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An Exploration of Internal Decision Support Tools used in Forest Operations

PROJECT NUMBER: 301012718

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FPInnovations Forestry group has extensive experience in designing and developing practical operational tools for maximizing efficiency in forest harvest and fibre supply operations. This knowledge can extend into wildfire management by developing a decision support tool to inform vegetation management treatments.

The design and decision-making processes involved in the creation of three forest operations decision support system tools was reviewed with the intention of scoping the possibility of creating a decision support system tool for stand level vegetation management decisions.

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Table of contents

List of figures

INTRODUCTION

FPInnovations Forestry group has developed a variety of computer-based systems or tools to aid forestry practitioners with decision making in harvest operations. These information systems, aptly called Decision Support Systems (DSS), allow the simulation of operational decisions using software applications. With these simulations, the outcomes of operational decisions can be promptly forecasted. DSSs thus allow users to compare the feasibility and economic value of different potential operational decisions.

The following diagram represents the flow of information in a hypothetical DSS:

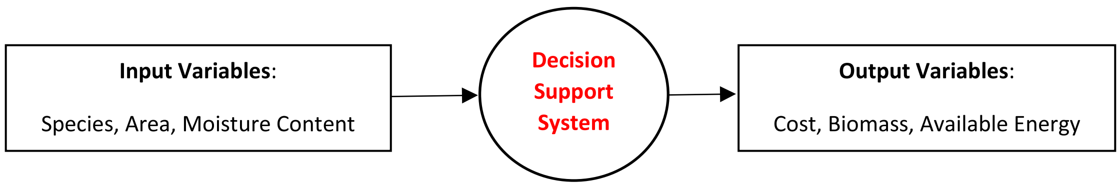


Figure 1. A simplified example of information flow in a DSS simulation

Components of a decision support system

A decision support system often has four key components:

1. **Database management system (DBMS):** Collects and processes information (input data).
2. **Models**: Specific calculations or computations that the DSS executes to provide a usable output.
3. **User interface:** The interface where the user and the application interact.
4. **Non-primary components:** Additional code to enhance the application (for example: GIS maps with data layers, networks to enable data sharing and/or collaboration, etc.)

FPINNOVATIONS DECISION SUPPORT TOOLS

In order to better understand DSSs and how they can be used to aid decisions related to fuel treatments, a review of three FPInnovations Decision Support System products was conducted. The DSSs studied were: FPInterface, FPJoule, and Steep Grade Descent (SGD) Guidelines. The design and decision-making processes involved in the creation of these applications was reviewed with the intention of scoping the possibility of creating a decision support for stand level vegetation management decisions.

1.1 FPInterface

FPInterface is a desktop software that is used to simulate the activities involved in the forest supply chain. The main areas of focus in the forest operations supply chain are harvesting, transportation, and biomass. The program leverages GIS and forestry maps, optimization models, and other studies to produce data on expected productivity, costs, and value of products delivered to customers. The software is highly detailed and is able to predict the cost of operations, cutblock dispersion impact, density of road networks, transportation and wood flow analysis, biomass recovery costs and flow, and many other factors that influence the decision-making process.

To facilitate the highly detailed simulation process, FPInterface makes use of six modules that behave as 'add-ons' to the main application. The modules are:

- **Work schedule:** Creates an operations schedule and visualizes fibre based on schedule.
- **Stand establishment:** Modeling stand establishment after silviculture activities.
- **Max tour:** Identifies hauling opportunities.
- **BiOS:** Calculates volumes and costs of biomass supply
- **Value simulation:** Calculates network of harvest block.
- **Bucking simulation:** Simulates bucking operation.
- **FPAlloc:** Optimizes product allocation based on mill demand and transportation cost.

To understand the process involved in the making of this DSS, a single area of focus from FPInterface was reviewed in further detail. The program selected for this was BiOS since it most closely resembles a fuel treatment DSS in terms of portability of the application, the size of the application, and the content involved.

BiOS – Biomass Module in FPInterface

BiOS is a FPInterface desktop module and a stand-alone mobile application to access the biomass volumes and potential GHG benefits in real time. The user interface is broken down into five sections – project info, species, logging, biomass, and media. Each of these five sections takes the user through a step-by-step process of inputting variables that alter the outcome.

Project info – General project information such as project name, location of site, and area of site is entered here. An interactive map that leverages Google Maps is used to locate the site.

Species - The user can select the species of interest at the site from 26 softwood options and/or 21 hardwood options. Pictorial representation of the different species provides greater visual interaction with the user. In addition to selecting the species type, users can enter information such as volume per hectare, harvest removal, and volume per stem.

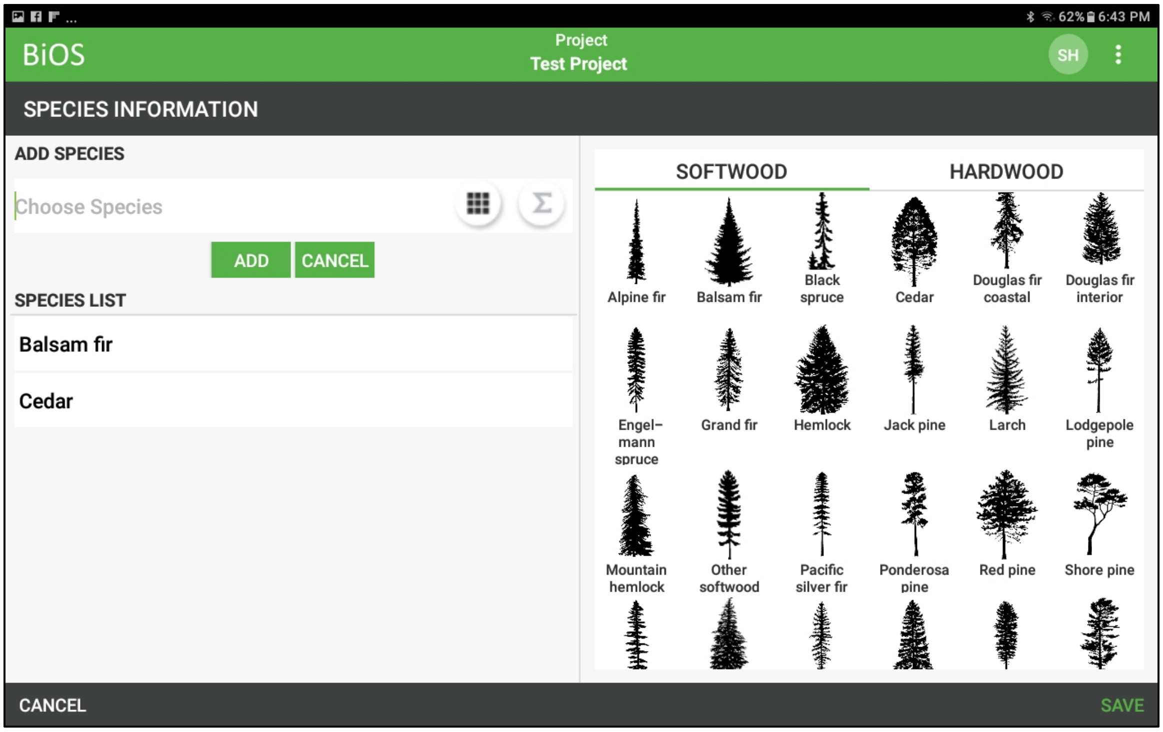


Figure 2. Selection of species and characteristics definition in BiOS.

Logging – The logging section requires the user to select a harvest system. The application offers selection between:

- Full tree (feller buncher, grapple skidder, delimber)
- Cut-to-length (shortwood harvester, forwarder)
- Man tree-length (manual felling and delimbing, cable skidder)
- At the stump processing (feller buncher, processor at the stump, forwarder)
- Full tree with roadside processing (feller buncher, grapple skidder, processor at roadside)
- Full tree with roadside chipping (feller buncher, grapple skidder, delimber-debarker-chipper)
- Full-tree with loader-forwarder (feller buncher, loader-forwarder-delimber)

Each type of harvest system can be fine-tuned, with details such as hours per shift, shift per day, utilization rate, fuel cost, etc. to allow productivity and cost estimations.

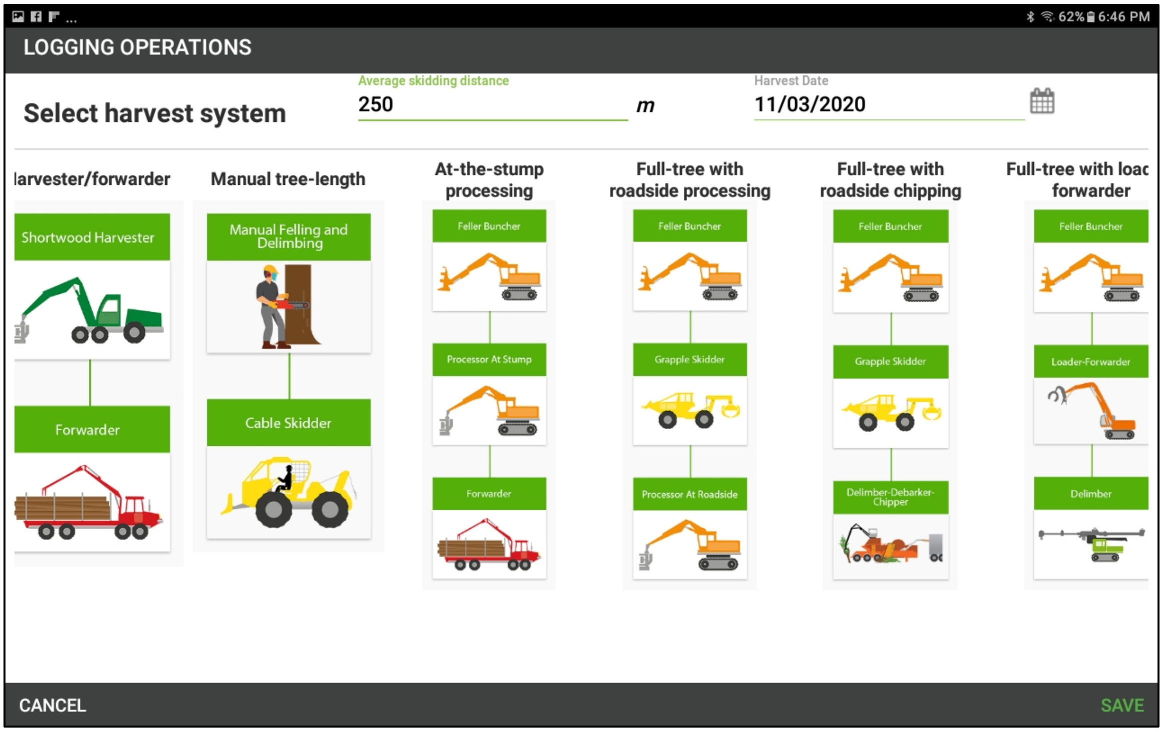


Figure 3. BiOS' logging activity selection section.

Biomass operations – This section of the application allows users to enter the destination (user defined or select from existing destinations), comminution (option between roadside chipper and horizontal grinder) and truck configuration (semi-trailer with 3 axles or B-train).

Media - Users have the option to add media files to the project – images, videos, etc.

Report - The report section generates the output after computing the different input parameters in a usable form. The following are the items displayed in the report:

- Biomass recovery – Area, recovered biomass, average moisture content, biomass yield, biomass, available energy, fuel consumption, carbon emitted.
- Biomass transport – Distance by road (primary, public, operational), fuel consumption, carbon emitted.
- Biomass supply cost – Recovery (stump to roadside), transport (roadside to mill).
- Species breakdown – Carbon delivered, ODT, ODT/m^3, ODT/ha for each species.
- Biomass flow – visual representation of how the total biomass breaks down into uncut trees, available biomass, merchantable volume harvested and more.

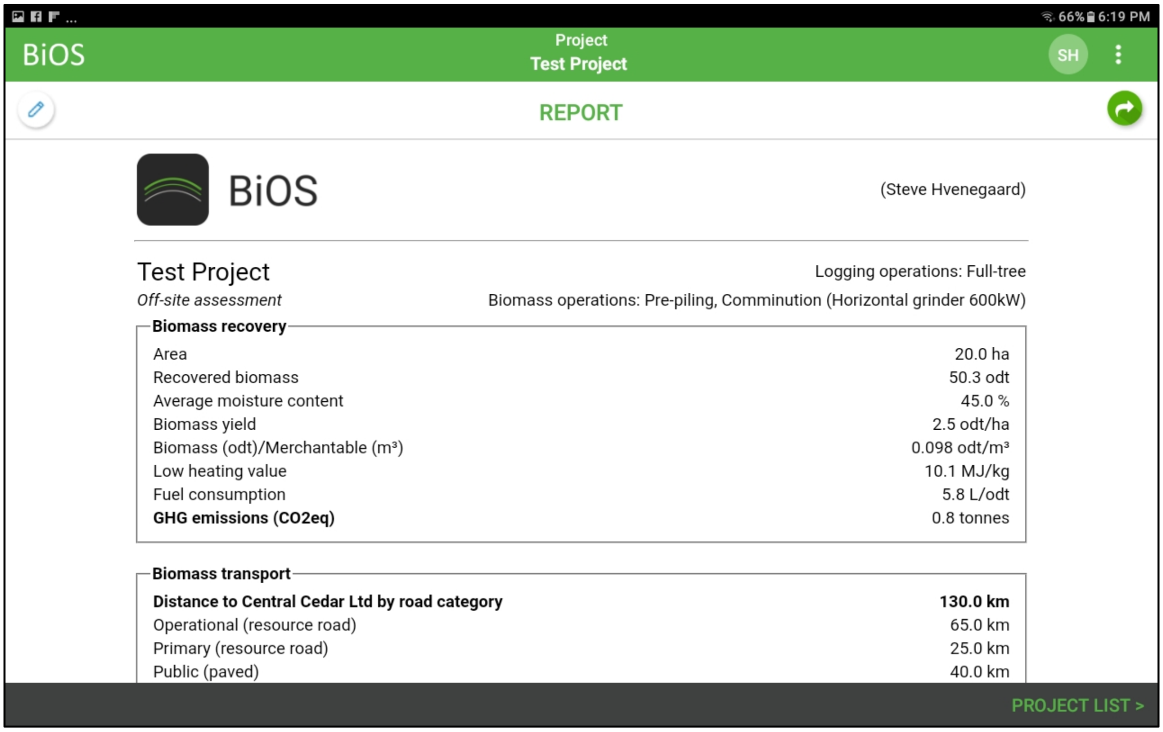


Figure 4. BiOS' quantitative report generated.

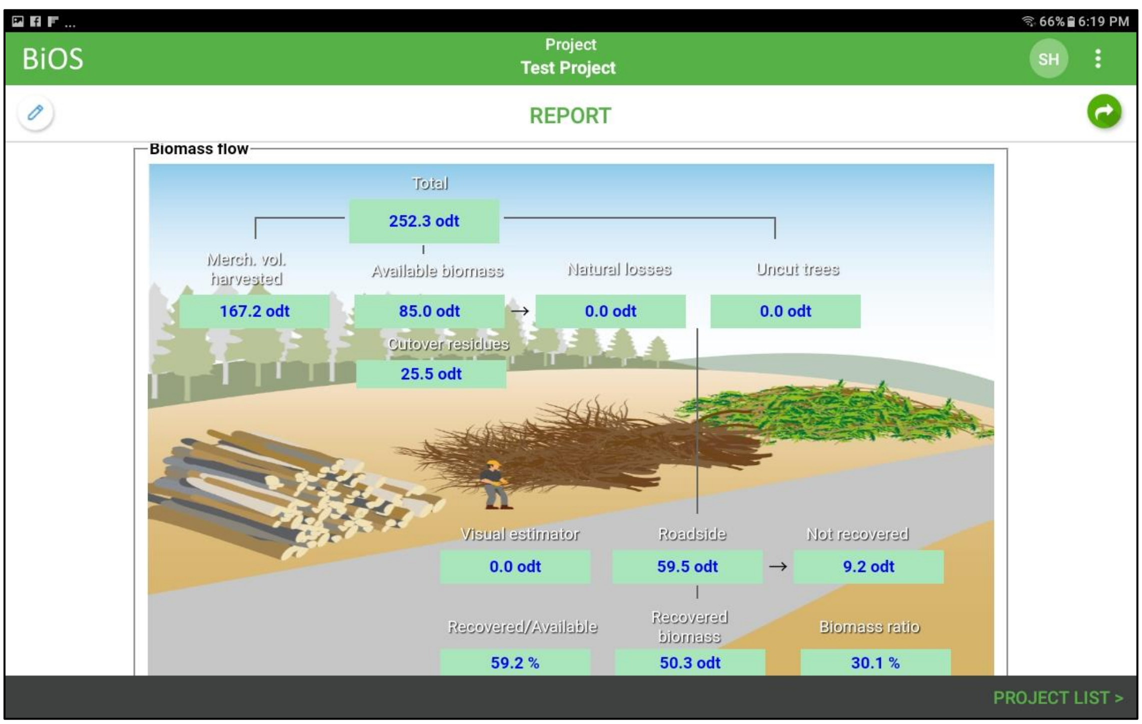


Figure 5. BiOS' report generated as a path flow diagram.

1.2 FPJoule

FPJoule is an online browser application that is used to estimate monetary and energy values in biomass from harvest residues. The application allows fuel parameters to be entered and modified such that estimates of energy obtained from the burning of biomass can be generated. The economics of the available biomass as an energy source can be then compared to other energy sources.

The application has four distinct sections: Energy cost, Economic advantages, and Fuel parameters that serve as input portals and Report that serves as an output or reporting portal.

Energy cost: This section allows users to enter biomass descriptions (species group, tree section, moisture content, boiler thermal efficiency), and energy cost (biomass price).

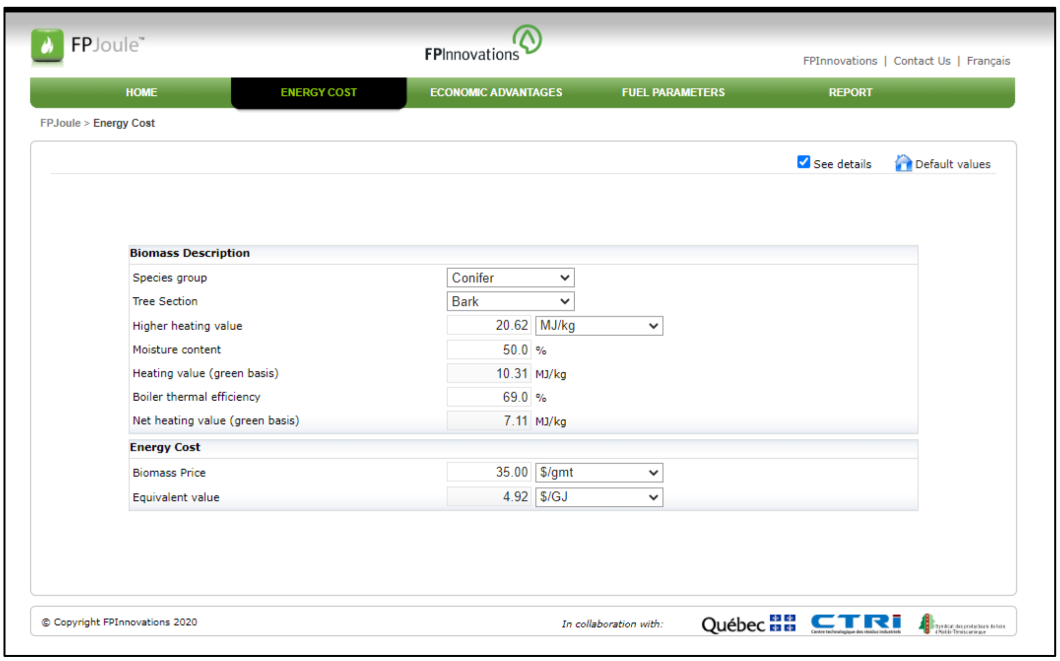
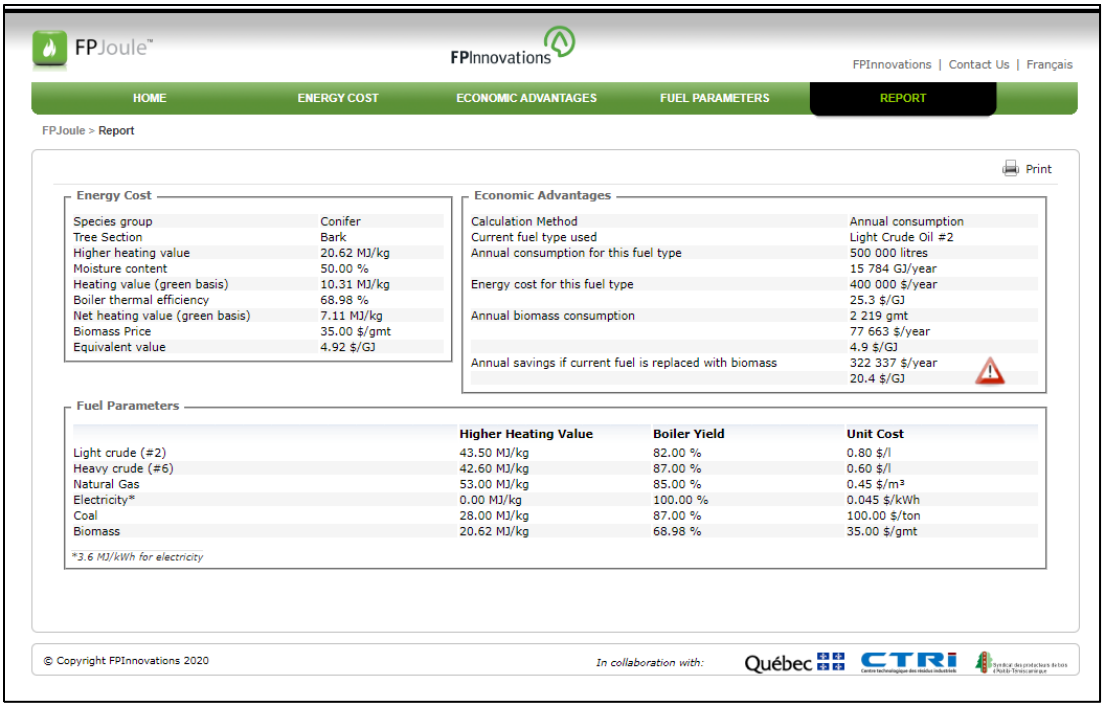


Figure 6. FPJoule's energy cost section with input variables.

Economic advantages: Actual energy costs based on alternative fuel types and calculations method are estimated. Depending on annual consumption or boiler power capacity, the application is able to estimate the cost of energy required for the selected fuel type and for biomass energy to provide a side-by-side comparison. Any savings gained from the use of biomass energy are also displayed.

Fuel parameters: In this section, users can compare different fuel types based on their higher heating value, boiler yield, and unit costs. Values for biomass are taken from the estimations made in the previous two sections.

Report: FPJoule generates a report that summarizes the energy costs, fuel parameters, and economic advantages with values that the user has entered.



Energy Cost

Species group	Conifer
Tree Section	Bark
Higher heating value	20.62 MJ/kg
Moisture content	50.00 %
Heating value (green basis)	10.31 MJ/kg
Boiler thermal efficiency	68.98 %
Net heating value (green basis)	7.11 MJ/kg
Biomass Price	35.00 $/gmt
Equivalent value	4.92 $/GJ

Economic Advantages

Calculation Method	Annual consumption
Current fuel type used	Light Crude Oil #2
Annual consumption for this fuel type	500 000 litres
	15 784 GJ/year
Energy cost for this fuel type	400 000 $/year
	25.3 $/GJ
Annual biomass consumption	2 219 gmt
	77 663 $/year
	4.9 $/GJ
Annual savings if current fuel is replaced with biomass	322 337 $/year
	20.4 $/GJ

Fuel Parameters

	Higher Heating Value	Boiler Yield	Unit Cost
Light crude (#2)	43.50 MJ/kg	82.00 %	0.80 $/l
Heavy crude (#6)	42.60 MJ/kg	87.00 %	0.60 $/l
Natural Gas	53.00 MJ/kg	85.00 %	0.45 $/m³
Electricity*	0.00 MJ/kg	100.00 %	0.045 $/kWh
Coal	28.00 MJ/kg	87.00 %	100.00 $/ton
Biomass	20.62 MJ/kg	68.98 %	35.00 $/gmt

*3.6 MJ/kWh for electricity

Figure 7. FPJoule's generated report.

1.3 Steep Grade Descent (SGD) Guidelines

SGD guidelines is a mobile and tablet application used by forestry operations planners to conduct risk assessments for loaded log hauling trucks attempting to make steep descents. This decision support tool enables users to estimate braking system temperatures based on the loading condition of the truck as well as road conditions. With these temperature estimates, the application is able to dispense a recommendation to the user on whether it is safe to execute the descent or not.

The application has a fairly straightforward interface: the user enters the necessary variables required to compute the braking system temperature. The input variables required are GCW limit, traction level, number of axles, descent length, pitch grade, pitch length, pitch curve radius, and minimum turning radius.

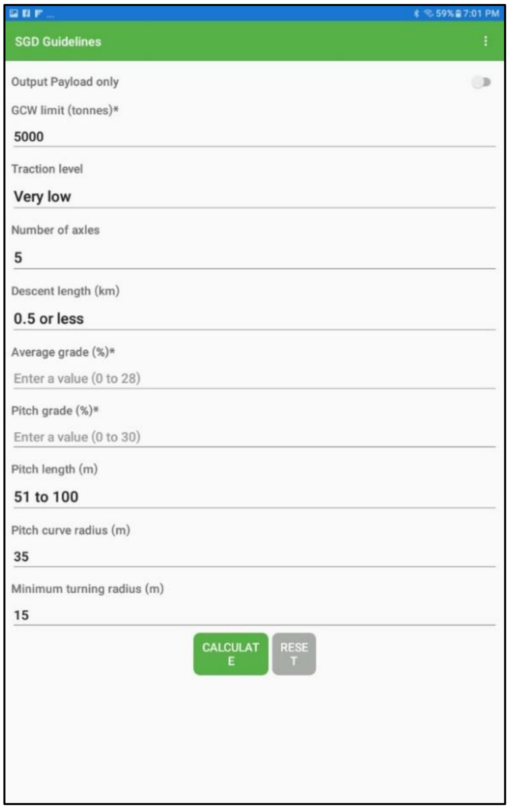


Figure 8. SGD Guidelines' input variables to compute braking system temperature.

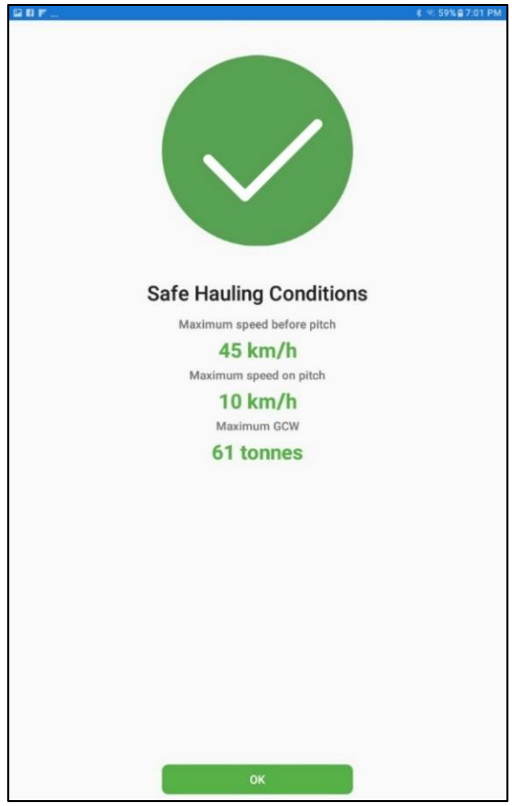


Figure 9. SGD Guidelines' recommended safe hauling conditions.

The application computes whether the criteria for safe hauling are met or not. If conditions are not met, the application tells you which input variables are causing the conditions to be dangerous and unsafe for operations. If the conditions are met, certain criteria such as maximum GCW, maximum speed before pitch, and maximum speed on pitch to ensure hauling operations are conducted safely.

CONCLUSION

The design and decision-making processes involved in the creation of three forest operations decision support system tools was reviewed with the intention of scoping the possibility of creating a decision support system tool for stand level vegetation management decisions.

The designed structure of these tools provides a framework that can be replicated in the development of vegetation management decision support tools. Future conceptualization and design of operational tools to be used in vegetation management planning will require establishment of functional objectives with clear identification of input variables and outputs.

A large dataset collected from monitoring specific forestry operations was required to develop robust models to simulate the specific operations. With this in mind, data requirements will need to be considered in the future development of operational tools as a vegetation management decision support system.

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