

Long-term effects of clear-cutting and site preparation on carbon, nitrogen, phosphorus and suspended solids export to boreal first order streams

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Clear-cutting has been observed to generally increase leaching and element exports to adjacent watercourses. Most studies on the effects of clear-cutting on nutrient export in north European boreal forests have been short-term and were carried out in the 1970s and 1980s when forestry practices were different from those of today. Nowadays clear-cut areas are smaller, soil preparation methods are lighter (less soil disturbance), and buffer zones are left along watercourses. Several hundred thousand hectares of forests are clear-cut and soils are scarified before regeneration operations in Fennoscandia, but little is known of the long-term impacts of the current methods on the surface water quality.

We studied the long-term (14 years) effects of clear-cutting and site preparation on runoff (mm) and the export of total nitrogen (total N), total organic nitrogen (TON), ammonium (NH4-N), nitrate (NO₃-N), total phosphorus (total P), phosphate (PO4-P), total organic carbon (TOC) and suspended solids (SS) in two paired-catchments in Eastern Finland. In accordance with current forest management guidelines, clear cutting (stem-only removal) were carried out on 34% (C34) and 12% (C12) of the area of the treated catchments, scarification carried out after 2 years and planting with Scots pine seedlings after 3 years. Buffer zones were left between the clear-cut areas and the catchment outlet stream.

In the case of the C34 catchment, clear-cutting increased annual runoff and exports of total N, TON, NO₃-N, PO4-P and SS. Annual runoff increased by 4 - 102 mm (1-30%). The annual exports of total N, TON, NO₃-N, PO4-P and SS increased by at most 0.36 (72%), 0.35 (76%), 0.15 (1056%), 0.002 (35%) and 2.0 (715%) kg/ha, respectively. For the C12 catchment, annual runoff did not change and only exports of PO4-P and SS increased. Annual export of PO4-P increased by at maximum 0.007 kg/ha (69%) and that of SS by at maximum 0.55 kg/ha (271%). Clear-cutting induced increases in runoff and element export loads were at the lower end of the range reported in the other Fennoscandian studies.

The results indicated that clear-cutting and subsequent soil preparation, even with the current methods have potential to increase runoff and the export of N, P and SS and the effects can be long-term (> 10 years). The results suggest that the leaching losses are diminished when the size of the clear-cut area in relation to the size of the catchment decreases.