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Establishing mixed forests in Sweden by combining planting and natural regeneration—Effects of shelterwoods and scarification

Urban Nilsson [a,*], Göran Örlander [b], Matts Karlsson [a]

[a] SLU, Southern Swedish Forest Research Centre, Box 49, 230 53 Alnarp, Sweden
[b] School of Industrial Engineering, Växjö University, SE-351 95 Växjö, Sweden

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Abstract

This study investigated the combination method which is defined as a method where natural regeneration of Scots pine (*Pinus sylvestris* L.) is combined with planting of Norway spruce (*Picea abies* L. Karst.). An experiment with planting of Norway spruce seedlings with and without soil scarification in shelterwoods of Scots pine and on clearcuts was established on 22 sites in southern, central and northern Sweden. Survival of Norway spruce and density of Scots pine was higher in shelterwoods than on clearcuts whereas height growth of Norway spruce, Scots pine and birch (*Betula pendula* Erh. and *Betula pubescens* Roth.) was lower in shelterwoods. Survival and height of planted Norway spruce, density and height of naturally regenerated Scots pine and density of naturally regenerated broadleaved species were positively affected by scarification. Naturally regenerated Scots pine seedlings were small in comparison to planted Norway spruce seedlings 5–8 years after planting. This was most evident in southern Sweden where the height difference between the planted Norway spruce and naturally regenerated Scots pine was too large for pine to be a part of the future stand.

Keywords: Regeneration; Silviculture; *Pinus sylvestris* L.; *Picea abies* L. Karst.; *Betula pendula* Erh.; *Betula pubescens* Roth.

1. Introduction

The combination method is defined as a method where natural regeneration of Scots pine (*Pinus sylvestris* L.) is combined with planting of Norway spruce (*Picea abies* L. Karst.) (Karlsson and Örlander, 2004). In this method, shelter trees of selected Scots pine (100–150 per ha) are left at final cutting and the area is subsequently scarified and planted with Norway spruce. The combination method is recommended on medium fertile sites where a mixed conifer stand is desired and/or where natural regeneration is difficult (Karlsson and Örlander, 2004). An inventory by the Swedish National Board of Forestry in 1999–2001 showed that a combination of natural regeneration and planting was used on ca. 10% of the regenerated area in Sweden, mostly in southern and central Sweden (Strömberg et al., 2001). Despite the extensive use of this method, it has not yet been examined on a larger scale.

One important objective when using the combination method is to create mixed forests consisting mainly of Scots pine and Norway spruce. Mixed forests are, in comparison to monocultures, regarded to be advantageous concerning risk for e.g. damage by root-rot and wind, and also to have increased forest productivity on medium fertile sites (Lindén, 2003). They are also considered to preserve biological diversity better (Meilikäinen and Hynynen, 2003), and are more sustainable regarding nutrient balance than monocultures (Sverdrup et al., 2002).

Natural regeneration of Scots pine is usually carried out using seed trees. The numbers of seed trees per ha are typically 50–100 ha^{-1}, i.e. lower density than in a shelterwood. The cone production of Scots pine is variable between years, especially in northern Sweden (Leikola et al., 1982). Generally, seed trees increase their seed production after release (Karlsson, 2000b; Karlsson and Örlander, 2002), but since there is a 3-year seed cycle in Scots pine, the increase does not normally occur until the fourth season after release (Karlsson, 2000b). The cones open and disperse most seeds in May–June during the year after seed ripening. Seeds are usually only dispersed short distances (Hagner, 1962; Beland et al., 2000; Karlsson, 2000a). Soil

* Corresponding author. Tel.: +46 40 415193; fax: +46 40 462325.
E-mail address: Urban.Nilsson@ess.slu.se (U. Nilsson).

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