Performance of Post-Silviculture Individual-Tree Growth Model (ITGM)

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EXECUTIVE SUMMARY

The post-silviculture individual-tree growth model (ITGM) was developed for the Stand Growth Modelling Cooperative (see SGMC reports 58, 59, 60, 77). A validation study was carried out in 2000 (SGMC Report No. 79) using individual growth PSPs meeting strict criteria of 5 yearly measurements from age 15 onwards. No further validation has been carried out since this time.

The objective of this study was to determine how ITGM performed for some of the trials managed by the SGMC. Three trial series were considered:

- 1975 final crop stocking trials
- 1978 genetic gain trials
- 1987 silviculture/breed trials

The performance of ITGM with respect to 3 factors was considered:

- different starting ages
- different silviculture treatments
- different genetics (GF7 versus GF14)

From this study the following conclusions may be drawn:

- ITGM performs reasonably well when the increment period is short
- ITGM performs better if the starting age is several years after the thinning
- ITGM performs reasonably with starting ages below 15 years provided that the starting age is several years after thinning
- It is considered that uneven thinning may cause problems if ITGM is started immediately after thinning

Performance of post-silviculture individual-tree growth model (ITGM)

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INTRODUCTION

The post-silviculture individual-tree growth model (ITGM) was developed for the Stand Growth Modelling Cooperative (see SGMC reports 58, 59, 60, 77). A validation study was carried out in 2000 (SGMC Report No. 79) using individual growth PSPs meeting strict criteria of 5 yearly measurements from age 15 onwards. No further validation has been carried out since this time.

OBJECTIVE

The objective of this study was to determine how ITGM performed for some of the trials managed by the SGMC. Three trial series were considered:

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The performance of ITGM with respect to 3 factors was considered:

- different starting ages
- different silviculture treatments
- different genetics (GF7 versus GF14)

ITGM was developed using data from GF7 (or less) seedlots, so it was decided to test plots with GF14 seedlots, as a large majority of current harvestable stock is of GF14 or greater.

METHOD

Specific plots were selected for this study as outlined below:

At all sites in the 1975 and 1978 trial series, plot selection was based on the plot having previously been selected for a PhotoMARVL and sensitivity analysis of TreeBLOSSIM study. All plots considered from the 1975 Final Crop Stocking Series (Appendix 1) are GF14 seedlots, and cover 7 treatments with no replication.

In the 1978 series plots of GF7, GF14 and GF22 seedlots were PhotoMARVLed but only the GF7 and GF14 plots were selected (Appendix 2) for this study. There is only one treatment in each of these trials and plots are replicated 6 times.

In the 1987 trial series, only the FR8 and FR10 trials have been assessed in a PhotoMARVL study, with three seedlots (GF14, GF21 and LI28) selected. For these two trials only the GF14 plots were used (Appendix 3). Plots were selected from the other trials, FR7, FR9, FR11 and FR12 based on a GF14 seedlot and where the data best matched the treatment (Appendix 3). In this trial series there are 5 treatments with two replications. The latest measurement in this series is only age 17 years, so ITGM was tested from time of silviculture (between age 5 and 7 years) to 17 years.

Individual tree growth data and stand information was extracted from the Scion PSP system. The following variables were included:

- Individual tree DBH and height for all start ages and final age (Appendices 1-3)
- Measurement date and age
- Region
- Latitude
- Planted SPH
- SPH before thinning
- SPH of thinned trees
- SPH of live trees (at each measurement age)
- Mean prune height

In terms of site quality 1987 silviculture breeds trials generally correspond to either a 1975 or a 1978 trial (Table 1). But 1975 trials were thinned from a constant initial stocking to variable final stockings whereas 1987 trial had a constant thinning ratio.

Table 1. Site types covered by above selection

Region	High Site	Medium Site	Low site	High BA Site
Sands		✓✓ (75, 87)	✓ (78)	
CNI	✓ (78)	✓✓ (75, 87)	✓ (87)	
Hawkes Bay				✓✓ (78, 87)
Nelson		✓ (78)	✓✓ (75, 87)	
Southland				✓✓ (78, 87)
Canterbury		✓ (78)	✓ (75)	

The performance of ITGM was tested for the selected plots in each of the trial series. The

- 1975 trials tested starting ages of first thinning (11 or 14), 15 and 21 years growing forward to age 27 with 7 different silvicultural treatments
- 1978 trials tested starting ages of first thinning (9, 10, 11,13 or 14), 15 and 20 years growing forward to age 26 with two different genetics (GF7 versus GF14)
- 1987 trials tested starting ages of first thinning (5, 6 or 7) and 13 years growing forward to age 17 with 4 different silvicultural treatments (GF14 seedlot only)

RESULTS

The model is said to over-predict where the actual – predicted is negative, and under-predict where the actual – predicted is positive.

1975 Final Crop Stocking Trials

For each model run (start age/end age combination) the actual minus predicted DBH was calculated and graphed using all plots (Figure 1), subset by region (Figure 2) and subset by silvicultural treatment (Figure 3).

When the model was started closest to the end-age (age 21 to 27 years) there was less error in the DBH prediction. The plots thinned at the later age (14 vs 11 years) tended to have the most error when the model was started just after silviculture.

The unthinned plots (trt 4) performed very well in the model, but the plots thinned to 100 sph (trt 1 and 5) showed the largest prediction error.

Regionally, plots performed similarly except for Auckland, which had some large errors particularly for the age 14 data (late thinning treatment).

Figure 1. Individual tree differences in DBH between PSP measurements and ITGM predictions

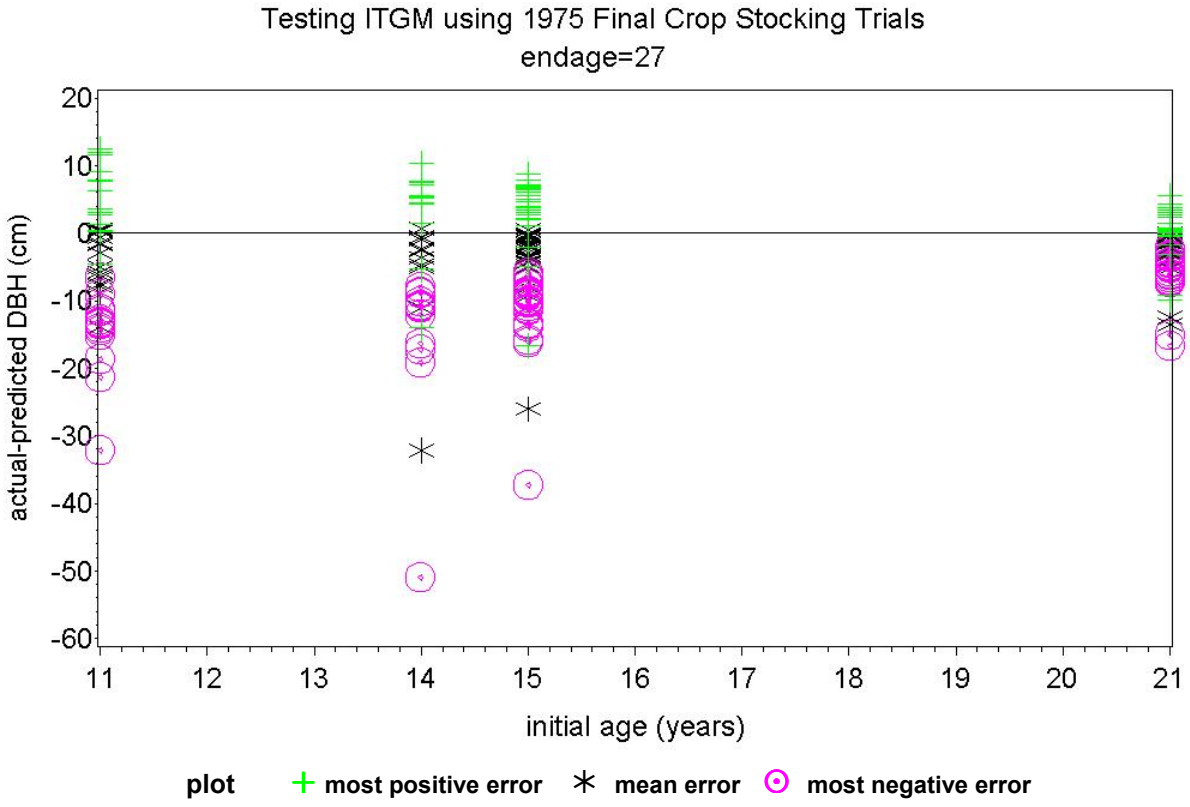


Figure 2. **Plot average differences in DBH between PSP measurements and ITGM predictions (labelled by region)**

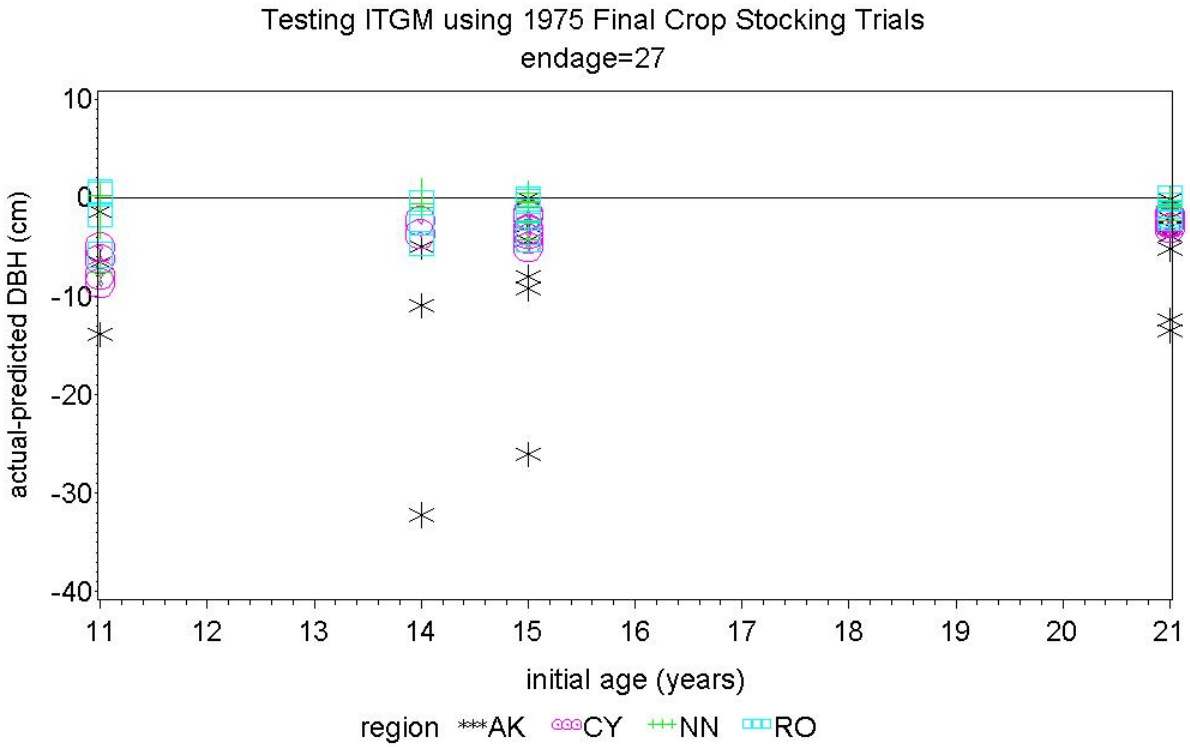
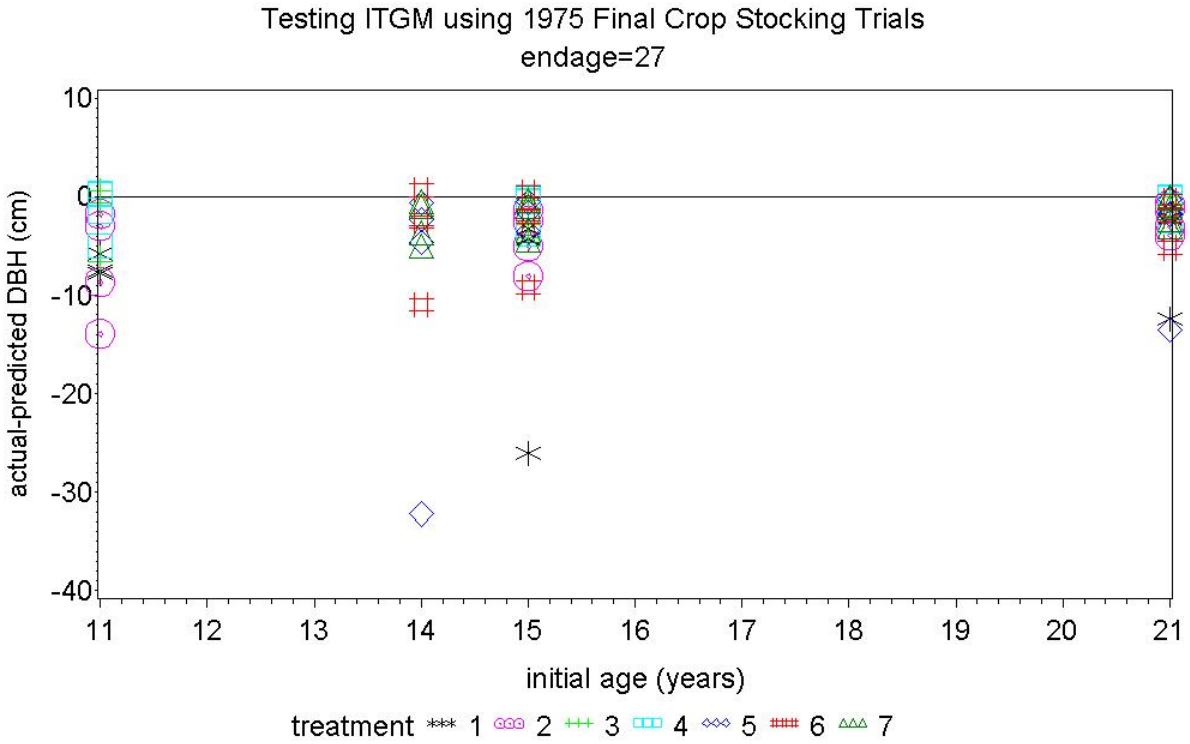


Figure 3. **Plot average differences in DBH between PSP measurements and ITGM predictions (labelled by treatment)**



1978 Genetic Gain Trials

For each model run (start age/end age combination) the actual minus predicted DBH was calculated and graphed using all plots (Figure 4), subset by region (Figure 5) and subset by GF rating (Figure 6).

As in the 1975 trial, when the model was started closest to the end-age (age 20 to 26 years) there was less error in the DBH prediction (Figure 4)

Regionally, plots performed similarly except for Auckland and Nelson, which had some large negative errors. Predictions in the Southland region tended to be small over-predictions (Figure 5).

There is no noticeable trend in under or over-prediction between the GF7 and GF14 seedlots (Figure 6).

Figure 4. Individual tree differences in DBH between PSP measurements and ITGM predictions

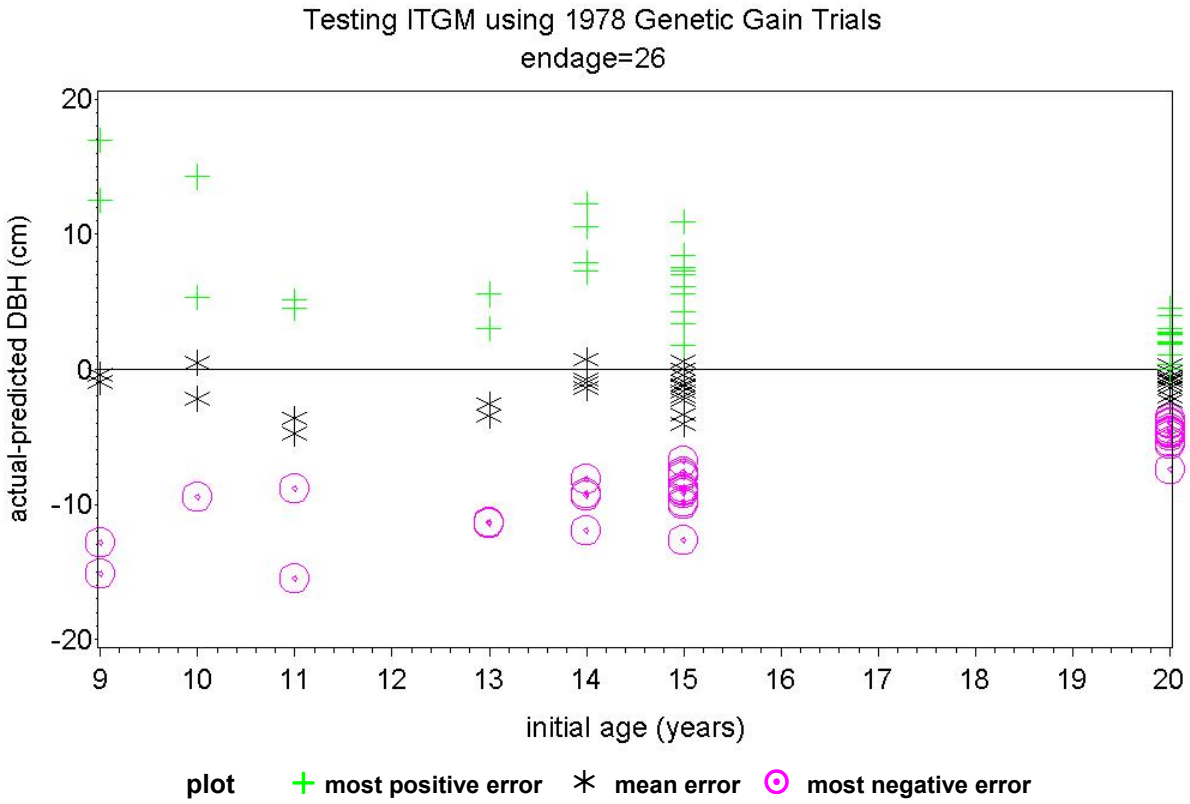


Figure 5. **Plot average differences in DBH between PSP measurements and ITGM predictions (labelled by region)**

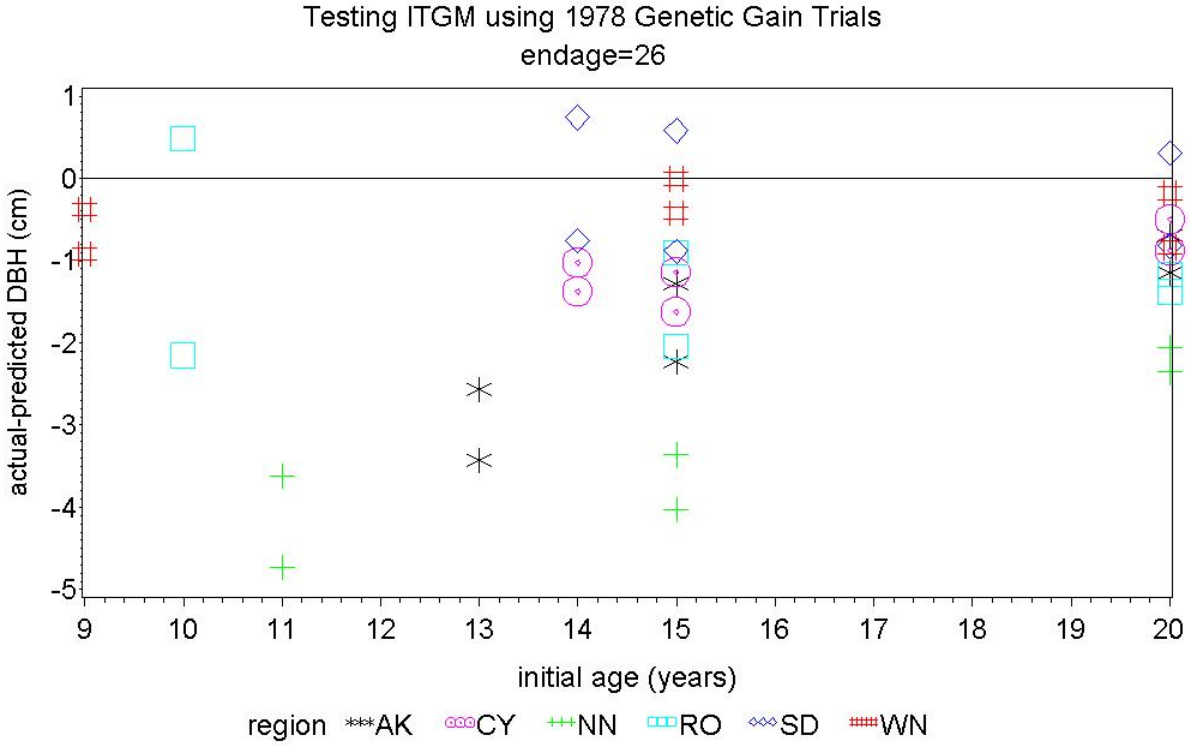
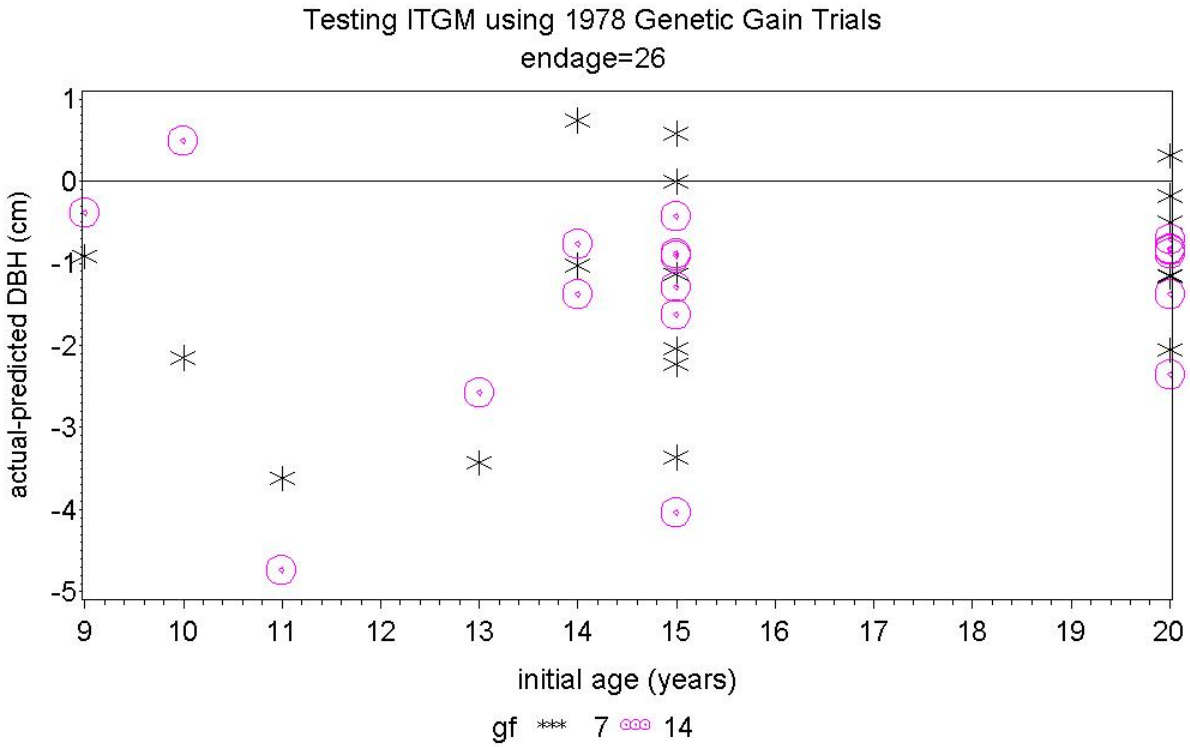


Figure 6. **Plot average differences in DBH between PSP measurements and ITGM predictions (labelled by seedlot)**



1987 Silviculture – Breed Trials

For each model run (start age/end age combination) the actual minus predicted DBH was calculated and graphed using all plots (Figure 7), subset by region (Figure 8) and subset by silvicultural treatment (Figure 9).

For this trial series the model was only run until age 17, as this was the latest measurement age for comparison.

The plots with final silviculture at the youngest age (5 years) showed the largest prediction errors. When predicting from age 13 to 17 years, the results showed very little error (Figure 7)

Figure 7. Individual tree differences in DBH between PSP measurements and ITGM predictions

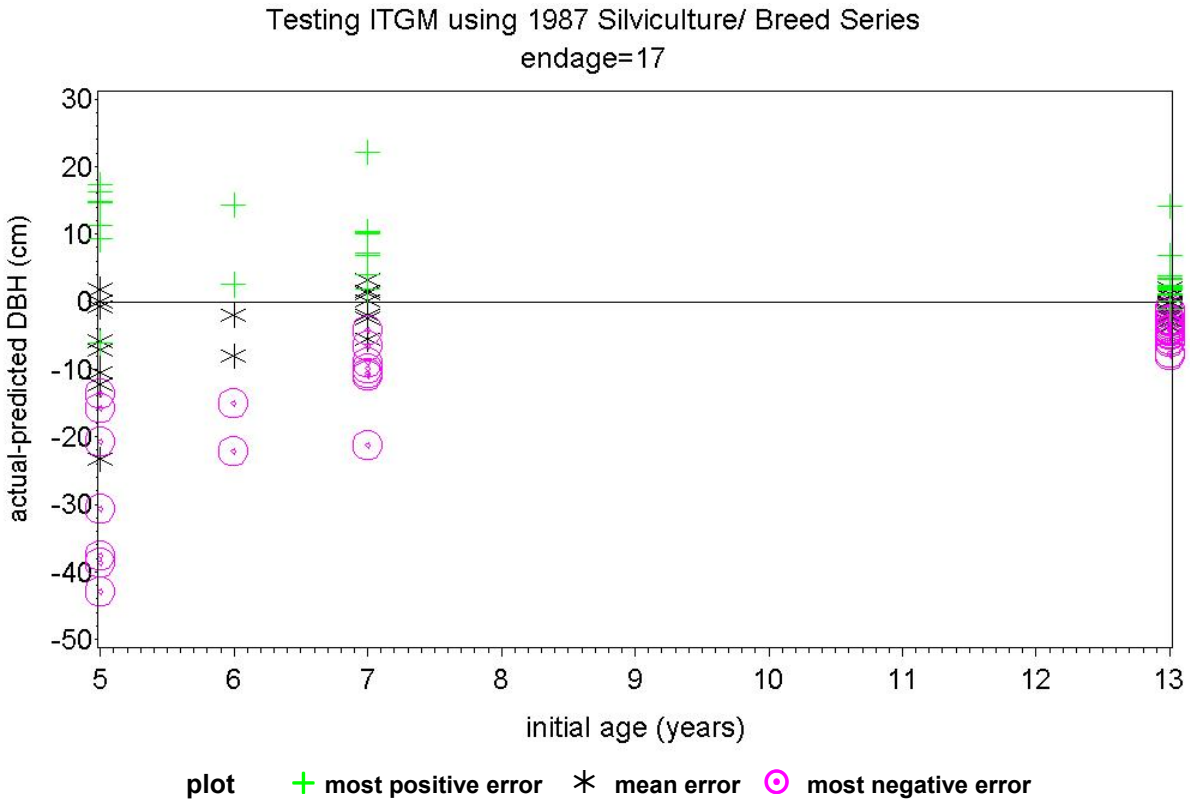


Figure 8. **Plot average differences in DBH between PSP measurements and ITGM predictions (labelled by region)**

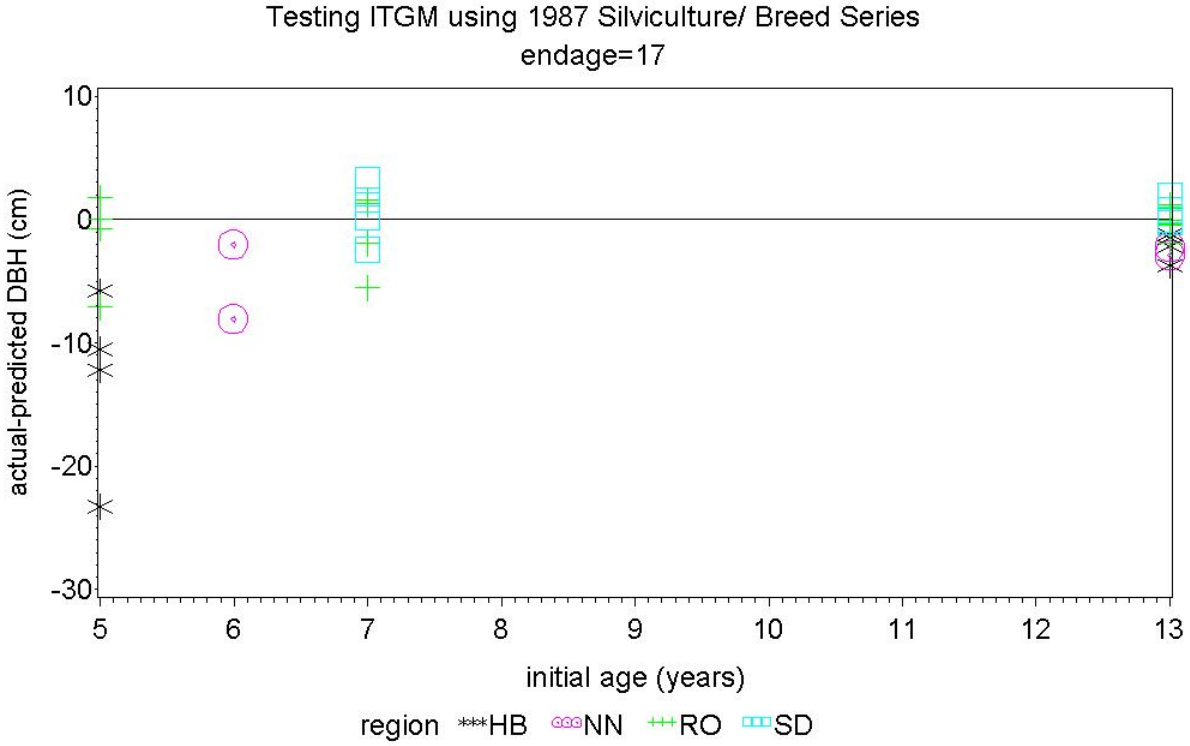
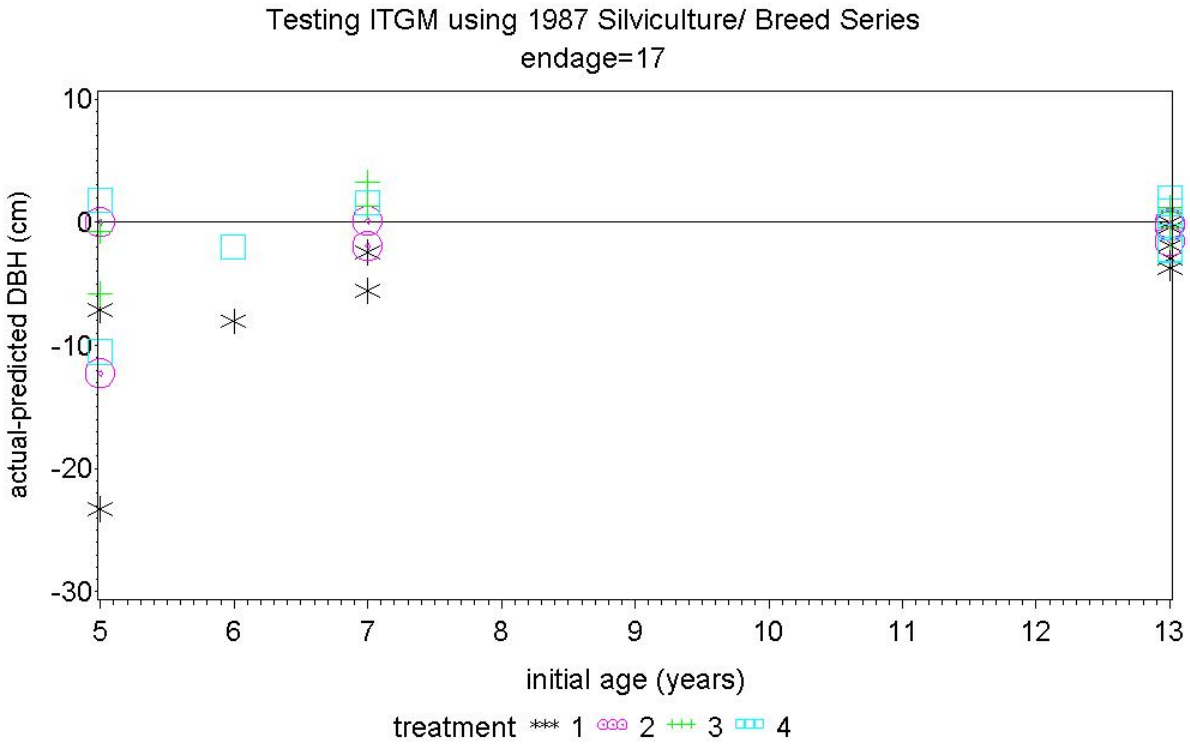


Figure 9. **Plot average differences in DBH between PSP measurements and ITGM predictions (labelled by treatment)**



CONCLUSIONS

These analyses have considered ITGM predictions of DBH. From this the following conclusions may be made:

- There is less error with short increment periods
- For individual trees there are some large errors in DBH, particularly when model is started immediately after silviculture

Considering the individual trial series:

1975 trials

- Poor performance for plots thinned to 100 stems/ha at Woodhill (AK Region) but the unthinned plots (625 sph) performed very well.

1978 trials

- On average, performed well, but some individual trees were poorly predicted

1987 trials

- Prediction from age 13 years to 17 years was reasonable even though the data, where all silviculture was completed by age 7 years, is outside the model (the model was developed from age 15 onwards)

ITGM appears to perform better if it is started several years after silvicultural treatment has been completed.

This conclusion seems logical, given that ITGM is an individual-tree distance-dependent model. In this respect it assumes tree growth depends only on tree size and essentially assumes any thinning is 'uniform' (i.e. large gaps are not created around small trees). If the real situation deviates from these assumptions then errors may occur (Hasenauer, 2006). It is suggested that the large errors observed may be a result of uneven thinning.

REFERENCES

Hausenauer, H. 2006. Sustainable Forest Management: Growth models for Europe. *Springer 398pp.*

Appendices 1 - 3. Plots used for analysis in TreeBLOSSIM

Appendix 1. Plots from 1975 final crop stocking trials (all plots GF14)

Experiment	Region	Treatment	Trt No.	Plot	Ages to start	Final age
AK1056	AK	625→100 age 11	1	2/11	11, 15, 21	27
	AK	625→200 age 11	2	5/12	11, 15, 21	27
	AK	625→400 age 11	3	3/13	11, 15, 21	27
	AK	625→625 (unthinned)	4	9/14	11, 15, 21	27
	AK	625→100 age 14	5	8/15	14, 15, 21	27
	AK	625→200 age 14	6	4/16	14, 15, 21	27
	AK	625→400 age 14	7	1/17	14, 15, 21	27
CY597	CY	625→100 age 11	1	15/21	11, 15, 21	27
	CY	625→200 age 11	2	9/22	11, 15, 21	27
	CY	625→400 age 11	3	10/23	11, 15, 21	27
	CY	625→625 (unthinned)	4	13/24	11, 15, 21	27
	CY	625→100 age 14	5	14/25	14, 15, 21	27
	CY	625→200 age 14	6	11/26	14, 15, 21	27
	CY	625→400 age 14	7	12/27	14, 15, 21	27
RO2098	RO	625→100 age 11	1	7/11	11, 15, 21	27
	RO	625→200 age 11	2	5/12	11, 15, 21	27
	RO	625→400 age 11	3	6/13	11, 15, 21	27
	RO	625→625 (unthinned)	4	10/24	11, 15, 21	27
	RO	625→100 age 14	5	9/25	14, 15, 21	27
	RO	625→200 age 14	6	19/36	14, 15, 21	27
	RO	625→400 age 14	7	15/27	14, 15, 21	27
NN529/1	NN	625→100 age 11	1	6/31	11, 15, 21	30
	NN	625→200 age 11	2	3/32	11, 15, 21	30
	NN	625→400 age 11	3	5/33	11, 15, 21	30
	NN	625→625 (unthinned)	4	4/34	11, 15, 21	30
	NN	625→100 age 14	5	1/35	14, 15, 21	30
	NN	625→200 age 14	6	7/36	14, 15, 21	30
	NN	625→400 age 14	7	8/37	14, 15, 21	30

Treatment: initial stocking, final stocking and age of thinning
Ages to start: ages at which TreeBLOSSIM has been initiated
Final age: age at which TreeBLOSSIM results are compared with PSP data

Appendix 2. Plots from 1978 Genetic Gain Trials

Experiment	Region	GF	Treatment	Plot	Ages to start	Final age
NN530/2	NN	7	1111→600 →300	7/41	11, 15, 20	26
	NN	14	1111→600 →300	6/31	11, 15, 20	26
AK1058	AK	7	1111→600 →300	7/41	13, 15, 20	26
	AK	14	1111→600 →300	8/41	13, 15, 20	26
RO2103/1	RO	7	1111→600 →300	7/31	10, 15, 20	26
	RO	14	1111→600 →300	10/51	10, 15, 20	26
SD564/1	SD	7	1111→600 →300	7/51	14, 15, 20	26
	SD	14	1111→600 →300	5/61	14, 15, 20	26
WN377	WN	7	1111→600 →300	1/61	9, 15, 20	26
	WN	14	1111→600 →300	6/41	9, 15, 20	26
CY421	CY	7	1111→600 →300	1/61	14, 15, 20	26
	CY	14	1111→600 →300	9/21	14, 15, 20	26

Treatment: initial stocking, first residual stocking, final residual stocking
Ages to start: ages at which TreeBLOSSIM has been initiated (the first age ie. 9, 10, 11, 13 or 14, is the age the trial was first thinned)
Final age: age at which TreeBLOSSIM results are compared with PSP data

Appendix 3. Plots from 1987 Silviculture-Breed trials (all plots GF14)

Experiment	Region	Trt No.	Treatment	Plot	Ages to start	Final age
FR7	AK	2	500→200 age 6	13/12	6, 13	17
	AK	3	1000→400 age 6	23/13	6, 13	17
	AK	4	1500→600 age 6	32/14	6, 13	17
	AK	5	500→500 age 6	40/15	6, 13	17
FR8	RO	2	500→200 age 5	10/12	5, 13	17
	RO	3	1000→400 age 5	20/13	5, 13	17
	RO	4	1500→600 age 5	25/14	5, 13	17
	RO	5	500→500 age 5	34/15	5, 13	17
FR9	RO	2	500→200 age 7	23/12	7, 13	17
	RO	3	1000→400 age 7	7/13	7, 13	17
	RO	4	1500→600 age 7	15/14	7, 13	17
	RO	5	500→500 age 7	9/15	7, 13	17
FR10	HB	2	500→200 age 5	12/12	5, 13	17
	HB	3	1000→400 age 5	17/13	5, 13	17
	HB	4	1500→600 age 5	26/14	5, 13	17
	HB	5	500→500 age 5	34/15	5, 13	17
FR11	NN	2	500→200 age 6	16/12	6, 13	17
	NN	3	1000→400 age 6	20/23	6, 13	17
	NN	4	1500→600 age 6	26/24	6, 13	17
	NN	5	500→500 age 6	38/15	6, 13	17
FR12	SD	2	500→200 age 7	36/22	7, 13	17
	SD	3	1000→400 age 7	45/23	7, 13	17
	SD	4	1500→600 age 7	42/24	7, 13	17
	SD	5	500→500 age 7	21/25	7, 13	17

Treatment: initial stocking, final stocking and age of thinning
Ages to start: ages at which TreeBLOSSIM has been initiated
Final age: age at which TreeBLOSSIM results are compared with PSP data