DIVERSIFIED SPECIES TECHNICAL NOTE

Number: DSTN-021
September 2010

Improvements to the Douglas-fir Growth Model and Calculator

Summary

This report describes Version 4.0 of the Douglas-fir Calculator. This new version of the Calculator contains a number of changes including various improvements to the productivity index calibration algorithm, a batch-run facility allowing productivity indices to be obtained, and removal of a bias in the growth model which caused under-prediction following thinning. Further validation of the growth model indicates that it generally performs well and is unbiased overall. However, several mostly minor shortcomings in model performance have been identified that will be corrected in future releases of the model. This updated version of the Douglas-fir Calculator is available to FFR members.

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Changes to the Douglas-fir Calculator

This report describes Version 4.0 of the Douglas-fir Calculator. The new version has the following changes:

- Modification to the growth model to remove bias following thinning as outlined in the following section.
- Correction of a serious bug which caused incorrect 500 Index estimation when calibrating with rotation age set to less than about 30 years.
- Timing of thinning in previous versions of the Calculator was specified using MTH. In the new version, this is now specified by age. This brings the D-fir Calculator into line with Radiata Calculator.
- In previous versions of the Calculator, the actual stocking of the calibration measurement was ignored. This meant that the 500 Index tended to be under-estimated if the calibration measurement was from a plot with a high level of mortality. The new version of the Calculator uses actual stocking of the measurement when estimating the 500 Index.
- The new version has a facility allowing batch runs for estimating the 500 Index and Site Index for a list of plots. This is described in the Appendix of this report.
- The minimum allowed 500 Index has been reduced from 5 to 1 to allow for calibration of very low productivity sites.
- An overflow error which sometimes occurred when more than 3 thinning were specified has been eliminated.
- In earlier versions, it was necessary for the user to specify latitude. A default value of 41° is now assumed if the user does not specify it.

Because predictions from calibration runs now use actual stocking rather than estimating stocking using the mortality function, the predictions from a calibration run are for the individual calibration plot.

If predictions (e.g., of volume, log grades, etc.) are required more generally for the stand in which the calibration plot is located rather than for the plot itself, it may be better to re-run the Calculator after manually entering the productivity indices so that the model mortality function is used to predict stocking.

Correction to bias in the Douglas-fir Growth Model

A validation of the Douglas-fir growth model performed for FFR in 2009/10 indicated that it under-predicted growth following thinning. To confirm and correct this result, an analysis was performed of Permanent Sample Plot (PSP) data from forests belonging to FFR members from throughout New Zealand. Unlike previous analyses, care was taken to limit the validation to stands which had been planted after the arrival of Swiss needle cast (SNC) disease. This was thought advisable as recent work confirms that the disease has a substantial impact on Douglas-fir growth rate.

SNC was first recorded in the Central North Island in 1959 and spread throughout most of the North Island in the following decade. It was first observed in the northern South Island in 1969 and spread throughput the remainder of the island in the following two decades. Restriction of the validation dataset to plots established in post-SNC stands was made possible using records of the year the disease was first observed for all significant forests in New Zealand provided by Ian Hood of Scion.

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After removing pre-SNC plots, 460 plots containing 2617 measurement increments remained for use in the analysis (Table 1). This dataset covers all regions where Douglas-fir is an important plantation species except for Nelson. Unfortunately, most available PSP data from Nelson was from stands planted prior to the initial detection of the disease.

Table 1. Numbers of plots and measurement increments used in analysis.

G.M. Region	No. plots	No. increments
Central North Island	164	1584
Hawke Bay	65	236
Nelson	22	22
Canterbury	93	212
Southland/Otago	116	563
Total	460	2617

The analysis used the calibration routine implemented in the Douglas-fir Calculator. For each measurement increment (consecutive pair of measurements from one plot), basal area (BA) and MTH were estimated for the second measurement age using indices calibrated using the first measurement. The ratio of actual to predicted BA increment was then used to determine whether the model was biased. A mean ratio of 1 indicates the model is unbiased while ratios below or above 1 indicate over- or under-prediction respectively. When the ratio was plotted against years since thinning, it demonstrated that the model slightly under-predicts for a period of about 5 years following a thinning (Fig. 1). To correct this bias, the 'thinning shock' parameter in the growth model was reduced until the bias was eliminated (Fig. 1).

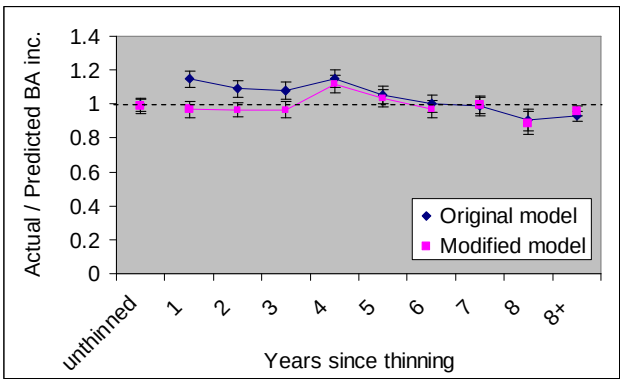

Fig. 1. Mean actual / predicted BA increment versus number of years from thinning for the original and modified models. Error bars are 95% confidence intervals.

Further Model Validation

The validation dataset summarised in Table 1 was next used to test the model for any remaining bias. Across the entire dataset, the actual/predicted BA increment ratio averaged 1.001, demonstrating that overall, the model is unbiased.

Mean BA increment actual/predicted ratios are shown plotted against various stand variables grouped into classes in Figs. 2 to 6. These reveal the following:

- The model has no regional biases except for a slight tendency to under-predict in Otago/Southland (Fig. 2).
- The model is unbiased for stockings below 1000 stems/ha but has a tendency to under-predict at stockings of 1500-2000 stems/ha (Fig. 3).
- The model tends to under-predict at ages >40 years (Fig. 4).
- There is a tendency to under-predict both for very low and especially for very high productivity sites (Fig. 5).
- The model shows no bias against age of thinning (Fig. 6).

The above results suggest that the model has a number of minor shortcomings which could fairly readily be corrected. It is intended that these issues can be addressed in future releases of the Douglas-fir Calculator and other implementations of the growth model.

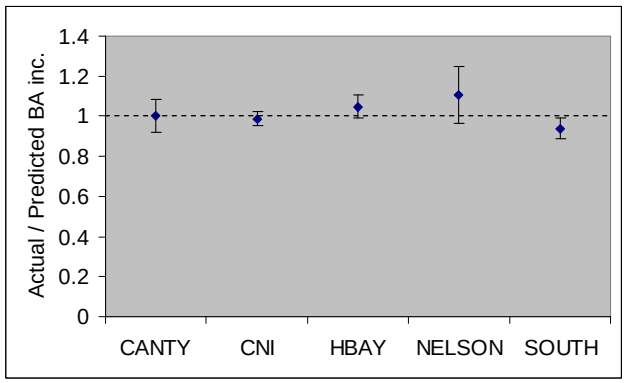

Fig. 2. Actual / predicted BA increment averaged for each Growth Modelling region. Error bars are 95% confidence intervals.

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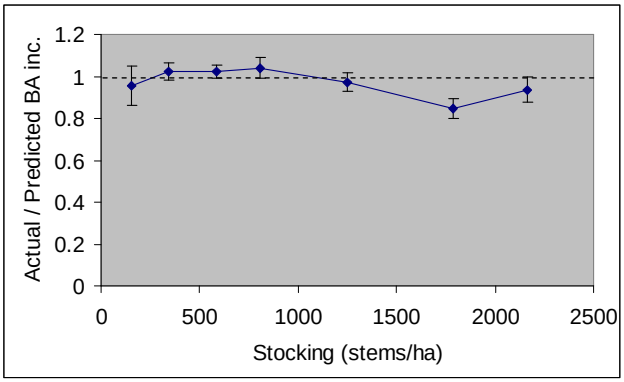

Fig. 3. Mean actual / predicted BA increment by stocking. Error bars are 95% confidence intervals.

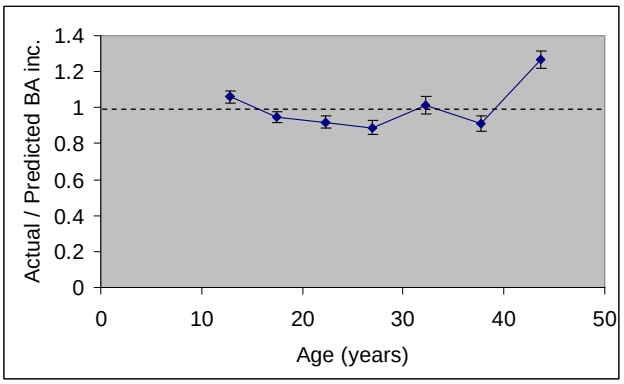

Fig. 4. Mean actual / predicted BA increment by age. Error bars are 95% confidence intervals.

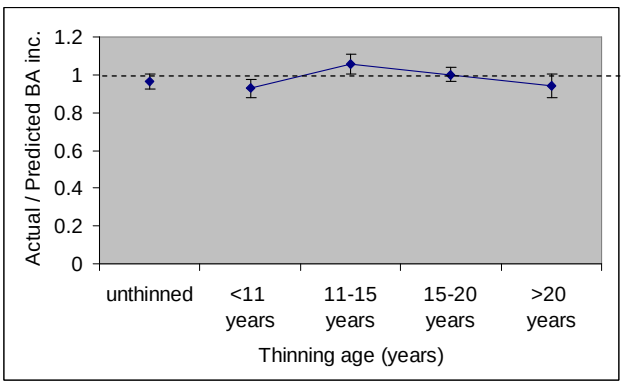

Fig. 5. Mean actual / predicted BA increment by 500 Index. Error bars are 95% confidence intervals.

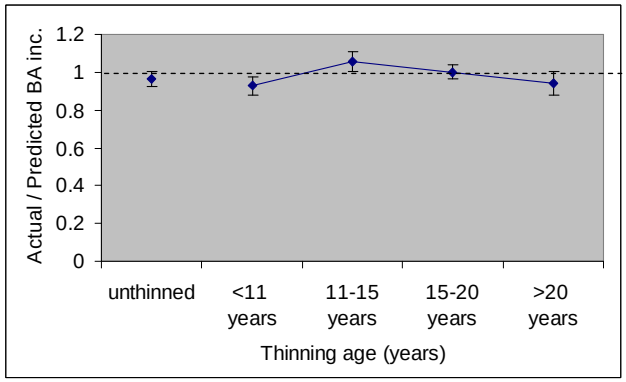

Fig. 6. Mean actual / predicted BA increment by age of last thinning. Error bars are 95% confidence intervals.

Updates and Support

Version 4.0 of the Douglas-fir Calculator is the first version with a batch-run productivity index calculation facility which is described in the Appendix. It is intended to update relevant modules in future as new information from the Scion/FFR Diversified Species Program becomes available.

We also intend to make improvements to subsequent versions as its use becomes more extensive and the need for either new features or enhancements is identified. To this end, we welcome any feedback or suggestions for improvements.

NOTE:

It is always important to be aware of the limitations of the models and the assumptions that are embedded in the calculation routines, and to apply the results with caution (or modify them appropriately using experience and local knowledge) if local conditions are different.

For support, queries or feedback, please contact one of the following:
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Appendix. Batch run facility for estimating productivity indices for multiple stands

Fig. A1 presents an overview of the structure of the new PSP batch run facility within Douglas-fir Calculator version. 4.0

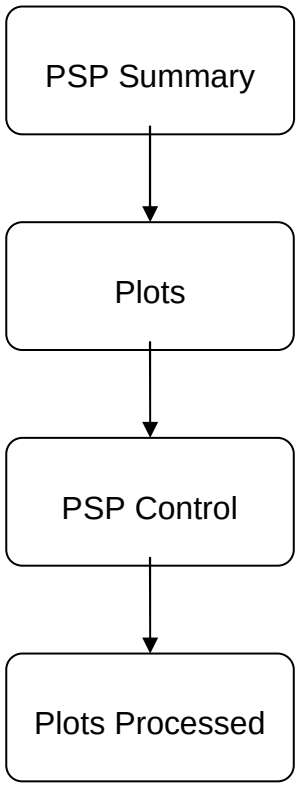

Fig. A1. Structure of batch run in the calculator

The new version of the calculator performs batch runs using stand summary information (such as PSP data) enabling growth prediction across multiple stands. This facility is designed for quick and easy calculation of Site Index (SI), SBAP and 500Index showing the growth potential for a list of the PSP plots.

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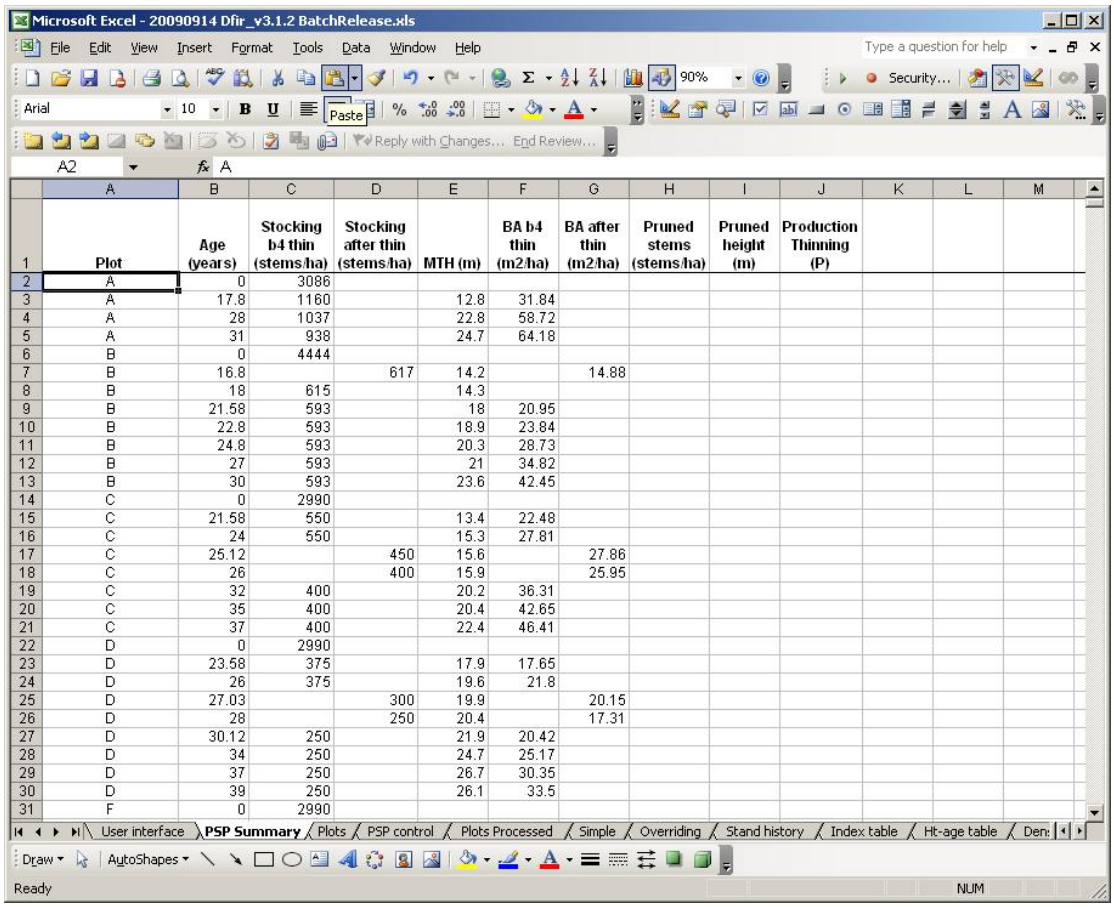
Inputs: PSP Summary

The procedure for entry of inputs is as follows. PSP data must be entered into the "PSP Summary" worksheet in the Calculator. Fig. A2 shows the interface of this worksheet.

Definition of columns in PSP Summary worksheet:

Column A: The Plot id (in alphanumeric)
Column B: Age (years)
Column C: Stocking before thinning (stems/ha)
Column D: Stocking after thinning (stems/ha)
Column E: MTH (m)
Column F: Basal Area before thinning (m^2/ha)
Column G: Basal Area after thinning (m^2/ha)
Column H: Pruned stems (stems/ha)
Column I: Pruned height (m)
Column J: Production thinning (P)



Microsoft Excel - 20090914 Dfir_v3.1.2 BatchRelease.xls

Plot	Age (years)	Stocking b4 thin (stems/ha)	Stocking after thin (stems/ha)	MTH (m)	BA b4 thin (m2/ha)	BA after thin (m2/ha)	Pruned stems (stems/ha)	Pruned height (m)	Production Thinning (P)
A	0	3086							
A	17.8	1160		12.8	31.84				
A	28	1037		22.8	58.72				
A	31	938		24.7	64.18				
B	0	4444							
B	16.8		617	14.2		14.88			
B	18	615		14.3					
B	21.58	593		18	20.95				
B	22.8	593		18.9	23.84				
B	24.8	593		20.3	28.73				
B	27	593		21	34.82				
B	30	593		23.6	42.45				
C	0	2990							
C	21.58	550		13.4	22.48				
C	24	550		15.3	27.81				
C	25.12		450	15.6		27.86			
C	26		400	15.9		25.95			
C	32	400		20.2	36.31				
C	35	400		20.4	42.65				
C	37	400		22.4	46.41				
D	0	2990							
D	23.58	375		17.9	17.65				
D	26	375		19.6	21.8				
D	27.03		300	19.9		20.15			
D	28		250	20.4		17.31			
D	30.12	250		21.9	20.42				
D	34	250		24.7	25.17				
D	37	250		26.7	30.35				
D	39	250		26.1	33.5				
F	0	2990							

Figure A2. PSP Summary worksheet example

For each plot, initial stocking (age 0) must be entered, along with subsequent entries showing age and stocking after each thinning operation, any pruning lift information, and at least one PSP measurement containing age, stocking, BA and MTH.

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Inputs: Plots

Once all of the required "PSP Summary" input data has been entered, a row for each plot must be included in the "Plots" worksheet. This worksheet requires the following mandatory entries for all Plots: Plot id, Year Planted, and Latitude. Entry for other columns is optional (Fig. A3).

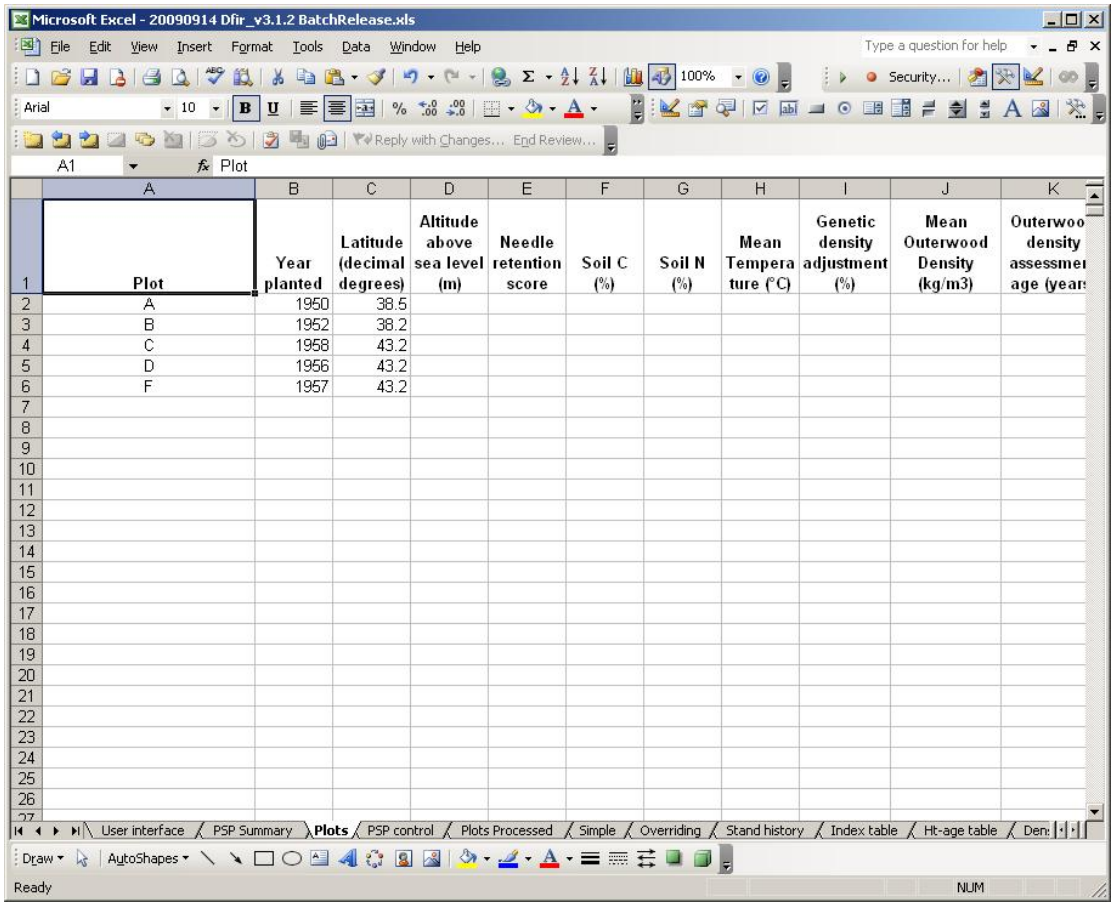

Figure A3: Plots worksheet example

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Inputs: PSP Control

In the "PSP Control" worksheet, enter the first and last row numbers in the "PSP Summary" worksheet that are to be processed (Fig. A4). Then, press the "Estimate 500Index & SI" button to submit the plots for batch run. A lengthy list of plots can take some time to process.

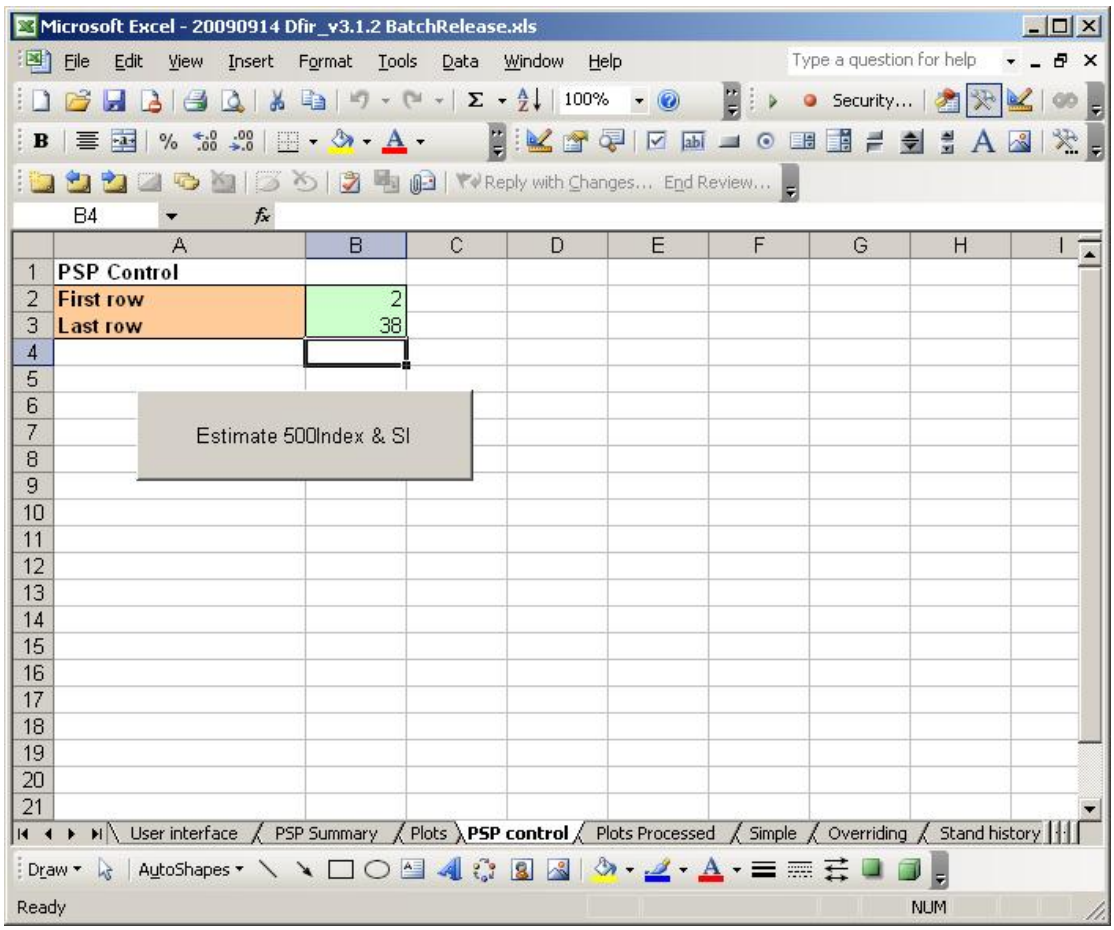

Fig. A4: PSP Control worksheet example

Outputs: Plots Processed

All output is written to the "Plots Processed" worksheet. Definition of columns in the "Plots Processed" worksheet are as follows:

Column A: The Plot id (in alphanumeric)
Column B: Age (years)
Column C: Predicted MTH (m)
Column D: Latitude
Column E: Predicted 500 Index
Column F: Predicted Site Index