

Introduction: Ecology and silviculture of temperate mixedwood forests¹

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Mixed-species forests are, or were, a common feature of most forested regions around the globe (Bauhus et al. 2017b). The ecology and silviculture of these systems has been a consistent area of study given the potential benefits of mixed-species forests in relation to minimizing forest health and climate change impacts (Bauhus et al. 2017a) and the occasional higher levels of productivity observed for species mixtures relative to single-species stands (Lu et al. 2016). Nevertheless, the restoration and maintenance of mixed-species forests remains a significant challenge given the complexities of developing silvicultural systems that accommodate a range of silvical traits and resource requirements, particularly where historic land use and current stressors limit recruitment opportunities for constituent species (Pach et al. 2018).

This special issue explores the ecology and silviculture of mixed-species, hardwood–softwood forests in temperate regions of eastern North America, ecosystems frequently referred to as “mixedwoods” in various regions. The “mixedwood” classification has largely been applied in the context of north-temperate and boreal mixtures of hardwood and softwood species in North America (e.g., Bouchard et al. 2007; Leak et al. 1987; Lieffers et al. 1996; Reinikainen et al. 2012), with softwood components composed of shade-tolerant genera, namely *Abies*, *Picea*, *Thuja*, and *Tsuga*. Nevertheless, hardwood–softwood mixtures are a natural component of many regions beyond those in which this term has been historically used, and this special issue examines their silviculture and dynamics across temperate regions of the eastern United States (US) and Canada, including *Quercus–Pinus* mixedwoods in which the conifer is the more shade-intolerant, and disturbance-dependent species compared with the competing hardwood species. This special issue brings together four papers representing the culmination of several years of collaboration on temperate mixedwoods between scientists in the USDA Forest Service Northern Research Station, Quebec Ministry of Forests, Wildlife, and Parks, and several US and Canadian universities. These papers provide an expanded look at the ecological and economic importance of temperate mixedwoods across a diverse and broad geography spanning from the Central Hardwood Forest Region to the Acadian Mixed Forest Region and describe a general framework for guiding silvicultural strategies to restore and maintain key attributes of these systems, namely their mixed-species condition.

In many temperate regions of eastern North America, the extent of mixedwood forests has been greatly reduced, largely due to past land-use practices that either discriminately removed high-value conifer species or generated disturbance regimes that differentially favored hardwood regeneration via vegetative reproduction (Kenefic et al. 2021). Despite this historic dynamic, mixedwood

forests still occupy large areas of the eastern US and Canada, including over one-quarter of the total area of northern US forests (Vickers et al. 2021). The first set of papers in this special issue describe the current status of mixedwood systems in the northern US based on recent inventories collected as part of the USDA Forest Service Forest Inventory and Analysis Program, as well as the associated ecological mechanisms underlying the stability and dynamics of these systems (Kern et al. 2021). Collectively, these works underscore the challenges with sustaining these mixtures in managed areas, with recent transitions away from mixedwood conditions towards greater hardwood or conifer dominance often associated with forest harvesting (Vickers et al. 2021).

MacLean and Clark (2021) review the consequences of the above-mentioned loss of mixedwood conditions from a forest health perspective with examples from native and non-native insect pests in eastern North America. This work highlights several case studies from temperate mixedwood forests in which these systems experienced both lower levels of mortality and higher rates of recovery from insect outbreaks relative to stands composed of a single species or genus (MacLean and Clark 2021). Given observed and projected increases in the prevalence and impacts of native and non-native insects and diseases with climate change (Lovett et al. 2016; Seidl et al. 2017), these findings underscore the importance of silvicultural strategies that can restore and sustain mixedwood conditions that are more resilient to these threats. To this end, the final paper in this special issue explores the silvicultural challenges associated with maintaining mixedwood conditions for five ecologically and economically important temperate mixedwood systems (Kenefic et al. 2021). These challenges largely relate to sustaining the conifer components of each mixedwood system, and several potential silvicultural systems and strategies for maintaining these species are outlined based on their respective shade tolerance and dependence on disturbance to promote regeneration and recruitment into positions of dominance in the overstory canopy.

Together, the papers in this partial special issue of the *Canadian Journal of Forest Research* highlight the importance and benefits provided by temperate mixedwood forests, as well as the associated challenges with sustaining these systems due to the legacies of past land use and changes to disturbance regimes. In the past, mixedwoods resulted from natural disturbances and processes or were unplanned artifacts of human land use. This synthesis lays the foundation and recommends approaches for restoration and sustainable, purposeful management of mixedwood forests. The ecological mechanisms underlying the historic maintenance

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of these mixtures and associated silvicultural frameworks for restoring these systems are broadly applicable to mixedwoods in other regions of the globe and can inform efforts to increase mixed-species forest conditions to address changing climate and disturbance regimes.

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