PASTURE GROWTH CONSTRAINTS ON DRY STEEP EAST COAST HILL COUNTRY

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ABSTRACT

Dry hill country provides a diverse environment in which variations in aspect and slope affect pasture growth and soil processes in a number of different ways.

The AgResearch fertiliser and pasture growth trial at Waipawa in the east coast of the North Island of New Zealand, provided an ideal location, with contrasting topography and fertiliser treatments at which to measure pasture growth constraints, with particular reference to nitrogen (N), in dry east coast hill country over the period of a year.

Initial soil testing at the trial site revealed large differences in soil total N and phosphorus (P) concentrations between aspects, slopes and P fertility regimes in the top 75 mm of the Waipawa silt loam soil. The measured differences in soil N concentrations (ranging from 2.60-5.80 mg N/g) are a result of contrasting energy and moisture regimes between the aspects and slopes, affecting soil forming processes and subsequent soil total N concentrations. The differences in soil total P concentrations (ranging from 0.42-0.88 mg P/g) between aspects and slopes can be largely attributed to stock transfer, while the variation between P fertility regimes can be attributed to a large application of P fertiliser to the high P treatment before commencement of the trial.

The existing trial provided three main contrasts over which the major restrictions on pasture growth could be measured. These were phosphate status (high phosphate (HP) and low phosphate (LP)), aspect (North and South), and slope (steep (25° +), easy (15-20°) and flat (0-12°)). This gave a total of ten combinations of P status and topography. Each of these sites was replicated three times to give a total of 30 locations. At each location two 0.5 m^2 cages were used to measure pasture growth. One of the cages was used to measure pasture growth under the current soil fertility regime, while the other cage had 120 kg N/ha as urea applied to it, to allow growth under non-limiting N conditions. The cage locations were pretrimmed before cage placement and pasture was cut monthly (or when growth conditions permitted) and analysed. Soil samples were taken from adjacent to the cage under which pasture growth was measured in the absence of added N fertiliser. Each sample comprised six cores that were taken to a depth of 75

mm at the start of each growth period and analysed for a range of soil measurements, which were related to pasture growth.

There was a wide range of total pasture yield and pasture growth rates between sites and seasons. Measured total annual pasture production ranged from 2394 – 9067 kg DM/ha/yr in the absence of added N on HP northerly steep (HPNS) and HP northerly easy (HPNE) sites respectively. Total annual pasture production in the presence of non-limiting N (potential yield) ranged from 8001 – 18532 kg DM/ha/yr on LP northerly steep (LPNS) and HPNE sites respectively. Daily pasture growth rates in the absence of added N ranged from 1.13 kg DM/ha/day on the LPNS sites in mid spring to 34.51 kg DM/ha/day on HP southerly easy (HPSE) sites in the same period. Daily pasture growth rates in the presence of non-limiting N ranged from 3.78 kg DM/ha/day on LPNS sites in mid spring to 77.95 kg DM/ha/day on the HPNE sites in early spring.

The major constraints on pasture growth within each site fluctuated throughout the year, between climatic and nutrient inputs. However, the most consistent and major constraint on all sites was N deficiency. Total annual pasture yield depression from potential due to N deficiency ranged from 5757 – 9465 kg DM/ha/yr on LPNS and HPNE sites. Daily pasture yield depression from potential growth rate ranged from 2.65 kg DM/ha/day on LPNS sites in mid spring to 45.36 kg DM/ha/day on HPNE sites in early spring.

Increased P levels provided increased total annual yields, with HP sites yielding on average 1038 and 2209 kg DM/ha/yr more pasture in the absence and presence of non-limiting N respectively than LP sites. NE and flat sites produced the largest and most consistent P responses throughout the year, whilst the P response was generally largest in dry periods when soil moisture was limiting. This was suggested to result from an increased rooting depth on HP sites allowing them to source more water.

Sunlight and temperature were major constraints on pasture growth on southerly and flat sites throughout late autumn and winter, whilst soil moisture was the major constraint on northerly sites from mid spring through to the end of summer as well as on southerly and flat sites from mid to late summer.

Clover yields were small and scattered throughout the trial in all seasons. The HPNE and HPSE sites generally yielded the most clover throughout the year, with the highest yield of 1497 kg DM/ha/yr measured on HPNE sites in the presence of non-limiting N.

The mineralisable N soil test showed some potential for use as an indicator of potential pasture yield, however the varying temperature regimes between aspects and slopes limited its applicability to all sites due to the heavy dependence of the mineralisation rate on temperature. The Olsen P and ammonium-N and nitrate-N soil tests provided no significant relationship with pasture yield.

A pasture growth model relating pasture growth (G) to evapotranspiration (E_t) according to the equation $G = kE_t$ (where the proportionality constant (k), with units of kg D.M./ha/mm, is a site-specific factor which could be an index of soil fertility status), showed potential to be used in hill country.

The model was able to account for much of the greater than two fold difference in total annual pasture yields between the lowest producing and highest producing sites in the presence of non-limiting N ($R^2 = 0.66$), using a single growth constant (k) for LP and HP sites. When separate k values were used for LP and HP sites the relationship between measured and predicted total annual yield improved ($R^2 = 0.89$ & 0.73 for LP and HP sites respectively). When the seasonal accuracy of the model was tested, prediction on some sites in some periods was found to be inaccurate. Some simple adjustments such as altering the depth of available water and winter growth rates on southerly steep (SS) sites was able to increase the accuracy of the model on some of the sites. Major factors decreasing the accuracy of the model appear to be depth of available water, soil hydrophobicity in summer, recharging of soil water through capillary action in spring and warm convection currents increasing pasture growth on SS sites in winter to above predicted levels. Further development of the model will require the effect of these factors to be quantified and accounted for.

The model was also able to reasonably accurately predict the soil gravimetric water contents (top 75 mm) of sites of contrasting aspect and slope over a four year period.

Overall, dryland hill country provides an extremely variable pasture production system which is affected by a great number of factors. The greatest factor affecting pasture growth appears to be plant available N, which in dryland hill country is inherently severely deficient. The other major factors are mostly climate-related and vary between sites depending on aspect and slope location. The intensification of farming systems demands that thesc variations can be accurately accounted for so that more accurate whole farm system models can be used to develop farming policy and economic models. Calculating E_t and the subsequent depression from maximum yield by soil fertility, appears to be a method by which future models may more accurately aid farmers in analysing the efficiency of their system.

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TABLE OF CONTENTS

ABSTRACT ii
ACKNOWLEDGEMENTS vi
TABLE OF CONTENTS vii
LIST OF TABLES xv
LIST OF FIGURES xviii
LIST OF PLATES xxiv

CHAPTER 1

INTRODUCTION

INTRODUCTION 1

CHAPTER 2

LITERATURE REVIEW

2.1 DRYLAND HILL COUNTRY FARMING SYSTEMS 4
2.1.1 Introduction 4
2.1.2 Characteristics of Dryland Hill Country 4
2.1.2.1 Stock 4
2.1.2.2 Climate 5
2.1.2.3 Slope and Aspect 5
2.1.2.4 Soil Fertility 6
2.1.2.5 Grazing Management 6
2.1.2.6 Pasture composition 7

2.2 FERTILISER USE IN NEW ZEALAND 7

2.2.1 Environmental impact of fertiliser use 9

2.3 NITROGEN IN SOILS 10

2.3.1 Introduction 10

2.3.2 Geochemistry of nitrogen 10

2.3.3 Inorganic forms of nitrogen in soil 11

2.3.3.1 Exchangeable and water soluble forms 12

2.3.3.2 Mineral fixed ammonium 12

2.3.3.3 Soil nitrogen gases 13

2.3.4 Organic forms of soil nitrogen 13

2.3.4.1 Amino Acids 13

2.3.4.2 Amino Sugars 14

2.4 NITROGEN TRANSFORMATIONS IN SOIL: THE NITROGEN CYCLE 14

2.4.1 Mineralisation and Immobilisation 15

2.4.1.1 The Carbon : Nitrogen ratio 16

2.4.1.2 Temperature 17

2.4.1.3 Moisture 18

2.4.1.4 pH 19

2.4.1.5 Other factors 19

2.4.2 Nitrification 20

2.4.3 Biological N fixation 21

2.4.4 Denitrification 23

2.4.5 Fixation and mobilisation of ammonium 25

2.4.6 Volatilisation 25
2.4.7 Leaching 27
2.4.8 Other inputs and losses 28
2.4.9 Conclusion 28

2.5 PASTURE GROWTH AND NITROGEN RESPONSE 28

2.5.1 Factors affecting pasture growth and N response 29
2.5.1.1 Temperature 29
2.5.1.2 Soil moisture 30
2.5.1.3 Light 31
2.5.1.4 Rate of defoliation 32
2.5.1.5 Nutrients 33
2.5.1.5.1 Phosphorus 33
2.5.1.5.2 Potassium 34
2.5.1.5.3 Sulphur 34
2.5.1.6 pH 35
2.5.1.7 Species 35

2.5.2 Dry Hill Country 36

2.6 PASTURE GROWTH MODELLING 38

2.6.1 Evapotranspiration 39

2.7 CONCLUSIONS 41

CHAPTER 3

THE WAIPAWA FERTILISER TRIAL

3.1 TRIAL LOCATION AND SET UP 44

CHAPTER 4

PRE TRIAL SOIL TESTING

4.1 INTRODUCTION 48

4.2 MATERIALS AND METHODS 49

4.2.1 Soil sampling 49
4.2.2 Soil analysis 49

4.3 RESULTS AND DISCUSSION 49

4.3.1 Total N 49
4.3.2 Total P 55

4.4 CONCLUSIONS 57

CHAPTER 5

SOIL MEASUREMENTS AND RESULTS FOR THE TRIAL PERIOD

5.1 INTRODUCTION 59

5.2 MATERIALS AND METHODS 60

5.2.1 Nitrogen response trial design 60
5.2.2 Soil analyses 61
5.2.2.1 Soil moisture 61
5.2.2.2 Ammonium-N and Nitrate-N 61
5.2.2.3 Mineralisable N 62
5.2.2.4 Olsen P 62
5.2.2.5 Soil temperature 63

5.3 RESULTS AND DISCUSSION 63
5.3.1 Soil Moisture 63
5.3.2 Soil Temperature 66
5.3.3 Ammonium-N and Nitrate-N 67
5.3.4 Olsen-P 73
5.3.5 Mineralisable Nitrogen 74

5.4 CONCLUSIONS 81

CHAPTER 6

PASTURE GROWTH DATA

6.1 INTRODUCTION 83

6.2 MATERIALS AND METHODS 83
6.2.1 Herbage dry matter and composition 83
6.2.2 Pasture N content 84

6.3 RESULTS 84

6.3.1 Pasture yields in the absence of added nitrogen 85

6.3.2 Pasture growth in the presence of non-limiting nitrogen 95

6.3.3 Pasture yield limitation due to N deficiency 106

6.3.4 Estimated N fertiliser uptake 116

6.3.5 Clover growth 119

6.4 DISCUSSION 124

6.4.1 Nutrients 124

6.4.1.1 Nitrogen 124

6.4.1.2 Phosphorus 129

6.4.2 Micro-climatic effects 132

6.4.2.1 Temperature and Radiation 132

6.4.2.2 Soil moisture 134

6.4.3 Summary of pasture growth constraints 136

6.4.4 Potential for N fertiliser use 138

6.5 CONCLUSIONS 141

CHAPTER 7

PASTURE GROWTH MODELLING

7.1 INTRODUCTION 145

7.2 MODEL DEVELOPMENT 146

7.2.1 Calculation of E_t 147

7.3 DATA FOR MODEL PARAMETERISATION AND VALIDATION 152

7.4 MODEL EVALUATION 155

7.4.1 Gravimetric soil moisture validation 156

7.4.1.1 Gravimetric soil water content 1996-99 156

7.4.1.2 Gravimetric soil water content for the trial period 159

7.4.2 Prediction of pasture growth rates at individual sites 162

7.4.2.1 Predicted pasture production across sites 169

7.5 MODEL OVERVIEW 179

7.6 RELATIONSHIP BETWEEN k AND FERTILITY 184

7.7 MODEL APPLICATION 188

7.8 CONCLUSIONS 191

CHAPTER 8

CONCLUSIONS

CONCLUSIONS 193

CHAPTER 9

FUTURE RESEARCH

FUTURE RESEARCH.. 200

REFERENCES 203

APPENDICES.. 220

LIST OF TABLES

CHAPTER 2

Table 2.1 Inventory of N in the four spheres of the earth.. 11

CHAPTER 3

Table 3.1 Average monthly and yearly rainfall from 1994-1999 in mm.................. 44

CHAPTER 4

Table 4.1 Total N concentrations (mgN/g) of soils in the 0-37.5 mm depth. 50

Table 4.2 Statistical significance of total N and P concentrations in the 0-37.5 mm and 37.5-75 mm soil depths... 51

Table 4.3 Total soil N (mgN/g) in the 37.5-75 mm depth.. 54

Table 4.4 Total soil P (mgP/g) in the 0-37.5 mm depth. 56

Table 4.5 Total soil P (mgP/g) in the 37.5-75 mm depth.. 57

CHAPTER 5

Table 5.1 Date of soil sample collection. 61

Table 5.2 Monthly rainfall for the trial period (mm).. 61

Table 5.3 Gravimetric soil moisture (%) (0 – 75mm depth) on sites of contrasting slope, aspect and P status at each of the 8 sampling times........................ 63

Table 5.4 Statistical analysis of the soil moisture data for the 8 sampling times. ... 65

Table 5.5 Soil ammonium-N concentrations (μg N/g) (0 – 75mm depth) on sites of contrasting slope, aspect and P status at each of the sampling times........ 68

Table 5.6 Soil nitrate-N concentrations (μg N/g) (0 – 75mm depth) on sites of contrasting slope, aspect and P status at each of the sampling times........ 68

Table 5.7 Statistical analysis of the soil ammonium-N data for each of the samplings. 69

Table 5.8 Statistical analysis of the soil nitrate-N data for each of the samplings. .. 70

Table 5.9 Average Olsen P results (0 – 75mm depth) for each site........ 73

Table 5.10 Statistical analysis of the Olsen P results for the varying slopes and aspects. 74

Table 5.11 Soil mineralisable N concentrations (μg/g) (0 – 75mm depth) on sites of contrasting slope, aspect and P status at each of the 8 sampling times..... 75

Table 5.12 Statistical analysis of the mineralisable N data for each of the sampling times. 76

Table 5.13 Regressions of soil moisture (x) and mineralisable N values (y) within each site for the period of the trial........ 78

CHAPTER 6

Table 6.1 The dates of the 8 pasture growth periods........ 84

Table 6.2 Statistical analysis of selected contrasts of total pasture growth........ 87

Table 6.3 Daily pasture growth rates of sites in the absence of added N (kg D.M./ha/day) for the 8 growth periods........ 89

Table 6.4 Statistical analysis of selected contrasts of rate of pasture growth between sites in the absence of added N over 8 growth periods. 90

Table 6.5 Daily pasture growth rates of sites in the presence of non-limiting N (kg D.M./ha/day) for the 8 growth periods........ 98

Table 6.6 Statistical analysis of selected contrasts of rate of pasture growth between sites in the presence of non-limiting N over 8 growth periods. 99

Table 6.7 Limitation of pasture growth rate due to N deficiency (kg D.M./ha/day) over the 8 sample periods. 108

Table 6.8 Statistical analysis of the extent of limitation in pasture yield due to N deficiency for the 8 growth periods........ .108

Table 6.9 Apparent uptake of added fertiliser N in each growth period expressed as A (kg N/ha) and B (kg N/ha/day) 118

Table 6.10 Clover growth rates for sites in the absence of added N (kg D.M./ha/day) for the 8 growth periods. 120

Table 6.11 Clover growth rates for sites in the presence of non-limiting N (kg D.M./ha/day) for the 8 growth periods 121

Table 6.12 Statistical analysis of clover growth rates of all sites (N limiting and N non-limiting) combined for the 8 growth periods. 121

Table 6.13 Pasture growth statistics (when N limited and N non-limiting sites are considered together) for the 8 growth periods 127

Table 6.14 Summary of possible pasture growth constraints in autumn 137

Table 6.15 Summary of possible pasture growth constraints in winter. 137

Table 6.16 Summary of possible pasture growth constraints in spring. 137

Table 6.17 Summary of possible pasture growth constraints in summer. 137

CHAPTER 7

Table 7.1 Calculated sloping solar radiation (MJ/m^2) on varying slopes (0 and 30°) and aspects (north and south) in summer and winter 152

Table 7.2 Table showing the total growth of LP and HP sites (non-limiting N), the calculated total E_t and calculated k values 163

Table 7.3 Table showing the total growth of LP and HP site (N-limited), the calculated total E_t and calculated k values (once suggested alterations to the model have been made) 185

Table 7.4 Total calculated cumulative E_t (mm) from each treatment for the years 1972-1992 191

LIST OF FIGURES

CHAPTER 2

Figure 2.1 The various components of the N cycle and the pathways between each of the pools 15

CHAPTER 4

Figure 4.1 Total soil N averaged within each aspect and slope in the 0-37.5 mm depth. 53

Figure 4.2 Total soil P averaged within slopes and aspects for LP and HP treatments in the 0-37.5 mm depth. 55

CHAPTER 5

Figure 5.1 Gravimetric soil moisture (%)(0 – 75mm depth) on sites of contrasting slope, aspect and P status at each of the 8 sampling times. 64

Figure 5.2 Average daily soil temperatures (0 – 100mm depth) for individual days at 15-day intervals for the period of the trial. 67

Figure 5.3 Average daily soil temperatures (0 – 100mm depth) for the NE sites...... 67

Figure 5.4 Soil mineral N (ammonium-N + nitrate-N) (0 – 75mm depth) at each site at each of the sampling times. 69

Figure 5.5 Frequency distribution of measured ammonium-N concentrations from all replicate cage sites and sampling times. 71

Figure 5.6 Frequency distribution of measured nitrate-N concentrations from all replicate cage sites and sampling times. 71

Figure 5.7 Average available mineral N (μg N/g) (0 – 75mm depth) averaged over all sites for the 8 sampling times. 72

Figure 5.8 Soil mineralisable N (μg/g) (0 – 75mm depth) values on sites of contrasting slope, aspect and P status at each of the 8 sampling times..... 76

Figure 5.9 Mineralisable N values (0 – 75mm depth) averaged across all sites for each sampling time 77

Figure 5.10 Relationship between soil moisture and soil temperature throughout the year on LPSE sites 79

Figure 5.11 Graph showing the relationship between soil moisture and soil temperature for the LPSE site over the period of the trial. 79

Figure 5.12 Graph of average soil moisture vs. average mineralisable N (0 – 75mm depth) values for each replicate over the period of the trial. 80

Figure 5.13 Average mineralisable N for each site vs. total N in the top 75 mm. 81

CHAPTER 6

Figure 6.1 Comparison of total growth between nitrogen limited and nitrogen unlimiting plots within each site 86

Figure 6.2 Annual pasture production in the absence of added N highlighting some important contrasts. 88

Figure 6.3 Averaged daily growth rates (kg D.M./ha/day) across slopes and aspects showing the effect of soil P status in each growth period for sites in the absence of added N 90

Figure 6.4 Averaged daily growth rates (kg D.M./ha/day) across slopes and P fertilities showing the effect of aspect in each growth period for sites in the absence of added N. 91

Figure 6.5 Daily pasture growth rates on HP sites in the absence of added N, highlighting the variation between aspects throughout the year. 92

Figure 6.6 Averaged daily pasture growth rates (kg D.M./ha/day) across P fertilities and aspects showing the effect of slope in each growth period for sites in the absence of added N. 93

Figure 6.7 Daily pasture growth rates on HP sites in the absence of added N, highlighting the variation between slopes throughout the year. 94

Figure 6.8 Total annual pasture production in the presence of non-limiting N, highlighting some important contrasts. 97

Figure 6.9 Daily pasture growth rates in the presence of non-limiting N (kg D.M./ha/day) averaged across slopes and aspects showing the effect of P fertility in each growth period. 100

Figure 6.10 Daily pasture growth rates of sites in the presence of unlimiting N (kg D.M./ha/day) averaged across slopes and P fertilities showing the effect of aspect in each growth period. 101

Figure 6.11 Daily pasture growth rates on individual HP treatments highlighting the variation between aspects throughout the year. 103

Figure 6.12 Daily pasture growth rates (kg D.M./ha/day) averaged across P fertilities and aspects showing the effect of slope in each growth period. 104

Figure 6.13 Daily pasture growth rates of individual HP treatments highlighting the variation between slopes throughout the year. 105

Figure 6.14 Limitation in annual pasture production due to N deficiency for all sites 107

Figure 6.15 Pasture yield limitation for all sites displayed as a quantitative value (A) and a percentage (B) for the autumn period. 110

Figure 6.16 Pasture yield limitation for all sites displayed as a quantitative value (A) and a percentage (B) for the winter period. 111

Figure 6.17 Pasture yield limitation for all sites displayed as a quantitative value (A) and a percentage (B) for the spring period. 113

Figure 6.18 Pasture yield limitation for all sites displayed as a quantitative value (A) and a percentage (B) for the summer period. 115

Figure 6.19 Apparent total uptake of added fertiliser nitrogen. 116

Figure 6.20 Apparent uptake of added fertiliser N on each site in each growth period 118

Figure 6.21 Total annual N uptake by pasture in the absence of added N and in the presence of non-limiting N at each site 119

Figure 6.22 Total growth of clover (kg D.M./ha) for each site for the trial period. .. 120

Figure 6.23 Clover growth for sites in the absence of added N for the 8 sample periods. 123

Figure 6.24 Clover growth for sites in the presence of non-limiting N for the 8 sample periods. 124

Figure 6.25 Relationship between total growth in the absence of added N and total pasture yield depression. 126

Figure 6.26 Relationship between individual pasture growth rates at each site in the absence of added N and the pasture yield depression at each site for each growth period 126

Figure 6.27 Relationship between average soil mineralisable N throughout the year at each replicate and total annual growth of pasture in the absence of added N. 128

Figure 6.28 Relationship between the percentage of depression in potential growth and average mineralisable N throughout the year at each replicate. 128

Figure 6.29 Total pasture growth averaged across all sites showing the effect of phosphate fertility. 130

Figure 6.30 Total grass growth on sites in the presence of non-limiting N. 131

Figure 6.31 Average soil temp on NE, NS, SE and SS sites for the first four growth periods vs. the average growth on the corresponding HP + N sites. 134

Figure 6.32 Average total pasture growth with or without N fertiliser showing the effect of slope. 136

Figure 6.33 Average total pasture growth with or without N fertiliser showing the effect of aspect. 136

CHAPTER 7

Figure 7.1 Measured and predicted gravimetric soil moisture content for the NE sites from 1996-1999 157

Figure 7.2 Measured and predicted gravimetric soil moisture content for the NS sites from 1996-1999 158

Figure 7.3 Measured and predicted gravimetric soil moisture content for the SE sites from 1996-1999 158

Figure 7.4 Measured and predicted gravimetric soil moisture content for the SS sites from 1996-1999 158

Figure 7.5 Measured and predicted gravimetric soil moisture for the NE sites 159

Figure 7.6 Measured and predicted gravimetric soil moisture for the NS sites 160

Figure 7.7 Measured and predicted gravimetric soil moisture for the SE sites 161

Figure 7.8 Measured and predicted gravimetric soil moistures for the SS sites....... 161

Figure 7.9 Measured and predicted gravimetric soil moistures for the flat sites...... 162

Figure 7.10 Daily calculated evapotranspiration rates for NS (A), SS (B) and flat (C) sites throughout the period of the trial 164

Figure 7.11 Relationship between measured and predicted daily growth rates for unlimiting-N sites, averaged for the 8 growth periods when individually calculated *k* values for each site are used....... 165

Figure 7.12 Relationship between measured and predicted daily growth rates for HPNE unlimiting-N sites, averaged for the 8 growth periods when an individual calculated *k* value was used 166

Figure 7.13 Relationship between measured and predicted daily growth rates for LPNE unlimiting-N sites, averaged for the 8 growth periods when an individual calculated *k* value was used 167

Figure 7.14 Relationship between measured and predicted daily growth rates for LPSE unlimiting-N sites, averaged for the 8 growth periods when an individual calculated *k* value was used 168

Figure 7.15 Relationship between measured and predicted daily growth rates for LPF unlimiting-N sites, averaged for the 8 growth periods when an individual calculated *k* value was used 168

Figure 7.16 Comparison of measured total growth and predicted total growth when *k* is calculated by averaging both LP and HP treatments....... 171

Figure 7.17 Relationship between measured and predicted daily growth rates for unlimiting-N sites, averaged for the 8 growth periods when a single *k* value of 28.5 is used....... 172

Figure 7.18 Measured and predicted cumulative pasture growth on NE sites receiving non-limiting N 175

Figure 7.19 Measured and predicted cumulative pasture growth on NS sites receiving non-limiting N 175

Figure 7.20 Measured and predicted cumulative pasture growth on SE sites receiving non-limiting N 176

Figure 7.21 Measured and predicted cumulative pasture growth on SS sites receiving non-limiting N 176

Figure 7.22 Measured and predicted cumulative pasture growth on flat sites receiving non-limiting N 177

Figure 7.23 Comparison of measured total growth and predicted total growth when *k* is calculated by averaging HP treatments 178

Figure 7.24 Comparison of measured total growth and predicted total growth when *k* is calculated by averaging LP treatments 178

Figure 7.25 Measured and predicted cumulative growths for SS sites using the readjusted model 181

Figure 7.26 Relationship between measured and predicted daily growth rates for HP non-limiting N sites, averaged for the 8 growth periods when a single *k* value of 28.5 is used 183

Figure 7.27 Relationship between measured and predicted daily growth rates for HP non-limiting N sites, averaged for the 8 growth periods when amendments have been made to the depth of available water on NE sites and winter growth rates on SS sites 183

Figure 7.28 Comparison of measured total growth and predicted total growth on HP sites when suggested adjustments have been made using an adjusted *k* value for HP sites only 184

Figure 7.29 Relationship between mineralisable N and calculated *k* values for N limited treatments 186

Figure 7.30 Relationship between the calculated *k* values of N limited LPNE and HPNS treatments and mineralisable N 187

Figure 7.31 Relationship between the calculated *k* values of N limited HPSE and HPSS treatments and mineralisable N 188

LIST OF PLATES

Plate 3.1 View of the typical dry hill country at Waipawa. 47

Plate 6.1 The effect of N fertiliser on a LPSE site in late autumn. 143

Plate 6.2 Pasture growth on a HPNE site in late autumn with N fertiliser added. 144

Plate 6.3 Pasture growth on a HPNE site in late autumn without N fertiliser. 144