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Broadleaved tree species in conifer-dominated forestry: Regeneration and limitation of saplings in southern Sweden

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Abstract

Forests and forestry in Sweden are dominated by conifers. Silviculture using mixed or broadleaved stands is often recommended, but the degree to which broadleaves regenerate naturally needs to be clarified. The Swedish National Forest Inventory is here used for a region-wide study of broadleaved saplings (1.3 m tall to 4.9 cm dbh) regenerated naturally. For 12 species (taxa) in young forests (<7 m tall) and high forests (≥7 m), sapling densities were related to seven forest types and three productivity classes. Birch had highest densities in all but two broadleaved forest types. Birch, oak, rowan and sallow had 70–85% of their total sapling populations in conifer-dominated forest types, indicating good potential for mixed stands. Beech, lime, hornbeam, ash and elm were mostly restricted to 'noble' (hardwood) forests. The regeneration success (saplings per mature tree) for birch, rowan and oak was highest in conifer-dominated forest; beech was about equally successful in conifer-dominated and broadleaved forests, and ash was very successful in broadleaved forest. Oak regeneration may be problematical in broadleaved forests, but we suggest this is not the case in conifer-dominated forests (where oaks have rarely been studied). Sapling densities of the species in the forest types were not consistently correlated with productivity, but birch and aspen generally regenerated strongest at intermediate and at high productivity, respectively. In noble forests, oak, ash and elm regenerated strongest at low productivity. The role of asexual regeneration (sprouting) remains to clarify. Our results suggest that lime, elm, ash and some other trees currently are limited mainly by poor dispersal, rather than habitat availability. The results are promising for various forms of mixed-species forestry that does not require planting (or little planting) and that would be beneficial for nature conservation.

Keywords: Sustainable forestry; *Betula*; *Populus*; *Quercus*; *Fagus*; *Sorbus*; *Salix*; *Fraxinus*; *Ulmus*; *Tilia*; *Acer*

1. Introduction

In many parts of Europe and elsewhere, forestry is based mostly on even-aged conifer stands harvested under short rotations by clearcutting (or removal of

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almost all large trees). In repeated thinnings, most of the broadleaved trees are cut or harvested. There are disadvantages with such forestry, if it comes to dominate as in Sweden. Even-aged conifer stands generally have low value for wildlife (SEPA, 1994; Gustafsson and Ahlén, 1996; Hunter, 1999), may be susceptible to pests and global warming (Young and Giese, 2003; Sykes and Prentice, 1996; Bradshaw et al., 2000) and may create more acid soils (Nordborg and Olsson, 1999). Norway spruce (*Picea abies*), common in Europe, is also susceptible to wind-throw. Forest owners have been encouraged to plant or to favour native broadleaved trees for forestry and biodiversity purposes (Persson, 1990; Gustafsson, 2000; Zerbe, 2002). In these contexts, the benefits of mixed coniferous-broadleaved forests are often mentioned (Mosandl and Kleinert, 1998; Olsthoorn et al., 1999; Thelin et al., 2002; Johansson, 2003).

In northern Europe, the most common broadleaved trees are silver birch (*Betula pendula*) and hairy birch (*B. pubescens*), forming 10% of the total wood volume and 53% of the volume of broadleaves in southern Sweden (see below). High seed production and rapid growth in open clear-cut areas favour birches; however, they are mostly eliminated in repeated thinnings (Simard et al., 2004, and references therein). In Sweden, usually only a few mature trees per hectare (mainly birch, aspen *Populus tremula*, and/or Scots pine *Pinus sylvestris*) are retained for biodiversity at clearcutting. Given the goal of changing the forest composition to resemble more natural conditions (SOU, 1992), the broadleaved trees need more attention. For both forestry and conservation work, the factors limiting regeneration of broadleaved tree species are of interest. Beside historical human use of forests (Peterken, 1996; Lindbladh et al., 2000), tree species may be limited by, e.g., seed production, seed dispersal, and availability of habitat for growth (Clarke et al., 1999). Most of the present south Swedish forest consists of planted coniferous trees, whereas natural forests in this region were dominated by broadleaves, or mixed coniferous-broadleaved forests (Lindbladh et al., 2000 and references therein). Conversion of especially spruce forest to mixed or broadleaved stands is desirable (SOU, 1992; Spiecker et al., 2004). Here we analyse regeneration of 12 broadleaved tree species that occur in or have colonized the forests of southern Sweden. Moreover, to examine habitat limitation in these species, we analyse regeneration in relation to site productivity (site index).

Below, we first briefly present regeneration patterns (sapling densities) of broadleaves in the forests. The data are then used to answer the following three questions: (1) do the 12 broadleaved tree species differ in regeneration (i.e. production of small trees, saplings) in the forest types; in particular, does regeneration differ in coniferous versus broadleaved forests, indicating conditions that limit some species? (2) Are some species more successful in producing saplings (per capita mature trees) in coniferous than in broadleaved forest? (3) To what extent is regeneration in the species related to, or limited by site productivity?

Broadleaved trees in conifer-dominated forestry occur naturally as seedlings and saplings, while their densities as larger trees are determined mainly by the cutting regime, where thinning is important. In Sweden, regeneration of broadleaves has not been analysed at regional level, which is done here for saplings using data from the Swedish National Forest Inventory (NFI). We selected the southern part of Sweden for study, where most of the broadleaved tree species occur. Although seedlings of trees (<50 cm tall) may be 'persistent juveniles' for long periods (Grime et al., 1988; Tapper, 1992), saplings more reliably indicate regeneration potential of the species, as mortality is lower for saplings than for seedlings. We studied saplings defined as stems from breast height (>1.3 m) up to stem diameter of 4.9 cm, dbh (referred to as 0.1–4.9 cm dbh). The majority of these saplings had not been affected by thinning (the cohort is dominated by small saplings about 0.1–2.5 cm dbh; see also below), and so regeneration was mainly determined by the natural processes of seed production, seed dispersal, germination, growth, or sprouting from cut stems or roots. For larger saplings (diameter interval 5.0–9.9 cm dbh in our data sets), densities were much lower, mainly due to thinning. We compared regeneration in all major forest types in the landscape of southern Sweden; three coniferous ones (strongly predominating in area), one mixed, and three broadleaved forest types. We analysed regeneration in young forest and in higher forest where saplings form advance regeneration that may be important for the stand after cutting (Greene et al., 1999; Nyland, 2002). We end by discussing factors limiting the broadleaved tree species in relation to