SUSTAINABLE FOREST MANAGEMENT NETWORK
RÉSEAU DE GESTION DURABLE DES FORÊTS
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SFM Network
Research Note Series
No. 72

Understory plant diversity and composition in boreal mixedwood forests

Highlights

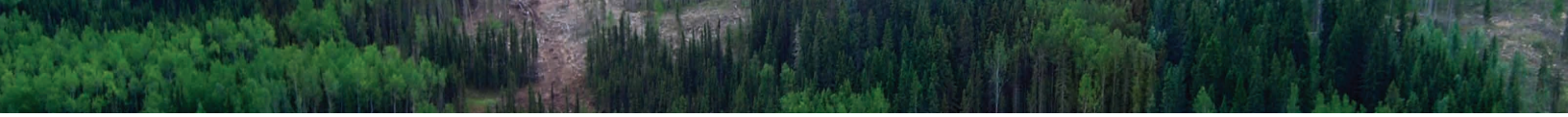
- Understory plant communities are critical components of boreal mixedwood forests because they hold most of the plant diversity and influence the regeneration and development of canopy trees.
- Mixedwood stands are comprised of small canopy patches with varying dominance by conifer and broadleaf trees. These patches resemble a microcosm of the larger boreal mixedwood landscape and play an important role in providing habitat islands for understory species, in turn, contributing to greater plant diversity in mixedwood stands and landscapes.
- Maintaining the mixture of canopy patch types, and their associated heterogeneity in internal stand structure, is likely important for conserving understory plant diversity and the natural structure of boreal mixedwood forests.
- In addition to the influence of canopy tree patches, the natural structure of boreal understory plant communities is also affected by interactions among understory plant species.

The importance of understory plant communities

Mixedwood forests dominate moist upland sites across the southern portion of the Canadian boreal forest. At the landscape level, boreal mixedwood forests resemble a mosaic of stands with varying dominance by conifers (mostly white spruce in western Canada and black spruce in eastern Canada) or broadleaf trees (mostly trembling aspen but also balsam poplar and paper birch) (Figure 1). At a finer scale, this mosaic includes 'mixed' forest stands which are comprised of a mixture of small canopy patches of varying conifer and broadleaf composition. These mixed stands have been associated with higher diversity of several biotic groups, including understory vascular plants (SFMN Research Note No. 59).

Figure 1. At the landscape level, boreal mixedwood forests resemble a mosaic of stands with varying dominance by conifer and broadleaf trees, while mixed stands consist of a mosaic of small patches of varying broadleaf- to conifer-dominance. Photo courtesy of J. Edwards.

There is growing interest among researchers and forest managers to understand patterns



of understory biodiversity, and to incorporate this knowledge into sustainable forest management practices. Understory plant communities represent most of the vascular plant diversity in boreal forests, and are important sources of food and habitat for a large number of wildlife species. Despite their importance, we currently have a relatively poor understanding of how understory communities are structured within mixedwood forest stands. In particular, more information is needed on how broadleaf and conifer trees differ in the way they influence the understory environment (light, soil nutrients, microclimate and physical environment of the forest floor).

In this research note, we synthesize some of our recent findings related to the patterns of diversity (richness and species number) and composition (species identity and relative abundance) of vascular understory plants within unmanaged mixedwood boreal forest stands. We describe the influence that small patches (50 m^2) of differing canopy composition have on structuring understory communities in these forests. Canopy patches were characterized as conifer-dominated, mixed, broadleaf-dominated, or gaps based on crown closure and tree density by species (total N=98). All stands were approximately 100 years old and were located in east-central Alberta. We purposely selected a 'patch-level' approach to detect the environmental heterogeneity that occurs at a fine scale as a product of the mosaic of canopy patches found within mixed stands.

The importance of small canopy patches for understory plants

Assessing variation in patch types

We found that conifer and mixed patches had similar plant composition, while broadleaf and gap patches were more similar to one another. Differences in understory communities among patch types were driven mostly by changes in the relative abundance of species. However, we did find some species that were only present under one particular canopy patch type. Interestingly, the variation in understory communities among patch types mirrored patterns that had previously been observed at the landscape scale among different mixedwood forest stands (i.e. fine scale differences between patch types were similar to large scale differences in stand types). This suggests that the high understory diversity found in mixedwood stands is partly explained by differences in the four canopy patch types, and that regeneration efforts should focus on maintaining a diversity of canopy patch types.

Variation of understory assemblages across canopy patch types

Further analyses revealed that differences in microhabitat conditions among the four canopy patches were driving the patterns described above. For example, conifer patches had drier, cooler soils and the lowest understory light among the four patch types. These micro-environmental conditions were associated with the lowest understory richness (number of species) among the four patch types (Figure 2). Despite having the lowest number of species, conifer patches had a relatively higher abundance and frequency of sensitive and/or uncommon species (e.g., the orchids *Goodyera repens*, *Habenaria obtusata* and *Habenaria orbiculata*) (Figure 3). These species were also present under mixedwood patches where conifer trees were co-dominant. Thus, these patches are likely to be important for the preservation of sensitive species, such as orchids.

Meanwhile, within mixed patches the co-dominance of conifer and broadleaf trees resulted in understory assemblages that consisted of both sensitive species from conifer patches, as well as common species from broadleaf patches. As such, mixed patches had the highest overall richness (number of species) of all the patch types, presumably because of this mixture of conifer and broadleaf trees.

In comparison to conifer patches, broadleaf patches gave rise to more benign micro-environmental conditions (higher light, nutrient-rich litter and warmer soils). These conditions led to higher abundance of pioneer and shade-intolerant herbs and shrubs leading to the highest richness at the scale of a small plot (Figure 2).

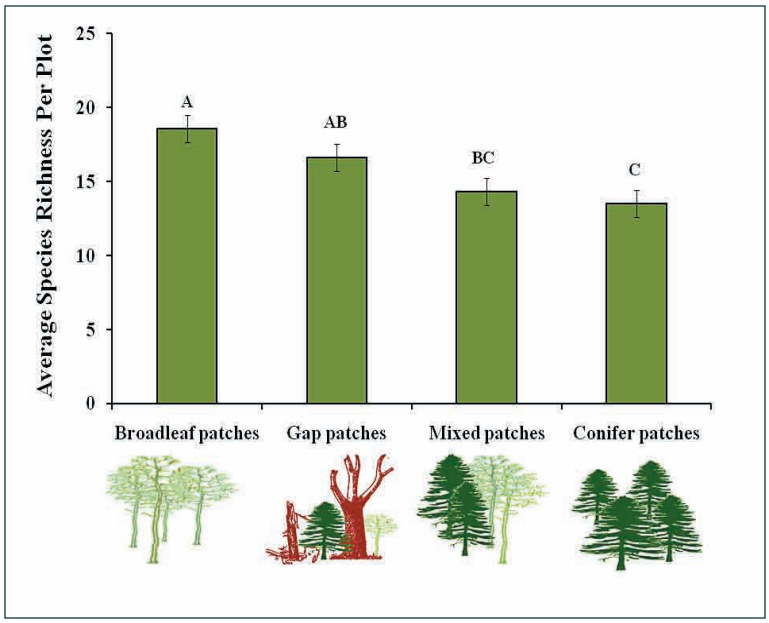


Figure 2. Comparison of species richness patterns observed in the four canopy patch types studied in the boreal mixedwood. Although conifer patches had the lowest richness, they contained the highest number of uncommon and sensitive species.

Finally, the increase in resource availability, particularly light, in canopy gap patches allowed for the co-habitation of pioneer species that were able to quickly colonize the newly-available space, with species that were present prior to gap formation. As such, canopy gaps acted as transient patches for understory plants where the increase in resource availability lowers the dominance of pre-gap species and allows for the re-establishment of early successional or pioneer species.

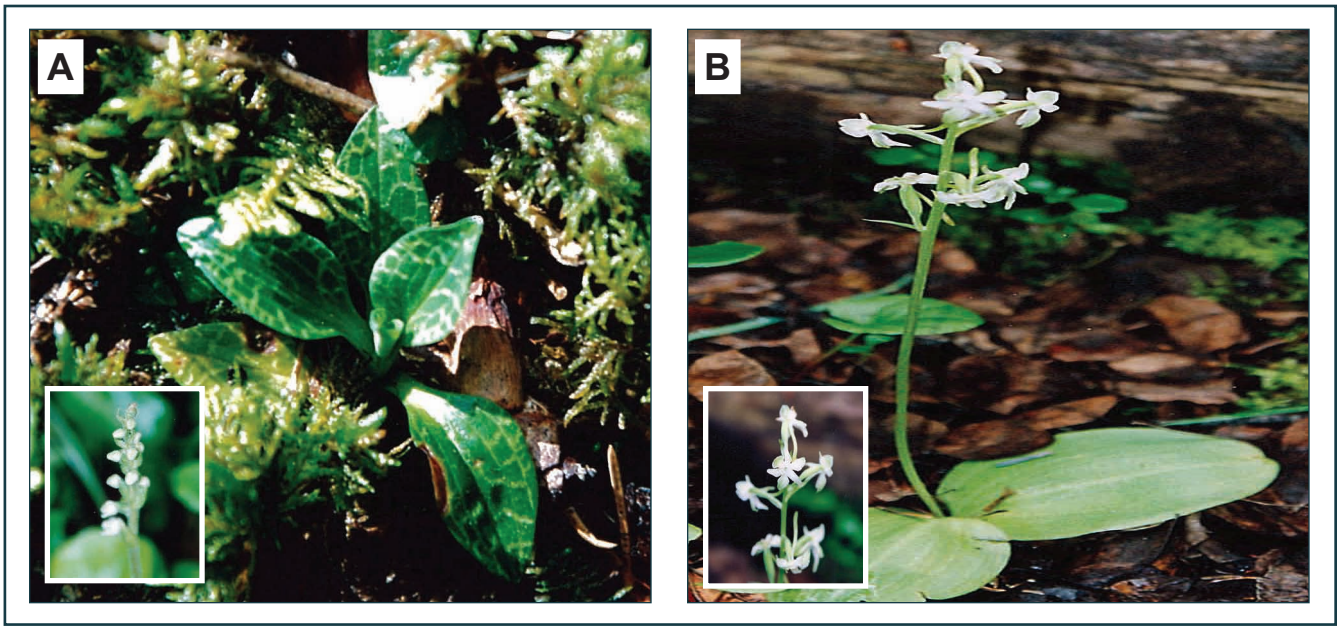


Figure 3. Conifer patches are important refuges for uncommon and sensitive species such as the orchids (A) *Goodyera repens* and (B) *Habenaria orbiculata*. Inset photos: orchid flowers. Photos courtesy of V. Chávez.

Canopy patches support mixedwood diversity

We documented an important role of canopy patches in providing habitat islands for species in the mixedwood forest, and that these patches contribute to greater diversity in mixedwood landscapes. We also found that mixedwood stands, composed of various canopy patch types, are a microcosm of the larger boreal mixedwood landscape for understory communities. In this way, maintaining the mixture of canopy patch types, and the associated heterogeneity in internal stand structure, within mixedwood stands is likely important for conserving the natural patterns of understory plant diversity and composition in boreal mixedwood forests.

Understory species interactions in mixedwood forest stands

In addition to the influence of canopy composition on understory communities, interactions among plant species play an important role in regulating composition and diversity of understory communities. It is well acknowledged that trees and understory plant species interact with one another throughout the different stages of boreal forest succession, but we know very little about the effect of interactions between shrub and herb species on understory community structure.

Thus, to further assess the natural structure of boreal understory communities, we examined plant interactions in mature and unmanaged boreal mixedwood forests by investigating the effect of shrub removal on biomass, composition and diversity of herbs (forbs and grasses). For this, we established 10 pairs of plots under mixed patches of mixedwood forest stands in which we removed all the tall shrubs in one plot (removals) while leaving the shrubs intact in the other plot (controls). Two years later, we harvested all the above-ground herb biomass from the 20 plots. This study was conducted at the Ecosystem Management Emulating Natural Disturbance (EMEND) research site.

We observed significant effects of shrub removal on herb biomass and community composition, but not on the number of herb species. Changes in species composition were mainly explained by increases in biomass of dominant herbs in the removal plots. Most of this biomass increment was explained by the rapid growth of *Linnaea borealis* and *Cornus canadensis* (Figure 4). These results demonstrate that the shrub layer, in addition to the canopy layer, has a direct influence on the understory plant community. In addition, the fact that we saw substantial changes after only two years supports the idea that boreal understory herbs have the capacity to quickly respond to changes in their environment following disturbance. These findings are important because they enable us to begin to understand the processes influencing understory vegetation, and assist us to better understand how to manage understory biodiversity in managed forests.

Overall, this study indicates that while canopy tree species have an important influence on understory plant communities, interactions among understory plant species can also play an important role in structuring boreal understory communities. Changes in the natural dynamics of interactions between shrub and herb species may indirectly modify the natural structure of boreal understory communities.

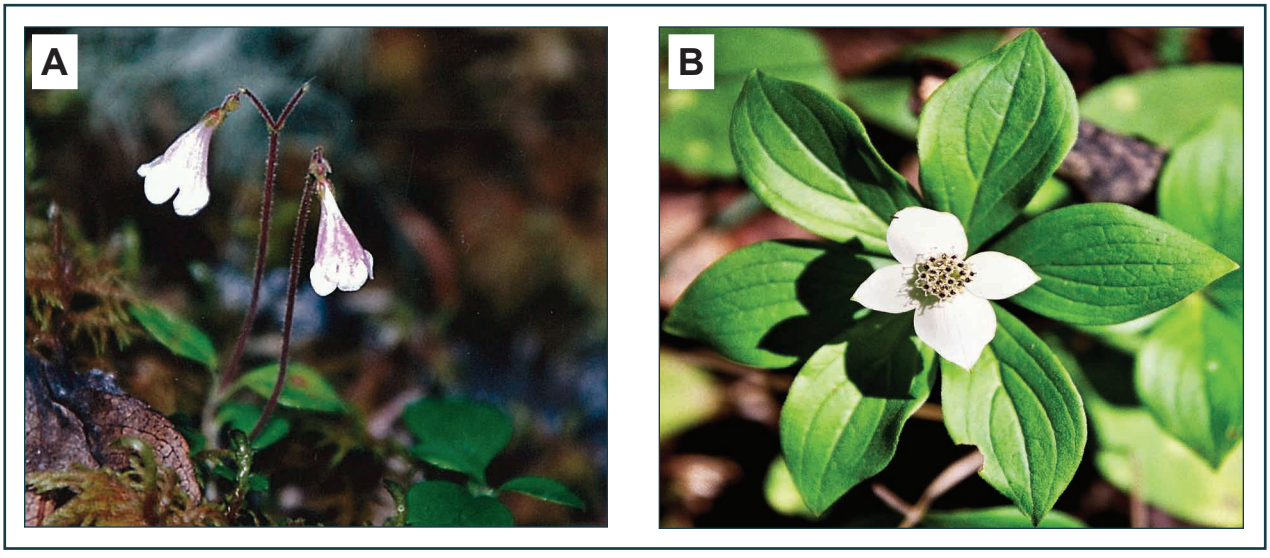
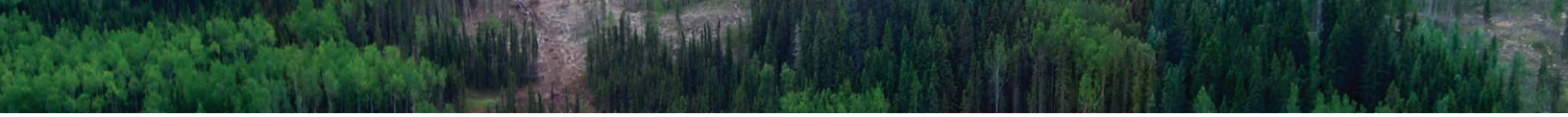


Figure 4. Changes in understory species composition after shrub removal were mainly explained by increases in biomass of dominant herbs such as (A) *Linnaea borealis* and (B) *Cornus canadensis*. Photos courtesy of V. Chávez.



Further reading

Chávez, V. and S.E. Macdonald. 2010. *The influence of canopy patch mosaics on understory plant community composition in boreal mixedwood forest.* For. Ecol. and Manage. 259(6): 1067-1075.

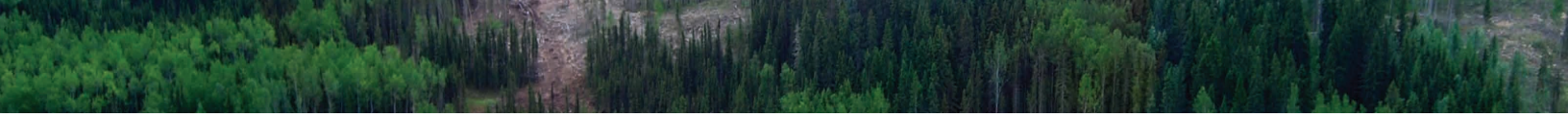
Macdonald, S.E. and T.E. Fenniak. 2007. *Understory plant communities of boreal mixedwood forests in western Canada: natural patterns and response to variable-retention harvesting.* For. Ecol. and Manage. 242: 34-48.

Macdonald, S. E., T. Work, P. Drapeau, Y. Bergeron, S. Quideau, H. Chen, J. Spence and N. Lecomte. 2010. *Biodiversity and canopy composition in boreal mixedwoods: different roofs – different inhabitants?* Research Note No. 59. Sustainable Forest Management Network. Edmonton, Alberta. Online: http://www.sfmnetwork.ca/docs/e/RN_En59MixedwoodBiodiversity_Lecomte.pdf

EMEND website: http://www.emend.rr.ualberta.ca/index.asp

Management Implications

- Maintaining the mixture of small canopy patches found in the boreal forest is important for the conservation of natural habitat structure and heterogeneity required by understory plants, and other species that depend on these plants for food and habitat. The maintenance of conifer and mixed patches is particularly important for the preservation of sensitive species such as orchids.
- It is important to develop regeneration standards that allow for development of natural mixtures of canopy species in mixedwood forests, both at the landscape level and fine scales.
- These findings could also be useful in planning for patch retention after partial harvesting: large retention patches could include small patches (approximately 4 m radius, such as those studied here) of both conifer and broadleaf trees. This could help to preserve natural patterns of understory composition and diversity after forest harvesting.



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Ecosystem Management Emulating Natural Disturbance

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

ISSN 1715-0981