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Influences of stand composition and age on forest floor processes and chemistry in pure and mixed stands of Douglas-fir and paper birch in interior British Columbia

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Abstract

The influence of stand composition and age on forest floor chemical properties, nitrogen availability, and microbial activity was examined in mixed and pure stands of Douglas-fir (*Pseudotsuga menziesii*) and paper birch (*Betula papyrifera*). Decomposition of Douglas-fir and birch litter over two years as well as annual litter input was also measured. Mixed and pure stands of each species aged 10–25, 50–65 and >85 years old were selected in the Interior Cedar Hemlock (ICH) zone of southern interior British Columbia. Significantly more total N was mineralized in the forest floor of pure birch compare to that of pure Douglas-fir stands while forest floor of mixed species stands had intermediate N mineralization values. When sampling times were pooled forest floor N mineralization was lowest in the young stands compared to the older stands. Stand composition did not significantly affect litter decomposition were found in litter decomposition, microbial respiration and biomass. Stand age, however, did affect these parameters significantly. More birch litter mass was lost in young stands than in their older counterparts while the opposite trend was observed for fir litter. Generally, lower basal respiration, microbial biomass and C_{mic}/C_{org} was found in young compared to older stands. Concentrations and contents of forest floor total N and exchangeable K and Mg, and pH under pure birch were consistently higher compared to pure Douglas-fir. While forest floor total C, available P contents, exchangeable K and Mg concentrations were lowest in young stands, no differences were observed for total N and exchangeable Ca. All litter nutrient concentrations and contents were highest in pure birch stands. No clear trends could be discerned in litter nutrient concentration data among stand ages, although when converted to nutrient contents, there was a general increase with stand age. Both stand type and age had significant effects on forest floor properties and processes suggesting that stand age is another factor to evaluate when assessing the influence of forest composition on forest floor

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processes and chemistry. In terms of the effect of mixture, the data indicated that the maintenance of paper birch in mixed stands in these forest may have some effect on nutrient availability and status.

Keywords: Douglas-fir; Paper birch; Mixed-species stands; Stand age; Forest floor processes; Forest floor chemistry

1. Introduction

In the Cedar-Hemlock forest zone (ICH) in the southern interior of British Columbia, regenerating and early seral stands often contain a mixture of broadleaved species, especially paper birch, and conifer species. As these stands develop, forest cover moves from broadleaf dominance to predominantly conifers. This change is generally assumed to be associated with changes in forest floor and mineral soil properties, although there are few published studies confirming these soil changes in the region (Simard, 1996). In other forest types, forest composition affects both forest floor and mineral soil processes. In the boreal forests of eastern Canada, for example, organic carbon (C), total nitrogen (N) and pH were found to be higher (Brais et al., 1995; Paré and Bergeron, 1996; Bauhus et al., 1998) under broadleaved stands compared to conifers, whereas N availability was significantly lower in the broadleaved stands.

The influence of species, particularly the difference between broadleaves and conifers, on N mineralization rates has been demonstrated in many field and laboratory trials (Gower and Son, 1992; Harmer and Alexander, 1986; Prescott and Preston, 1994; Thomas and Prescott, 2000). Many studies have observed significantly higher net N mineralization rates under broadleaves compared to conifers in both the forest floor and mineral soil (Flanagan and Van Cleve, 1983; Gower and Son, 1992; Van Cleve and Viereck, 1981). However, results are far from consistent and appear to be highly species dependent. Binkley and Valentine (1991) observed higher net N mineralization under white pine compared to green ash while Côté et al. (2000) found higher net N mineralization (expressed on a C weight basis) in the forest floor of boreal deciduous stands compared to conifers. On the other hand Prescott (1996) found higher forest floor net N mineralization in Douglas-fir compared to red alder and in a subsequent study, Thomas and Prescott (2000) also found significantly higher potential N mineralization in the forest floor of Douglas-fir compared to birch.

Species mixtures have complex effects on forest floor processes that do not appear to be easily predictable from the effects of their pure counterparts. Some have suggested that soil nutrient cycling may be enhanced in mixtures, particularly mixtures of broadleaves and conifers (Aber and Melillo, 1991; Simard and Vyse, 1994; Peterson et al., 1997). Rothe and Binkley's (2001) review of the literature, however, notes a wide range of effects for mixedwoods with respect to nutrient cycling. Mixtures with broadleaves or other conifers can have the same, positive or negative impacts on nutrient cycling compared to pure stands. For example, Chapman et al. (1988) found that decomposition increased under spruce/pine mixture compared to their pure counterparts while decomposition proceeded slower in spruce/alder and spruce/oak mixtures. Côté et al. (2000) found higher N mineralization in the forest floor of broadleaf compared to conifer-dominated boreal mixedwood stands. These contrasting results point to the need for studies within specific ecological areas. A move towards more extensive, less intrusive silvicultural practices, which allows the development of mixed stands in northern temperate forests also underlines the need for such studies.

Stand age can also play a significant role in determining forest floor processes and chemistry. It has been suggested that substrate quality declines with stand development and that mineralization and decomposition are incomplete as succession proceeds (Bauhus et al., 1998). Brais et al. (1995) and Paré and Bergeron (1996) found sharp declines in forest floor nitrification rates with increasing age in boreal mixedwoods. Bauhus et al. (1998) found a decline in microbial respiration with stand age but an increase in specific microbial respiration ($qCO_2 = CO_2 - C$