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PROJECT RECORD NO.: 4348

DIVISION: FOREST TECHNOLOGY

RESOURCE CENTRE: PLANTATION MANAGEMENT

CODE:

94 / 95	105	0267	02	0266	54
Financial Year	Resource Centre No.	Project	Sub-project	FRST Output	Prog.

WORK PLAN NO.: [ ] **EXPERIMENT NO.:**

TITLE: A MORTALITY FUNCTION FOR DOUGLAS-FIR UP TO STAND AGE 30 YEARS

AUTHOR(S): M. MIDDLEMISS AND R.L. KNOWLES **DATE:** 18.10.94

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DIVISION: FOREST TECHNOLOGY

RESOURCE CENTRE: PLANTATION MANAGEMENT

CODE: 94 / 95 (Financial Year) | 105 (Resource Centre No.) | 0267 (Project) 02 (Sub-project) | 0266 (FRST Output) 54 (Prog.)

WORK PLAN NO.: EXPERIMENT NO.:

TITLE: A MORTALITY FUNCTION FOR DOUGLAS-FIR UP TO STAND AGE 30 YEARS

AUTHOR(S): M. MIDDLEMISS & R.L. KNOWLES DATE: 18.10.94

KEYWORDS: DOUGLAS-FIR, MORTALITY, STOCKING, SPACING, ALTITUDE, WIND

ABSTRACT*

The study reports on mortality in 2474 measurements taken from 299 permanent sample plots in Douglas-fir stands, aged between 9 and 30 years, located throughout New Zealand.

Functions were fitted to the data expressing mortality as a function of stocking and height.

Analysis of residuals showed that there was no significant improvement in fit from including basal area, dbh or altitude in the function.

Regional differences were observed for Auckland (mortality underpredicted) and Nelson (mortality overpredicted) but overall these differences were relatively small and the use of a single function for NZ seems justified.

* **Note: This material is unpublished and must not be cited as a literature reference.**

Introduction

PSP data was read into the Excel Spreadsheet for screening and to complete an exploratory data analysis. Fields are: plot id, year planted, record type, plot area in hectares, measurement month, measurement year, SPH of live trees, Basal area (m^2/Ha) of live trees, number of height trees used in Petterson equation, Mean top height (m), number of stems with crown heights, mean crown height, number of predominant height trees, average height of predominants (m), volume of live trees (m^3/Ha), SPH of dead or thinned trees, SPH of windblown trees, Basal area of dead or thinned trees, Basal area of windblown trees, volume of dead or thinned trees, volume of windblown trees.
Annual Basal Area Increment (m^2/Ha) and Crown/Ha were calculated.
There were 2999 increment points for measurements up to 30 years of age, which is the main focus of interest for the EARLY growth model.
Points where the next measurement was after a thinning or mean top height was not recorded were removed. This left 2474 points.
These points were distributed regionally as follows:

Auckland	62
Canterbury	86
Nelson	574
Rotorua	1207
Southland	188
Westland	98
Wellington	249

Where there had been a number of windblown trees this number was added back to the stocking measurement for these points so "competitive" mortality rather than "catastrophic" mortality was being predicted.

The model used was initially developed by Beekhuis (1966), approximated algebraically by Oscar Garcia (1981) and describes the changes in average spacing (or stocking) with the height of the stand. The spacing used is average triangular spacing which is $107.4/\sqrt{sph}$.

The form of the function initially used is as follows:

$$S = (S0^c - (b*H0)^c + (b*H)^c)^{1/c}$$

where S = spacing at end of increment period
S0 = spacing at beginning of increment period
H = mean top height at end of increment period
H0 = mean top height at beginning of increment period

This form is an approximation for the Beekhuis model developed by Oscar Garcia.

Results

The NLIN procedure in SAS gave the following output.

Non-Linear Least Squares Summary Statistics Dependent Variable S

Source	DF	Sum of Squares	Mean Square
Regression	2	47694.195	23847.10
Residual	2473	108.35	0.0438
Uncorrected Total	2475	47802.54	
(Corrected Total)	2474	5861.100	

Paramater	Estimate	Std. Error	Confidence Interval	
			Lower	Upper
B	0.01844	0.0020764	0.0143721	0.022516
C	1.00116	0.0015129	0.9981976	1.004131

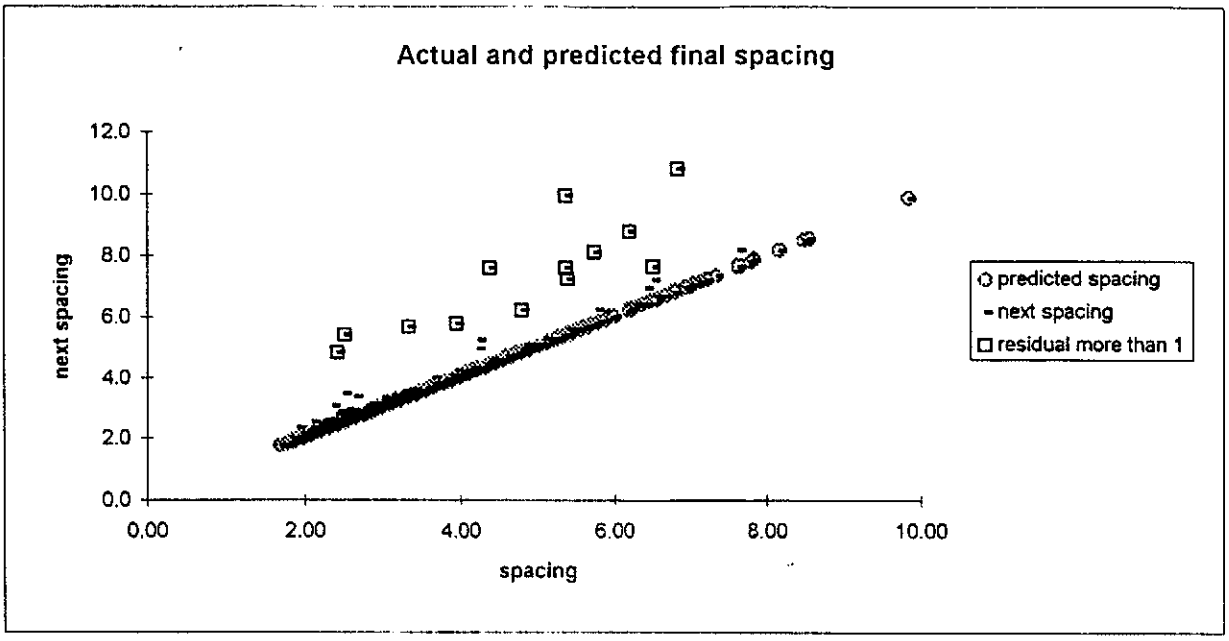
Asymptotic Correlation Matrix

Corr	B	C
B	1	-0.3600
C	-0.3600	1

As C is not significantly different to 1. the function can be simplified to a linear form:

$S - S0 = B * (H - H0)$ or
$S = S0 + B * (H - H0)$

To fit this function and also test if the variables altitude. dbh, or ba should be included a linear regression was performed in Excel.

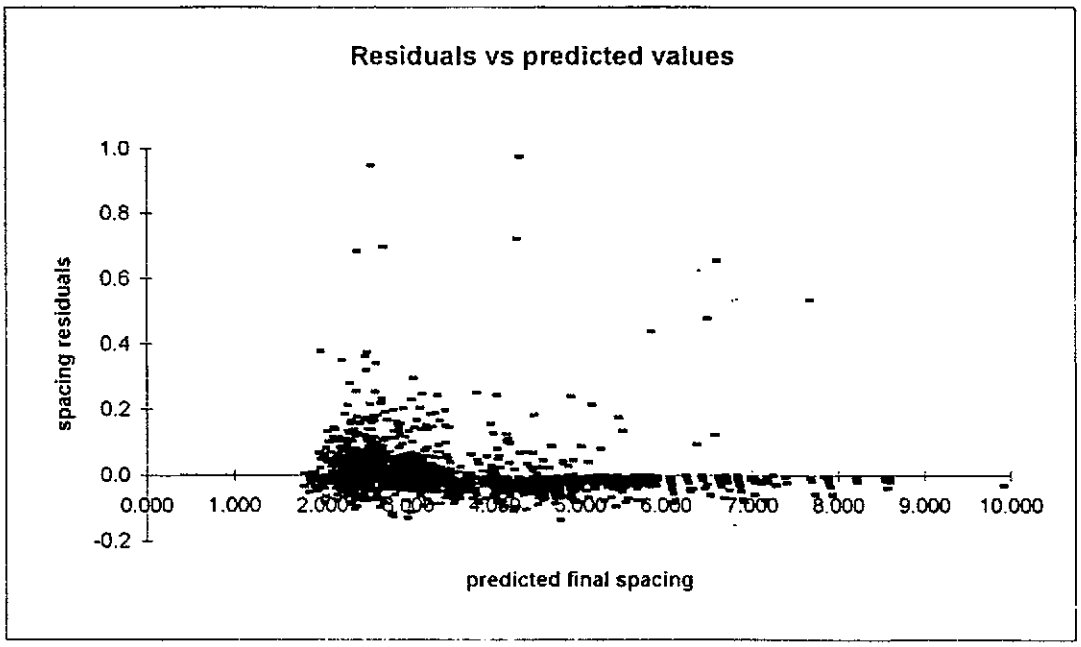


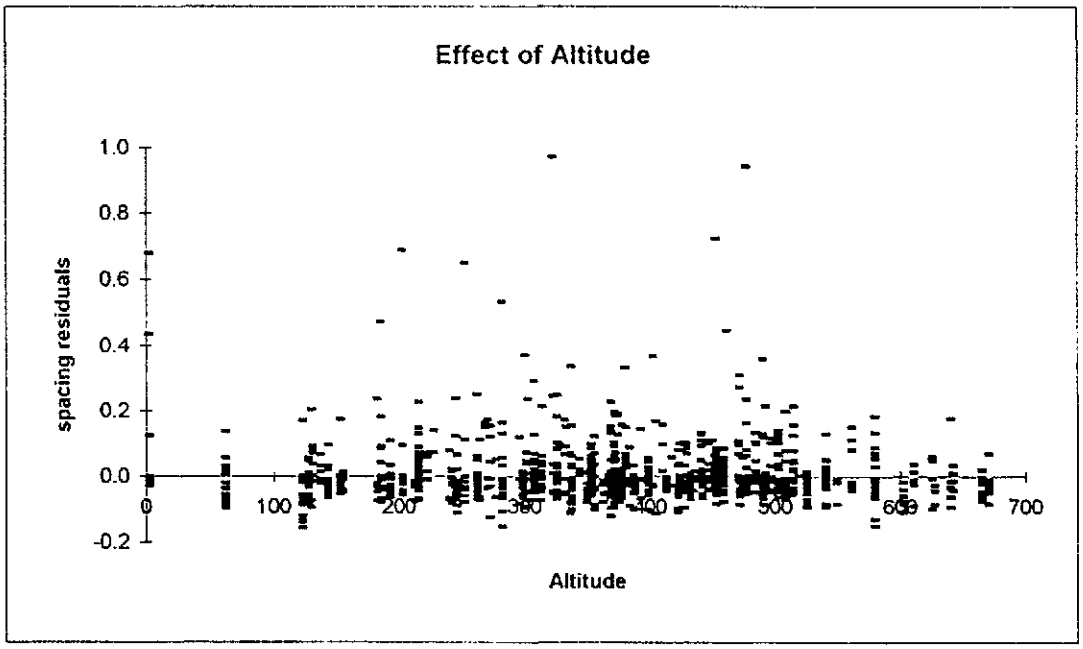
The points marked by squares had residuals of more than 1 and were considered to be examples of sporadic unpredictable mortality caused by catastrophic events but they had no major influence on the function. The mortality may also be exaggerated in these points by a low stocking level which amplifies the increase in spacing when mortality occurs.

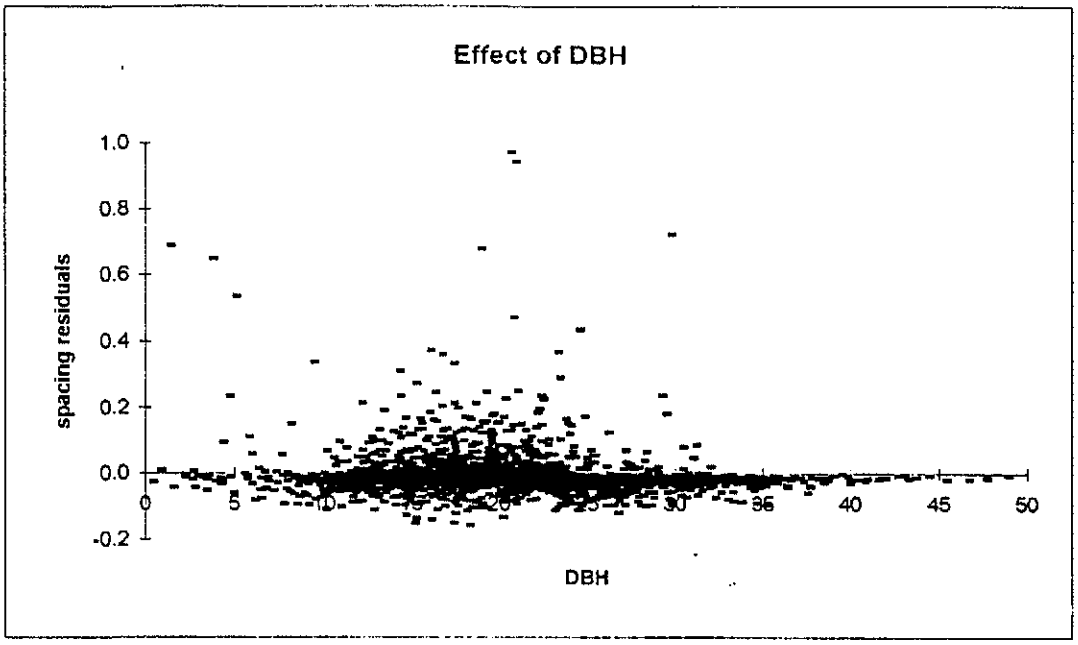
The mortality function is thus:

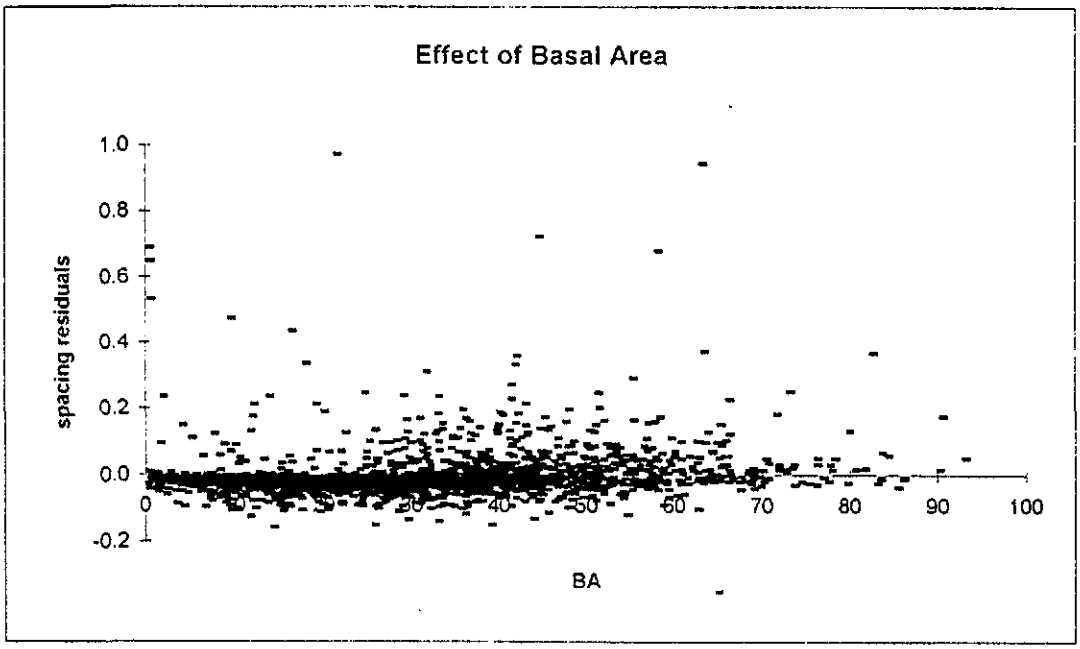
$S = S0 + 0.016 \times (H - H0)$

This function was used to predict spacing and the residuals of non-catastrophic points were plotted against the following variables. A positive residual here represents an *under*-prediction in the increase in spacing and therefore mortality

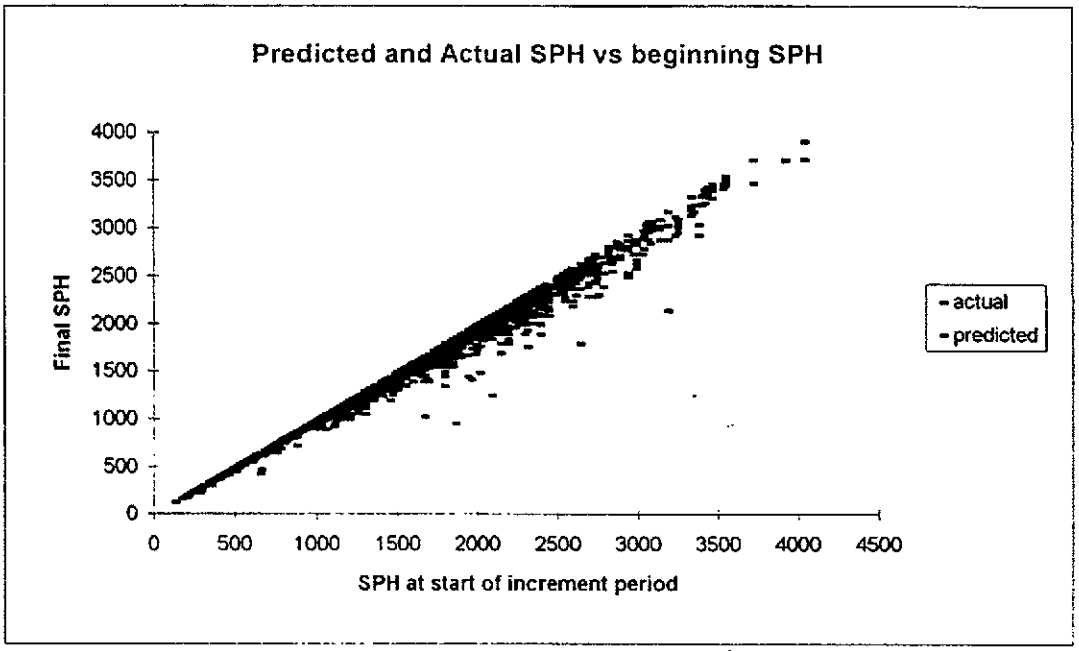


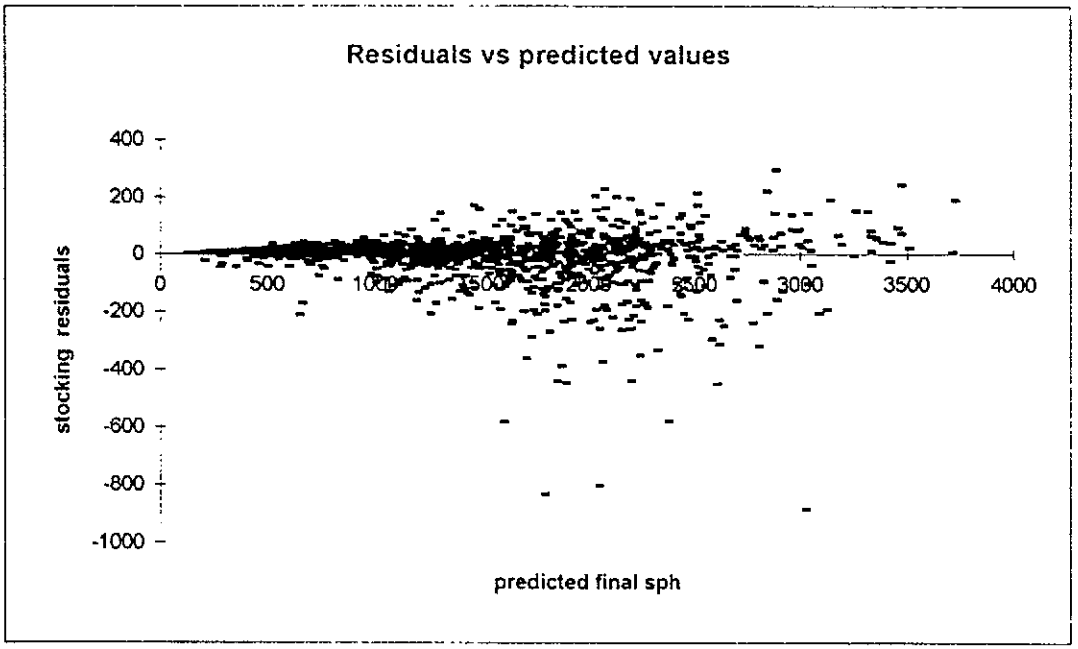


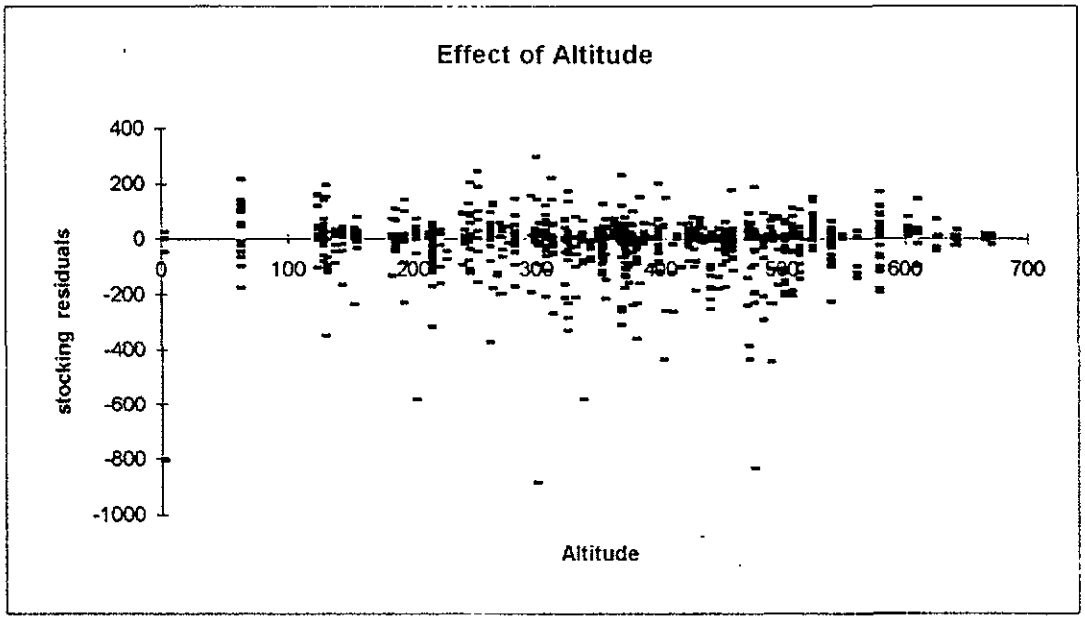

Effect of DBH
spacing residuals
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
0
5
10
15
20
25
30
35
40
45
50
DBH

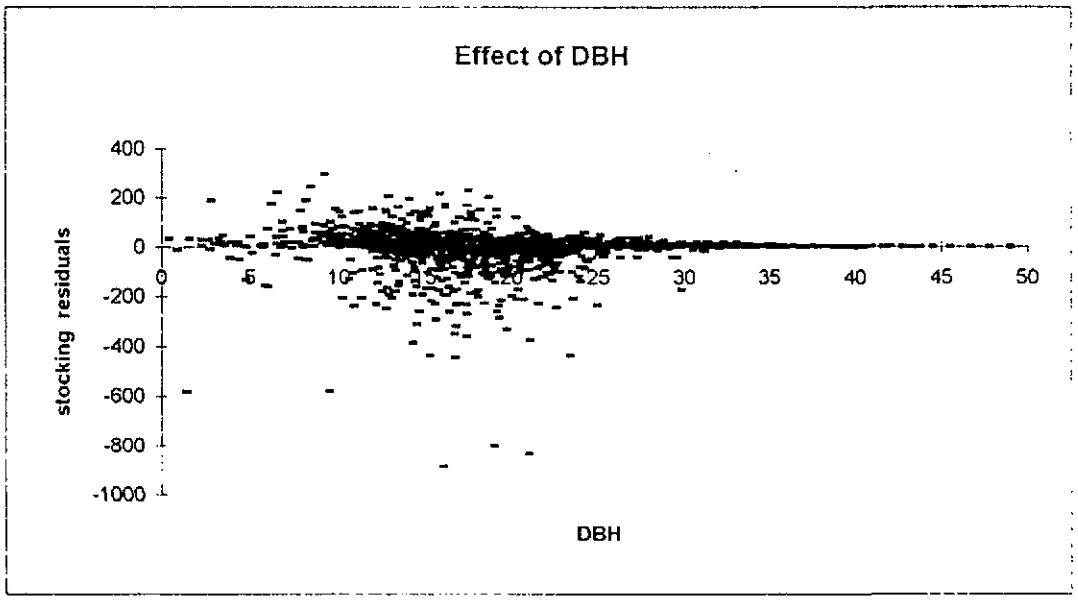

Effect of Basal Area
spacing residuals
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
0
10
20
30
40
50
60
70
80
90
100
BA

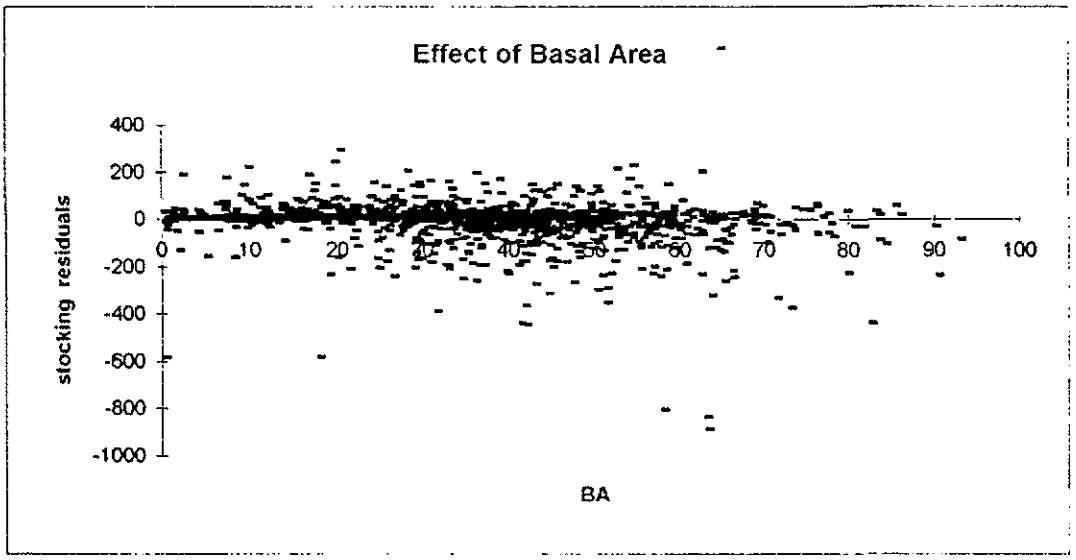
The spacing was translated back into predicted stocking and the residuals plotted to further illustrate the nature of the function. At very high stocking levels a small change in spacing can represent a large number of trees hence the high residuals in these charts even with the "catastrophic" points removed.





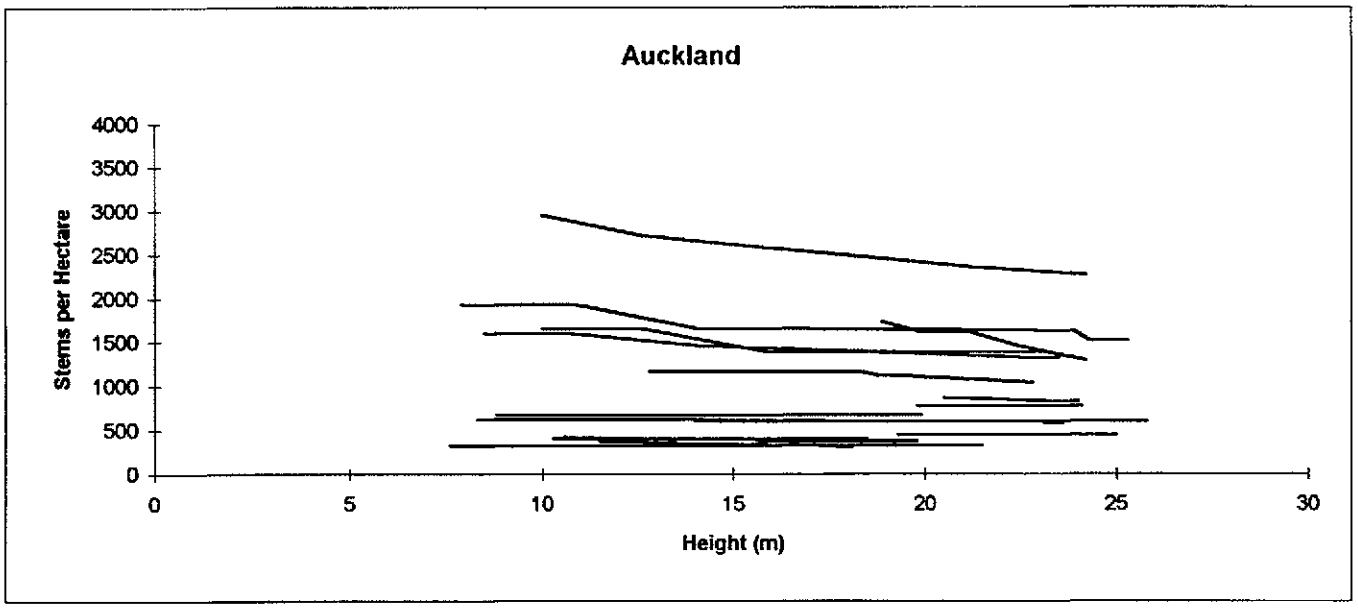


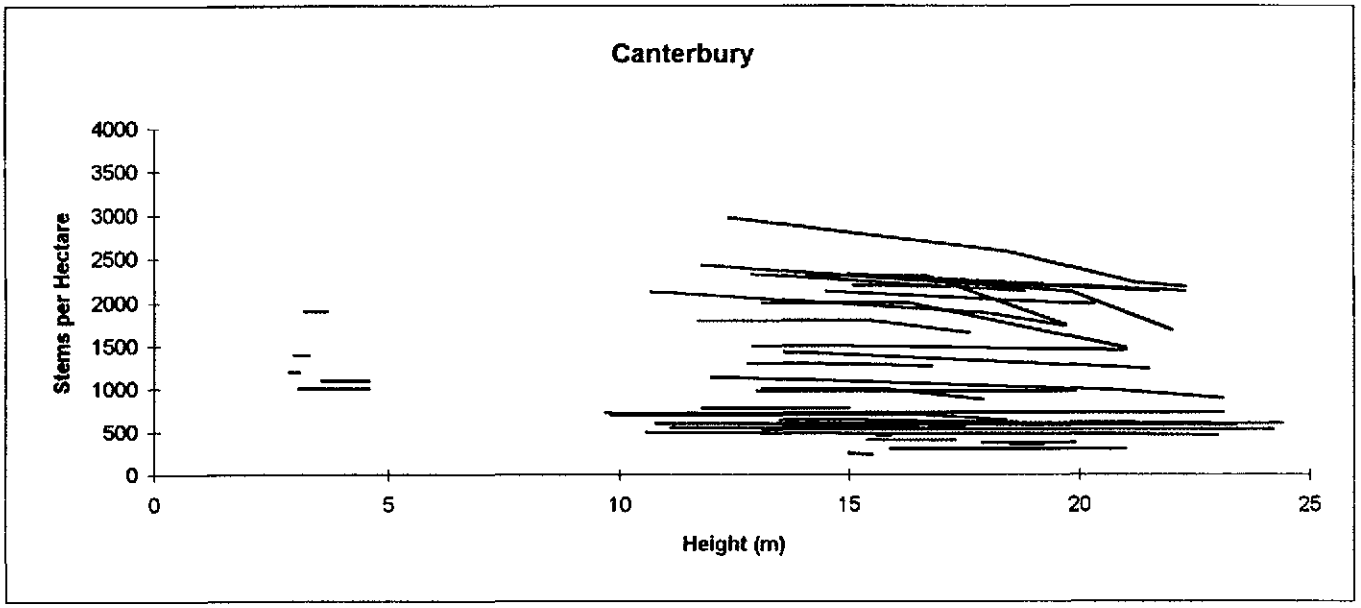


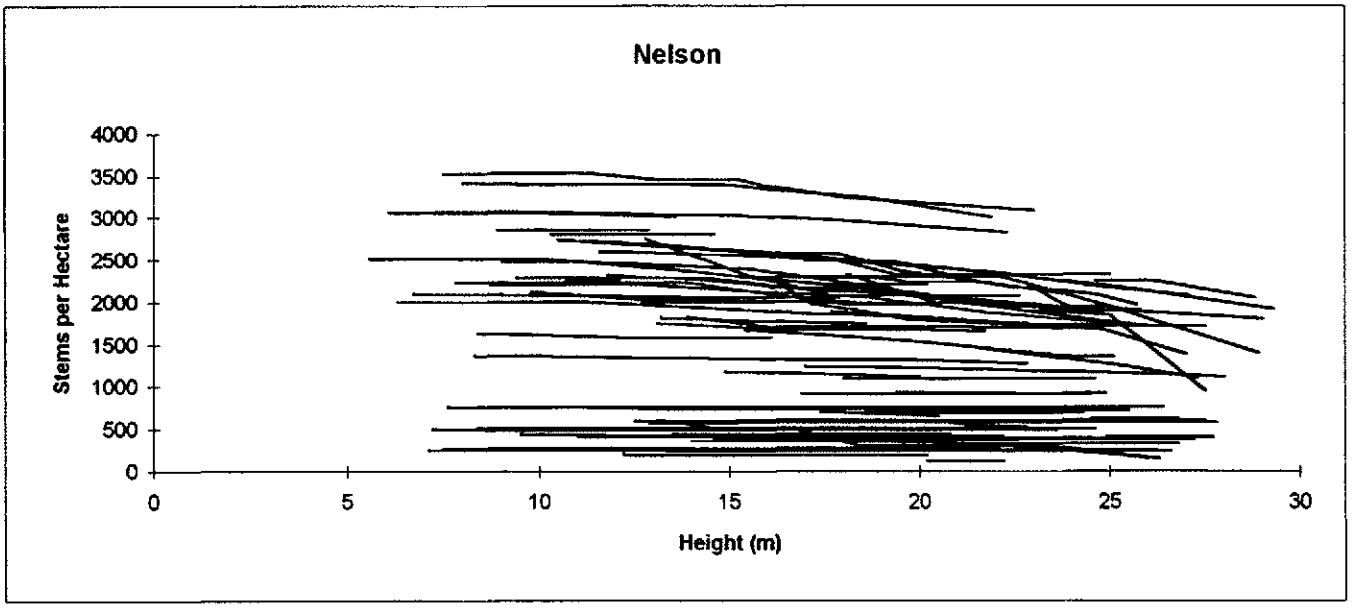


As no pattern is apparent in any of the residual plots the large differences between some actual and predicted final stocking level is considered to be random "unusual" mortality and the function is accurately predicting "normal" mortality.

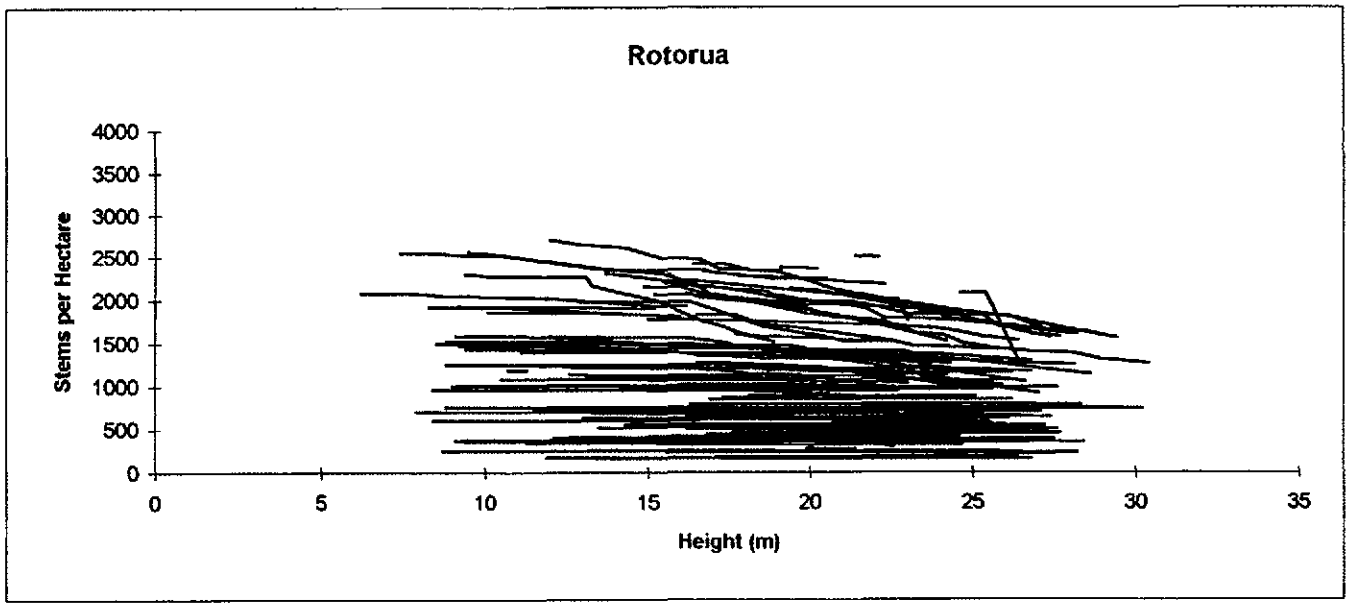
STEMS PER HECTARE vs MEAN CROP HEIGHT BY REGION

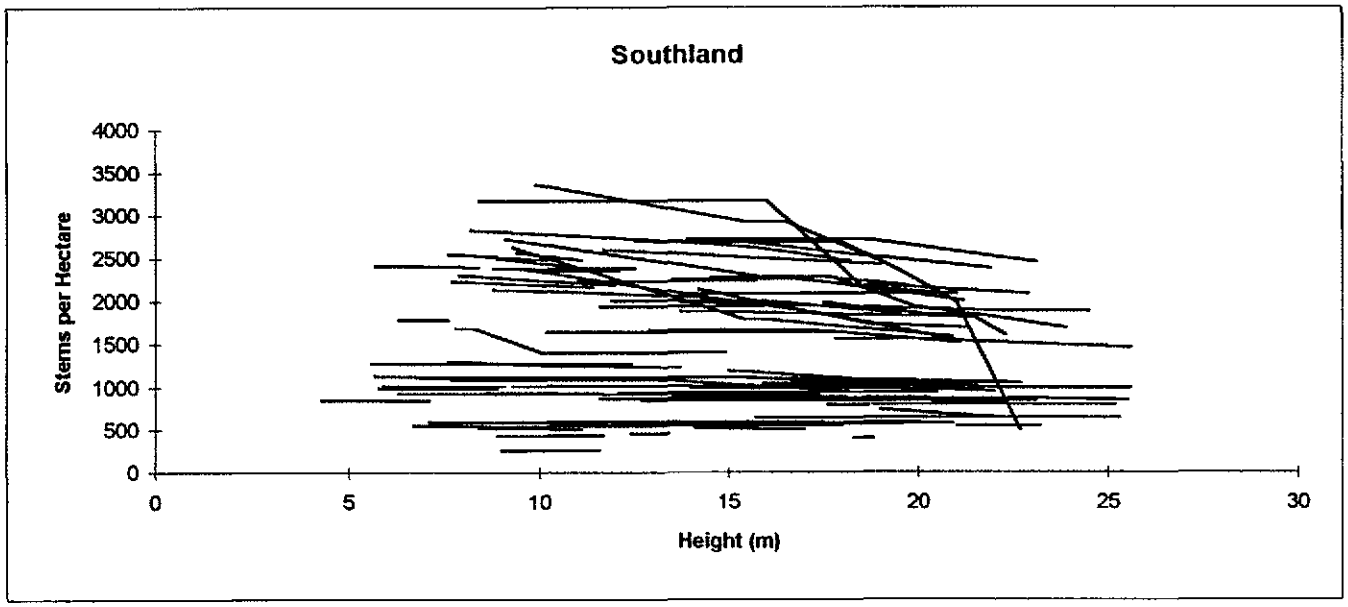


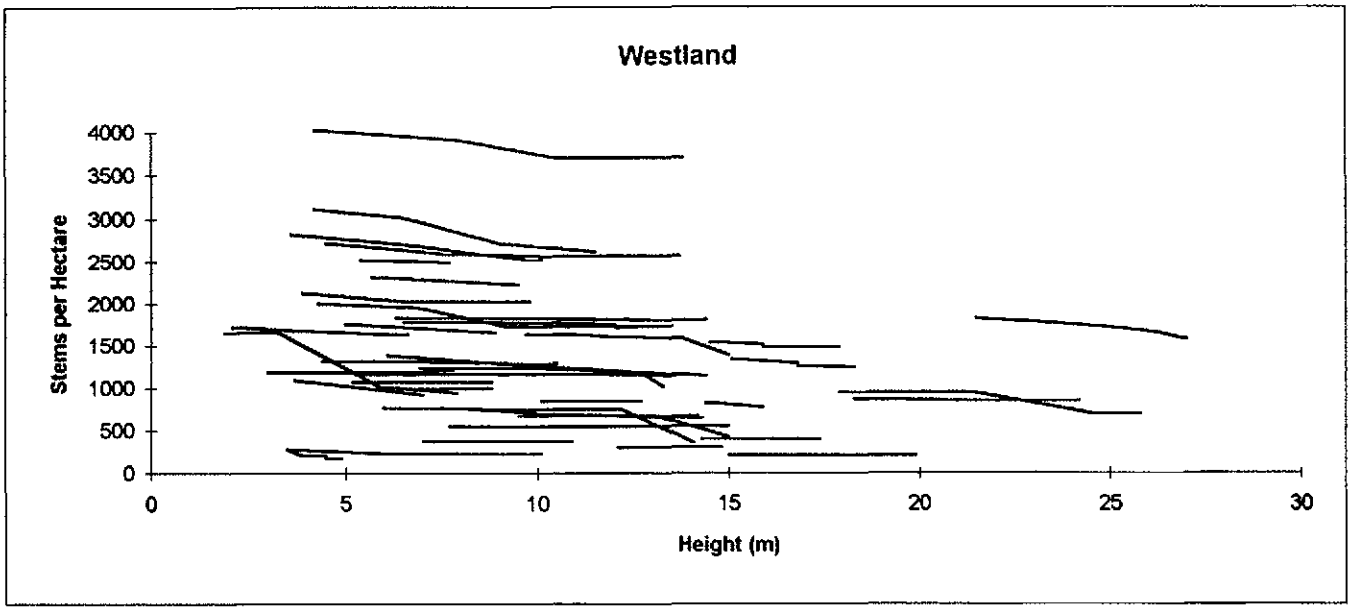




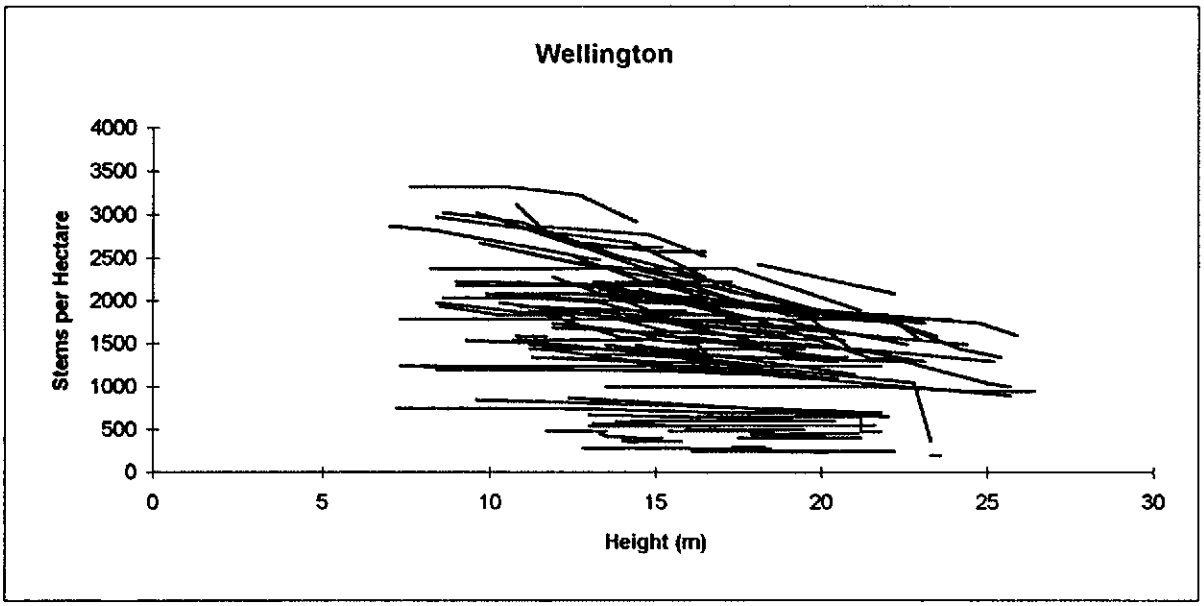
STEMS PER HECTARE vs MEAN CROP HEIGHT BY REGION



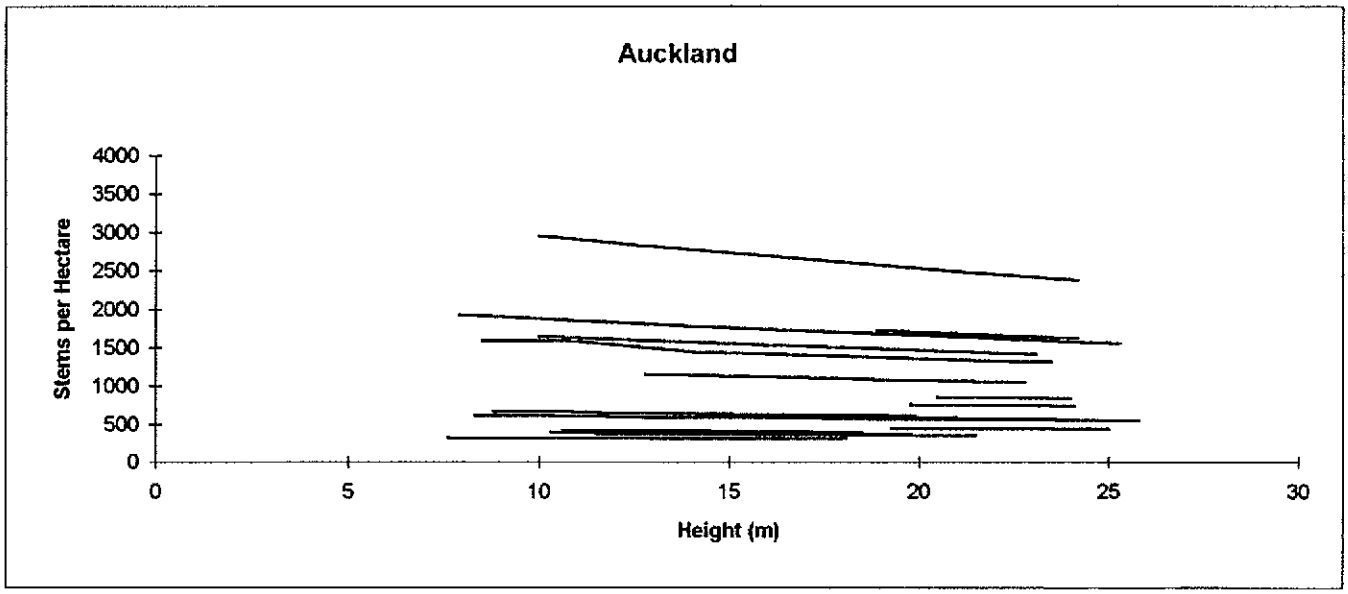


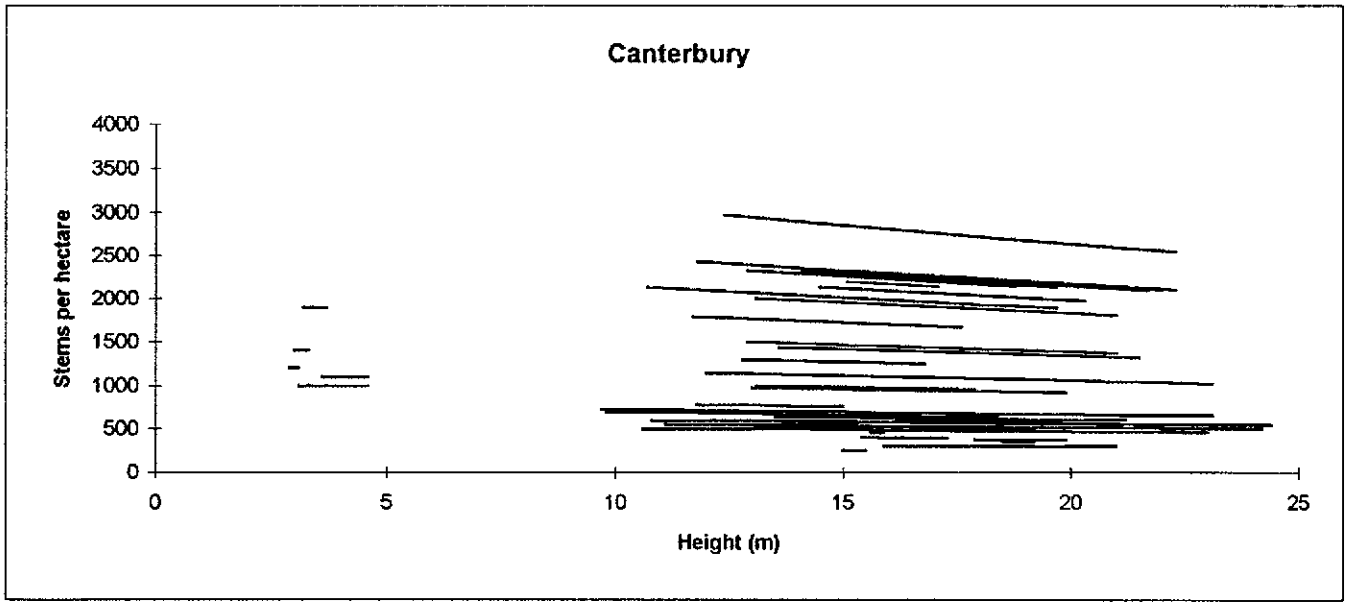


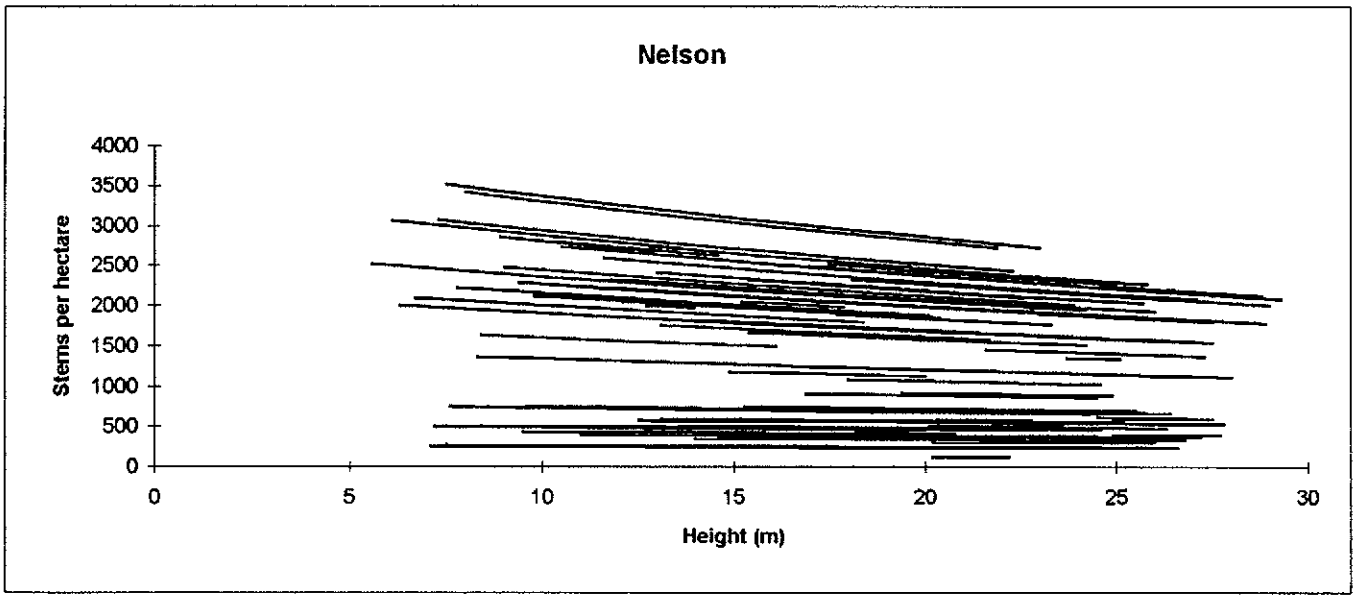
STEMS PER HECTARE vs MEAN CROP HEIGHT BY REGION



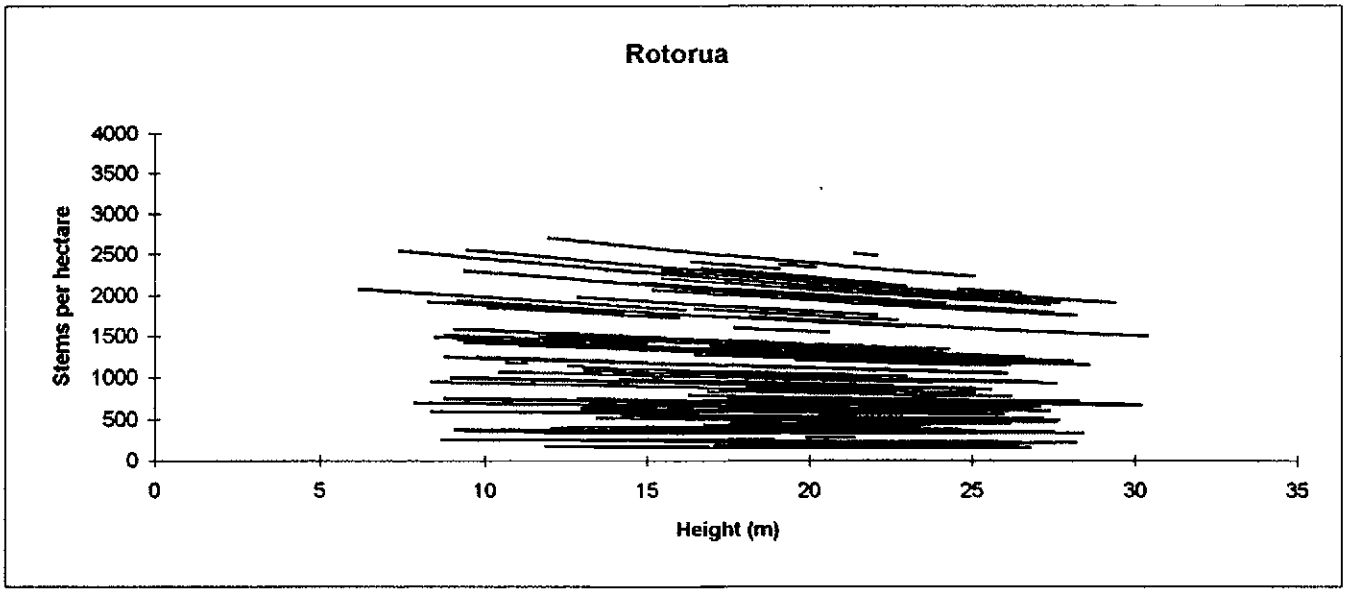
PREDICTED STEMS PER HECTARE vs MEAN CROP HEIGHT BY REGION

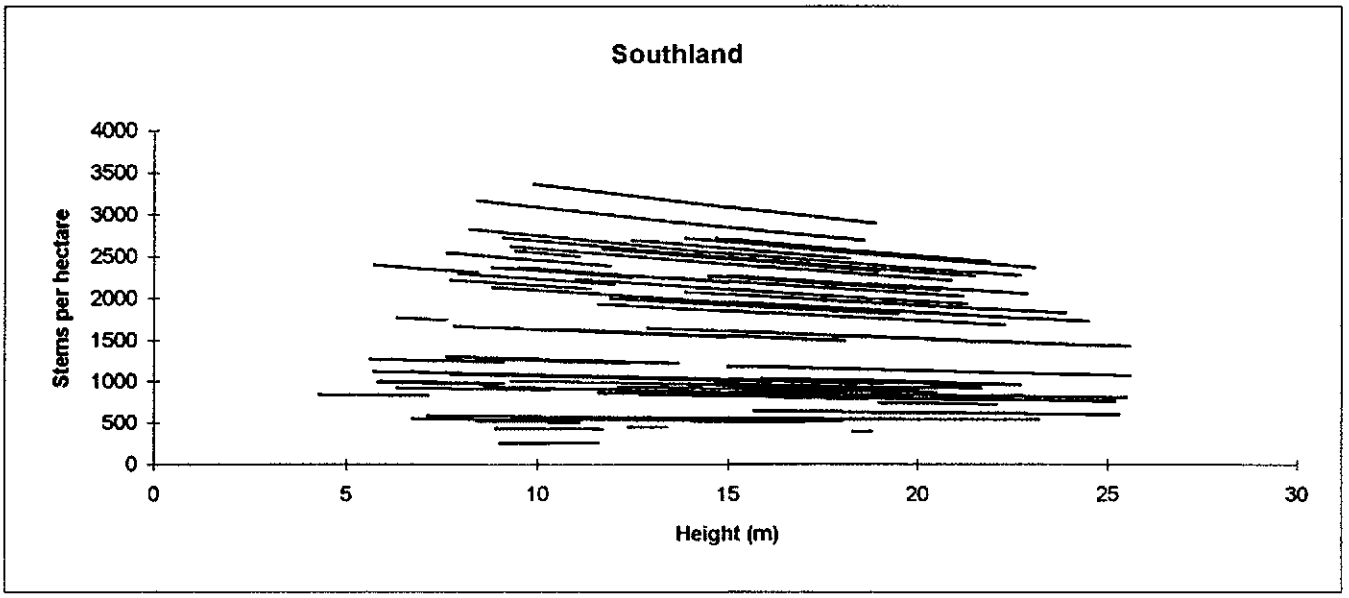


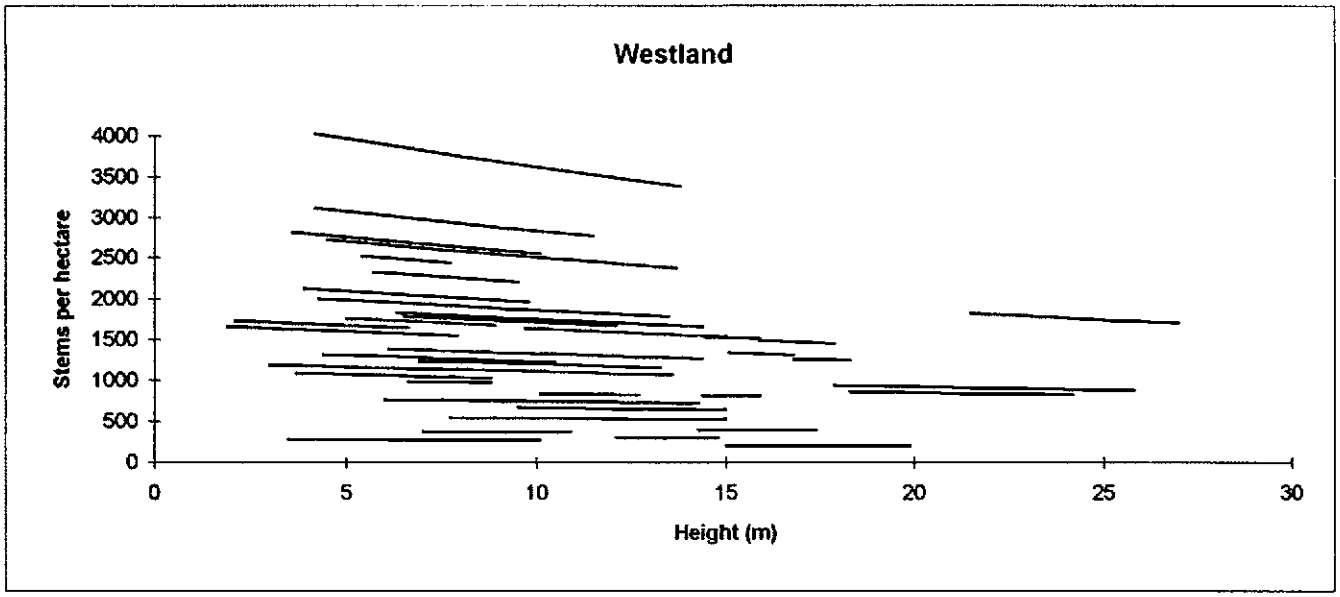




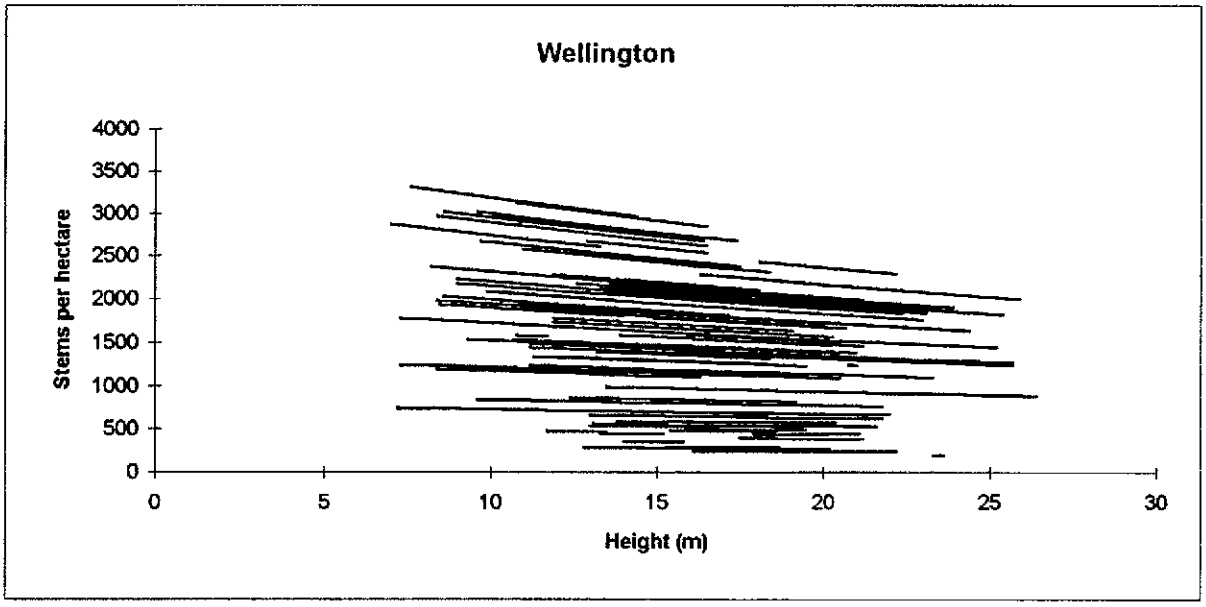
PREDICTED STEMS PER HECTARE vs MEAN CROP HEIGHT BY REGION



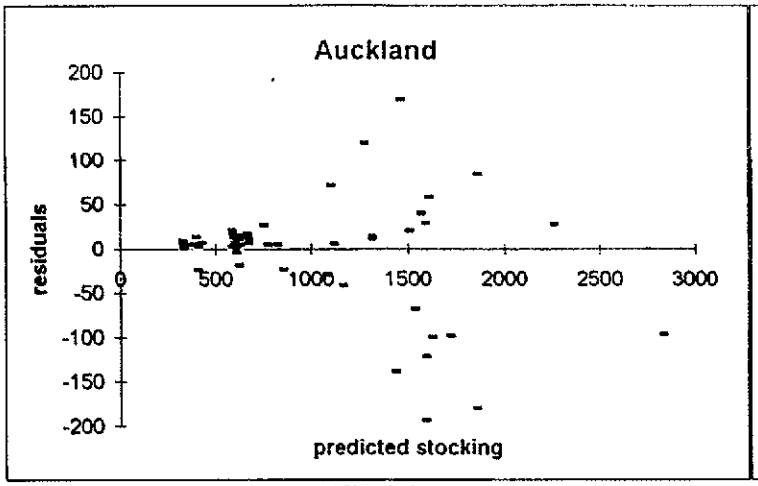


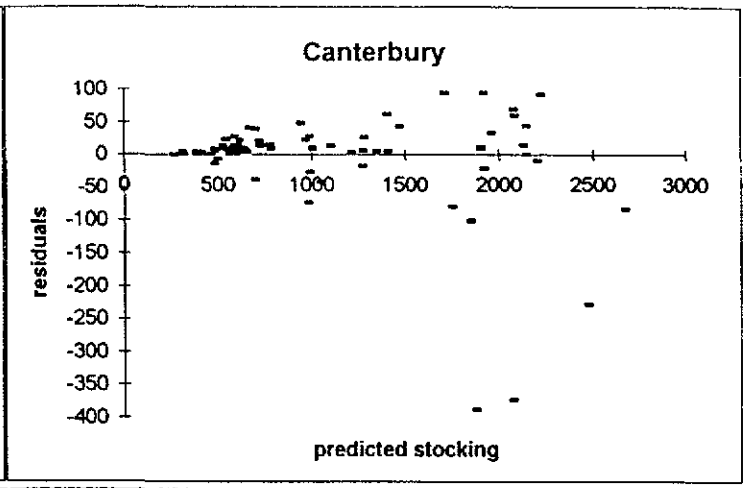


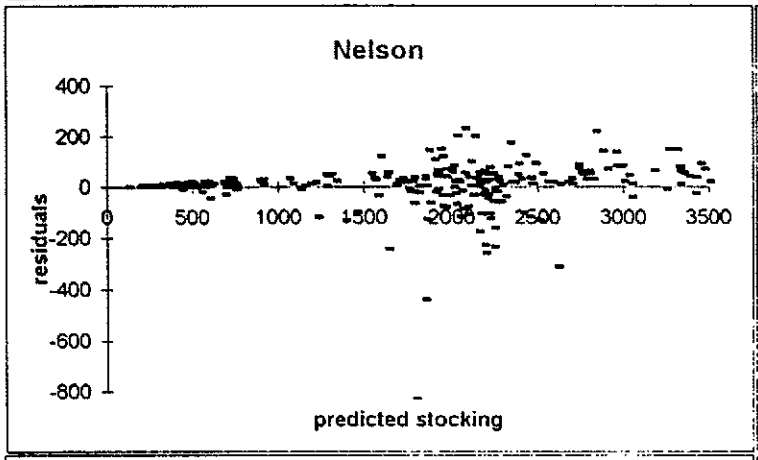
PREDICTED STEMS PER HECTARE vs MEAN CROP HEIGHT BY REGION

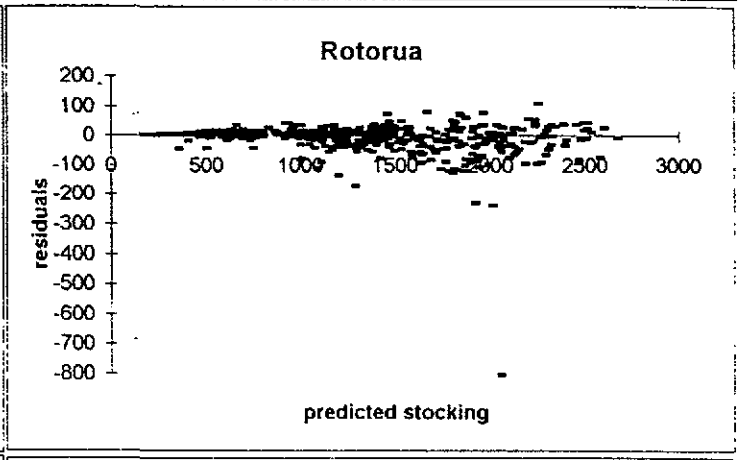


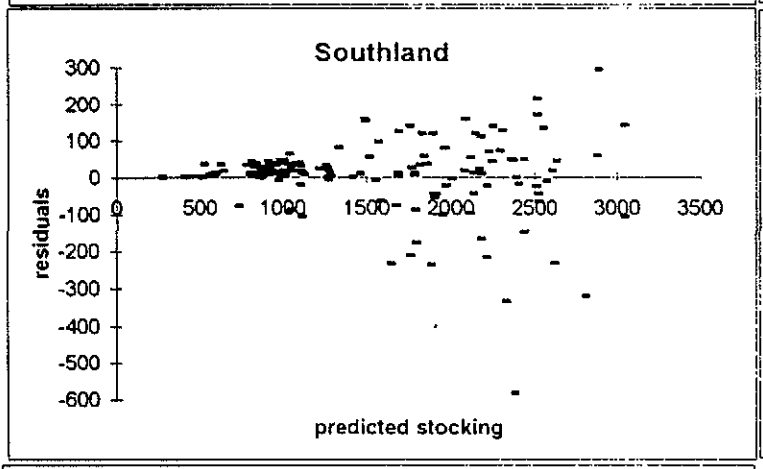
Residuals plotted by region

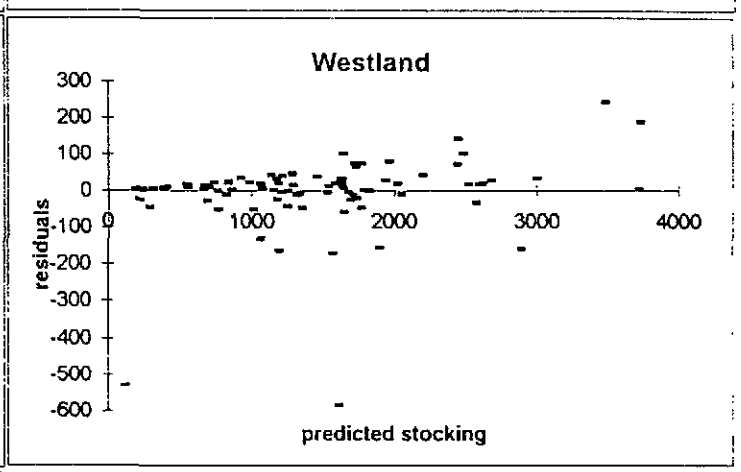


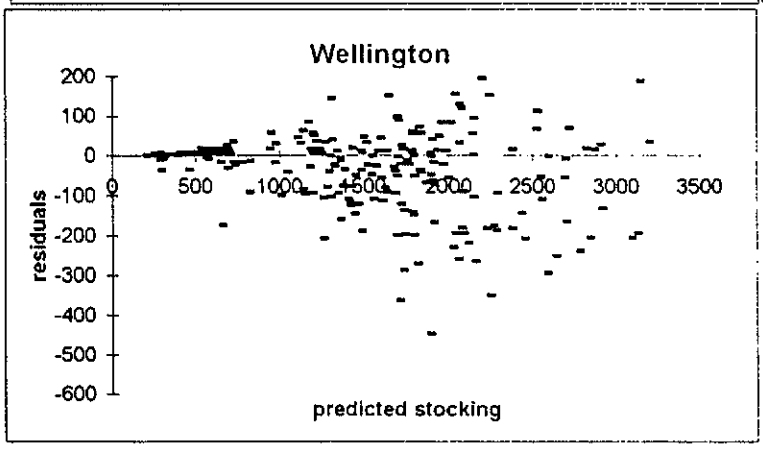












Here positive residuals represent an *under*-prediction in final stocking and hence an *over*-prediction of mortality. It appears that mortality was slightly over predicted for Nelson and Southland plots and slightly under predicted for Auckland and Wellington plots but overall there is no obvious regional difference in the fit of the model.

References

Beekhuis (1966): Prediction of Yield and Increment in Pinus Radiata Stands in New Zealand, Technical Paper No. 49 1966, O.D.C.564

Garcia (1981): pers. comm. An Approximation for Beekhuis Mortality Model

Acknowledgements

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