With live fuels the fuel moisture content variation is less, and not that much dependent on weather conditions. In Fennoscandian conditions, live fuels are not very flammable, but are still important, as they are the main component in crown fires, thus affecting fire spread. For example, needles of coniferous trees contain terpenes that have been shown to contribute to flammability, fire spread and even crown fire regimes (Dewhirst et al., 2020). Relatively small changes in the fuel moisture contents of the needles can increase crown fire risk and fire spread (Agee et al., 2002).

At the forest stand level, there are horizontal and vertical fuel components that affect fire

spread, and at the landscape level, myriad patches of forest exist, each with a unique fuel structure that may carry fire along the surface or through the tree crowns (Ryan, 2002).

**Fire spread.** Fire spread is a function of fuels, weather and topography, and could be called

the fire behaviour triangle (Agee, 1993). All have significant effects on fire behaviour and

spread, but the fuels are most related to forest structure, and are the only one of the three that

can be controlled. Topography, slope and aspect affect fire spread. Changes in slope, aspect,

elevation and soil affect available energy and water budgets and plant communities. These

features also have a major influence on fire-caused disturbance through their role in

determining moisture conditions and flammability of fuels on hourly, seasonal and successional timescales (Ryan, 2002).

Some forest floor

fuels, such as mosses (Hylocomium splendens, Pleurozium schreberi) and reindeer lichens

(Cladonia spp.) do not have good water-holding capacity, and therefore their moisture content

varies largely with weather conditions. Thus, they dry quickly and are important fuels for

ignition and fire spread (Schimmel and Granström, 1997; Tanskanen, 2007). In Scots pine

forests, the dominance of pleurocarpous mosses and occasionally lichens in the forest floor

vegetation leads to higher ignition risk than in spruce forests, where lichens are much rarer.

Lichens also dry more quickly than pleurocarpous mosses (Lindberg et al., 2021)

Different

fuels have varying moisture-holding capacities, and finer surface fuels, for example, can

become flammable during periods of warm and dry weather much more quickly than the

organic layer in the soil (e.g. Van Wagner, 1974). Depending on the moisture content,

consumption of the organic layer in surface fires can sometimes be very limited (Schimmel and

Granström, 1997; Tanskanen et al., 2005; Lindberg et al., 2021). Normal seasonal changes in the dryness of the fuel load, its packing and possible periodic

drought influence fire intensity (Ryan, 2002). Despite the relatively low flammability of

spruce stands, Norway spruce is the most susceptible tree species in Northern Europe to burn

explosively (Lindberg et al., 2011). The role of coarse woody debris (CWD) for fire intensity has not been studied much (but see review by Hyde et al., 2011), but it is likely to be higher in drier ecosystems with high amounts of CWD. With today’s intensive forestry, CWD levels are low in Fennoscandian forests, except in pristine Russian forests and it can be assumed that the role of CWD for fire intensity is rather low.

The principles of lower fire risk and fire intensity, such as reducing surface fuels, increasing

the height to the live crown and decreasing crown density as suggested in North America (Agee

and Skinner, 2005) have largely been normal practices in Fennoscandian forestry for about 60–

70 years, which has lowered fire risk and fire intensity (Lindberg et al., 2011)

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