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VALIDATION OF GROWTH RATE MULTIPLIERS FOR THE SANDS AND NAPIRAD MODELS

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This is an unpublished report and MUST NOT be cited as a literature reference.

EXECUTIVE SUMMARY

For over a year, growth models which reflect genetic gain have been available for five of New Zealand's seven growth modelling regions. The mathematical forms of the NAPIRAD (Hawkes Bay region) and SANDS (West Coast North Island Sands region) growth models are different than for the other regions and consequently have not previously had the growth rate multipliers incorporated. The growth rate multipliers estimated previously, were incorporated into NAPIRAD and SANDS, and predictions were compared with genetic gain trial data from these growth modelling regions. There is no reason to believe that the predictions of improved seedlots planted in the NAPIRAD and SANDS regions would be less valid than for models from other growth modelling regions.

VALIDATION OF GROWTH RATE MULTIPLIERS FOR THE SANDS AND NAPIRAD GROWTH MODELS

S. D. Carson and J. D. Dunlop

INTRODUCTION

Of New Zealand's seven growth modelling regions (Goulding 1994) growth models for five have been modified to reflect genetic gain by incorporating growth rate multipliers (Carson *et al.* 1994, Carson and Garcia 1995). Multipliers were estimated from genetic gain trial data by predicting growth from each annual increment and comparing deviations of the measurements from the predictions. The genetic gain trials used for estimation of the multipliers were within the five regions which have the multipliers incorporated into their models. Only a limited amount of genetic gain data was available for multiplier estimation (especially for GF22 where there was only one measurement at each of only three sites), so predictions must be viewed with caution, but represent the best available prediction to date.

Data from genetic gain trials in the growth modelling regions covered by the SANDS model (Dunningham 1985) (sandy soils on the west coast of the North Island, largely north of Auckland) and NAPIRAD model (Lawrence 1994) (Hawke's Bay) were not used to estimate the genetic gain multipliers. The interactions of growth with site quality, as predicted by site index, were modelled differently for these regions, which lead to better predictions of growth. The mathematical forms of these two models, therefore, are different than for the other regions, and, thus, different methods than those used for the other models would have to be employed for multiplier estimation. The multipliers have not been incorporated into NAPIRAD and SANDS to date for this reason. The genetic gain trials in these regions can serve as independent sources of data for validation of the growth rate multipliers.

OBJECTIVE

To incorporate the genetic gain multipliers, which were estimated using genetic gain trial data from several other growth modelling regions, into NAPIRAD and SANDS, and compare the predictions obtained with genetic gain trial data available from these growth modelling regions.

METHODS

Data from two genetic gain trials were available for both the NAPIRAD and SANDS regions. Both regions have one site of the 1978 genetic gain trial. The site in the Hawke's Bay region is at Mohaka Forest (WN377) and the site on sandy soil is at Aupouri Forest (AK1058). The 1978 genetic gain trial compares large blocks of different seedlots with seed certification ratings of GF2 (Kaingaroa bulk unselected seedlot), GF7 (a Kaingaroa climbing select), GF14 (Gwavas open-pollinated orchard),

and GF22 (a cross of 850-55 x 850-96). All plots were thinned to 300 stems per ha at mean crop height 12m. An interim thinning from planting stocking of 1111 stems per ha to 600 stems per ha was carried out at mean crop height 6.2m. Annual PSP measurements were available from six replicate blocks of the GF7 and GF14 from age 8 to age 16, and in three replicate blocks of the GF2 and GF22 from age 14 to age 16 and 17, respectively.

Both regions also have one site of the 1987 Silviculture/Breed trials. The site in the Hawke's Bay region is at Glengarry Forest (FR10) and the site on sandy soil is at Woodhill Forest (FR7). These trials compare two replicate large blocks of seedlots rated GF7, GF14, and GF21 with 100, 200, 400, and 600 stems per ha final crop stocking and at 500 stems per ha with no thinning. Thinning was carried out with a thinning ratio of 2.5:1 for all plots at mean crop height 7.2m at Glengarry and 6.9m at Woodhill (Skinner *et al.* 1994). Annual PSP measurements were available from age 5 to age 8 for both sites.

The growth rate multipliers (Carson *et al.* 1994) were incorporated into the GROPAK versions of the SANDS and NAPIRAD models. We ran each growth model from the default stand parameters to predict MTH, mean diameter, stocking, basal area and volume, using the site index (based on the unimproved crop) and the silviculture of the genetic gain trials. Having no starting values for tree size provided a very stringent test of validity of the model predictions.

Actual stand parameters were obtained from PSP plot measurements. In the 1978 genetic gain trials, actual stand parameters were obtained by averaging over six plots for GF7 and GF14, and over three plots for GF2 and GF22. All plots in these trials had the same silvicultural treatment. In the 1987 silviculture / breed trials, actual stand parameters were obtained by averaging over two plots for each treatment and GF level combination (the exceptions were four plots for both 200 stems per ha at Glengarry and 500 stems per ha at Woodhill). Predicted and actual stand parameters were plotted over stand age, and the actual minus predicted stand parameters were calculated for the oldest age of measurement of each trial.

RESULTS

Hawke's Bay Region

1978 genetic gain trial (Mohaka - WN377)

The prediction of mean top height was very good for all seedlots (Figure 1, Table 1). The GF2 and GF7 seedlots predicted very well for height, basal area and volume (Table 1). For basal area the predictions of differences between the seedlots rated GF7 and GF14, and especially between GF7 and GF22, were very conservative, that is, the actual difference in their performance was larger than predicted (Figure 2). Volume and mean diameter predictions reflected the trends in the basal area predictions (Figure 3, Appendix 1.)

1987 Silviculture/Breed trial (Glengarry - FR10)

Trial data for basal area and volume appear to fit model predictions better at low stocking than high stocking for all GF ratings (Table 2). There appears to be a clear and consistent trend from 600 stems per ha down to 100 stems per ha with good predictions at 100 stems per ha, and substantial under prediction at 600 stems per ha. There may be a slight trend in the opposite direction for mean top height, that is, predictions of height were slightly better at high stockings.

Deviations of actual from predicted tree parameters for the GF7 and GF14 seedlots are often very close (Table 2), suggesting that, at most stockings, the difference between GF7 and GF14 seedlots is being predicted fairly well. In a number of stocking treatments, however, the GF21 is not performing as well as expected for mean top height and diameter, and therefore, the difference between GF21 and the lower rated seedlots may not be as great as the model predicts (see plots of predicted and actual stand parameters in Appendix 2).

Sandy soils

1978 genetic gain trial (Aupouri - AK1058)

The GF2 seedlot is performing much better on this site relative to the other seedlots than it has on the 13 other sites of the 1978 genetic gain trial (including the row plot trials), and wood density (a highly heritable trait) of this seedlot is much lower than at all of the other locations (Sorensson and Low 1995). For these reasons, we have concluded that the GF2 seedlot is miss-labelled at this site and is, therefore, omitted from further consideration in this study.

The prediction of mean top height was lower than the actual for all seedlots, but the predicted difference between the GF7 and 14 was reasonably good (Figure 4, Table 1). The GF22 seedlot did not perform as well as expected for mean top height, and so the predicted difference between this seedlot and the lower rated seedlots is larger than the actual difference.

For basal area the GF7 and GF14 predictions were high, but the actual difference between them was only slightly larger than predicted (Figure 5, Table 1). The performance of the GF22 was substantially higher than predicted, so, as with the GF7 and the GF14, the difference between the GF22 and the lower rated seedlots was under predicted. The under prediction of height and over prediction of basal area for GF7 and GF14 balance each other to make the volume predictions fairly good for these seedlots and thus the difference between them is predicted fairly well (Figure 6). Volume prediction of the GF22, however, is substantially less than the actual. The trends for mean diameter are similar to those for volume (Appendix 1).

1987 Silviculture/Breed trial (Woodhill - FR7)

Trial data at this site tends to fit model predictions better for all GF ratings at high stocking than at low stocking, particularly for basal area and volume. There appears to be a trend in the opposite direction for basal area and volume at this site than at the Glengarry site (Tables 2&3).

Deviations of actual from predicted tree parameters for the GF7 and GF14 seedlots are often very close (Table 3), suggesting that the difference between GF7 and GF14 seedlots are being well predicted for mean top height, basal area, and volume. However, as at Glengarry, the GF21 is not performing as well as expected in a number of treatments, especially for mean top height and for basal area at the lower stockings. Therefore, the difference between GF21 and the lower rated seedlots may not be as great as the model predicts (see plots of predicted and actual stand parameters in Appendix 3).

DISCUSSION

The data from the younger plots, that is, the Silviculture/Breed trials (current age 8), show large percentage errors, particularly for basal area and volume. Errors are smaller for the older plots, that is, the 1978 Genetic Gain trials (current age 17). This is not surprising, as the growth models are intended for prediction of growth at older ages and errors are expected to decrease with time. For this reason and because there are only two plots per stocking treatment per GF rating, interpretations have been largely based on the accuracy of predicting the differences between the seedlots over all stocking treatments.

The actual difference between stand variables for the GF7 and GF14 rated seedlots was either close to the predicted difference or somewhat larger than predicted at all four genetic gain trial sites. The data suggests, therefore, that predictions from NAPIRAD and SANDS will give reasonable approximations of the difference between GF7 and GF14 seedlots, but could be conservative in some cases.

Results from the higher rated seedlots, however, are somewhat conflicting. The basal area of the highest rated seedlot in one set of trials was greatly under-predicted, but somewhat over-predicted in another set of trials. The GF22 seedlot in the 1978 genetic gain trial performed much better than predicted for basal area at both the Aupouri and Woodhill sites. In contrast, the performance of the GF21 seedlot in both of the 1987 Silviculture/Breed trials (Glengarry and Woodhill) for basal area was most often lower than predicted. The seedlots in the two sets of trials were different, so the differences may be due to the confounding of stem form traits in the assignment of GF rating. For mean top height, the actual performance of the highest rated seedlots on both sites was often not as different from the lower rated seedlots as predicted, that is, the predicted difference was larger than the actual difference.

CONCLUSION

Keeping in mind the limited amount of data available for validation, there is no reason to believe that the predictions from NAPIRAD and SANDS with the growth rate multipliers incorporated to reflect the affect of genetic gain would be less valid than for models from other growth modelling regions. The data which is available suggests that the difference between GF7 and GF14 seedlots (that is, climbing select and open-pollinated seed orchard) is predicted fairly well. Predictions for higher rated seedlots, however, might be less accurate.

Acknowledgments

Dr C. Goulding incorporated the genetic gain multipliers into the GROPAK versions of NAPIRAD and SANDS, which enabled this project to be carried out.

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Table 1. Stand parameter differences at two 1978 Genetic Gain trial sites

MOHAKA FOREST (WN377) - Age 16

	GF2		GF7		GF14		GF22	
Parameter	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference
Height (m)	0.6	2%	0.1	0.4%	0.8	3%	-0.5	2%
Basal Area (sq.m/ha)	-0.1	0.3%	-0.5	1%	5.9	12%	12.6	22%
Volume (cu.m/ha)	18	5%	0	0%	71	15%	121	22%

AUPOURI FOREST (AK1058) - Age 17

	GF2		GF7		GF14		GF22	
Parameter	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference
Height (m)	3.1	14%	2.3	10%	3	12%	1.8	8%
Basal Area (sq.m/ha)	0.6	3%	-3.1	15%	-2.2	9%	5.2	16%
Volume (cu.m/ha)	31	15%	-7	4%	7	3%	59.0	22%

Table 2. Stand parameter differences at the 1987 Silviculture/Breed trial

GLENGARRY FOREST (FR10) - Age 8

Height (m)

		GF7		GF14		GF21		AVERAGE	
Trt. No.	Treatment	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference	Actual Diff	Percent Diff
1	Thin to 100sph	-1.4	11%	-1.4	10%	-1.8	13%	-1.5	11%
2&6	Thin to 200sph	-0.9	7%	-1.1	8%	-1.6	12%	-1.2	9%
3	Thin to 400sph	-0.4	3%	-0.4	3%	-0.1	1%	-0.3	2%
5	Unthin 500sph	-0.6	4%	-0.8	6%	-1.2	8%	-0.9	6%
4	Thin to 600sph	0.5	3%	-0.3	2%	-1.2	8%	-0.3	4%
	AVERAGE	-0.6	6%	-0.8	5%	-1.2	8%		

Basal Area (sq.m/ha)

		GF7		GF14		GF21		AVERAGE	
Trt. No.	Treatment	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference	Actual Diff	Percent Diff
1	Thin to 100sph	0.5	7%	1.4	16%	0.9	10%	0.9	11%
2&6	Thin to 200sph	2.9	20%	1.9	13%	1	7%	1.9	13%
3	Thin to 400sph	5.3	24%	5.7	23%	2.2	10%	4.4	19%
5	Unthin 500sph	10.9	36%	8.7	28%	7.7	24%	9.1	29%
4	Thin to 600sph	9.5	31%	9.1	28%	8.5	24%	9.0	28%
	AVERAGE	5.8	24%	5.4	22%	4.1	15%		

Volume (cu.m/ha)

		GF7		GF14		GF21		AVERAGE	
Trt. No.	Treatment	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference	Actual Diff	Percent Diff
1	Thin to 100sph	-0.4	1%	3.6	9%	1.0	2%	1.4	4%
2&6	Thin to 200sph	11.2	16%	6.0	8%	-1.9	3%	5.1	9%
3	Thin to 400sph	25.3	23%	24.3	19%	12.7	11%	20.8	18%
5	Unthin 500sph	50.0	34%	40.7	25%	28.9	18%	39.9	26%
4	Thin to 600sph	54.8	34%	45.7	27%	46.6	26%	49.0	29%
	AVERAGE	28.2	19%	24.1	20%	17.5	12%		

Table 3. Stand parameter differences at the 1987 Silviculture/Breed trial

WOODHILL FOREST (FR7) - Age 8

Height (m)

		GF7		GF14		GF21		AVERAGE	
Trt. No.	Treatment	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference	Actual Diff	Percent Diff
1	Thin to 100sph	-0.6	6%	-0.9	9%	-1.5	14%	-1.0	10%
2	Thin to 200sph	-0.3	3%	-0.3	3%	-0.8	8%	-0.5	5%
3	Thin to 400sph	0.4	4%	-0.6	6%	0.2	2%	0.0	4%
5 &6	Unthin 500sph	0.5	4%	0.4	3%	-0.3	3%	0.2	3%
4	Thin to 600sph	-0.5	5%	0.7	6%	-0.3	2%	0.0	4%
	AVERAGE	-0.1	4%	-0.1	5%	-0.5	6%		

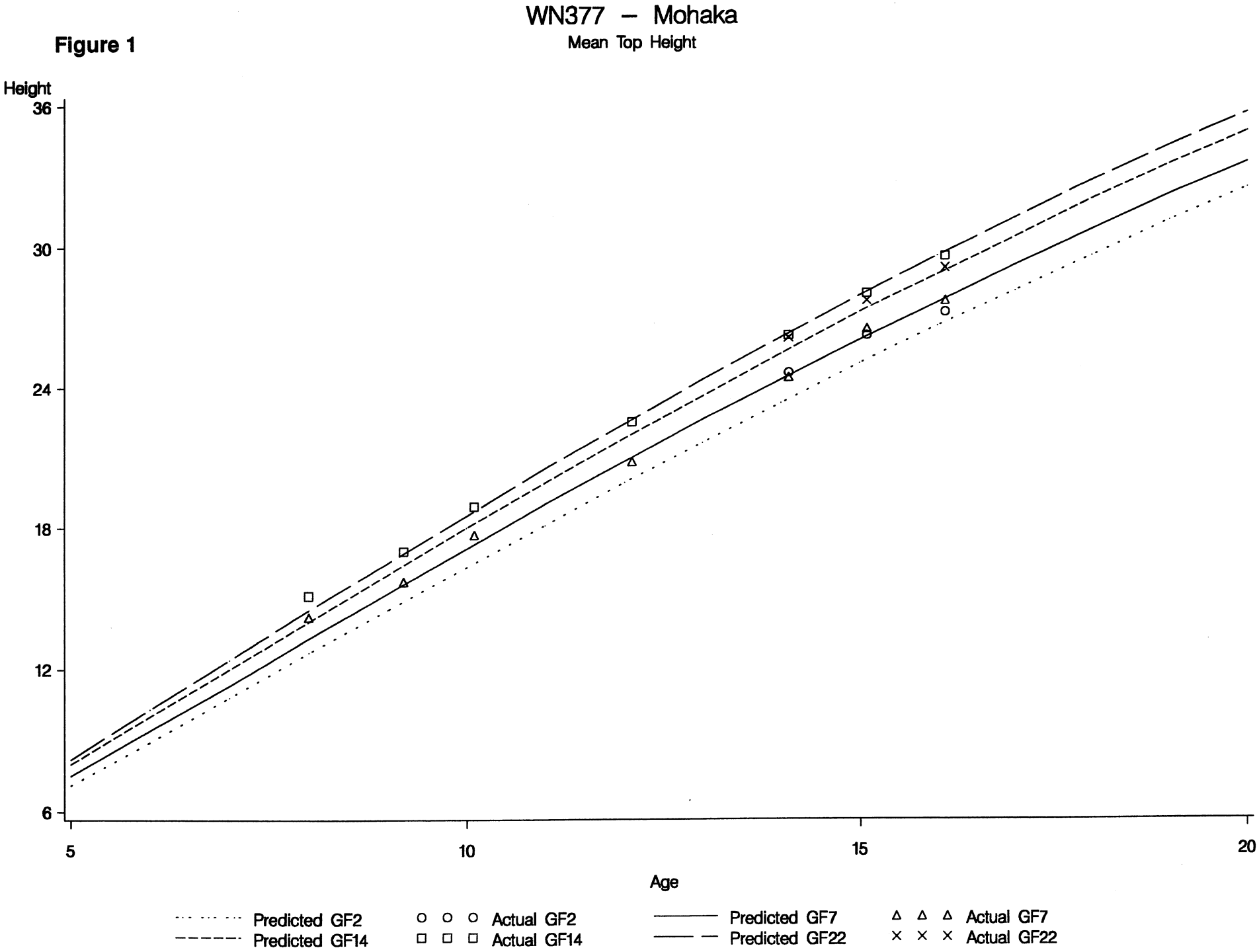
Basal Area (sq.m/ha)

		GF7		GF14		GF21		AVERAGE	
Trt. No.	Treatment	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference	Actual Diff	Percent Diff
1	Thin to 100sph	-2.7	64%	-3	68%	-3.3	78%	-3.0	70%
2	Thin to 200sph	-2.1	30%	-1.2	14%	-2.6	36%	-2.0	27%
3	Thin to 400sph	-1.1	10%	-0.4	3%	0.7	6%	-0.3	6%
5 &6	Unthin 500sph	-1.2	8%	-1.1	8%	-1.2	8%	-1.2	8%
4	Thin to 600sph	-0.3	2%	0	0%	0.5	3%	0.1	2%
	AVERAGE	-1.5	23%	-1.1	19%	-1.2	26%		

Volume (cu.m/ha)

		GF7		GF14		GF21		AVERAGE	
Trt. No.	Treatment	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference	Actual - Predicted	Percent Difference	Actual Diff	Percent Diff
1	Thin to 100sph	-15	100%	-17	110%	-20	140%	-17.3	117%
2	Thin to 200sph	-14	56%	-13.0	43%	-16	64%	-14.3	54%
3	Thin to 400sph	-10	24%	-12	27%	-5	9%	-9.0	20%
5 &6	Unthin 500sph	-14	27%	-15	27%	-19	35%	-16.0	30%
4	Thin to 600sph	-13	26%	-6	10%	-8	13%	-9.0	16%
	AVERAGE	-13.2	47%	-12.6	43%	-13.6	52%		

Figure 1


WN377 – Mohaka
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Height
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24
18
12
6
5
10
15
20
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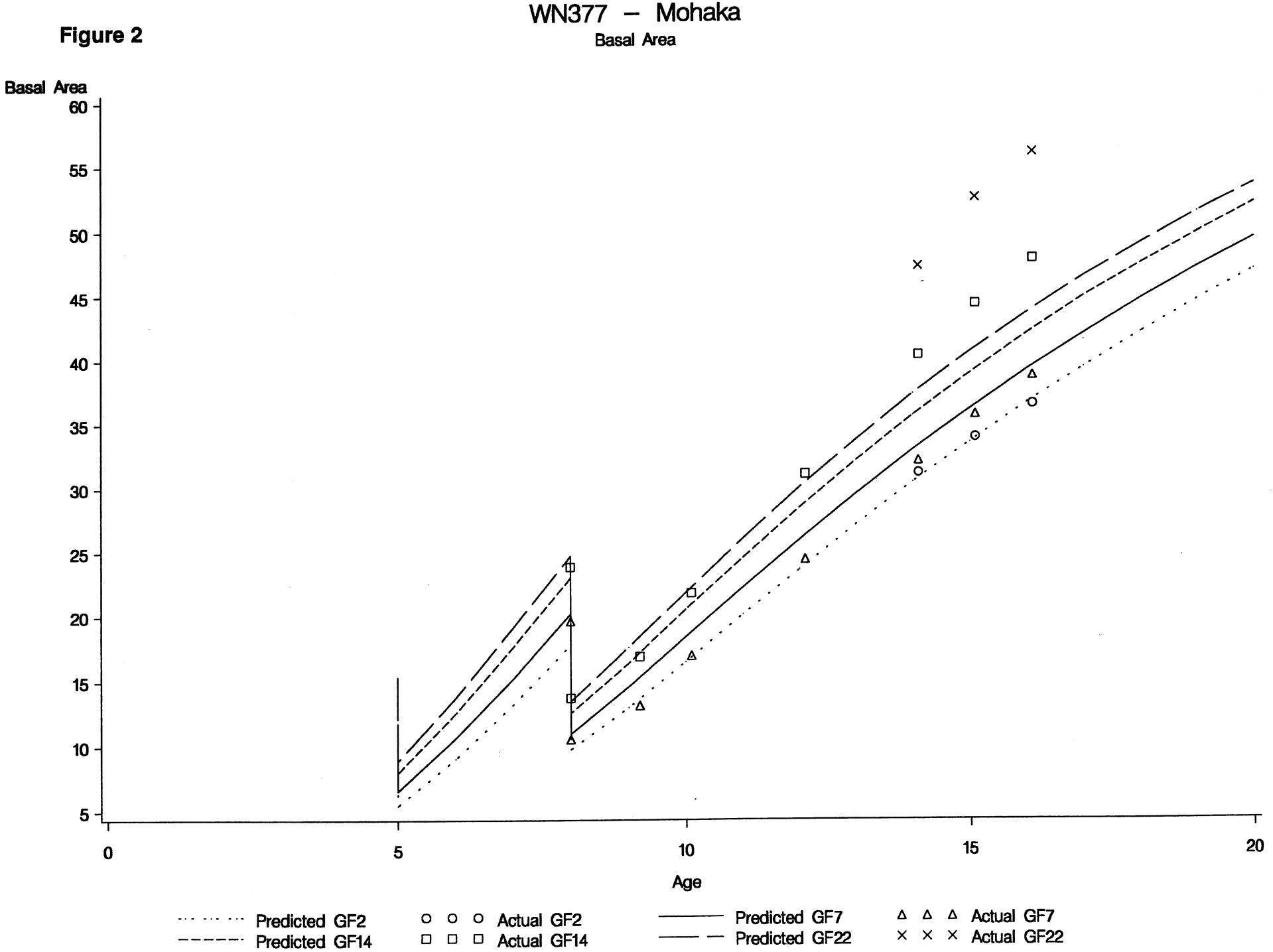
Actual GF2
Actual GF14
Predicted GF7
Predicted GF22
Actual GF7
Actual GF22

Figure 2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Basal Area
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Age
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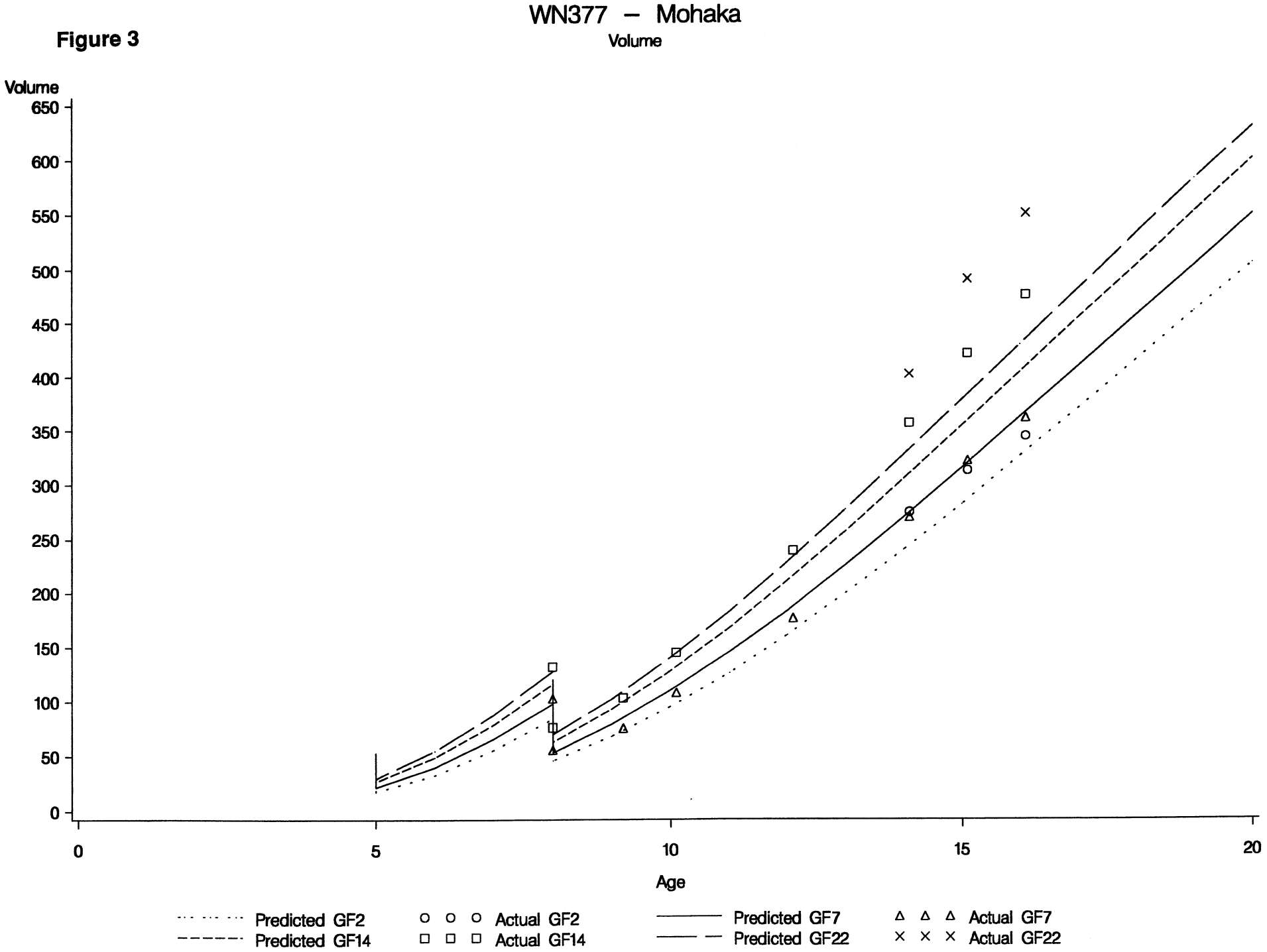
Predicted GF7
Predicted GF22
Actual GF7
Actual GF22

Figure 3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15
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Age
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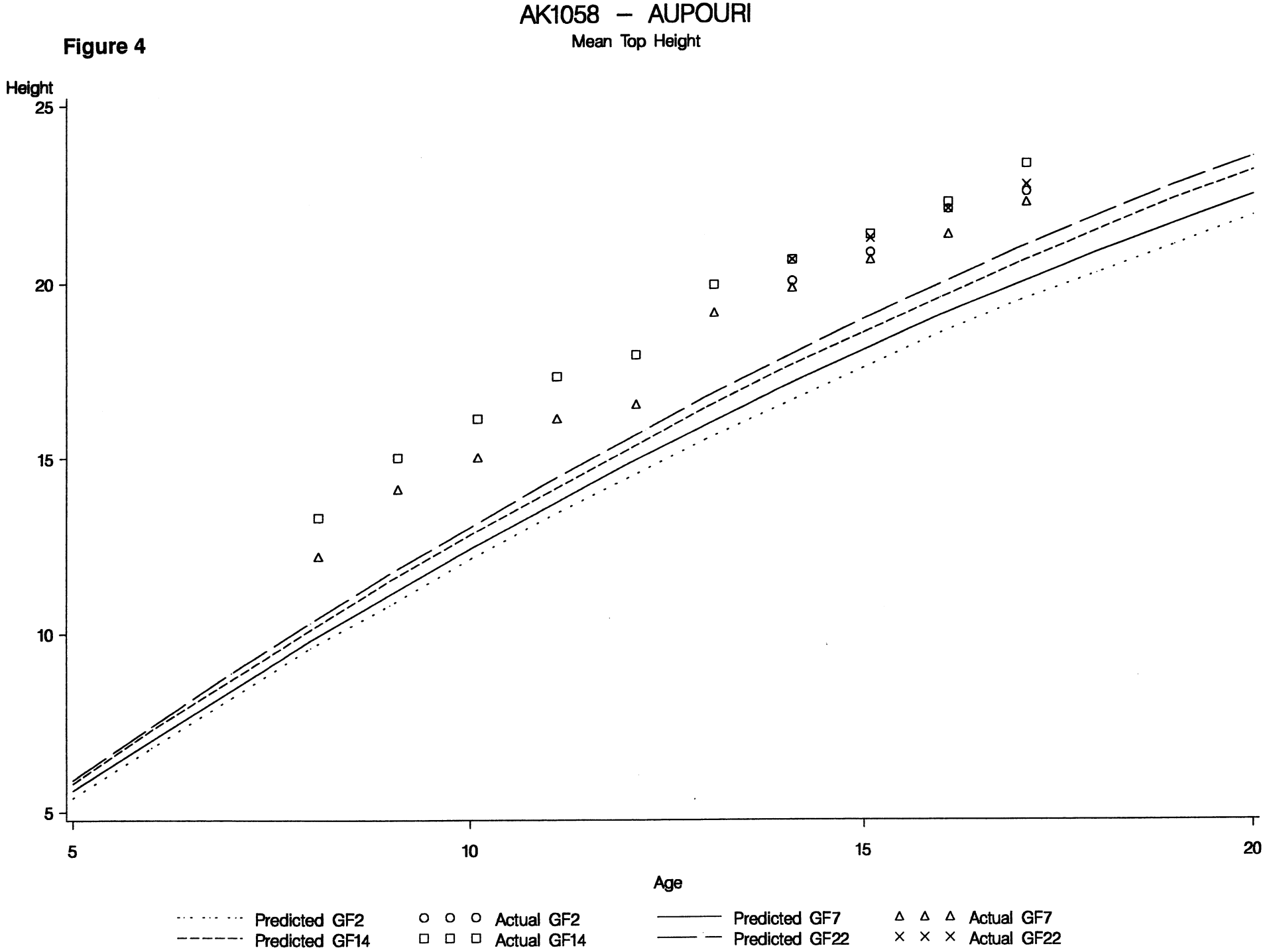
Predicted GF14
Actual GF2
Actual GF14
Predicted GF7
Predicted GF22
Actual GF7
Actual GF22

Figure 4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10
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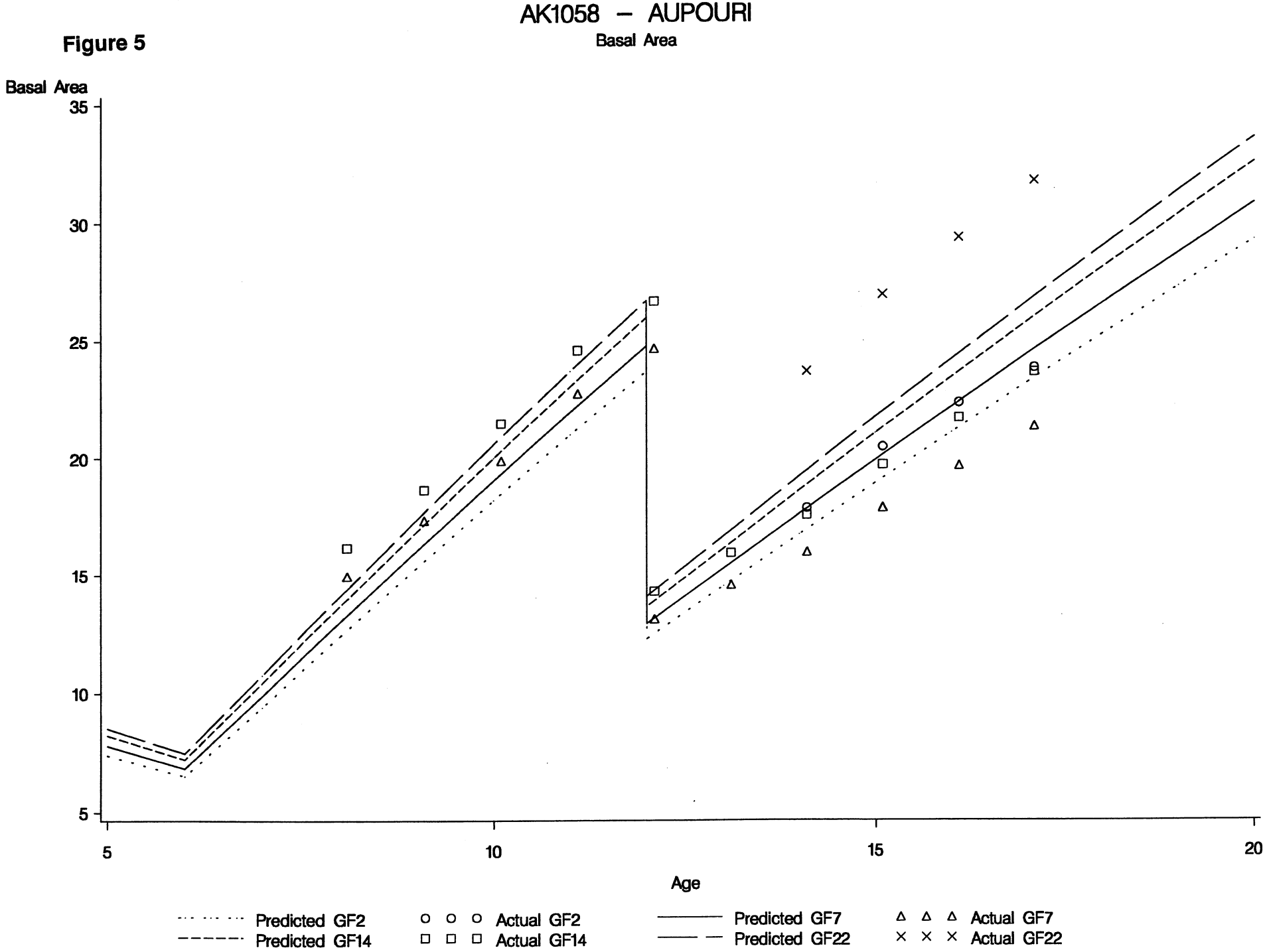
Actual GF2
Actual GF14
Predicted GF7
Predicted GF22
Actual GF7
Actual GF22

Figure 5


AK1058 – AUPOURI
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Basal Area
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10
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10
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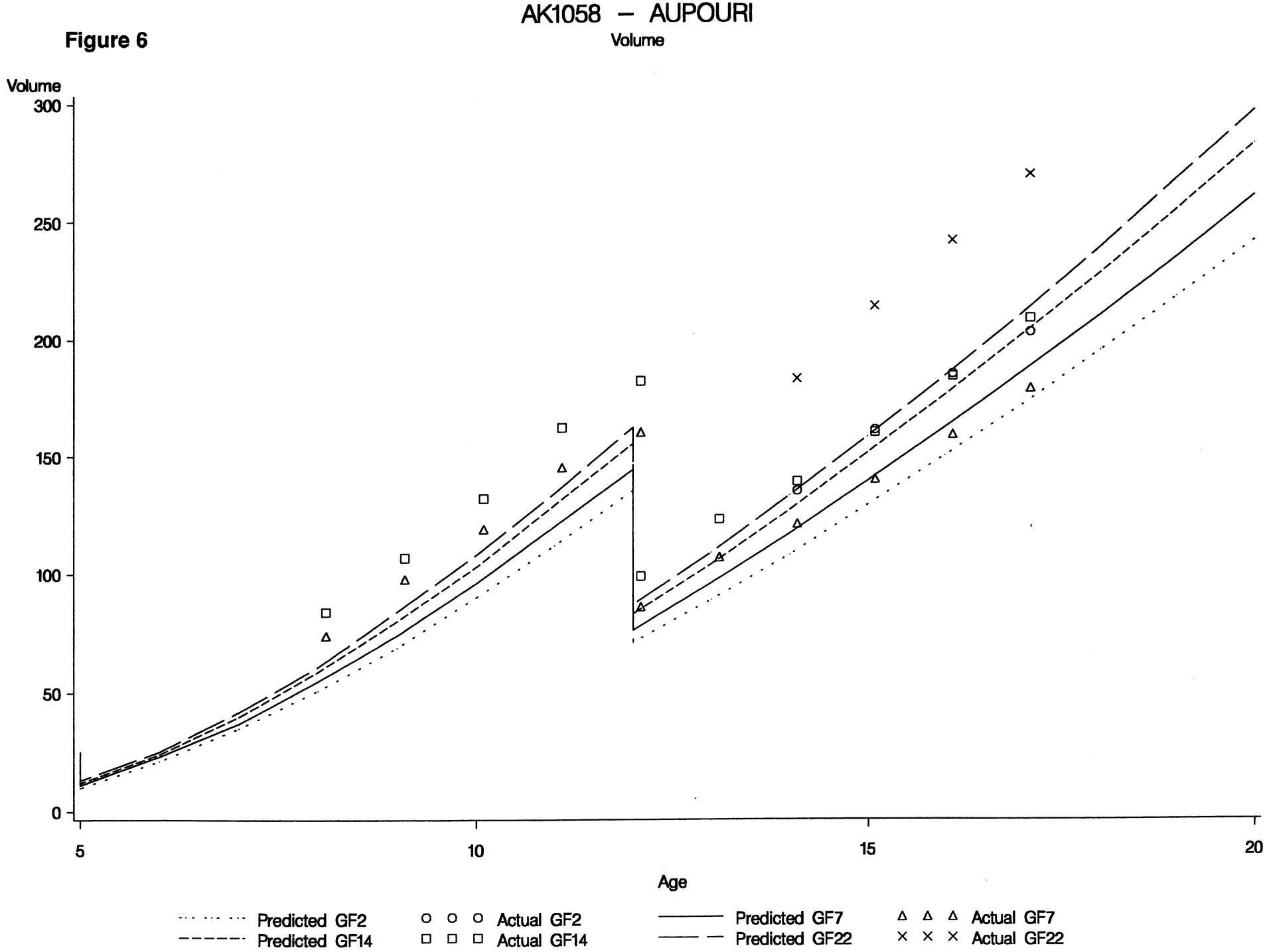
Predicted GF2
Predicted GF14
Actual GF2
Actual GF14
Predicted GF7
Predicted GF22
Actual GF7
Actual GF22

Figure 6


AK1058 – AUPOURI
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Volume
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200
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100
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5
10
15
20
Age
Predicted GF2
Predicted GF14
Actual GF2
Actual GF14
Predicted GF7
Predicted GF22
Actual GF7
Actual GF22

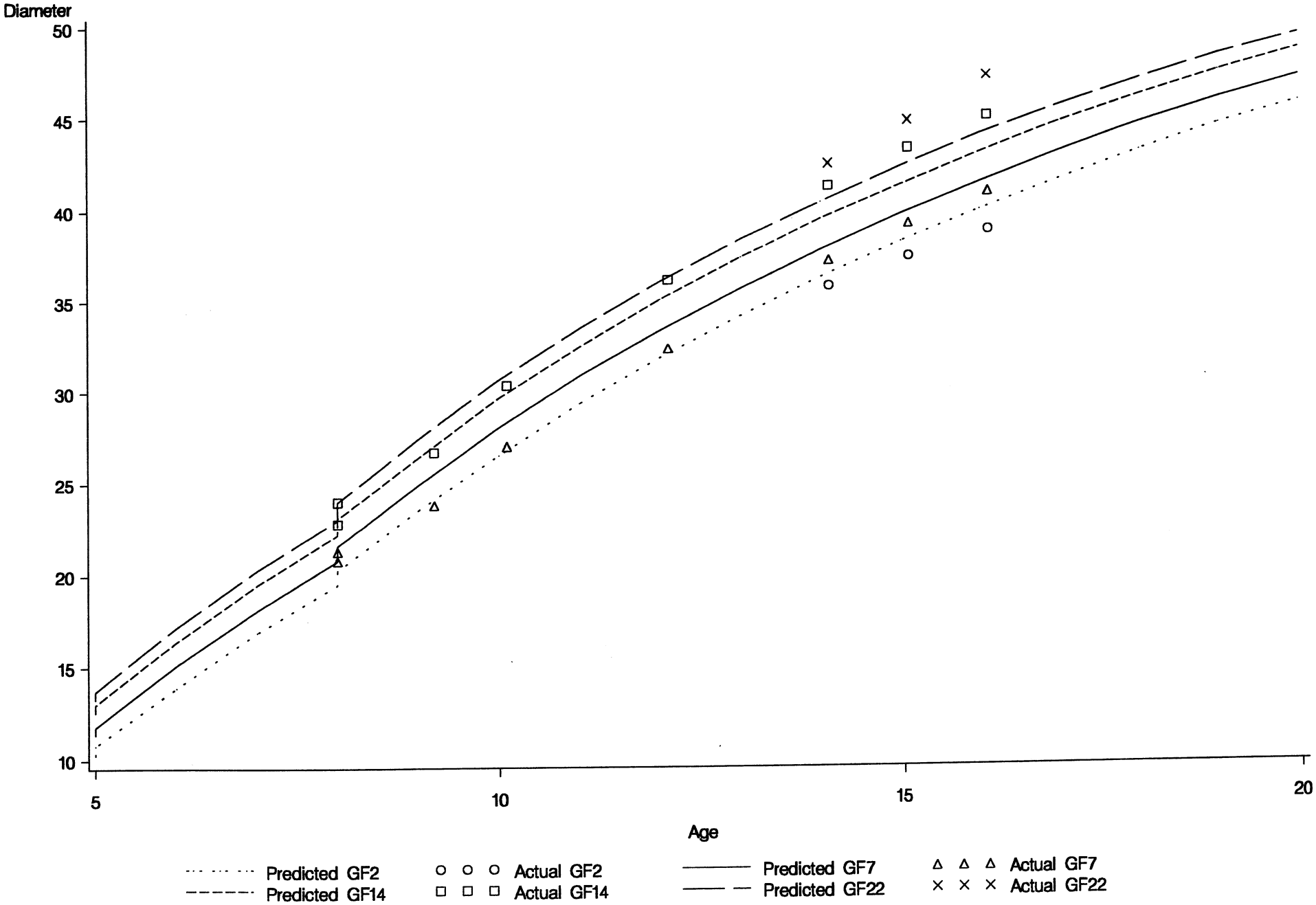
APPENDIX 1

Plots of Predicted and Actual Mean Diameter
at Mohaka and Aupouri Forests

Appendix 1

WN377 – Mohaka

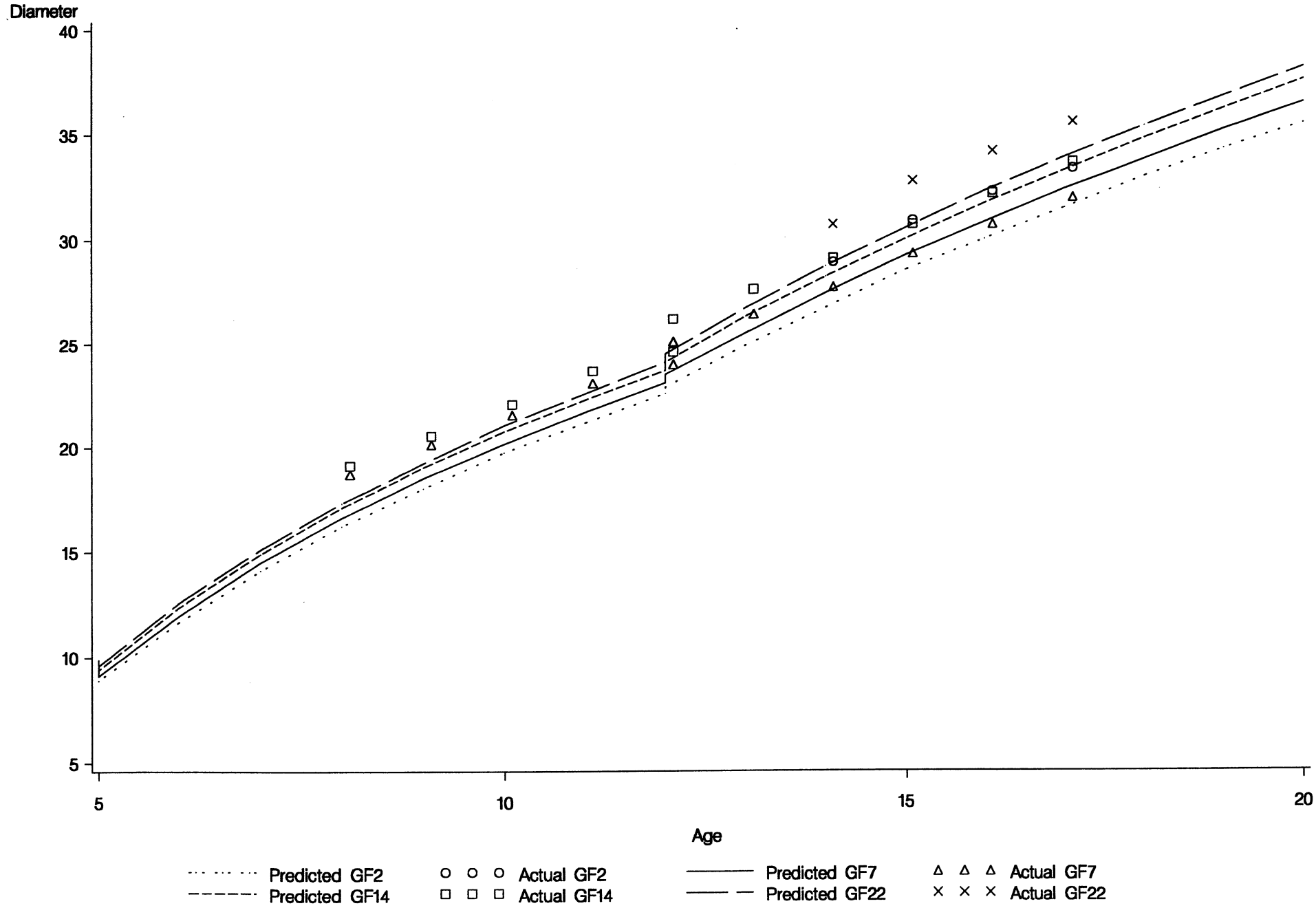
Mean Diameter



Appendix 1

AK1058 – AUPOURI

Mean Diameter



APPENDIX 2

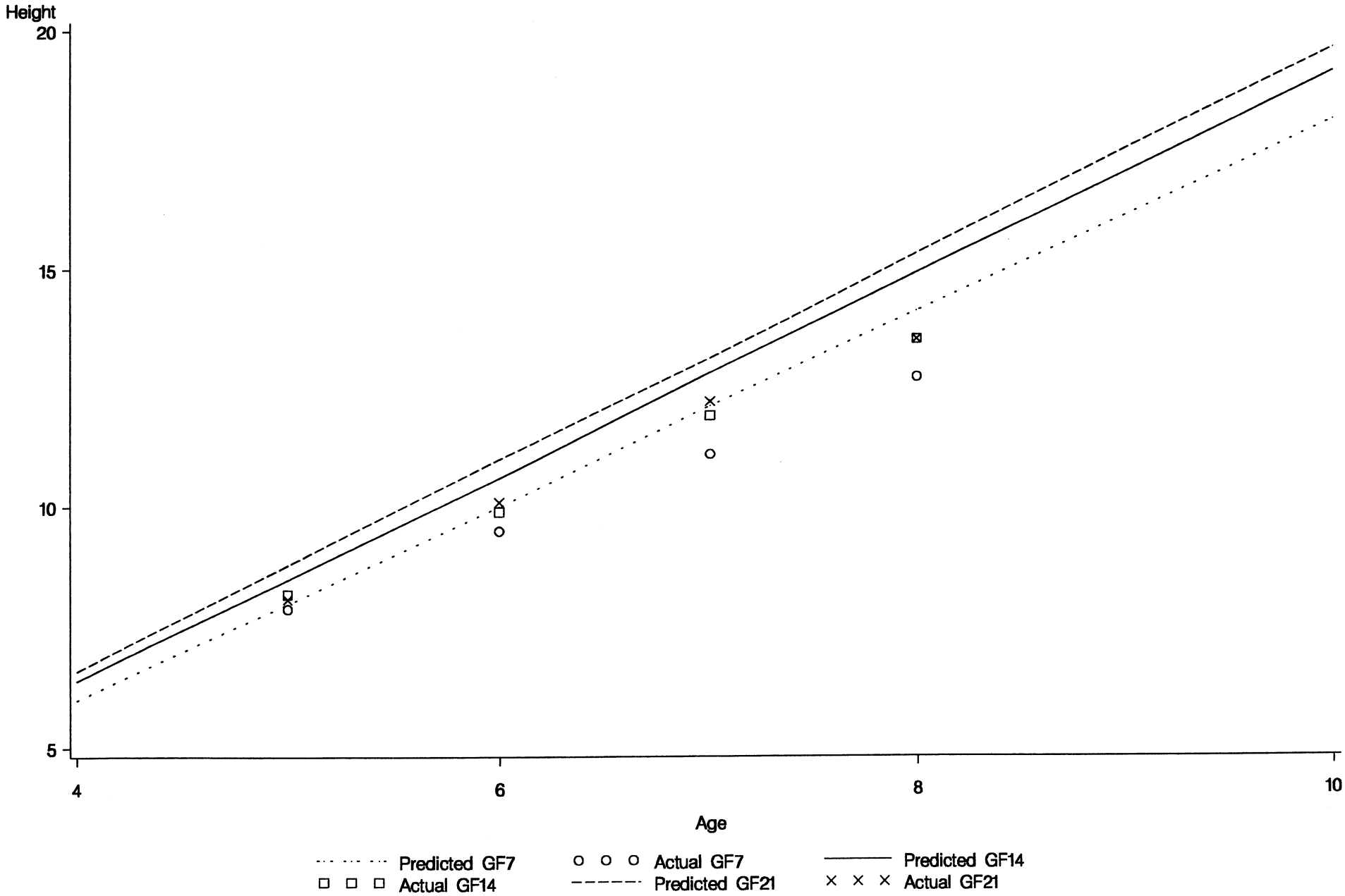
Plots of Predicted and Actual Stand Parameters
at Glengarry Forest (FR10)

Appendix 2

FR10 – Glengarry

Mean Top Height

Planted 500 sph, thinned to 100 sph

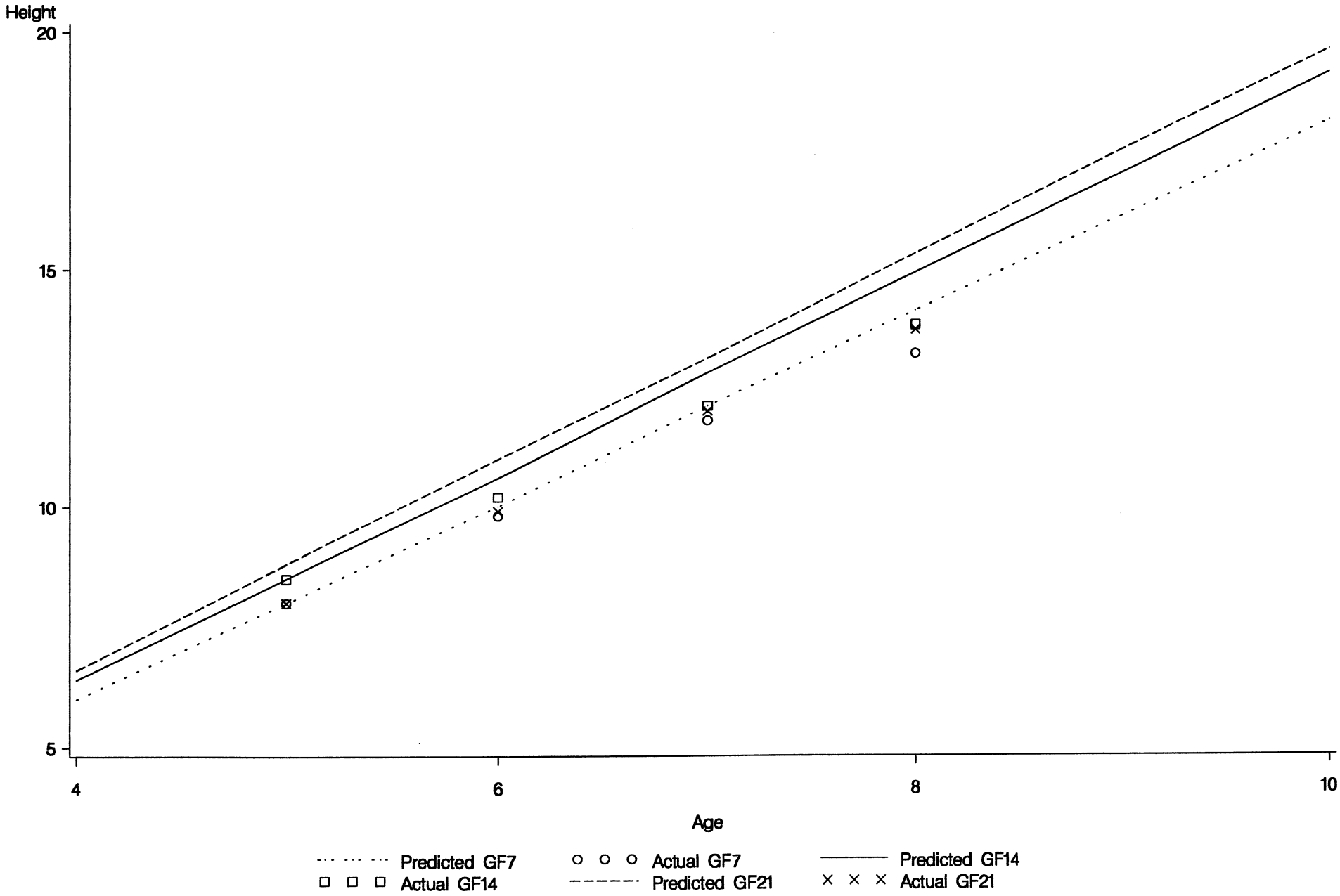


Appendix 2

FR10 – Glengarry

Mean Top Height

Planted 500 sph, thinned to 200 sph

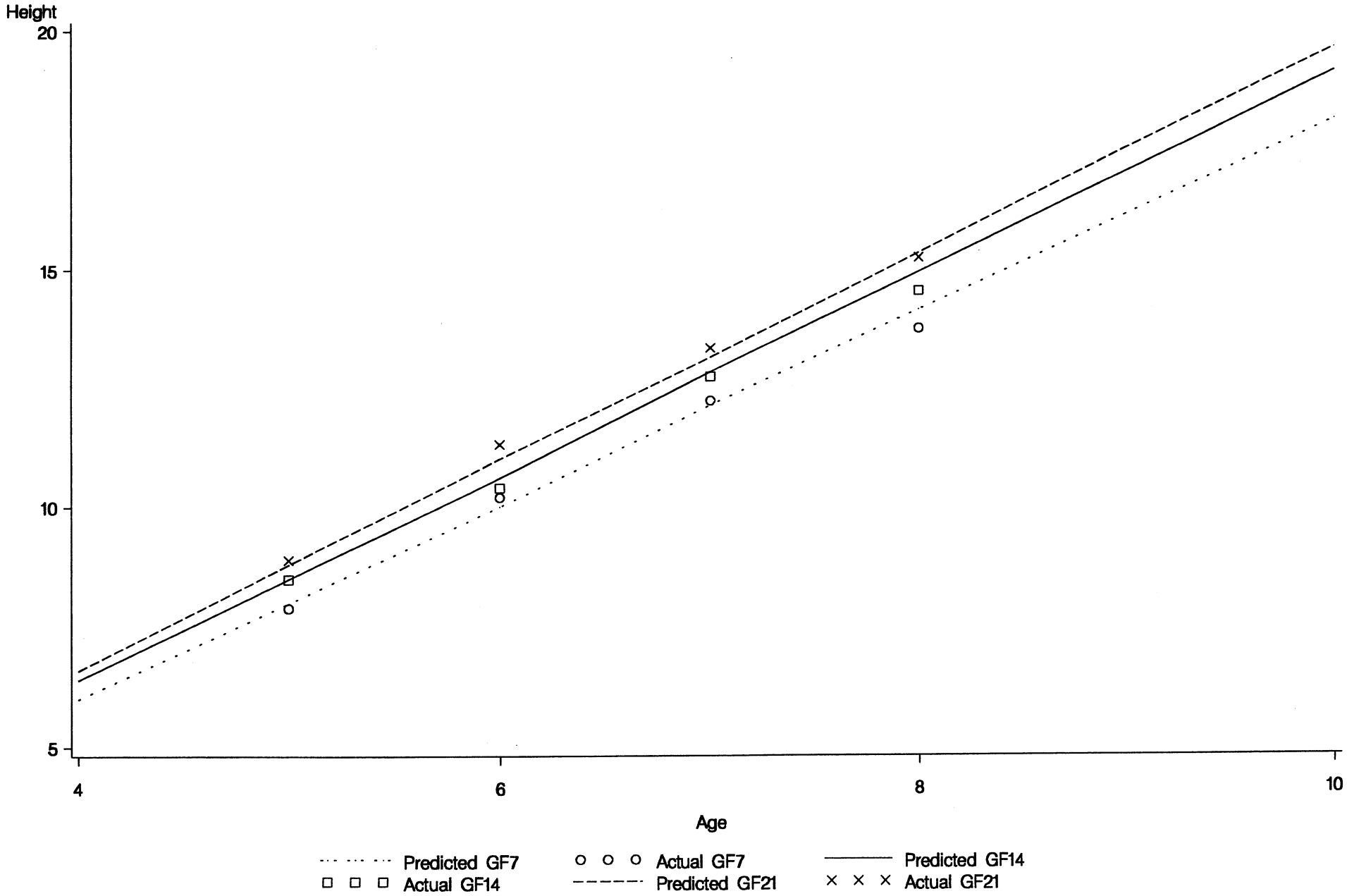


Appendix 2

FR10 – Glengarry

Mean Top Height

Planted 1000 sph, thinned to 400 sph

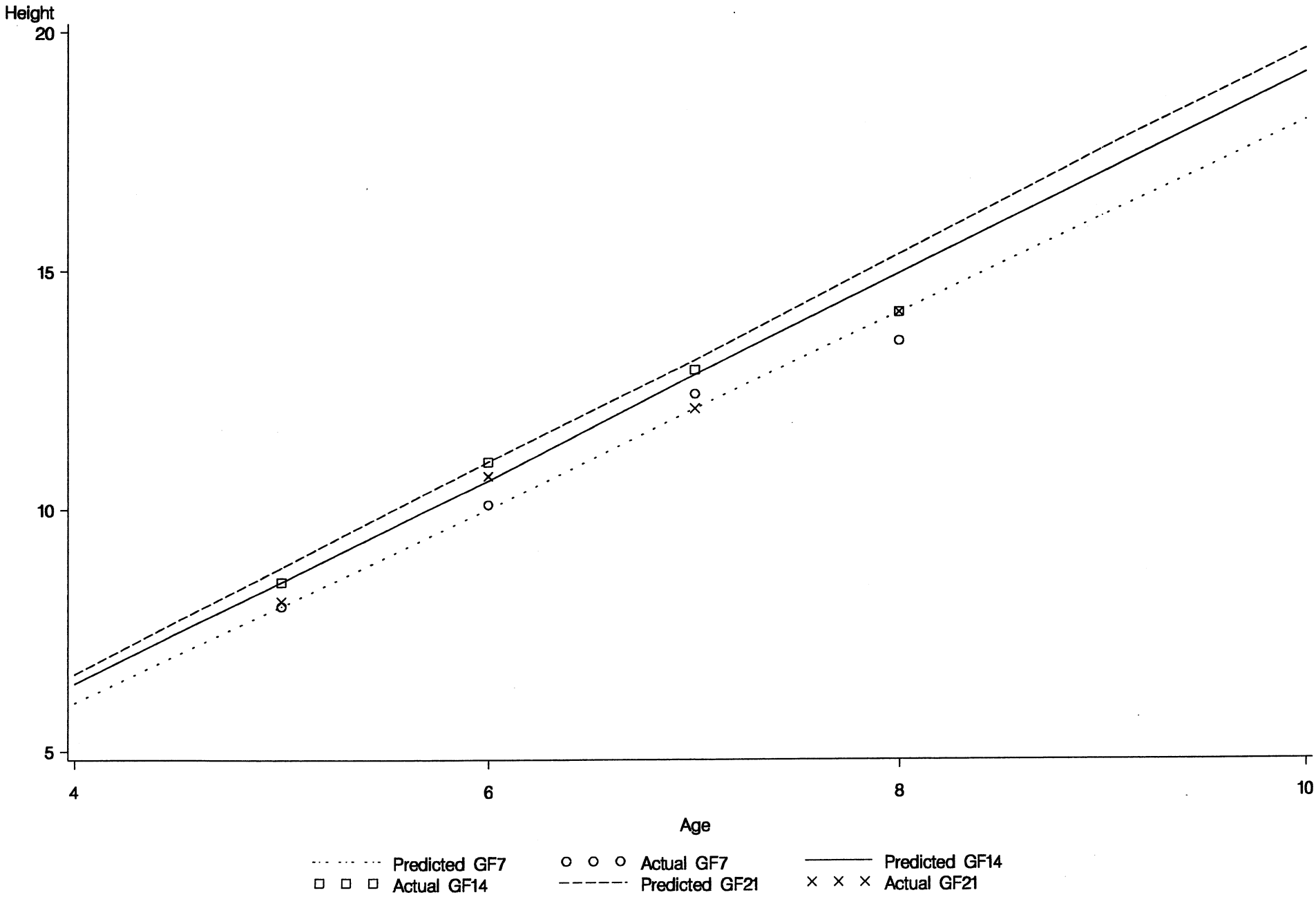


Appendix 2

FR10 – Glengarry

Mean Top Height

Planted 500 sph, unthinned

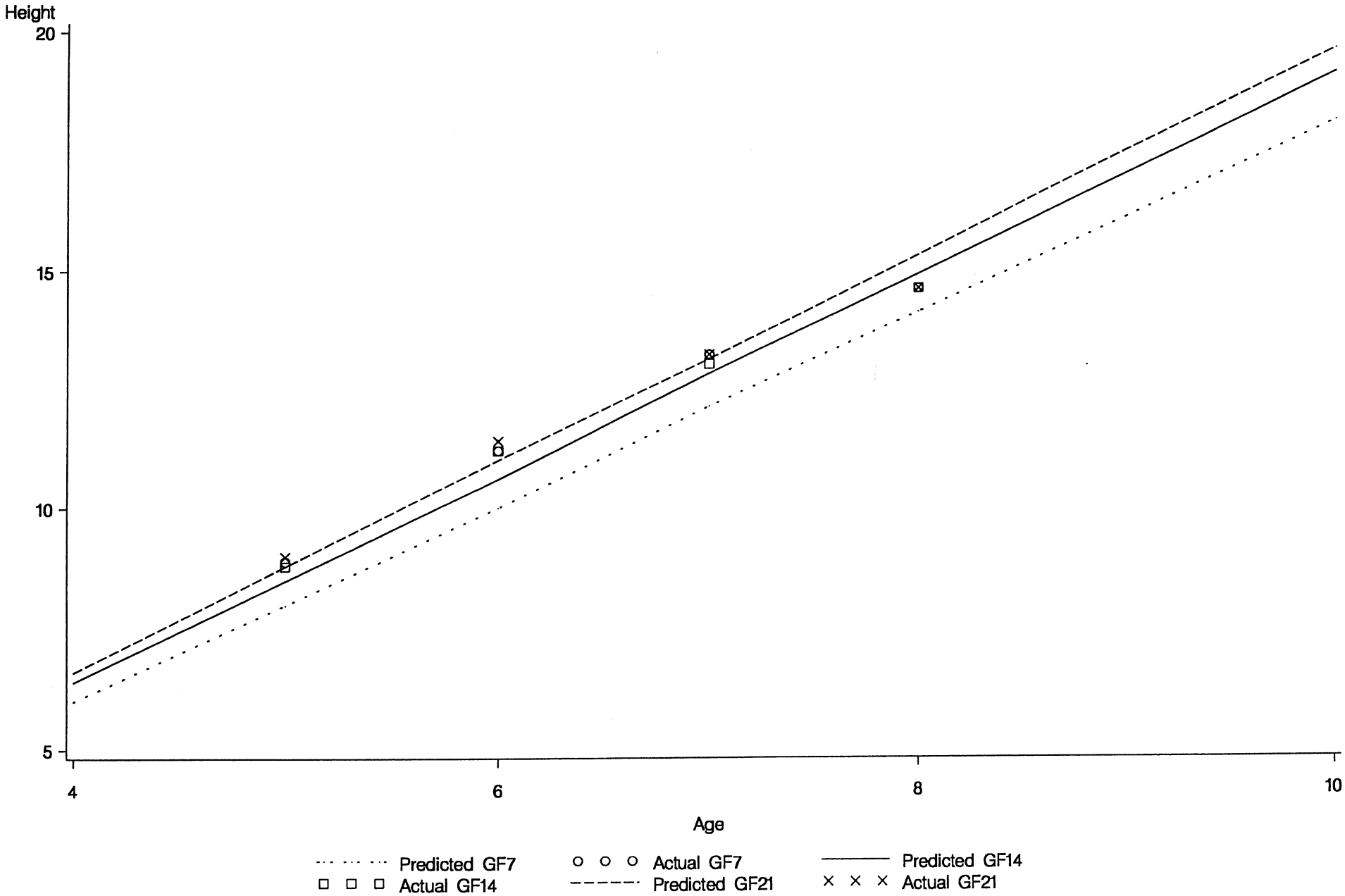


Appendix 2

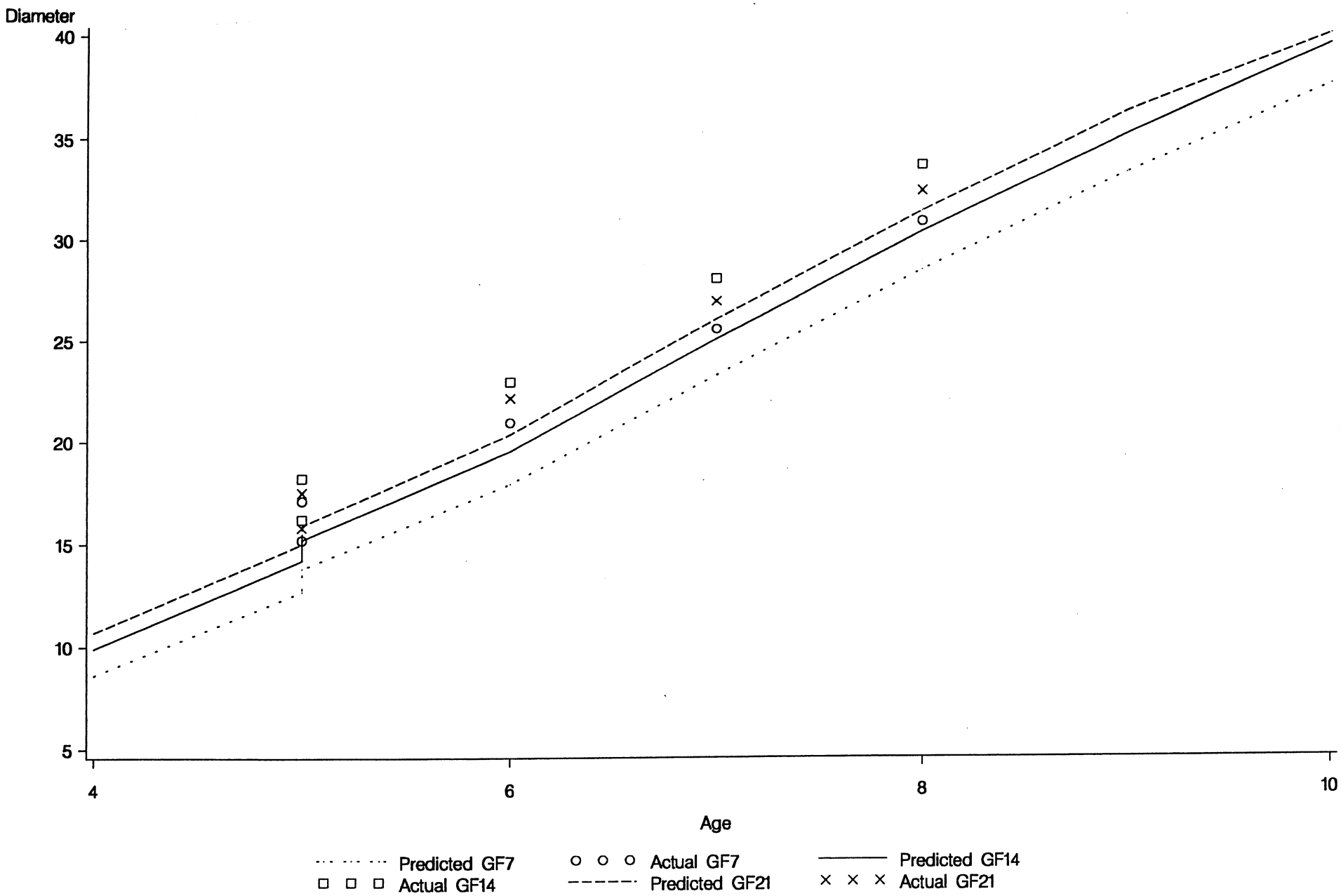
FR10 – Glengarry

Mean Top Height

Planted 1500 sph, thinned to 600 sph



Appendix 2

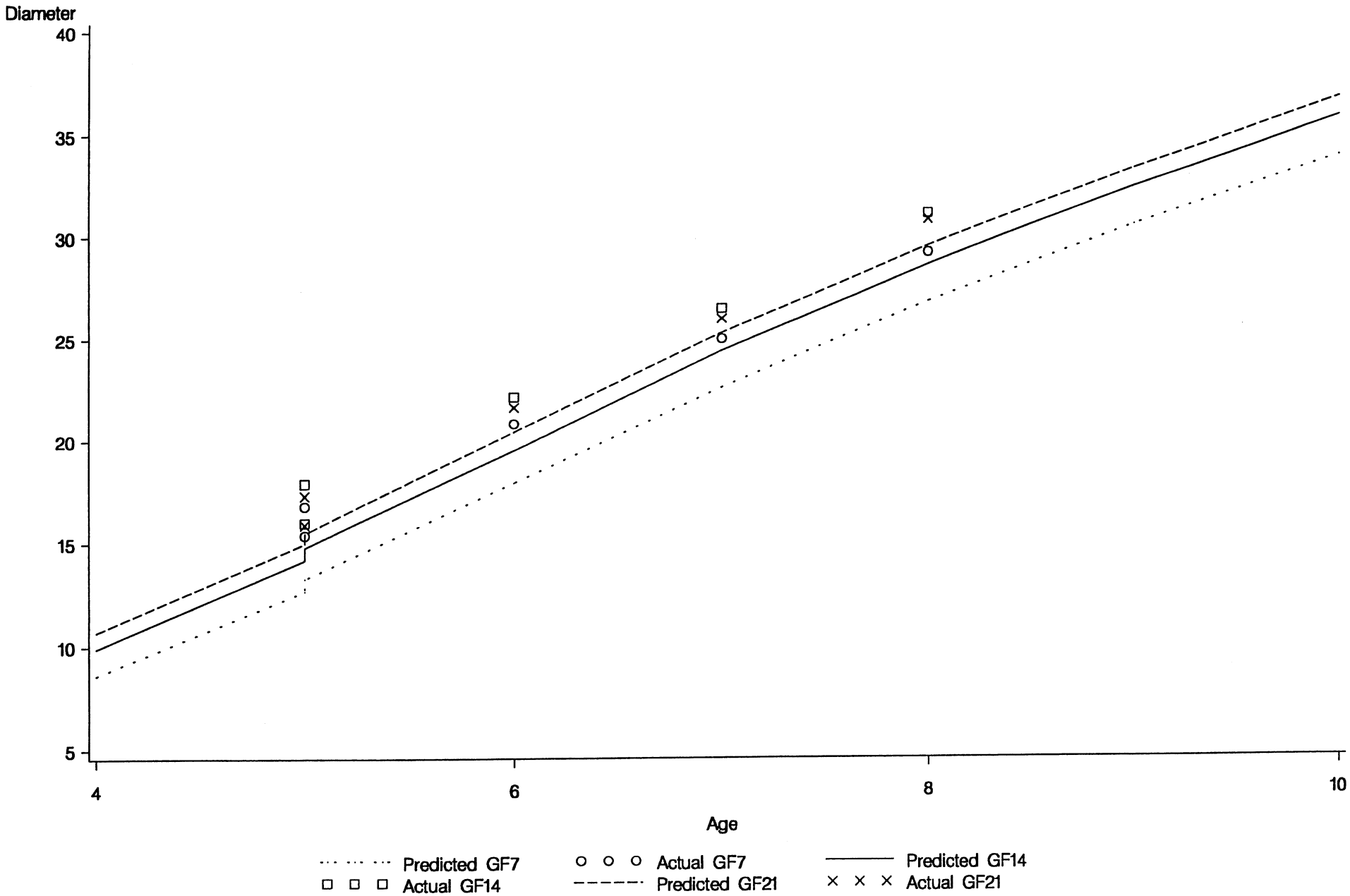

FR10 – Glengarry
Mean Diameter
Planted 500 sph, thinned to 100 sph
Diameter
40
35
30
25
20
15
10
5
4
6
8
10
Age
Predicted GF7
Actual GF14
Actual GF7
Predicted GF21
Predicted GF14
Actual GF21

Appendix 2

FR10 – Glengarry

Mean Diameter

Planted 500 sph, thinned to 200 sph

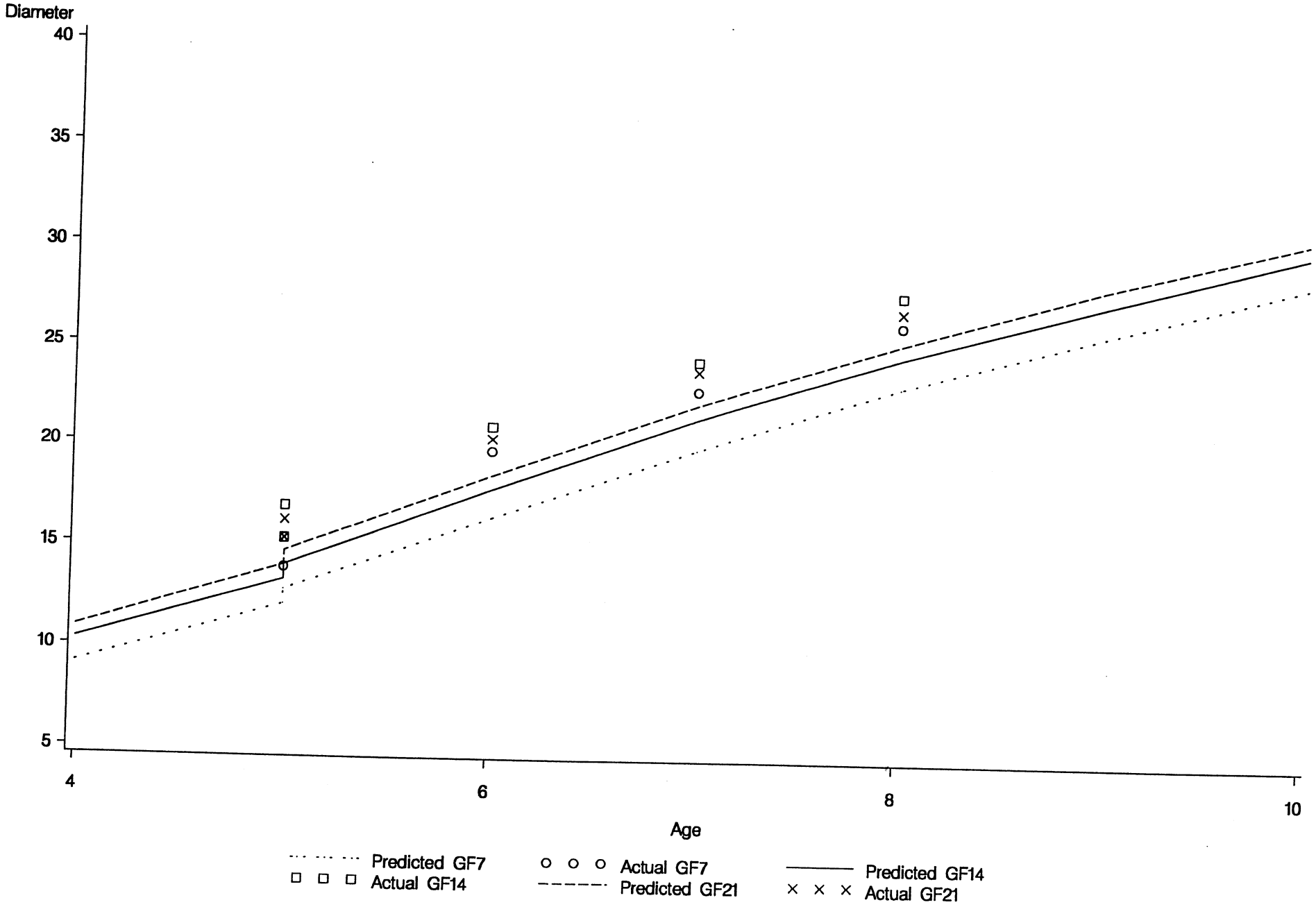


Appendix 2

FR10 – Glengarry

Mean Diameter

Planted 1000 sph, thinned to 400 sph

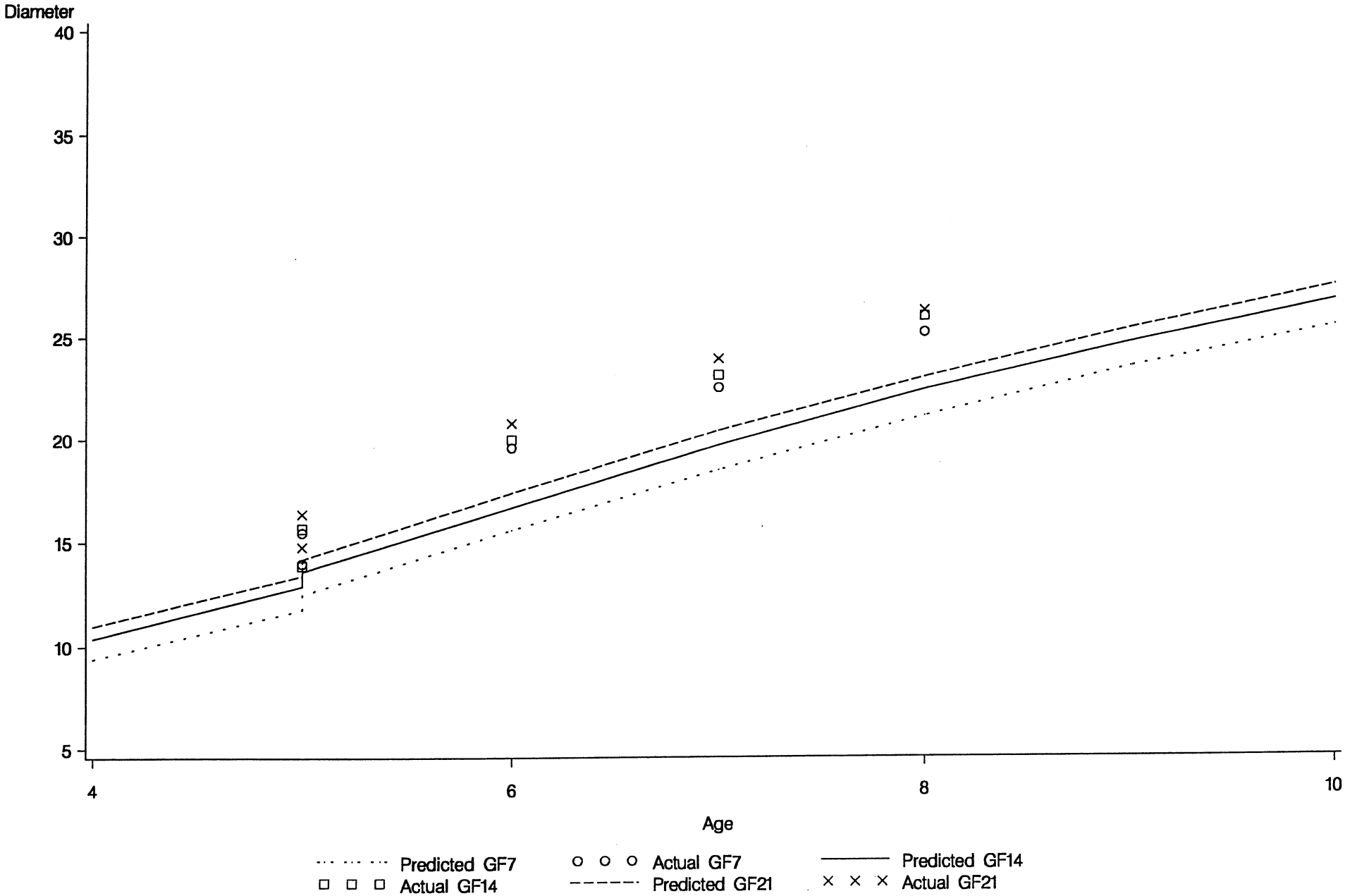


Appendix 2

FR10 – Glengarry

Mean Diameter

Planted 1500 sph, thinned to 600 sph

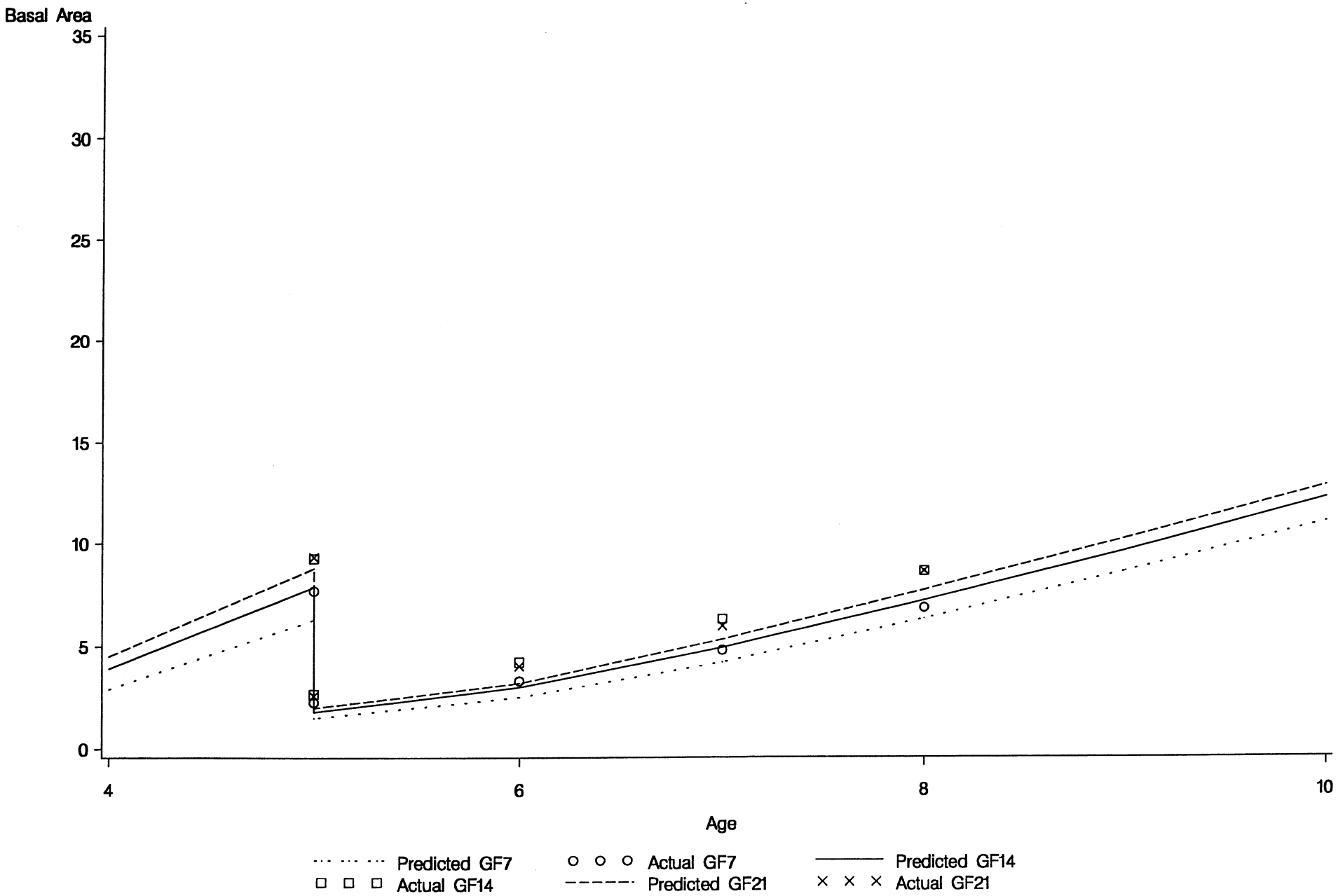


Appendix 2

FR10 – Glengarry

Basal Area

Planted 500 sph, thinned to 100 sph

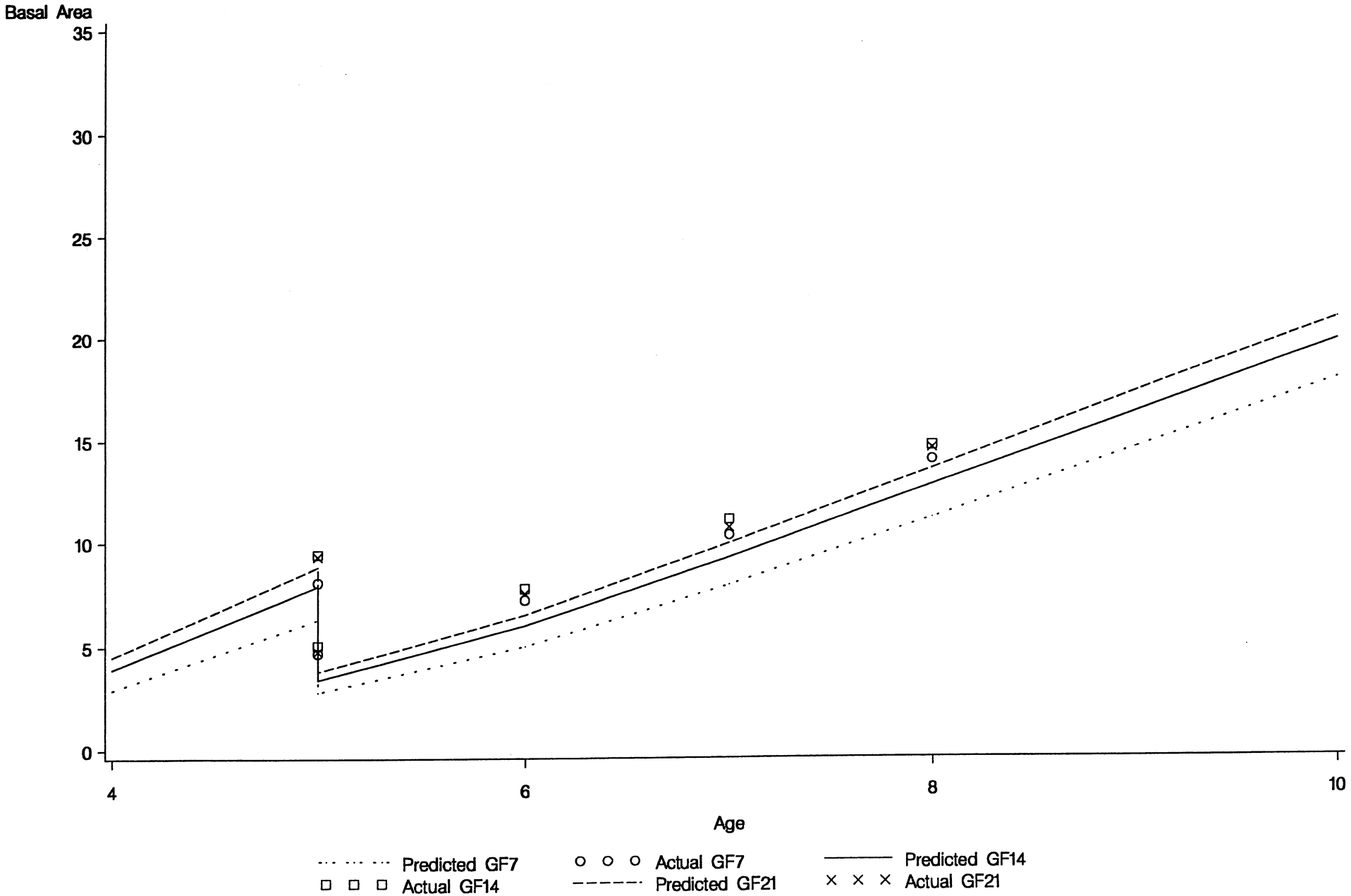


Appendix 2

FR10 – Glengarry

Basal Area

Planted 500 sph, thinned to 200 sph

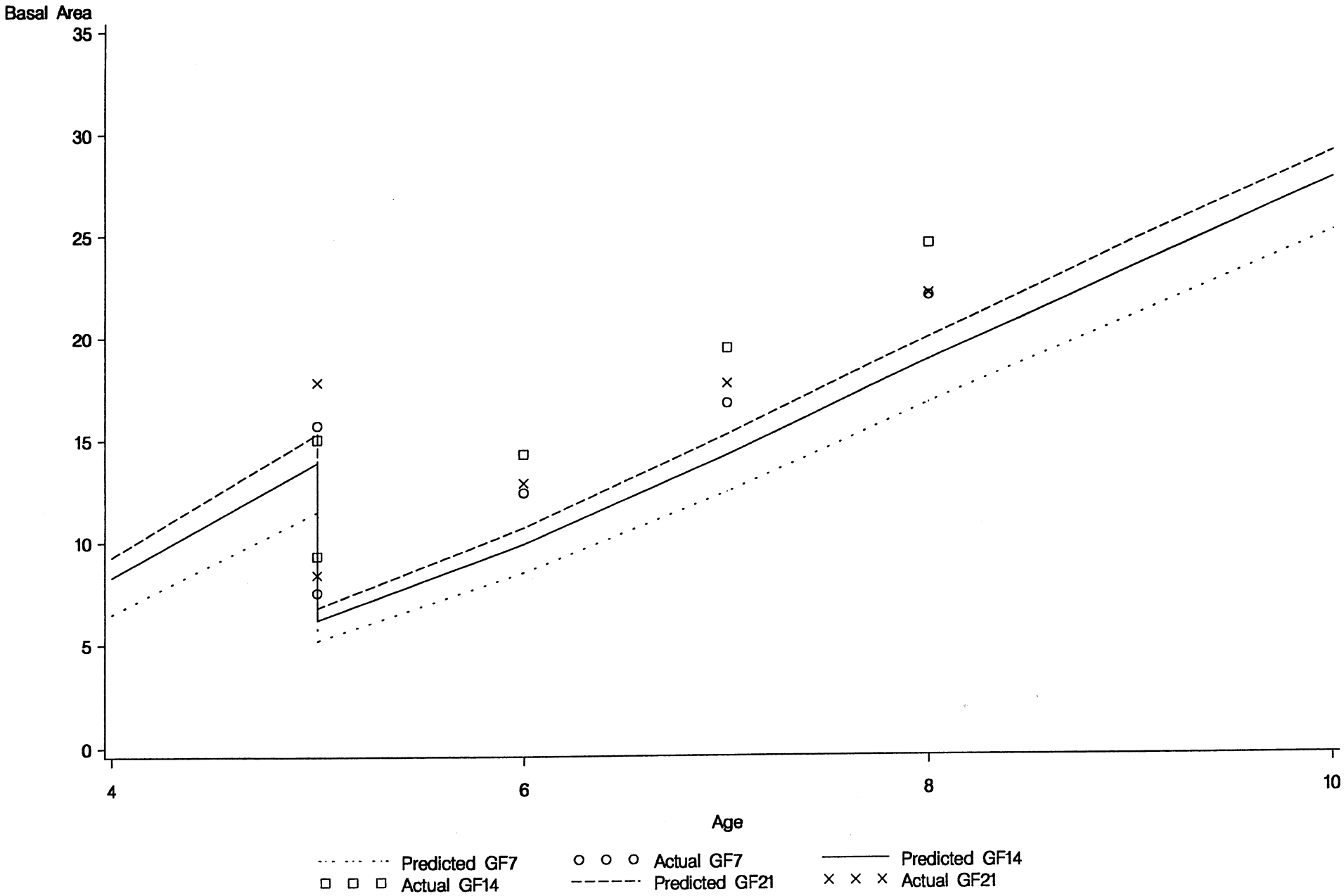


Appendix 2

FR10 – Glengarry

Basal Area

Planted 1000 sph, thinned to 400 sph

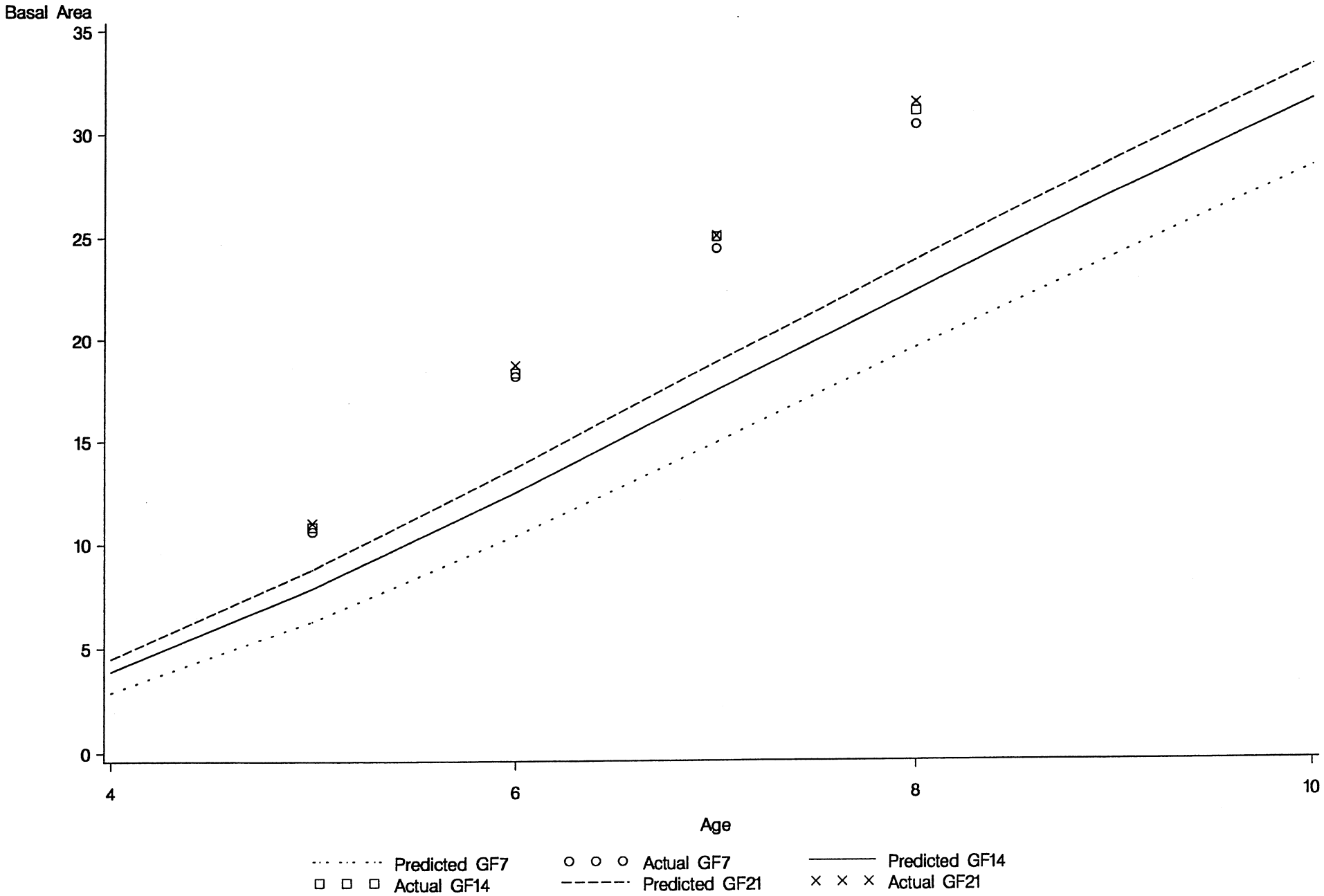


Appendix 2

FR10 – Glengarry

Basal Area

Planted 500 sph, unthinned

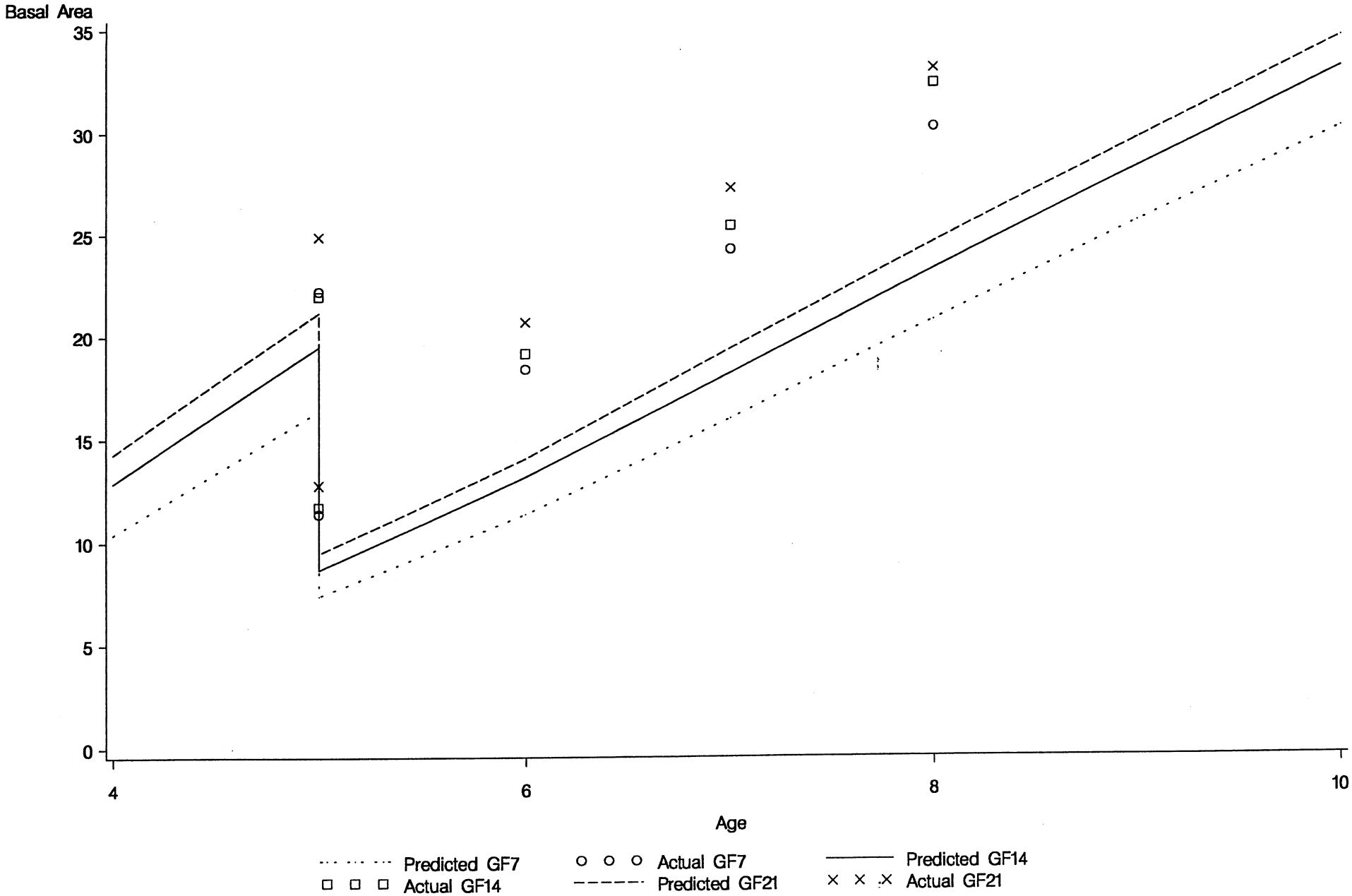


Appendix 2

FR10 – Glengarry

Basal Area

Planted 1500 sph, thinned to 600 sph

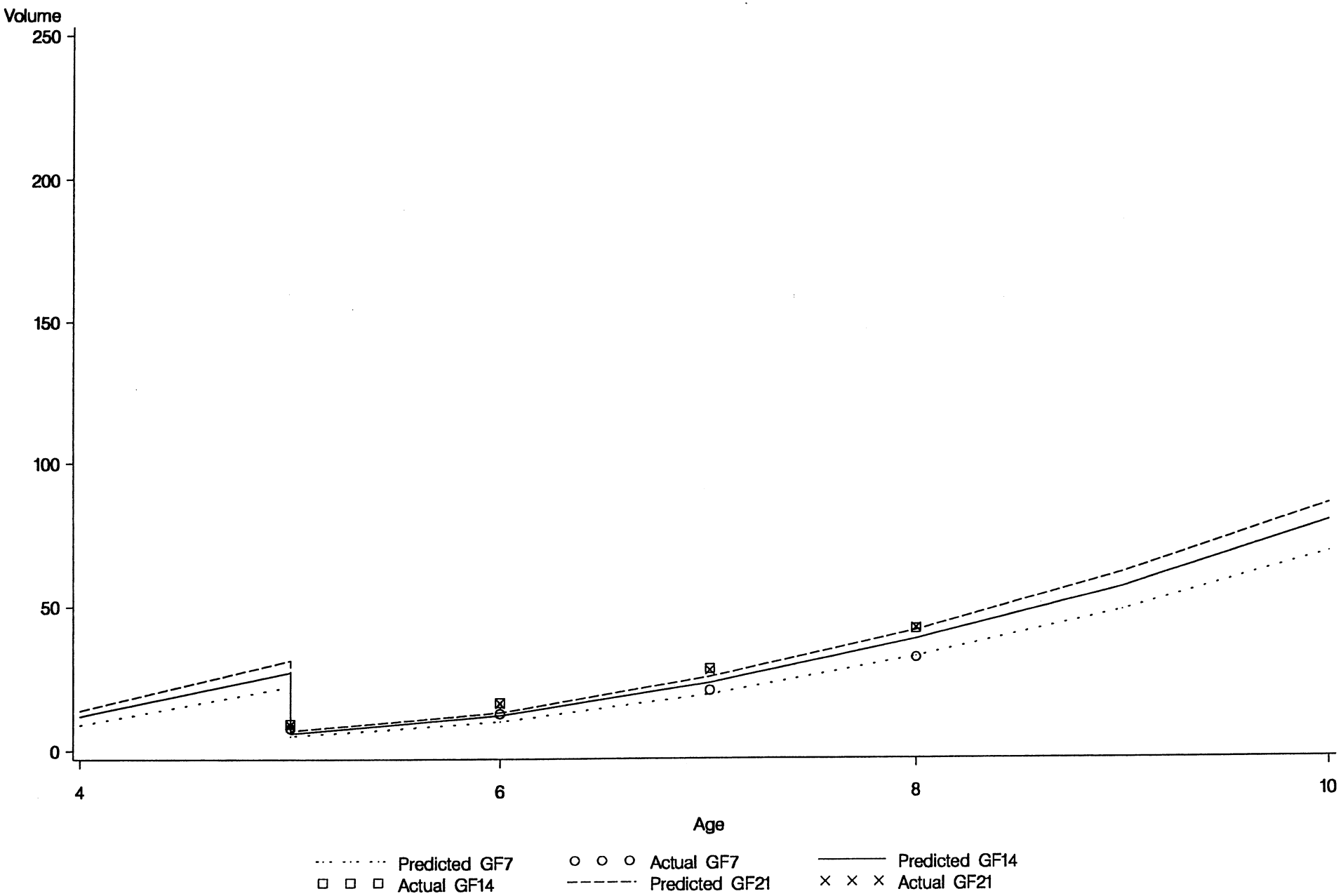


Appendix 2

FR10 – Glengarry

Volume

Planted 500 sph, thinned to 100 sph

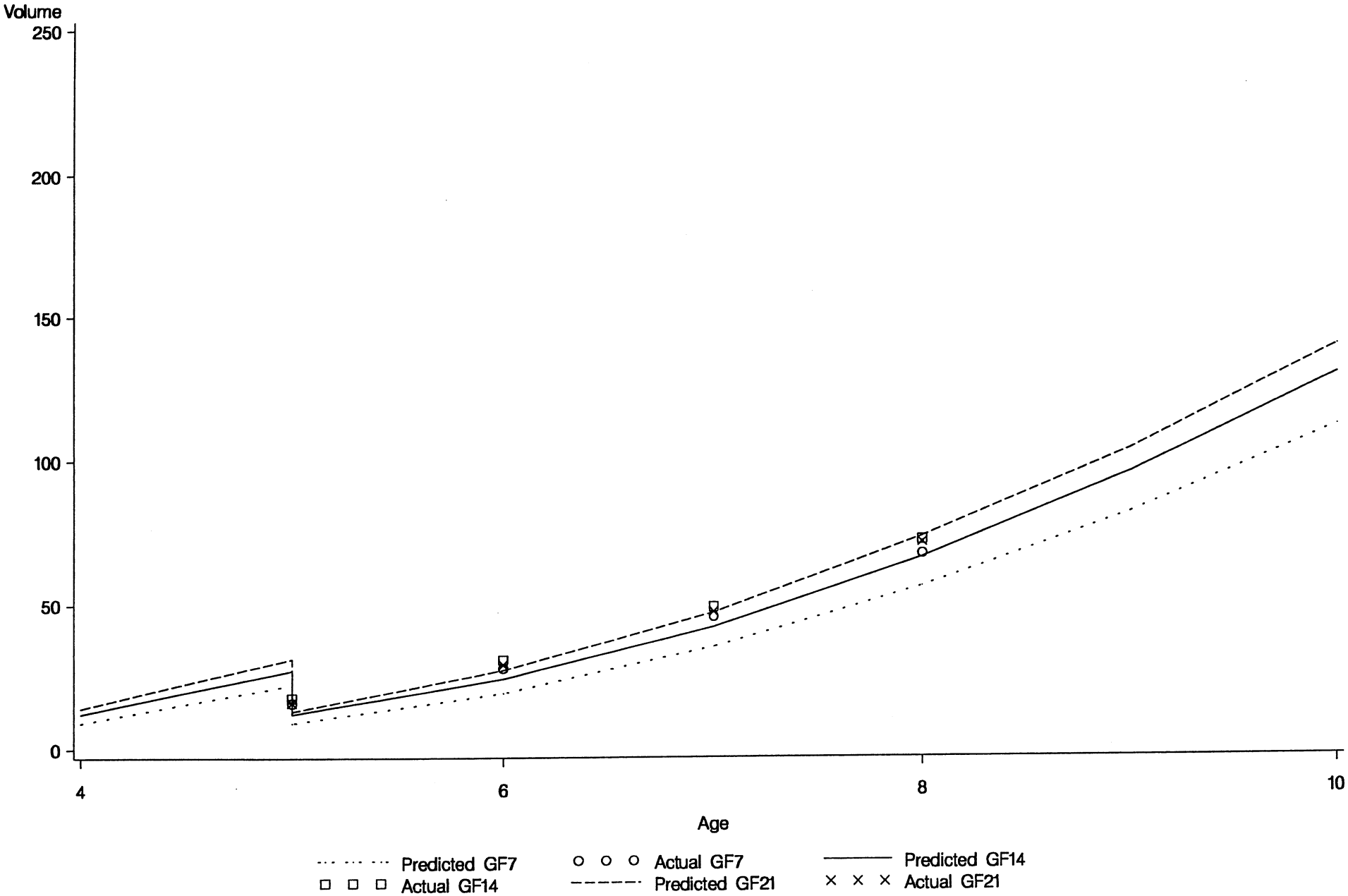


Appendix 2

FR10 – Glengarry

Volume

Planted 500 sph, thinned to 200 sph

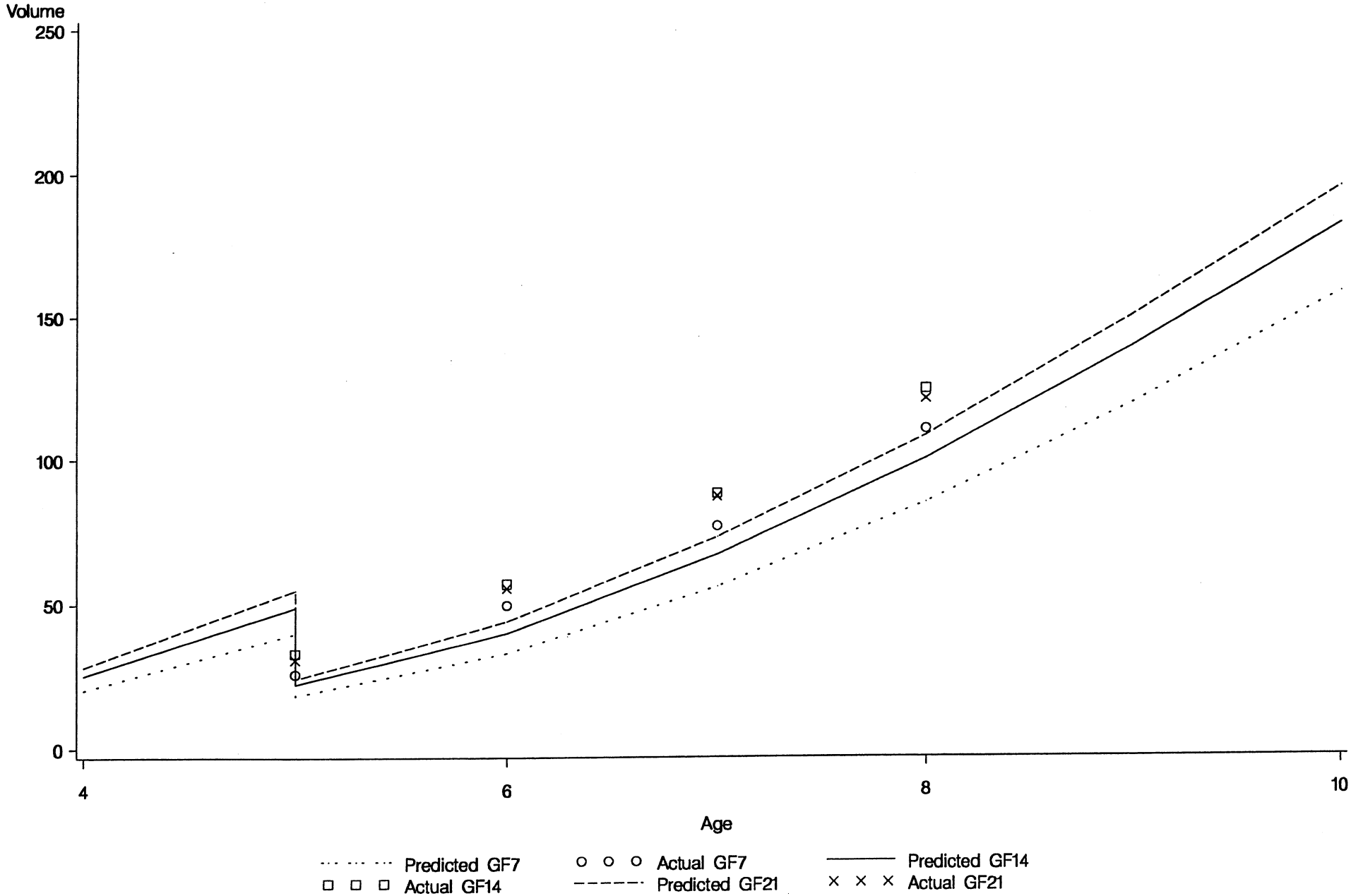


Appendix 2

FR10 – Glengarry

Volume

Planted 1000 sph, thinned to 400 sph

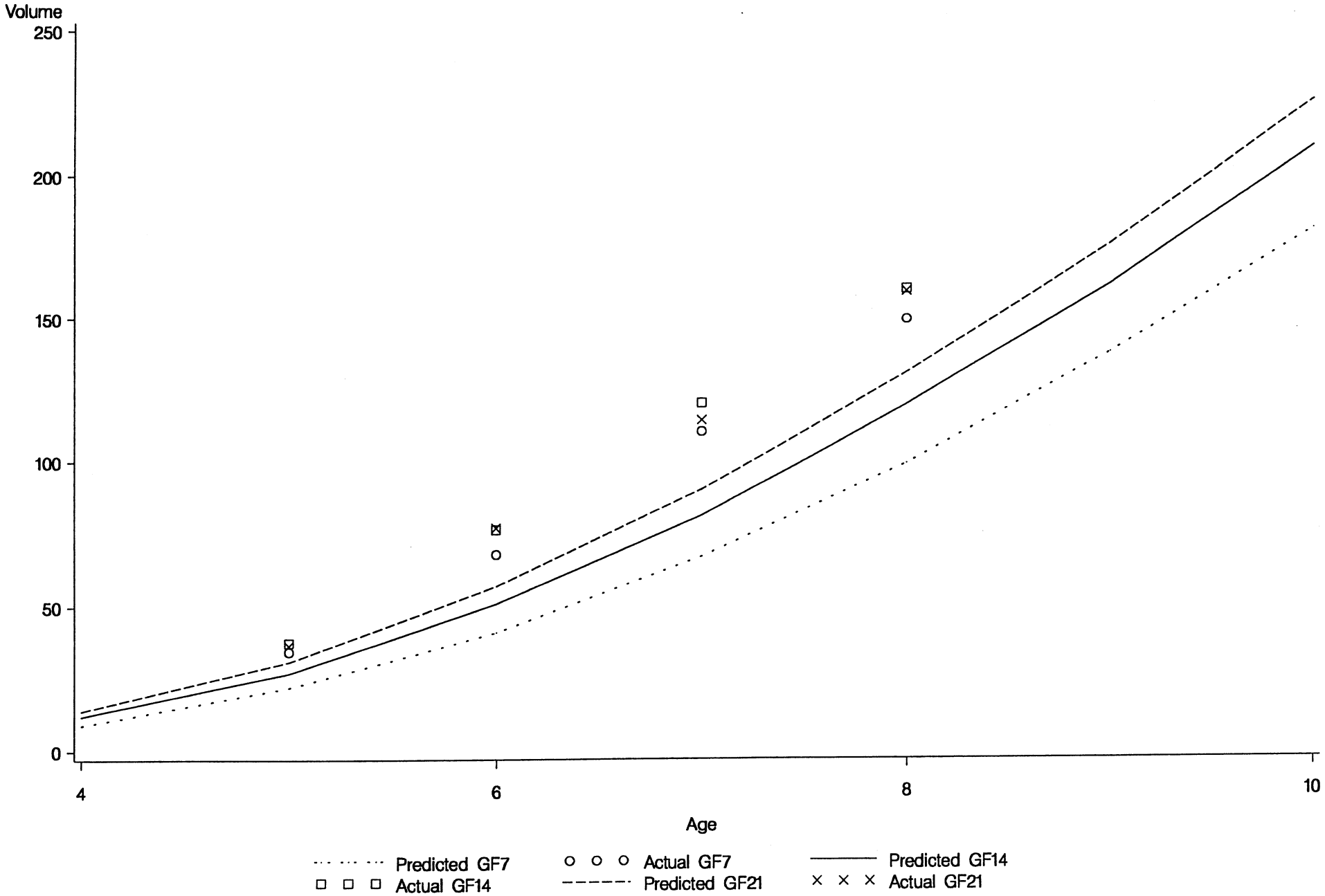


Appendix 2

FR10 – Glengarry

Volume

Planted 500 sph, unthinned

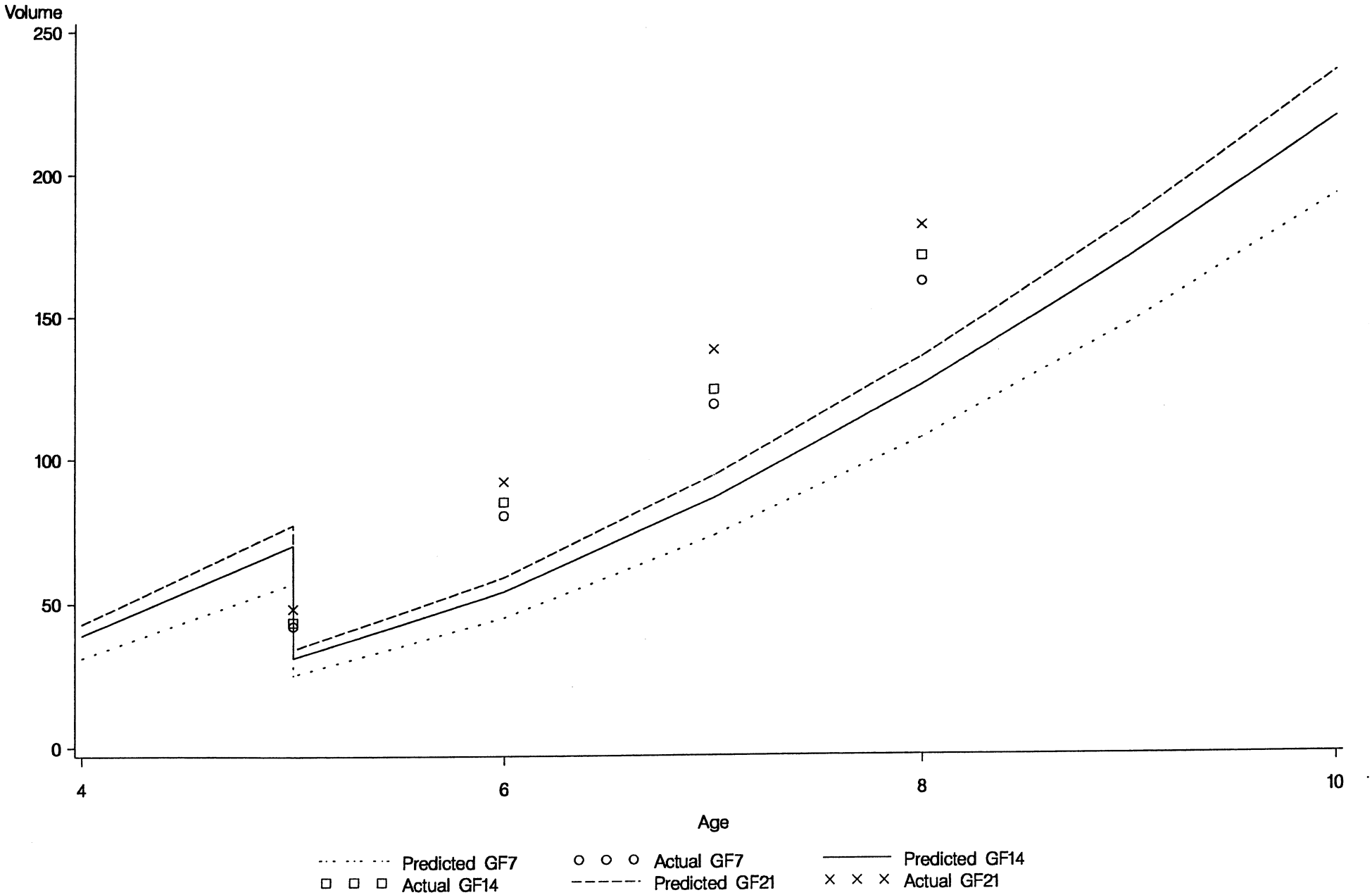


Appendix 2

FR10 – Glengarry

Volume

Planted 1500 sph, thinned to 600 sph



APPENDIX 3

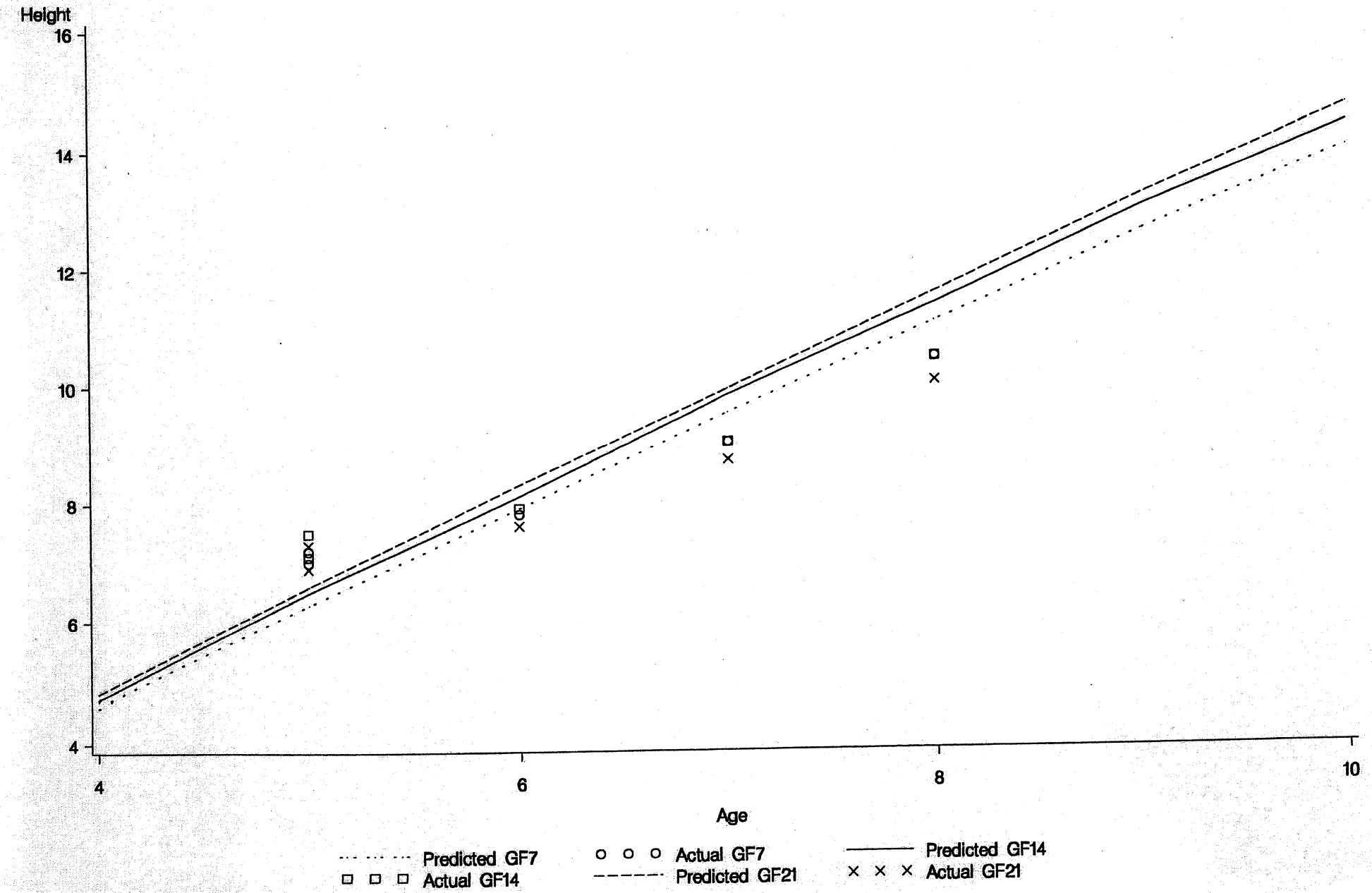
Plots of Predicted and Actual Stand Parameters
at Woodhill Forest (FR7)

Appendix 3

FR7 – WOODHILL

Mean Top Height

Planted 500 sph, thinned to 100 sph

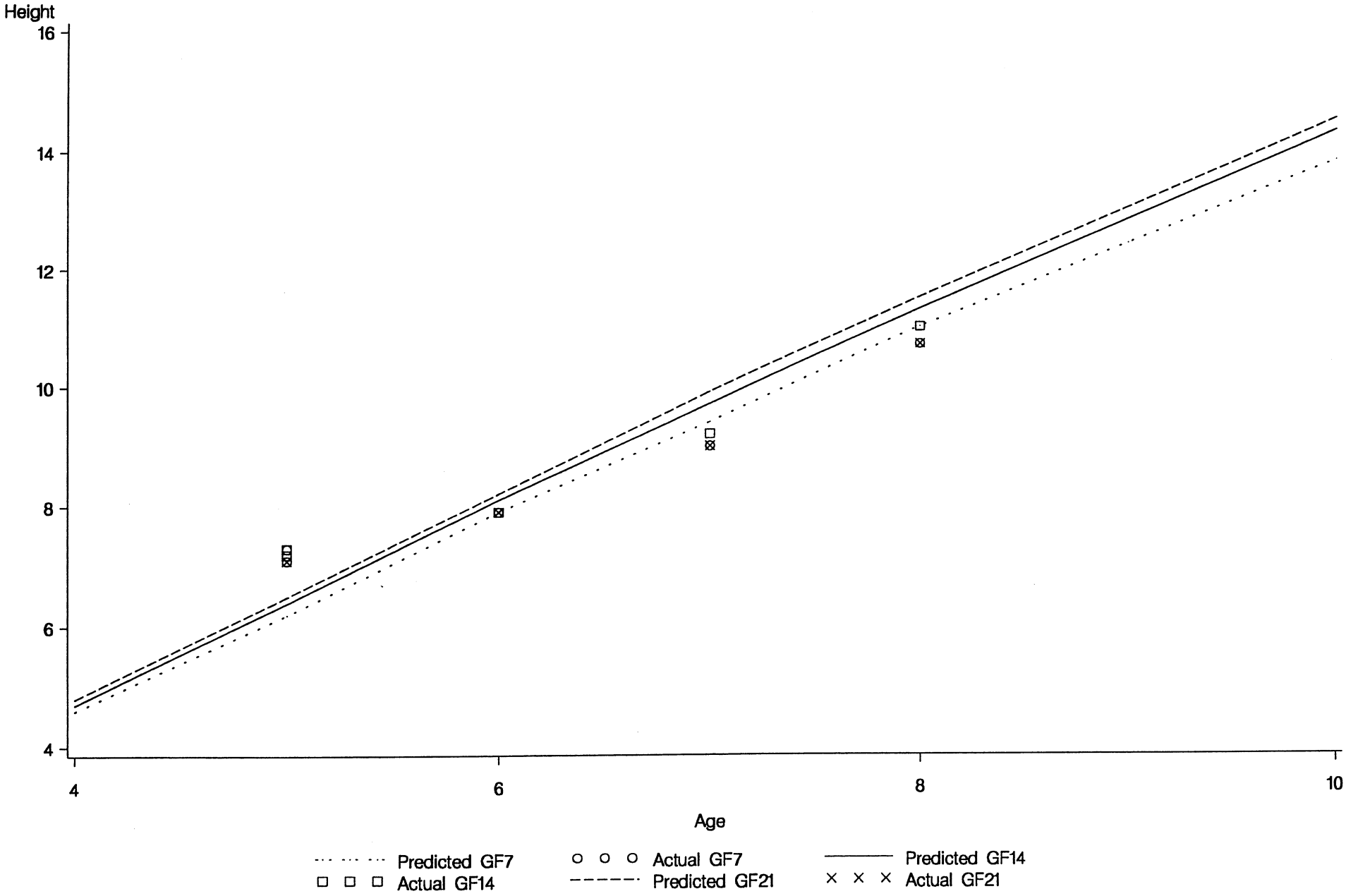


Appendix 3

FR7 – WOODHILL

Mean Top Height

Planted 500 sph, thinned to 200 sph

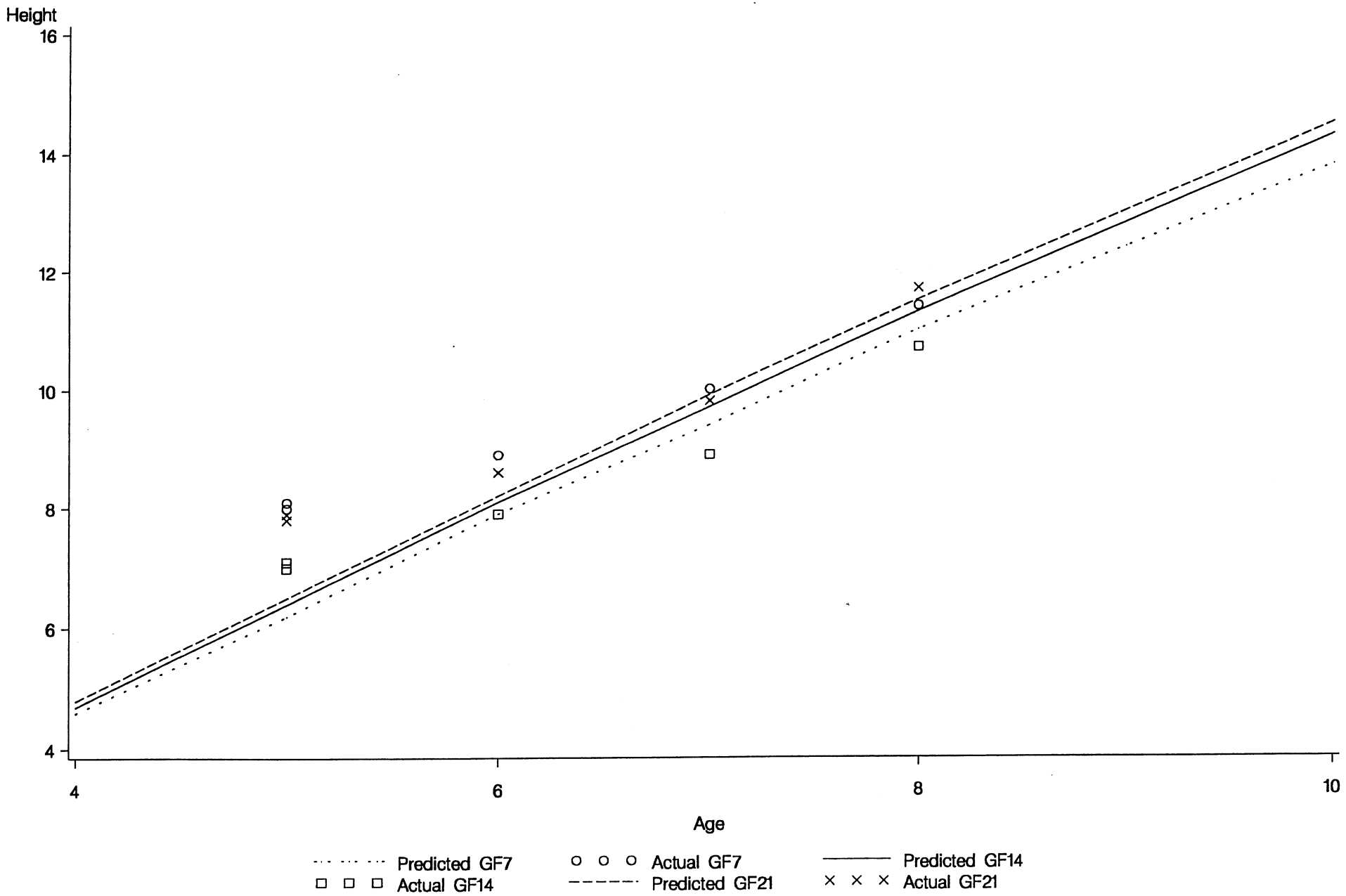


Appendix 3

FR7 – WOODHILL

Mean Top Height

Planted 1000 sph, thinned to 400 sph

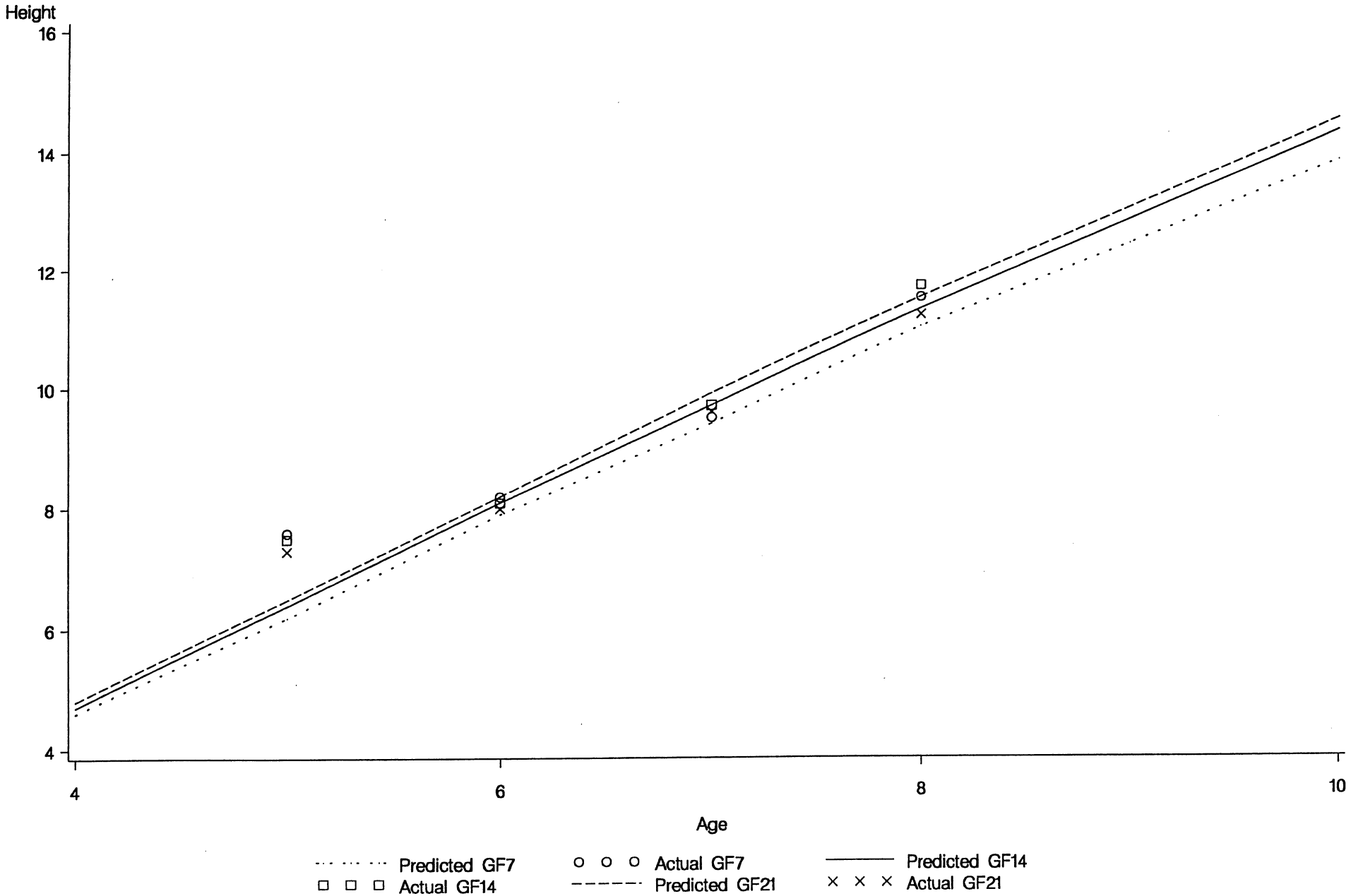


Appendix 3

FR7 – WOODHILL

Mean Top Height

Planted 500 sph, unthinned

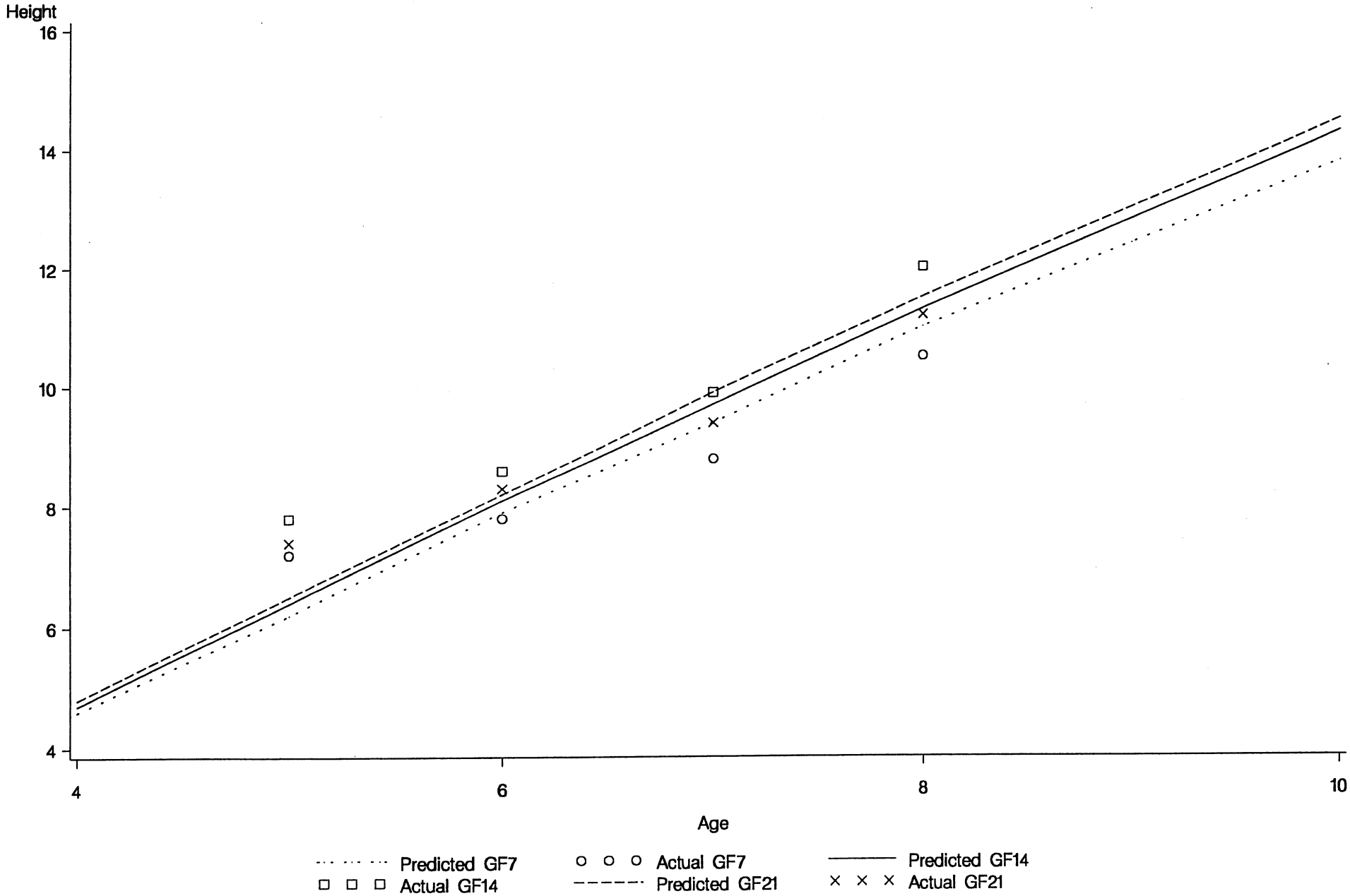


Appendix 3

FR7 – WOODHILL

Mean Top Height

Planted 1500 sph, thinned to 600 sph

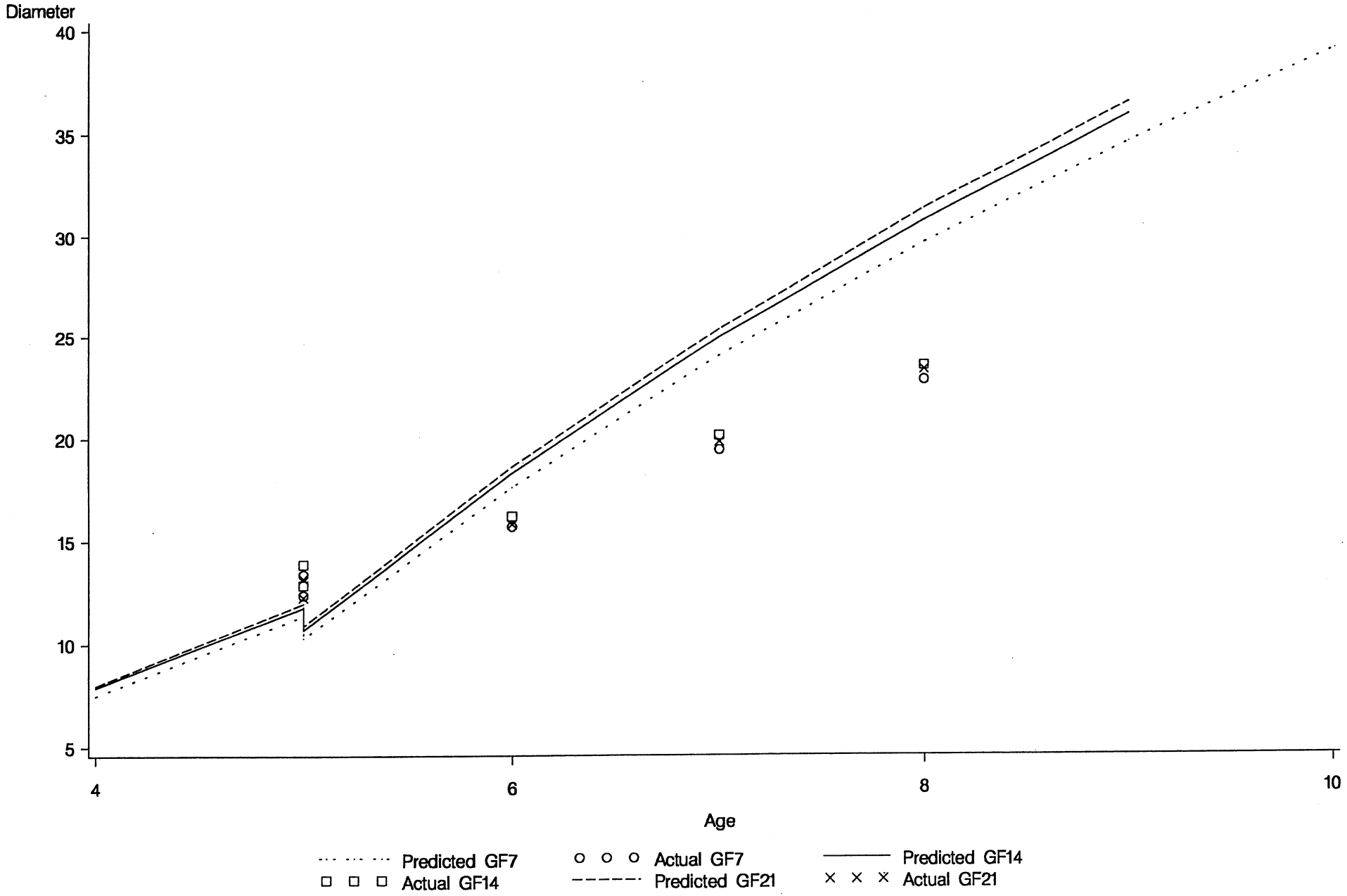


Appendix 3

FR7 – WOODHILL

Mean Diameter

Planted 500 sph, thinned to 100 sph

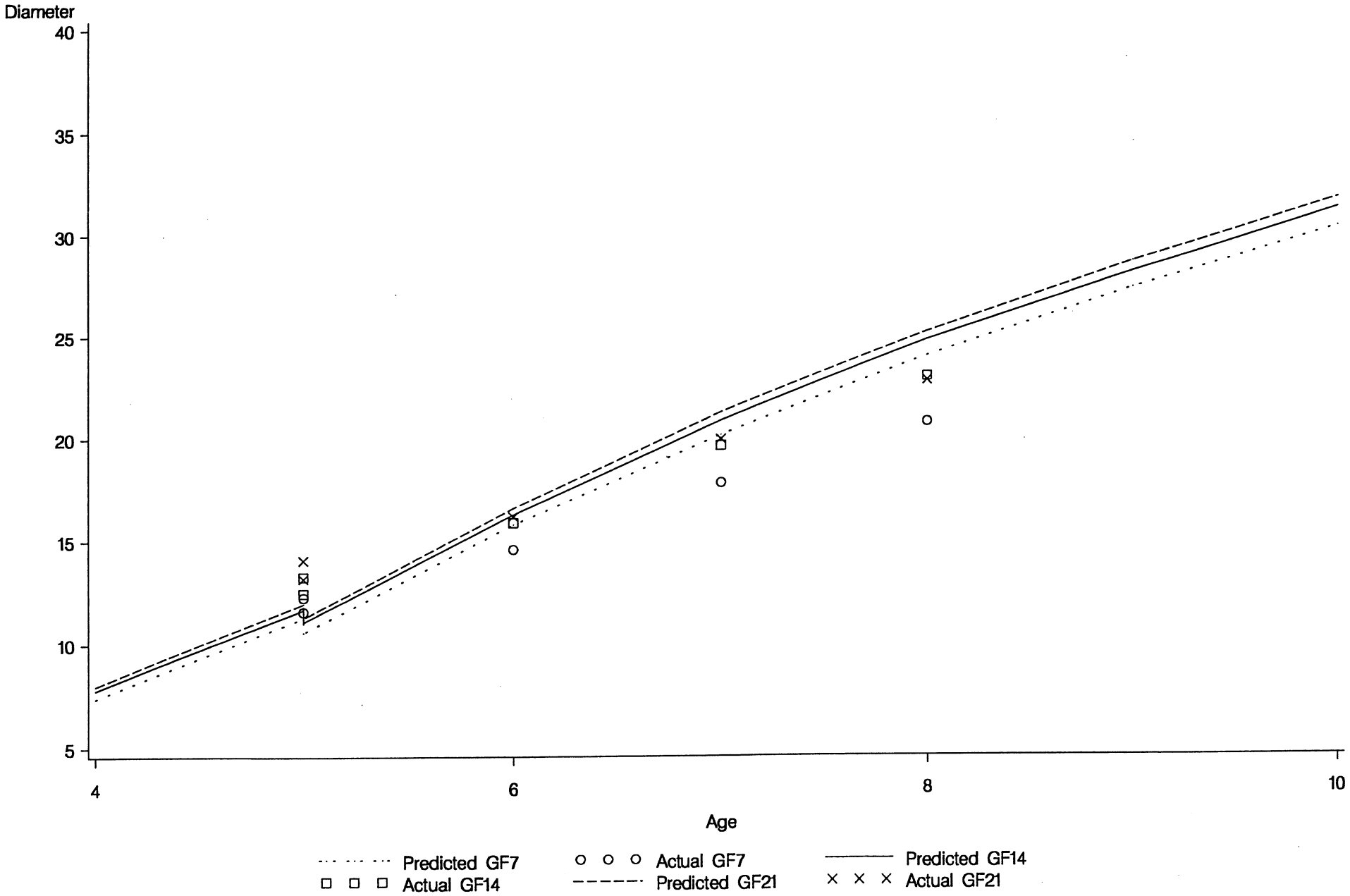


Appendix 3

FR7 – WOODHILL

Mean Diameter

Planted 500 sph, thinned to 200 sph

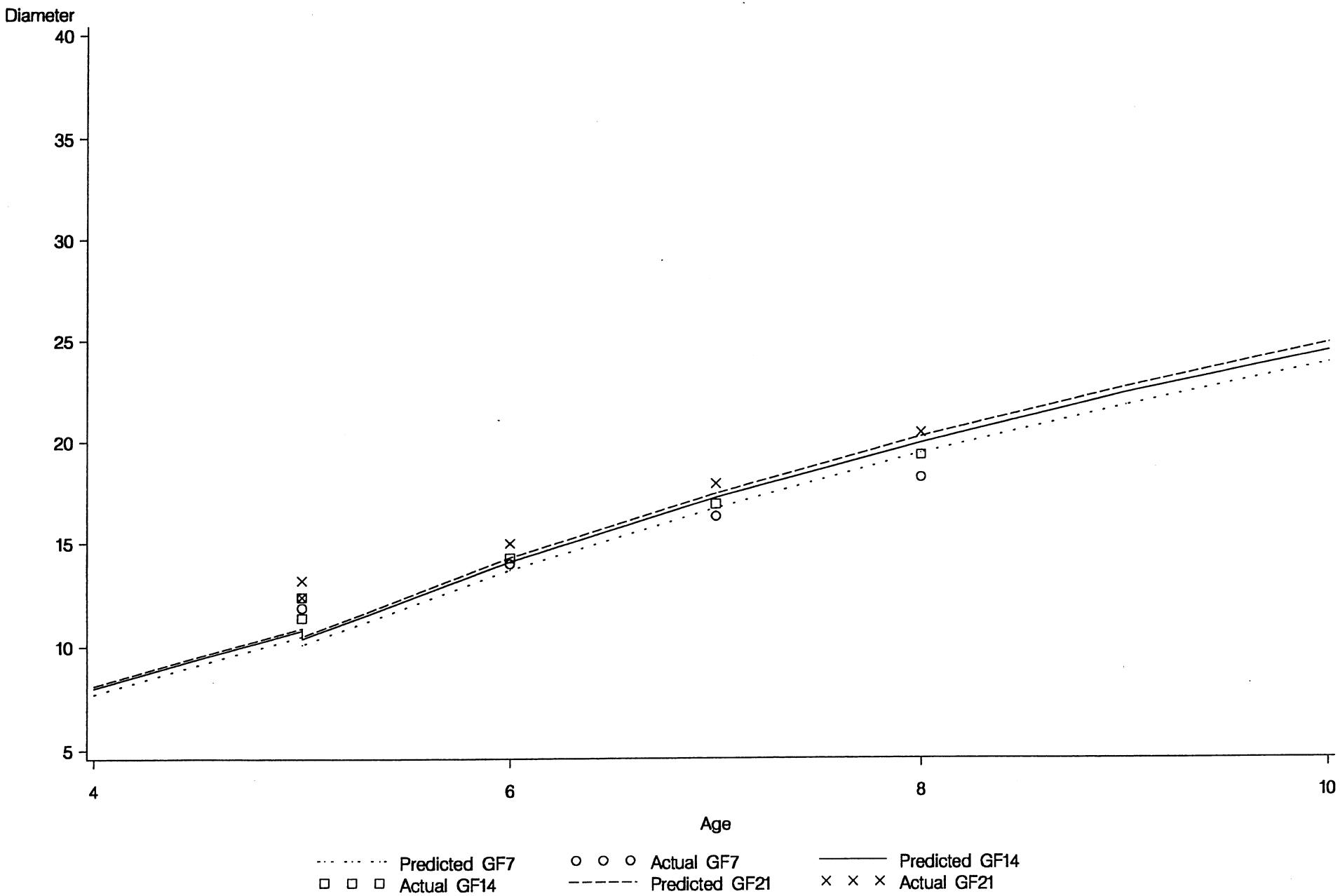


Appendix 3

FR7 – WOODHILL

Mean Diameter

Planted 1000 sph, thinned to 400 sph

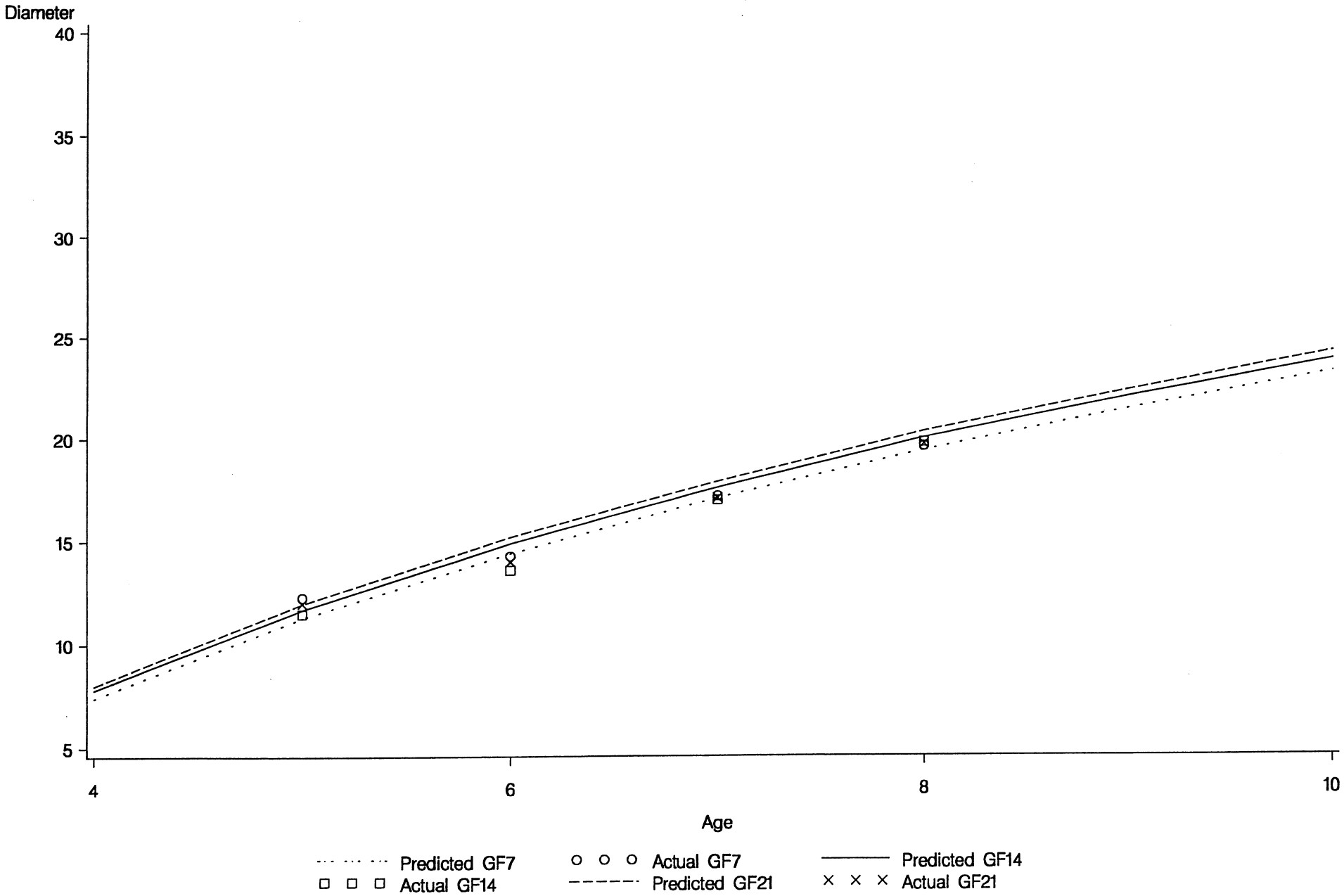


Appendix 3

FR7 – WOODHILL

Mean Diameter

Planted 500 sph, unthinned

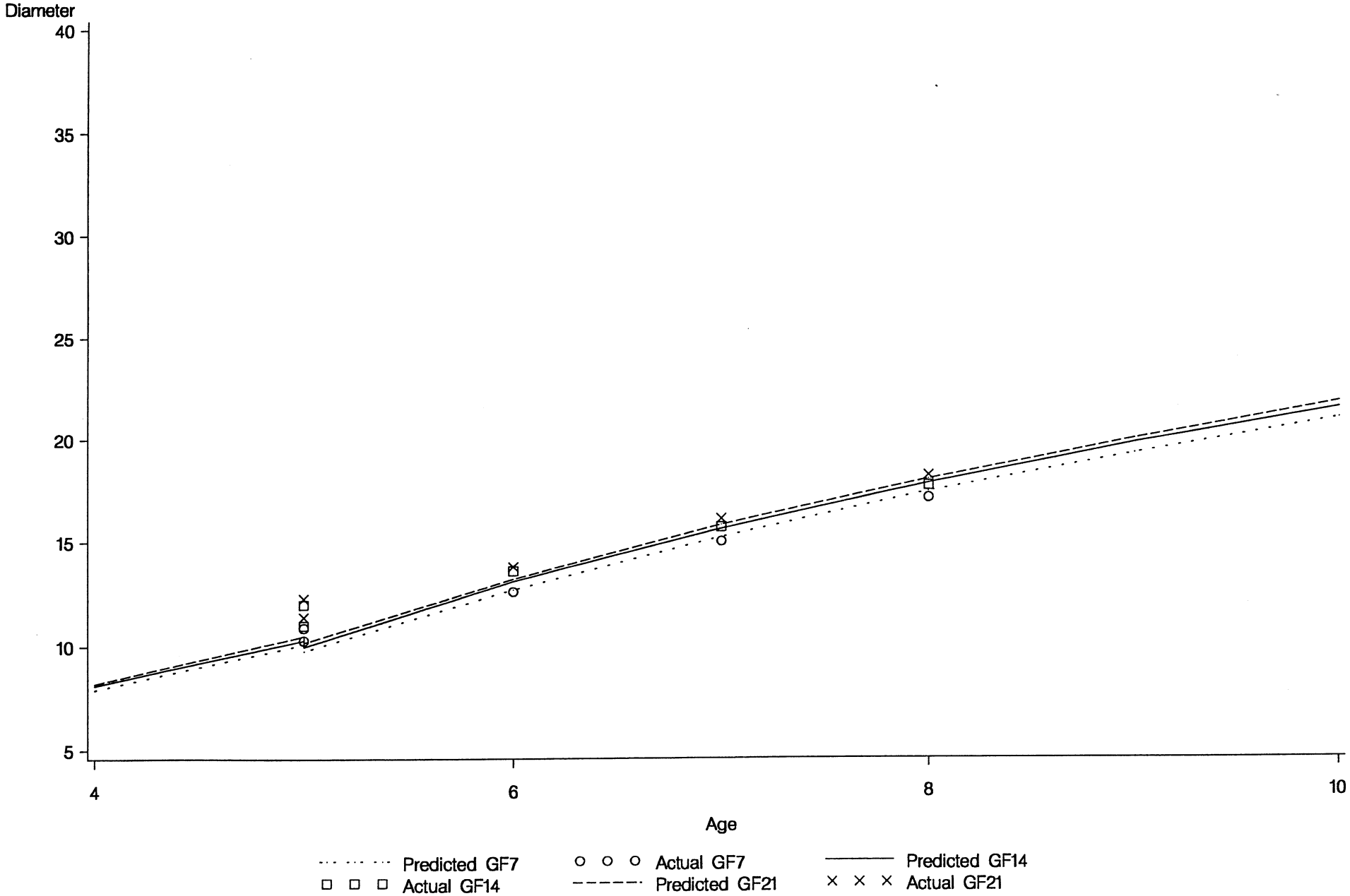


Appendix 3

FR7 – WOODHILL

Mean Diameter

Planted 1500 sph, thinned to 600 sph

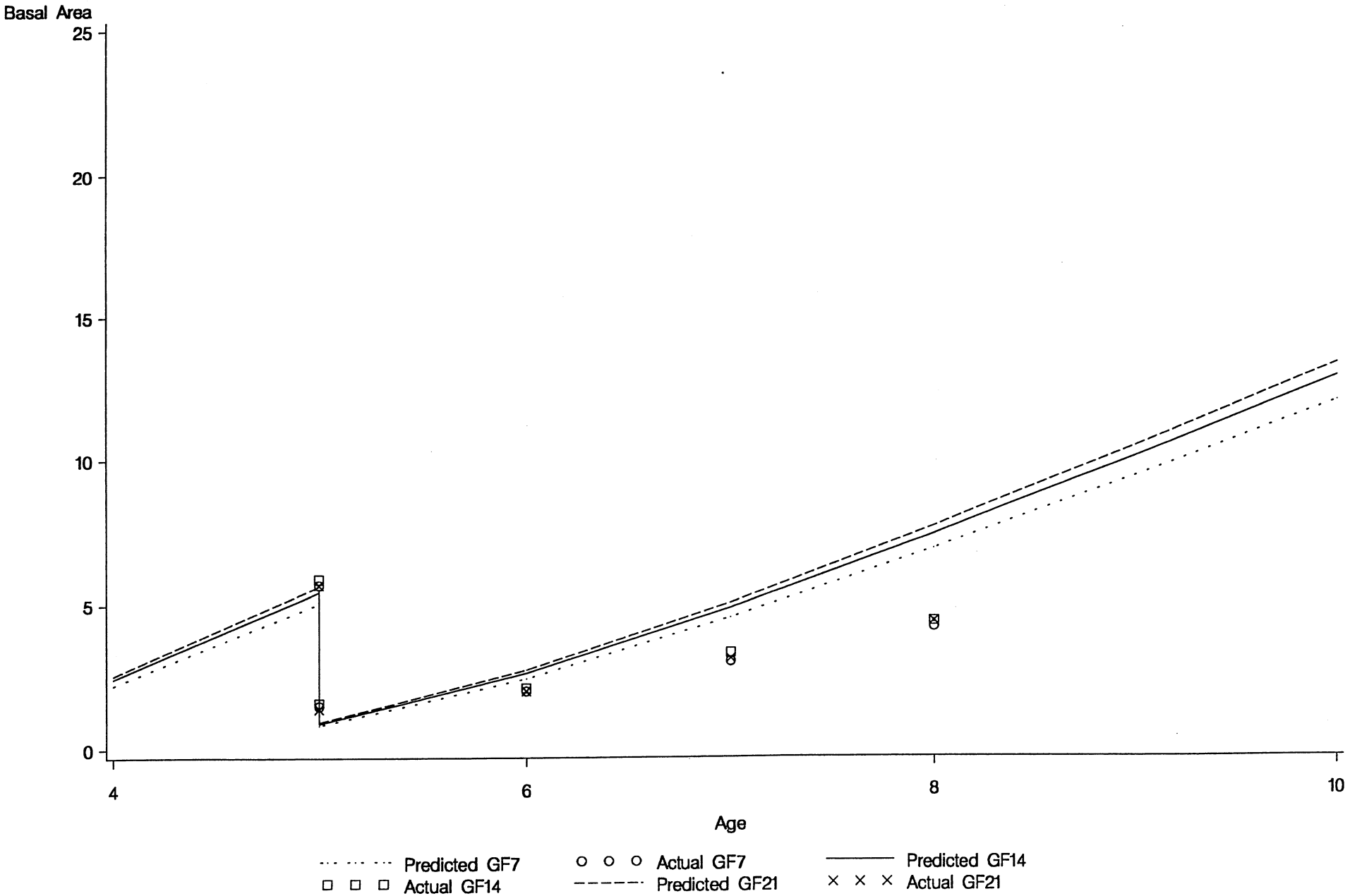


Appendix 3

FR7 – WOODHILL

Basal Area

Planted 500 sph, thinned to 100 sph

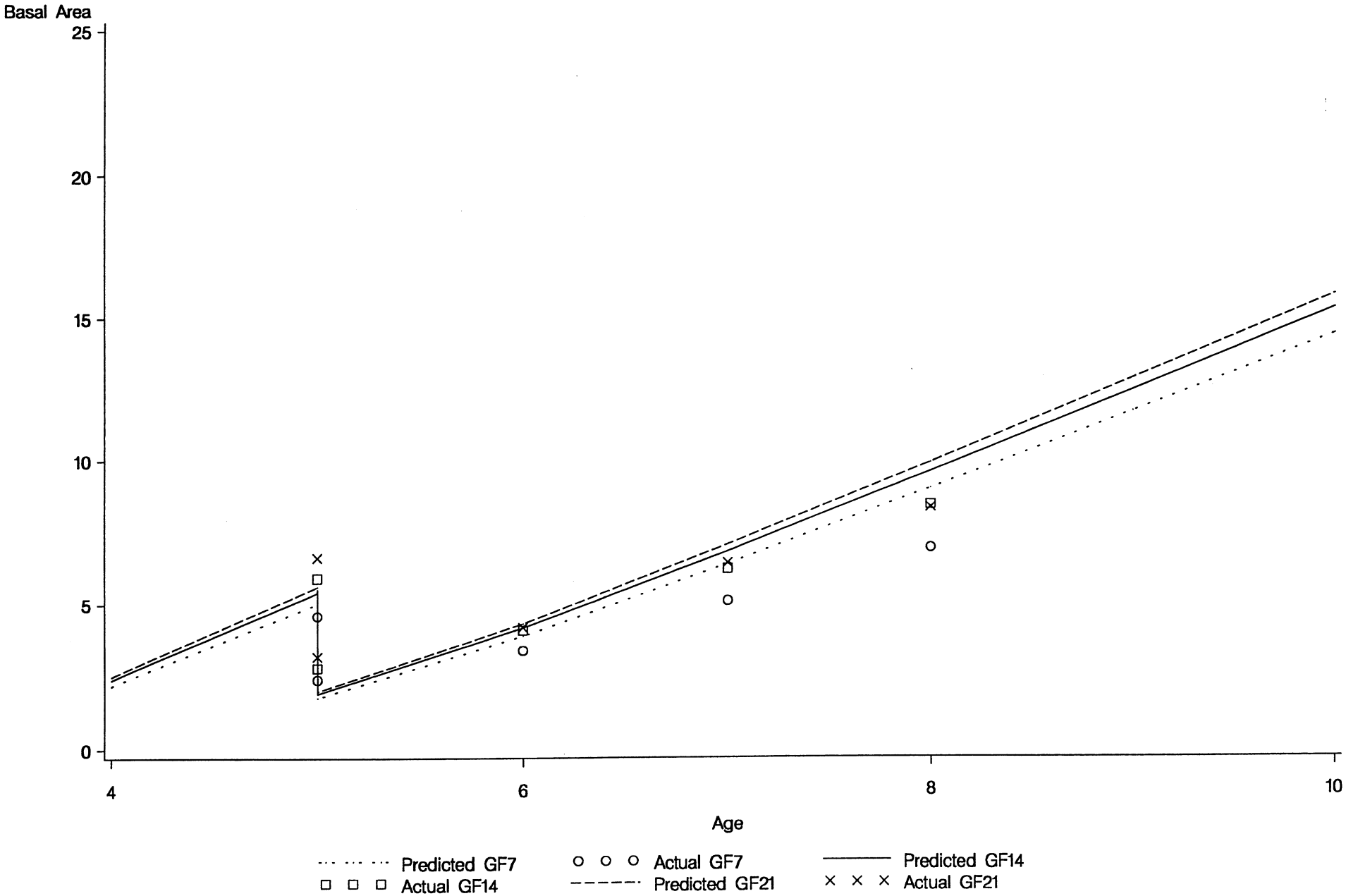


Appendix 3

FR7 – WOODHILL

Basal Area

Planted 500 sph, thinned to 200 sph

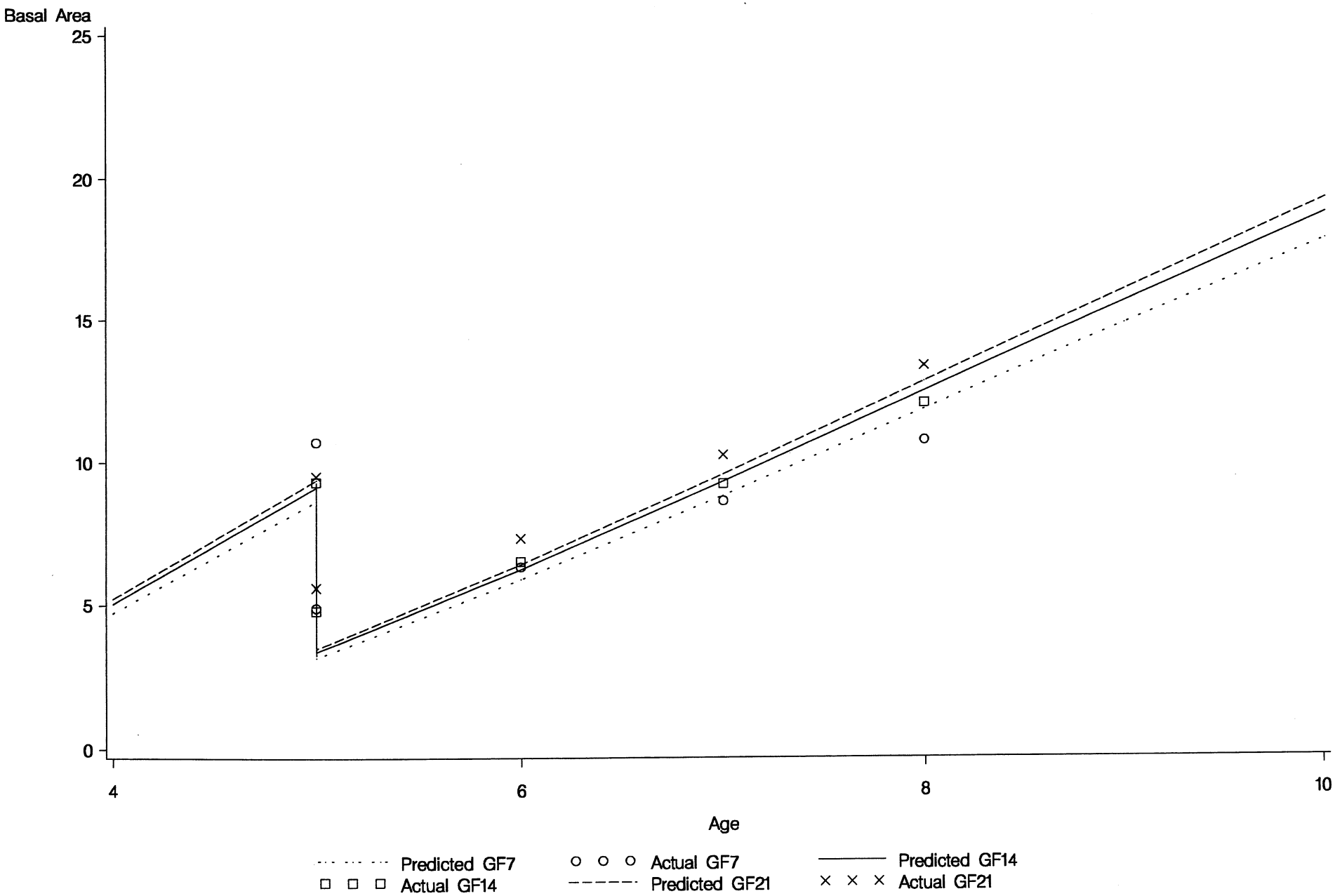


Appendix 3

FR7 – WOODHILL

Basal Area

Planted 1000 sph, thinned to 400 sph

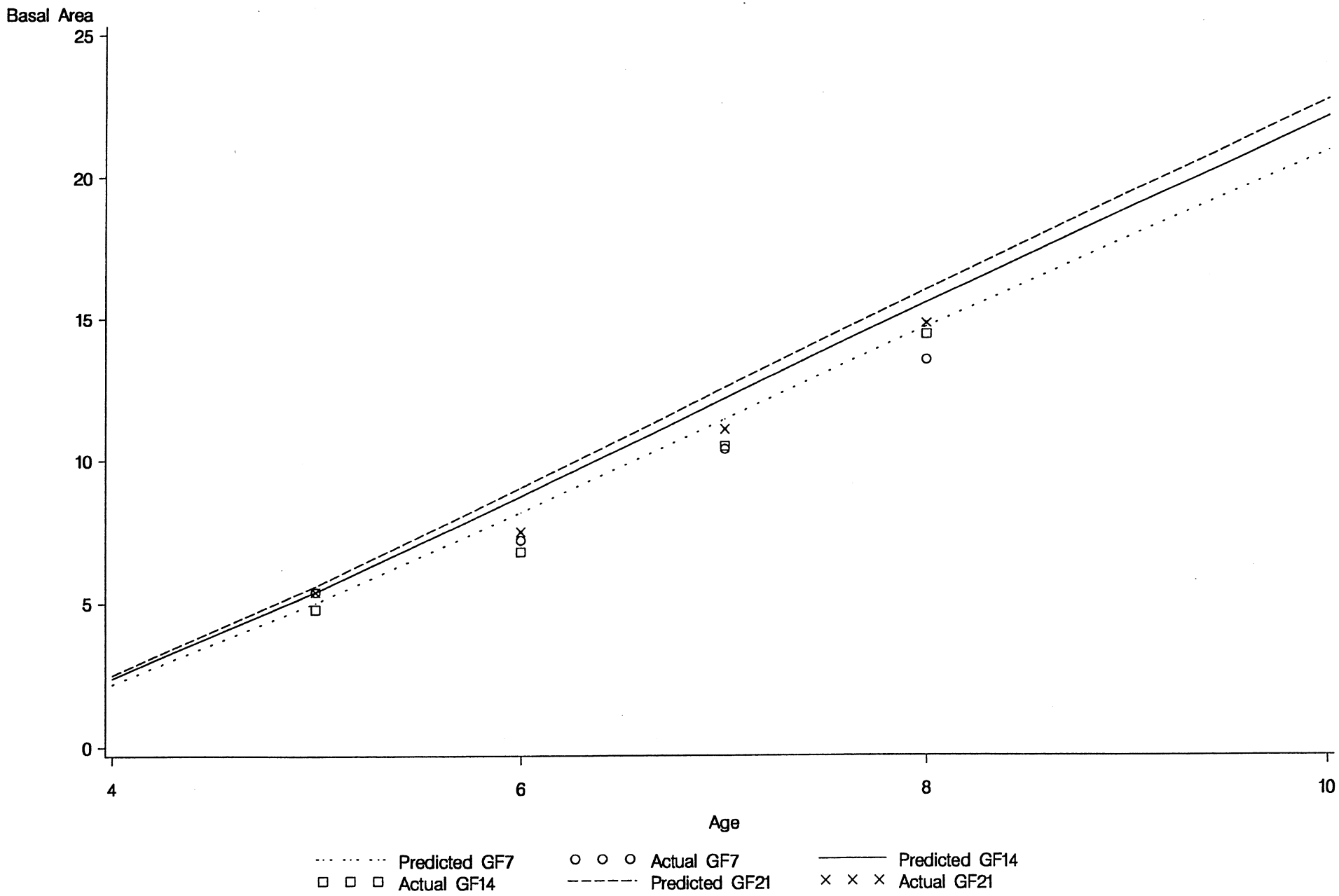


Appendix 3

FR7 – WOODHILL

Basal Area

Planted 500 sph, unthinned

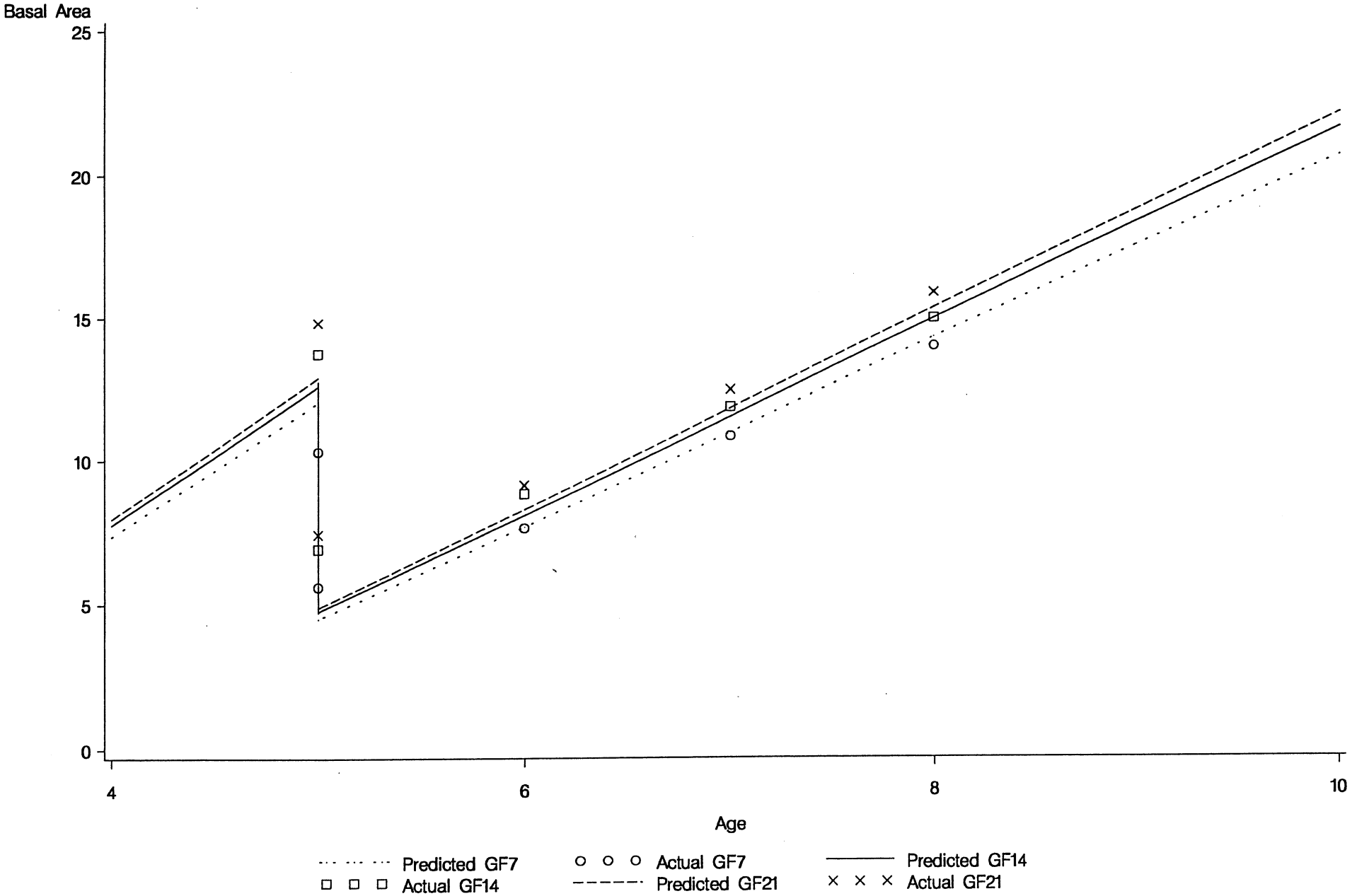


Appendix 3

FR7 – WOODHILL

Basal Area

Planted 1500 sph, thinned to 600 sph

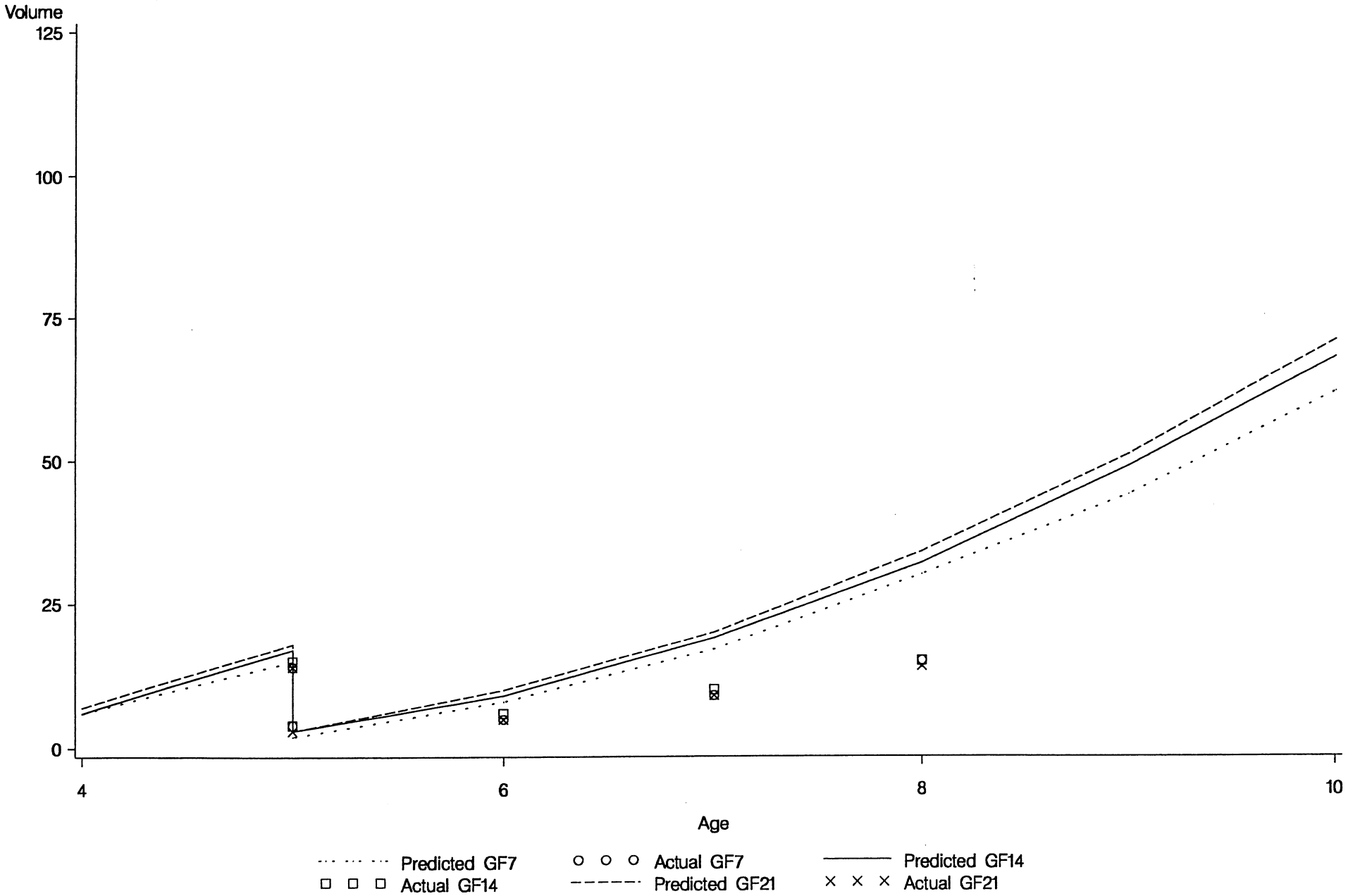


Appendix 3

FR7 – WOODHILL

Volume

Planted 500 sph, thinned to 100 sph

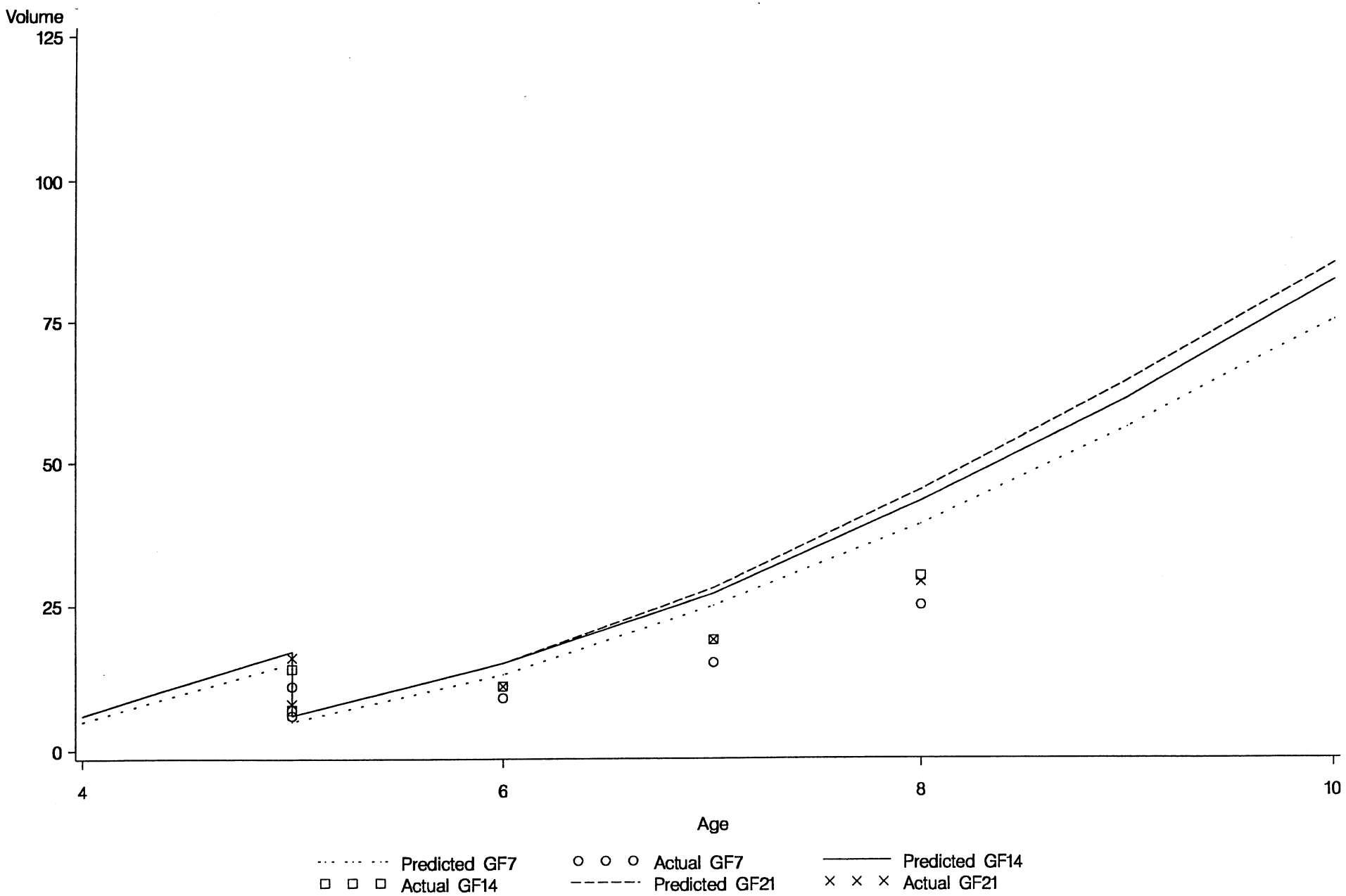


Appendix 3

FR7 – WOODHILL

Volume

Planted 500 sph, thinned to 200 sph

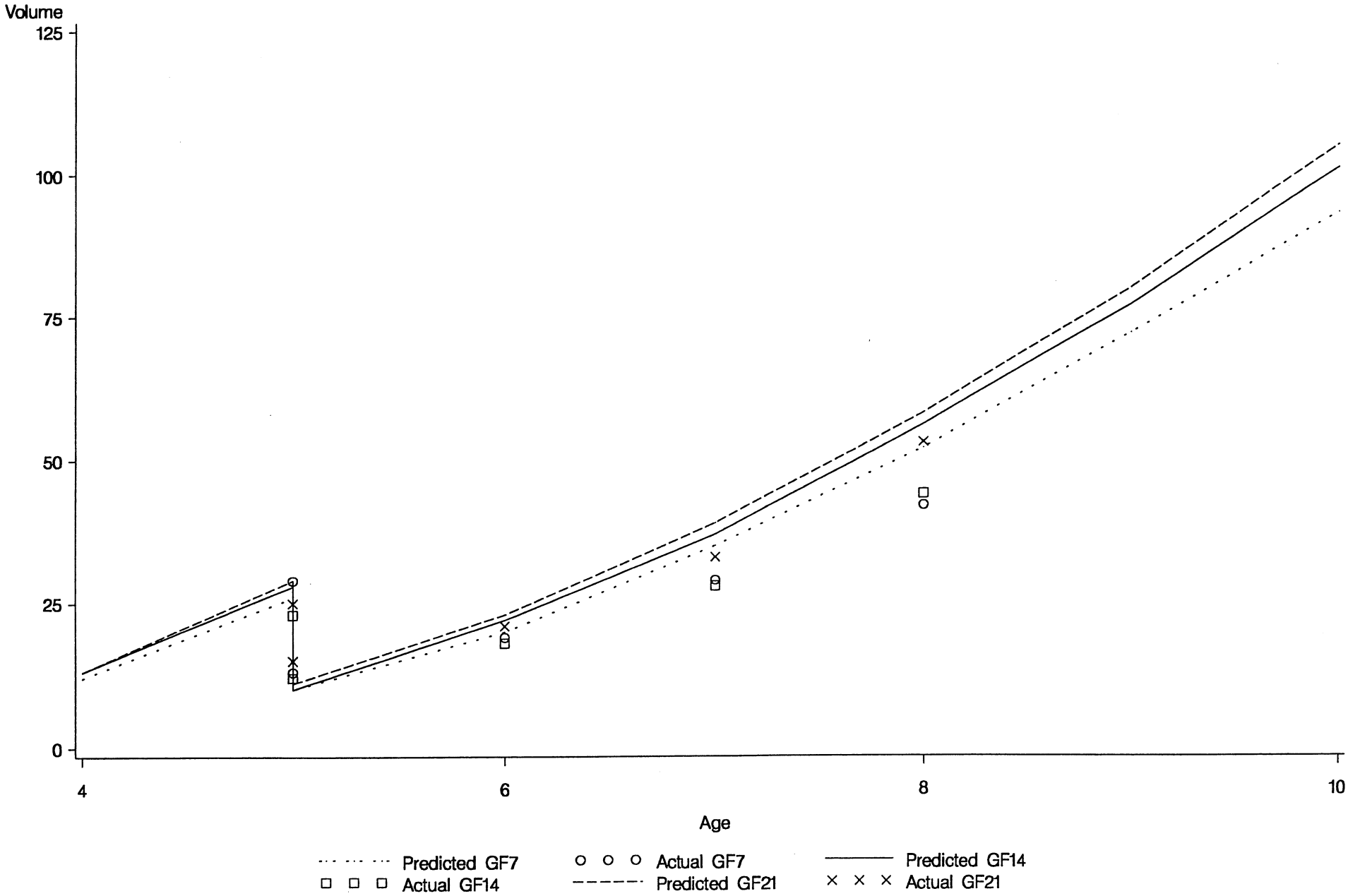


Appendix 3

FR7 – WOODHILL

Volume

Planted 1000 sph, thinned to 400 sph

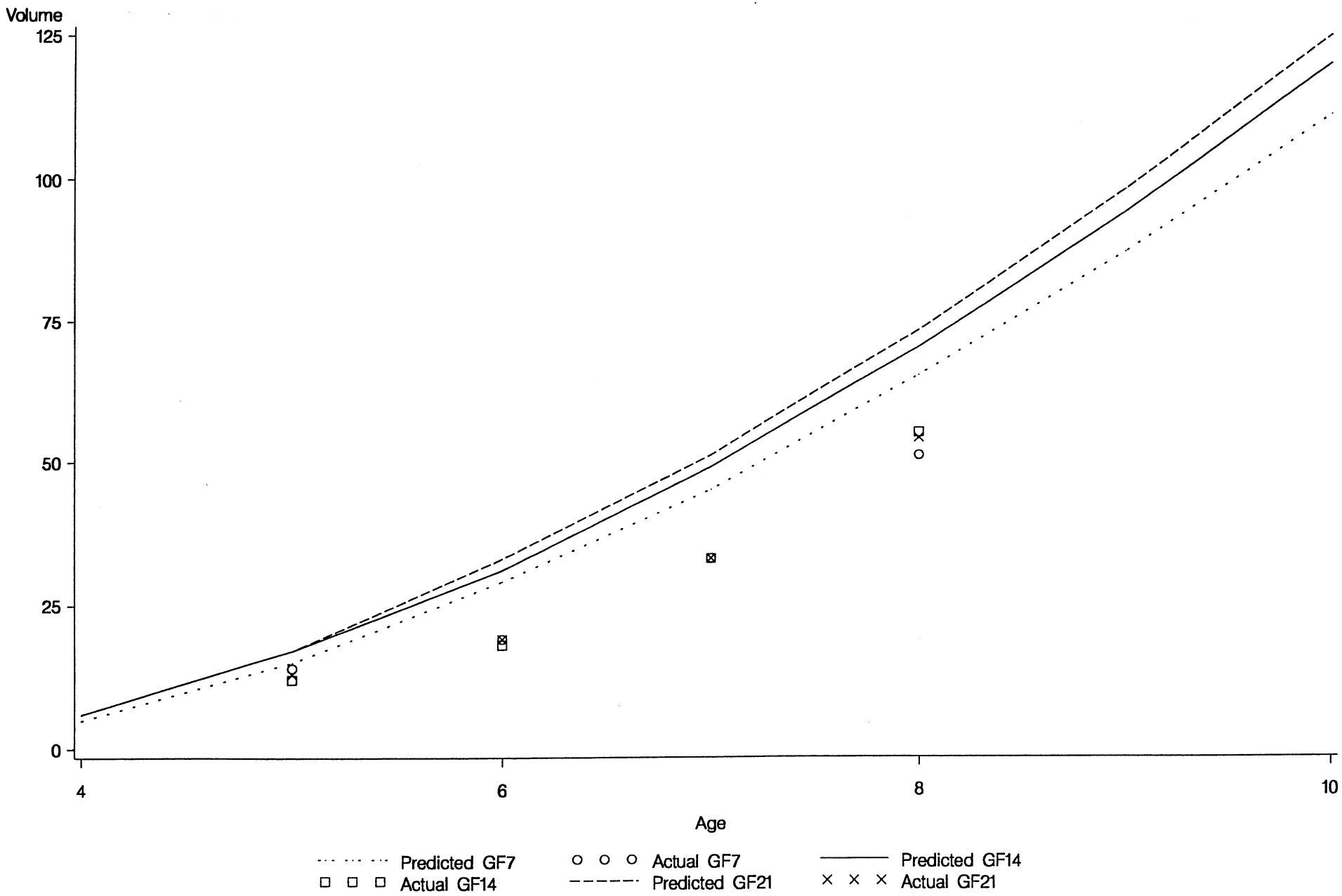


Appendix 3

FR7 – WOODHILL

Volume

Planted 500 sph, unthinned



Appendix 3

FR7 – WOODHILL

Volume

Planted 1500 sph, thinned to 600 sph