Comparison of Tree Growth in 1975 FCS Trials and 1978 GG Trials

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EXECUTIVE SUMMARY

The 1975 Final Crop Stocking Trials and the 1978 Genetic Gain Trials are close to rotation age. The objectives of this study were to assess previously collected growth and quality data for these trials, and then develop a strategy for any future destructive sampling in these trials prior to clearfell. The aim of any future destructive sampling would be to collect data to develop an integrated tree growth and wood property model.

1975 FCS Trials

There were only small differences in height development between different silvicultural treatments but large differences between sites. Both site and silvicultural treatment influenced basal area development, with silvicultural treatment having more influence than site. Basal area per hectare decreased with decreasing stocking.

Branching characteristics are influenced by both site and silvicultural treatment, with bigger branches on the faster growing sites and at the lower stockings.

The percentage trees with defects tended to be lower in the plots thinned at age 11 years compared to the plots thinned at age 14 years.

1978 GG Trials

There were only small differences in height development between different seedlots, but larger differences between sites. Both seedlot and site influenced basal area development, with site having more influence than seedlot.

Branching characteristics were also more strongly affected by site than seedlot, as was the case for basal area growth.

The percentage of trees with defects varied with both site and seedlot. Possibly the GF14 seedlot had the least defects.

Future Strategy

It is proposed that a selection of sites, and treatments within sites be sampled. These have been chosen to cover the range of variation within the trials (see below). The number of trees sampled will depend on the budget available.

- 1975 Final Crop Stocking Trials
  - Treatments: thinned to 200 stems/ha at age 11 years, thinned to 400 stems/ha at age 11 years and the unthinned control)
  - Sites: Golden Downs NN529/1; Woodhill AK1056
- 1978 Genetic Gain Trials
  - Seedlots: GF14 only
  - Sites: Golden Downs NN530/2; Mohaka WN377; Longwood SD564/1

COMPARISON OF TREE GROWTH IN THE 1975 FINAL CROP STOCKING TRIALS AND 1978 GENETIC GAIN TRIALS

J.C. Grace and J.D. Hayes

INTRODUCTION

Two trial series, managed by the Stand Growth Modelling Cooperative, are close to rotation age. The trial series are:

- 1975 Final Crop Stocking (FCS) trials where 7 silviculture regimes were imposed on an area planted with an '850' seedlot.
- 1978 Genetic Gain (GG) trials where plots planted with 4 different seedlots (GF2, GF7, GF14 and GF22) were managed under a sawlog regime.

The objectives of the current study are to:

- To quantify effect of site and silviculture on tree development using previously collected data from the 1975 FCS trials.
- To quantify effect of site and seedlot on tree development using previously collected data from the 1978 GG trials.
- To utilise the above results to develop a workplan for how these trials should be handled at rotation age, i.e. what further data, in particular wood property data, should be collected.

Features of tree development discussed are:

- Height (MTH) growth
- Basal area (BA) growth
- Stem form
- Branching
- Wood density

Several of the analyses were carried out using the SAS® procedure PROC GLM. This procedure uses the method of least squares to fit mathematical equations to observed data. Both continuous variables (such as mean top height and basal area) and class variables (such as site and treatment) may be included in the equation as independent variables. An illustrative example equation is:

$$y = c + a_1 x_1 + a_2 x_2 + \sum_i b_{1i} z_{1i} + \sum_j b_{2j} z_{2j}$$

Where:

y	is the dependent variable to be predicted
c	is the model intercept
x_1, x_2	are continuous variables
a_1, a_2	are the model parameters associated with the continuous variables (actual predicted values are the model coefficients)
z_1, z_2	are class variables. These have the value 1 if the data corresponds to that class, otherwise the value is zero
b_{1i}, b_{2j}	are the model parameters associated with the class variables (actual predicted values are model coefficients)

1975 FINAL CROP STOCKING TRIALS - HISTORY

The final crop stocking trials were planted in 1975 as a ‘850’ polycross trial with an initial stocking of 625 stems/ha. Permanent sample plots (PSPs) for this trial were established in 1986. There were seven treatments (Table 1):

Table 1. Silvicultural treatments applied in the 1975 FCS trials.

Treatment No.	Initial Stocking (stems/ha)	Final Stocking (stems/ha)	Age at thinning (years)
1	625	100	11
2	625	200	11
3	625	400	11
4	625	625	Unthinned
5	625	100	14
6	625	200	14
7	625	400	14

The trials were established on 4 sites:

- Woodhill Forest, AK 1056, Auckland Sands growth region (AK)
- Kaingaroa Forest, RO 2098, Central North Island growth region (RO)
- Golden Downs Forest, NN 529/1, Nelson growth region (NN)
- Eyrewell Forest, CY 597, Canterbury growth region (CY)

1975 FINAL CROP STOCKING TRIALS – HEIGHT AND BASAL AREA DEVELOPMENT

Methods

There are a total of 95 PSP plots that have been measured regularly from 1986 onwards. These plots have up to 14 remeasurements (a total of 1245 plot measurements) aged from 11 to 27 years. The latest measurement was in 2002. The following data was extracted from the Forest Research PSP database system: Plot Id; forest; measurement date; age at measurement; stems/ha; mean top height (MTH), basal area (BA) and volume.

A site id and treatment number were added to the data file.

The trends in both MTH and basal area with age were plotted two ways:

- By site and labelled by treatment
- By treatment and labelled by site

The SAS procedure PROC GLM was used to determine the influence of site and silvicultural treatment on the 2002 measurements (age 27 years) of MTH and BA. Independent variables considered were site, treatment and the interaction of site and treatment.

Results

For both MTH and BA the interaction with site and treatment was not significant, so the model was re-run without the interaction term (the coefficients from this run are in Table 2). The model explained 93% of the MTH variation and 81% of the BA variation.

MTH varied slightly with treatment (Figure 1). MTH was generally, but not necessarily lower in plots thinned to 100 stems/ha (treatments 1 and 5). PROC GLM analysis, using data collected in 2002 (Table 2), indicated that MTH varied by up to 1.5 m due to treatment. There were obvious differences in MTH with site (Figure 2). MTH was lowest for the Canterbury (CY) site, and was highest for the Rotorua (RO) site. PROC GLM analysis, using data collected in 2002 (Table 2), indicated that MTH varied by up to 12 m due to site.

There was greater variation in BA with treatment (Figure 3). BA was lowest in plots thinned to 100 stems/ha (treatments 1 and 5). BA was generally highest in the unthinned plots (treatment 4). PROC GLM analysis, using data collected in 2002 (Table 2), indicated that BA varied by up to 31 m^2 due to treatment. BA was lowest for the Canterbury (CY) site, and tended to be highest on the Rotorua (RO) site. There was some tree mortality at the Rotorua (RO) site after age 20 years. This resulted in a decrease in basal area (see Figures 3 and 4). PROC GLM analysis, using data collected in 2002 (Table 2), indicated that BA varied by up to 16 m^2 due to site variation. The model predicted that basal area would be slightly higher for the Nelson (NN) compared to the Rotorua (RO) site.

The other point worth noting is MTH and BA increase more rapidly with increasing age at the Golden Downs (NN) site compared to the Woodhill (AK) site.

Table 2. 1975 FCS Trials – Model coefficients from PROC GLM analysis of 2002 MTH and BA measurements where independent variables were site and treatment

Parameter	Value	MTH Coefficient (m)	BA Coefficient (m^2/ha)
Intercept		39.9	51.7
SITE	AK	-8.5	-11.0
SITE	CY	-12.0	-15.8
SITE	NN	-2.2	0.4
SITE	RO	0.0	0.00
TREATMENT	1	-1.5	-21.8
TREATMENT	2	-0.5	-9.4
TREATMENT	3	-0.7	4.2
TREATMENT	4	-0.4	7.4
TREATMENT	5	-1.3	-23.6
TREATMENT	6	-0.5	-10.4
TREATMENT	7	0.00	0.00
Model R^2		0.93	0.81

Figure 1. 1975 FCS Trials - Trends in mean top height with age for each site, labelled by treatment

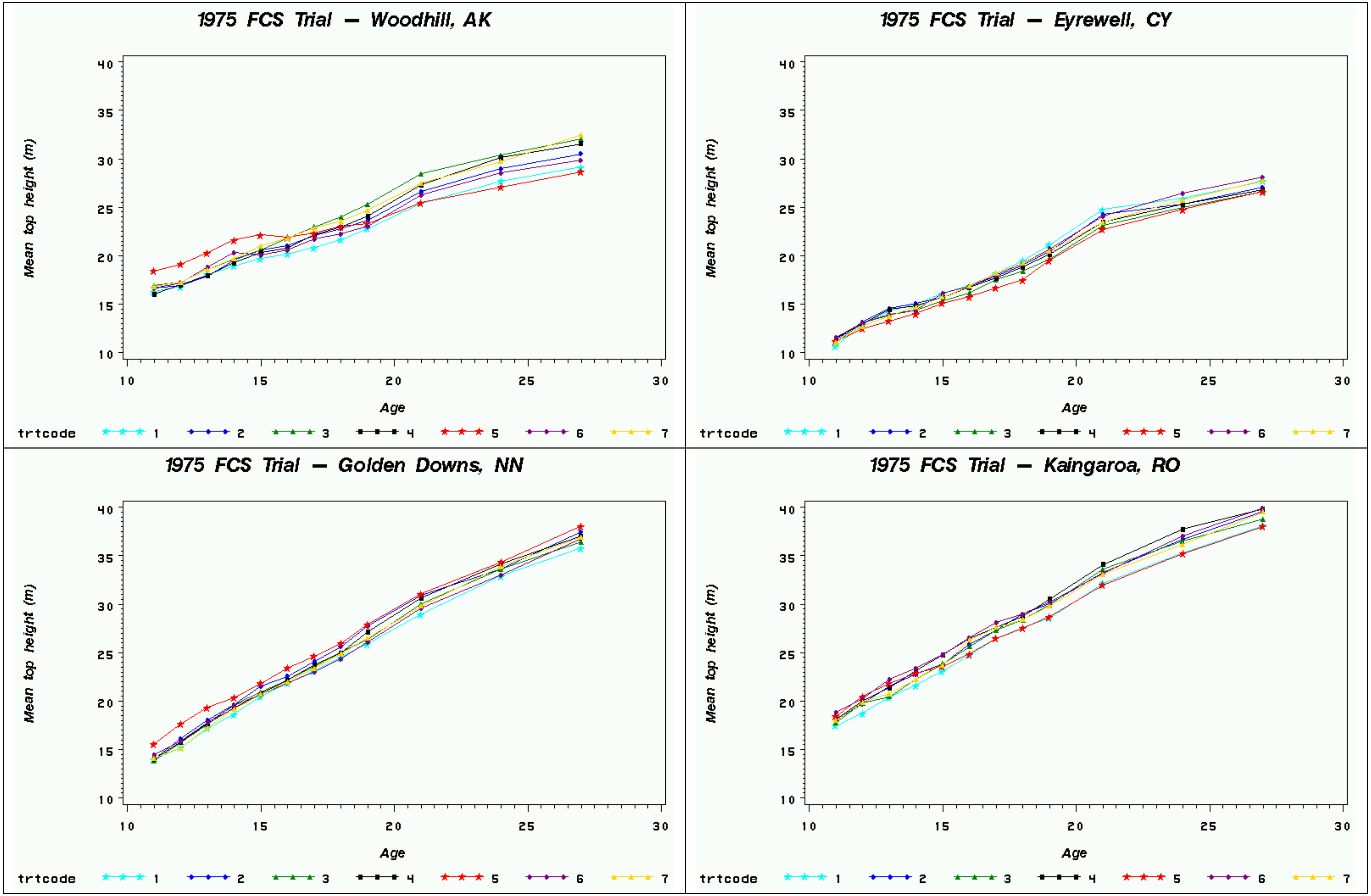


Figure 2. 1975 FCS Trials - Trends in mean top height with age for each treatment, labelled by site

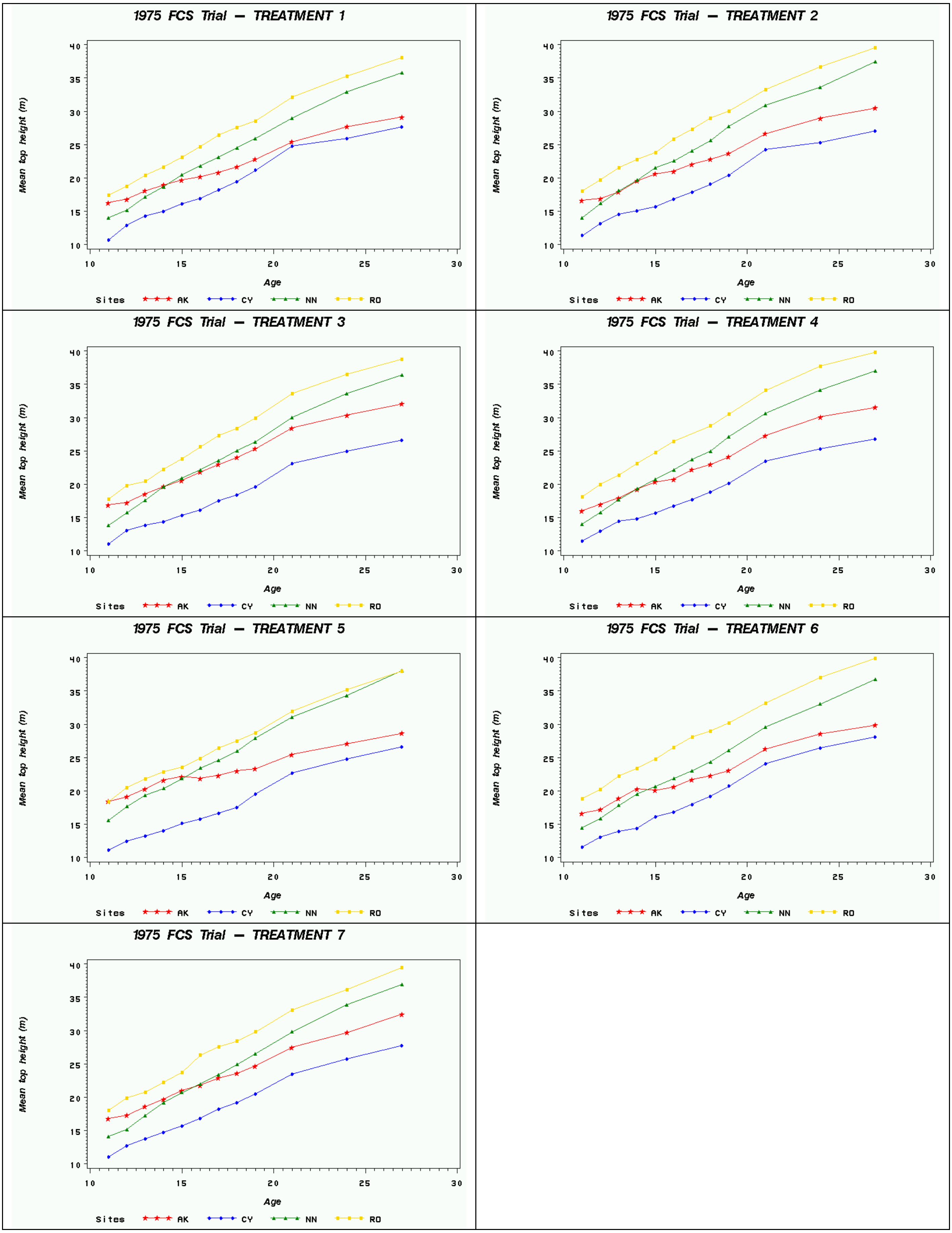


Figure 3. 1975 FCS trials - Trends in basal area with age for each site, labelled by treatment

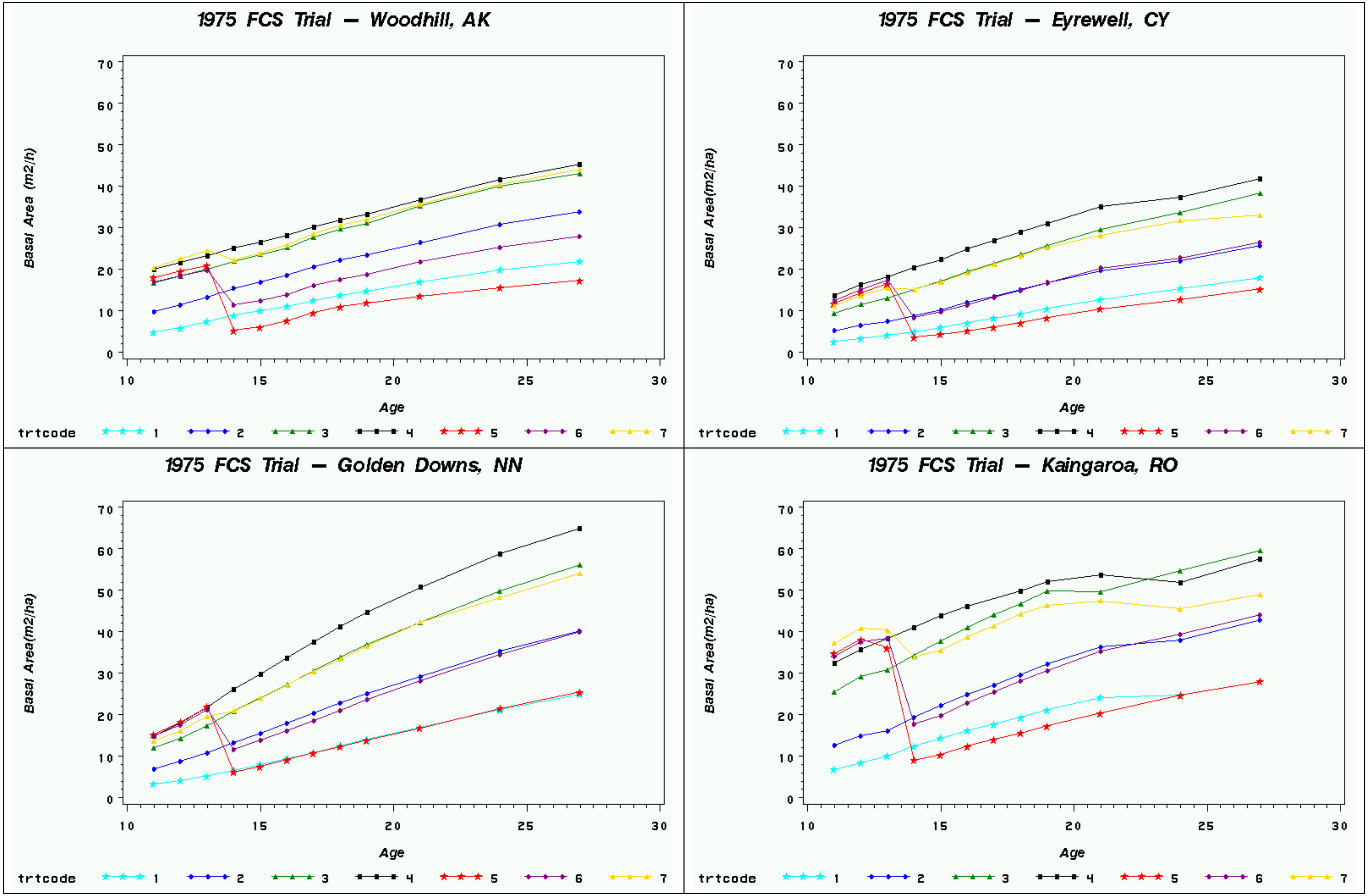
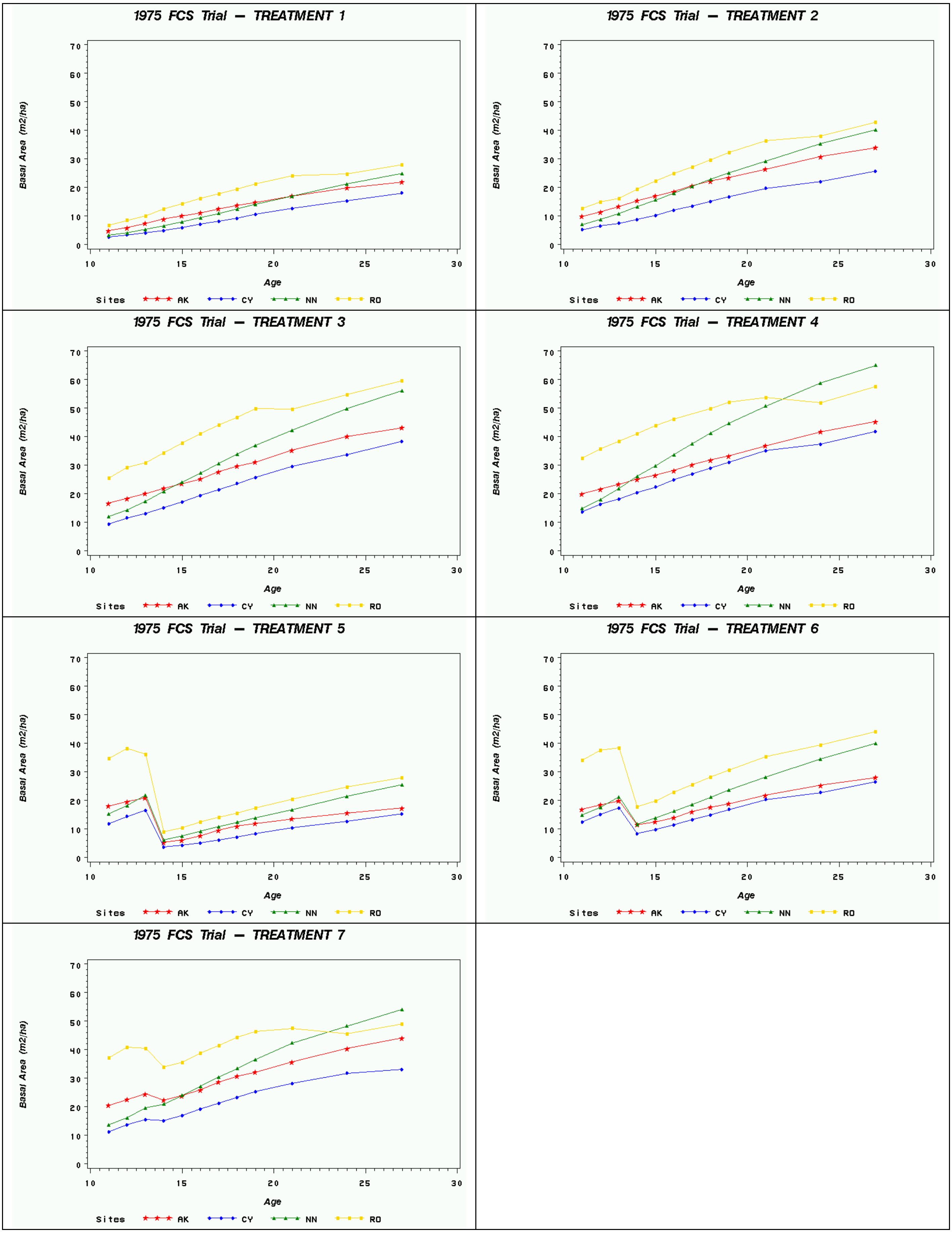


Figure 4. 1975 FCS trials - Trends in basal area with age for each treatment, labelled by site



1975 Final Crop Stocking Trials – Assessment of stem form.

Methods

Stem form is currently assessed and recorded on the PSP system in the form of defect codes by tree and by measurement. Defect codes include the following: dead top, broken top, toppled, leaning, swept, crooked, forked or multi-leader. To analyse these data, trees were identified as having a defect or not having a defect. Any tree that was assessed as having a defect at any measurement was considered to be defective (some trees had more than one defect over time). To ensure compatibility between plots, only trees remaining after the last thinning age (14 years) were considered. (Very few defects were recorded before age 14 years.)

Each plot had a variable calculated to give the percentage of trees with stem defects (ie. total no. trees with defects/ total no. of trees in the plot).

Results

There were obvious differences between sites in the percentage of trees with stem defects (Figure 5) with the Woodhill have the least and Kaingaroa the most damaged trees. There were generally only small differences between treatments (Figure 6). Plots thinned at 11 years (treatments 1, 2, 3) tended to have less damage than plots thinned at 14 years (treatments 5, 6, 7). The unthinned treatment tended to have more damaged trees than the plots thinned at 11 years.

Figure 5. 1975 FCS trials - Percentage of trees with defects for each site, labelled by treatment

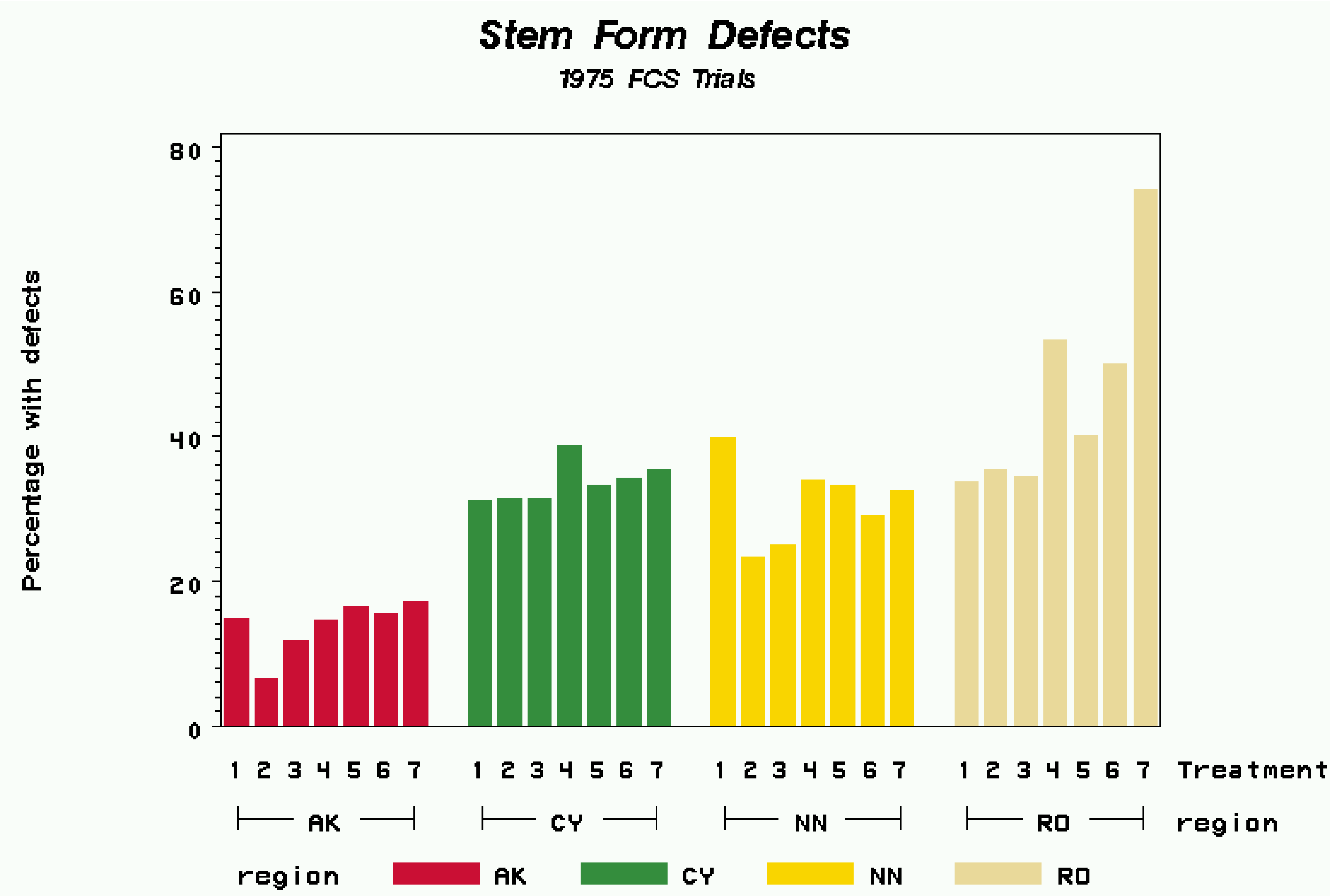
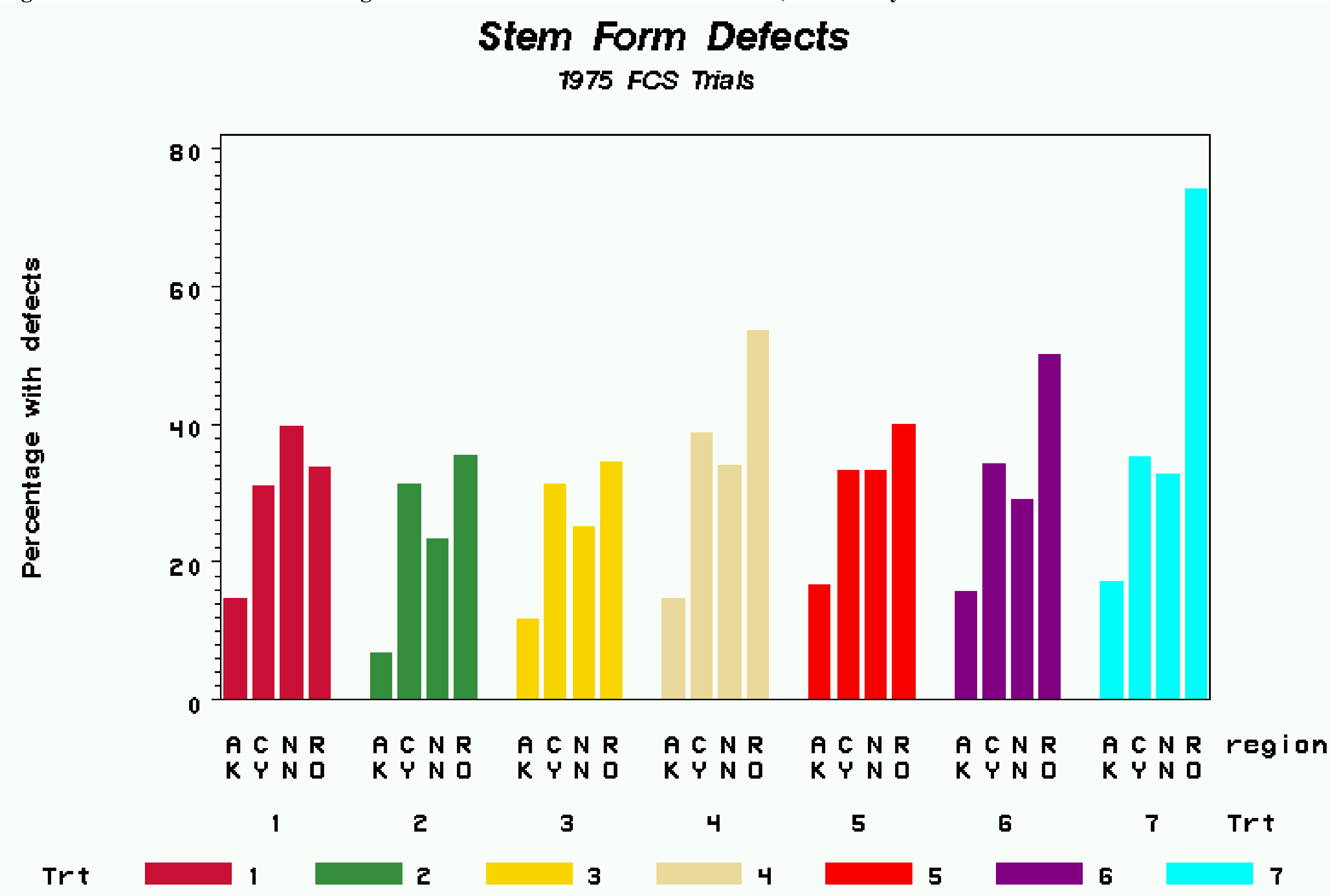


Figure 6. 1975 FCS trials - Percentage of trees with defects for each treatment, labelled by site



1975 FINAL CROP STOCKING TRIALS – BRANCHING CHARACTERISTICS

The branching characteristics of 3 to 5 trees per treatment were assessed previously using PhotoMARVL (see SGMC Reports 93, 99, 104, 112). The text below, briefly summarises and then extends the analyses in the above reports. For further details see the above reports.

Methods

At each site, one plot per treatment was selected and the trees within the plot ranked according to DBH. Trees closest to given percentage ranks were selected in the office for PhotoMARVL. In the field these trees were assessed for suitability, and if damaged (e.g. leader change) replaced by the next most suitable tree in terms of DBH rank.

For each PhotoMARVL tree, 3 regression equations (horizontal line, sloping line and sigmoid curve) describing the relationship between largest observed branch diameter in a cluster, $bd_{\max}$, and height to base of cluster were fitted and the most appropriate curve selected. The horizontal line indicated that there was no change in $bd_{\max}$ due to thinning and the coefficient indicated the mean $bd_{\max}$ before and after thinning. The sigmoid curve indicated that there was a change in branch diameter, assumed to be a result of thinning. The lower asymptote indicated the mean $bd_{\max}$ before thinning and the upper asymptote the mean $bd_{\max}$ after thinning. The sloping line indicated that $bd_{\max}$ changed continuously.

The mean $bd_{\max}$ before thinning, and the change in $bd_{\max}$ due to thinning were analysed using PROC GLM. Independent variables considered were nominal DBH rank (i.e. selected ranks rather than actual ranks), site and treatment.

Results

One tree at Golden Downs stood out as having extremely large branches throughout the crown. It was so large that it altered the ranking of sites. It was included in previous analyses but has been excluded from the analysis below.

The mean $bd_{\max}$ before thinning was significantly influenced by DBH rank and site. Silvicultural treatment was not quite significant ($p< 0.05$). The R^2 was 0.43 indicating that these variables only explained about half the observed variation. The estimated coefficients are given in Table 3.

The predicted change in branch diameter due to DBH rank was 0.9 cm between a tree with 10% DBH rank and a tree with 100% DBH rank. The change in branch diameter due to site was 1 cm with the smallest branches at Eyrewell and the largest branches at Kaingaroa. Treatment was not quite significant. Previously this was interpreted as the lower part of the crown was unaffected by thinning.

The change in $bd_{\max}$ due to thinning was significantly influenced by DBH rank and treatment but not site. The R^2 was 0.43 indicating that these variables only explained about half the observed variation. The estimated coefficients are given in Table 3.

The increase in branch diameter in the upper part of the crown was approximately 1.7 cm when thinned to 100 stems/ha, approximately 0.6 cm when thinned to 200 stems/ha and negligible when thinned to 400 stems/ha.

Table 3. 1975 FCS Trials – Model coefficients from PROC GLM analysis of PhotoMARVL data.

Parameter	Value	mean bd_{max} before thinning (cm)	Change in mean bd_{max} due to thinning (cm)
Intercept		2.38	-0.26
DBH RANK		0.01	0.02
SITE	AK	0.00	0.00
SITE	CY	-0.33	-0.55
SITE	NN	0.49	-0.41
SITE	RO	0.65	-0.38
TREATMENT	1	0.76	1.77
TREATMENT	2	0.68	0.66
TREATMENT	3	0.30	0.25
TREATMENT	4	0.00	1.65
TREATMENT	5	0.52	0.60
TREATMENT	6	0.38	0.00
TREATMENT	7	0.43	Unthinned treatment

1975 FINAL CROP STOCKING TRIALS – WOOD PROPERTIES

To our knowledge, no wood property data have been collected in these trials.

1978 GENETIC GAIN TRIALS - HISTORY

The 1978 genetic gain trials were established to compare the gain in growth from improved seedlots planted in large blocks. The seedlots included an unimproved GF2, a climbing select GF7, a Gwavas seed orchard GF14 and an '850' control pollinated cross GF22. Permanent sample plots (PSPs) were established in 1986 in the GF7 and GF14 seedlots with six replications of each seedlot. In 1991, PSPs were established in the GF2 (except at Aupouri Forest) and GF22 seedlots with three replications of each seedlot. All trials had a sawlog regime with the prescribed silviculture of:

- Plant at 1111 stems/ha
- Thin to 600 stems/ha at MCH 6.2m (age 5 years)
- Thin to 300 stems/ha at MCH 12m (age 10years*)
- Three pruning lifts: 2.2m, 4.2m and 6m

* this thinning did not take place at the Canterbury site in Waimate Forest.

The trials were established on 6 sites:

- Aupouri Forest, AK 1058, Auckland Sands growth region (AK)
- Kaingaroa Forest, RO 2103/1, Central North Island growth region (RO)
- Mohaka Forest, WN 377, Hawkes Bay growth region (HB)
- Golden Downs Forest, NN 530/2, Nelson growth region (NN)
- Waimate Forest, CY 421/1, Canterbury growth region (CY)
- Longwood Forest, SD 564/1, Southland growth region (SD)

1978 GENETIC GAIN TRIALS – HEIGHT AND BASAL AREA DEVELOPMENT

Methods

There are a total of 98 PSP plots that have been measured regularly from either 1986 (GF7 and GF14) or 1991 (GF2 and GF22) onwards. These plots have up to a maximum of 15 and a minimum of 8 remeasurements (a total of 1173 plot measurements) aged from 8 to 24 years. The latest measurement was in 2002. The following data was extracted from the Forest Research PSP database system: Plot Id; forest; measurement date; age at measurement; stems/ha; MTH, BA and Volume.

A site id and treatment number were added to the data file.

The trends in both MTH and basal area with age were plotted two ways:

- By site and labelled by GF rating
- By GF rating and labelled by site

The SAS® procedure PROC GLM (see description on page 4) was used to determine the influence of site and GF rating on the 2002 measurements (age 24 years) of MTH and BA. Independent variables considered were site, GF rating and the interaction of site and GF rating.

Results

For both MTH and BA the interaction with site and GF rating was not significant, so the model was re-run without the interaction term (the coefficients from this run are in Table 4). The model of the dependent variables explained 91% of the MTH variation and 79% of the BA variation.

MTH varied slightly with GF rating (Figure 7). MTH was generally slightly higher in the GF14 and GF22 seedlots compared with the GF2 and GF 7 seedlots. PROC GLM analysis, using data collected in 2002 (Table 4), MTH varied by up to 2 m due to seedlot. There were obvious differences in MTH with site (Figure 8). MTH was similar and high for the Kaingaroa and Hawkes Bay sites. MTH was similar and low for the Auckland, Canterbury and Southland sites. PROC GLM analysis, using data collected in 2002 (Table 4), indicated that MTH varied by up to 12 m due to site.

There was greater variation in BA with GF rating (Figure 9). BA was generally highest in the GF 22 seedlot. PROC GLM analysis, using data collected in 2002 (Table 4), indicated that BA varied by up to 15 m^2 due to seedlot. BA tended to be highest for the Canterbury site, basically because this site did not receive a second thinning. Of the sites that received a second thinning, BA tended to be highest at the Hawkes Bay site and lowest at the AK site (Figure 10). PROC GLM analysis, using data collected in 2002 (Table 4), indicated that BA varied by up to 28 m^2 due to site variation.

As was the case in the 1975 trials, MTH and BA increased more rapidly with increasing age at the Golden Downs site compared to the Auckland site.

Table 4. 1978 GG Trials – Model coefficients from PROC GLM analysis of 2002 MTH and BA measurements where independent variables were site and GF rating.

Parameter	Value	MTH Coefficient (m)	BA Coefficient (m^2/ha)
Intercept		40.7	74.1
SITE	AK	-11.3	-27.6
SITE	CY	-8.6	-3.8
SITE	NN	-6.1	-20.7
SITE	RO	0.9	-14.9
SITE	SD	-8.7	-4.9
SITE	HB	0.00	0.0
GF_rating	2	-2.0	-15.2
GF_rating	7	-1.3	-14.4
GF_rating	14	0.1	-6.8
GF_rating	22	0.0	0.0
Model R^2		0.91	0.79

Figure 7. 1978 GG Trials - Trends in mean top height with age for each site, labelled by GF rating

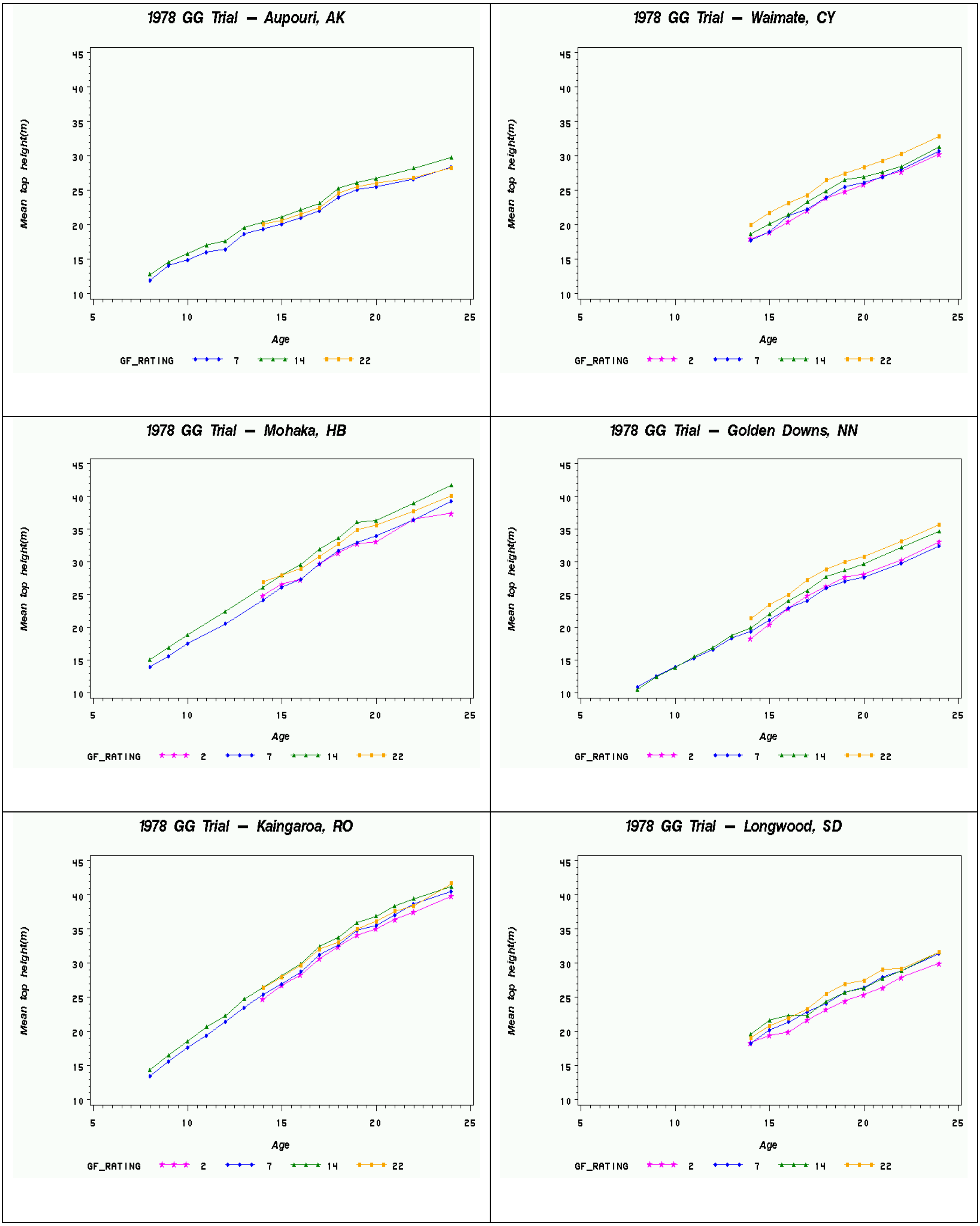


Figure 8. 1978 GG Trials - Trends in mean top height with age for each GF rating, labelled by site

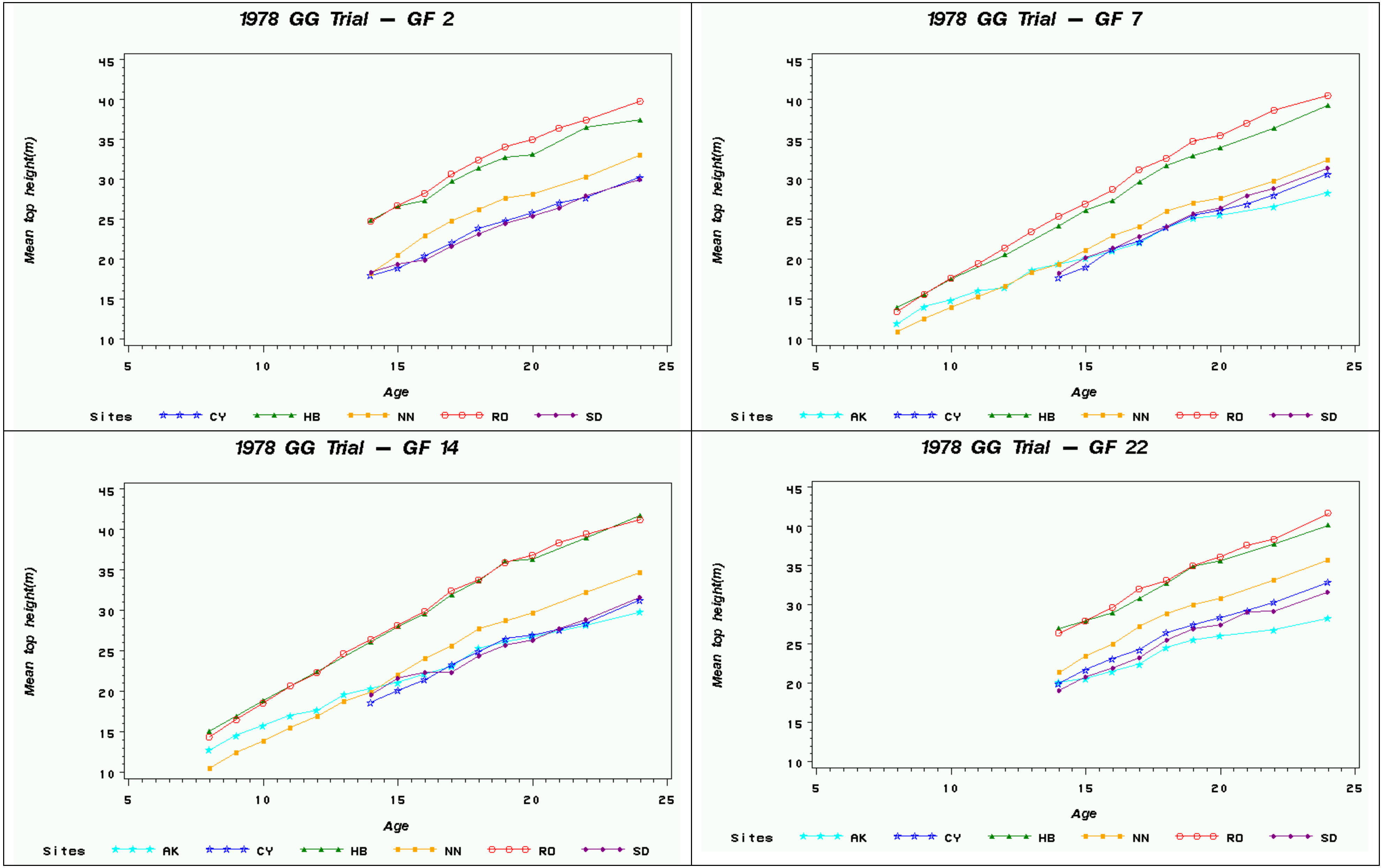


Figure 9. 1978 GG Trials - Trends in basal area with age for each site, labelled by GF rating.

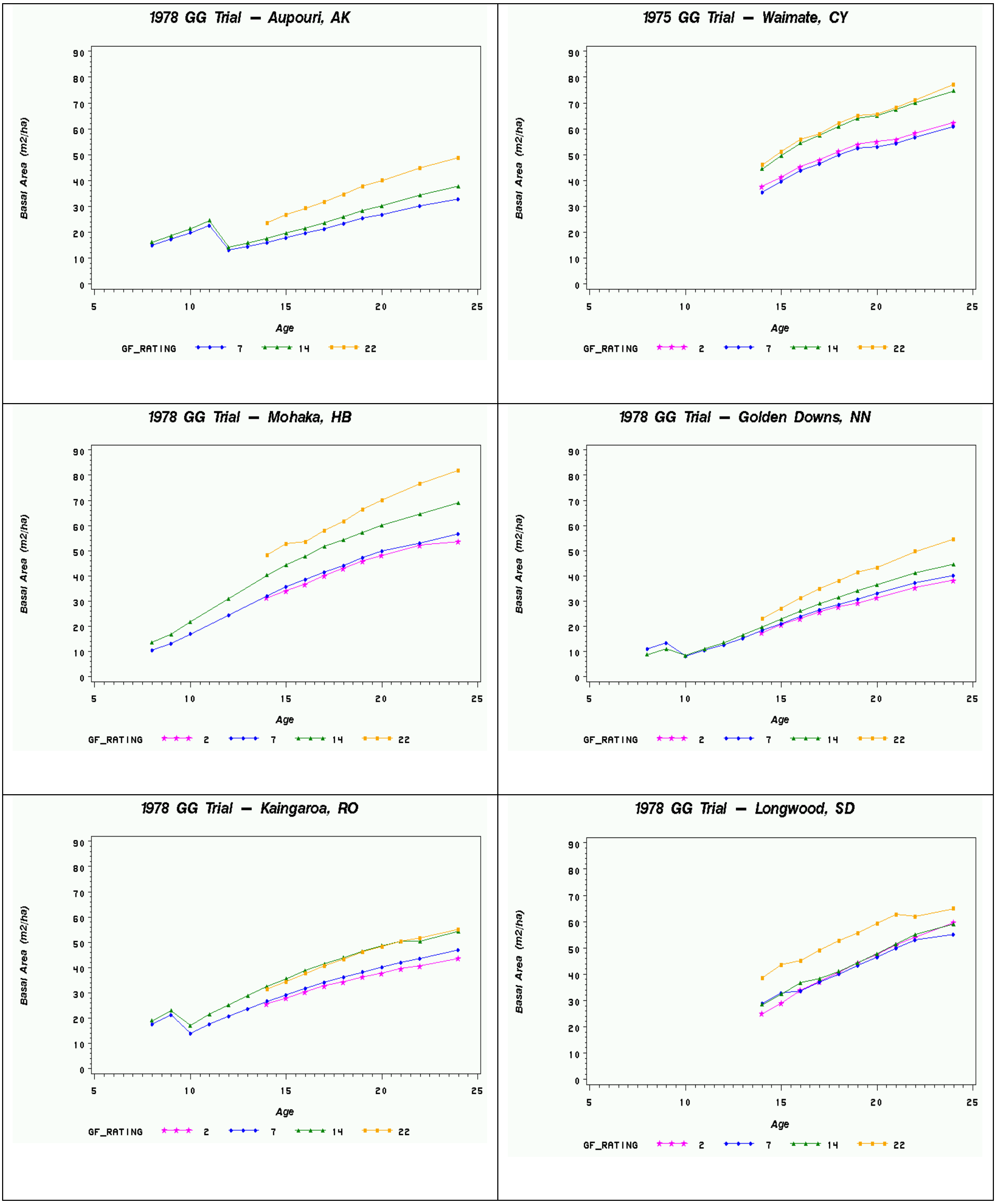
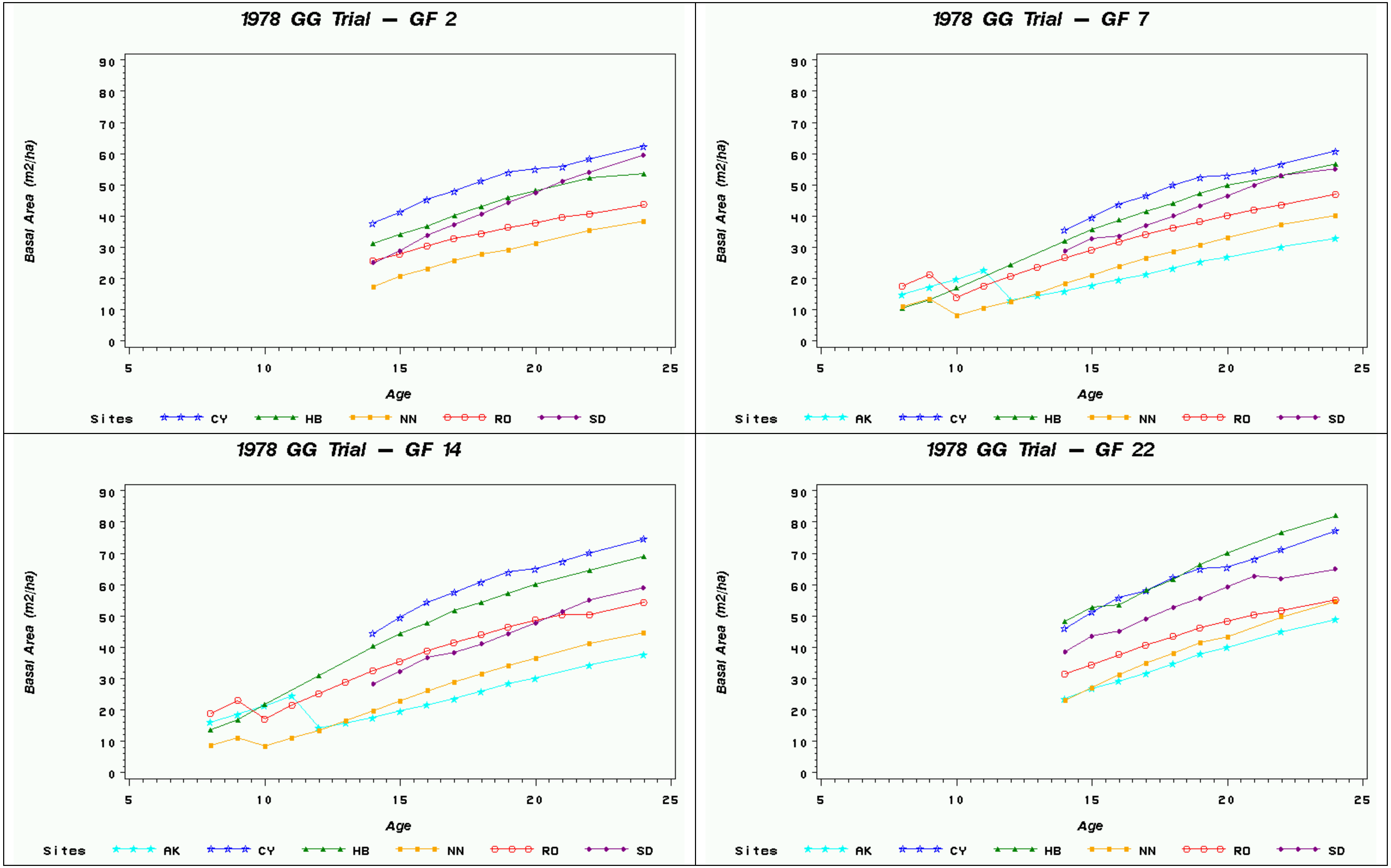


Figure 10. 1978 GG Trials - Trends in basal area with age for each GF rating, labelled by site



1978 GENETIC GAIN TRIALS – ASSESSMENT OF STEM FORM

Methods

Stem form is currently assessed and recorded on the PSP system in the form of defect codes by tree and by measurement. Defect codes include the following: dead top, broken top, toppled, leaning, swept, crooked, forked or multi-leader. To analyse these data, trees were identified as having a defect or not having a defect. Any tree that was assessed as having a defect at any measurement was considered to be defective (some trees had more than one defect over time). To ensure compatibility between plots, only trees remaining after the last thinning age (10 years) were considered. (Very few defects were recorded before age 10 years.)

Each plot had a variable calculated to give the percentage of trees with stem defects (i.e. total number of trees with defects/ total number of trees in the plot).

Results

The GF rating with the most damage varied between sites (Figure 11). Overall the GF14 seedlot probably had the least amount of damage. The amount of damage tended to be least at the Nelson and Rotorua sites (Figure 12).

Figure 11. 1978 GG trials - Percentage of trees with defects for each site, labelled by GF rating

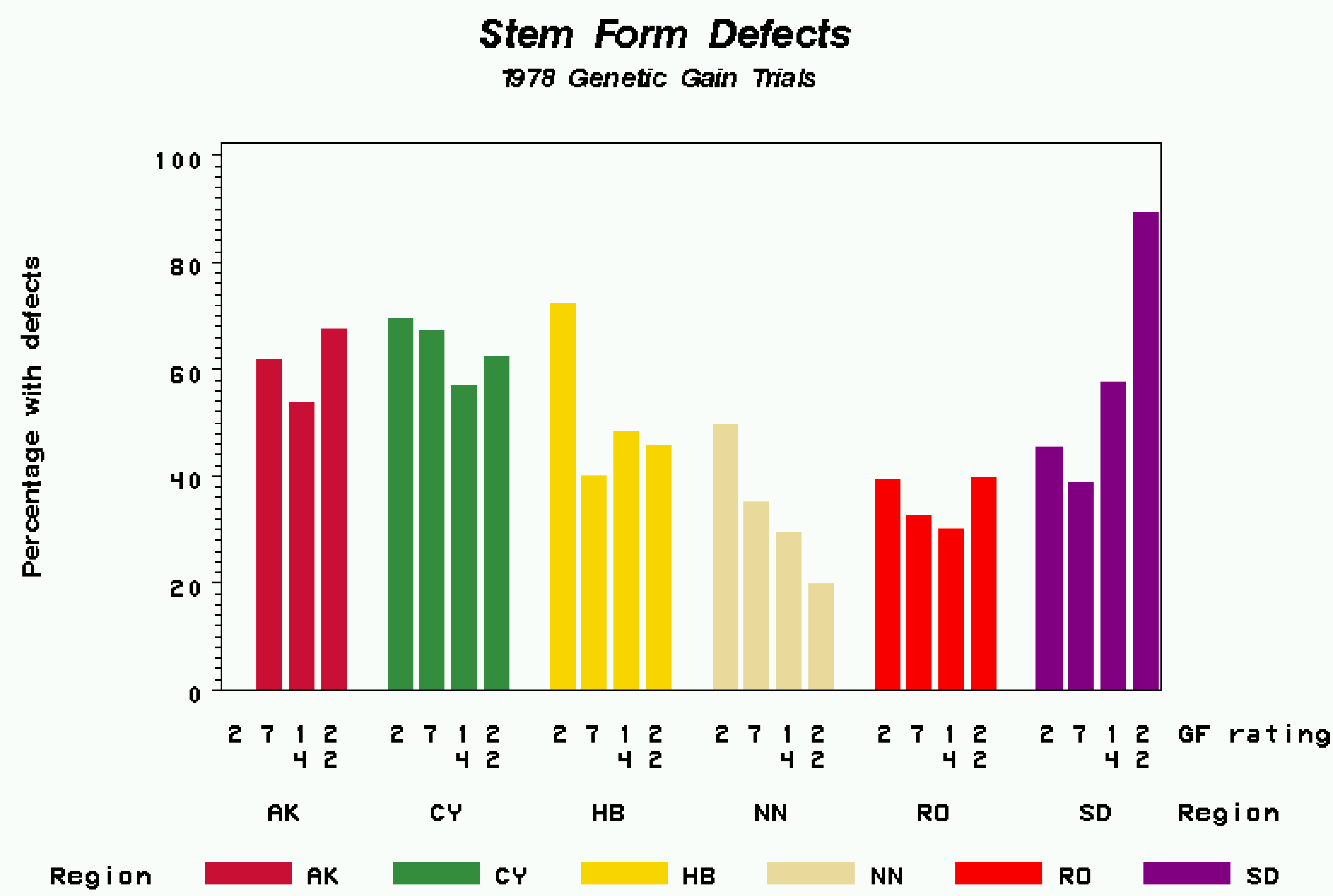
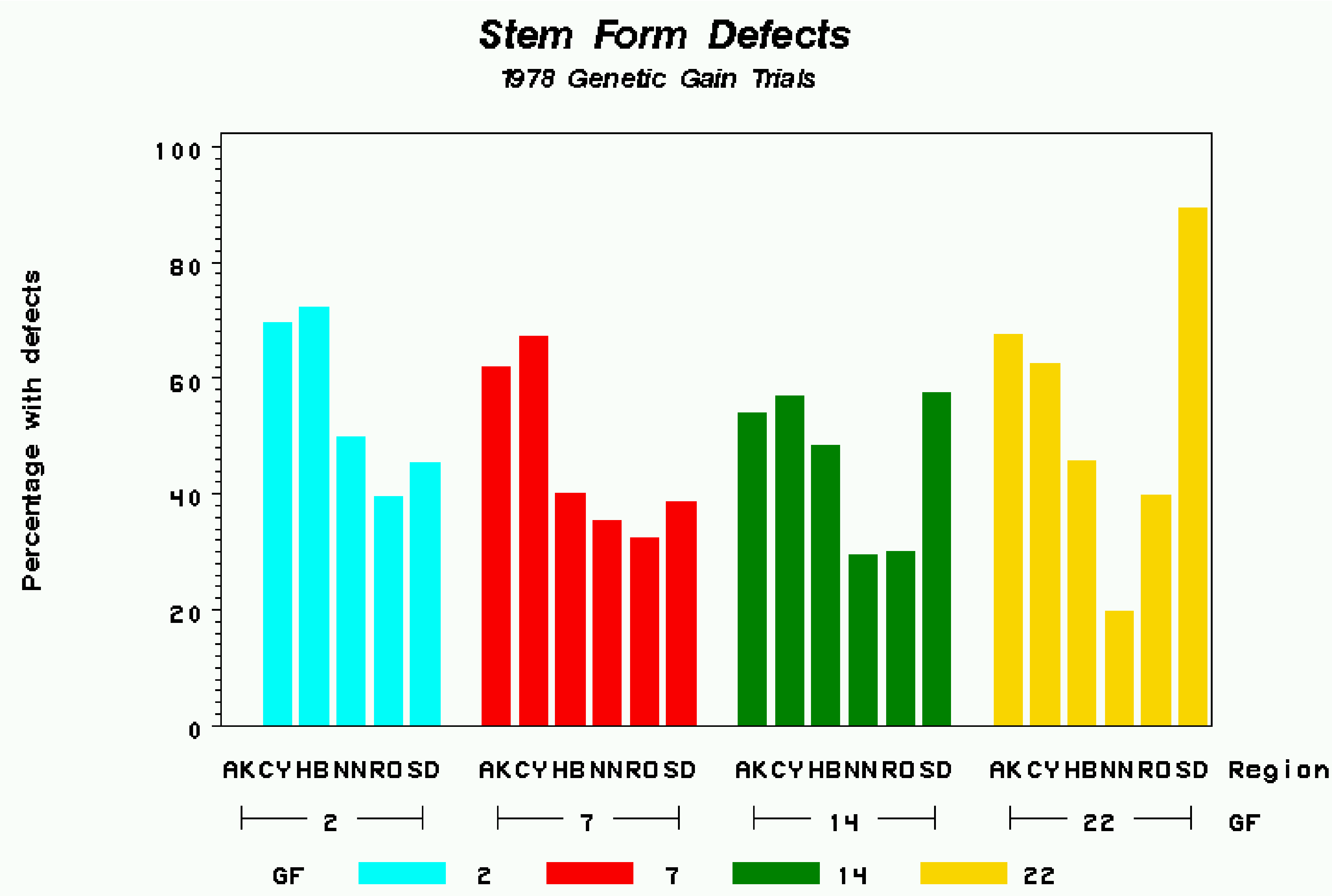


Figure 12. 1978 GG trials - Percentage of trees with defects for each GF rating, labelled by site



1978 GENETIC GAIN TRIALS – BRANCHING CHARACTERISTICS

The branching characteristics of 5 trees from the GF7, GF14 and GF22 were assessed previously using PhotoMARVL (see SGMC Report 119). The text below, briefly summarises and then extends the analyses in the above report. For further details see the above report.

Methods

At each site, one plot per treatment was selected and the trees within the plot ranked according to DBH. Trees closest to given percentage ranks were selected in the office for PhotoMARVL. In the field these trees were assessed for suitability, and if damaged (e.g. leader change) replaced by the next most suitable tree in terms of DBH rank.

For each PhotoMARVL tree, 3 regression equations (horizontal line, sloping line and sigmoid curve) describing the relationship between largest observed branch diameter in a cluster, bd_{max}, and height to base of cluster were fitted and the most appropriate curve selected. The horizontal line indicated that there was no change in bd_{max} due to thinning and the model coefficient indicated the mean bd_{max} before and after thinning. The sigmoid curve indicated that there was a change in branch diameter, assumed to be a result of thinning. The lower asymptote indicated the mean bd_{max} before thinning and the upper asymptote the mean bd_{max} after thinning. The sloping line indicated that bd_{max} changed continuously.

The mean bd_{max} before thinning, and the change in bd_{max} due to thinning were analysed using PROC GLM. Independent variables considered were actual DBH rank, site and GF rating. An assumption was that all plots had received the prescribed treatment and were at the prescribed stocking. This was not strictly true.

Results

Less than half the variation in the mean bd_{max} before thinning was explained by DBH rank, site and GF rating ($R^2 = 0.35$).

The predicted change in branch diameter due to DBH rank was 1.4 cm between a tree with 10% DBH rank and a tree with 100% DBH rank. The predicted variation in mean bd_{max} due to site was 1.4 cm with the smallest branches at Golden Downs and the largest branches at Longwood. The predicted variation in mean bd_{max} due to seedlot was 0.7 cm with the GF 14 seedlot having the smallest value and the GF 7 the largest.

Less than half the variation in change in mean bd_{max} due to thinning was explained by DBH rank, site and GF rating ($R^2 = 0.33$). Only site was a significant effect. The fact that DBH rank was not important suggests that changes to the local stocking of the sample tree may be important than the actual size of the tree.

Table 5. 1978 Genetic Gain Trials – Model coefficients from PROC GLM analysis of PhotoMARVL data.

Parameter	Value	mean bd_{max} before thinning (cm)	Change in mean bd_{max} due to thinning (cm)
Intercept		3.68	0.47
DBH rank		0.015	0.007
SITE	AK	-0.34	1.21
SITE	CY	0.00	No thinning
SITE	NN	-0.68	-0.14
SITE	RO	-0.25	1.43
SITE	SD	0.76	0.50
SITE	HB	0.29	0.00
GF_rating	7	0.50	-0.36
GF_rating	14	-0.21	-0.55
GF_rating	22	0.00	0.00

1978 GENETIC GAIN TRIALS – WOOD PROPERTIES

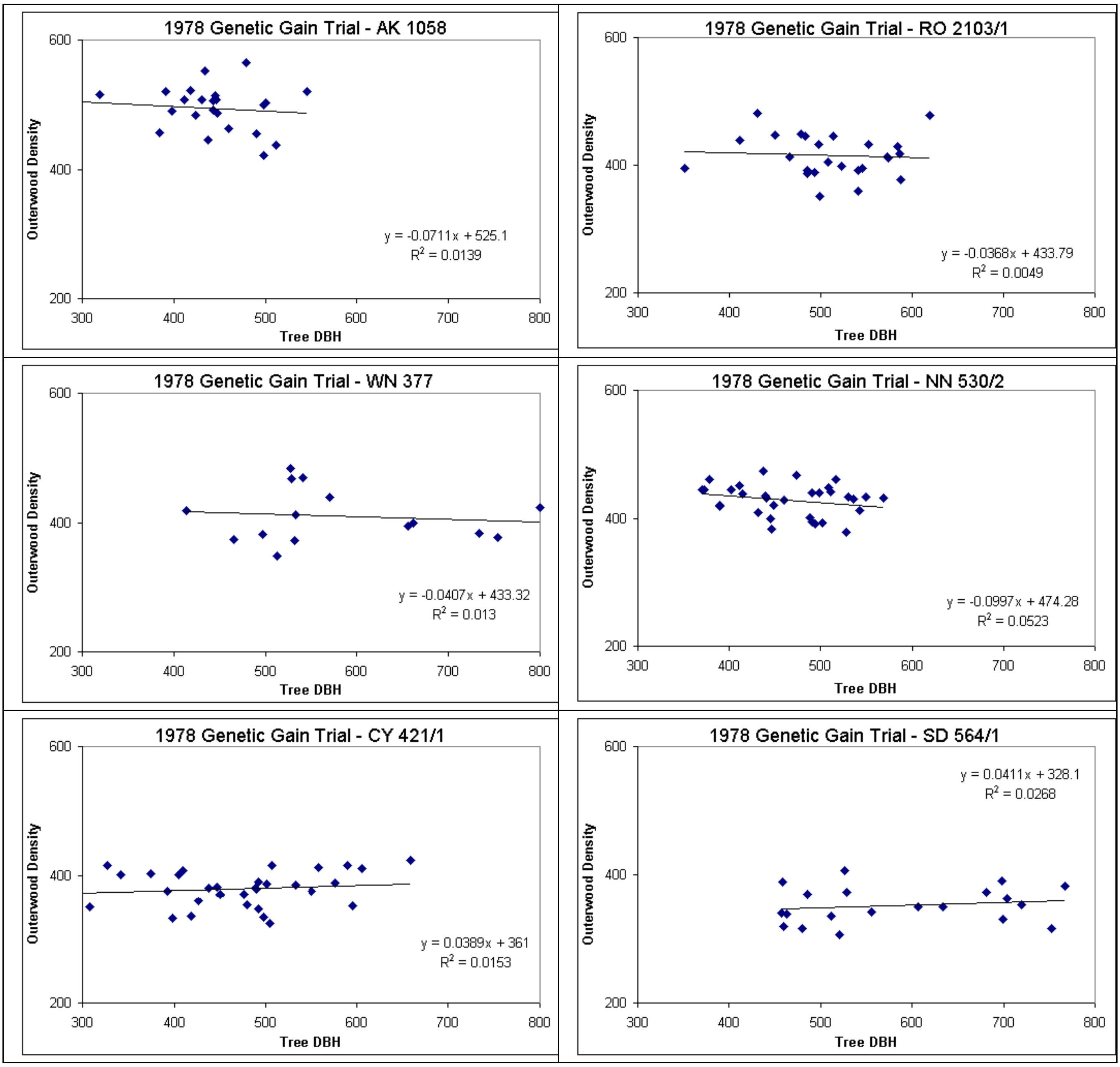
These trials are being used by the Wood Quality Initiative for their benchmarking study. The initial phase was to sample approximately 30 trees from the GF14 seedlot for outerwood density (see WQI/SGMC Report No. 1a). The site mean values are shown in Table 6.

Table 6. Average outerwood density for GF14 seedlot in 1978 Genetic Gain Trials.

Region	Forest	Outerwood density (kg m^{-3})
Auckland	Aupouri	494
Central North Island	Kaingaroa	415
Hawkes Bay	Mohaka	410
Nelson	Golden Downs	437
Canterbury	Waimate	379
Southland	Longwood	352

The relationship between tree DBH and outerwood density was very weak at each site (Figure 13). It is possible that there is a stronger relationship between tree characteristics and other wood properties (see SGMC Report 114).

Figure 13. **1978 Genetic Gain Trials: relationship between tree DBH (mm) and outerwood density (kg m^{-3})**



The second phase of the WQI study was to destructively sample 10 trees per site. This has been carried out for:

- Aupouri (WQI/SGMC Report 5a)
- Mohaka (WQI/SGMC Report 8)
- Longwood (WQI/SGMC Report 6)

For each tree, samples were collected for measuring:

- Wood density in 5-ring blocks
- Shrinkage in 5-ring blocks
- Spiral grain in 5-ring blocks
- Internal checking
- Wood Colour
- Fibre length

Samples were also saved for measuring a range of wood properties using SilviScan.

While branch index and internode index were visually assessed on these sample trees, more detailed crown data are required to investigate the link between crown and wood properties and to test a prototype model to predict wood density using TreeBLOSSIM.

DISCUSSION

Summary of data analyses

1975 FCS Trials

There were only small differences in height development between different silvicultural treatments but large differences between sites. Both site and silvicultural treatment influenced basal area development, with silvicultural treatment having more influence than site. Basal area per hectare decreased with decreasing stocking.

Branching characteristics are influenced by both site and silvicultural treatment, with bigger branches on the faster growing sites and at the lower stockings.

The percentage trees with defects tended to be lower in the plots thinned at age 11 years compared to the plots thinned at age 14 years.

1978 GG Trials

There were only small differences in height development between different seedlots, but larger differences between sites. Both seedlot and site influenced basal area development, with site having more influence than seedlot.

Branching characteristics were also more strongly affected by site than seedlot, as was the case for basal area growth.

The percentage of trees with defects varied with both site and seedlot. Possibly the GF14 seedlot had the least defects.

Objective of future data collection

The objective of any future destructive sampling in these trials would be to collect the necessary data to develop an integrated tree growth and wood property model as per SGMC Theme 4. It will build on previous research along this line:
- SGMC Internal stem modelling literature review (SGMC Report No. 114)
- The sub-modules developed by D. Pont as additions to TreeBLOSSIM that enable ring width and wood density to be predicted as a function of crown structure in a straight tree
- Forest Research “2-tree studies” that have investigated the interactions between crown, stem form and wood properties
- SGMC pilot study in trial FR172/3

The next phases in the model development are:

- To determine whether, and if necessary modify, the extended TreeBLOSSIM to apply across sites, silvicultural treatments and different seedlots.
- To further extend TreeBLOSSIM to predict the circumferential variations in wood properties as a function of stem form (SGMC Report No. 114).

Sampling Priorities – General

The 1975 FCS trials are higher priority than the 1978 GG trials as no wood property data have been collected in these trials (See Appendix 1 for proposed clearfell dates). Also WQI has indicated that it is interested in the effects of silviculture on wood properties.

The amount of sampling that can be achieved will obviously depend on available funding so priorities have been assigned for:
- Sites
- Treatments within sites
- Sample trees within treatments

This modular approach will allow sampling schemes to be tailored to available funding.

1975 FCS trials - priorities

Site

Minimum sampling: slow-growing site and a fast-growing site
Additional sampling: intermediate site
Maximum sampling: all 4 sites

1a. Golden Downs or Kaingaroa as representative of a fast-growing site
1b. Eyrewell as representative of a slow-growing site – but already felled
2. Woodhill as representative of an intermediate site

Treatments

Minimum sampling: 3 treatments
Maximum sampling: all treatments

1a. Comparison of plots thinned to 200 stems/ha at age 11 and age 14 (a realistic minimum for stocking in practice)
1b. Unthinned plots as a control
2. Comparison of plots thinned to 400 stems/ha at age 11 and age 14 (an intermediate treatment)
3. Comparison of plots thinned to 100 stems/ha at age 11 and age 14 (the extreme treatment, but unlikely to be used in commercial forestry)

Note that the preferred sampling strategy from the July 2004 SGMC meeting was a comparison of:
- unthinned control plots,
- plots thinned 200 stems/ha at age 11, and
- plots thinned to 400 stems/ha at age 11

Trees

See below.

<u>1978 GG Trials – priorities</u>

Site

Minimum sampling: slow-growing site and a fast-growing site
Additional sampling: intermediate site
Maximum sampling: all 6 sites

1a. Hawkes Bay as representative of a fast-growing site
1b. Golden Downs or Aupouri as representative of a slow growing site
2. Longwood or Kaingaroa as representative of an intermediate site

Note that at the July 2004 SGMC meeting a maximum of three sites was recommended.

Treatments

Minimum sampling: 2 seedlots
Maximum sampling: 3 seedlots

1. Comparison of GF 14 seedlot with GF 22 seedlot to investigate whether differences in wood properties can be explained by variation in crown structure.
2. Comparison of GF 14 seedlot with GF 7 seedlot to investigate whether differences in wood properties can be explained by variation in crown structure.

Note that at the July 2004 SGMC meeting it was recommended that only the GF14 seedlot be sampled.

Trees- both trials

There are several variables that can be used to categorise trees within a plot:

- Tree DBH
- Stem straightness
- Crown structure: cluster frequency, branch diameter, crown eccentricity

Wood properties could be used as a 4th category, but the "hypothesis" is that wood properties can be predicted from tree and crown structure so there is no need to sort by this category. Possible sampling strategies are given in Table 7. The more trees sampled, the more information but the greater the cost.
It is considered that a minimum of two trees is needed in the above categories because of the poor relationship between tree DBH and wood density.

Table 7. Possible sampling strategies for number of trees per treatment

Sample Code	Number of trees per treatment	Trees to be sampled for wood properties	What can be achieved with this sample size
A	3	3 trees of average DBH, all with straight stems	Investigate relationship between crown structure and wood properties –assume no circumferential variation
B	4	2 trees of average DBH with straight stems 2 trees of average DBH with bent, but “acceptable” stems	Investigate relationship between crown structure and stem wood properties and influence of stem form on circumferential variation
C	4	2 trees with small DBH 2 trees with large DBH all straight stems	Investigate relationship between crown structure and wood properties –assume no circumferential variation
D	6	2 trees with small DBH 2 trees with average DBH 2 trees with large DBH all straight stems	Investigate relationship between crown structure and wood properties –assume no circumferential variation
E	8	4 trees with small DBH 4 trees with large DBH In each category, 2 straight stems and 2 bent, but “acceptable” stems	Investigate relationship between crown structure and stem wood properties and influence of stem form on circumferential variation
F	8	2 trees with small DBH 2 trees with average DBH 2 trees with large DBH all straight stems 2 trees of average DBH with bent, but “acceptable” stems	Investigate relationship between crown structure and stem wood properties and influence of stem form on circumferential variation
G	10	2 trees with small DBH 2 trees with average DBH 2 trees with large DBH all straight stems 2 trees of average DBH with bent, but “acceptable” stems 2 trees straight trees with asymmetrical crowns	Investigate relationship between crown structure and stem wood properties and influence of stem form on circumferential variation

Proposed Sampling per sample tree

- Non-destructive /Subjective assessment of all trees in plot (DBH, stem form, branching, and possibly wood properties) order to select sample trees
- PhotoMARVL image of sample trees prior to felling as reference
- Fell tree
- Select sample branches for foliage measurements and measure
- Mark and measure position of clusters
- Mark discs for measuring wood properties
- Mark extra discs to photograph to provide visual assessment of wood
- Cut trees into discs to save and branch clusters
- Measure branch clusters
- Cut sample branches, plane and measure their growth through time
- Photograph discs
- Cut wood property samples for SilviScan

SGMC Project Approval 2004/05

At the July 2004 meeting, it was agreed that a project to destructively sample in a rotation-age trial would be carried out in the 1978 Genetic Gain trial in Golden Downs Forest (NN530/2). The sampling strategy would be to fell 8 trees of the GF14 seedlot only.

Appendix 1. 1975 FCS Trials and 1978 GG Trials - Proposed dates fof latest year for sampling before clearfell

Trial Series	Location	Current Owner	Indicative Year Clearfell	Latest Year for Destructive Sampling
1975 FCS	Woodhill AK1056	CHH	2008	2006-2007
	Kaingaroa RO2098	Kaingaroa Timberlands	Indefinite hold	None – due to indefinite hold
	Golden Downs NN529/1	Weyco	Roadlining 2007/8 Cleafell 2009	2007-2008
	Eyrewell CY597	CHH	Already felled	None
1978 GG	Aupouri AK1058	Juken Nissho (non-coop member)	Not known	None – Growth at Golden Downs similar
	Kaingaroa RO2103/1	Kaingaroa Timberlands	Indefinite hold	None – due to indefinite hold
	Mohaka WN377	Panpac	March 2006-April 2007	2005 – 2006
	Golden Downs NN530/2	Weyco	2005/6	2004 – 2005
	Waimate CY421/1	Blakely Pacific (non-coop member)	Not known	None – no second thinning
	Longwood SD564/1	Rayonier	2010	2008-2009