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Radiata Pine Branching: A comparison of TreeD Data and TreeBLOSSIM Predictions for Experiment FR7, Woodhill Forest

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EXECUTIVE SUMMARY

TreeBLOSSIM is an integrated individual tree – distance independent stem growth and branch development model. Due to the complex structure of a tree crown, between 50 and 100 trees have been destructively sampled to develop the mathematical functions in the branching component (BLOSSIM) of the model. The functions in Version 3 (used in this study) have been derived using data from a GF14 seedlot.

The non-destructive imaging and data analysis tool, TreeD, is being used to determine whether TreeBLOSSIM produces realistic results for a wide range of site conditions, silvicultural treatments and improved seedlots/genotypes.

In the current study, TreeD images were collected for 102 trees from 17 different combinations of six silvicultural treatments and three seedlots in Experiment FR7, Woodhill Forest.

The observed branching patterns were compared with TreeBLOSSIM predictions.

- TreeBLOSSIM peformed well for the GF14 seedlot – the seedlot for which the model was developed.
- The performance was reasonable for the GF21 seedlot.
- The performance was poor for the long internode (GF13/LI28) seedlot.

This is not unexpected, as the long internode seedlots have been selected to have fewer branch clusters than the “Growth and Form” seedlots upon which TreeBLOSSIM was based.

These results are in line with results from the previous studies that have covered:

- 17 region × site quality combinations for seedlots rated GF14;
- 12 region × site quality combinations for seedlots rated between GF21 and GF25;
- 7 region × site quality combinations for seedlots with a long internode rating.

The TreeD methodology is a useful approach for testing the performance of selected functions within the BLOSSIM branch growth model.

Further TreeD studies are required to cover all region × site quality combinations to provide confidence in results from BLOSSIM, and to determine which seedlots will require their own functions within BLOSSIM. The results to date indicate that long internode seedlots will require their own functions.

BACKGROUND

A tree is a complex organism, designed to survive and grow in a changeable environment for many years.

There are three aspects of a tree that are of particular interest in the context of forestry:

- the shape and volume of the stem;
- the location and diameter of branches attached to the stem; and
- the distributions of wood properties within the stem.

These are in turn influenced by the environment (climate and soil conditions), initial stocking and silvicultural treatment, and the genetic makeup of the trees.

For many years the Stand Growth Modelling Cooperative, now incorporated within FFR, supported research to understand and model the development of radiata pine crowns. The model developed, TreeBLOSSIM, is an integrated stem and crown growth model comprising an individual tree-distance independent growth model, ITGM, and a branching model, BLOSSIM [(1,2)].

The TreeBLOSSIM model can be classified as a dynamic model in that it assumes that tree structure is gradually formed in the growth process such that not only the current state, but also the history of the stand influences the current stem and branch properties.

The branching component does not model the whole crown architecture; it models those components considered important to the value of the tree at the end of the rotation. The specific aspects are:

- The number of branch clusters formed in an annual shoot (annual height increment)
- The distribution (relative location) of these branch clusters within the annual shoot
- The number of branches and cones in each branch cluster
- The azimuthal distribution of these branches and cones
- The change in branch diameter through time (at a point adjacent to the stem but avoiding a nodal swelling)
- The angle of the branch from verticality and its pattern through time
- When each branch dies – becomes bark encased
- If bark is trapped above a live branch.

This level of detail is more than sufficient to grow inventory data forward in time, but has the added advantage of providing input to a sawing simulator such as AUTOSAW [(3)].

The latest functions are described in SGMC Report No. 125 [(1)] and a summary of the model development and future directions are described in SGMC Report No. 150 [(2)].

Due to the complex structure of a tree crown, the number of trees for which data have been collected to be used in model development is limited. As a consequence it is important to ensure that TreeBLOSSIM produces realistic results for a wide range of sites, silvicultural treatments, and improved seedlots / genotypes. To this end, the non-destructive method, TreeD, has been used to provide data from an extensive range of sites, silvicultural treatments and seedlots (see Appendix 2). The current study contributes towards filling this matrix.

INTRODUCTION

This report documents branching data collected from Experiment FR7 using TreeD, and a comparison of these data with TreeBLOSSIM predictions.

Ground-based photogrammetric method (TreeD)

TreeD is a non-destructive, ground-based photogrammetric method that allows measurements of tree characteristics to be extracted from digital images of a tree. Obtaining quantitative measurements of stem and branching characteristics requires a clear view of the stem in question. To obtain this view it may be necessary to clear ground vegetation and dead branches obscuring the stem. A hanging pole of known length provides a scale for the image. The system was originally developed to use film and named PhotoMARVL [(4)]. The system has now been upgraded to work with digital images and renamed as TreeD [(5)].

TreeD data may be utilised in two ways. Firstly it is used to compare TreeD measurements of branch diameter with TreeBLOSSIM predictions to determine how well TreeBLOSSIM predicts branch diameter on independent sites. Secondly the TreeD data can be used to examine the variation in branching due to site, silviculture and seedlot.

Experiment FR7

Experiment FR7, in Woodhill Forest, is one of six "Silviculture/Breed" trials that were established in 1987 at various sites throughout New Zealand [(6)]. These experiments contained six common silvicultural treatments (Table 1) and four common seedlots with the following ratings: GF7, GF14, GF21 and GF13/LI28. There were two replicates for each silviculture / seedlot combination (i.e., two PSPs).

Table 1. Silvicultural treatments common to the 1987 Silvicultural/Breed Trial series.

Treatment	Initial stems/ha	Final stems/ha	Mean crop height at time of thinning (m)	Pruning – crown remaining (m)
1	500	100	6.2	4.0
2	500	200	6.2	4.0
3	1000	400	6.2	4.0
4	1500	600	6.2	4.0
5	500	500	-	-
6	500	200	20.0	4.0

This site, FR7, was classified as a medium site index within the Sands growth modelling region. In terms of the Land Environments of New Zealand [(7)], this trial falls into the Level 2 Environment, G1[(8)].

METHODS

Treatments Considered

For each treatment one replicate was selected. The percentage of trees with recorded stem damage was calculated for each PSP, and the replicate was selected so as to minimise both the extent and variation in the percentage stem damage within a treatment. The PSPs selected for each seedlot /treatment combination are shown in Table 2.

Table 2. PSPs from which images were collected

Treatment	GF14	GF21	LI28/GF13
1	4/21	3/21	1/21
2	10/22	11/22	9/22
3	23/13	22/13	24/13
4	27/24	26/24	28/24
5	35/25	34/25	33/25
6	43/26	41/26	42/26

Selection of Sample Trees

As with previous TreeD studies, all the trees within the selected PSP were ranked according to DBH at last measurement (in this case the 2006 measurement when the trees were 19 years old). Sample trees were selected at given percentage ranks, i.e:

- if there are n trees in the plot, then the ranks are 1….n
- the percentage rank for j^{th} tree is $100 \times j/n$, giving values between $100 \times 1/n$ and 100.

Six trees per plot were selected in the office. These were trees whose percentage rank was closest to 10, 30, 50, 70, 90, and 100 percentiles and that had no incident of stem damage recorded in the PSP system. The complete list of trees imaged is provided in Appendix 1, and the variable, **rel_pos,** is the percentage rank of the tree.

Site Conditions

The site was essentially flat with little understorey. Plot 1/21 (GF13 / LI28 seedlot at 100 stems/ha) was adjacent to a road, and the trees had extremely large live branches low on the stem (see Appendix 3). It would have been necessary to remove some of these branches to obtain the TreeD images. As the future growth of the trees might have been influenced by the removal of live branches, it was decided not to image the trees, so as not to compromise the growth results from the trial.

Image Analysis

An example of a TreeD image is shown in Appendix 4. Using the program TreeD, the following measurements were extracted from the images:

- stem diameter below the cluster,
- height to base and top of the cluster,
- diameter of the largest branch in the cluster that was visible on the image (*BDI)*.

Branching Characteristics Calculated

For each image the base of the lowest and highest branch cluster measured was extracted, and the length of stem common to all images was calculated.

The length of each complete internode within this common stem section was calculated and the distribution plotted.

Three summary branch characteristics were calculated for this common stem section on each tree:

- the mean internode length
- *BDI_{av}* The mean of the largest branch diameters measured by TreeD (i.e., average value of *BDI* for the tree)
- *BDI_{max}* The maximum of the largest branch diameters measured on the TreeD image (i.e., maximum value of *BDI* for the tree)

TreeBLOSSIM Simulations

For each selected sample plot, the latest PSP measurements (at age 19 years) were imported into Version 3.1 of TreeBLOSSIM.

TreeBLOSSIM was set up so that there was no tree mortality (i.e., mortality equations in the individual tree growth model were not used). Any mortality that had occurred in the PSP before age 19 years was accounted for by assuming a thinning at that age. This approach allows the actual stocking of the plot to be maintained through time.

TreeBLOSSIM then estimated the growth and branching pattern of each tree from age 0 to age 19 years. The trees were then grown forward one year in TreeBLOSSIM to age 20 years so that the simulated trees most closely matched the age of the trees when the images were collected. The images were collected in November 2007, and it was considered that little of the branch growth for the 2007-08 season would have taken place by that date.

Comparisons

For each tree, the TreeBLOSSIM branching pattern for the section of stem measured by TreeD was extracted. The position of each cluster and the diameter of the largest branch in that cluster were retained. A graph was plotted showing both the TreeBLOSSIM prediction for diameter of the largest branch in a cluster (*BDTB)* and the image measurement of the largest visible branch in a cluster (*BDI)* versus the height of the cluster. This approach gives a good visual impression of how the model performs for each tree.

The data for each tree were then summarised to give:

- *BDI_{max}* The maximum branch diameter measured on the TreeD image (i.e., maximum value of *BDI* for the tree)
- *$BDTB_{max}$* The maximum branch diameter predicted by TreeBLOSSIM for that stem section (i.e., the maximum value of *BDTB* for the stem section)
- *BDI_{av}* The mean branch diameter measured by TreeD (i.e., average value of *BDI* for the tree)
- *$BDTB_{av}$* The mean branch diameter predicted by TreeBLOSSIM for that stem section (i.e., average diameter *BDTB* for the stem section)
- *CLI* Number of branch clusters on the stem section measured by TreeD
- *CLTB* Number of branch clusters on the same stem section in the TreeBLOSSIM prediction
- *zonelength* height to base of highest cluster – height to base of lowest cluster (both measured from the image)

The following differences were then calculated for each tree:

$DIFF_{max} = BDI_{max} - BDTB_{max}$

$DIFF_{av} = BDI_{av} - BDTB_{av}$

$DIFF_{CL} = (CLI – CLTB) / zonelength.$

These differences were then plotted against the relative position of the tree in the DBH distribution (equivalent to percentage rank) for each plot.

RESULTS

TreeD images were analysed for 102 trees from 17 different silvicultural treatments. The section of stem visible on the images varied between trees. This is not an issue for comparing TreeD measurements with TreeBLOSSIM predictions.

Common Stem Section

The base of the lowest and highest cluster digitised on each image was calculated to determine the section of stem measured on all images. For this study the common stem section was 4.5 m to 13.5 m.

Internode Length

The distribution of internode length for the above stem section was calculated for 3 classes (**Figure 1**):

- internodes between 0 and 0.6 m (midpoint 0.3 m)
- internodes between 0.6 and 1.0 m (midpoint 0.8 m)
- internodes greater than 1 m (midpoint 2.0 m)

For the GF14 and GF21 seedlots approximately 90% of the internodes were less than 0.6 m. For the long-internode seedlot (GF13/LI28) over 70% of the internodes were less than 0.6 m.

For each tree, the mean internode length in the above stem section was calculated. For a given tree DBH, mean internode length was noticeably longer for the GF13/LI28 seedlot. Within a seedlot, there was no significant correlation ($p<0.05$) with either tree DBH (Figure 2) or with nominal final crop stocking.

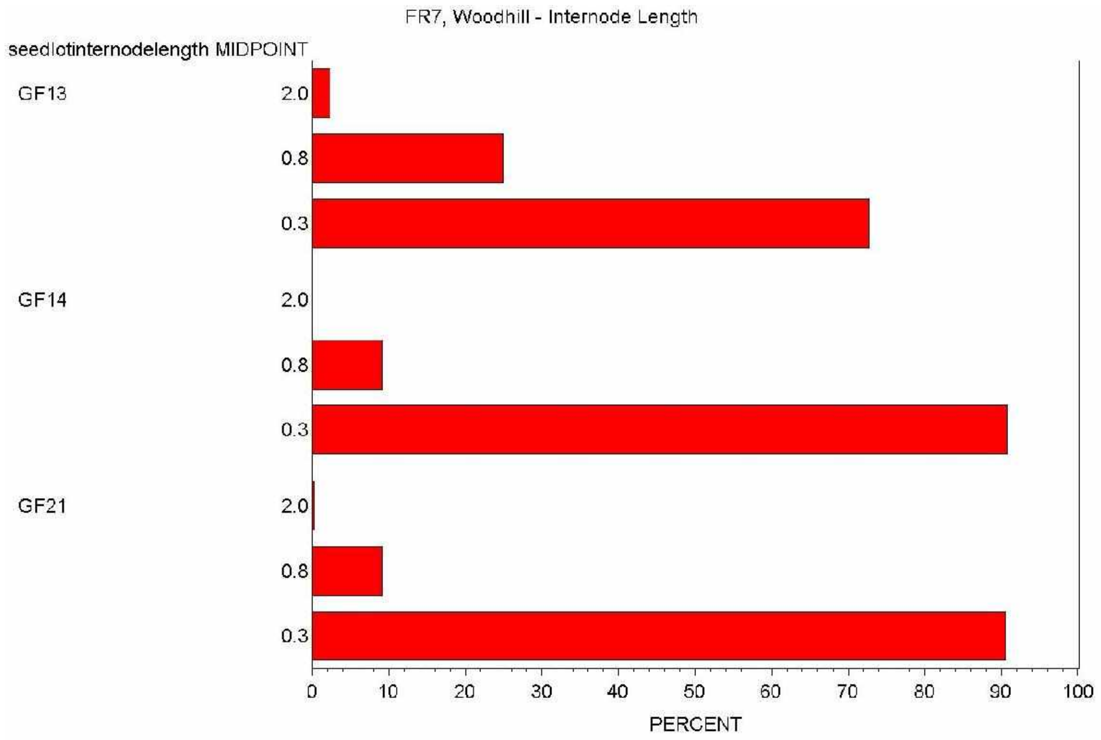


Figure 1. Distribution of internode lengths between 4.5 and 13.5 m at Woodhill, FR7.

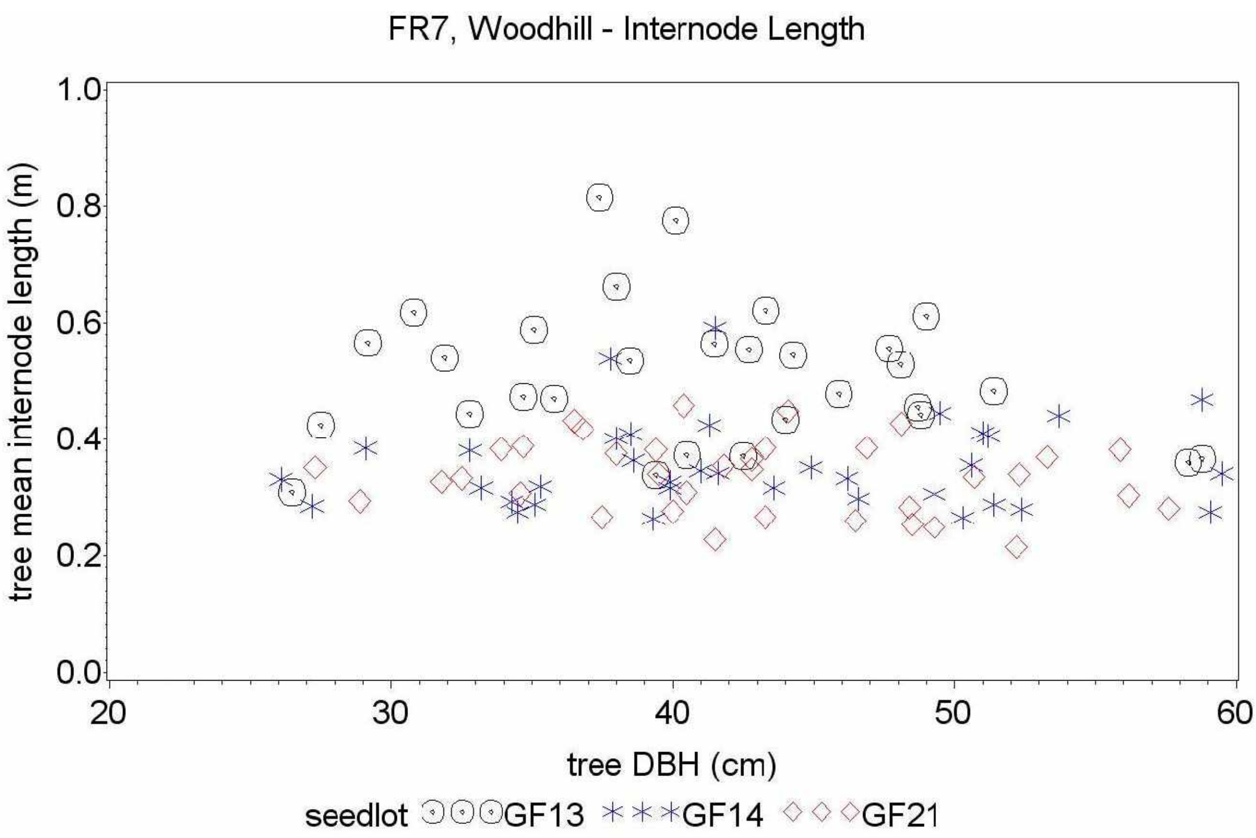


Figure 2. Tree mean internode length between 4.5 and 13.5 m at Woodhill, FR7.

Branch Diameters

For the same section of stem, the mean, BDI_{av}, and maximum, BDI_{max} branch was calculated for each tree. Both variables increased with current tree DBH. For a given tree DBH, the mean, BDI_{av}, and maximum, BDI_{max} branch diameter was obviously larger for the long internode seedlot (GF13/LI28) than for the other two seedlots (see Figure 4 and Figure 6). Variations between silvicultural treatments were not obvious (see Figure 3 and Figure 5).

It is important to realise that the relationship between branch diameters and tree DBH will vary with tree age. The period of active branch growth is only a few years, whereas trees increase in diameter for many years (usually they have not stopped increasing in diameter by the end of the rotation).

An analysis using the SAS procedure, PROC GLM with tree DBH as a continuous variable and seedlot and treatment as class variables, indicated that the mean branch diameter, BDI_{av} was influenced by tree DBH, seedlot and treatment ($p<0.05$), and maximum branch diameter, BDI_{max} was influenced by tree DBH and seedlot ($p<0.05$). Treatment was not significant ($p<0.05$) but there is a trend with respect to stocking treatment (Table 4).

Least square mean values with respect to seedlot (Table 3) indicate that for a given tree DBH and silvicultural treatment, branch diameters are smallest for the GF14 seedlot, slightly larger for the GF21 seedlot and largest for the long internode seedlot. For the long internode seedlot, the least square mean values of BDI_{av} and BDI_{max} (mm) were 11 mm and 20 mm larger than the GF14 seedlot.

Table 3. Least Square mean values with respect to seedlot for the mean, BDI_{av}, and maximum, BDI_{max} branch diameter.

Seedlot	BDI_{av} (mm)	BDI_{max} (mm)
GF13 / LI28	55	94
GF14	46	74
GF21	50	84

Least square mean values with respect to treatment indicate that for a given DBH and seedlot, branch diameters will be slightly larger for stands at lower final crop stockings. In a typical forest the differences will be larger because the distribution of tree DBH varies with final crop stocking.

Table 4. Least Square mean values with respect to treatment for the mean, BDI_{av}, and maximum, BDI_{max} branch diameter.

Treatment No.	Treatment	BDI_{av} (mm)	BDI_{max} (mm)
1	FCS 100, Thin 6.2	57	90
2	FCS 200, Thin 6.2	53	89
3	FCS 400, Thin 6.2	52	87
4	FCS 600, Thin 6.2	50	81
5	FCS 500, No Thin	48	77
6	FCS 200, Thin 20.0	46	79

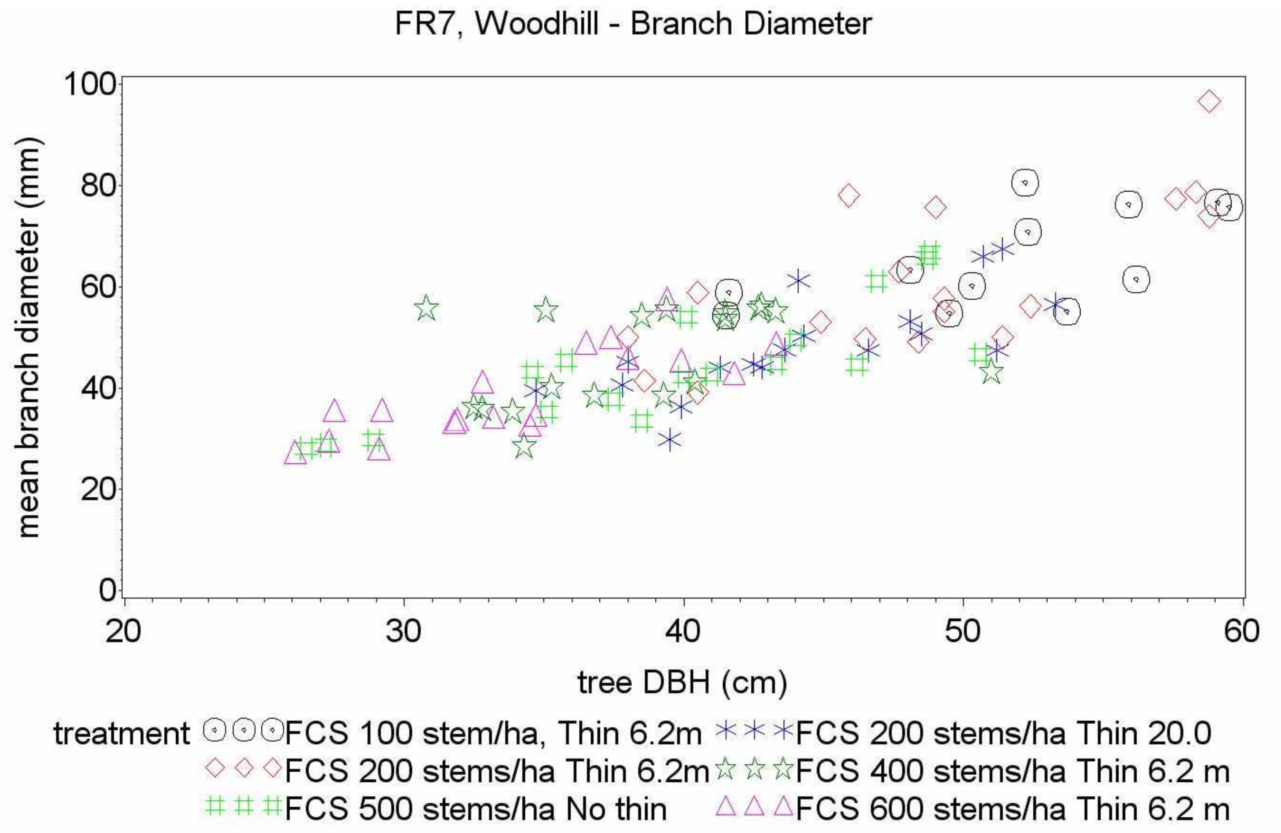


Figure 3. Variation in mean branch diameter, BDI_{av} with respect to tree DBH and treatment.

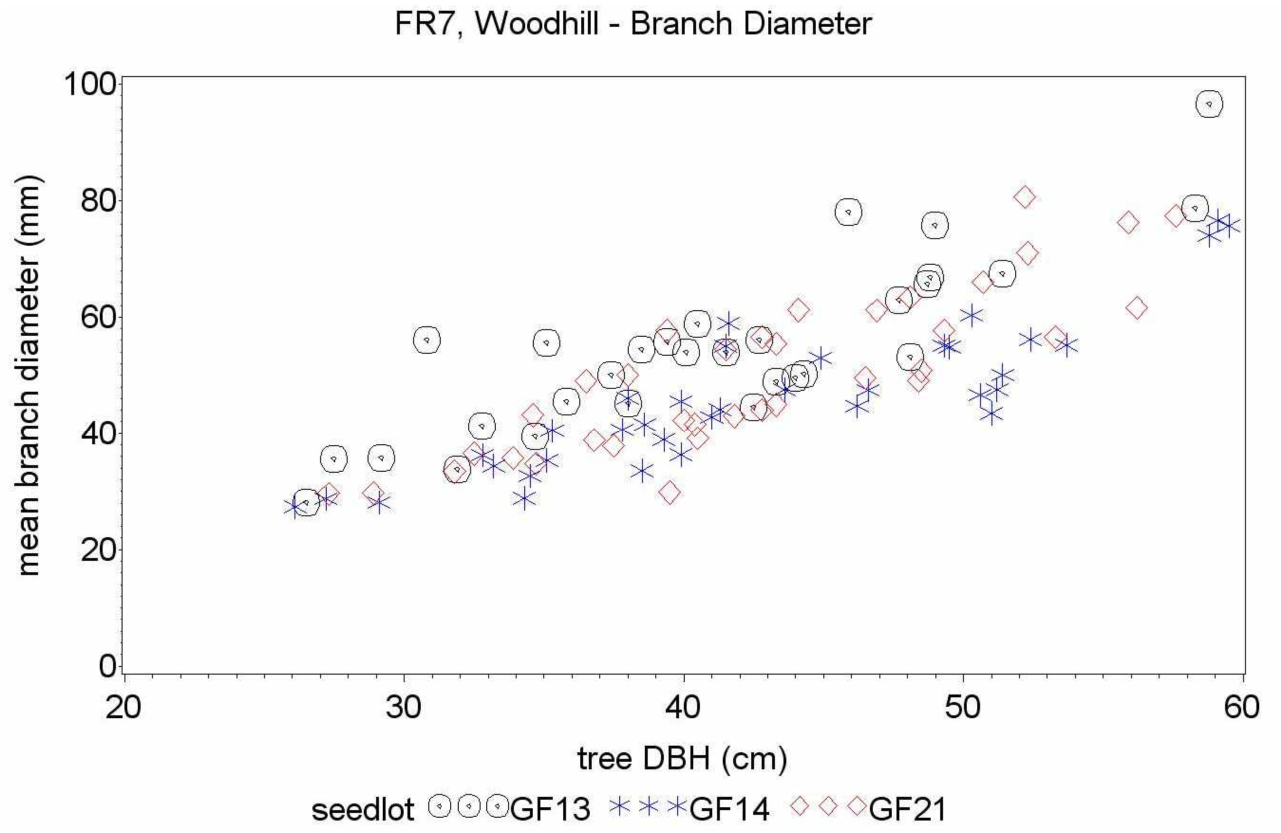


Figure 4. Variation in mean branch diameter, BDI_{av} with respect to tree DBH and seedlot.

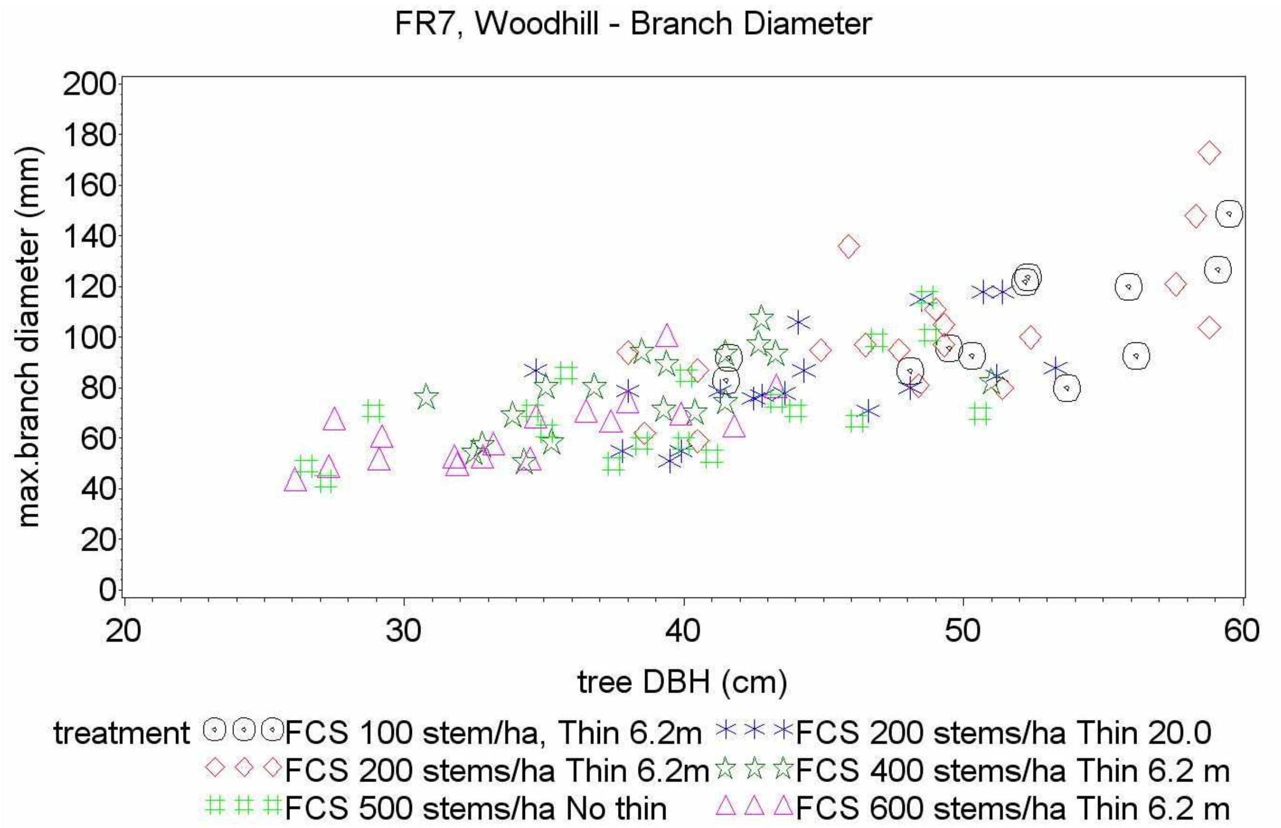


Figure 5. Variation in maximum branch diameter, BDI_{max} with respect to tree DBH and treatment.

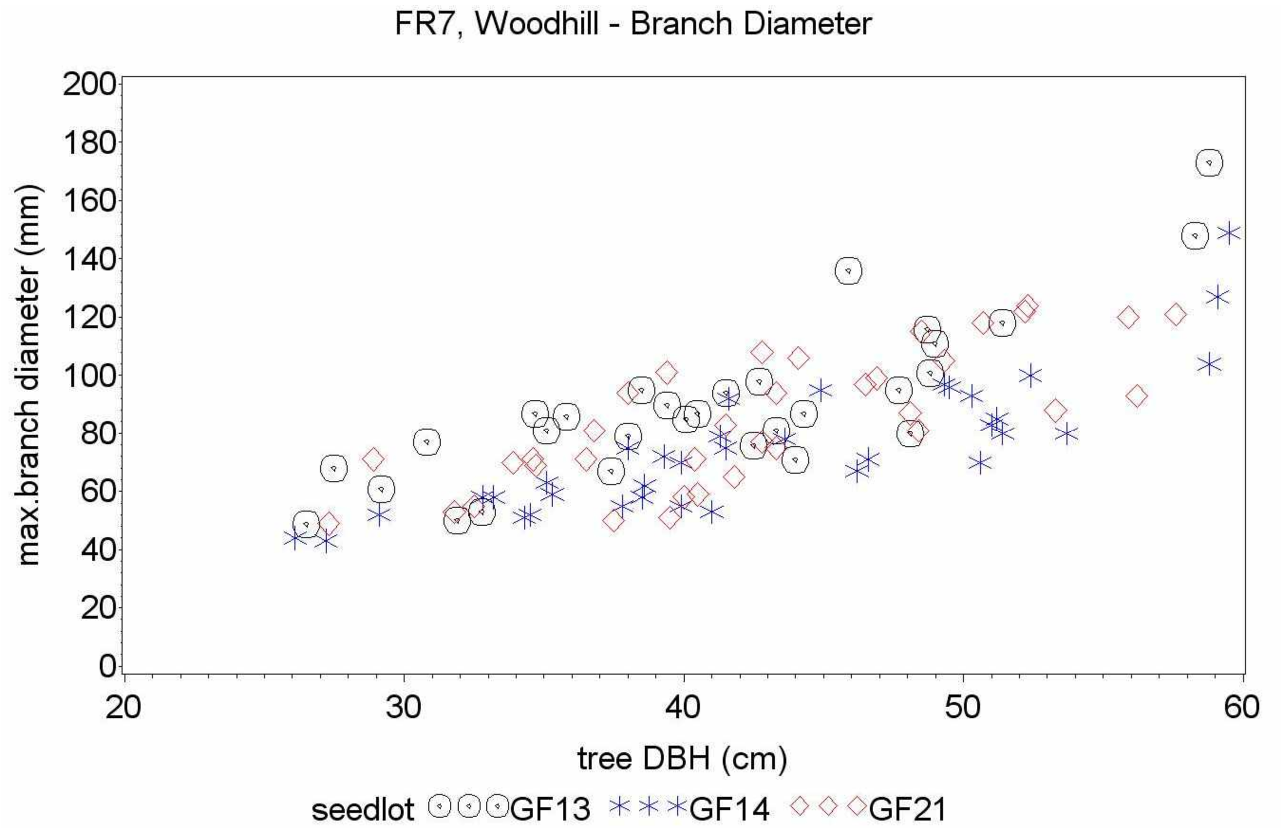


Figure 6. Variation in maximum branch diameter, BDI_{max} with respect to tree DBH and seedlot.

TreeBLOSSIM Comparisons

Three variables were calculated for examining the performance of TreeBLOSSIM for individual trees:

- $DIFF_{CL} = (CLI – CLTB) / zonelength$
- $DIFF_{max} = BDI_{max} - BDTB_{max}$
- $DIFF_{av} = BDI_{av} - BDTB_{av}$.

For each plot, these differences were plotted against the relative position of the tree in the DBH distribution (equivalent to percentage rank). A visual examination of these graphs showed no obvious and consistent trends with respect to relative position. This indicates that TreeBLOSSIM is adequately accounting for the differences between trees within a plot.

Bar charts summarising the differences with respect to seedlot and stocking treatment indicate that:

- $DIFF_{CL}$ is clearly influenced by seedlot (Figure 7).
- $DIFF_{av}$ is within 10 mm for over 70% of the trees and with 20 mm for over 90% of the trees (Figure 8).
- $DIFF_{max}$ is within 20 mm for over 70% of the trees (Figure 9).

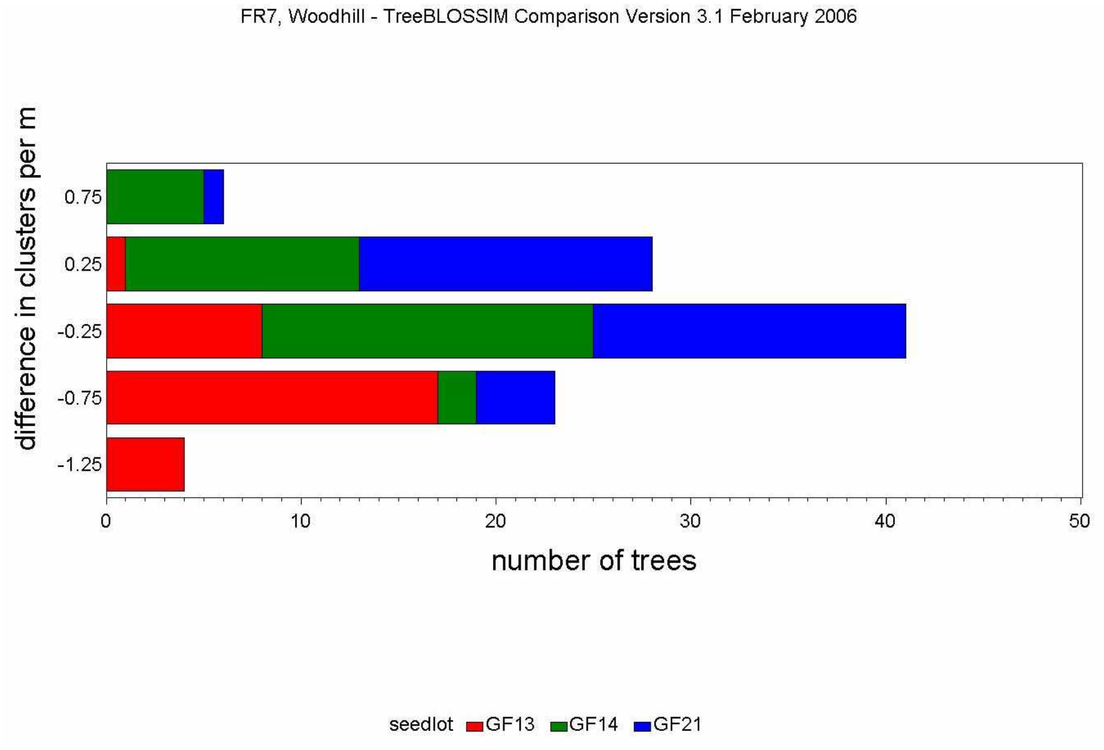
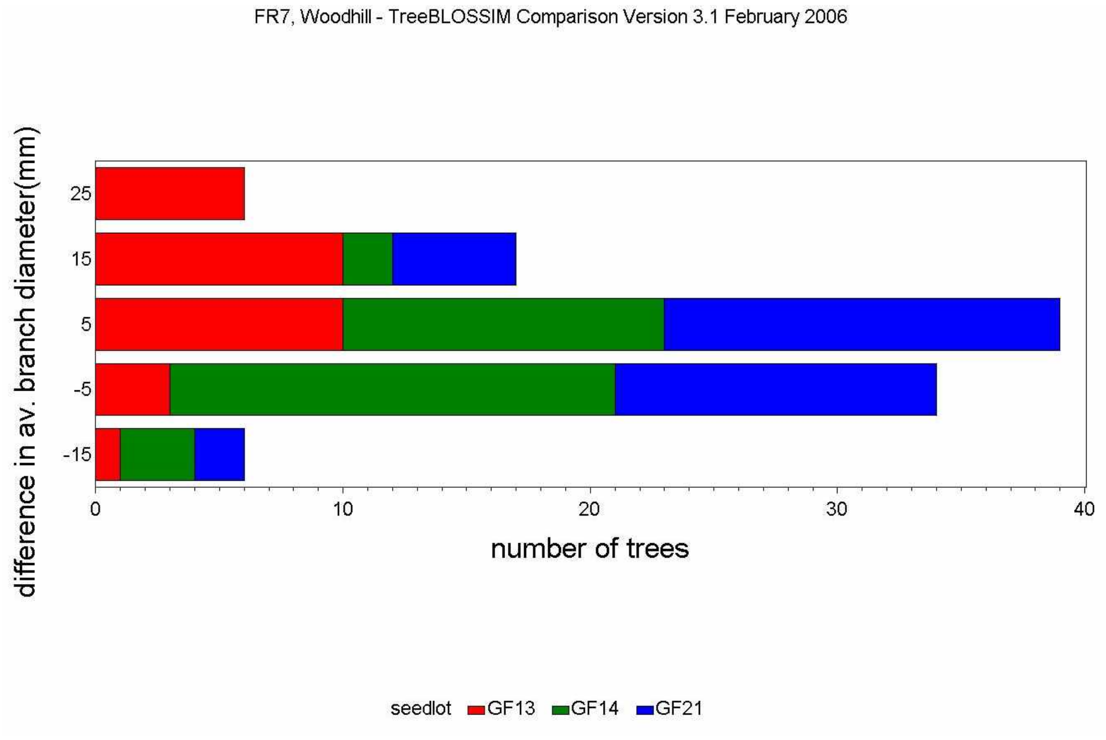


Figure 7. Distribution of $DIFF_{CL}$ with respect to seedlot.



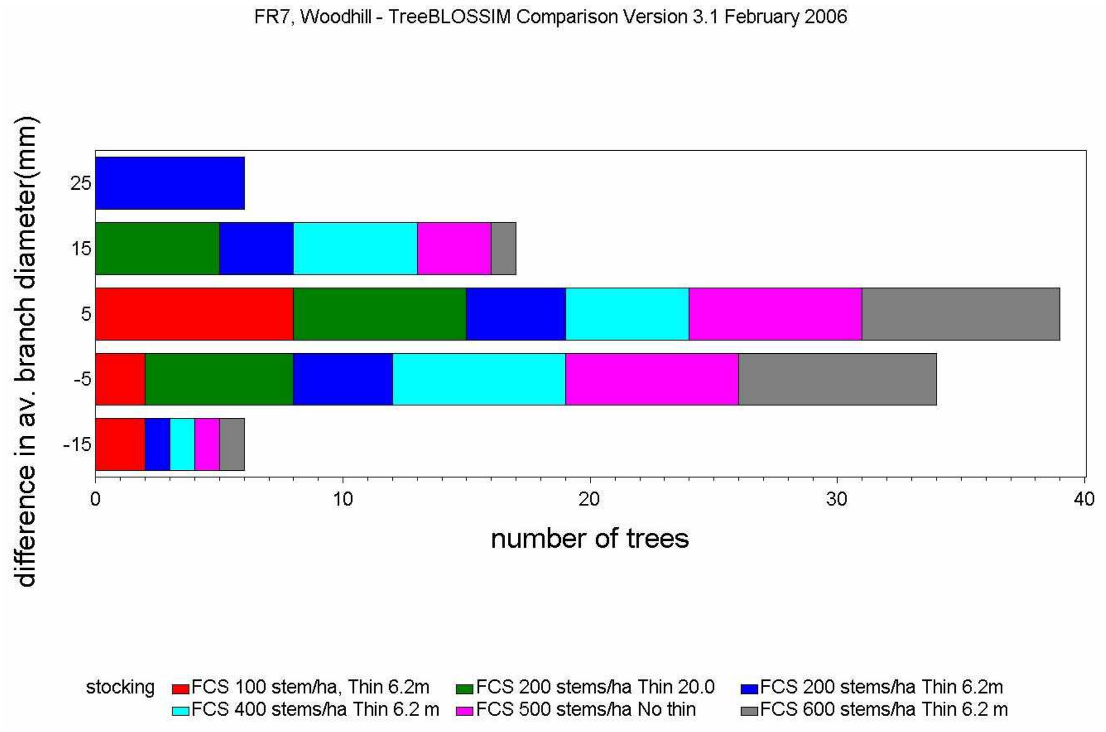
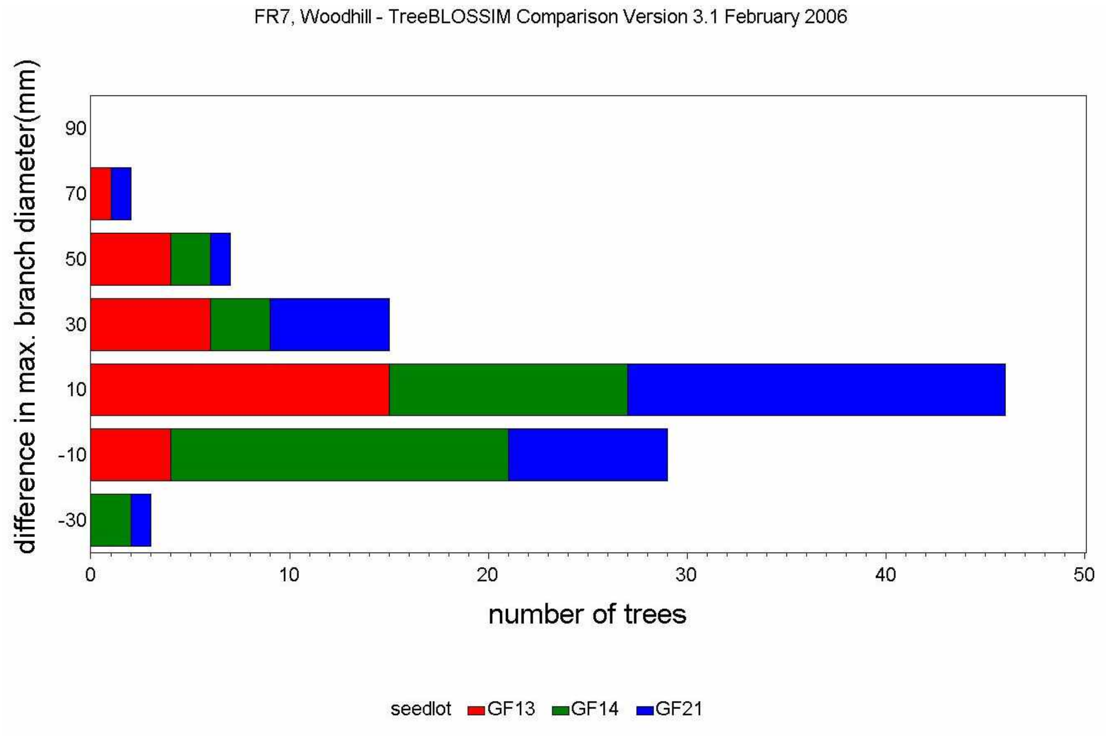


Figure 8. Distribution of $DIFF_{av}$ (mm) with respect to (a) seedlot and (b) silvicultural treatment.



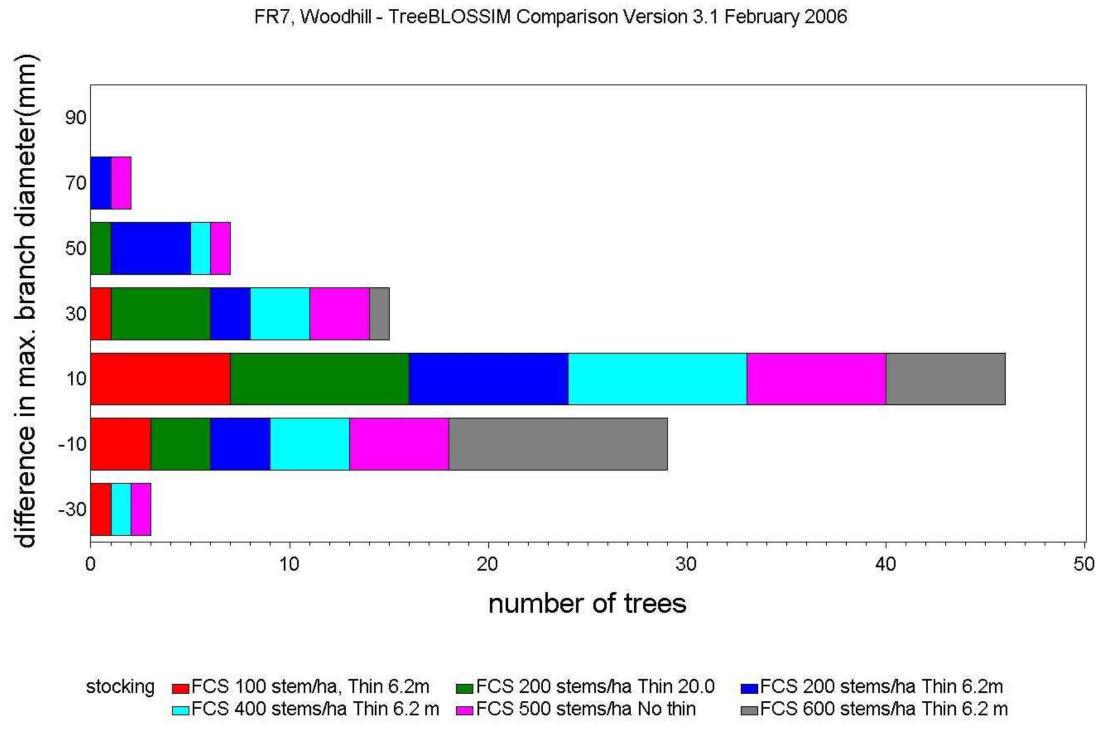


Figure 9. Distribution of $DIFF_{max}$ (mm) with respect to (a) seedlot and (b) silvicultural treatment.

The SAS procedure, PROC GLM, with treatment and seedlot as class variables, was used to examine the effect of seedlot and treatment on the differences.

Both treatment and seedlot influenced $DIFF_{av}$ and $DIFF_{max}$. Only seedlot influenced $DIFF_{CL}$. The least square mean values with respect to treatment (Table 5) show no obvious trend with respect to final crop stocking. It should be borne in mind that no images were collected for the long internode seedlot at 100 stems/ha, and that the few trees with very large branches have an impact on the mean values. The least square mean values with respect to seedlot (Table 6) indicate TreeBLOSSIM performed very well for the GF14 seedlot (TreeBLOSSIM was derived using data from trees from “850” seedlots. The performance is slightly poorer for the GF21 seedlot, the worst performing variable being $DIFF_{max}$. This difference is more likely to be related to the extent of stem damage for that seedlot, than to the average branching pattern. The performance was noticeably poorer for the long internode seedlot, suggesting that separate functions may be needed for this seedlot.

Table 5. Least square mean values for $DIFF_{av}$ and $DIFF_{max}$ with respect to treatment.

Treatment No.	Treatment	$DIFF_{av}$ (mm)	$DIFF_{max}$ (mm)
1	FCS 100, Thin 6.2	3	6
2	FCS 200, Thin 6.2	9	19
3	FCS 400, Thin 6.2	4	9
4	FCS 600, Thin 6.2	-1	-2
5	FCS 500, No Thin	2	12
6	FCS 200, Thin 20.0	4	15

Table 6. Least square mean values for $DIFF_{av}$, $DIFF_{max}$ and $DIFF_{CL}$ with respect to seedlot.

Seedlot	$DIFF_{av}$ (mm)	$DIFF_{max}$ (mm)	$DIFF_{CL}$
GF13 / LI28	10	18	-0.6
GF14	-1	1	-0.0
GF21	2	10	-0.1

CONCLUSION

This study compared branching characteristics measured on TreeD images with predicted branching characteristics from the model TreeBLOSSIM for radiata pine seedlots growing on a sand dune forest under different silvicultural regimes.

Branching data, obtained from TreeD images were available for 102 trees from 17 seedlot × silviculture combinations. The common stem length visible on all the images was between 4.5 m and 13.5 m. Mean internode length, and an average branch diameter (BDI_{av}) and the largest branch diameter (BDI_{max}) were calculated for the above stem section on each tree.

Over 70% of internodes were less than 0.6 m for all three seedlots considered (GF13 / LI28, GF14 and GF21). The long internode seedlot did have a greater proportion of longer internodes than the other two seedlots (**Figure 1**). Silvicultural treatment and tree DBH did not influence mean internode length.

In contrast, tree DBH and silvicultural treatment influenced tree average branch diameter, BDI_{av}. Tree DBH, but no treatment influenced tree maximum branch diameter, BDI_{max}.
The results from comparing the TreeBLOSSIM predictions are in line with results from previous studies [(2)]. The model:

- performs well for the GF14 seedlot,
- marginally worse for the GF21 seedlot,
- and poorly for the long internode seedlot.

The latter result is not unexpected as the long internode seedlots are selected to have fewer branch clusters than the “Growth and Form” seedlots upon which TreeBLOSSIM is based.

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APPENDICES

Appendix 1. List of sample trees from FR7

Image	Plot no	Seedlot	Final stems	Tree no	Tree key	rel_pos	DBH
732	4126	GF21	200	12	12	35	42.8
734	4126	GF21	200	23	23	70	48.5
736	4126	GF21	200	32	32	10	39.5
738	4126	GF21	200	37	38	45	44.1
740	4126	GF21	200	39	40	90	50.7
742	4126	GF21	200	48	49	100	53.3
744	922	GF13	200	9	9	50	47.7
746	922	GF13	200	26	26	70	49
748	922	GF13	200	28	28	90	58.3
750	922	GF13	200	36	36	10	40.5
752	922	GF13	200	39	39	30	45.9
754	922	GF13	200	44	44	100	58.8
756	3525	GF14	500	1	1	47.9	38.5
758	3525	GF14	500	3	3	33.3	35.1
760	3525	GF14	500	8	8	100	50.6
762	3525	GF14	500	23	24	89.6	46.2
764	3525	GF14	500	34	35	70.8	41
766	3525	GF14	500	43	44	12.5	27.2
768	4326	GF14	200	2	2	100	51.2
770	4326	GF14	200	27	27	70	43.6
772	4326	GF14	200	32	32	85	46.6
774	4326	GF14	200	34	34	50	41.3
776	4326	GF14	200	49	49	10	37.8
778	4326	GF14	200	11	11	25	39.9
780	3325	GF13	500	16	17	70.7	44
782	3325	GF13	500	17	18	29.3	35.8
784	3325	GF13	500	26	27	14.6	26.5
786	3325	GF13	500	30	31	90.2	48.8
788	3325	GF13	500	48	49	48.8	40.1
790	3325	GF13	500	19	20	85.4	48.7
792	2213	GF21	400	15	15	30	33.9
794	2213	GF21	400	27	27	75	40.4
796	2213	GF21	400	30	30	95	42.8
798	2213	GF21	400	45	46	20	32.5
800	2213	GF21	400	43	44	55	36.8
802	2213	GF21	400	49	50	90	43.3
804	2413	GF13	400	2	2	60	39.4
806	2413	GF13	400	16	16	10	30.8
808	2413	GF13	400	25	26	100	42.7
810	2413	GF13	400	43	44	90	41.5
812	2413	GF13	400	47	48	50	38.5
814	2413	GF13	400	27	28	35	35.1
816	2313	GF14	400	6	6	50	35.3
818	2313	GF14	400	11	11	75	39.3
820	2313	GF14	400	19	19	25	34.3

822	2313	GF14	400	27	27	90	41.5
824	2313	GF14	400	29	29	15	32.8
826	2313	GF14	400	35	35	100	51
828	1022	GF14	200	1	1	70	52.4
830	1022	GF14	200	5	5	30	44.9
832	1022	GF14	200	6	6	100	58.8
834	1022	GF14	200	23	23	50	49.3
836	1022	GF14	200	28	28	75	51.4
838	1022	GF14	200	32	32	15	38.6
840	2724	GF14	600	5	5	70.9	34.5
842	2724	GF14	600	12	12	29	29.1
845	2724	GF14	600	32	32	100	39.9
847	2724	GF14	600	47	47	9.7	26.1
849	2724	GF14	600	52	52	90.3	38
851	2724	GF14	600	74	74	51.6	33.2
853	321	GF21	100	18	21	70	52.3
855	321	GF21	100	45	49	90	56.2
857	321	GF21	100	43	47	30	48.1
859	321	GF21	100	75	79	95	55.9
861	321	GF21	100	83	87	50	52.2
863	321	GF21	100	3	3	5	41.5
865	3425	GF21	500	3	3	50	37.5
867	3425	GF21	500	5	5	100	46.9
869	3425	GF21	500	11	11	89.1	43.3
871	3425	GF21	500	14	14	8.7	28.9
873	3425	GF21	500	32	34	30.4	34.6
875	3425	GF21	500	39	41	69.6	40
877	4226	GF13	200	14	14	30	38
879	4226	GF13	200	16	17	55	42.5
881	4226	GF13	200	19	20	70	44.3
883	4226	GF13	200	40	42	90	48.1
885	4226	GF13	200	45	47	10	34.7
887	4226	GF13	200	48	50	100	51.4
896	2624	GF21	600	11	11	71	36.5
898	2624	GF21	600	30	31	6.5	27.3
900	2624	GF21	600	39	40	29	31.8
902	2624	GF21	600	43	44	100	41.8
904	2624	GF21	600	44	45	90.3	39.4
906	2624	GF21	600	60	61	51.6	34.7
910	421	GF14	100	18	18	100	59.5
912	421	GF14	100	20	20	5	41.6
914	421	GF14	100	25	25	95	59.1
916	421	GF14	100	40	40	60	53.7
918	421	GF14	100	52	52	50	50.3
920	421	GF14	100	81	81	30	49.5
922	2824	GF13	600	12	12	100	43.3
924	2824	GF13	600	16	16	90.3	37.4
926	2824	GF13	600	21	21	71	32.8
928	2824	GF13	600	32	32	12.9	27.5
930	2824	GF13	600	44	44	51.6	31.9
932	2824	GF13	600	56	56	29	29.2
934	1122	GF21	200	13	13	100	57.6

936	1122	GF21	200	22	22	90	49.3
938	1122	GF21	200	24	24	10	38
940	1122	GF21	200	29	29	25	40.5
942	1122	GF21	200	33	33	70	46.5
950	1122	GF21	200	26	26	80	48.4

Appendix 2. List of trials where TreeD data have been collected (grey) and proposed future trials for data collection (black).

Region	Low site index	Medium site index	High Site Index	High Basal Area
Clays	NO TRIAL	Tungrove FR121/1 stocking + seedlot	Tairua FR121/4 stocking + seedlot	Mamaranui FR54 stocking + seedlot
Sands	Aupouri (1978GG) only seedlot Santoft, FR121/9	Woodhill (1975 FCS) only stocking Woodhill, FR7 stocking + seedlot	NO TRIAL	NO TRIAL
CNI	Kaingaroa FR9	Kaingaroa (1975 FCS) only stocking Tahourakuri (1987 SB) stocking + seedlot Kinleith FR121/2 stocking + seedlot	Kaingaroa (1978 GG) only seedlot Tarawera FR121/6	Kawerau FR84 stocking + seedlot
East Coast	NO TRIAL	Mangatu FR121/8 Not suitable – too much damage	NO TRIAL	Huanui FR121/7 2004 – 23.5m
Hawkes Bay	Gwavas FR 121/3 stocking + seedlot	Trial not suitable	Tikokino FR 57	Mohaka (1978 GG) only seedlot Glengarry (1987 SB) stocking + seedlot
Nelson	Golden Downs (1975 FCS) only stocking Ditchlings FR11	Golden Downs (1978 GG) only seedlot Golden Downs FR86	Golden Downs FR121/13 stocking +seedlot	NO TRIAL
Canterbury	Eyrewell (1975 FCS) only stocking	Waimate (1978 GG) only seedlot FR56, Dalethorpe	Ashley, FR121/12	NO TRIAL
Southland	FR121/10	Dean, SD 682 Only seedlot	NO TRIAL	Longwood (1978 GG) only seedlot
Westland	NO TRIAL	NO TRIAL	NO TRIAL	NO TRIAL

In addition to these trials, regional TreeD datasets have been collected from Southland, Westland, and the Hawke's Bay response Surface trial.

Appendix 3. Image of Plot 1/21.

Appendix 4. TreeD Image 887 (see Appendix 1 for details of sample tree).