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Simulation tool to analyze the silvicultural results of conceptual autonomous tree planting machines: a sub-study of the Swedish AutoPlant project

Jussi Manner
Skogforsk, Uppsala, Sweden
jussi.manner@skogforsk.se

Anders Eriksson
Skogforsk, Uppsala, Sweden
anders.eriksson@skogforsk.se

Linnea Hansson
Skogforsk, Uppsala, Sweden
linnea.hansson@skogforsk.se

Back Tomas Ersson
SLU, School of Forest Management, Skinnskatteberg, Sweden
back.tomas.ersson@slu.se

ABSTRACT

Today's commercially available tree planting machines provide good silvicultural results, but they cannot economically compete with mechanized site preparation followed by manual tree planting. Consequently, tree planting machines plant <5% of all seedlings within Nordic forestry. Because the labour costs of manual tree planting are steadily increasing, there is a clear need within Nordic forestry to mechanize tree planting to prevent overly high regeneration costs in the near future. The development of fully autonomous planting machines is of special interest. Hence, we created a general simulation tool to analyse the potential of conceptual autonomous planting machines.

Obstacles, both above and below the ground surface, are one of the main reasons preventing large-scale break-through of today's mechanised tree planting machines. Undoubtedly, these obstacles will be the main challenge also for autonomous planting machines. The inclusion of such obstacles in the simulation tool is therefore essential. In our simulation tool, an obstacle can be a stone, root or stump, and they all come in different sizes and in varying frequencies. Together these obstacles constitute a total obstacle quota.

The future's autonomous planting machines should be capable of detecting obstacles. Our simulation tool sets (by default) stumps as detectable objects above ground, and roots as non-detectable objects below ground. Meanwhile, bigger stones are (by default) detectable objects above the surface and smaller stones are non-detectable objects below the surface. However, these default settings are easily adjustable so as to analyse different machine generations with different detecting capabilities. In addition, the size of the digging tool (i.e. area requirement) and the minimum distance between planted seedlings can be adjusted.

The outcome of the simulations includes all the traditional measures such as planted seedlings/ha, time consumption, distance driven, etc. Additionally, it includes spatial distributions (coordinates) of both successful planting attempts

(i.e. planted seedling) and failed planting attempts. It might happen that the landowner is not content with the simulated planting results or that legislative requirements concerning regeneration are not met. In such cases, specific machine settings can be readjusted. For instance, on stony soils, the minimum distance between the seedlings probably should be decreased to sustain the desired stocking rate (seedlings/ha). In practice, this means that seedlings will be planted, at least to some extent, in groups. Meanwhile on obstacle-free soils, the situation is opposite: seedlings can be evenly distributed all over the site.