



Biodiversity and canopy composition in boreal mixedwoods: different roofs - different inhabitants?

Highlights

- Only in a few instances do mixed forest stands have unique species; however, some species are more abundant in mixed as compared to pure stands.
- Mixed forests often have distinct biotic communities including a combination of species found in broadleaf- and conifer-dominated forests with overall higher abundance and species richness.
- Occurrence of individual species is a function of their habitat requirements, i.e., whether the forest includes the structural / compositional features that are important to them.

Mixedwood biodiversity

Across the southern portions of the boreal forest in Canada, moderately moist sites are often dominated by forests that are a mixture of broadleaf (mainly trembling aspen, balsam poplar and birch) and conifer (mainly white spruce, black spruce, jack pine and balsam fir) trees. These forests exist as a complex mosaic of tree species and age classes shifting in time and space. The relative proportion of broadleaf and conifer species varies depending on site conditions, regeneration success of each species after disturbance, and subsequent differences in survival and growth of the tree species over time. As a consequence, 'mixed' forests have a wide compositional range that includes more or less 'pure' broadleaf, mixtures of broadleaf and conifer, and more or less 'pure' conifer stands. The different mixedwood forest types (canopy compositions) can exist either

as stands of similar age distributed across a landscape or as stands of different ages representing successional change over time.

Although many research initiatives and operational trials have been undertaken in the boreal mixedwoods, the absence of an integrated understanding of these results may hinder development and application of ecosystem management in boreal mixedwoods. As part of the 'State of Knowledge' program of the Sustainable Forest Management Network (SFMN), a group of research scientists from across Canada examined the current state of knowledge regarding the potential ecological impacts of changing the canopy composition of mixedwood forest stands and landscapes in terms of effects on biodiversity, tree productivity and soil processes. This research note is one of a series arising from this project.

Mixed forests in general are thought to be more productive than single-species stands (see SFMN Research Note No. 46, "Growing conditions and tree productivity in boreal mixedwoods: hidden opportunities for forest managers"). Likewise, there is some evidence that 'mixed' forests host a greater abundance and diversity of species. This is thought to be due to a greater variety of habitats (structural diversity, microclimatic conditions, food variety and abundance). By including elements of both conifer

and broadleaf forest types, mixed forests may provide a unique variety of habitats, thus supporting high biodiversity.

In this research note we aim to clarify our current understanding of the influence of mixedwood forests of varying broadleaf-conifer composition on their biotic communities. The following are three preliminary generalizations that emerged from this research.

Mixedwood forests can contain greater biodiversity than 'pure' forests

The literature points to several different patterns in terms of how the biotic richness (number of species) and community composition (which species) relate to variation in canopy composition in mixedwood forests. Our review suggests that broadleaf-dominated, mixed, and conifer-dominated forests do not host distinct biotic communities. There was little evidence that mixed forests are home to 'unique' species, not found in the other two forest types. However, mixedwood forests often contain more species, with greater abundances, than do 'pure' broadleaf or conifer forests. Below we summarize some of the known responses to forest canopy composition for different biotic groups.

Vascular plant understory communities

Most species occur in multiple forest types but mixed forests tend to have greater species richness because they host a combination of understory species associated with a broadleaf canopy (shade intolerant) and with a conifer canopy (shade tolerant). Heavily conifer-dominated forests may have lower vascular understory plant species richness, particularly in black spruce-dominated forests.

Nonvascular plant communities (mosses and liverworts)

Species occurrence is determined by the availability of specific substrates and microsites, for which species have strong and particular affinities. Broadleaf forests are generally recognized as having low abundance and richness of non-vascular plants. Richness and abundance increase from mixed to conifer forests as the microclimate becomes moister and a greater variety of substrates (live and dead trees of different species, sizes, and decay stages) become available.



Example of vascular plants from the mixedwood boreal forest. Photo courtesy of A. Craig.

Soil microbial communities

These organisms, which are critical to nutrient cycling and forest productivity, are a function of forest floor and soil properties. Richness of soil microbial communities is greater in mixed forests than in conifer or broadleaf stands.

Arthropods

Ground beetles and moths

Species richness is similar in all three forest types with a high degree of overlap in species presence among them.

Litter-dwelling spiders

Conifer-dominated forests have greater species richness; they include a number of species that are not found in either broadleaf-dominated or mixed forest stands.

Saproxyllic (deadwood-dependent) beetles

Mixed forests have greater species richness because of additional species not found in pure broadleaf forests. As such, mixed forest communities consist of a combination of species from broadleaf- and

conifer-dominated forests. This is likely due to the diversity of types, sizes and decay stages of downed wood and snags.

Rove beetles

Broadleaf-dominated and mixed forests have similar richness and share most species while conifer forests have lower richness; they are missing some species found in the other two forest types.

Songbirds

In Quebec, landscapes with a greater proportion of mixedwood forest have higher abundances of certain species which have been identified as mixedwood specialists (e.g., Swainson's Thrush, Blackburnian Warbler, Red-breasted Nuthatch, Black-throated Green Warbler, Bay-breasted Warbler). Mixed forest stands in Saskatchewan have higher abundance and species richness of songbirds because they host a combination of species found in broadleaf- and conifer-dominated forests. Also, some species are particularly abundant in mixedwoods or mainly occur in mixed forest stands – including the five species identified as mixedwood specialists in Quebec.



Deadwood associated beetle (*Cucujus clavipes*) from the boreal forest. Photo courtesy of C. Wood.

Overall, the response of biotic groups to varying canopy composition in mixedwoods is variable.

However for several biotic groups, mixedwood forests can be considered to host unique biotic communities because they include a combination of species found in each of the 'pure' forest types and because they often host higher abundances of certain species.

Mixedwood biotic communities reflect the habitat

A number of the studies we examined showed that the occurrence and abundance of species in different forest types is related to whether a particular forest type meets their particular habitat requirements. A common thread in these relationships is that structural features of the forest, which change with age, may be just as important as canopy composition when it comes to provision of habitat.

Vascular understory plant species are closely associated with canopy composition at the stand scale and also at the scale of small conifer-, mixed- or broadleaf-canopy patches within mixed forest stands. This almost certainly reflects the influence of canopy composition on microclimate, light, and soil conditions.

Presence and abundance of moss and liverwort species depend heavily on moisture conditions of the microsites they occupy and the availability of substrates for establishment (e.g., exposed mineral soil, live trees of different species, standing and downed dead wood of different species, sizes, and decay stages). Thus, their greater richness and abundance in conifer forests is due to moist, shady conditions and availability of a variety of types and decay stages of live and dead wood. Likewise, conifer forests have greater richness of some arthropod groups, presumably reflecting a greater reliance on large/old conifer trees. Further, arthropods depending on dead wood habitats are more species rich in mixed forests because those forests have a greater abundance and variety of dead wood.

Finally, some groups (vascular plants in black spruce-aspen mixedwoods, and rove beetles) have lower richness in conifer-dominated forests, reflecting the loss of species which require the higher light, more open and heterogeneous conditions found in mixed or broadleaf-dominated forests.



The Blackburnian Warbler, which has been repeatedly identified as a mixedwood specialist, is more likely to occur in New Brunswick stands that contain a combination of both large deciduous and conifer trees. Even a small patch which includes both large deciduous and conifer trees, which are used for both foraging and singing, is suitable for establishment of a territory.

In summary, it is not *only* the mixture of tree species in the canopy that is important for the canopy composition - biodiversity relationships in mixedwood forests. Rather, it is the canopy composition, forest age and the habitats provided. It is therefore important to preserve mixedwoods of various ages and regenerate many different mixedwood types to maintain habitat for the full range of mixedwood forest species. In addition, there are potential productivity benefits in preserving the natural diversity of tree species, and the biota that depend upon the resulting heterogeneity in these forests.

Can we maintain forest type – biodiversity relationships in managed forests?

Little empirical evidence exists about how forest canopy composition – biodiversity relationships will develop over time in managed mixedwood forests. The history of managed mixedwoods in North America is too recent to draw conclusions about long-term influences of management practices on canopy composition, or to determine the implications for biodiversity. Studies from Fennoscandian countries, where boreal forests have been managed over a longer time frame, provide important insights. The vast majority of species which have experienced extirpation or dramatic declines in abundance are those which depend upon the occurrence of broadleaf trees, the availability of deadwood, or the occurrence of wildfire. Thus we may conclude that these are important considerations in maintaining biodiversity in managed mixedwood forests.

Some experimental studies in Canada are beginning to yield results as well. Several studies have shown, for example, that early post-fire forests host unique biotic communities and that salvage harvesting dramatically changes these. Thus, retaining some unmanaged post-fire forests may be critically important for the long-term sustainability of these fire-specialist species. For understory vascular plant communities and arthropods, some evidence suggests that harvested and post-wildfire forests 'converge' over time (by about 30 years) but the influence of canopy composition on these communities develops quickly. Thus, management effects on canopy composition will have important implications for development of the associated biotic communities. Other studies are beginning to provide important information on how innovative harvesting approaches can be used to create forest structural and habitat characteristics that will help retain, or facilitate rapid redevelopment of, biotic communities of arthropods, birds, amphibians and mammals. It is critical to understand, however, whether stands of the same canopy composition but of different age will have similar biodiversity. For example, will managed conifer stands that are less than 100 years old provide the same habitats as older (more than 100 years) unmanaged stands? In other words, if we build it, will they come?

What can managers and policy makers do?

- **Manage mixedwoods as a mosaic of patches of varying canopy composition at a variety of spatial scales.** The biotic communities that currently exist in the boreal mixedwood landscape are a function of the natural mosaic of forest types, which is dynamic in time and space. Maintenance of this natural mosaic, including mixtures of stand types across the landscape as well as some stands with heterogeneous and intimate mixtures of broadleaf and conifer trees, is a safeguard to continued sustainability of mixedwood biotic communities. In other words, don't do the same thing everywhere.
- **Recognize the importance of structural habitat elements.** Many biotic groups depend not only on the canopy composition of a given forest type, but also on key environmental or structural characteristics (dead wood, larger conifer trees, gaps, moist microsites) that



are associated with a given forest type and age. Maintaining these important structural elements in managed forests will be important for sustaining biotic communities.

- **Recognize the biodiversity value of both young and old forests.** Some of the important structural elements in forests become available only given enough time and some biotic groups require long time periods after disturbance to colonize a forest stand and establish viable populations. Conversely, forests during the short time-frame after natural disturbance provide unique structural and environmental characteristics that are critical for certain ‘disturbance-’ or ‘fire-’ dependent species. To support all the different types of biota, it will be important to maintain some naturally-disturbed, unmanaged forests as well as some unmanaged older forests within the mixedwood landscape.

Further reading

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Management Implications

- The inherent variability in mixedwoods is critical to biodiversity. Maintaining patches of varying canopy composition at a variety of spatial and temporal scales will help to ensure this variability persists.
- In addition to maintaining a variety of mixedwood forest types, ensuring a diversity of forest ages and the structural features associated with them is important for provision of habitat for a wide variety of forest biota.
- Both old forests and those which are recently disturbed provide unique habitats. It is therefore important to maintain older forests as well as unsalvaged burnt stands on the landscape.



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