mature deciduous' and 'mature conifer' species. These species are negatively affected by forest harvesting when they are located in their 'non-preferred' habitats. This is equivalent to adding an additional stress to a species that already exists in a sub-optimal habitat. In addition to this pattern of response, we also observe a subset of species that are sensitive to any level of forest harvest in later successional stages. We call these 'old-growth' specialists. These can be considered a special case of 'mature conifer specialists' and will likely require relatively large quantities of old-growth to maintain viable populations.

Further reading

Jacobs, J., T. T. Work, and J. R. Spence. 2008. *Influences of succession and harvest intensity on ground beetle (Coleoptera:Carabidae) populations in the boreal mixedwood forests of Alberta, Canada: species matter.* **In:** Back to the Roots and Back to the Future? Towards a new synthesis between taxonomic, ecological and biogeographical approaches in carabidology: Proceedings of the XIII European Carabidologists Meeting, Blagoevrgard, August 20-24, 2007, eds. L. Penev, T. Erwin, and T. Assmann. Pensoft, Sophia-Moscow.

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Work, T. T., D. P. Shorthouse, J. R. Spence, W. J. A. Volney, and D. Langor. 2004. *Stand composition and structure of the boreal mixedwood and epigaeic arthropods of the Ecosystem Management Emulating Natural Disturbance (EMEND) landbase in northwestern Alberta.* Can. J. For. Res. 34:417-430.

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

Management Implications

- We suggest that there are implications of the response of ground beetles to the interaction between harvesting and cover-type on long-term forest planning. Generalized responses of 'mature deciduous', 'mature conifer' and 'old-growth' species of carabid beetles argue against any approach that converts the mosaic of stand-types and age classes in the boreal forest to one stand-type, be it deciduous or conifer, throughout a larger region. Such a management objective would be detrimental to resident biodiversity.
- Our results also suggest that lower levels of retention, particularly in mixed and conifer stands, will result in a measurable change in species composition, including the elimination of particular species at the stand-level. We have been unable to observe any 'recovery' of the biota as compared to uncut control stands within the initial 5 years of the project suggesting that changes affected by forest management may indeed be longer term.

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Ecosystem Management Emulating Natural Disturbance

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