A Knowledge-base system approach—Integrated Assessment of Mechanised Harvesting Operation on Forest Environment

Lan Zhangren[1]

Abstract

Due to rapidly increasing mechanised timber harvesting operation in commercial forest, new and increasing pressures are being brought to bear on environment issues. Estimating the environmental risk of timber harvesting operations plays an important role in selecting suitable machines of harvesting system on wood procurement chain in environmental-oriented procedure. It is obvious that main impacts of harvesting operations concentrate on the soil compaction, site disturbances and biological damage. From the view point of pre-operational damage risk evaluation, the relevance of soil compaction and other consequences derived from harvesting operation is not directly from the results of associated changes of the soil properties but rather from the environmental and technical parameters of harvesting machine which are defined in the methods of harvesting with specific operational modes and type of machine.

In this paper, a knowledge-base system (KBS) approach in co-operation with a fuzzy integrated assessment was developed for pre-operational evaluation of timber harvesting activities. The critical factors concerning the damage risk of harvesting operations to forest target area were extracted, evaluated, weighted and encoded into the knowledge-base system based on topographical conditions of forest area, machine parameters, harvesting system types and so on concerning harvesting operation as following:

- **Ground slopes and slope capacity of machine**: ground slope is one of the critical factors that identify the operability of individual machine and harvesting system in a give condition. The slope capacity of machine to some extent means for machine to be operated efficiently at the productivity, cost, and less impacts of operations.
- **Soil condition and ground strength**: the soil characteristic is a main factor for defining the trafficability of the machine and risk of various damages to the soil

[1] Department of Forest Resource Management, P.O. Box 24 (Unioninkatu 40 B), 00014 University of Helsinki, Finland, email: zhangren.lan@helsinki.fi

at the time of traffic. Generally, ground conditions worsen, wider range of machine traffic capacity should be taken into consideration for the choice of machines and their equipment.

- **Logging patterns and machine size**: machine size to a large extent identifies the ground pressure of machine and risks of various damages to the soil and remaining trees in thinning operation. Defining the parameters of machine size could induce the extent of environmental consequence dominating concerns of damage to soil and remaining trees in given logging pattern.
- **Harvesting method and machine types**: three types of harvesting system, i.e. cut-to-length, tree-length, and whole tree system corresponding to harvesting methods and machines applied determine the types and extent of environmental consequences, which are indicated by the machine performance varying with the logging patterns from thinning to final cutting.
- **Machine productivity and operating cost**: there might be some extent of conflict among the machine productivity, costs effectiveness and forest damage risk. Machine to be operated in the most-efficient way implies larger machine employed and less restricted impact of harvesting operation. There might be a compromise required between maximising financial benefit and minimising site damage.
- **Operational modes**: harvesting and forwarding with the crane work operated at wider spacing cause much of damage to trees; direct dragging and winching are often more dangerous for the standing trees; skidding and feller-bunching will disturb more area, incurring more damage risk to stands.
- **Ground pressure of harvesting machine**: maximum site protection would require low ground pressure. Machinery with low ground pressure could greatly reduce the extent of damage to the forest floor.
- **Tyre types and tracks**: the extensive disturbance indicated with the rut depth depends strongly upon the types, size and inflation pressure of tyres besides the ground pressure of machine. Wider tyres or tracks facilitate efficiently to reduce soil damage and rut depth.

The values of those variables concerning forest machine performance and environmental parameters are converted into a scaling system in numerical way. Fuzzy method involved in pre-operational evaluation of timber harvesting is employed to integrating assessment and analysis based on critical factors and machine performance level indicated with index method of harvesting operation. The purpose of KBS is to provide the knowledge that can evaluate environmental issues, and interpret its generated output. In the case of the machine pre-operational assessment, potential risk of harvesting operations is primary goal to be specified through the inference engine of knowledge-base system. Further more, the management objective of timber harvesting operations will be reached by examining rules and executing spe-

cial search, which then provided the recommendations for suitable choice of sound environmental harvesting machines.

The window-based application of pre-operational evaluation system was built with Borland Delphi development tool. Friendly user interface environment is suitable for users to control data input and output. The output data could be extended to various kinds of timber harvesting planning and management of environment-oriented procedure at company level.