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Inverting Improves Establishment of *Pinus contorta* and *Picea abies*—10-year Results from a Site Preparation Trial in Northern Sweden

GÖRAN ÖRLANDER[1], GÖRAN HALLSBY[2], PER GEMMEL[3] and CHRISTER WILHELMSSON[2]

[1]*Swedish University of Agricultural Sciences (SLU), Southern Swedish Forest Research Centre, Asa Forest Research Station, S-360 30 Lammhult, Sweden,* [2]*SLU, Department of Silviculture, S-901 83 Umeå, Sweden and* [3]*SLU, Southern Swedish Forest Research Centre, P.O. Box 49, S-230 53 Alnarp, Sweden*

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Örlander G.[1], Hallsby, G.[2], Gemmel, P.[3] and Wilhelmsson, C.[2] ([1]Swedish University of Agricultural Sciences (SLU), Southern Swedish Forest Research Centre, Asa Forest Research Station, S-360 30 Lammhult, Sweden, [2]SLU, Department of Silviculture, S-901 83 Umeå, Sweden, and [3]SLU, Southern Swedish Forest Research Centre, P.O. Box 49, S-230 53 Alnarp, Sweden). *Inverting improves establishment of Pinus contorta and Picea abies—10-year results from a site preparation trial in northern Sweden.* Received Jan. 15, 1997. Accepted Apr. 10, 1997. Scand. J. For. Res. 13: 160–168, 1998.

The effects on seedling survival and growth of a new scarification method, inverting, were evaluated over 10-yrs after planting lodgepole pine and Norway spruce on a 2-yr-old clear-cut in northern Sweden. Inverting, which provides planting spots containing humus turves covered in loose mineral soil without making mounds or ridges, was compared with ploughing, mounding, disc trenching, and no scarification. Subplots with high or low planting positions were used to assess small-scale topographical effects. For both species, the treatment ranking according to stem volume production after 10-yrs was inverting > ploughing ≥ mounding = disc trenching > no scarification. Inverting improved seedling height growth by approximately 35% compared with mounding or disc trenching and by more than 100% compared with no scarification. High survival rates were also found following inverting, but only the no-scarification treatment resulted in a statistically significant reduction in survival rates (ca. 25%) for both species. Further development of the inverting technique might give environmental advantages compared with conventional mechanical site preparation. *Key words: disc trenching, inverting, mechanical site preparation, mounding, Picea abies, Pinus contorta, plantation establishment, ploughing, soil temperature, soil water potential.*

INTRODUCTION

Mechanical site preparation is generally considered an efficient method to achieve acceptable seedling survival and growth in boreal forest plantations. Over the years, various machines and equipment have been developed for this purpose. Soil treatments usually involve exposing the mineral soil, often through the formation of mounds or ridges, with the aim of creating a favourable microclimate, soil temperature, and water supply for seedling establishment. At the same time, frost injuries, insect damage, especially that caused by the pine weevil (*Hylobius abietis* L.), and competing vegetation can be reduced (Örlander et al. 1990). At present, the most common mechanical site preparation methods used on boreal sites are disc trenching, patch scarification, mounding, and ploughing. In the case of mounding and ploughing, forest floor material is usually incorporated at the planting spot in order to improve mineral nutrient availability. The terms "ploughing" and particularly "mounding" have wide definitions (Sutton 1993). Nevertheless, provided that the planting position and planting depth are chosen with care, these two methods (in their various forms) generally improve conditions for seedling establishment and growth in most of the aforementioned respects (Söderström et al. 1978, Örlander et al. 1990, 1991, Sutton 1993).

A number of disadvantages related to ploughing and mounding have also been identified. Inverted mounds of humus, or mounds on undisturbed humus (and the corresponding results from ploughing), can cause seedling drought, especially in areas with low humidity during the growing season (Örlander 1986, Örlander et al. 1991). Asymmetric root development (Coutts et al. 1990) and reduced stability of young trees (Veremeva & Smirnov 1985) have also been observed after ploughing. Planting in mounds might restrict root development and lead to stability problems, at least on wet sites or sites with a compact surface layer (cf. Pryce 1983). Furthermore, the high

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