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ASSESSING THE EFFECT OF HARVESTING METHOD ON SOIL DISTURBANCES WITH A SPATIAL HARVESTING SIMULATOR

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Abstract: *Traditionally harvesting operations on peatlands have been accomplished during the period of ground frost. More intensive utilization of peatland forest requires increasing logging activity during unfrozen conditions, when the soil load bearing capacity forms a severe obstacle for the prevailing harvesting machinery. The paper presents a new spatial harvesting simulator that is capable in assessing the number of passes of a forwarder for each single spot on a strip road when harvesting is carried out. The simulator may be used in finding a balance between the magnitude of logging activities and the damage imposed to the forest terrain. The simulator has two main data components. A tree list-file contains full specification of all trees to be placed in stand and a stand-file describes shape of stand and locations of strip roads in a raster format. The simulator cuts the trees and places all wood cut in the piles by the strip road. Thereafter the simulator generates all possible routes to collect a load and transport it to road side storage. An optimized set of routes is then selected so that all piles become collected, while resulting in the lowest possible terrain damage. The paper demonstrates how the simulator may be used in analyzing the effect of harvesting method and strip road spacing on the productivity and damage occurred to the strip roads.*

1. Introduction

Peatlands are very problematic from a logging operations point of view. The mean tree size and density are generally lower than that on mineral soils leading to low harvesting removal. The ditch network hampers machine mobility and the average driving distance from the site to the road site is generally double compared to mineral soils. The low bearing capacity (the strength of soil to prevent vehicles from sinking into it), is however the most difficult factor affecting tree harvesting (Ala-Ilomäki, 2004; 2006; Suvinen, 2006; Suvinen and Saarilahti 2006). Operating conditions lead to poor vehicle mobility (the ability of a vehicle to travel from point A to point B) and poor terrain trafficability (the ability of terrain to support vehicular traffic).

So far logging activities on peatlands are mainly carried out during the coldest weeks in winter time. There are however local and annual differences as to what extent peatlands freeze. Warm autumn months and the insulative effects of snow cover and upper peat layers hinder the freezing process and make many areas impossible to access even in winter time. The pronounced climatic change at high latitudes predicted to occur as a result of global warming is expected to prevent winter time logging on peatland in these areas. More intensive utilisation of peatland forests requires logging activities to be increasingly carried out during unfrozen conditions.

In a research project carried out by the Finnish Forest Research Institute (METLA) and in close collaboration with the forest industry and the machine manufactures new harvesting solutions for effective and economically viable utilization of peatland forests is developed. In the project we have focused on two main themes, on prediction of bearing capacity and on new thinning treatments of peatland forests. In order to link these two researches object together and examine the features of peatland harvesting as a whole, a new type of spatial harvesting simulator has been developed together with the researchers from the Tampere University of Technology.

The paper presents the features of this new spatial harvesting simulator that is capable in assessing the number of passes of a forwarder for each single spot on a logging trail when harvesting is carried out. The simulator may be used in finding a balance between the magnitude of logging activities and the damage imposed to the forest terrain.

2. Description of the LOGTRACK simulation platform

The LOGTRACK platform comprises four GIS-based data layers, namely a logtrail-file, a treelist-file, a boundary-file and a ditch-file. Out of these only the first two layers the logtrail-file and the treelis-file are compulsory to make the simulation run. The logtrail-file, the ditch-file and the boundary-file can be generated from standard GIS coverages.

The logtrail-file is the backbone of the simulation platform. It comprises all logging trails within the stand we want to simulate. The charachteristics of the logtrails are expressed with spefic code that indicates the nominal width of the logging trail. In typical situation we may define three different logging trail categories; a cutting trail (used only to cut the trees, width <4m), a standard logging trail (width 4-5m) and an arterial (main) logging trail (width 6m). The orginal network of logging trails can be defined from a thinning stand that has already been harvested by a GPS recorder or the network can be digitized in advance by aid of orginal map or satelite map. If the orginal data are collected by a GPS recorder, the tracked routes may be improved with the ArcGIS tool or similar software. The improved version of the logging routes are then converted to raster format (cell size 1x1m) utlizing ArcGIS/RASTER and ArcGIS/ASCII–procedures.

The wood to be extracted via the logging trail network can be expressed in two different ways. In the most typical case, a forest is described with a list of standing trees. In this list each tree is given the location (x,y-coordinates), species, diameter, the proportion of the wood assortments within the tree and a code that indicates whether tree is proposed to be thinned or remained standing. The wood to be extraced can be defined also as cut logs or piles of them laying on the ground by the logging trail. The cut logs are expressed in pri-format (StandForD) which enables input of data from harvesters.

We may want reduced the area from where the trees are harvested. For this reason it may be useful to construct boundaries for the operation. The area we want to include within the simulation is digitized in ArcGIS and then converted to raster-format. That boundary-file can then be utilized in the simulator. In peatland areas where ditches form a major problem for hindering the extraction of timber, a user may also localize and digitize ditches within the stand and construct a ditch-file with the same technique as with case of logging trails. The width of the ditches can also be categorized into three groups with a special coding system.

3. Simulation procedures of the LOGTRACK simulator

Cutting of trees and placing the logs cut into the piles is the first step in the simulation procedure of the LOGTRACK. The simulator does not take into consideration the lengths and diameters of logs. It only locates the whole volume of each assortment given in the treelist-file to the nearest pile. The pile where the volume is placed can not be located farer than the reach of the boom of the forwarder. When the pri-file is utilized cutting of trees and location of wood into the piles is not necessary since the file already contains this information.

After the simulator has placed the transported volumes into the piles, the system generates all possible routes to collect a load and transport it to road side storage(s). The number of roadside storages can be fixed. A sophisticated algorithm has been constructed that selects an optimized set of routes so that all piles become collected, while resulting the lowest possible terrain damage.

The restrictions and options of the simulation are expressed in a settings-file. This file includes among others following parameters: a) the width of the logging trail and ditch classes b) the intensity on how each forwarder passage (empty, partly loaded and fully loaded) reduce the bearing capacity and the amount of passages making the logging trail or ditch class non-accessible c) location of each roadside storage and d) the speed of the forwarder moving empty, fully loaded and when moving while loading. In addition certain specific parameters can be given that controls tracking algorithm, the input and output-files.

The simulator does possess advanced tools for analyzing and visualizing the location of trees, piles and the routes along the forwarder has been moving (figures 1, 2 and 3). The simulator reports the length of the route of forwarding (separately for moving empty, moving while loading and moving fully loaded), the time consumption for each load separately and in total for each assortment. The simulator also can depict the route for each load and as a summary the total disturbance caused by the complete forwarding operation (Fig. 4).

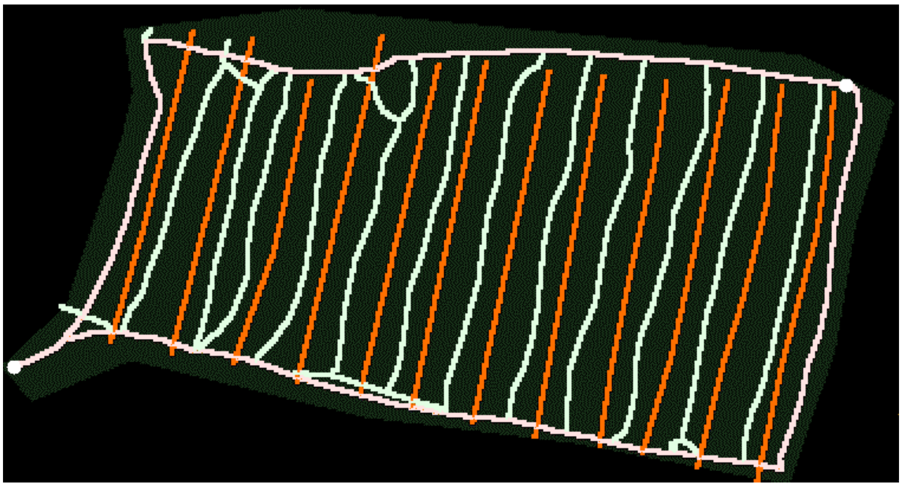

Figure 1. General overview of the LOGTRACK report window that visualize the boundaries, log trails and the ditches.

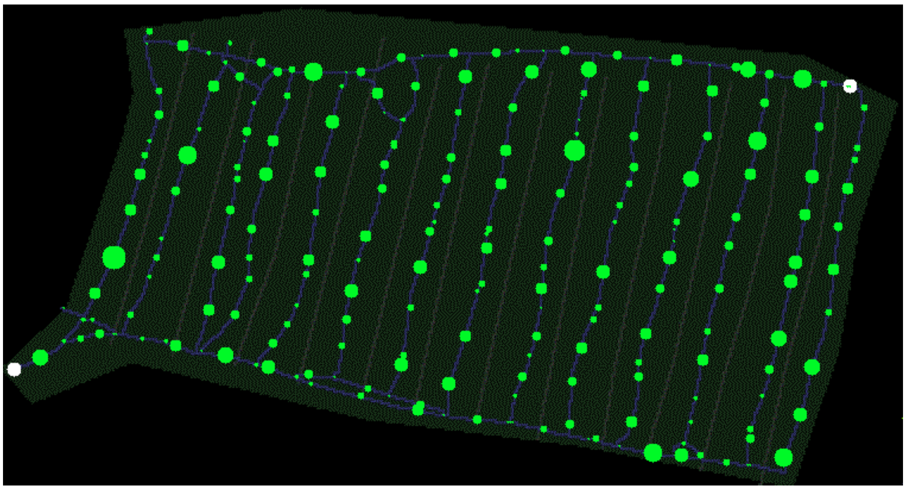

Figure 2. LOGTRACK report of the piles of one wood assortment along the log trails.

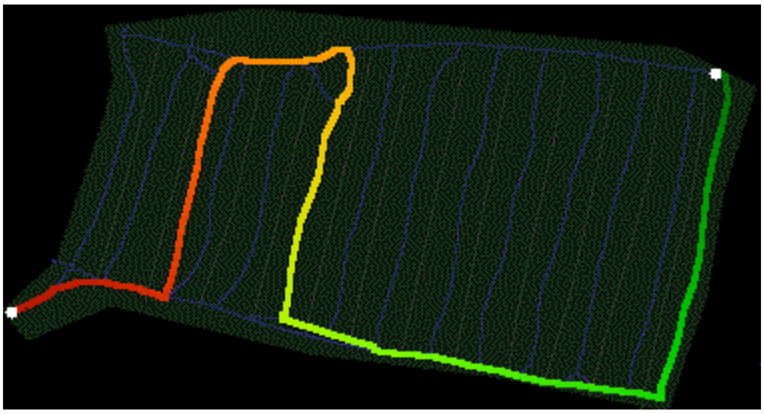

Figure 3. A LOGTRACK report of one route out of the optimized set of routes. There are two possible road side storages in this stand.

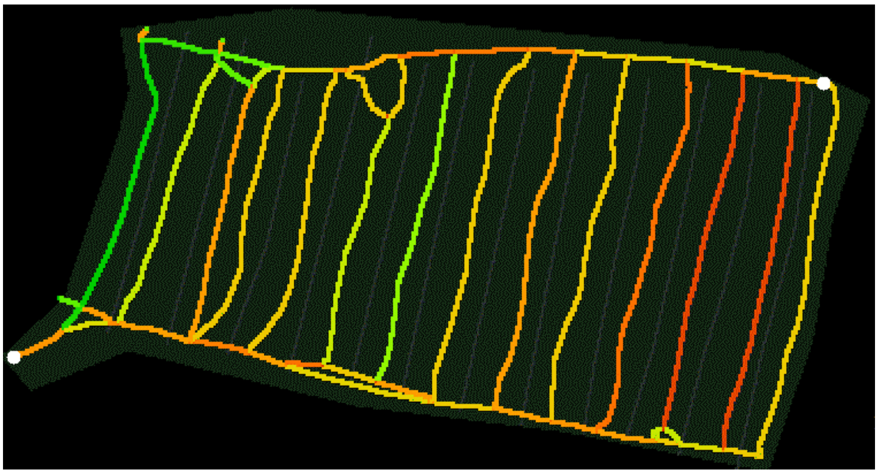

Figure 4. The LOGTRACK report that visualizes the proportional damage caused by the logging operation.

4. Future testing and development of the LOGTRACK simulations

To date we are still at the development phase of the simulator and only the first attempts to run the simulation has been carried out. We have collected material from five typical peatland stand that has been recently logged in winter time conditions. We intend to use the simulator to examine whether the harvesting operations could have been carried out in summer time conditions also. The knowledge on the bearing capacity of various types of peatland forests and the rut formation of certain types of machines are derived from our latest experiments within the project. We will focus on analyzing the effect of the number of road size storages and the machine type on the success of the operation.

In the coming tests we will also vary the harvesting technique by changing the logging trail spacing and width and examine what kind of effect that will have on the productivity of the logging activities and the remaining stand. The simulation will also give clear indication about the suitability of machine type on logging operations carried out in certain peatland types. We may also vary the size of the load. In the drive tests it was proved that with certain machine type it may be wise not to load the log bunk full. Driving fully loaded may destroy the ground so drastically that the trail may come non-accessible after two loads. Instead, driving half-loaded may enable ten passages or even more over a single spot.

It is also possible to utilize the simulator to analyses of optimal set of load picking routes. We may track the work of a forwarder in a typical peatland working environment and compare the routes of the simulator to the routes actually carried out in practice. If clear differences between the optimized set of routes and actual routes are found, the simulator may be used in tutorial role to analyze the reason for the differences. The possibility to input the log piles in pri-format enable us also to test whether it is advantageous to calculate the optimal set of routes for forwarder after the harvesting operations with the harvester having tracking possibility has been carried out.

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