EMEND





ECOSYSTEM-BASED MANAGEMENT EMULATING NATURAL DISTURBANCE

EMEND Insights #21

Ecological Messages:

- Wetter sites in coniferous and mixed stands contained the greatest abundance of mosses and liverworts and a higher number of species than deciduous stands.
- Site wetness can be used to identify areas of conservation interest for bryophytes and influences how bryophytes respond to retention harvesting.

Management Implications:

- Dispersed retention (>10%) should be left, particularly in wetter areas of coniferous and mixed stands as part of a plan to conserve bryophytes and promote successional transition.
- Use of retention patches is recommended to act as lifeboats for this sensitive species group.
- Unharvested, mature forest reserves continue to play an important role in maintaining species which cannot persist in even high-retention harvest areas (e.g., liverworts).

Using Wet Areas Mapping to plan retention for bryophytes

Research led by Samuel Bartels, Ryan James, Richard Caners, and Ellen Macdonald

Bryophytes are an often-overlooked group of species, yet the close association of many forest bryophytes with humid conditions makes them ideal indicators of forest habitat. Many forest-dwelling mosses and liverworts can only grow where moisture is readily available: unlike other plants, they lack the tissues needed to pull up and store water from the soil. This limitation makes them sensitive to changes in microclimate caused by disturbance and presents a unique challenge to forest managers concerned about forest biodiversity.

We asked whether retention harvesting is an effective tool for managing bryophytes over time. If so, could we optimize retention to maximize conservation gains from the trees left behind?

Unsurprisingly, bryophytes were highly sensitive to increasing harvest intensities—however, retention levels >10% were associated with higher overall bryophyte cover and more species than clear-cuts. This effect was most pronounced in forest stands which contained the highest pre-harvest bryophyte diversity: namely, coniferous and mixedwood forests.

Bryophytes were also found to be more abundant and diverse on wetter sites within this upland forest landscape and more bryophyte species were uniquely affiliated with wetter (versus drier) sites. ***Retention on wetter sites in mixedwood and coniferous stands was most effective at maintaining high bryophyte cover, richness, and species unique to wet sites.***

Interior, unharvested forest also continues to play an important role for conserving the most sensitive species such as liverworts. Dispersed and patch retention on wetter sites within coniferous-dominated and mixed stands will be an important part of a landscape-level strategy to conserve this highly sensitive group of species.

Many bryophytes grow on moist substrates like well-decayed dead wood. Photo by R. Caners.

Forest Bryo-diversity

Mosses and liverworts ("bryophytes") are small, inconspicuous plants that commonly occupy humid, shady habitats in forests. Unlike herbaceous and woody species, they lack root systems and vascular tissues, meaning they are not able to take up water from below-ground and transport it to their above-ground stems and leaves. While most bryophyte species can survive drying up for short periods, many species will die if they remain dry for long periods.

For this reason, many bryophytes are particularly sensitive to disturbance. Natural and human disturbances that open the canopy, increase light, and reduce humidity can cause many bryophytes to dry out and die. Fire also, however, leaves large volumes of dead wood on the forest floor, providing some species important habitat in the long term as it decays.

Variable retention harvesting presents an interesting opportunity for improving habitat quality for bryophytes within harvested stands and promoting post-harvest recovery. Until now, however, there have been few long-term studies evaluating the effectiveness of retention in conserving bryophytes and facilitating their transition back into harvested areas. There has also been little direction to guide where to place retention, and at what levels, to provide refuge and promote recovery of this sensitive group of species.

Box 1. What is Wet Areas Mapping?

Aerial photo interpretation has typically been used to develop maps showing surface drainage networks, but these maps often lack the level of detail needed to plan forest operations. Following recent advancements in remote sensing, LiDAR data were used in the Wet Areas Mapping tool to create an index of soil depth-to-water (referred to as "site wetness" within this note). A low depth-to-water value, for example, means there is a high probability that water is near or even at the surface of the ground.

It is important to note that depth-to-water is not an empirical measure of site wetness, but rather represents the probability of encountering water at a given depth. Researchers can adjust the model to improve its performance at different sites and under different conditions (e.g., drought).

About EMEND:

The Ecosystem-based 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 and research scheduled for an entire forest rotation (i.e. 80 years).

How much?

Bryophytes were surveyed throughout EMEND three, six, and eleven years after harvest treatments were applied in 1998–99. We used data collected across all retention treatment levels (clear-cut (2%), 10%, 20%, 50%, and 75%) and in unharvested controls to ask, ***"how much retention is needed to lifeboat bryophytes and increase their recovery?"***

Where?

In 2014–15, we conducted additional bryophyte surveys in the clear-cuts, 20% retention, 50% retention, and unharvested stands. Using depth to surface water as indicated by Wet Areas Mapping, we asked, ***"where can we place retention to better conserve bryophytes?"***

Coniferous forest with high moss cover. Photo by R. Caners.

Key Findings

Dispersed retention >10% mitigated harvest effects… somewhat

Dispersed retention mitigated bryophyte declines following harvest, and these benefits increased with increasing retention. This trend was most obvious for bryophyte cover (i.e., the abundance of bryophytes), which was very low in stands with 2%, 10%, and in some cases 20% retention.

Mosses were less sensitive to harvest than liverworts and increased with increasing retention. This was particularly evident in the conifer-dominated stands, where average moss cover more than doubled between 10% and 20% retention treatments. Liverworts, which were already very rare (<3% cover on average), dwindled to <1% cover in even the 75% retention treatments.

Our results suggest that harvests with >10% retention will provide biodiversity benefits for bryophytes, particularly compared with clearcuts, where bryophytes declined and continued to be dominated by a small number of species 11 years after harvest. These benefits are most apparent in conifer dominated or mixedwood stands as these stands contained the highest cover and diversity of bryophytes prior to harvest.

Bryophytes benefit most from retention on wetter sites

We examined relationships between site wetness and bryophytes and asked: does a site's wetness influence bryophyte response to harvesting? Understanding this can help us understand if Wet Areas Mapping could be used to plan retention harvesting to maximize its benefit to bryophytes.

Leaving retention in wetter areas will better conserve bryophytes. In coniferous and mixedwood stands, bryophytes had higher cover on wetter sites and a greater total number of species; more species were also uniquely associated with wetter habitats. Leaving even low (20%) levels of retention on wetter (versus drier) sites better conserved bryophytes as compared to clearcutting. Bryophytes on drier sites, in contrast, seemed to be very sensitive to harvesting such that they experienced little benefit from leaving retention. While the reasons for this sensitivity are unclear, it may be that wetter sites are less prone to drying out following harvesting.

Patterns in deciduous-dominated stands were inconclusive, as overall stand conditions (drier, deep leaf litter) are unsuitable to many bryophyte species.

Indicator species of unharvested coniferous forest include Red-stemmed Feathermoss (Pleurozium schreberi), left, and Knight's Plume Moss (Ptilium crista-castrensis), right. Photos by R. Caners.

Management Implications

High levels of dispersed retention improved the overall condition of harvest blocks, supporting higher bryophyte cover and richness at the stand level compared to clear-cuts. This finding was most striking for coniferous forests. While high retention levels were most effective, even >10% retention was a suitable alternative to clear-cutting within these conifer stands. The rationale for this positive impact on bryophytes is likely that even modest amounts of retention serve to conserve more moisture on sites and provide microsites for bryophytes to grow.

Site wetness, as quantified using Wet Areas Mapping, was related to bryophyte cover, richness and composition and also mediated the response of bryophytes to harvesting. This finding suggests that Wet Areas Mapping can be useful to identify areas of particular conservation interest for bryophytes and to more effectively plan retention harvesting.

Leaving retention on wetter sites in conifer and mixed forests is recommended as it will bring more benefit in terms of bryophyte conservation than retention left on drier sites. These results concur with the responses of understory plant communities, which were more sensitive to harvesting on wetter sites within conifer-dominated stands (see EMEND Insights #18).

Locating retention on wetter sites has the benefit of "lifeboating" this sensitive species group. While the studies focused on dispersed retention, the results likely apply to other types of retention such as aggregate or patch retention, with larger patches likely to be most effective in protecting sensitive species by reducing edge effects and providing heavily decayed coarse woody debris (see EMEND Insights #9).

Our research has shown, however, that several bryophyte species are extremely sensitive to disturbance (e.g., liverworts), and that even very high retention levels may be inadequate to support them. Unharvested interior forests contributing to landscape-level targets are an important component for conserving these species, particularly within conifer-dominated forests or conifer-leading mixedwoods occupying wetter sites on the landscape.

Further reading

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Caners, R.T., S.E. Macdonald, and R.J. Belland. 2013. Bryophyte assemblage structure after partial harvesting in boreal mixedwood forest depends on residual canopy abundance and composition. Forest Ecology and Management 289: 489-500. https://doi.org/10.1016/j.foreco.2012.09.044

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RECOMMENDED CITATION:
Bartels, S., S.G. Odsen, R. James, R. Caners, and E. Macdonald. 2018. Using WAM to plan retention for bryophytes. S. Odsen and M. Pyper, eds. EMEND Insights Research Note Series, Number 21. Available online: https://emend.ualberta.ca/knowledge-exchange/.

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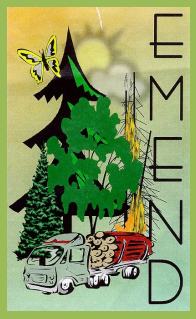

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