AutoStem Value Recovery Study

West Argyll

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Context

From the scanning results and cross-cutting options obtained from the Argyll study, we are able to simulate the best plans for the supply and distribution of logs to the market, whilst maximising the potential harvest value of each forest.

The sites were laser scanned and 3d stem files were created to represent the variation of stem straightness and taper in each stand. Harvest simulation software, AutoStem Harvest, was used to generate an extended set of log demands and analyse the impact on forest value. This allows us to assess the actual harvest value achieved compared to the potential optimal value of the stands, given the current market demands.

The Planning Problem

The problem we are addressing here is a decision-support one, where several inter-related decisions need to be made on the cutting pattern and distribution of logs from several forest to satisfy (or partially) demand for different log lengths from various sawmills. If these decisions can be made together, so that the problems is solved as a whole (instead of solving one part which then sets up another problem), then we can hope to achieve better informed solutions.

The decisions to be made regarding planning include,

1. Whether a forest is cut,
2. how that forest is cut (harvester instruction set) and
3. where the logs are then sent (logs may be distributed across several sawmills)

This is a multi-criteria problem reflecting the various stakeholders objectives (primarily forest owners and sawmill owners) and the different 'costs' associated with harvesting plan. These criteria include,

1. Loss of value – this is the perceived cost to the forest owner and sawmiller in using a set of harvester instructions which do not extract the most book value from the forest. Commonly a different instruction set might be used which matches better the demand. Currently, this factor is measured in Pounds, although it does not necessarily mean that the full value could have been obtained in the current market. The forest owner would like to see this measure as small as possible in a resulting plan.
2. Log Shortage – this is a measure of the shortage to a sawmill's demand. This represents both the loss of goodwill between the log supplier and the sawmill, as well as lost profit to the sawmill. Currently, this is measured as the volume of logs which cannot be supplied towards the overall demand. To compete in the Global Market place the industry would like to see this factor as low as possible.
3. Stock – this measure represents the volume of logs which have been cut and stored at roadside or mill yard. This factor is measured currently in terms of volume. The forest industry would like to see this factor as small as possible in the resulting plan.

4. Revenue – this measures the actual value of the transaction between forest owner and sawmill. Both the forest owner and sawmiller would like to see this measure as high as possible. It has an upper limit of satisfying demand fully.
5. Transportation – finally, this measure is the cost associated with transportation of logs from the forests (to be cut) to the sawmills. Currently, this is measured in Pounds. Do we satisfy demand if it entails high transportation costs? Both forest owner and sawmill would like this factor as low as possible in any plan.

As can be seen, these different criteria are often contradictory (e.g. satisfy demand vs cut to value, satisfy demand vs transportation) and further, are not measured in the same units (Pounds and cubic metres). We therefore adopt a weighted factor approach to handling these in the objective function of any model. This means that the actual weights have to be determined through real-life evaluation with the planner. In the rest of the report we show how various plans can be produced through changing this weighting of Value or Demand.

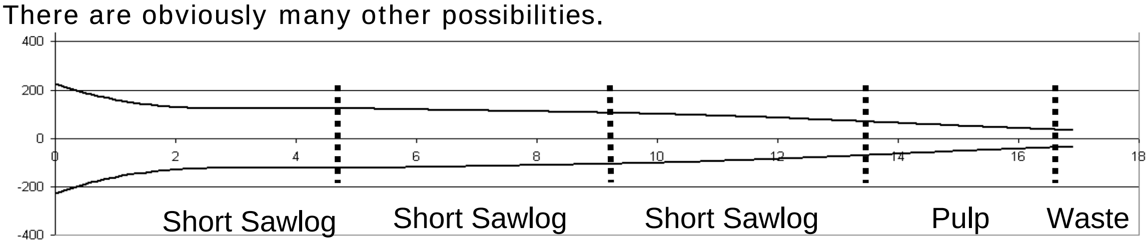
Online Log Exchange

As part of the Argyll study, an online Decision Support System (DSS) site was created to present the cross-cutting software and allow the user to assess the different harvest options, given the current market demands and current available forests. The system shows how different demands and log values result in different harvesting instructions and consequently different quantities of logs being produced from the same forest. The site can be accessed from the following link www.4c.ucc.ie/trio/

Cross-cutting software

Cutting a stem

For a single stem described in a series of circles up along the truck, the software evaluates the different combinations of log types which can be extracted from the tree, taking into account the log length, minimum top diameter and acceptable sweep. From Figure 1 we can see two possible options for harvesting a single stem. There are obviously many other possibilities.



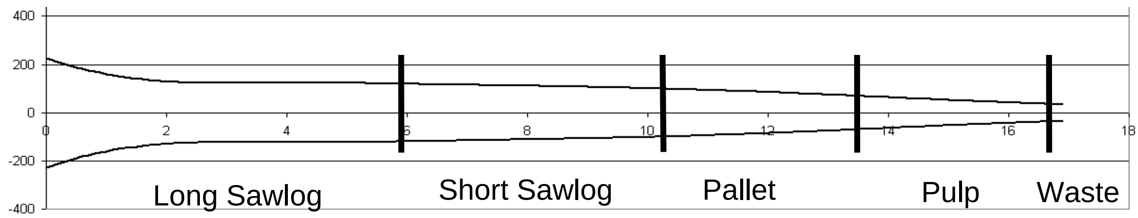


Figure 1: Possible Log Breakouts from a Single Stem

Therefore, by repeating this cross-cutting process over each stem in the stem bank and extrapolating the results over an area of the forest, this gives us an estimation of the total content of the area in terms of product volume.

Which way to cut

There are two philosophies for cutting a forest, cut to value and cut to demand.

Cut to value is where we cut to try and achieve the maximum value for the forest owner from each single stem. The way to cut is based on the knowledge that each log has a value per cubic metre. Typically the longer lengths of log have higher unit value as these are the only lengths capable of certain uses and also there are fewer of them (a 4.3m log can always be cut short for 3.7m). Therefore, from Figure 1 we can calculate easily the value of a stem cut in each way, once we know the cost per cubic metre for each log type.

Cut to demand is where we cut to try and satisfy the demand. Again from Figure 1 we are more likely to cut using the first option if there is a higher demand for short sawlogs.

As can be envisaged, the two options are sometimes contradictory if the demand represents low value logs. Sometime sawmills require pallet rather than long sawlog which means that 'value is lost' to the forest owner. However, if the forest was cut to value, then logs would be left as there is no demand or perhaps sold for low cost as pulp. The forest owner instead could choose not to cut and then incur dissatisfaction with the sawmills. What all this means is that to satisfy demand there may be a 'cost' to the forest owner in loss of value and hence the sawmills making this demand should realise this. If a forest is poor and can only deliver pallet, then this forest would better match the demand for pallet and without such a loss of value to the forest owner.

Generation of APT file

The final part of the cross-cutting software is to translate the recommended instructions of cutting the stems in the bank into an APT file – the instructions or weights passed to the harvester to determine how it cuts each tree.

The Portal Interface

The Portal presents five measured forests throughout the Argyll region of Scotland. Each forest has associated with it a bank of stem files representing the distribution of tree types in that area. There are seven considered log types which can be cut from each forest representing typical demand from the sawmills in the region. The logs are, sawlog 5.5m, sawlog 4.9m, sawlog 4.3m, sawlog 3.7m, pallet 3.1m, pallet 2.5m and pulp 3.0m. Each of these lengths also has the industry specifications for maximum butt end, minimum top diameter and a maximum sweep deviation. For each of these lengths we can specify the cost per cubic metre and the percentage we are seeking from each forest (see

Figure 2).

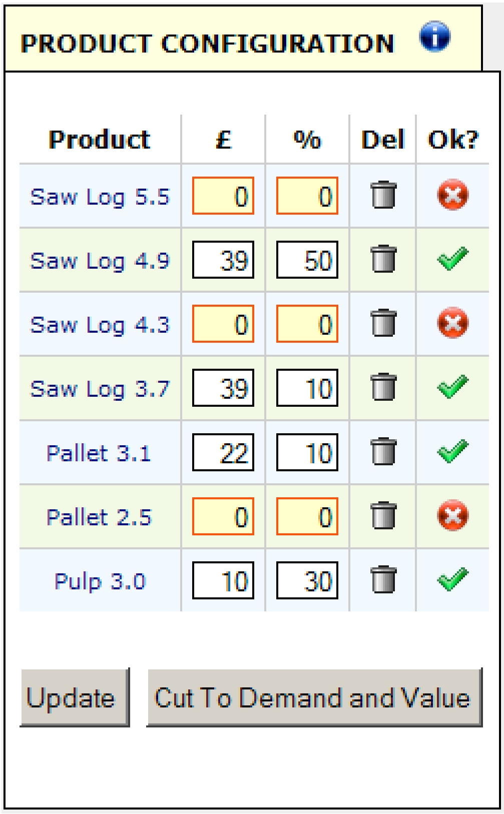


Figure 2: Interface to Specify Value and Demand Parameters

Once the demands/values have been specified for a particular scenario, we can then simulate the best way of cutting each forest for both value and demand.

The results are presented through the Google Maps icon of each forest (see Figure 3).

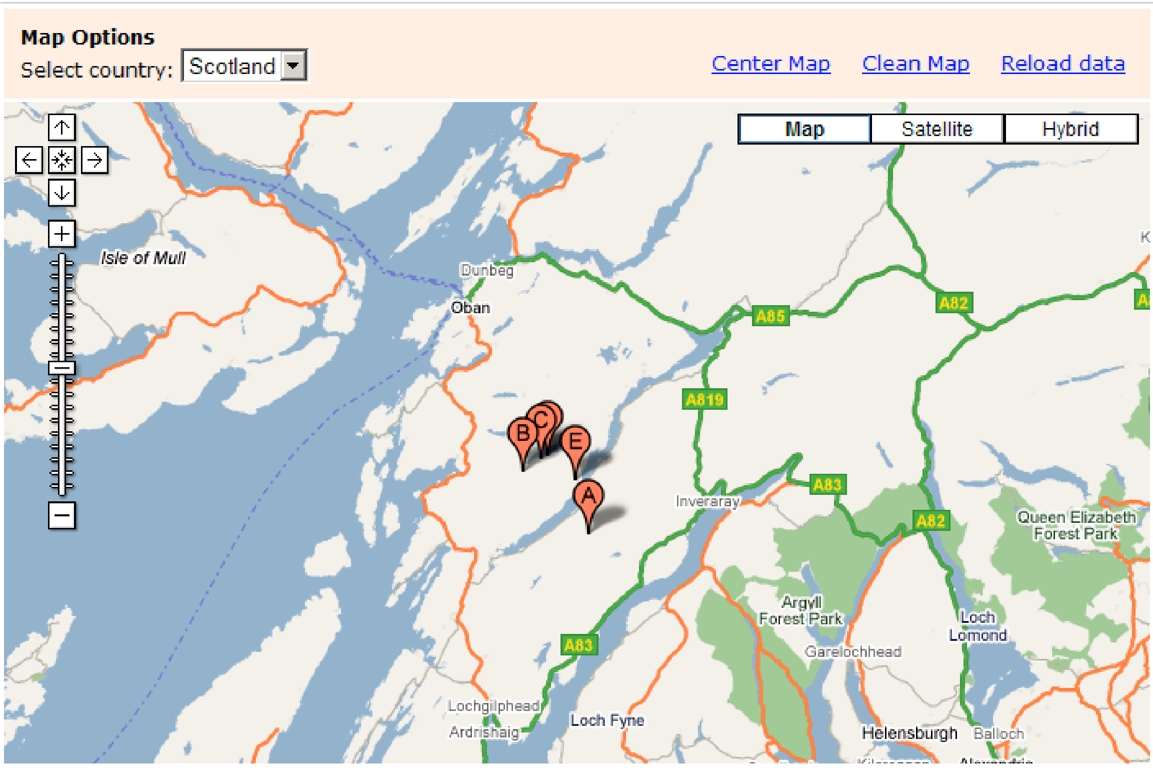


Figure 3: Location of Each Forest

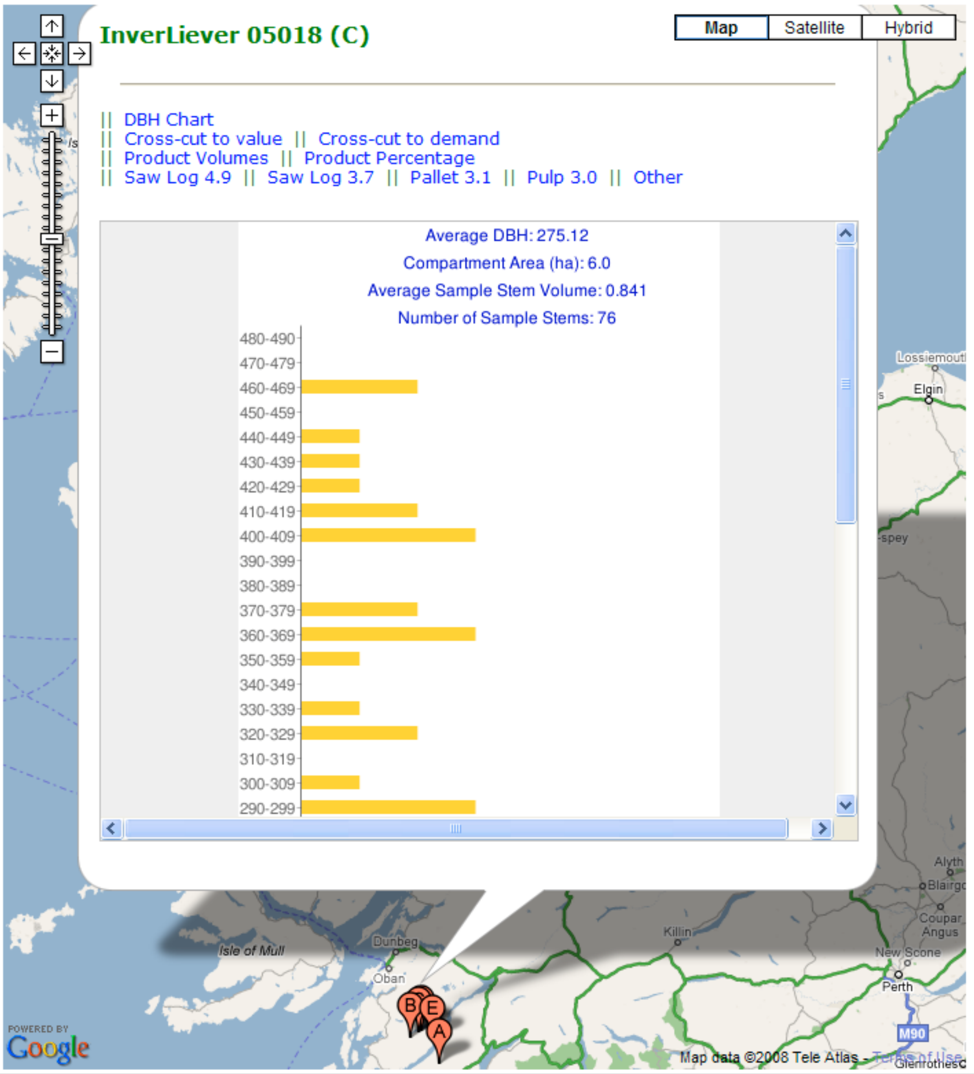


Figure 4: Navigation of Results through Google maps

Type of Information

The results of the simulation of cross cutting each forest according to demand/value are shown in several categories.

Distribution of Diameter at Breast Height (DBH)

For each forest an estimation of the DBH can be made for each stem scanned and therefore extrapolated across the whole area to give an overall distribution (Figure 5).

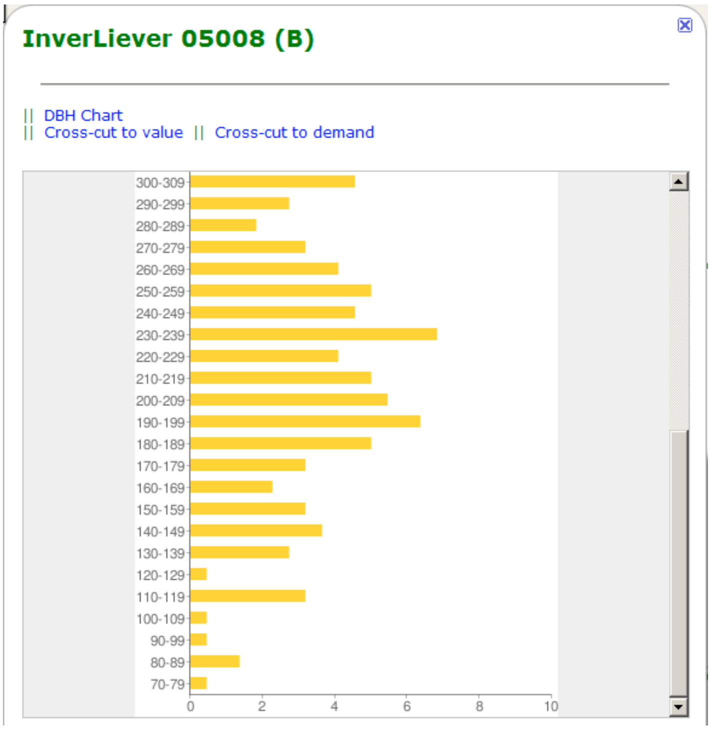


Figure 5: Distribution of DBH across one Forest

Cut to Value distribution in cubic metres

From the scanning and simulation we can also estimate the total volume of the forest and break this down into volume per log type (Figure 6).

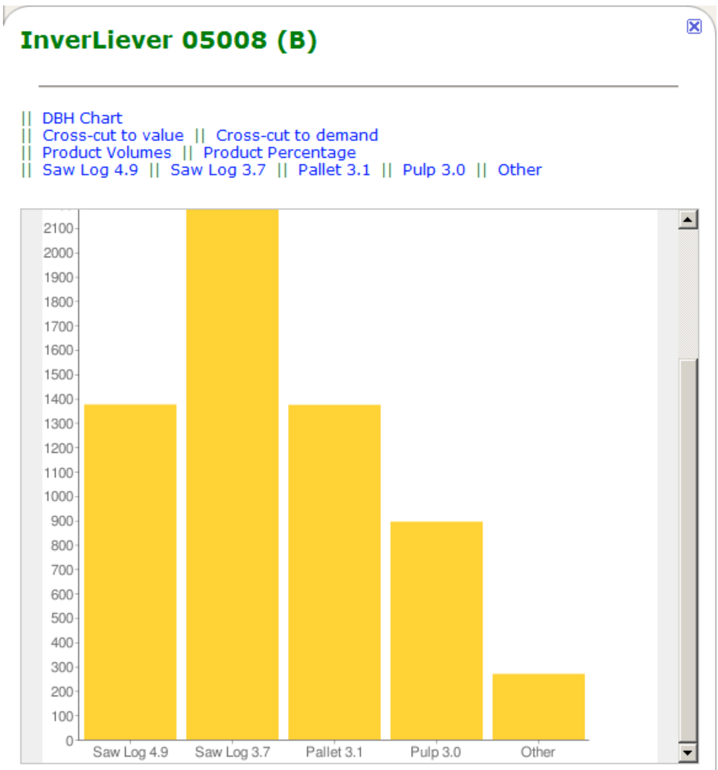


Figure 6 Breakout of Volume per Log Type

Actual % breakout for demand

How well the harvest simulation addresses the demand is shown in Figure 7 . In this case the option to cut to demand has been taken.

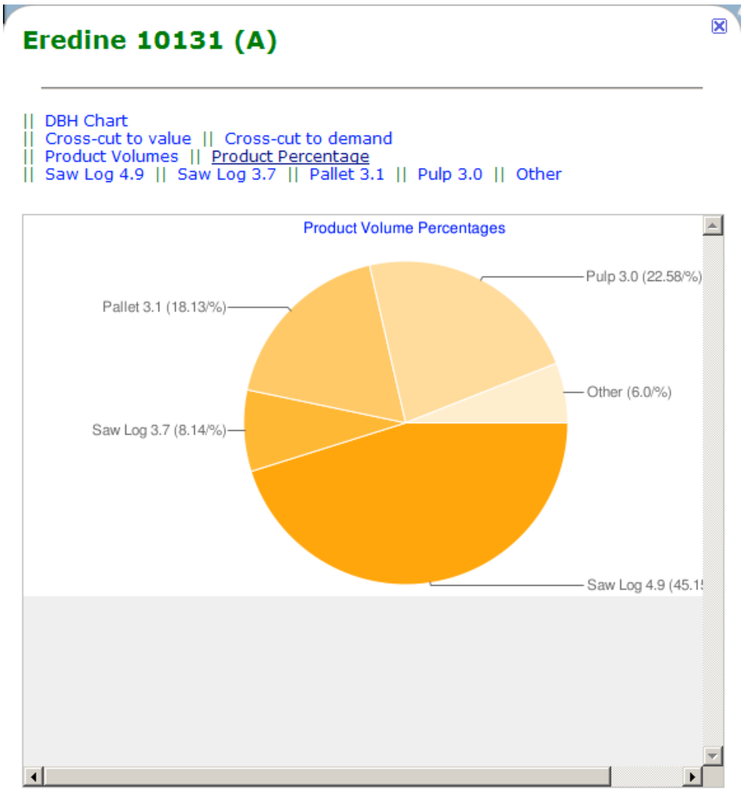


Figure 7: Percentage Breakout for one Forest and one Demand Pattern

Top diameter distribution

As each stem is cut during the simulation, so the top diameter of each log can be recorded (Figure 8).

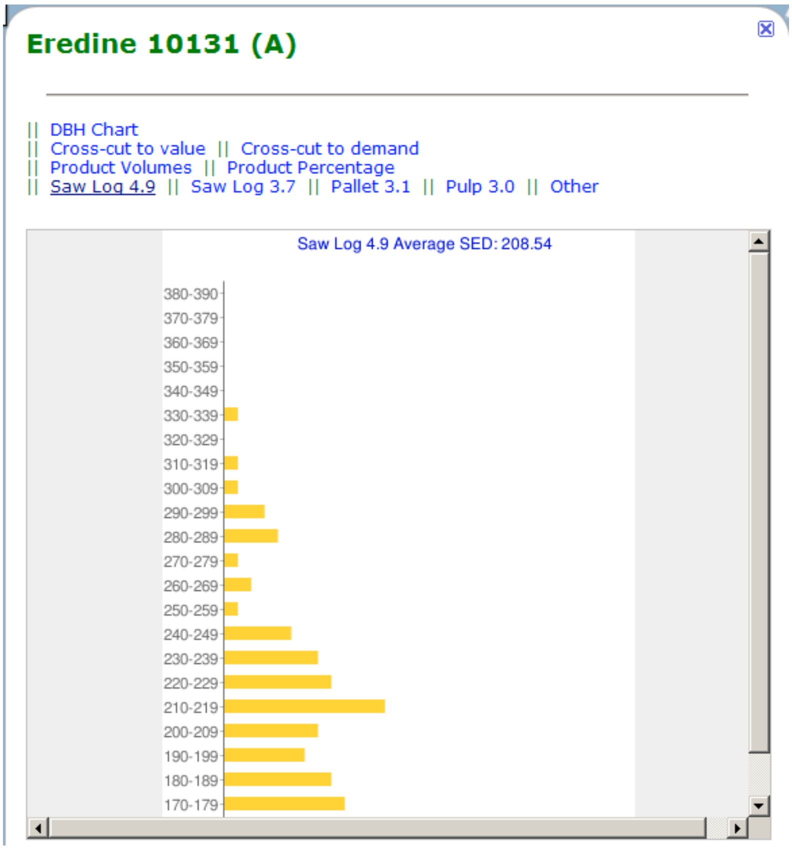


Figure 8: Distribution of Top Diameter for Sawlog 4.9m

Results

Four of the Stands in the study have currently been felled. To demonstrate the potential for improvement in the value of each stand, a harvest instruction with all log options was selected and cut to value. The optimal value of each stand can be estimated using the estimated roadside values in table 1 below.

Product	Value £/m3
Sawlog 4.9m	39
Sawlog 3.7m	39
Pallet 3.1m	22
Pulp 3.0m	10

Table 1: Log product Roadside Values

Using the values in table 1 above, the actual harvest value was calculated using the volumes of the different logs cut in each forest. The analysis of the results is presented in table 2 below.

	Optimal Value (£)	Actual Value (£)	% Loss	Actual Total Value (£)	Optimal Total Value (£)
Eredine 10131	28.57	27.19	-4.83	124,339.87	130,650.61
InverLiever 05008	30.29	25.03	-17.37	195,584.42	236,686.06
InverLiever 05018	31.42	27.20	-13.43	56,875.20	65,699.22
InverLiever 05103	25.66	22.56	-12.08	66,980.64	76,184.54
			Total	**443,780.13**	**509,220.43**

Table 2: Harvest Analysis

When using a cutting to value instruction for all logs the total potential value loss is £65,440 which is an average loss of 11.93%. Allowing multiple log options for each sample tree enables the best possible use of the higher value sections of each tree. Given that there is no difference in the values of different lengths of Sawlog and Pallet, there will be a higher proportion of short logs cut in the different assortments.

What-if Scenarios

1. For a given demand/value which is the best forest to address this?

Each forest was cut to value using the log values presented in Table 1 above. Then the stands were cut to demand to try and satisfy a log mix 50% 4.9m, 10% 3.7m, 10% 3.1m Pallet and 30% Pulp.

Forest	Eredine 10131	InverLiever 05008	InverLiever 05018	InverLiever 05023	InverLiever 05103
% breakout *	45/8/18/23	49/10/9/29	52/9/26/10	51/9/23/13	32/9/16/36
Ave stem volume (m^3)	0.42	0.59	0.84	0.71	0.27
Value per cubic metre £ (cut to value)	27.77	29.54	30.78	30.31	24.71
Value per cubic metre £ (cut to demand)	27.03	27.69	30.53	29.71	23.24
Loss of value per cubic metre (£)	0.74	1.85	0.25	0.6	1.47

* other lengths will unavoidably be generated during the cutting making up the percentage.

In terms of matching the demand, forest InverLiever 05008 gets closest to this. In other words this forest has the right proportions to satisfy this type of demand profile. However, the loss of value indicates that there is greater potential value in this forest. InverLiever 05018 may be more suitable as it has a lower loss of value and meets 3 of the four percentage requirements.

Other information we can derive from the simulation is an estimation of the volume of timber each forest holds with InverLiever 05008 appearing to have greatest volume, and the quality of the trees (in terms of the average stem volume) with InverLiever 05018 appearing the best quality. Of course straightness and quality is not presented explicitly, but curvature is taken into consideration when simulating the harvesting

2. Change the product demand to show different value recovery

In this scenario we demonstrate the value impact of cutting a high proportion of pallet. This will enable the industry to select poorer stands to meet lower value log mix's.

Forest	Eredine 10131	InverLiever 05008	InverLiever 05018	InverLiever 05023	InverLiever 05103
Value per cubic metre £ (cut to demand)	27.03	27.69	30.53	29.71	23.24
Target % Breakout 5/5/60/30	2/8/71/19	1/0/84/14	0/0/89/10	0/0/88/11	6/6/61/26
Value per cubic metre £ (new demand) 5/5/60/30	21.14	20.24	20.63	20.46	20.51
Loss of value (£)	5.89	7.45	9.90	9.25	2.73

Notice how some poorer forest closely meets the demand for higher proportions of pallet log.

3. Typical Industry harvester APT. If I make log lengths significantly more valuable, what is the impact on volume recovery?

Forest	Eredine 10131	InverLiever 05008	InverLiever 05018	InverLiever 05023	InverLiever 05103
4.9m log recovery at £39/m3	24.43%	21.76%	21.22%	24.09%	20.58%
Sawlog 4.9 up from £39 to £78/m3	48.43%	52.32%	55.88%	54.99%	32.35%
% Increase	24%	31%	35%	31%	12%

It can be seen that doubling the value (or weighting) for 4.9m logs you will significantly increase the amount harvested. This is the preferred method for cutting to demand in the Scottish Industry. In scenario 5 below we are able to assess the maximum potential output for each log length.

4. Quantity of any log length from each forest i.e. which has got most of a certain type if only cutting for that.

Forest	Eredine 10131	InverLiever 05008	InverLiever 05018	InverLiever 05023	InverLiever 05103
Sawlog 4.9m 100%	62.64	63.16	63.77	60.68	50.78
Sawlog5.5m 100%	57.18	60.25	60.88	56.74	47.9
Pallet 3.1m 100%	85.11	87.31	90.73	89.73	76.91
Pallet 2.5m 100%	85.3	88.17	91.27	90.84	78.96

It is possible to extract an average of 60% 4.9m logs from the five stands.

Conclusions

We have developed a decision support tool which provides many of the indicators that timber professionals are looking for when making harvesting decisions. Some of these indicators are new to the industry but will provide more relevant information. This will facilitate better utilisation of the forest resource and allow the industry to react cohesively to changing market conditions. As part of the study we developed the Portal system to demonstrate to both forest owners and saw millers that they can work together to implement win win harvesting strategies. All harvest options can be assessed before felling, to ensure best possible use of the resource whilst keeping the market satisfied. Forests can be better selected for harvest on value terms, to meet different demands.

The information is based on stem files that describe the variation of taper and straightness in the stand. The information is delivered in a format that estimates the overall log breakout throughout a given Stand. A key issue to the success of this system is proper stratification of the Stand during the scanning operation.

All felling decisions can to be benchmarked during and after harvest operations to audit the value effect of the actual decision. This will enable, process control leading to lean resource management.

