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FPInterface – BiOS

Contents

Abstract

The BiOS (*Biomass Opportunity and Supply*) module in FPInterface is a tool for spatially evaluating available volumes and recovery costs of forest-origin biomass from a provided timber harvest area.

Keywords

FPSuite, FPInterface, BiOS, Computer software, Models and simulation, Biomass, Costs, Fiber supply, Energy efficiency, Cost analysis, Forest operations.

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Description of tool

The BiOS module is integrated within the FPInterface software, a component of FPSuite developed by FPInnovations to help manage forest operations. FPInterface can simulate forest supply activities and features various analysis, modelling and optimization tools (Figure 1). The BiOS component within FPInterface estimates the cost of mill-delivered forest biomass based on annual or five-year harvesting scenarios. Forest operations planners can use BiOS to select the best supply scenario based on their particular harvest systems and supply chains. FPInterface is a stand-alone software that allows users to work directly from digitized forest maps in the Windows operating system environment.

BiOS helps to:

- Calculate estimated available and recoverable biomass for each cut block;
- Analyze biomass flow;
- Identify the harvest operating areas that provide the best chances for recovering biomass;
- Estimate the energy balance of biomass recovery operations;
- Estimate all phase costs required for delivering biomass to a processing mill;
- Estimate the impacts on delivery costs and biomass availability when seasonal or economic factors change in harvest plans.

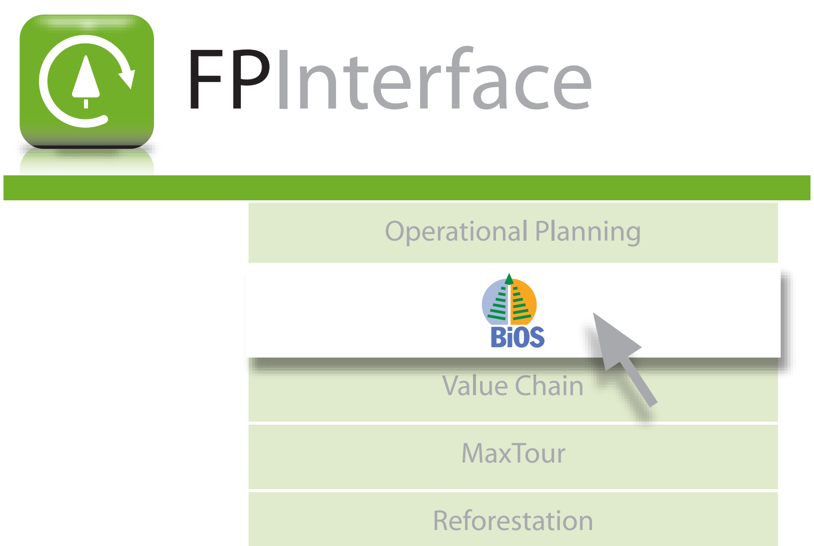


Figure 1. The BiOS model has been fully integrated within the FPInterface platform.

BiOS overview

BiOS allows users to estimate the amount of biomass using a decreasing gradient based on biomass that is potentially available (all tops, branches, and foliage from merchantable and non-merchantable stems) and technically recoverable (biomass recovered and transported to the mill). These estimates take into account tree species, the terrain, the harvest system, the delay period from harvesting to recovery of the biomass, the season of recovery, and the equipment used to recover and transport the biomass. Reduction factors used to determine technically recoverable biomass are derived from FPInnovations studies.

Biomass calculations are based on equations derived from scientific research by Lambert, Ung and Raulier (2005) for the major Canadian tree species. These equations were modified to accept the volume per stem and topping diameter as input rather than the diameter at breast height (dbh) and stem height. BiOS estimates projected by the equations reflect the relative difference in biomass type (bark, branches, foliage) as stem size changes.

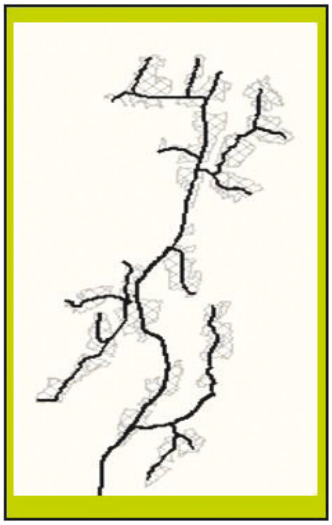
BiOS outputs include the amount of biomass and its estimated delivered cost to specific destinations from individual cut blocks, regions, or operating areas. The outputs are presented in units of weight (oven-dry tonnes, green tonnes) and energy (MWh).

Required inputs

The inventory information required for BiOS can come from ecological or forest resource inventory data or pre-harvest cruise data. Users not having this information can use a default volume for each tree species when starting the BiOS analysis. Two spatial layers are also required: one describing the cut blocks and the other describing the road network. Data required in each of these layers are as follows:

Cut blocks:

1. Merchantable volume per hectare (m^3/ha) for each species;
2. Merchantable volume per stem (m^3/stem) for each species;
3. Type of harvest (clearcut, commercial thinning, or other partial cut);
4. Percentage of merchantable wood harvested for each species;
5. Harvest system used for merchantable wood.



Road network:

1. Topological compliance is essential (road segments must not have missing segments and must intersect properly);
2. Clean network – only roads used for transport are kept;
3. Road class identified for each segment (paved, primary, secondary, tertiary, or operational);
4. Travel speed for each road segment can be included (optional).

Users can add other parameters to refine analyses. These parameters are described in the following sections.

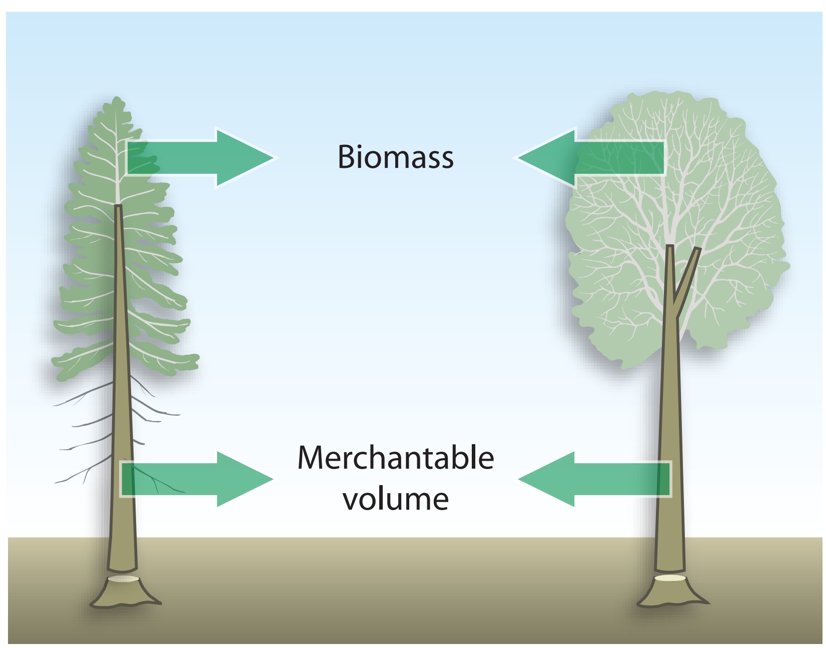
Product management

Stand, stem, and biomass attributes can be reviewed and modified using the Merchantable and Biomass management tables. The Available Biomass estimate is composed of branches, tops, foliage, and bark and is the amount of biomass available from processing activities. Users can also identify specific merchantable species harvested as biomass. Quantities available and recovered are reported by product for each cut block.

The product management tables also allow users to modify parameters, including but not limited to: basic density, moisture content, topping diameter, stumpage fees, product value, mill destination, transport configuration, and bulking factor (the ratio of the loose volume of chips to the solid volume).

The topping diameter input determines the portion of the stem available for biomass recovery, left either at in the cutover or at roadside. It should be noted that the topping diameter not only has an impact on the proportion of merchantable vs. non-merchantable volume of the stem but also on the volume from the branches in hardwoods. As a result, the amount of biomass is underestimated in hardwoods since, in reality, any merchantable volume included in large branches is often not recovered during "normal" harvesting operations (Figure 2).

Figure 2. Representation of merchantable volume and biomass for a softwood species and a hardwood species.



Recovery properties

BiOS allows users to choose either at-the-stump or roadside biomass recovery systems and the product delivered (energy chips, bundles, loose harvest residues, stems, and logs) to processing mills (Figure 3). Users can use either predefined equipment productivity and cost data based on FPInnovations studies or their own data (Figure 3). BiOS can output results based on an integrated operation that includes the harvesting phases, or it can output results based on the biomass recovery phase alone.

BiOS adjusts the potential biomass recovered depending on the recovery season and the freshness of the harvest residues. Recovery season influences the amount of deciduous foliage available. The freshness of the harvest residues relates to the time from harvesting to biomass recovery, and impacts losses of foliage, bark, and small branches as stem components become brittle with drying. Reduction factors based on field observations were developed: fresh = ≤ 3 months (1 season), brown = > 3 months and < 2 years (2 winters), brittle = ≥ 2 years (Figure 4).

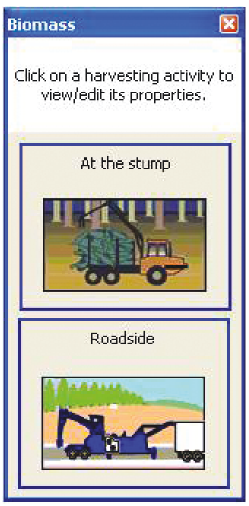
Silvicultural or "environmental biomass retention" levels can be included as inputs that influence the total quantity of recoverable biomass (Figure 5). Since biomass flow depends on harvesting practices (technical efficiency of recovery) and the basket of products (merchantable volume used as biomass), it is recommended that values be validated and adjusted locally.

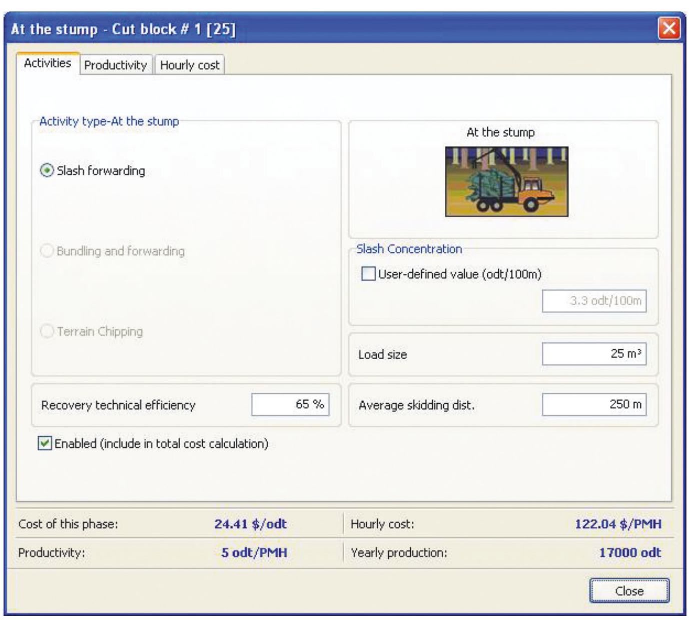
Energy balance

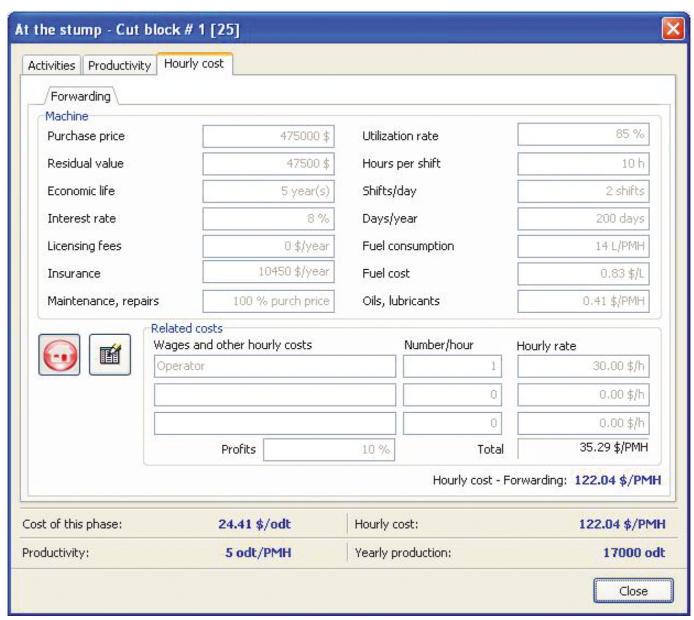
BiOS provides an energy balance calculation as output data. The energy balance is the ratio of the amount of energy expended during the recovery phases to the amount of energy contained in the biomass. To obtain the energy expended, BiOS calculates the fuel consumed and its energy equivalent for the recovery of the biomass from the forest and its transport to the mill. The quantity of energy available from the biomass is determined from the heating values of the species and moisture content.

BiOS reports the quantity of energy contained in the delivered biomass (MWh) and the estimated number of litres of fuel required to get one oven-dry tonne (odt) of biomass to its destination.

Figure 3. BiOS uses customizable production and cost values for biomass recovery at the stump or at roadside.







[1] The quantity of biomass (percentage of quantity at the stump) left at cutover to meet silvicultural or environmental objectives.

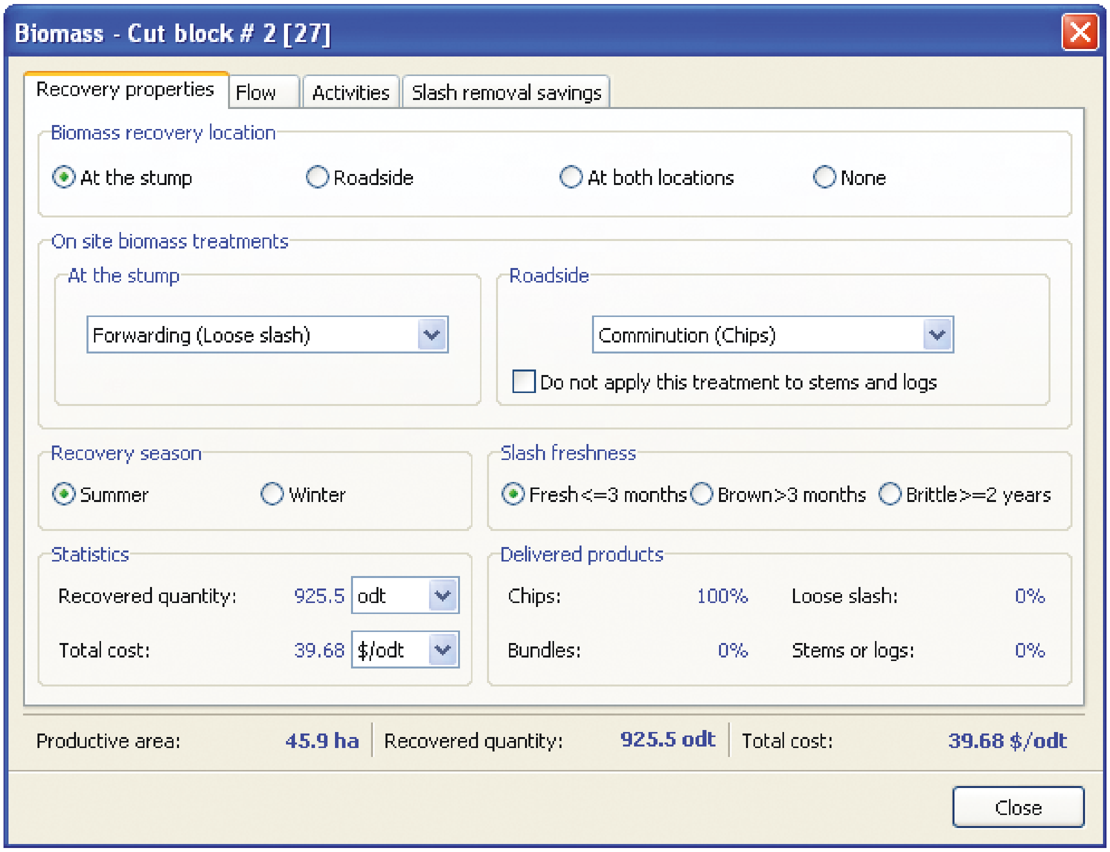


Figure 4. Recovery properties in BiOS.

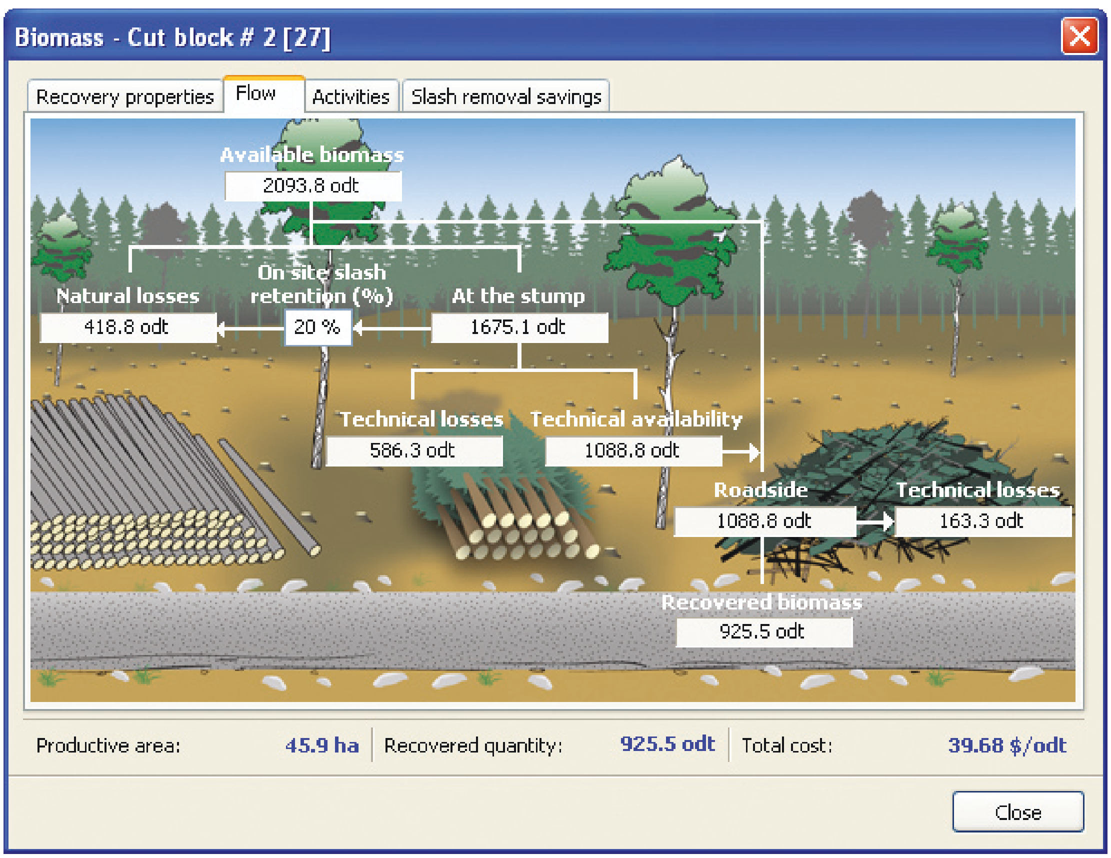


Figure 5. Biomass flow in a cut-to-length harvesting system.

Another FPInterface function helps determine the carbon ratio related to biomass recovery and transport. The report gives a visual image of carbon emissions from forest operations compared to the carbon contained in the wood delivered at the mill (Figure 6).

Applications and results

The BiOS interface allows users to analyze various management scenarios. BiOS provides the opportunity to estimate the proportion of costs associated with each step in the biomass supply chain. Users are then able to pinpoint the area(s) in the chain where most savings can be made.

BiOS data export tools allow users to conduct various feasibility studies on the potential for recovering forest biomass from specific cut blocks, sites, or areas, or for a group of blocks based on a database attribute (Figure 7). This information helps managers determine the best location for establishing a new processing facility, and the most cost-effective locations for biomass recovery.

BiOS can be used to sequence the delivery of biomass into plants so that seasonal moisture content fluctuations are minimized and to determine the impact changes in harvest scheduling may have on biomass deliveries and cost.

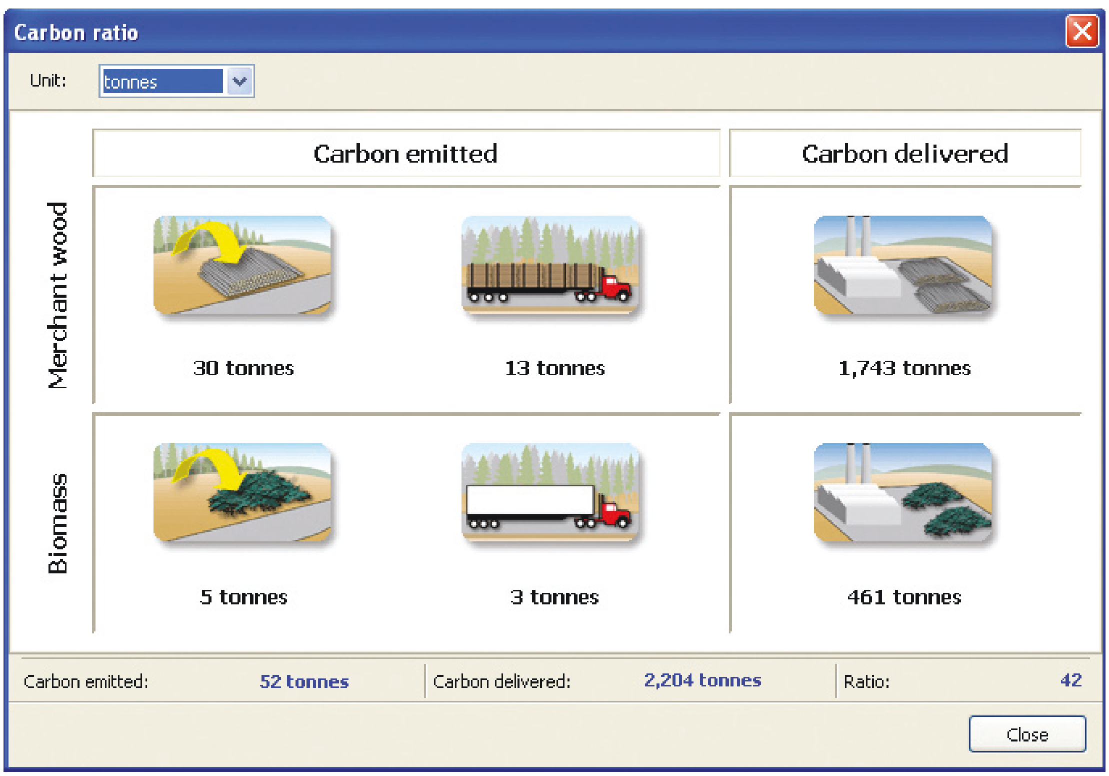


Figure 6. Carbon ratio (one-way distance of 55 km).

Finally, the recoverable biomass volume from a given area can be determined based on a maximum cost of recovery that can fluctuate with negotiated rates and market price (Figure 8).

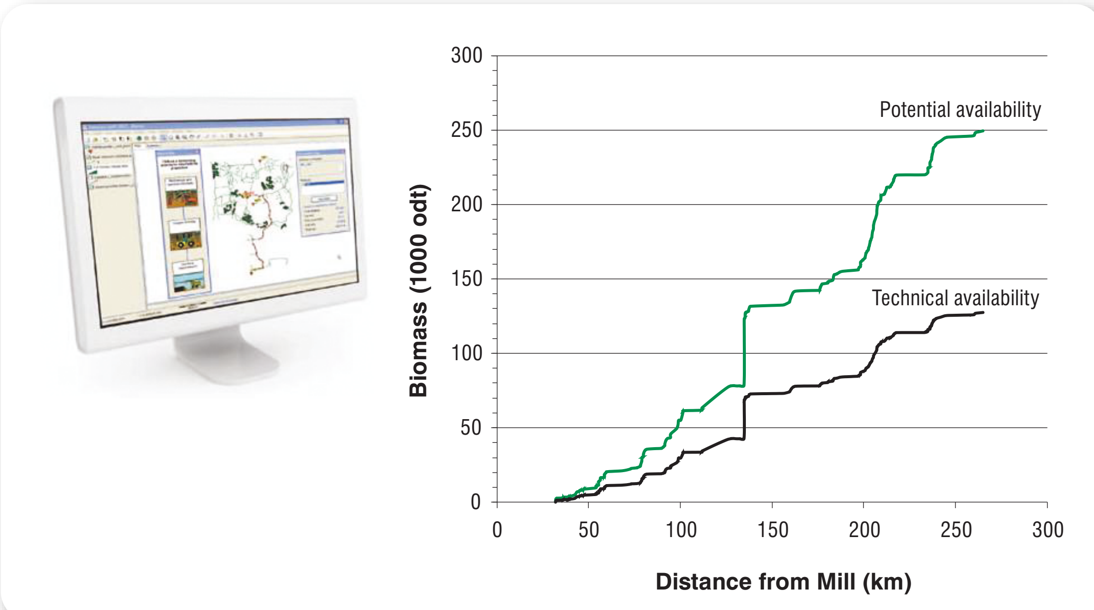


Figure 7. Regional availability of biomass around a mill.

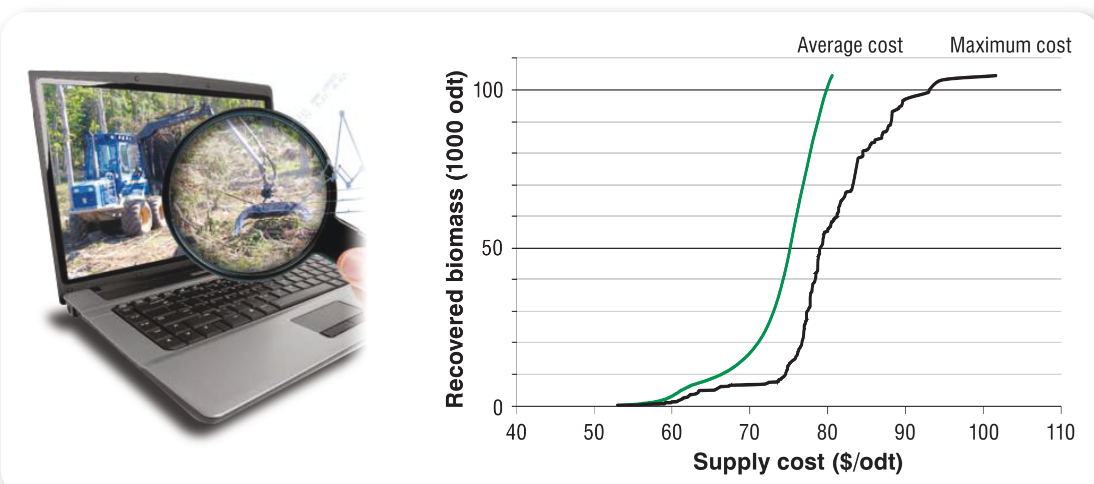


Figure 8. Supply analysis based on delivery cost for a mill.

Validation

The BiOS module in FPInterface has been validated for the boreal forest conditions of Quebec and Ontario. It is currently being calibrated for British Columbia, Alberta, and Saskatchewan.

In general, the scientific research and equations used in BiOS suggest that the larger the area considered for biomass recovery, the more likely BiOS outputs as presented will correlate to actual results. For smaller areas of study, validation studies should be considered to verify and, if needed, adjust BiOS to support the local stand conditions.

Validation studies should provide guidance for:

- The volume of standing timber by species available for harvest, the volume (or weight) of merchantable logs produced, the log weight-to-volume conversion factor, and the topping diameter;
- The volume of biomass at roadside or in the cut block after harvesting, and remaining in the cut block as unharvested stems, coarse woody debris, and non-recovered stems or logs;
- The weight of biomass delivered and its moisture content;
- The cycle times and fuel consumption for the specific haul configurations used.

Based on the results of the validation studies, modifications to freshness and seasonality factors may be required.

BiOS Availability

FPInterface and BiOS are available to members of FPInnovations. Individuals who would like additional information, a demonstration, or are interested in acquiring the tool should contact:
supportfp@fpinnovations.ca

Acknowledgments

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