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Deep Planting Has No Short- or Long-Term Effect on the Survival and Growth of White Spruce, Black Spruce, and Jack Pine

Alain Paquette, Jean-Pierre Girard, and Denis Walsh

ABSTRACT

Although studies in the past have reported that the deeper planting of conifers has no effect on seedling performance, most planting guidelines in use today still recommend that seedlings be planted to the root collar. Past studies were mostly observational, used bareroot seedlings, and often reported early results from just one or two depths of planting treatments. Most of the results available regarding planting depth for boreal species are anecdotal, although they are planted by the hundreds of millions every year. The present study reports no short-term (1 year) or long-term (15 to 19 years) negative effect of planting depth on the survival and height and diameter growth of black spruce, white spruce, and jack pine seedlings over three large, replicated experiments in the boreal forest of eastern and northern Quebec (eastern Canada). Four different depth treatments were compared, from manual planting at the root collar to the deepest mechanical planting treatment at 10 cm or more, making this the largest, longest-lasting study of its kind. Although, as expected, important differences in growth were present between species, all three commonly planted conifers reacted similarly to the planting depth treatments (no effect). This result can in part be attributed to an almost perfect control of frost heaving in the deepest two treatments. Planting depth effects were assessed using analysis of variance, multiple Tukey honestly significant difference, and uncorrected pairwise one-tailed *t*-tests to increase the probability of detecting a negative effect. Absolute differences and effect sizes (generally small and often positive with greater depths) were also analyzed.

Keywords: *Picea glauca*, *Picea mariana*, *Pinus banksiana*, planting depth, reforestation, frost heaving

Planting depth has a long history of controversy in North America. Despite the lack of demonstrated detrimental effect of deep planting for most North American conifers, most planting guidelines in North America recommend that they be planted at the root collar, with some tolerance for planting deeper (up to 3 cm) (e.g., ministère des Ressources naturelles et de la Faune [du Québec] 2006, Schwan 1994). Logic and a long tradition guided early reforestation efforts toward planting trees to a depth that placed their root collar close to where it was in the nursery (Nisbet 1905, Stroempl 1990, Sutton 1995). Accordingly, planting operations were and still are often judged unsatisfactory because of planting depth. Unfortunately, although unsupported by data, such decisions may have great economical importance, as planting contract credits may be reduced or not paid (Schwan 1994, Sutton 1995). The advent of planting machines did not improve the situation because exact planting depth at the root collar with no roots exposed was difficult to obtain (Smith 1955, Slocum and Maki 1956). At the same time, in Europe, where the machines came from and where tree planting enjoyed a long tradition, conifers were regularly planted deeper than the root collar, often even including a significant part of the foliage (Sutton 1993).

Past studies, many dating back several decades, overwhelmingly showed no effect or even a positive effect of deeper planting on the survival and growth of conifers. For example, the deep planting of southern pines has long been shown to be advantageous to their survival and growth in difficult xeric environments, where access to soil moisture is crucial (Slocum and Maki 1956, Switzer 1960, Swearingen 1964). The technique also demonstrated beneficial or no detrimental effect on red and white pine (*Pinus resinosa* and *Pinus strobus*) (Mullin 1964, 1967) and a number of other species (Sutton 1967, Stroempl 1990). Exceptions were noted on wet sites (Switzer 1960, Sutton 1995) and for very deep planting (e.g., 15 cm or more [1]) (Carvell and Kulow 1964, Sutton 1995).

The vast majority of observational and experimental studies that examined the effect of planting depth on the survival and growth of boreal conifers, notably black spruce (*Picea mariana*) and jack pine (*Pinus banksiana*)—the two most common species used for reforestation in northeastern North America—showed no decline in performance with increased depth of planting. Schwan (1994) reported either small advantages or no effect of deeper than normal planting (up to 8 cm) of jack pine on various sites in Quebec and Ontario. Unfortunately, the results reviewed in Schwan (1994) were often

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This article uses metric units; the applicable conversion factors are: millimeter (mm): 1 mm = 0.039 in.; centimeters (cm): 1 cm = 0.39 in.; meters (m): 1 m = 3.3 ft; kilometers (km): 1 km = 0.6 mi; milliliter (mL): 1 mL = 0.061 in.³ (dry), = 0.27 fluid dram (liquid).

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