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Evaluating the effects of fire severity and post-fire management decisions on the carbon balance of a Swedish forest

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Boreal forest fires are increasing in frequency and intensity due to climate change. Yet there is little knowledge on the impacts of fire severity and post-fire management decisions on the regeneration and carbon balance of production forests in Eurasia. To investigate these issues, we established 6 sites in a Swedish *Pinus sylvestris* forest that burned in 2018. Specifically, we evaluated the effects of (i) fire severity (low severity ground fire vs high severity stand-replacing canopy fire), (ii) post-fire wood management (salvage-logged vs unlogged) and (iii) post-fire vegetation management (natural regeneration, seeding or planting nursery seedlings of *P. sylvestris*). At each site, we measured soil respiration (CO_2 release to the atmosphere) and methane fluxes (soil CH_4 uptake) using the manual chamber approach, soil microclimate and vegetation cover for the first 3 years after the fire (2019-2021). Two of the sites also have eddy covariance flux measurements, which provided an insight into the ecosystem-scale carbon balance.

Fire severity had a strong impact on forest soils, with high fire severity sites having lower soil respiration, warmer soils and less vegetation regrowth compared to a low fire severity site. Surprisingly, soil respiration was similar at a low fire severity site and unburnt site, despite the almost complete loss of the soil organic layer during the ground fire. There were no clear effects of fire or post-fire management on the soil methane fluxes. Salvage-logging of a high fire severity site had no additional effects on soil respiration compared to leaving the dead trees standing. Salvage-logging of a low fire severity site led to a decline in soil respiration, but turned the ecosystem into a net source of CO_2 due to the removal of the living trees. In terms of *P. sylvestris* regeneration, our results showed that the seedling density following natural regeneration was similar to or higher than the seedling density in sites which had been manually seeded or replanted with nursery seedlings.

Our results suggest that post-fire management interventions may not facilitate faster vegetation regrowth and the recovery of carbon uptake by forests compared to natural regeneration in the immediate post-fire years. Furthermore, despite the start of new vegetation growth and declines in soil CO_2 release, the high fire severity and/or salvage-logged sites remain net CO_2 sources 3 years after the fire, which must be considered in estimations of the net effect of fires on Sweden's forest carbon balance.