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Comprehensive radiative forcing assesment highlights trade-offs in climate mitigation potential of managed boreal forests

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Boreal forests have an important role in the mitigation of climate change. In this study we evaluated four key climate impacts of forest management: (1) carbon sequestration (in forest ecosystems and wood products), (2) surface albedo of forest area, (3) forest originating Secondary Organic Aerosols (SOA) and (4) avoided CO_2-emissions from wood energy and product substitution. We calculated their net effect at both a single stand and regional level using Finland as a case study. We made analyses both in current climate up to a year 2050 and in the projected climate of year 2050.

At the stand level, the carbon sequestration effect and avoided CO_2 emissions due to substituted materials dominated in net RF in current climate. The warming effect of surface albedo of forest cover was lower or of same magnitude than cooling effect of SOAs. Together, the rarely considered SOAs and product substitution corresponded over 70% of the total cooling effect of forest cover. The cooling effect of net radiative forcing increased along the increasing site fertility. Although the carbon stocks of broadleaved trees were smaller than that of conifers their total radiative cooling effect was larger due to the integrated albedo and aerosol effects. In the projected climate of 2050, the radiative cooling of aerosols approached the level of forest carbon fixation. These results emphasize the need for holistic evaluation of climate impacts over simple carbon sequestration analysis to understand the role of forest management in climate change mitigation.

Landscape level analyses emphasized the broad range of options to reach the cooling effect. The lowest harvest regime, 50% of current annual increment (CAI), yielded the largest cooling effect. Yet, harvests up to CAI produced only slightly less cooling RF if avoided emissions were considered. This result was highly sensitive to used substitution factors. Our result highlights that the combination of intensive harvests and the use of wood for bioenergy is not beneficial from a climate change mitigation viewpoint while sustainable use of timber is. If the goal is to mitigate climate change, boreal forest management should favor mixed forest stands and intensive harvests are preferable only if coupled with long lasting end products replacing energy intensive products.